May 14, 2018

BY ELECTRONIC FILING

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

Re: *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz*, GN Docket No. 17-183

Dear Ms. Dortch:

This letter responds to filings by the Fixed Wireless Communications Coalition ("FWCC"), AT&T Services, Inc. ("AT&T"), and National Spectrum Management Association ("NSMA")[1] that discuss the 6 GHz band engineering analysis prepared by RKF Engineering Solutions. The RKF Study demonstrated the feasibility of sharing between 6 GHz band incumbents and unlicensed Radio Local Area Network ("RLAN") operations.[2] The undersigned companies are committed to protecting 6 GHz incumbent operations from harmful interference. The RKF Study and the recent letters filed by FWCC, AT&T, and NSMA combine to show that

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1 Letter from Mitchell Lazarus, Counsel for the Fixed Wireless Communications Coalition to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 17-183 (filed Mar. 13, 2018) ("FWCC *Ex Parte*"), *attaching* George Kizer, *Studies Regarding RKF's Frequency Sharing for Radio Local Area Networks in the 6 GHz Band Proposal* (Mar. 9, 2018); Letter from Stacey G. Black, Vice President, AT&T Services, Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 17-183 (filed Mar. 19, 2018) ("AT&T March 19 *Ex Parte*"), *attaching* AT&T Services, Inc., *Radio Local Area Network ("RLAN") and Microwave Fixed Service ("FS") Sharing in 6 GHz* (Mar. 16, 2018); Letter from Stacey G. Black, Vice President, AT&T Services, Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 17-183 (filed Mar. 26, 2018) ("AT&T March 26 *Ex Parte*"), *attaching* AT&T Services Inc., *Radio Local Area Network ("RLAN") And Microwave Fixed Service ("FS") Sharing in 6 GHz* (Mar. 26, 2018); Letter from Dave Meyer, Board Member and Former President, National Spectrum Management Association, to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 17-183 (filed Mar. 27, 2018) ("NSMA *Ex Parte*").

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

the circumstances in which there is a real-world risk of harmful interference are very limited. As we explained in our comments in this proceeding,[3] and as the RKF Study itself acknowledges,[4] the Commission should adopt careful rules that address the discrete situations where that risk exists. In fact, our comments provide concrete proposals on how the Commission could design these protections.[5]

Despite those important areas of agreement, FWCC, AT&T, and NSMA present unrealistic assessments of the likelihood of interference and its potential magnitude. As explained in detail below, FWCC, AT&T, and NSMA appear to mischaracterize or misunderstand important aspects of the RKF Study, and their filings depend on unsupported technical assumptions. For example:

- FWCC, AT&T, and NSMA all question RKF's use of statistical modeling to assess the true risk of interference. But the Commission's Technical Advisory Committee has specifically endorsed this method. Instead of using statistical modeling, FWCC, AT&T, and NSMA unreasonably ask the FCC to focus its analysis on a few unlikely and misleading scenarios.

- FWCC and NSMA assume that RLAN devices transmit 100% of the time when, in fact, RLAN technologies make efficient use of airtime by transmitting in very short, infrequent bursts.

- FWCC, AT&T, and NSMA all mistakenly suggest that RKF did not consider line-of-sight conditions.

- FWCC considers only outdoor RLAN devices that unrealistically are assumed to transmit at 35 dBm in all directions. Real devices reach peak radiated power output at only certain elevations resulting in *average* E.I.R.P. that is approximately 17 dB lower than what FWCC assumes. FWCC also ignores lower-power 6 GHz RLAN devices, such as low-power access points and mobile devices.

- FWCC proposes replacing the internationally accepted, up-to-date link availability model that RKF used with one last updated 40 years ago, which is heavily influenced by arbitrary scaling factors.

- NSMA unrealistically assumes that free-space propagation conditions will apply in every case and ignores the real-world fading environment and performance margin of fixed links.

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3 Reply Comments of Apple Inc., Broadcom Limited, Cisco Systems, Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, MediaTek Inc., Microsoft Corporation, and Qualcomm Incorporated at 16-21, GN Docket No. 17-183 (filed Nov. 15, 2017) ("Joint 6 GHz Reply Comments").

4 RKF Study at 5.

5 Joint 6 GHz Reply Comments at 16-21.

- NSMA's oversimplified analysis suggests an implausible "safe" power limit that is 8,000 times lower than the unintentional emissions limit in the 6 GHz band for all unlicensed devices.

By contrast, the RKF Study is intentionally conservative in nearly every respect. A close reading of the Study and the FS incumbents' responses demonstrate this conservatism and the resulting reliability of RKF's conclusions. For example, FWCC suggests replacing RKF's use of ITU-R Rec. F.1245-3 in the analysis with modeling based on larger diameter, ultra-high-performance antennas. But, as discussed below, adopting FWCC's alternative greatly *reduces* the already low probability and impact of possible interference as compared to RKF's highly conservative assumptions.

To give another example, FS interests claim that the RKF Study did not properly evaluate the effect of an RLAN transmitter located in the main beam of a fixed link. But this is incorrect. RKF considered this scenario, as well as many other far more likely morphologies based on comprehensive, nationwide FS deployment data. What RKF did not do is focus *exclusively* on this rare scenario. Rather, it appropriately assessed both the magnitude of potential interference in this unusual case as well as its probability of occurring. Although FWCC unreasonably faults RKF for taking this approach, RKF's Study provides a realistic, albeit conservative, assessment of the interference risk, rather than focusing on unrealistic hypothetical cases.

Indeed, contrary to FS companies' claims, RKF specifically studied the small number of cases, involving 0.2% of FS links, where RLAN deployment could cause interference in excess of -6 dB I/N due to RLAN operation in the main beam of a fixed link. The key difference is that while FWCC and AT&T exaggerate the frequency and interference impact of these unusual cases, RKF rightly concluded that even in these situations, link reliability would be unchanged. Furthermore, RKF found that its results support "national deployment of RLAN devices (RLANs) in the 6 GHz band, using *established RLAN mitigation techniques* and regulatory constraints similar to those applied in the neighboring 5 GHz band."[6] In other words, RKF recognized that FCC rules should enable strategies to protect FS incumbents even in these corner cases.

The bottom line is that AT&T's, FWCC's, and NSMA's filings are important parts of the engineering-focused dialogue that the RKF Study was intended to advance. By demonstrating that potential interference between RLAN devices and FS is confined to only specific, rare situations, and ruling out the possibility of widespread aggregate interference to FS, the RKF Study has narrowed the appropriate technical discussion to two discrete issues, suitable for discussion within the context of a notice of proposed rulemaking that should be issued promptly:

- Under what circumstances will RLAN operation within the main beam of an FS link pose a substantial risk of harmful interference?

- What are the most appropriate mitigation measures to effectively address that risk?

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6 RKF Study at 4 (emphasis added).

The record already suggests answers to both questions. On the first, RKF demonstrated that even in the case of main-beam RLAN operations, RLAN devices are very unlikely to cause harmful interference to FS by materially degrading overall link reliability. This is the case because of, among other things, the significant fade margin designed into FS systems and the fact that main-beam RLAN signals will still be subject to clutter and other losses. On the second issue, the undersigned companies have provided a framework for interference-protection rules that would segment the 6 GHz band and would allow the FCC to apply specific mitigation measures tailored to each sub-band.[7] As a result, the Commission now has the record it needs to advance quickly to an NPRM.

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[7] Joint 6 GHz Reply Comments at 16-21.

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I. STATISTICAL MODELING IS THE MOST APPROPRIATE WAY TO ASSESS INTERFERENCE RISK, ESPECIALLY FOR RLAN SYSTEMS.

FWCC, AT&T, and NSMA categorically, and unreasonably, reject RKF's statistical approach to evaluating the risk of harmful interference.[8] These fixed-wireless interests imply that, by using a statistical approach, RKF somehow hid potential instances of interference through averaging. Notably, according to FWCC, a study should be able to demonstrate the impossibility of interference "without recourse to probabilities."[9]

These claims are puzzling because there is no more effective way of quantifying the interference risk of RLAN devices to other services besides statistical modeling. Indeed, the Commission's own Technical Advisory Committee has recommended this approach, suggesting, for example, that the Commission "quantify likelihoods and consequences" and "document relative and absolute changes in interference impact along with the probability of being unaffected by new rules."[10] Statistical modeling is indispensable when evaluating potential interference from RLAN devices, given their typical operational characteristics. As we explain in detail below,[11] RLAN devices, and especially emerging 802.11ax devices that would operate in the 6 GHz band, typically transmit for only a few milliseconds at a time, and then wait to listen for other transmissions and facilitate shared access to the channel. Engineers design the timing of these transmissions to be random to maximize aggregate throughput among multiple transmitters. Accordingly, the actual aggregate energy transmitted in a band at a given time can *only* be understood as a probabilistic function of, among other things, the number of transmitters, their levels of activity, their individual power levels, etc.—exactly the factors that RKF considered. As FWCC's own analysis illustrates, other approaches are simply inadequate to provide a realistic picture of RLAN operations.[12]

RKF did not use probabilistic techniques to conceal adverse results. Quite the opposite. Another study *might* have hidden adverse results by, for example, reporting an average I/N across every simulated morphology, which would have resulted in an average I/N far below the established interference criterion of -6 dB. RKF, in contrast, reported the *distribution* of results, thereby providing the information necessary to assess interference risk accurately. It transparently concluded that 99.8% of FS stations would experience interference levels below -6 dB, and that the remaining 0.2% represent cases where a single interferer dominated due to its presence in or near the main beam of the FS receiver.[13] This is characteristic of RKF's approach throughout the Study. Whenever possible, RKF used distributions of possible

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8 AT&T March 26 *Ex Parte*, Attachment at 2-3; FWCC *Ex Parte* at 11; NSMA *Ex Parte* at 4.

9 FWCC *Ex Parte* at 11. *See also* AT&T March 26 *Ex Parte*, Attachment at 2-3.

10 *Office of Engineering and Technology Seeks Comment on Technological Advisory Council Spectrum Policy Recommendations*, Public Notice, 32 FCC Rcd. 10160, 10164 (2017).

11 *See infra* at 3-4.

12 *See infra* Section IV.

13 RKF Study at 5-7.

simulation parameters and very large numbers of simulation runs to ensure that every case was covered, including rare worst-case scenarios.

FWCC appears to be confused about RKF's statistical approach when it claims that RKF's identification of 1,904 specific FS paths for which interference thresholds may be exceeded is "a 50% confidence result."[14] This suggests FWCC incorrectly believes that RKF considered only median propagation conditions when identifying paths for further study, and not the full distribution of possible propagation scenarios. On the contrary, RKF used standard propagation models with their full temporal and spatial variability. These were used in a Monte-Carlo simulation resulting in highly granular probability distributions that reflected the full range of possible propagation scenarios.[15]

II. THE RKF STUDY'S ASSUMPTIONS ABOUT RLAN DEVICES ARE WELL SUPPORTED.

FWCC and AT&T level several criticisms regarding RKF's assumptions relating to RLAN devices. As a coalition of companies that includes some of the foremost manufacturers of chips and equipment operating in unlicensed spectrum, we are well positioned to address AT&T's and FWCC's claims on these points.

A. RKF's RLAN Activity, Duty Cycle, and Loading Assumptions Are Conservative

FWCC and AT&T both claim, with no justification, that RKF's conclusions about likely RLAN duty cycles in the 6 GHz band are too low.[16] FWCC goes so far, in its own attempt to simulate possible RLAN interference, as to assume a duty cycle of 100%—an assumption that is entirely unjustifiable. By contrast, RKF's conclusion that RLAN devices would exhibit duty cycles of approximately 0.44% is demonstrably conservative based on both future RLAN forecasts and on empirical data about current RLAN operations.

As described in Section 3.1 of the RKF Study, RKF first assumed that, in 2025, *every* active user in the United States will stream high-definition video on one device (high-activity mode) while also using nine other devices in a low-activity mode, continually, throughout the four "busy hours" of each day.[17] This is undeniably a conservative model of nationwide user behavior.[18]

It is important to note that although a device may appear to be continuously active *from a user's perspective* (for example, while streaming high-definition video), in terms of the radio link

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14 FWCC *Ex Parte*, Attachment at 21.

15 *See* RKF Study at 7.

16 AT&T March 26 *Ex Parte*, Attachment at 8; FWCC *Ex Parte*, Attachment at 21.

17 As noted below, RKF excluded the 10% of users that live in areas the U.S. Census Bureau defines as "barren."

18 Other studies have concluded that a significant percentage of users do *not*, in fact, use their devices during busy hour. *See infra* at 6.

activity, individual RLAN devices using modern protocols are actually silent far more frequently than they transmit, even under heavy traffic loads. This "bursty" behavior on the radio link is by design and is invisible to the end user. It balances individual users' performance needs with the broader imperative of achieving the maximum *aggregate* throughput for numerous devices that may be sharing a channel, such as spectators' smartphones at a sporting event, or devices in a densely populated apartment building.

As RKF explained, it assumed that every residential user[19] transmitted 4.4 Mb/s to his or her high-activity device (such as a laptop, smartphone, or tablet),[20] which is a conservative estimate of the average throughput demands of streaming high-definition video.[21] RKF also assumed that users would have nine additional low-activity devices operating at 2.2 kb/s. These devices do not contribute significantly to overall traffic relative to high-usage devices, however.

RLAN devices operating in the 6 GHz band will likely have average throughputs in excess of 1 Gb/s. In fact, gigabit throughputs are possible with existing RLAN technologies, such as 802.11ac. While these speeds are not yet ubiquitous in existing unlicensed bands due to the widespread deployment of legacy devices, greenfield deployments in the 6 GHz band would result in average speeds that meet or exceed this level.[22]

These gigabit speeds result in a 0.44% duty cycle when transmitting data at 4.4 Mb/s. In other words, while streaming a 4.4 Mb/s high-definition video per the high-activity case used in the RKF analysis, an RLAN device operating at a 1 Gb/s link speed needs to actively transmit for only 0.0044 seconds (4.4 Mb divided by 1 Gb/s) out of every total second of airtime, in order to achieve a seamless user experience.

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[19] Users in other environments, such as enterprise settings and public hotspots, consume significantly less data during busy hour.

[20] RKF Study at 15.

[21] *See, e.g.*, Hewlett Packard Enterprise, *Video Streaming Airtime Consumption Measurements*, CEPT WGSE PT45, Doc. SE45(18)014 (issued Mar. 8, 2018) (describing average throughputs for high-definition video of various resolutions on multiple streaming services). These demands are likely to remain largely unchanged between now and 2025. Although a growing share of consumers may begin to demand higher-resolution, e.g., 4K video, the evidence suggests that compression technology is likely to keep pace with this demand, preventing a significant net increase in data consumption. The recently announced AV1 standard, for example, has been designed to achieve a further 30% improvement in compression efficiency over existing formats and appears on track to possibly even exceed this goal. Facebook, Inc., *AV1 Beats x264 and libvpx-vp9 in Practical Use Case* (Apr. 10, 2018), *available at* https://code.facebook.com/posts/253852078523394/av1-beats-x264-and-libvpx-vp9-in-practical-use-case/.

[22] *See, e.g.*, Broadcom Corporation, *Proposed Parametric Values for RLAN Parameters*, CEPT WGSE PT45, Doc. SE45(18)034A1 (issued Apr. 26, 2018).

As a point of reference to reinforce the conservative nature of RKF's assumptions, the minimum IMT-2020 average spectral efficiency requirement for future devices implies a link throughput rate of *more than* 1 Gb/s in a 160 MHz channel.[23] Similarly, the forthcoming 802.11ax standard, which is the version of the 802.11 standard likely to be deployed in the 6 GHz band, will achieve even higher throughputs. Both suggest that actual RLAN duty cycles may be *below* the 0.44% used in the RKF Study.

By contrast, FWCC's assumption of a 100% duty cycle is clearly unrealistic by a wide margin, even allowing for reasonable differences of opinion on future link speed, user data consumption, and aggregate users. Because 6 GHz devices will likely transmit at no less than 1 Gb/s, a duty cycle of 100% implies an hourly data consumption of an impossible-to-justify 3.6 *terabits* per hour. This is far more than the average consumer's *monthly* usage both today and projecting current trends out to the year 2025. This would be especially implausible for users with data caps since it implies that a 1 TB monthly cap, for example, would be exhausted within the first few hours of use.

AT&T's claim that RKF failed to account for likely growth in RLAN device usage is also incorrect. RKF assumed that each user would consume 240 GB per month during the four busiest hours per day—4.4 Mb/s, divided by eight bits per byte, times 3600 seconds in an hour, times four busy hours in a day, times 30 days in a month. Using a conservative assumption that monthly busy hour consumption is 32% of the total monthly consumption[24] gives 750 GB/month of total consumption per person.[25]

As a point of comparison, one can extrapolate from the most recent Cisco VNI report (which forecasts out to 2021). Using the Cisco projection for 2021 total U.S. IP data consumption, including wired and wireless traffic, of 237.1 GB per capita[26] and assuming 20% year-over-year growth in data consumption—i.e., continuing Cisco's assumed growth rate beyond the year 2021—implies that the average U.S. consumer would be expected to consume 491.7 GB per month in 2025. Therefore, far from "assum[ing] zero growth in data use between now and 2025,"[27] the figures used in the RKF Study assume growth to a level that is approximately 50% higher than a reasonable forecast for *all U.S. IP traffic*. AT&T's erroneous conclusion appears to

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23 International Telecommunication Union, *Minimum requirements related to technical performance for IMT 2020 radio interfaces*, ITU-R M.2410-0 § 4.5 (Nov. 2017).

24 This assumes residential usage patterns. In other environments busy hour usage constitutes a smaller share of overall data consumption during busy hour.

25 *See* Stephen Strowes, Yahoo, *Diurnal and Weekly Cycles in IPv6 Traffic* (2016), *available at* https://irtf.org/anrw/2016/slides-anrw16-final29.pdf.

26 Cisco, *VNI Forecast Highlights Tool*, *available at* https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html# (last visited May 8, 2018).

27 AT&T March 26 *Ex Parte*, Attachment at 8.

be a result of its incorrect assumption that nearly all data consumption occurs during busy hour and that, contrary to the best available evidence,[28] U.S. busy hour is only three hours long.

B. RKF Considered Both Access Points and User Equipment

AT&T claims that RKF considered only RLAN user equipment and ignored the interference contribution of access points.[29] This is incorrect. When a user streams high-definition video, it is the access point, not the user's device, that transmits at a rate of 4.4 Mb/s—the user device only *receives* those transmissions. This is consistent with RKF's methodology. RKF assumed that 10% of *devices* were transmitting in a high-activity mode, including access points, and considered the effects of these transmissions in thousands of different RLAN morphologies. RKF also accounted for the differences in typical transmit power of client devices and access points in its distribution of RLAN EIRP levels, with a 2.3:1 ratio of downlink to uplink traffic for residential users.[30]

AT&T claims that the access-point/user-equipment network topology, in effect, concentrates transmissions in a single device—i.e., the transmissions corresponding to a user's high- and low-activity 6 GHz devices would all be transmitted from a single device.[31] As noted above, low-activity devices make an insignificant contribution to the interference equation. But in any event, AT&T oversimplifies the traffic patterns of these devices. Although a high-activity device primarily generates transmissions from the access point to user devices, low-activity devices may, in many cases, do the opposite, transmitting device status and other telemetric data from the device *to* the access point. More fundamentally, even if *all* of a given user's transmissions were assumed to originate from a single access point, and other devices were assumed to transmit nothing, this would not alter the total amount of time an RLAN device is transmitting in the band. It would merely concentrate transmissions at a single source that, in typical usage scenarios, would most likely be located centrally within a structure. Even with these stylized assumptions, the interference risk would not be materially increased due to maximization of building-entry-loss between the RLAN transmitter and fixed links.

C. RKF Properly Calculated the Number of RLAN Devices Transmitting in the 6 GHz Band

AT&T contends that RKF miscalculated the total number of RLAN devices expected to operate in the 6 GHz band at a given time. AT&T does not appear to disagree with RKF's basic assumptions—that there will be 3.47 billion RLAN devices in 2025, that 45% of these devices will be 6 GHz-capable, and that 68% of suitable unlicensed spectrum would be located in the

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[28] Chitika Insights, *Hour-by-Hour Examination: Smartphone, Tablet, and Desktop Usage Rates* (Mar. 26, 2013), *available at* https://chitika.com/browsing-activity-by-hour.

[29] AT&T March 26 *Ex Parte*, Attachment at 8.

[30] RKF Study at 22-23.

[31] *Id.*

6 GHz band.[32] However, AT&T appears to claim that RKF misapplied these parameters to arrive at the number of operating 6 GHz devices.[33]

RKF's math was transparent and correct. It assumed that, in 2025, 45% of RLAN devices, or 1.56 billion devices, would be capable of operating in the 6 GHz band. It then assumed that the actual bands of operation of these 1.56 billion devices would be evenly distributed across the available spectrum in the 2.4, 5, and 6 GHz bands. The 6 GHz band would comprise 1200 MHz of the total 1760 MHz that would be available for broadband unlicensed use—or 68%. Thus, again assuming even distribution,[34] 68% of the RLAN devices capable of operating in the 6 GHz band would actually operate there at a given time, for a final total (excluding the 10% of devices that may operate in barren areas) of 954 million devices.[35] Notably, RKF conservatively assumed that each RLAN would be in use simultaneously when, in fact, a significant percentage of users do *not* actively use their devices during busy hour.[36] It also assumed that all busy hour traffic would be transmitted over unlicensed mid-band spectrum, and not over unlicensed millimeter wave spectrum or licensed spectrum.

AT&T seems to suggest that either all of the 45% of RLAN devices *capable* of operating in the 6 GHz band would *actually operate there simultaneously*, or that all RLAN devices would be evenly distributed across the available channels, without regard to the channels in which they are able to operate.[37] Both scenarios are implausible. It may be rational, if all RLAN deployments were centrally planned, to evenly distribute all RLAN devices across all of the available channels. But RLAN deployments—unlike the mobile deployments with which AT&T may be most familiar—are *not* centrally planned. Thus, because some devices will be unable to operate in the 6 GHz band, RLAN devices, taken as a whole, will disproportionately operate in the 2.4 and 5 GHz band. This is consistent with deployment patterns today, in which 50% of deployed Wi-Fi devices continue to operate in the 2.4 GHz band, even though it comprises only 15% of the available unlicensed spectrum and is not compatible with the most advanced Wi-Fi technologies.[38]

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32 *See id.* at 14.

33 AT&T March 26 *Ex Parte*, Attachment at 7.

34 RKF's assumption that 6 GHz capable RLAN devices would be evenly distributed is actually quite conservative. Deployment patterns indicate that devices are more likely to be deployed in longer-established bands, even when they are capable of operating in *all* bands.

35 *See* RKF Study at 13.

36 *See, e.g.*, Annex 22 to Working Party 5A Chairman's Report, Working Document Towards a Preliminary Draft New Report ITU-R M.[Aggregate RLAN Measurements], Document 5A/650-E, Annex 22 (Nov. 16, 2017). Note, however, that active use does not imply 100% duty cycle. *See supra* at 2-5.

37 AT&T March 26 *Ex Parte*, Attachment at 7.

38 *See* European Conference of Postal and Telecommunications Administrations Working Group SE45, *6GHz Market Penetration*, Document No. SE45(18)024A2 (Mar. 27, 2018),

D. RKF's Assumptions on Outdoor Deployments Are Reasonable

AT&T claims that RKF underestimates the antenna heights and radiated power levels of outdoor RLAN devices. AT&T claims that outdoor 6 GHz unlicensed devices, which AT&T assumes will be License-Assisted Access ("LAA") access points, virtually always operate at full power (4W) and at antenna heights of 30 feet.[39] AT&T attempts to support these assertions by invoking its experience deploying a limited number of LAA access points in a small number of U.S. cities.

AT&T's LAA deployments represent a small number of extreme outliers within the far broader scheme of all RLAN deployments. The available data clearly indicate that in 5 GHz bands that would be most similar to the 6 GHz band, such as U-NII-3, average transmitter powers and antenna heights are far lower than AT&T suggests and are in line with RKF's assumptions for the 6 GHz band.

Although the availability of 4W maximum power levels is important for a small number of deployments such as AT&T's LAA operations, the large majority of outdoor uses are better addressed using lower-power devices, at or below the roof line. These use cases are primarily adjacent to structures such as loading docks, restaurant patios, and public spaces that are part of or adjacent to retail outlets.[40] Or they may involve large-scale, high-capacity deployments, where operators prefer to deploy a large number of lower-power devices to achieve high degrees of frequency reuse.

Nor is it true, as AT&T claims, that RKF failed to account for the introduction of LAA devices, which are a type of RLAN from the 3GPP standards family. According to AT&T, this category will see steep growth, and, as a result, the RKF Study underestimates outdoor deployments and the heights of the transmitters.[41]

While LAA deployments will no doubt grow, in raw numbers the units shipped will continue to be dwarfed by existing RLAN devices. The RKF Study accounts for LAA deployments by including a percentage of high-power outdoor devices with large antenna heights, based on data from the Small Cell Forum's forecast for outdoor devices.[42] This issue also was recently evaluated in Europe, where the Electronic Communications Commission found

a*vailable at* https://cept.org/Documents/se-45/42230/se45-18-024a2_rlan-market-comparison.

39 AT&T March 26 *Ex Parte*, Attachment at 4. FWCC similarly asserts that there is no basis for the RKF Study's assumption that outdoor installations are 1.5 meters for 95% of the cases. *See* FWCC *Ex Parte*, Attachment at 17.

40 *See* Joint 6 GHz Reply Comments at 18-19.

41 AT&T March 19 *Ex Parte*, Attachment at 5; AT&T March 26 *Ex Parte*, Attachment at 4 (noting that LAA transmitters are likely to be deployed at distances ranging from 330-1000 feet).

42 RKF Study at 14.

that even the impact of radically increasing the prevalence of LAA to 15% of outdoor deployments has a minimal effect on overall compatibility and sharing.[43] In any event, to reiterate, AT&T's projections of 4,000 LAA devices next year constitutes a mere rounding error within the broader scope of the RKF Study that assumed 1.56 *billion* 6 GHz RLAN devices by 2025.

III. FIXED-WIRELESS INTERESTS' CRITICISMS OF THE RKF STUDY'S SIMULATION OF FIXED LINKS AND INTERFERENCE MORPHOLOGIES ARE MISTAKEN.

In addition to criticizing RKF's well-supported conclusions about RLAN operations—which were informed by the undersigned companies' extensive RLAN engineering experience—the FS interests also question RKF's evaluation of fixed links, and the possible interference morphologies that might occur between these links and RLAN devices. These concerns appear to be driven primarily by misunderstandings of the RKF Study.

A. RKF's Antenna Size and Performance Assumptions Are Conservative

FWCC falsely claims that the RKF Study ignored antenna size.[44] In fact, RKF faithfully reflected the actual gain of every FS transmitter in each of the 91,187 active transmitters listed in the Commission's ULS database. For antenna sidelobe performance, RKF conservatively assumed *higher* sidelobe gain than the antennas typically used in FS links. Here, RKF used ITU-R Rec. F.1245-3, which was specifically adopted for use in this type of simulation.

FWCC effectively confirms the extreme conservativism of RKF's analysis in this respect. In its own analysis, FWCC uses four common high-performance antennas: UHX6-59, UHX10-59, UHX12-59, UHX15-59 (with antenna diameters of 6, 8, 10, and 12 feet respectively).[45]

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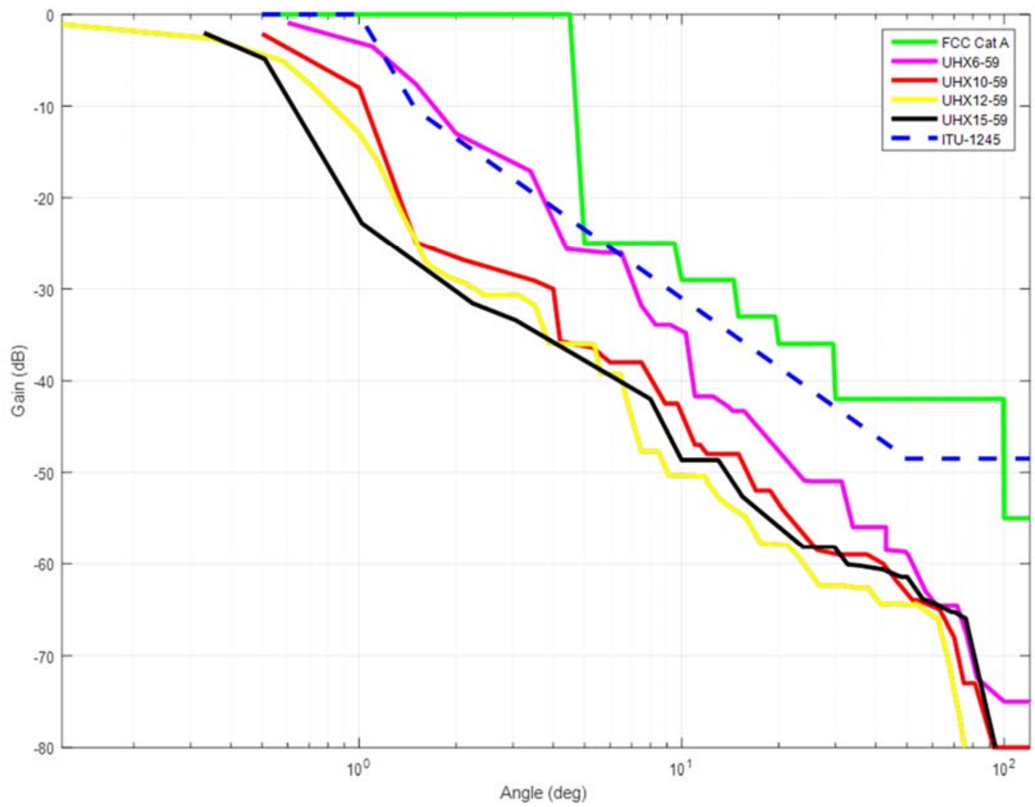
43 *See* European Conference of Postal and Telecommunications Administrations, Electronic Communications Committee, *Compatibility studies related to RLANs in the 5725-5925 MHz band*, ECC Report at 244 (approved Jan. 29, 2016), *available at* https://www.ecodocdb.dk/download/97d65d77-816b/ECCREP244.PDF.

44 FWCC *Ex Parte* at 12.

45 *Id.* at 7 n.3.

As illustrated below, each of these antennas exhibits better sidelobe rejection—and therefore would experience *less interference*—than the antenna pattern RKF conservatively assumed.[46]



In fact, for the very small number of cases where RKF's simulations predicted interference in excess of -6 dB I/N, RKF did evaluate the interference based on the actual antenna patterns, as recommended by FWCC, to quantify the degree to which the generic ITU-R Rec. F.1245-3 pattern exaggerated the potential for interference. In doing so, using the antenna characteristics FWCC proposes further reduces the probability of interference:

46 Although the UHX6-59 pattern exceeds the ITU-R Rec. F.1245-3 pattern by a small amount between approximately 10 and 150 degrees, that antenna substantially outperforms the ITU pattern overall.

Antenna Pattern	Interferers where I/N ≥ -6 dB	Probability of Interference
ITU-R Rec. 1245	1847	0.2%
UHX6-59	1395	0.015%
UHX10-59	659	0.007%
UHX12-59	474	0.005%
UHX15-59	384	0.004%

AT&T objects to RKF's use of ITU Rec. 1245 on two other grounds. It contends that this internationally accepted model understates antenna gain for certain discrimination angles for three specific antennas, UHX6-59, PARX6-59, and VHLPX4-59. Therefore, AT&T argues, RKF should have assumed the FCC antenna *mask* pattern, instead of the characteristics of any particular real-world antenna. However, the difference between these antennas and the ITU-endorsed antenna pattern is minor, and there is no reason to believe that using the patterns AT&T suggests would produce materially different results. In fact, as illustrated in the table above, specific analysis of one of the antennas that AT&T highlights, UHX6-59, confirms that it would experience *less* interference overall than the ITU-R F.1245 mask used by RKF suggests. AT&T has offered no reason why RKF or the Commission should assume performance no better than the Commission's Category A requirements when the record evidence makes clear that real-world antenna performance significantly exceeds this standard. Although we are committed to ensuring non-interference to *actual* fixed links, the Commission need not consider imaginary links, using antennas that are not actually in use and that are not likely to be deployed in the future.[47]

B. RKF Properly Considered Line-of-Sight Concerns

FWCC, AT&T, and NSMA also incorrectly claim that the RKF Study fails to consider line-of-sight conditions between RLANs and microwave receivers.[48] In fact, the RKF Study not

47 AT&T also appears to suggest—inconsistently—that RKF should have used a different ITU model, ITU-R F.699-8. AT&T March 26 *Ex Parte*, Attachment at 6 n.4. However, ITU-R F.1245 explains specifically that ITU-R F.699 is not appropriate for this type of study because, in predicting aggregate interference, "the predicted interference will result in values that are greater than values that would be experienced in practice." Rec. ITU-R F.1245-2 *considering* (b).

48 *See* FWCC *Ex Parte* at 2, 10; AT&T March 19 *Ex Parte*, Attachment at 6; NSMA *Ex Parte* at 3-4.

only considers this case, it goes so far as to highlight it in the executive summary.[49] As the RKF Study explains, RKF evaluated the potential for interference by considering a large number of potential interferer morphologies—i.e., RLAN transmitters in numerous different locations—and their impact on each registered FS link listed in the Commission's ULS database. This included cases in which one or more transmitters are located in or near the main beam of an FS receiver, where line-of-sight propagation conditions could apply.

Indeed, RKF explained that its ability to model line-of-sight as well as non-line-of-sight paths was an important reason for its selection of the WINNER II model over other models such as the ITU-R P.1411 model FWCC recommends.[50] This feature allowed for "random assignment of line-of-sight and non- line-of-sight paths in the simulation."[51] In addition, RKF conservatively assumed line-of-sight whenever the RLAN antenna height in a given morphology exceeded ten meters.

C. RKF Employed a Highly Conservative Implementation of WINNER II

FWCC agrees with RKF that "WINNER II is an excellent choice for average propagation."[52] AT&T, however, faults RKF for using WINNER II instead of its preferred model, 3D UMa. AT&T does not explain why 3D UMa is more accurate than WINNER II, other than claiming that it is "more typically used by the mobile industry."[53] Moreover, AT&T overlooks that 3D UMa is essentially unusable for simulations like the one that RKF performed because it requires site-specific building height and street width information. RKF considered a similar, but more usable model, ITU-R P.1411, but, as RKF explained, it decided against using that model because that model provides no guidance for combining line-of-sight and non-line-of-sight propagation scenarios.[54] Moreover, by assuming line-of-sight conditions for all RLAN antenna heights greater than 10 meters, RKF substantially underestimated path loss compared to 3D UMa for the RLAN morphologies most likely to generate significant interference.

While FWCC contends that RKF's implementation of the WINNER II propagation model is "oversimplified,"[55] this belief appears to stem from FWCC's review of Figures 4-2 and 3-2 of the RKF Study that, in FWCC's mistaken view, indicates that RKF did not consider line-of-sight conditions, and improperly implemented WINNER II as to urban or suburban non-line-of-sight cases. These figures illustrated the differences between various candidate propagation

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[49] RKF Study at 6-7.

[50] *Id.* at 33-34.

[51] *Id*. at 33.

[52] FWCC *Ex Parte*, Attachment at 19.

[53] AT&T March 26 *Ex Parte*, Attachment at 5.

[54] RKF Study at 33-34.

[55] FWCC *Ex Parte* at 12.

models and, specifically, that ITU-R P.1411 significantly underestimates clutter loss.[56] They do not show RKF's implementation of the model.

Rather, RKF's implementation of WINNER II was robust and in accordance with the WINNER II Final Report—in particular scenario C1, as summarized in Table 4-4 of the Final Report.[57] The Final Report defines one model for non-line-of-sight propagation and two separate models for line-of-sight propagation, with a break-point that determines when each line-of-sight model applies in a given scenario. RKF used the probability of line-of-sight provided in Table 4-7 of the Final Report to determine whether line-of-sight conditions applied for a given path and, if so, correctly used the break point defined in Table 4-4 to determine which line-of-sight model was appropriate.

Moreover, the RKF Study only used WINNER II for distances between 30 m and 1 km of the FS receiver. While WINNER II is valid out to 5 km, RKF used the more conservative ITM/STRM+P.2108 model for distances greater than 1 km. For morphologies where WINNER II was used, a random determination was also made for each RLAN, based on the probability of line-of-sight, as to whether the path is line-of-sight or non-line-of-sight, with propagation loss calculated accordingly.[58] But because the majority of path simulations were more than 1 km in length, RKF's conservative choice to limit use of WINNER II to paths under 1 km resulted in its application to very few RLAN-FS paths.

D. RKF's Fade Margin Analysis Is Correct

FWCC and AT&T both claim that RKF improperly considered the role of FS fade margins in its simulations and assessment of the risk of harmful interference. They fault RKF for assuming that "RLAN interference, multipath and rain fade are all independent," claiming that this statement implies that RKF assumes that "interference ordinarily occurs only when the FS receiver is operating at normal received signal level."[59] But the RKF Study implies nothing of the sort. RKF's simulations included cases where RLAN interference occurred simultaneously with multipath and other fade conditions. Furthermore, as NTIA and the author of FWCC's own study have concluded, multipath fading primarily occurs between the hours of midnight and

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56 RKF Study at 33-34.

57 *See* Pekka Kyösti et al., *WINNER II Channel Models*, IST-4-027756 WINNER II, D1.1.2 V1.2 (last updated Apr. 2, 2008), *available at* https://cept.org/files/8339/winner2%20-%20final%20report.pdf.

58 FWCC also claims that "[n]o details of how the ITM, STRM or P.2108 pieces were merged are given." FWCC *Ex Parte*, Attachment at 13. This seems to reflect yet another misinterpretation of the RKF Study. RKF did not perform any merging of models. The WINNER II model was used for distances ≤ 1 km. For distances > 1 km, RKF conservatively used ITM, STRM and P.2108, likely underestimating loss by 10 dB compared to WINNER II.

59 *Id.*, Attachment at 23.

9 AM—outside of the RLAN busy hour. Therefore, RKF was correct to assume that these phenomena are independent.

FWCC also disagrees with RKF's calculation of path fade margins,[60] raising several general criticisms of the RKF methodology that we address below.[61] FWCC ultimately presents no argument to support its bare assertion that FS fade margins are 10 dB less than RKF concluded, based on link characteristics listed in the Commission's ULS database. Moreover, FWCC overlooks the fact that RKF conservatively did not apply the relaxed interference-protection criteria that are relevant in the absence of multipath fade conditions as well as numerous other link characteristics that tend to make them more robust to interference.[62]

E. <u>RKF Appropriately Calculated Link Availability</u>

To realistically calculate the effect of RLAN interference on FS link availability—crucial for determining whether an FS link would experience *harmful* interference—RKF assessed the impact of multipath and rain fade on each FS link. FWCC criticizes this analysis, however, for using ITU-R P.530 instead of Barnett-Vigants.[63] FWCC does not indicate the impact, if any, that using the Barnett-Vigants model would have on RKF's results. Presumably, however, FWCC intends to imply that using Barnett-Vigants would have resulted in a prediction of greater FS link baseline availability and, therefore, greater susceptibility to harmful interference.

The Barnett-Vigants model that FWCC favors was published in 1975 and has not been updated since. It therefore does not take into account 40 years' worth of scientific and engineering progress. P.530, on the other hand, is a modern engineering model that is updated regularly by ITU-R. There are also compelling engineering reasons to prefer P.530. First, Barnett-Vigants relies on a largely arbitrary factor, *C*, to account for a variety of specific geoclimatic and morphological characteristics of the link. P.530, by contrast, separately parameterizes each of these factors, allowing it to more faithfully reflect the real propagation environment. Moreover, the scientific literature has identified important cases where Barnett-Vigants is inaccurate.[64]

Finally, AT&T appears to contend that any contribution to conditions that overall could result in link unavailability, no matter how small the contribution, must be considered harmful interference even if it does not materially alter overall reliability.[65] AT&T here again overlooks the fact that even these seconds per year of theoretically noticeable interference would be addressed by the mitigation techniques that we have proposed separately.[66] More fundamentally,

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60 *Id.*, Attachment at 21-23.

61 *See id.*, Attachment at 17-25.

62 RKF Study at 30-31.

63 FWCC *Ex Parte*, Attachment at 21.

64 *See, e.g.*, Basile L. Agba et al., *Comparison of Microwave Links Prediction Method: Barnett-Vigants vs. ITU Models*, PIERS Proceedings, 788, 789 (Mar. 2010).

65 *See* AT&T March 26 *Ex Parte*, Attachment at 4.

66 Joint 6 GHz Reply Comments at 16-21.

AT&T does not point to a single instance where the Commission has endorsed such a radical view of harmful interference. This is for good reason: a harmful-interference standard that is unconnected from real effects on incumbent operations would needlessly prevent sharing in virtually *any* band, or even the use of a band adjacent to an existing system, because it requires effectively perfect performance of any sharing solution. This would impermissibly read the word "harmful" out of the phrase "harmful interference."

F. <u>RKF Properly Accounted for FS Link Proliferation</u>

AT&T contends that the RKF Study considered only today's links and did not account for future proliferation of FS links. AT&T suggests that there is dramatic growth in FS deployments but, in fact, 6 GHz deployments are increasing at a rate of only approximately 3% per year, if one takes into account both new registrations and expirations.

These new links are no doubt important and must be protected. But they have no material effect on RKF's conclusions. The number of potential interference cases identified by the RKF Study is so small that even a large percentage increase in the number of fixed links would have little impact on the feasibility of sharing. Whether or not more 6 GHz fixed links come online, the interference challenge will remain limited to a small number of cases and can be addressed using the proven mitigation techniques that we have already proposed.[67]

G. <u>RKF Correctly Excluded the Census Bureau's "Barren" Areas</u>

FWCC argues that the RKF Study's exclusion of "barren" areas—a term defined by the U.S. Census Bureau—raises issues because there are FS links in these locations.[68] RKF did not ignore these FS links. As FWCC acknowledges in Figure 8 of its *ex parte* filing, and as the RKF Study notes,[69] barren areas are areas "where few people live." Due to the very small number of 6 GHz RLAN users, any contribution that barren areas would have made to RKF's overall simulation results would have been negligible. Moreover, the RKF Study explained that low population density implies a very low probability of congested spectrum. Finally, any incremental mitigations required to resolve the main beam issues in urban and suburban areas will also resolve any equivalent (and highly speculative) scenarios in barren areas.

H. <u>RKF Accounted for Multistory Buildings</u>

AT&T argues that the RKF Study fails to account for RLAN deployment on the upper stories of tall buildings, a morphology that AT&T claims is problematic due to the presence of FS transmitters and receivers on roofs of buildings.[70] This appears to reflect another

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[67] *Id.*

[68] FWCC *Ex Parte*, Attachment at 18.

[69] RKF Study at 10-11. The Study noted that while barren areas comprise 10% of the U.S. population, that population is spread out over 90% of the Continental U.S. land mass—a population density that does not qualify as "rural".

[70] AT&T March 19 *Ex Parte*, Attachment at 7; AT&T March 26 *Ex Parte*, Attachment at 3.

misunderstanding of the RKF Study, which drew from U.S. government data on actual building heights.

RKF assumed that RLAN transmitters operated no higher than the 10th floor of a building because RLAN devices above the 10th floor represent a vanishingly small percentage of total devices. Moreover, the increase in RLAN height above the 10th floor would not generally alter the interference risk within the context of the RKF Study, as RKF assumed that any device at or above ten meters would have line-of-sight to an FS receiver. A device on the 20th floor of a building would therefore not be more likely to cause interference than a device on the 10th floor, given the typical elevation angle of FS links. In any event, devices above the 10th floor of a building will be subject to the same mitigation rules as other devices, thereby preventing interference in the unusual case where a device at such an extreme elevation appears within the main beam of a fixed link. Whether these devices are included in the simulation results or not, it remains clear that these situations will be rare and manageable through proven mitigation techniques.

I. RKF's Population Grid Modeling Is Reasonable

AT&T states that the RKF Study does not indicate the resolution of the population grid it used to distribute RLAN devices,[71] but then immediately notes, correctly, that RKF indicated a 60 arc second resolution, providing a grid size of approximately 1.2 km by 1.8 km. AT&T then goes on to question why RKF did not use census blocks instead of these 1.2 km by 1.8 km cells. The answer is simple: computational complexity. Further increasing resolution of the population dataset would add significantly to the computational burden of RKF's already highly sophisticated and time-consuming simulations, without any reason to believe that this even more granular population data would significantly change the results. In fact, more granular population data would also highlight cases where RKF overestimated the population density, for example by revealing rural areas adjacent to suburban areas.

J. RKF Correctly Analyzed "Worst Case" Links

To ensure that it thoroughly evaluated the interference risk to FS, RKF closely scrutinized the 165 worst-case links drawn from one of its ten CONUS-wide simulations. For these 165 links, RKF performed an additional *1,000* simulations, each with randomly distributed transmitters, thus ensuring that it had captured the most problematic RLAN-to-FS interference morphologies. AT&T claims that it is unclear how RKF selected these 165 links and that the additional 1,000 simulations somehow make the Study less reliable. Both issues, however, result from a misunderstanding of RKF's methodology.

In selecting the worst-case links for further simulation, RKF explained that it "selected one CONUS simulation and identified the 165 worst-case links that exceeded the -6 dB I/N threshold."[72] In other words, RKF selected one of its ten CONUS-wide simulations at random.

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71 AT&T March 26 *Ex Parte* at 7.

72 RKF Study at 51.

Then, after examining the results of that simulation, there were 165 links that exceeded the -6 dB I/N threshold. These links were singled out for further analysis.

AT&T implies that RKF's selection of the worst-case from only one study suggests that it might have overlooked other links that might have been even more severely affected. But this overlooks two key features of RKF's approach. First, the simulation RKF focused on was selected at random. Therefore, there is no reason to expect that the chosen simulation would understate the interference probability. Moreover, one "key finding" of the RKF Study was that "the affected FS receivers were strongly random in nature. . . . [N]o specific RLAN-FS geometry is more likely to occur with higher frequency."[73] This randomness undermines AT&T's hypothesis that RKF may have systematically excluded vulnerable links from the simulation.

AT&T also misunderstands the role of the additional 1,000 simulations. Although RLAN devices were randomly assigned to new locations in each run, this does not imply that the devices necessarily were assumed to be "moved" by end users as AT&T suggests.[74] The random reassignment of RLAN locations reflects a variety of possible RLAN morphologies that might occur in the world at any one time, not just how the devices could be moved over time. Time was relevant to these simulations mainly in that RLAN transmissions and fade conditions vary over time.

IV. FWCC's Study Is Fundamentally Flawed.

FWCC submitted its own study assessing the risk of harmful interference. However, this study is obviously flawed in a number of fundamental respects. We discuss some of the most egregious errors below.

Even with the errors, however, it is striking how little interference risk FWCC predicts. FWCC's results suggest that, without employing any mitigation techniques at all, only an average of 5.6 RLAN devices throughout a dense urban market—out of 3,000 simulated high-power outdoor transmitters—operating in or near the mean beam of an FS link would even have the *potential* to cause measurable interference to an FS receiver.[75] Given that FWCC actually exaggerated the interference risk by several orders of magnitude, as we explain below, this result underscores how remote the possibility of interference truly is. It also highlights the conservativism of the mitigation strategies we have proposed:[76] although FWCC's unrealistic study predicts only 5.6 potentially interfering outdoor RLAN devices in an entire urban market of more than 37,000 square miles (i.e., a square that is 193 km on each side),[77] the mitigation strategies already discussed in this proceeding would clearly restrict the operations of far more

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73 *Id.*

74 AT&T March 26 *Ex Parte*, Attachment at 3.

75 FWCC *Ex Parte*, Attachment at 3, 5-6. Although FWCC did not study other types of RLAN devices, they would pose less interference risk due to factors such as building entry loss.

76 Joint 6 GHz Reply Comments at 16-21.

77 FWCC *Ex Parte* at 6.

than five or six devices. This extreme overprotection would provide a large additional margin of protection to prevent any harmful interference to FS links.

A. FWCC Unreasonably Assumes Extreme RLAN Duty Cycles of 100%

FWCC incorrectly assumed that RLAN devices operate in the same manner as FS links: with continuous transmissions resulting in a duty cycle of 100%. As explained above, however,[78] and as RKF documents in its Study,[79] this assumption is demonstrably unrealistic. At a duty cycle of 100%, real-world 6 GHz RLAN devices operating at throughputs of at least 1 Gb/s would transmit several terabits of data *per hour*, far beyond even the projected *monthly* data usage of the average consumer.

Real 6 GHz RLAN devices will operate with average duty cycles of only 0.44%—considering only the residential users, whose use is typically the most intense. FWCC's error in this regard results in a more than 200-fold exaggeration of the total power emitted by RLAN devices over time. Therefore, the magnitude of this error alone renders FWCC's results completely unreliable. Indeed, it is remarkable that even with this significant error, FWCC's study still concludes that interference to FS would only arise due to "free-space (line of sight) interference from locations where consumers would be free to operate unlicensed emitters."[80] Thus, even FWCC's extremely distorted results generally predict interference in the same types of scenarios identified by RKF, which could be addressed through the mitigation strategies described in our comments[81]—but which FWCC ignores.

B. FWCC Exaggerates RLAN Power Levels

FWCC limits its analysis to outdoor, high-power devices operating at 35 dBm. This presents an unrepresentative view of potential RLAN interference because high-power outdoor devices constitute only a small fraction of total RLAN deployments. But even for the limited universe of devices that FWCC considers, it incorrectly models RLAN device power levels by assuming that a fixed device operating at 35 dBm E.I.R.P. transmits at that power level in all directions. In fact, 35 dBm is the *peak* power limit, meaning that RLAN devices would be limited to no more than that radiated power level in any direction. RLAN antennas typically provide peak gain near 0 and 180 degrees—i.e., towards the horizons—but significantly lower gain at higher and lower angles. Taking into account the relationship between elevation and antenna gain, and the various types of RLAN devices operating outdoors, results in a far lower *average* power for RLAN devices—approximately 17 dBm.[82]

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78 *See supra* at 4.

79 RKF Study at 16.

80 FWCC *Ex Parte* at 13. *See also id.*, Attachment at 7 ("All microwave antennas have a strip of area in front of them in which they are sensitive to interference.").

81 Joint 6 GHz Reply Comments at 16-21.

82 *See generally* RKF Study at 21-22 (depicting typical RLAN antenna gain patterns).

This is particularly significant when modeling potential RLAN interference to FS because, as FWCC points out, the FS receiver is often not at the same elevation. For example, FWCC highlights the case of a "microwave receiver on mountaintop overlooking city on flat terrain."[83] By overlooking the role of RLAN antenna elevation, FWCC therefore overestimates the average interference to FS receivers by a factor of 40.

C. FWCC Erroneously Applies Unrealistic Busy-Hour Assumptions to *Outdoor* Devices

FWCC's analysis considers only outdoor devices.[84] At the same time, FWCC focuses on multipath fading which occurs only during nighttime hours and extreme traffic and device usage conditions well beyond even the most extreme busy-hour scenario. In addition to dramatically overestimating busy-hour usage, FWCC overlooks the fact that outdoor RLAN usage declines after dark and moves indoors. Therefore, although FWCC's busy hour assumptions are incorrect with respect to any time of day, in any location, they are doubly incorrect for nighttime outdoor use.

D. FWCC's Channelization Assumptions Are Incorrect

FWCC's analysis appears to assume that every potentially interfering RLAN device operates in a 20 MHz channel that fully overlaps a 30 MHz FS channel.[85] In fact, however, RKF observes that only a small minority of RLAN devices—10%—use 20 MHz channels. The rest use larger channels, meaning that RLAN interference would be spread across a wider range of frequencies resulting in less interference at any given frequency. Rather than concentrating *all* of the energy emitted by an RLAN device within a 20 MHz channel that is co-channel with FS transmissions, only a fraction of the RLAN energy would likely be co-channel with a given FS beam. For example, if an RLAN device transmits at 30 dBm in a 20 MHz channel wholly contained by a 30 MHz FS channel, all 30 dBm of those RLAN transmissions would have the potential to interfere with the FS signal. But if, more realistically, the RLAN device transmits at 30 dBm across an 80 MHz channel, the energy in a 30 MHz portion of that wider channel would only amount to approximately 25.74 dBm, less than half as much power.

Similarly, according to the Commission's ULS database, more than 40% of fixed links operate in bandwidths less than 30 MHz, and over 30% are 10 MHz or less. FWCC ignores this fact and assumes 30 MHz bandwidths for every fixed link. The analysis above would apply equally to situations with RLAN channels wider than 20 MHz (the large majority) and situations with FS channels narrower than 30 MHz, or both. Therefore, FWCC's assumption that RLAN transmissions would be contained within 20 MHz channels, that themselves are entirely contained within the 30 MHz channels occupied by FS links, greatly exaggerates the interference risk. Most RLAN channels are wider than this, and many FS channels are narrower. Moreover, there is no basis for FWCC's assumption that the channels would entirely overlap. In reality,

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83 Letter from Cheng-yi Liu, Counsel for the Fixed Wireless Association, to Marlene H. Dortch, Secretary, Federal Communications Commission at 14, GN Docket No. 17-183 (filed Mar. 30, 2018). *See also* FWCC *Ex Parte* at 10.

84 FWCC *Ex Parte*, Attachment at 2.

85 *See, e.g.*, FWCC *Ex Parte*, Attachment at 7, 15.

channels would typically overlap only partially. The RKF Study took all of these diverse possibilities into account in assessing the risk of interference, while FWCC's study focuses only on a single contrived radiofrequency environment.

E. Other Issues

These are merely some of the most significant mistakes in the FWCC study, each of which, even standing alone, renders its results unreliable. In addition, a large number of other errors are apparent, including:

- Exaggerating the potential for multipath fading between sunset and midnight;
- Assuming that there is no FS-to-FS interference;
- Assuming free-space path loss in calculating exclusion zones;[86]
- Simplistically using the WINNER II path loss model when it is only appropriate for certain cases (which is why RKF used both WINNER II and ITU-R P.2108); and
- Providing no information about FS antenna heights.

V. NSMA's Analysis Is Fundamentally Flawed and Self-Refuting.

NSMA submitted a one-page analysis of potential RLAN interference to fixed links. This oversimplified, link-budget-style calculation repeats many of the errors described above, often in even more unreasonable ways. It performs a simple mathematical derivation that appears to (1) assume free-space path loss, (2) assume 30 MHz RLAN channels that perfectly overlap with FS channels (that do not exist in any planned IEEE or 3GPP standard), (3) ignore RLAN duty cycles (or assume a duty cycle of 100%), and (4) ignore available fade margin and link reliability requirements.

Because of these fundamental errors, NSMA reaches incorrect results. NSMA claims that, absent a height restriction, the maximum "safe" power level for an RLAN device is -59.9 dBm, approximately 1 *nano*watt. But FS links in the 6 GHz band are already subject to far stronger signals from potential interferers: the Commission's existing unintended emissions limits in the 6 GHz band, -21.2 dBm in a 100 MHz bandwidth,[87] are almost 8,000 times higher than the 1 nW limit that NSMA claims.

86 NSMA appears to have made the same incorrect assumption. NSMA *Ex Parte* at 5.

87 47 C.F.R. § 15.209(a).

CONCLUSION

The Commission should proceed expeditiously to a Notice of Proposed Rulemaking. The letters recently submitted by FWCC, AT&T, and NSMA criticizing the RKF Study include significant misunderstandings of the Study and inaccurate assumptions.

Strikingly, however, even with these widely divergent approaches, all parties continue to focus on a single issue that remains to be resolved: how to address interference to a fixed link in the unlikely event that an RLAN device is located in the FS main beam. While our companies disagree that this scenario presents a substantial risk of harmful interference, we agree with FS incumbents that the FCC should recognize and account for even these corner cases. Accordingly, we and others proposed mitigation measures to address these situations in response to the Notice of Inquiry. With the substantial technical record it now possesses, and armed with potential mitigation techniques to address the narrow main-beam scenario, the Commission should proceed promptly to a rulemaking.

Respectfully submitted,

Apple Inc.
Broadcom Limited
Cisco Systems, Inc.
Facebook, Inc.
Google LLC
Hewlett Packard Enterprise
Intel Corporation
Microsoft Corporation
Qualcomm Incorporated
Ruckus Networks, an ARRIS Company