September 25, 2019

<u>Ex Parte</u>

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Re: *Unlicensed Use of the 6 GHz Band*, ET Docket No. 18-295; *Expanding Flexible Use in Mid-Band Spectrum*, GN Docket No. 17-183

Dear Ms. Dortch:

The undersigned companies respond to the Fixed Wireless Communication Coalition's ("FWCC") recent filings discussing studies submitted by our group that demonstrate the feasibility of sharing between unlicensed RLAN devices and incumbent fixed services ("FS") in the 6 GHz band.[1] As the Commission has recognized[2] and the record demonstrates,[3] the 6 GHz

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[1] Letter from Donald J. Evans and Mitchell Lazarus, Counsel for the Fixed Wireless Communications Coalition ("FWCC"), to Marlene H. Dortch, Secretary, Federal Communications Commission ("FCC"), ET Docket No. 18-295, GN Docket No. 17-183 (filed July 25, 2019) ("First FWCC Letter"); Letter from Donald J. Evans, Mitchell Lazarus, and Seth L. Williams, Counsel for the FWCC, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed Aug. 22, 2019) ("Second FWCC Letter").

[2] *See Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Proposed Rulemaking, 33 FCC Rcd. 10496, ¶¶ 1, 3-4 (2018) ("6 GHz NPRM") (explaining that "[t]he broad spectrum swaths that we propose making available in this frequency band could promote new technology and services that will advance the Commission's efforts to make broadband connectivity available to all Americans, especially those in rural and underserved areas," and recognizing the "[e]xplosive [d]emand" for unlicensed spectrum and the growing demand on systems that rely on unlicensed devices to operate); *see also id.* at 10544, Statement of Chairman Pai (discussing a "shortage of airwaves dedicated" to unlicensed use); *id.* at 10547, Statement of Commissioner Rosenworcel (stating that "current Wi-Fi bands are congested because they are used by more than 9 billion devices").

[3] *See, e.g.*, Letter from Charter Communications, Inc., Comcast Corporation, Cox Enterprises, Inc., and NCTA to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed Aug. 9, 2019); *see also* Letter from the Open Technology Institute at New America to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295 (filed May 21, 2019); Reply Comments of Open Technology Institute at New America, American Library

band offers an extraordinary opportunity for the Commission to open up 1200 megahertz of critically needed unlicensed spectrum to enable the next generation of Wi-Fi, support 5G expansion, and connect more Americans, while protecting incumbent licensed services. FWCC's latest filings continue its strategy of questioning individual elements of our analysis—but as discussed in this letter, FWCC's critiques are incorrect, largely repetitive, and do not change the conclusion of our analysis in any meaningful way.

More telling is what is absent from FWCC's filing—new technical evidence to assist the Commission in determining whether unlicensed operations in the 6 GHz band pose any risk of harmful interference to licensees. Although FWCC presumably has access to comprehensive information about its members' links, it has yet to present at any stage in this proceeding any detailed evidence that operating links would be at risk of harmful interference, preferring instead to object to various aspects of our analysis. One possible reason for this omission is that operational FS links are even more robust than our conservative analyses have assumed.

Also absent from FWCC's response is any dispute of one of the central points of our July 31, 2019 filing—that FS main beams only rarely pass near high-rise buildings. FWCC has argued consistently since 2017 that the principal risk to FS incumbents is the occurrence of hypothetical RLANs in the main beam of an FS antenna. The RLAN Group undertook our New York Lidar analysis specifically to quantify this possibility. The results show that the occurrence rate is extraordinarily small even in New York City, thereby refuting the central pillar of FWCC's earlier arguments. Our filing goes on to show that even in the small number of instances where a high-rise building does intersect with an FS beam, there is no risk of harmful interference. We will respond to FWCC's claims on this secondary line of analysis separately. It is important for the Commission to recognize, however, that FWCC has effectively conceded that the geometry of RLANs in high rises in FS main beams is rare, and its filings instead consist of arguments on the right assumptions for considering these corner cases.

Even in making this far narrower complaint, FWCC fails to make a new and helpful contribution to the technical record that could help advance our mutual understanding of the band. Instead, FWCC's advocacy mischaracterizes our filings and repeats several earlier unfounded criticisms of our studies, as described in this letter. Our companies are committed to protecting incumbent services from harmful interference. We have worked hard to create a deep and substantial record, with technical studies and explanations responding to each of FWCC's assertions. We have performed both nationwide analyses and studies of worst-case links, in each case showing our conservative assumptions and calculations. Furthermore, we have met with several FS licensees to present our analyses and have invited them to work with us on studies of their networks—and we stand ready to engage further on an engineer-to-engineer basis to address any remaining technical concerns. We believe such engagement with individual licensees is important to ensure that parties are not talking past each other. Unfortunately,

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Association, Consumer Federation of America, COSN—Consortium for School Networking, Public Knowledge, Access Humboldt, and X-Lab at 4, ET Docket No. 18-295, GN Docket No. 17-183 (filed Mar. 18, 2019).

FWCC's latest filings do not take that path, making several heated assertions that are simply not supportable.

First, FWCC advances the eyebrow-raising claim that the very "existence [of unlicensed devices] appears to violate Section 301 of the Communications Act."[4] We assume that this is a rhetorical flourish. It would be extraordinary (and plainly wrong) for FWCC to argue that the FCC's 6 GHz proposal in this proceeding—as well as the operation of unlicensed Wi-Fi and LAA devices in the 5 GHz band and ultra-wideband devices that now operate in the 6 GHz band—are illegal. The Communications Act does not prohibit unlicensed devices. In fact, FWCC explains that this is the case in the very same letter. The Commission has confronted and rejected FWCC's recycled and incorrect assertion before and need not engage with it again here.[5]

There is no dispute that the Commission's operating rules for unlicensed devices require the protection of licensed operations from harmful interference. That is why we have submitted numerous detailed studies establishing that RLAN devices—very-low-power ("VLP") portable devices indoors and outdoors, low-power indoor-only ("LPI") devices, and standard-power devices under automatic frequency coordination ("AFC") control—will not cause harmful interference.[6] The FCC, however, is the ultimate arbiter of what constitutes "harmful interference" in particular spectrum bands. The Commission has great leeway to make rules that simultaneously respect licensees' need for continued, reliable operations while also ensuring that

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4 First FWCC Letter at 2.

5 *See Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, Second Report and Order and Second Memorandum Opinion and Order, ET Docket No. 98-153, 19 FCC Rcd. 24,558, 24,559 (2004).

6 *See, e.g.*, *Lidar Study of High-Rise Buildings in Fixed Service 3dB Beams in New York Metropolitan Area* (July 2019) ("Lidar Study"), *as attached to* Letter from Paul Margie, Counsel to Apple, Inc., Cisco Systems, Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, and Microsoft Corporation, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed July 31, 2019); *6 GHz Spectrum Sharing: Los Angeles Dep't of Water & Power Interference Protection Case Study* (July 2019) ("LADWP Study"), *as attached to* Letter from Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Marvell Semiconductor, Inc., Microsoft Corporation, Qualcomm Incorporated, and Ruckus Networks to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed July 5, 2019) ("LADWP Ex Parte"); Letter from Apple Inc., Broadcom Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Marvell Semiconductor, Inc., Microsoft Corporation, and Qualcomm Incorporated to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed July 2, 2019) ("VLP Ex Parte"); Letter from Paul Margie, Counsel to Apple, Inc., Broadcom Inc., Cisco Systems, Inc., Facebook, Inc., and Hewlett Packard Enterprise, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed June 24, 2019).

extremely valuable spectrum does not go unused due to an extremely small probability of effects that do not disrupt licensed services.[7]

FWCC, however, hopes the FCC will determine that any risk of *any* potential effect on an FS link constitutes harmful interference, no matter how remote the possibility, and even if it does not disrupt the link. The very case that FWCC cites for this proposition, *American Radio Relay League v. FCC ("ARRL")*, however, explicitly rejects this approach. Instead, *ARRL* defers to the Commission's definition of "harmful interference" as interference that "seriously degrades, obstructs or repeatedly interrupts" a radio communication and defers to the Commission's interpretation of that definition as applied to a particular set of facts.[8] *ARRL* confirms the FCC's well-established authority to weigh record evidence and adopt a threshold for harmful interference that meaningfully distinguishes it from mere interference.[9] The record in this proceeding demonstrates that RLAN devices—including VLP and LPI devices, as well as those under AFC control—lack a "significant potential"[10] for causing harmful interference under this or any other reasonable definition of the term.

Second, FWCC incorrectly asserts that our filings have shown only that harmful interference is unlikely for "a single RLAN at a typical location."[11] We have presented numerous analyses that show that 6 GHz RLAN devices will not cause harmful interference—and not one of them makes the error that FWCC claims. Instead, we have conducted a nationwide analysis of the risk of harmful interference on a *per-link* basis,[12] including RLAN devices placed in extremely unusual locations to ensure coverage of worst cases. Moreover, we supplemented this work with analyses of hundreds of individual, real, worst-case scenario links, complete with

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7 *See* 47 C.F.R. § 15.5.

8 *Am. Radio Relay League, Inc. v. FCC.*, 524 F.3d 227, 235 (D.C. Cir. 2008) ("*ARRL*").

9 "The Commission has long interpreted section 301 of the Act to allow the unlicensed operation of a device that emits radio frequency energy as long as it does not 'transmit[] enough energy to have a significant potential for causing harmful interference' to licensed radio operators." *Id.* at 234 (alteration in original) (quoting *Revision of Part 15 of the Commission's Rules Regarding Ultra–Wideband Transmission Systems*, 19 FCC Rcd. 24,558, 24,589 & n. 179 (2004)).

10 *Id*.

11 Second FWCC Letter at 2; *see also* First FWCC Letter at 2-3.

12 *See* RKF Engineering Services, *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band*, at 5-6 (Jan. 2018) ("RKF Study"), *as attached to* Letter from Paul Margie, Counsel to Apple, Inc., Broadcom Inc., Facebook, Inc., Hewlett Packard Enterprise, and Microsoft Corporation, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295,GN Docket No. 17-183 (filed Jan. 26, 2018).

detailed link budget calculations for specific FS receivers.[13] None suggest any material risk of harmful interference.

Even deeper problems with FWCC's bumper-sticker advocacy are revealed by examining the details. The statistical argument FWCC relies on when mischaracterizing our position does not provide a reliable or appropriate basis for Commission decision making. Most fundamentally, FWCC admits that its argument only addresses the probability of interference,"[14] which is permissible, and not *harmful* interference, which is not. Thus, accepting this argument would effectively prevent the Commission from drawing a meaningful distinction between interference and harmful interference. Virtually any incumbent will be able to devise simplistic probabilistic models that purport to show some risk of mere interference from other services seeking to share the band. That is why the Commission requires not just a remote chance of interference, but a real risk of *harmful* interference—i.e., a "significant potential" of interference that "seriously degrades, obstructs or repeatedly interrupts" a licensed service.[15] A back-of-the-envelope calculation that purports to show a small risk of mere *interference* falls far short of this standard.

Even by its own standard, FWCC's argument fails to make a reasoned prediction about the risk of interference (harmful or otherwise). FWCC begins with an assumed one-in-a-trillion probability that an RLAN will cause interference and multiplies that by the total number of RLAN devices and FS links in an over-simplified attempt to estimate the total incidence of interference nationwide geared more to rhetoric than engineering.[16] The actual risk of RLAN-to-FS interference is the result of an interaction that depends on characteristics of the RLAN device, the FS link, the propagation environment, the presence of a multipath fade event, and other factors that are well described on the record. In addition, only a small fraction of RLAN devices are likely to be located anywhere near the main beam of an FS link. Analyzing the 2011 National Land Cover Database, we find that 88.2% of the CONUS has no FS main beams overhead at all, while 10.64% of CONUS areas with FS main beams overhead are permanent bodies of water, forest, shrubland, or cultivated cropland. Just 1.17% of the continental United States land area has both a population and one or more FS main beams overhead.

	Urban (km^2)	Suburban (km^2)	Rural (km^2)	Barren (km^2)	Bodies of Water (km^2)	Forest & Cultivated	**Total Area (km^2)**	% CONUS Area
No FS Main Beam Overhead	52,755	93,353	222,830	90,455	376,918	6,290,546	**7,126,858**	88.2%
FS Main Beam(s) Overhead	20,050	25,134	40,233	9,015	46,692	813,237	**954,361**	11.8%
							8,081,219	100.0%
		1.17% of CONUS			**10.64% of CONUS**			

[13] *See, e.g.*, LADWP Study at slides 26-29; *see also* Lidar Study at slides 11-27.

[14] First FWCC Letter at 3; Second FWCC Letter at 2.

[15] *ARRL* at 231, 234.

[16] *See* First FWCC Letter at 3, n. 13; Second FWCC Letter at 2, n.5.

Further, as FWCC has repeatedly made clear, "*the enormously increased risk from very large numbers of RLANs is **not** due to signal aggregation from multiple devices … [but] from a single RLAN in or near the main beam of an FS receiver, with little or no intervening clutter*."[17] This statement is at odds, however, with FWCC's own methodology of multiplying gross RLAN distributions by gross FS link counts, which incorrectly assumes a comparable risk of harmful interference to a given FS receiver from all RLAN devices, including the large majority of RLAN devices nowhere near the main beam of an FS link.

FWCC further misconstrues a UK study that concludes that there is only a one-in-100-million-probability that an unconstrained RLAN would meet or exceed the study's interference criterion two percent of the time. FWCC multiplies this probability, as it did with its one-in-a-trillion figure, by both the total number of RLAN devices and the total number of FS receivers.[18] But FWCC has double counted as the 1-in-100-million probability already reflected the joint probability of interference to each of the 505 FS links considered in the study. Moreover, the one-in-100-million probability applies to the long-term protection criteria applicable in Europe of -10 dB I/N for 20% of the time, well below the -6 dB I/N value that FWCC has endorsed. Furthermore, that study found that RLAN devices would exceed the -10 dB I/N criterion infrequently enough that even this stringent criterion was not implicated. The probability of interference levels that are capable of noticeably degrading an FS link would be far lower. FWCC fails to reveal, however, that its argument depends on the -10dB level—less than half the power of even the conservative -6 dB I/N value—and even this does not account for the real-world operation of FS links that have far more margin than needed to operate when experiencing -6 dB I/N.

Third, FWCC contends that we "misuse" average values by taking "averages over multiple interference situations."[19] But FWCC's specific assertions about our arguments are either false or highly misleading. For example, FWCC claims that the New York City Lidar study used "median C/N" values to show a lack of harmful interference.[20] This is a misleading citation to the summary of our presentation. The actual analyses used real, calculated C/N ratios for the specific links in question, not median values.[21] Although FWCC cites filings where we have referenced average values of "FS receiver height, FS off-axis gain, and clutter attenuation,"[22] the New York filing to which FWCC is responding did not use average values for

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[17] Second FWCC Letter at 3; *see also* First FWCC Letter at 3.

[18] *See* Second FWCC Letter at 3, nn. 7, 8 (citing *Sharing and compatibility studies related to Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) in the frequency band 5925-6425 MHz*, ECC Report 302 at 72 (May 29, 2019), https://www.ecodocdb.dk/download/cc03c766-35f8/ECC%20Report%20302.pdf.)

[19] Second FWCC Letter at 3.

[20] *Id.* at 3 n.10 (citing to Lidar Study at slide 2).

[21] *See, e.g.*, Lidar Study at slides 12 (FS C/N of 80.6 dB), 14 (FS C/N of 68.5 dB).

[22] Second FWCC Letter at 3.

any of these parameters—it used real values for each link obtained from the Commission's ULS database and assumed zero clutter attenuation and worst-case free-space loss. FWCC ignores this.

FWCC also raises a handful of flawed technical arguments, many of which we have already addressed, but to which we briefly respond below.[23]

FWCC claims that FS links have "no excess fade margin."[24] FWCC's previous statements and licensees' own registration data disprove this claim. FWCC has previously claimed that FS links require "25–40 dB"[25] of fade margin to remain unaffected by atmospheric fade. However, application of industry-standard link planning algorithms to publicly available data, including actual link modulations, transmitter power, and receiver gain, makes clear that virtually all links have greater margin than required to achieve their availability design target.

FWCC complains that we "[m]isuse" diversity antennas. FWCC incorrectly claims that we mistakenly assume that the presence of diversity antennas "immunize[s] the link against RLAN interference."[26] We have never claimed this. What we have claimed is the proposition that FWCC confirms: "Fades tend to occur in vertical layers, so when the main antenna experiences a deep fade, the diversity antenna may have better reception."[27] Because diversity antennas minimize the probability that a link will be affected by atmospheric fade—since it is unlikely to affect both antennas simultaneously—the use of diversity antennas reduces the probability that the link will ever need to make use of its available fade margin simultaneously with the very unlikely event of interference from RLAN devices. In other words, while diversity antennas may not significantly reduce the risk that a link will receive energy from an RLAN device, they do further reduce the already low probability that this energy will cause harmful interference because they make links more resilient to the rare fade conditions that would render the link even possibly vulnerable to an RLAN.

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23 *See, e.g.*, Letter from Paul Margie, Counsel to Apple, Inc., Broadcom Inc., Facebook, Inc., Hewlett Packard Enterprise, and Microsoft Corporation, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295, GN Docket No. 17-183 (filed Apr. 12, 2018); Reply Comments of Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Marvell Semiconductor, Inc., Microsoft Corporation, Qualcomm Incorporated, and Ruckus Networks, ET Docket No. 18-295, GN Docket No. 17-183 (filed Mar. 18, 2019) ("RLAN Group Reply Comments").

24 First FWCC Letter at 4; Second FWCC Letter at 7.

25 *See* Comments of the FWCC at 16, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019) ("FWCC Comments").

26 First FWCC Letter at 4.

27 *Id.*

FWCC contends that we use the "[w]rong reliability target."[28] FWCC's letter implies that we "ignore" the 99.999% or 99.9999% reliability criterion for FS systems and base our interference calculations on a 99.99% criterion for critical FS systems. FWCC's contention that the LADWP filing used the incorrect reliability target mischaracterizes both our analysis and explanation. As we stated in our filing, the LADWP case study assumed 99.99% reliability *for each link*, not for the system overall. We explained that, as the Utilities Technology Council stated in its comments, utility communication systems typically achieve 99.999% (five nines) reliability through the use of redundant pathways and require approximately 99.7% availability *per path* to achieve a combined 99.999% availability per path for the whole system.[29] Thus, our use of a 99.99% per link value—greater than UTC's stated 99.7% value—was a conservative assumption that would, as we explained, provide even greater reliability than the design of individual links actually achieves.

FWCC claims that we have "improperly shift[ed] to a C/N standard"[30] *in assessing the probability of harmful interference.* FWCC claims that I/N is the "preferable—and universally used" metric for interference protection, because it does not require certain information about link operation that is often not available.[31] We agree that I/N is superior for these reasons for the rapid and automated calculations of *the AFC system,* but that is not the purpose of the analysis to which FWCC refers. Fundamentally, I/N only assesses levels of interference; it cannot determine whether interference is *harmful*—the key factor in the Commission's inquiry. While FWCC and most others have agreed to accept a -6 dB I/N protection level, in most cases, FS links can tolerate I/N levels significantly higher than -6 dB without experiencing harmful interference. Thus, it is not only appropriate, but necessary, to take FS receive signal strength, and not just I/N, into account when determining whether the FCC's rules will protect licensees from *harmful interference*. Exclusive reliance on I/N-based analysis disregards valuable information about FS links' vulnerability to harmful interference. Indeed, the Commission sought comment on whether to use a C/I ratio to specify interference protection criteria, explaining that the C/I ratio accounts for additional characteristics, such as a fixed service station's transmitted signal power and path length.[32] Such calculations help reveal the often large difference between a particular I/N protection level and the onset of harmful interference. It thus serves a critical analytical purpose

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28 *Id.* at 5.

29 *See* LADWP Ex Parte at 2 n.3; *see also* LADWP Study at slide 15 n.1; *see also* Comments of the Utilities Technology Council et al., Attachment at 15, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019).

30 First FWCC Letter at 5.

31 FWCC's claim that "I/N" is "universally used" is also clearly false. Comsearch explicitly recognized the viability of a C/I approach to interference protection: "a C/I criterion could be used for each receiver to preserve a fade margin needed for high availability." Comments of Comsearch at 21, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019).

32 *See* 6 GHz NPRM at ¶ 42.

in quantifying the overprotection relative to a purely I/N-based analysis, which is clearly in the public interest.

FWCC falsely contends that we have used an "[i]nappropriate propagation model," and have "selectively" used line-of-sight ("LOS") and non-line-of-sight ("NLOS") calculations.[33] To the contrary, we have used propagation models realistically and conservatively, not selectively. The analysis to which FWCC refers assumes free space path loss for ground-level (1.5 meter elevation) VLP devices very close to the FS receiver (less than 60 meters), uses the WINNER II LOS model for RLAN devices somewhat further away (approximately 100 meters), and uses the WINNER II NLOS urban macro clutter model for the longest distances (between 400 and 1200 meters).[34] This reflects the elevation angle from the RLAN device to the FS receiver at a given distance and the corresponding probability that the signal will be blocked by ground-level clutter. In fact, this approach is likely to *underestimate* the role of clutter in attenuating a potentially interfering RLAN signal because, although we use a LOS model for intermediate RLAN distances, ground clutter is likely to obstruct this line of sight at these distances in the large majority of cases. Further, our analyses incorporated a smooth earth model and do not account for the typical location of FS antennas on elevated terrain. And although FWCC raises vague objections to the propagation model we use at the longest distances, it provides no cogent reason to expect that RLAN devices will not be obscured by dense clutter where the devices are far from an FS receiver and where the FS receiver is, therefore, close to the horizon from the perspective of the RLAN devices.

FWCC claims that we have proposed an "[e]xcessive power" level for VLP devices.[35] FWCC mischaracterizes the *very low power* at which VLP devices operate. VLP devices subject to a 14 dBm EIRP power limit would operate at power levels 1/160th of today's standard Wi-Fi power limits. Existing technologies for short-range connectivity use cases, such as Bluetooth, can transmit at power levels substantially higher than 14 dBm. Furthermore, we have proposed a power spectral density limit that will further reduce the vanishingly small risk of harmful interference from VLP devices.

FWCC claims we chose an "obsolete" FS antenna to explain how VLP devices will not cause harmful interference to FS systems. FWCC contends that using a UHX6 antenna was incorrect and that Category A antennas such as PAD6 are more common.[36] FWCC's own filings contradict its claim that we picked the "wrong antenna." FWCC has repeatedly used UHX antennas in its own analysis and has stated that UHX antennas are typical.[37] Further, a search of

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[33] First FWCC Letter at 6.

[34] *See* VLP Ex Parte at slide 6.

[35] First FWCC Letter at 6.

[36] *Id.*

[37] *See* George Kizer, *Studies Regarding RKF's Frequency Sharing for Radio Local Area Networks in the 6 GHz Band Proposal*, at 5-7 (Mar. 2018), *as attached to* Letter from Mitchell Lazarus, Counsel for the FWCC to Marlene H. Dortch, Secretary, FCC, GN Docket

antennas listed in ULS reveals that UHX antennas are not "obsolete"—approximately 18% of antennas listed in ULS are UHX. Additionally, the choice of a 6-foot UHX antenna over other sizes (8, 10, or 12 feet) is conservative for the purposes of our coexistence analysis. Finally, there is no reason to suspect that conducting analyses using a PAD6 antenna pattern would result in any material difference in the result. In fact, notably, FWCC does not appear to claim that it would.

FWCC raises baseless and misleading complaints that we have "minimize[d] findings of interference" by studying the 152-link Los Angeles Department of Water and Power FS network.[38] We selected LADWP because it is a representative utility communications system and highlights the reality—backed up by the Commission's own ULS data—that FS receivers are generally located on mountaintops and other uninhabited locations. Additionally, as we explained in our conversations with the Utilities Technology Council, we decided to do a case study of LADWP after reviewing the utility's comments and reply comments and concluding that the LADWP had a high number of links. We further explained that we could extend this analysis to other licensees in the event that other utilities are interested in such a study. Furthermore, the LADWP presentation was just one of many studies we submitted, some of which are nationwide in scope, and was intended to illustrate our larger analysis in the context of a set of utility links. In particular, our July 31 presentation performed similar link-by-link analyses in the New York City area—clearly one of the most challenging sharing environments, due to the large concentration of both high-rise buildings and FS receivers.[39] One FWCC critique, however, applies to this analysis. Unlike LADWP, the New York City analysis is indeed a "poor model for FS operations generally."[40] Focusing on the New York City market dramatically *exaggerates* the risk of harmful interference because it is one of the densest residential areas and has a high number of sensitive FS links. Yet, even here, our analysis confirms that 6 GHz RLAN devices will not cause harmful interference to incumbent fixed services.

FWCC claims that the New York City Lidar study incorrectly uses a building entry loss ("BEL") value of 30 dB because some traditionally constructed buildings have lower BEL values and "can easily fall in the FS receiver main beam."[41] Notably, FWCC concedes that to assume 30 dB BEL for high-rise buildings "would make sense."[42] But the point of the Lidar

No. 17-183 (filed Mar. 13, 2018) ("FWCC Ex Parte"); *see also* FWCC Ex Parte at 7 n.13; *see* FWCC Comments Attachment C at 8; *see* Letter from Chen-yi Liu and Mitchell Lazarus, Counsel for the FWCC, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 17-183, Attachment at ii (filed June 25, 2018).

[38] First FWCC Letter at 7.

[39] *See* Lidar Study.

[40] *See* First FWCC Letter at 7.

[41] Second FWCC Letter at 5.

[42] *Id.* at 4.

study was to examine exactly these buildings and to analyze the metro area with the densest collection of high-rise buildings in the United States. The results were striking. Even in New York City: (1) just over 17% of FS paths had any building protrusion at all, (2) only 2.7% of FS paths had a building close enough to exceed -6 dB I/N, and (3) the median C/N of these links was 67 dB.

Perhaps to distract the Commission from this direct refutation of its longstanding core argument, FWCC criticizes the New York City Lidar study for not accounting for the possibility of non-high-rise buildings in the main beam of an FS receiver. But as the Lidar study illustrates, these buildings will be located within the clutter field and, especially in the New York City market, are overwhelmingly likely to be obstructed by foliage, terrain variation,[43] and high-rise buildings. In addition, thermal efficiency of buildings is a function of the year of construction and the applicable energy efficiency code in force at the time, not the height of the buildings. Even for particular low-rise buildings that might be less thermally efficient, clutter losses and other propagation conditions in these unusual (and, in New York City, likely theoretical) cases compensate for the difference in BEL. Because this situation may be marginally more likely in markets other than New York City, our other studies have accounted for this and confirmed that the greater propagation loss associated with low-rise buildings offsets the potentially decreased building entry loss.[44]

FWCC complains that signal-to-noise ratio (SNR) values are improperly used in our study in a way that impacts our conclusions.[45] This is false, and we stand by our conclusions. We based the values in our presentation on the link modulation listed in ULS, from which we derived actual SNR requirements from FS radios for such modulations. FWCC cites SNR values from George Kizer's textbook, which in turn are calculated based on a 2002 paper by Proakis and Salehi. But those calculations are theoretical values without channel coding gain. The RKF Study, for example, cited an equivalent theoretical model for QAM curves that included channel coding.[46] In fact, Mr. Kizer writes in his book that "[f]orward error correction coding gain (S/N improvement) is typically 2-5 dB for the 10^{-6} BER,"[47] which must be added to the SNRs quoted by FWCC. However, channel coding theory has advanced considerably since Proakis and Salehi wrote their paper, resulting in improvement to the theoretical SNR curves by 5-10 dB.

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[43] Manhattan Island has significant topographic elevation variation. The ground elevation of the nine highest neighborhoods or geographic features areas range from approximately 30 to 80 meters. *See* Michael Pollak, *Manhattan Highs and Your Permanent Record*, The New York Times (Feb. 26, 2010), https://www.nytimes.com/2010/02/28/nyregion/28fyi.html.

[44] *See, e.g.,* RKF Study at 32-33.

[45] Second FWCC Letter at 8.

[46] RKF Study at 49.

[47] George M. Kizer, *Digital Microwave Communication* 668 (Institute of Electrical and Electronics Engineers, Inc., 2013).

Comparing the values FWCC cites to the datasheets of actual FS equipment confirms that difference. The following table shows required minimum SNRs for five common QAM modulations from analytical QAM performances without the use of channel coding versus six commonly used FS radios all employing channel coding. For the New York City Lidar links running at 64 QAM, for example, the theoretical values in Mr. Kizer's book would overestimate the FS radio SNR requirement by an average of 7 dB. Likewise, an analysis of the New York City links running TCM 128 modulation shows that these theoretical values materially overstate the requirements of real hardware.

	QPSK	16 QAM	64 QAM	256 QAM	1024 QAM
Uncoded QAM	13.5 dB	20.2 dB	26.2 dB	32.0 dB	37.7 dB
Alcatel MDR-8606	6.2 dB	13.2 dB	19.2 dB	25.2 dB	n/a
ALFOplus2	5.7 dB	11.7 dB	19.7 dB	26.2 dB	30.2 dB
Cambium PTP820C	6.7 dB	13.2 dB	19.7 dB	26.2 dB	31.2 dB
Cerragon IP20	6.7 dB	13.2 dB	19.7 dB	25.7 dB	31.2 dB
SAF Integra	4.2 dB	10.7 dB	17.7 dB	23.7 dB	30.7 dB
Trango Gigalynx	6.9 dB	13.1 dB	19.5 dB	25.6 dB	32.6 dB
Average improvement over uncoded QAM	**-7.4 dB**	**-7.7 dB**	**-7.0 dB**	**-6.6 dB**	**-6.5 dB**

Even if we substitute the hardware values into our link budgets from the New York City Lidar presentation (resulting in an average SNreq increase of 4 dB), the change does not alter the study's conclusion: the long distance links studied in the New York City market would have more than 40 dB of fade margin in every case[48] and would therefore not be adversely affected by RLAN interference except in the very unlikely event that a 40 dB or more fade event coincides with the most unlikely scenario for RLAN transmission location and attenuation. This confluence of events is so unlikely, and would be so brief, that no FS operators would be likely to notice this even if it were to occur.

FWCC contends that we have incorrectly assumed an "unexplained" value of 5 dB for antenna pattern mismatch. FWCC contends that 5 dB is an unrealistically high value because the path from an RLAN device to an FS receiver is likely to be roughly horizontal and an RLAN device exhibits peak gain within 20 degrees of horizontal.[49] As we have established, the opposite is true. Cisco, HPE, and Ruckus submitted a joint declaration showing that enterprise grade access points are almost always designed to be ceiling-mounted with antenna patterns pointed

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48 Some short-distance links might have between 30 and 40 dB of fade margin. However, for these shorter links, deep fade is far less likely and would also be likely to attenuate the RLAN interference itself, further reducing the possibility of harmful interference.

49 Second FWCC Letter at 9, fig. 3.

down towards the floor, where unlicensed users are located, not sideways out the window.[50] Broadcom showed that each antenna in a MIMO system has a different direction of peak gain in the azimuth plane, such that the combined energy in any direction is well below the peak measured EIRP of the overall device.[51] FWCC's argument to the contrary depends on a highly selective, out-of-context citation to a single antenna pattern. The pattern it cites does not show the antenna pattern for a real integrated RLAN device. FWCC also overlooks the explanation that originally accompanied this pattern when Broadcom first put it on the record that explains that an integrated home access point typically exhibits negative gain in nearly every direction.[52]

FWCC identifies what it calls a "miscalculation" of the bandwidth mismatch value in each of the link analyses in the Lidar study. FWCC's supposed "miscalculation" is nothing more than a recycled argument that we have not accounted for FWCC's implausible claims about the potential for adjacent-channel interference. As we have previously explained, FWCC's adjacent-channel interference claims are unrealistic because they assume exceptionally poor FS receiver-filter performance (so poor that it is unclear how the FS link could operate in proximity to other 6 GHz FS links) and overlook the role of digital processing and other components of the 6 GHz receiver chain.[53] FWCC's claims are also incompatible with the Commission's own proposals not to require unnecessary adjacent-channel restrictions on RLAN operations.[54]

FWCC claims that we have "underestimate[d] interference distances."[55] This appears not to be a separate argument from FWCC's previous, incorrect assertions. Rather, it seems to reflect only FWCC's calculation of the separation distances that would apply if its other claims were correct, in conjunction with arbitrary and largely implausible hypothetical variations in building-entry loss. FWCC's assertions are, however, incorrect. Therefore, because these separation distances depend on numerous incorrect assertions, these errors compound to render these separation distances completely unreliable.

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50 Comments of Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Marvell Semiconductor, Inc., Microsoft Corporation, Qualcomm Incorporated, and Ruckus Networks, an Arris Company at Appendix D, ¶ 11 figs. 1-3, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019).

51 Comments of Broadcom Inc. at 12-15, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019).

52 *Id.*

53 RLAN Group Reply Comments at 26-27.

54 6 GHz NPRM at ¶ 44.

55 Second FWCC Letter at 11.

We appreciate the Commission's hard work in the 6 GHz proceeding, and we are confident that careful consideration of the technical analyses has produced a record that supports a framework for the 6 GHz band that protects licensed services while authorizing unlicensed use by RLAN devices. We encourage the Commission to base its decision on submissions that contain concrete analysis and to discount filings that contain unsupported claims that would dramatically limit unlicensed use of the 6 GHz band by exaggerating the probability of harmful interference.

Respectfully submitted,

Apple Inc.
Broadcom Inc.
Cisco Systems, Inc.
Facebook, Inc.
Google LLC
Hewlett Packard Enterprise
Intel Corporation
Marvell Semiconductor, Inc.
Microsoft Corporation
Qualcomm Incorporated