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

Re: ET Docket No. 18-295, *Unlicensed Use of the 6 GHz Band*
GN Docket No. 17-183, *Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*
***Ex Parte* Communication**

Dear Ms. Dortch:

The Fixed Wireless Communications Coalition (FWCC) responds to an *ex parte* letter from Apple Inc. *et al*. (collectively, RLAN Group) dated September 25, 2019 (RLAN Letter).[1]

A. INTRODUCTION

The RLAN Group seeks to deploy unlicensed Wi-Fi-type devices (RLANs) in the 6 GHz bands, projecting 958,062,017 units in operation.[2]

Licensed in these bands are about 97,000 Fixed Service (FS) links. Most operate at 99.999% or 99.9999% reliability. Many carry safety-critical services.[3]

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1 Letter from Apple Inc. *et al*., to Marlene H. Dortch, Secretary, FCC (filed Sept. 25, 2019), citing our July 25, 2019, *ex parte* filing as "First FWCC Letter," and our August 22, 2019, *ex parte* filing as "Second FWCC Letter."

2 *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band January 2018*, *attached to* Letter from Paul Margie, Counsel to Apple Inc., *et al*., to Marlene Dortch, Secretary, FCC, in GN Docket No. 17-183 at 12, Table 3-1 (filed Jan. 26, 2018) (RKF Study).

3 These include coordinating railroad trains, balancing the electric grid, maintaining service in water utilities, controlling pressure and flow in oil and gas pipelines, and backhauling public

The FWCC initially opposed RLANs in the FS bands, foreseeing widespread harmful interference to FS systems. We credit the RLAN companies with a major step toward a mutually workable middle ground by proposing to put the RLANs under the control of an Automatic Frequency Control (AFC) system, intended to prevent RLAN transmissions from locations and on frequencies that would cause harmful interference to FS receivers. The FWCC dropped its opposition to AFC-controlled RLANs, conditioned on the AFC system being property designed and implemented.[4]

The RLAN proponents then reneged, in part, by proposing to deploy RLANs with no AFC control in the FS bands, in large numbers—possibly making up the majority of RLANs.[5] These would transmit anywhere, anytime, at power levels up to 30 dBm EIRP for indoor devices, and 14 dBm EIRP for outdoor devices.[6]

The FWCC opposes non-AFC-controlled RLANs on the ground that some are statistically certain to cause harmful interference. When they do, there will be no way to turn them off.

B. Summary

The RLAN interests continue to insist that a typical RLAN is unlikely to cause harmful interference, thanks to shielding from building walls and ground clutter, locations outside FS antennas' main beams, distances from FS antennas, and so on.

We agree.

Our concern throughout the proceeding has been the anomalous RLAN located within an FS receiver's main beam, close to the antenna, lacking ground clutter, and either outdoors or inside a building with inadequate wall attenuation. The RLAN Group does not deny these cases will exist, but insists they will be rare. Again, we agree—as to individual RLANs. But the RLAN

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safety first responders' mobile communications. Many of these users and their associations have filed with the Commission to express alarm about RLAN deployment.

4 Several issues relating to the AFC system remain in contention. These include interference protection criterion, propagation models, guard bands, database specifics, RLAN location accuracy, RLAN probe requests, and more.

5 Letter from Alex Roytblat, Wi-Fi Alliance, to Marlene Dortch, Secretary, FCC at 2 (filed Oct. 16, 2019) (the proposed uncontrolled devices "are the majority of Wi-Fi use cases today") (Wi-Fi Alliance Letter).

6 Letter from Paul Margie, Counsel to Apple Inc., *et al.*, to Marlene Dortch, Secretary, FCC, attachment at 8 (filed April 26, 2019).

Group expects to deploy devices in the hundreds of millions. Numbers like these will make rare occurrences commonplace.

No need to worry, insists the RLAN Group, because even those corner-case RLANs will not cause harmful interference. Their argument rests on two shaky main pillars (plus some smaller ones we discuss below).

First, says the RLAN Group, interference is not "harmful" unless it actually causes the FS link to fail—and even then, in their view, the interference is not "harmful," and is therefore permissible, so long as the failures don't happen too often. This misreads the law, which bars unlicensed signals that present a "significant potential" for causing harmful interference to a licensed service like the FS. It would also be bad policy for the Commission to knowingly permit even occasional RLAN-caused failures of high-reliability FS links, many of which carry safety-critical services.

Second, the RLAN Group counts on FS fade margin to absorb RLAN interference. Fade margin is additional capacity built into an FS link to withstand atmospheric events that would otherwise reduce signal strength at the receiver. Because fade margin is expensive, FS designers build in only the necessary minimum, perhaps with a small safety margin. But the RLAN Group insists FS links have far more fade margin than they actually need, and so can tolerate even strongly interfering RLAN signals. The argument requires disagreeing with every FS engineer who ever designed a link now in service, as to how much fade margin the link needs. The argument goes on to assert the right of RLAN interests to unilaterally seize this supposed excess for their own use.

The record as a whole establishes that non-AFC-controlled RLANs present more than a significant potential for causing harmful interference to the FS. Even if the evidence were in equipoise, the Commission would have to look to the burden of proof (see below), which requires a finding against the RLAN Group. The Commission's getting this wrong would mean hundreds of millions of devices in the field, each with the potential to harmfully interfere with critical FS links—and without AFC, no way to shut them down.

C. THRESHOLD ISSUES

These two procedural principles should guide the Commission's consideration of the substantive issues.

1. Burden of proof

The RLAN Letter says:

> [FWCC] 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.[7]

The first clause baffles us. We have presented scores of pages of analysis and simulation showing that FS links are at risk of harmful interference from uncontrolled RLANs.

The second clause is inapposite. The Commission has always required a proposed unlicensed newcomer to show it will protect licensed incumbents. The FWCC could, if it wished, make its case by showing the RLAN Group had failed to make theirs. But in fact we have presented our own studies and calculations to show that uncontrolled RLANs are statistically certain to cause harmful interference.

2. Balancing risks

RLAN interests have been frank about their motives for distributing uncontrolled RLANs. One is the expectation that devices without AFC will cost less.[8] The RLAN proponents also expect uncontrolled RLANs can be put into service more quickly than AFC-controlled devices,[9] so that sales can generate revenue sooner.

The FWCC opposes uncontrolled devices because they risk the integrity of FS communications, including the safety-critical applications mentioned above. Moreover, FS operators have already invested billions of their own dollars in equipment, which a severely interfering environment will make worthless.

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[7] RLAN Letter at 2.

[8] Letter from Paul Margie, Counsel to Apple Inc., *et al*. to Marlene Dortch, Secretary, FCC at 1 (dated July 19, 2019); Wi-Fi Alliance Letter at 3.

[9] Wi-Fi Alliance Letter at 2. The Wi-Fi Alliance fears delays comparable to those in the Citizens Broadband Radio Service and TV White Space rollouts. Wi-Fi Alliance Letter at 2-3. The RLAN AFC is conceptually far simpler.

The Commission will have to balance the equities between expanding the frequencies for casual, unlicensed Internet access, on the one hand, and protecting a licensed, high-reliability, interference-protected service that carries safety-critical traffic, on the other.

If the RLAN proponents turn out to be wrong, as we have demonstrated, some fraction of hundreds of millions of uncontrolled RLANs will cause harmful interference to the FS. Those devices will continue transmitting and causing harmful interference for years, until they finally wear out.

D. PRINCIPLES NOT OPEN TO SERIOUS DISPUTE

These principles are the foundation of our argument. None is controversial:

1. The Communications Act and Section 15.5 of the Commission's rules bar unlicensed devices from creating a significant potential for harmful interference to licensed facilities.

2. The Commission, not the parties, determines what degrees of interference constitute harmful interference.

3. An RLAN that does cause harmful interference to the FS is most likely to be atypically located, with clear line-of-sight to the FS antenna.

4. Any single RLAN has a low probability of this configuration, but on average that probability is above zero.

5. Despite a low probability of harmful interference per RLAN, the deployment of hundreds of millions of RLANs raises the probability that some of these will cause harmful interference to a statistical certainty.

We take these points up individually, and respond to the RLAN Group's views.

1. RLANs may not cause harmful interference to the FS.

The RLAN Letter says:

> FWCC advances the eyebrow-raising claim that the very "existence [of unlicensed devices] appears to violate Section 301 of the Communications Act."[10]

That would indeed be eyebrow-raising, if we had said it. We did not. We said this:

> RLANs will be unlicensed devices. Their proposed existence appears to violate Section 301 of the Communications Act, whose plain language requires a Commission license for all radio transmitters, with no exceptions.
>
> The D.C. Circuit found the Commission may permit the use of unlicensed devices, notwithstanding Section 301, but only where it finds they present no "significant potential" for harmful interference to licensed operations. To lawfully authorize 6 GHz RLANs, the Commission must find they present no significant potential for harmful interference to FS receivers.[11]

The RLAN Group then disparages their own fallacious excerpt as a "rhetorical flourish"[12]—but the excerpt is their language, not ours.

The RLAN Group does agree, however, that unlicensed RLANs must protect licensed operations from harmful interference.[13]

2. *The Commission determines what constitutes harmful interference.*

The RLAN Letter emphatically and repeatedly documents the Commission's role as arbiter of what constitutes harmful interference, as though the point were in contention.[14] It is not. We agree the Commission has the authority to ascertain the degrees of interference that amount to harmful interference. Specifically, the Commission will determine whether signals from very

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10 RLAN Letter at 3 (square-bracket interpolation in original), *citing* First FWCC Letter at 2.

11 First FWCC Letter at 2 (citation footnotes omitted), citing *American Radio Relay League, Inc. v. FCC*, 524 F.3d 227, 234-35 (D.C. Cir. 2008).

12 RLAN Letter at 3.

13 RLAN Letter at 3.

14 RLAN Letter at 3, 4 & nn.6, 9,

large numbers of uncontrolled RLANs would have significant potential to "seriously degrade[], obstruct[], or repeatedly interrupt[]" FS communications.[15] (See also Part E.2, below.)

3. An interfering RLAN is most likely atypically located.

The RLAN Group's filings have repeatedly emphasized that an RLAN would cause harmful interference to an FS link only under these circumstances:

- the RLAN is in or near the FS receiver's main beam;
- there is little or no attenuating material between the RLAN and the FS receiver;
- the RLAN is close enough to the FS receiver (depending on attenuation, RLAN power, and angle from the FS antenna); and
- the FS system is in a fade (not always necessary).

We agree. We have said throughout the proceeding that our most serious concern is an RLAN that meets the above conditions.

4. Any one RLAN is unlikely to cause harmful interference.

A randomly chosen "arbitrary" RLAN has a low probability of the configuration above, and so has a low probability of causing harmful interference. The proponents themselves have made the same argument in the past, and support our view that the probability is (crucially) above zero.[16] They now try to disown this line of reasoning, saying counterfactually that "not one" of their filings showed harmful interference to be unlikely for "a single RLAN at a typical location."[17] But the RKF Study did just that.[18]

The RLAN Group has tried for two kinds of showings. One of those is indeed the argument that a harmfully interfering RLAN is unlikely because it would have to satisfy several conditions simultaneously—what a signatory to the RLAN Letter earlier called "win[ning] the 'interference lottery.'"[19] Perhaps because the RLAN Group dislikes where this argument will lead (see next

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15 47 C.F.R. § 2.1 (definition of harmful interference).

16 RKF Study at 54 (rate of occurrence of interfering geometries is "extremely low—on the order of two-tenths of one percent …")

17 RLAN Letter at 4.

18 RKF Study at 54.

19 Comments of Hewlett Packard in ET Docket No. 18-295 at 13 (filed Feb. 15, 2019).

section), they now prefer to focus on analyses that estimate interference per link, rather than per RLAN.[20] We discount these alternative studies, having shown in prior filings that each relies on unrealistic assumptions that severely underestimate the likelihood of harmful interference to the FS.[21]

There can be no serious disagreement that an arbitrarily chosen RLAN has a small but nonzero chance of causing harmful interference to an FS receiver.

5. *Deploying of hundreds of millions of RLANs vastly increases the probability of harmful interference.*

The proponents' insistence on a low probability of interference per RLAN does not take into account the very large numbers of RLANs proposed to be deployed: 958,062,017, by the proponents' own projection.[22]

To illustrate the effect of large populations on small probabilities, we hypothetically suppose that the odds of a single RLAN causing interference are one in a trillion. With 958,062,017 RLANs in the field, the overall risk of interference becomes 0.1%—a value that would predict interference into over 90 FS receivers.[23]

The RLAN Group read more into this calculation than we claim for it, then attack their own misconstruction.

We have said throughout this is not an estimate of actual interference. Rather, it is a demonstration that even extremely small probabilities become significantly large when computed across a large number of cases. Where the RLAN Group filings repeatedly use wording like "extremely small probability" of harmful effects,[24] or "vanishingly small" risk of harmful

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[20] RLAN Letter at 4-5, *citing* studies by RKF Engineering Services, the LADWP Study, and the New York City LIDAR Study. *See* the RLAN Letter for full citations.

[21] *See* First FWCC Letter; Second FWCC Letter.

[22] RKF Study at 12, Table 3-1.

[23] If the probability of one RLAN causing harmful interference is 1 in a trillion (10^{-12}), the probability of one or more of 958,062,017 deployed RLANs causing harmful interference is

$$[1-(1-10^{-12})^{958,062,017}] = 0.00096 \approx 0.1\%$$

Multiplying this probability by the 97,000 FS links in the 6 GHz band predicts about 93 interfered-with FS links.

[24] RLAN Letter at 4.

interference,[25] those small risks become much larger when applied to hundreds of millions of RLANs.

Unable to counter either the arithmetic or its implications, the RLAN Group resorts to calling it "bumper-sticker advocacy."[26] They also criticize us for the calculation's referring to interference, rather than harmful interference,[27] but the calculation is the same either way. If one RLAN has one chance in a trillion of causing harmful interference, then the overall risk of harmful interference from 958,062,017 RLANs is statistically certain to cause harmful interference into dozens of FS links

The RLAN Group further objects that any incumbent can devise "simplistic probabilistic models" that purport to show some risk of mere interference from others in the band.[28] Again, we do not mean the above as an estimate of actual interference, harmful or not. But as a demonstration of small probabilities over large numbers, it starts from a conservatively small probability: 3,300 times smaller than the odds of a single Mega Millions ticket winning the jackpot, and almost eight orders of magnitude smaller than the RLAN interests' own estimate of 0.2 percent.[29] Yet even if the actual odds of an RLAN causing harmful interference were that low, the impact on the FS would be far too high.

Finally, the RLAN Group doubts our assertion that we do not consider aggregate interference from multiple RLANs.[30] We ignore aggregate interference because of the inverse-square law: if two or more RLANs cause interference to the same FS receiver, the signal from the nearest would dominate over the others and make the others irrelevant.

The proponents find our disclaiming aggregate interference to be at odds with our probability calculations that take into account RLANs that are nowhere near an FS main beam.[31] The RLAN Group themselves used a comparable methodology in the RKF Study, in order to claim a supposedly low risk of harmful interference per RLAN.[32] If we considered only those RLANs in

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25 RLAN Letter at 9.

26 RLAN Letter at 5.

27 RLAN Letter at 5.

28 RLAN Letter at 5.

29 RKF Study at 45.

30 RLAN Letter at 6. The Letter (at *id*.) also argues that only a small fraction of U.S. land area has FS beams overhead. True; but the more densely populated areas, where most FS receivers are located, will also see the greatest concentration of RLANs.

31 RLAN Letter at 6.

32 RFK Study at 45.

or near the main beam of an FS receiver and lacking clutter, as the RLAN Letter seems to suggest, the likelihood of harmful interference would approach certainty.

E. PRINCIPLES IN CONTENTION

The following points in the RLAN Letter reflect disagreement between the RLAN Group and the FS community.

1. RLAN power

The RLAN Group defends its proposed 14 dBm EIRP power limit for outdoor uncontrolled RLANs as being a small fraction of the power limits for existing Wi-Fi and Bluetooth devices.[33] The comparison is not apt.

When the Commission first authorized the precursors to modern Wi-Fi and Bluetooth, with the same power limits as today, it relegated those devices to three ISM bands—those being the only bands under consideration whose incumbents did not object.[34] The ISM bands are rarely used for critical services, as they are inherently noisy. In consequence, even relatively high-power unlicensed devices in the ISM bands do not cause harmful interference to critical services.

The subsequent expansion of Wi-Fi to non-ISM 5 GHz bands threatened harmful interference to Terminal Doppler Weather Radars. The Commission imposed measures to block unlicensed operation at locations and on frequencies that might affect the radars[35]—a form of AFC.

The power limits for Wi-Fi and Bluetooth provide no useful guidance for uncontrolled devices that share frequencies with safety-critical services.

2. Specification of "harmful interference"

All parties agree that unlicensed RLANs may not cause harmful interference to FS links. The relevant definition of harmful interference is

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33 RLAN Letter at 9.

34 *See Authorization of Spread Spectrum and Other Wideband Emissions*, First Report and Order, 101 F.C.C.2d 419 at ¶ 13 (1985). These bands are allocated for devices that generate and use RF energy locally for industrial, scientific, medical, domestic, or similar purposes, excluding telecommunications. 47 C.F.R. § 18.107(c). Microwave ovens are one example.

35 47 C.F.R. § 15.407(h)(2).

> Interference which … seriously degrades, obstructs, or repeatedly interrupts a [licensed radio service].[36]

The RLAN Group accuses us of not knowing the difference between harmful and non-harmful interference,[37] and of seeking protection against "*any* potential effect on an FS link … no matter how remote the possibility, and even if it does not disrupt the link."[38] This caricatures our position. It also implies the RLAN Group believes RLAN interference is permissible until it actually does disrupt FS links. This misreads the law.

The U.S. Court of Appeals for the D.C. Circuit affirmed a more stringent standard. The Commission may lawfully authorize an unlicensed device only

> as long as it does not "transmit[ ] enough energy to have ***a significant potential*** for causing harmful interference" to licensed radio operators.[39]

An unlicensed device need not disrupt licensed communications to cause harmful interference; it need only present a "significant potential" for disruption. The distinction becomes important where the victim service carries safety-critical applications. The RLAN Group implies that RLAN interference is not harmful, and is therefore permissible, until it actually—and repeatedly—causes railroad trains to halt, or pipelines to shut down, or parts of the electric grid to black out, or 911 backhaul to fail. This cannot be right, as a matter of policy. It is wrong as a matter of law.

Modern digital FS radios do not respond gracefully to interference that overcomes the fade margin. The radios operate in various modulation modes specified by QAM (quadrature amplitude modulation) numbers: 8, 16, 32, 64, 128, etc. Higher QAM provides greater data throughput, but lower resistance to interference. Designers take the needed QAM rate into account when specifying a fade margin.

Some types of links support multiple virtual data channels (VLANs). Larger QAMs support more VLANs; smaller QAMs support fewer. As increasing interference degrades performance, the radio shifts to lower QAM in an attempt to maintain communications, but then can carry fewer VLANs. Some previously carried VLANs are blocked. The RLAN Group has previously

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36 47 C.F.R. § 2.1.

37 *E.g.*, RLAN Letter at 4, 5, 6.

38 RLAN Letter at 4 (emphasis in original).

39 *American Radio Relay League, Inc. v. FCC*, 524 F.3d at 234 (emphasis added), *quoting from Ultra–Wideband Transmission Systems*, Second Report and Order and Second Memorandum Opinion and Order, 19 FCC Rcd 24,558 at ¶ 68 & n. 179 (2004).

suggested that interference which "only" slows a link would be harmless,[40] but in fact that level of interference completely stops a subset of ongoing communications, thereby seriously degrading the link.

In other types of links, a sufficiently interfering signal simply takes out all communications.

The RLAN Group says, and we agree, the Commission has "great leeway" in saying what constitutes harmful interference in particular bands.[41] The Commission needs that leeway in part to customize findings of harmful interference according to the victim service. A degree of interference that is deemed not harmful to a hobby service, for example, may be harmful interference to a service whose disruption threatens human safety.[42] Applications carried on the FS call for a stringent standard as to harmful interference.

If RLANs outside AFC control do cause actual and repeated disruption to FS communications, there will be no way to call them back or turn them off. Large numbers of devices, perhaps in the hundreds of millions, will go on blindly causing slowdowns and outages in critical services for years. This risk reinforces the need for the Commission to take a conservative view in assessing RLAN-to-FS harmful interference.

3. *Role of fade margin*

The RLAN Group's efforts to show a lack of harmful interference depend on RLANs improperly preempting FS fade margin. This is a central point of dispute between RLAN and FS interests.[43]

Atmospheric layering during nighttime hours causes FS signal strength at the receiver to fluctuate downward, typically by tens of dB, due to multipath fading.[44] Other factors, noted

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40 Comments of Apple *et al.*, at 15 (filed Feb. 15, 2019).

41 RLAN Letter at 3.

42 The definition of "harmful interference" provides near-absolute protection to the functioning of "a radionavigation service or of other safety services …" 47 C.F.R. § 2.1. Some other services, including the FS, although not qualifying as "safety services" under the definition, nevertheless carry traffic critical to maintaining human safety.

43 We will respond separately to another filing by a subset of RLAN Group specifically on fade margin: Letter from Paul Margie, Counsel to Apple Inc., *et al.*, to Marlene Dortch, Secretary, FCC (filed Oct. 7, 2019).

44 Thermal layers form in the atmosphere after sundown. A component of the transmitted FS signal that would otherwise pass above the receive antenna can instead be refracted downward by the boundaries between atmospheric layers so that it impinges on the antenna. Because it takes a longer path, this refracted component can arrive out of phase with the direct signal and cause destructive interference.

below, also contribute to fading. In order to maintain reliable communication through all types of fades, FS designers build in a signal reserve: fade margin. Adequate, unimpaired fade margin is essential to FS reliability.

Fade margin is expensive. FS designers evaluate the climate, path length, needed data capacity, and other specifics for each individual link, so as to build in the minimum fade margin that will maintain the rated reliability for that particular link, usually 99.999% or 99.9999%. That leaves no excess fade margin to soak up RLAN interference.[45]

The RLAN interests think they know better. They insist the FS engineers are wrong—all of them. They insist that every FS link has many dB of surplus fade margin that will render RLAN interference harmless.[46]

Their discussion opens with another misleading misquotation: "FWCC has previously claimed that FS links require '25-40 dB' of fade margin to remain unaffected by atmospheric fade."[47] Our cited pleading actually said something different:

> ***Depending on the reliability needed***, fade margins are ***typically*** in the range of 25-40 dB.[48]

The 25-40 dB range is an estimate that applies in some cases, but not all. The estimate may be low for a link at a location subject to greater-than-typical multipath fading, or subject to fading other than multipath (see below), or requiring greater-than-typical reliability.

An NTIA report is clear on the role of fade margin:

> Regardless of the amount of fade margin or type of FEC [forward error correction] designed into the link, ***any reduction in fade margin due to interfering signals will lead to a reduction in performance***.[49]

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[45] Occasionally, where transmitter power options are limited, the link designer must use the next higher power available. These cases are the exception, not the rule.

[46] RLAN Letter at 7.

[47] RLAN Letter at 7.

[48] Comments of the Fixed Wireless Communications Coalition in ET Docket No. 18-295 at 16 (filed Feb. 15, 2019) (emphasis added).

[49] *Interference Protection Criteria: Phase 1 - Compilation from Existing Sources*, NTIA Report 05-432 at 4-4 (October 2005) (emphasis added).

The RLAN Group writes as though any incursion into fade margin that does not cause an immediate outage is harmless.[50] This fundamentally misunderstands the purpose of fade margin. Any RLAN interference that encroaches on fade margin will reduce FS reliability by raising the likelihood of outages during fades. Every 10 dB of fade margin taken up by an RLAN increases FS outage times by a factor of 10, and takes one "9" off essential reliability.[51]

The RLAN Group questions FS engineering practice, claiming:

> [A]pplication 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.[52]

The "industry standard link planning algorithms" RLAN Group purports to have used are just that: planning algorithms. They do not represent all considerations for path design. Microwave paths can be degraded by many factors, of which multipath fading is only one. If the path is located in a poor propagation area impacted by obstruction or ducting fading,[53] a practical solution may require short paths with tall towers and "excessive" fade margin. Some cascaded paths are over-designed so that more demanding longer paths can be under-designed to economically achieve adequate end-to-end reliability.

The RLAN community takes it on themselves to reengineer other people's FS paths, despite lacking full technical data on the link's design and performance requirements. But their plan is actually much worse. The RLAN Group does not intend to re-analyze each FS link individually for supposedly excess fade margin, even with insufficient data, so as to estimate how much interfering signal they think the particular link can withstand. That would be incompatible with the goal of shipping out hundreds of millions of uncontrolled RLANs that end users can turn on

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50 *E.g.*, RLAN Letter at 4 (criticizing the FWCC for opposing interference even if it does not at that moment disrupt the link.)

51 A prudent engineer may include a little more fade margin than the calculations indicate is strictly essential, to avoid having too little. But this is not the substantial excess that RLAN interests propose to rely on.

52 RLAN Letter at 7.

53 Ducting occurs when a layer of air near the Earth, having an unusually rapid decrease of water vapor with height, and/or increase in temperature with height, causes the curvature of radio rays to exceed the curvature of the Earth's surface, thus trapping or reflecting radio waves. Obstruction fading occurs when refractivity instead increases with height near the Earth, causing a positive refractive gradient condition called subrefraction that bends the electromagnetic wave upward to such an extent that the radio wave cannot reach the receive antenna. *See generally*, George Kizer, *Digital Microwave Communication* at ch. 12 (Wiley 2013).

anywhere. Their goal, rather, is to persuade the Commission that virtually every link was wrongly engineered to have excess fade margin it does not actually need.[54]

Consider what this says. The RLAN Group thinks it can generalize from incomplete ULS data to set aside at one stroke the careful work of the trained and experienced FS engineers who painstakingly calculated dozens of parameters for every one of the 97,000 individual 6 GHz links, so as to declare that all of those links have the same major design error: namely, multiple dBs of fade margin the FS engineers needlessly included.

There is more. Having unilaterally decided that (virtually) every link has excess fade margin, the RLAN Group next presumes that supposed excess as a common resource available to all for the taking. This is a startling view. FS operators spend hard cash for fade margin: an asset they build into their facilities to meet their own needs for reliability. Fade margin is not public property for anyone to use.

4. Role of diversity antennas

We acknowledge the RLAN Group's clarification of their view that diversity antennas improve FS link availability due to the low probability of simultaneous deep fading on both antennas.[55] But our objection is unchanged. As we noted in an earlier filing, diversity antennas are expensive to buy and install, and in ongoing tower fees.[56] Operators incur these costs only when diversity antennas, in combination with fade margin, are needed to achieve the required reliability.

Diversity antennas do not create surplus fade margin, as the RLAN Group seems to think. They do not reduce the effect of interference on the path in any respect. To the contrary, they can double the impact of RLAN interference.[57] Moreover, a diversity antenna is often smaller than the main antenna, and so has a broader antenna pattern that can receive interfering RLAN signals over a wider range of angles than the main antenna.

With or without diversity antennas, RLAN interference that cuts into fade margin will threaten link reliability.

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54 RLAN Letter at 7.

55 RLAN Letter at 7. We had read the passage to say that diversity antennas would reduce the interference received from RLANs.

56 First FWCC Letter at 4.

57 *See System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference*, Recommendation ITU-R F.758-6 at 8 (09/2015) ("The same degradation in fade margin will more impact systems with diversity reception resulting in about two times EP [error performance] degradation.")

5. *Misuse of signal-to-noise ratio*

We showed that the RLAN Group finds excess fade margin in part by miscalculating the FS links' signal-to-noise (SNR) ratio.[58] The RLAN Group challenges that showing.[59]

The FWCC data on SNR were derived from the new ANSI/TIA Standard 10, prepared in collaboration with the major frequency coordination organizations, which maintain large libraries of vendor FS radio specifications. ANSI/TIA Standard 10 lists default co-channel T/I values based on thousands of coordinated radio records. These were converted to SNR.

The RLAN Group data on SNR comes mostly from new outdoor-only radios that have little market presence. While newer radios may use coding to reduce SNR requirements, compared to legacy radios, the examples in the RLAN Group data do not represent current FS microwave radio deployment.[60] Furthermore, the RLAN Group SNRs are in many cases lower than suggested by the interference criteria for these radios provided to U.S. frequency coordinators, and are wrong for the Alcatel MDR-8606. The SNR data also do not acknowledge the impact of adaptive modulation on radio thresholds, which requires an additional 3 dB SNR for each QAM (except the lowest).

6. *Buildings and building entry loss*

From the RLAN Letter:

> 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.[61]

This omits two key points: RLANs in high rises in FS main beams will indeed be rare on per-RLAN basis, but will become far more likely when evaluated over hundreds of millions of RLANs overall; and RLANs in non-high-rise buildings will also be positioned in FS main beams. As we have emphasized repeatedly, the "corner cases" the RLAN Group dismisses so casually are precisely the cases that will most threaten FS links.

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58 Second FWCC Letter at 8.

59 RLAN Letter at 11-12.

60 Together the examples listed by the RLAN Group constitute fewer than 4% of the FS radios in service. Data courtesy of Comsearch.

61 RLAN Letter at 2.

The RLAN Group considers only two kinds of buildings: thermally efficient high-rise construction they acknowledge might intrude into an FS receiver's main beam, but discount because these buildings present a nominal 30 dB of building entry loss (BEL); and low-rise buildings, potentially having much lower BEL, which the RLAN Group discounts because they are "overwhelmingly likely to be obstructed by foliage, terrain variation, and high-rise buildings."[62] The proponents base the argument on New York City. They acknowledge that an FS receiver in other cities may have greater exposure to lower buildings, but claim that "greater propagation loss" offsets the potentially lower BEL, with a citation to a wholly probabilistic model[63]—one that improperly relies on FS fade margin to accommodate the all-important corner cases.

An RLAN can cause excessive interference from distances out to 10.5 km even if located in a recently-built, thermally efficient high-rise.[64] In a low-rise building, which can have far lower BEL, an RLAN can come within an FS receiver main beam at distances of 2.2 km or more from the tower,[65] from where it can produce truly severe interference. The RLAN Group argues that thermal efficiency (which correlates loosely with BEL) depends on the year of construction and the energy efficiency code then in force, not the height of the building.[66] But codes also vary with the type of building (residential or commercial), and to some extent on jurisdiction. And, of course, plenty of decades-old buildings of all sizes that predate the modern codes are still in use.

In short, an RLAN in a building of any height, age, or construction can lie in an FS main beam, close enough to the receiver to adversely affect the link.

7. *Misuse of propagation models*

The RLAN Group tries to defend its use of statistically averaged propagation models.[67] These do not represent any particular RLAN-to-FS interference link, but rather estimate the attenuation seen over some typical interference path in a specified kind of environment. Many of these models include a high-attenuation segment for some distance out from the wireless device, representing ground-level clutter, and a free-space segment the rest of the way to the FS antenna.

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62 RLAN Letter at 11 (footnote omitted).

63 RLAN Letter at 11, *citing* RKF Study at 32-33.

64 Second FWCC Letter at 11, table 3 (assuming 30 dB BEL). For other assumptions and calculation, *see* Second FWCC Letter at Attachment A.

65 Second FWCC Letter at 5, figure 1 (assumes a Category A or B1 antenna, axis 43 m high, and level ground).

66 RLAN Letter at 11.

67 RLAN Letter at 9.

The RLAN Group says the FWCC "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."[68] This is true. We have always agreed that an RLAN subject to any significant degree of ground clutter is unlikely to cause harmful interference to the FS.

The particular cases that concern us—an RLAN in or near an FS receiver main beam with no intervening clutter (other than possible building attenuation)—do not fit composite propagation models. The only model that applies to these cases is free space over the entire interference path.

8. Misuse of C/I protection criteria

The RLAN Group challenges our insistence that interference calculations use I/N as a criterion, rather than C/I.[69]

An NTIA report explains: I/N "defines the level of interfering signal level relative to the system noise level," while C/I "defines the interfering signal level relative to a known carrier level[.]"[70] The report goes on to consistently use I/N for evaluating interference into FS systems.[71]

Another misleading quotation in the RLAN Letter says, "Comsearch explicitly recognized the viability of a C/I approach to interference protection …"[72] But the cited paragraph begins with just the opposite:

> First, Comsearch recommends that the fundamental IPC [interference protection criterion] should be an I/N ratio.[73]

Comsearch's comment limits its support of C/I to the (uncommon) case where a receiver is known to have extra margin yet still must be protected to high availability, using 99.9999% as an example.[74] There is no suggestion that Comsearch generally supports C/I over I/N.

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[68] RLAN Letter at 9.

[69] RLAN Letter at 8.

[70] *Interference Protection Criteria: Phase 1 - Compilation from Existing Sources*, NTIA Report 05-432 at 2-3 (October 2005).

[71] *See generally*, *id*. at ch. 4.

[72] RLAN Letter at 8.

[73] Comments of Comsearch in ET Docket No. 18-295 at 21 (filed Feb. 15, 2019).

[74] *Id*.

The RLAN Group favors C/I even while admitting C/I calculations require information about link operation that is "not available."[75]

The RLAN Group then goes on to draw a false distinction, saying that "I/N only assesses levels of interference; it cannot determine whether interference is *harmful*[.]"[76] But neither can C/I alone determine whether a particular degree of RLAN interference has a significant potential to be harmful. The RLAN Group's claim that C/I calculations "help reveal the often large difference between a particular I/N protection level and the onset of harmful interference" is simply not true—and irrelevant besides, as much of the link data needed to assess harmful interference is not publicly available: most critically, the end user's criteria for path performance.

The RLAN Group's attempted shift from I/N to C/I is another effort to undermine the careful engineering of FS links, so as to falsely justify excessive levels of interfering RLAN signal.

9. Miscalculation of bandwidth mismatch

The RLAN Group insists there can be no such thing as interference from an RLAN on frequencies adjacent to the FS receiver channel, because the FWCC "assume[s] 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)."[77] It is a truism in radio engineering that ***all*** receivers (not just FS receivers) are sensitive to signals in adjacent channels.[78] To answer the RLAN Group's question: FS systems can operate in proximity because frequency coordinators will not approve a link that causes adjacent-channel interference to another link; and the Commission will not accept an application without successful frequency coordination.[79]

The frequency separation needed to avoid harmful interference must be determined from the characteristics of the RLAN transmitter and FS receiver, along with their relative physical locations—and not simply cut off at the channel edge.

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75 RLAN Letter at 8.

76 RLAN Letter at 8 (emphasis in original).

77 RLAN Letter at 13.

78 Over-engineering a receiver to reduce the degree of adjacent-channel sensitivity not only adds unnecessary cost, but introduces phase distortion that becomes more pronounced with a steeper cut-off at the channel edge. The FS is under no obligation to build needlessly expensive, distortion-prone receivers to accommodate RLANs.

79 47 C.F.R. § 101.21(f).

10. Misuse of pattern mismatch

The RLAN Group counters our objection to its inclusion of 5 dB of "pattern mismatch" in its New York City study link budgets.[80]

The line from a potentially interfering RLAN to an FS receiver will be within a few degrees of horizontal. The RLAN Group's correction for pattern mismatch supposes the RLAN antenna transmits most of its energy downward in an approximately vertical direction, with relatively low emissions toward the horizontal, and hence toward the FS receiver.

We acknowledge the information in the record cited by the RLAN Group that supports factoring in pattern mismatch for particular use cases, particularly ceiling-mounted enterprise access points where the maximum emissions are downward. Other cases, however, would present near-zero pattern mismatch. For example, a tabletop RLAN with a single vertical antenna would produce its maximum emissions in a horizontal direction, making any reduction for pattern mismatch inappropriate.

11. The LADWP study and FS reliability

We stand by the fact that most FS links are designed to 99.999% or 99.9999% reliability, and are entitled to interference protection that maintains this level of reliability.

The RLAN Group cites a comment from a group of utilities and their association in an effort to justify lower reliability numbers.[81] Because of electrical utilities' need for extreme reliability at the sub-ten-millisecond level,[82] many use redundant systems having multiple telecommunications pathways, which enable each individual telecommunications link to function at a marginally lower rated reliability. The RLAN Group relies on this proposition to justify using 99.99% reliability numbers in their study of the Los Angeles Department of Water and Power (LADWP) FS system.

Using this relaxed, four-9's criterion allows the study to say that a given level of RLAN signal is non-interfering, despite the RLAN signal being 10 dB higher than would be safe for a more typical five-9's link, and 20 dB higher than would be safe for a six-9's link.

But even the RLAN Group's assumption of four-9's reliability is guesswork: "The case study assumes 99.99% reliability for all LADWP links, because at the time of this analysis ***we did not***

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80 RLAN Letter at 12-13.

81 RLAN Letter at 8, citing Comments of Utilities Technology Council *et al.* in ET Docket No. 18-295, Attachment at 21 (filed Feb. 15, 2019) (UTC *et al.* Comments).

82 UTC *et al.* Comments at 6-7.

know which links employ redundant ring pathways."[83] In a real world of interfering RLANs, that would be a highly risky assumption.

The RLAN Group's presentation of the LADWP study has a far more serious problem. The study is part of a larger effort to show that non-AFC-controlled RLANs will not cause harmful interference to the FS. The cover letter filed with the study says:

> The interference protection analysis demonstrates that the potential interference from unlicensed LPI operations to any LADWP FS link is extremely unlikely even when an unlicensed device is operating within direct line of sight of a licensed FS link.[84]

The intended implication is that non-AFC-controlled RLANs are generally safe for FS links. The reader must scour the footnotes to learn the study used links with atypically low reliability requirements, and were thereby able to tolerate 10-20 dB higher RLAN signals without harmful interference than most other 6 GHz FS links.

The RLAN Group defends its choice of the LADWP system for study on the grounds that (a) it is a representative utility communications system; (b) "FS receivers are generally located on mountaintops and other uninhabited locations" [we disagree]; and (c) the system has a high number of links (152).[85] None of these counters the atypically low reliability figures the study relies on for its favorable results.

We ask the Commission to note that results of the LADWP study do not generalize to other, more usual FS environments.

12. New York City study

The RLAN Group challenges our critique of their New York City LIDAR study by claiming that "only" 2.7% of FS paths had buildings protruding into an FS main beam, and were close enough to exceed -6 dB I/N.[86] That 2.7% is a frighteningly high number—but no cause for concern, the proponents say, because the median C/N of these links was 67 dB.

The median C/N value says nothing about the number of individual FS links at risk.

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83 Letter from Apple Inc. *et al*. to Marlene H. Dortch, Secretary, FCC at 2 n.3 (filed July 5, 2019) (emphasis added).

84 *Id*. at 1.

85 RLAN Letter at 10.

86 RLAN Letter at 10-11.

Even if the RLAN Group estimates are accurate and the C/N really is 67 dB, that represents only typically needed fade margin, not excess fade margin, at moderate and high QAM. See Table 1.

Receiver Mode (QAM)	C/N for 30 dB Fade Margin	C/N for 40 dB Fade Margin
256	59	***69***
512	62	***72***
1024	65	***75***
2048	***68***	***78***
4096	***71***	***81***

Table 1
Needed C/N vs. QAM
(needed *C/N above 67 dB in bold italics*)

The proponents defend their failure to consider older, low-rise, low-BEL, buildings in the main beam because, "especially in the New York City market, [these] are overwhelmingly likely to be obstructed by foliage, terrain variation, and high-rise buildings."[87] The phrase "overwhelmingly likely" does not reassure us, inasmuch as one badly located RLAN is enough to take down a link—and cannot be turned off when it does. Moreover, the proponents concede this situation may be more likely in cities other than New York,[88] meaning the New York City results may not generalize elsewhere.

CONCLUSION

Our analyses have shown that RLANs without AFC control will present a significant potential for causing harmful interference to FS links.

The RLAN Group's efforts to show otherwise rely on questionable assumptions that mostly ignore the isolated "corner cases" most likely to actually cause harmful interference. These are relatively unlikely on a per-RLAN basis, but become statistically certain with hundreds of millions of RLANs in the field.

The RLAN Group's claims of no harmful interference also rely on improper (and potentially dangerous) encroachments into FS fade margin.

Because RLANs lacking AFC control have a significant potential for causing harmful interference to a licensed service, the Commission's authorizing them would violate the Communications Act. It would also be bad policy to threaten the integrity of safety-critical FS

87 RLAN Letter at 11 (footnote omitted).

88 RLAN Letter at 11.

operations merely to reduce the price or accelerate revenues from sale of unlicensed Wi-Fi-type devices.

Respectfully submitted,

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