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

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

Dear Ms. Dortch:

The Fixed Wireless Communications Coalition ("FWCC") responds to the *ex parte* filing in this docket by the Wi-Fi Alliance ("WFA") on September 18, 2018.[1]

We admire the WFA's having transformed IEEE 802.11 technology from the costly commercial applications of the 1990s into today's ubiquitous access to the Internet, and especially for its role in ensuring that every Wi-Fi-branded device works perfectly with every other. In this instance, however, WFA's engineering expertise comes up short.

WFA supports the introduction of unlicensed RLAN devices into the 6 GHz bands used by the Fixed Service ("FS"). In particular, it favors non-frequency-coordinated indoor RLANs at powers up to 30 dBm EIRP.[2] We show below that these will expose the FS to harmful interference.

The FWCC is in talks with other RLAN proponents toward a system of automatic frequency control that would protect FS receivers. Both sides have kept the Commission apprised of their

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[1] Letter from Alex Roytblat, Senior Director of Regulatory Affairs, Wi-Fi Alliance to Marlene Dortch, Secretary, FCC (filed Sept. 18, 2018) ("Wi-Fi Alliance Letter").

[2] Wi-Fi Alliance Letter at 2 (250 milliwatts with antenna gain of no more than 6 dBi).

evolving positions through public filings in the docket. The FWCC's filings have already addressed most of WFA's arguments.

### *1. Background: FS link reliability*

The FS operates about 95,000 links in the United States. Some carry critical applications such as controlling oil and gas pipelines, balancing the electric grid, synchronizing railroad trains, and backhauling public safety communications. Most FS links operate at reliability levels of 99.999% or 99.9999%. These numbers allow for total outages not exceeding five minutes or 30 seconds, respectively, per year.

Adequate FS protection will require keeping RLAN-caused outages well below the permitted levels from other causes—*i.e.*, on the order of 30 seconds or 3 seconds per year, for each individual FS link.

### *2. Protection "on average" would create extensive FS interference.*

WFA approvingly cites a study as showing the incidence of RLAN interference into the FS to be 0.2%.[3] But that is an average over many simulations.[4] Multiplying 0.2% by 95,000 links gives a crude estimate of 190 links affected by interference. This is wholly unacceptable under any standard. A predicted interference rate of 0.2% in an environment populated with 95,000 FS receivers, each with outages limited to 0.001% or 0.0001%, guarantees numerous FS interference cases far in excess of the design criteria.

Interference calculations cannot rely on average probabilities, but must consider each FS link individually.

WFA tries to push down the 0.2% number by arguing that a combination of automatic frequency control and indoor operation at reduced power will reduce the probability.[5] But WFA does not quantify the reduction. In particular, it offers no assurance whatsoever of maintaining the FS's current levels of reliability.

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[3] Wi-Fi Alliance Letter at 2, citing *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 (filed Jan. 26, 2018) ("RKF Study"). The FWCC has pointed out shortcomings in this study. George Kizer, *Studies Regarding RKF's Frequency Sharing for Radio Local Area Networks in the 6 GHz Band Proposal*, attached to Letter from Cheng-yi Liu and Mitchell Lazarus to Marlene H. Dortch, Secretary, FCC (filed March 13, 2018).

[4] RKF Study at 45.

[5] Wi-Fi Alliance Letter at 2.

The FWCC agrees that automatic frequency control can be effective, if properly implemented. But uncontrolled indoor operation at any useful power creates a serious risk of interference. We spell this out in Part 4, below.

### *3. The FS has no excess fade margin to absorb RLAN interference.*

FS System designers build in "fade margin": reserves of signal power to compensate for the loss of received power caused by atmospheric fading.[6] Fade margins are typically in the range 25-40 dB, depending on the reliability needed.

Interference that does not cause an immediate outage will nonetheless cut into fade margin, leaving the system more vulnerable to outage from fades it could otherwise withstand. If the system is already in a fade condition, even a small degree of interference may be enough to bring it down. A source of interference strong enough to overcome all of the remaining fade margin will cause errors in transmission. If the microwave link is part of a network—most are—this causes the network to lose synchronization. The whole network stays down while it resynchronizes. Cellular and land mobile radio sites commonly need fifteen minutes to resync after a short interruption. It takes just one such incident to consume several years' worth of outage allowance.

WFA misleadingly dismisses a 1 dB reduction in fade margin as not necessarily being harmful.[7] In a system under stress from deep fade, 1 dB of interference can cause errors in transmission. The FWCC is nonetheless willing to accept the criterion of a 1 dB reduction in fade margin, this being the national and international standard for FS facilities operating in shared spectrum.[8]

Fade margin is expensive. Link operators pay for it in equipment costs so they can maintain communications through deep fades. There is no excess to protect against RLAN interference.

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[6] At 6 GHz all fading is caused by "multipath": changes in temperature or humidity at different atmospheric elevations that bend an upward-traveling component of the signal back toward the receive antenna, just as a lens bends light rays. Because the refracted signal takes a longer path than the direct signal, it can arrive at the receiver out of phase with the direct signal, and partially cancel out the direct signal. This reduces the signal strength at the receiver by anywhere from a few dB to a few tens of dB.

[7] Wi-Fi Alliance Letter at 2.

[8] TIA/EIA, *Interference Criteria for Microwave Systems, Telecommunications Systems Bulletin TSB10-F* (June 1994); ITU-R Recommendation F.758-6, *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*. Geneva: International Telecommunication Union, Radiocommunication Sector (Sept. 2015).

WFA redoubles its misunderstanding in a discussion of a public safety FS link from a fire department facility in Queens, NY to Manhattan.[9] WFA compares the actual link fade margin of 46 dB to a "default" fade margin of 37 dB. Mistakenly assuming that the default fade margin is all the link really needs, WFA deduces that RLAN interference could cause fade margin degradation equal to the 9 dB difference between the actual and default made margins without affecting the link. This is nonsense. WFA finds the default fade margin in an NTIA report,[10] which in turn takes it from an appendix to the ITU-R Radio Regulations.[11] There, it is a reference figure for coordinating with fixed satellite earth stations, based on calculations that assume a low-capacity FS link of a kind little used today. The number has nothing to do with the actual fade margin needed for any real link. The operators of the Queens-Manhattan link designed in—and paid for—a higher fade margin presumably because they expected to need it to maintain high reliability in public safety communications. It is not available to accommodate RLANs.

### *4. Uncontrolled indoor RLAN operation poses serious interference risks.*

WFA contends that indoor RLANs pose little risk of interference to outdoor FS receivers because clutter loss from furniture, walls, and windows will keep the signal from escaping the building.[12] The idea has intuitive appeal, but the numbers do not work.

WFA proposes indoor operation at 30 dBm EIRP.[13] We showed in an earlier filing that RLANs at far lower power levels will cause interference even to relatively distant FS receivers:[14]

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9 Wi-Fi Alliance Letter at 4. The link is licensed in the Public Safety Pool.

10 *Interference Protection Criteria Phase 1 - Compilation from Existing Sources*, NTIA Report 05-432 at page 4-10, Table 4-4 (Oct. 2005). The report cautions, on the preceding page, "The technical parameters of [digital microwave systems] vary over a wide range and cannot be simply characterized even within a given frequency band." *Id*. at page 4-9.

11 *Radio Regulations Appendices* at Appendix 7, page 216, Table 7b (Edition of 2016).

12 Wi-Fi Alliance Letter at 3.

13 Wi-Fi Alliance Letter at 2 (specifying 250 milliwatts conducted power with antenna gain up to 6 dBi).

14 George Kizer, *Determining the Impact of Non-Coordinated Indoor 6 GHz RLAN Interference on Fixed Service Receivers*, attached to Letter from Cheng-yi Liu and Mitchell Lazarus, Counsel, FWCC, to Marlene H. Dortch, Secretary, FCC at 4. (Aug. 28, 2018). The calculation used the usual interference criterion of fade margin degradation of 1 dB.

| Maximum Safe RLAN EIRP (dBm) | Distance to FS Receiver (km) |
|---|---|
| -1.7 | 1 |
| 7.8 | 3 |
| 13.9 | 6 |
| 18.3 | 10 |

**Table 1**
Maximum Non-Interfering Powers of Indoor RLANs at Various Distances from an FS Receiver

Data in the table assume a building wall attenuation of 20 dB. WFA thinks this number is overly conservative because it combines many types of construction, rather than focusing on high-rise buildings.[15] But we took that into account. Our authority on wall penetration averages four types of high-rise construction for an attenuation (at 5.99 GHz) of 20.0 dB.[16]

WFA says 30 dB would be "more realistic," but the only support it offers is a guess that all indoor RLANs that might threaten interference will be in steel high-rises.[17] That is obviously wrong. In a residential area with a nearby antenna site on elevated terrain (as in Albuquerque, San Francisco, and Hollywood, for example), RLANs in countless city blocks of wood-frame homes will have line-of-sight with FS receivers.

The 30 dB wall that WFA prefers would not solve the problem. WFA's 30 dBm RLAN in the boresight of an FS receiver antenna—even behind a 30 dB wall—will cause interference within 12 km of the antenna.[18]

Moreover, no realistic estimate of wall attenuation can be a single number. Typically the value will vary over at least 10-20 dB according to the details of construction and the geometry of the emitter relative to the columns, joists, and the like—and particularly relative to the windows. The use of even an accurate average attenuation underestimates the possibility of interference from the 50% of emitters whose locations in the building provide less shielding than the average.

WFA assumes tall buildings will give better interference protection from indoor RLANs because, it says, they are more likely to be made of "dense, energy-efficient materials" that will

15 Wi-Fi Alliance Letter at 3.

16 Loew, L. H., Lo, Y., Laflin, M. G. and Pol, E. E., *Building Penetration Measurements from Low-height Base Stations At 912, 1920, and 5990 MHz*; NTIA Report 95-325 at 108, Table D-6 (Inst. for Telecom. Sciences, NTIA Sept. 1995).

17 Wi-Fi Alliance Letter at 4.

18 See the attached calculation.

attenuate more of the signal.[19] This, again, is the kind of probabilistic "on average" argument we rejected in Part 1, above. It is also factually unrealistic. Tall buildings are more likely to come within the boresight to an FS receiver. Tall buildings also have more glass, which offers little attenuation. In our own law firm's 18-story high-rise, every outside wall is made entirely of glass from waist height up to the ceiling. This is typical of the curtain wall construction used in high-rise commercial structures for the last fifty years. From an interference standpoint, an RLAN in a room on the building periphery might as well be outdoors.

Even indoor RLANs pose a serious interference threat to the FS, and for that reason must be subject to a frequency control regime.

### *5. Possible cost or delay is not a ground for causing interference to the FS.*

WFA objects to frequency coordinating indoor RLANs because it claims that doing so would add to costs and delay deployment.[20] WFA does not put numbers on these concerns. But even if the cost and delay were prohibitive, that would be irrelevant. The use of unlicensed 6 GHz RLANs is subject to the condition that no harmful interference be caused to the FS.[21] If the cost or delay of protecting the FS is too high, then RLAN proponents must look to alternatives in other bands.

Respectfully submitted,

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[19] Wi-Fi Alliance Letter at 4.

[20] Wi-Fi Alliance Letter at 5.

[21] 47 C.F.R. § 15.5(b).

# Indoor 6 GHz RLAN Interference into Fixed Service Receivers Based on Wi-Fi Alliance Assumptions

George Kizer
September 24, 2018

The Wi-Fi Alliance proposes to exempt from frequency coordination indoor RLAN systems at 250 milliwatts with an antenna gain of 6 dBi (30 dBm EIRP), claiming incorrectly that these devices pose no threat of interference to 6 GHz Fixed Service (FS) receivers.[1] We demonstrate below that indoor RLANs at this power, using Wi-Fi Alliance's unsupported overestimate of 30 dB building wall penetration, still risk unacceptable levels of interference into FS receivers from any distance within 12.2 km.

When sharing spectrum, the standard approach is to limit interference so that it increases the receiver front end noise by no more than a tolerable amount. We shall use the value adopted by the RLAN Group.[2] and accepted by the Wi-Fi Alliance[3] : I/N = -6 dB, which we show below is equivalent to 1 dB degradation in FS receiver fade margin.

[Allowable] Foreign System Interference = Radio Front End Noise – 6 dB (1)

Receiver front end noise N is given by the following:[4]

$$N(dBm) = -114 + NF + 10\ Log(B) \quad (2)$$

NF = receiver noise figure (dB)
B = receiver bandwidth (MHz)

RLAN Group took the typical receiver noise figure in this band to be about 5 dB,[5] and I/N = –6 dB, so the allowable foreign system interference I would be the following.

$$I(dBm) = -115 + 10\ Log(B) \quad (3)$$

The channel bandwidths having commercial significance are the following:

| Channel Bandwidth (MHz) | Lower 6 GHz | Upper 6 GHz |
|---|---|---|
| 60 | X | ---- |
| 30 | X | X |
| 10 | X | X |
| 5 | X | X |

**Table 1 – Most Used FS Channel Bandwidths (MHz)**

From the above equations, we can calculate receiver front end noise N and the allowable interference power I for these bandwidths:

[1] Letter from Alex Roytblat, Wi-Fi Alliance, to Marlene Dortch, Secretary, FCC, in GN Docket No. 17-183 at 2 (filed Sept. 18, 2018) (Wi-Fi Alliance Letter).
[2] *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band January 2018* at 5, 6, 11, attached to Letter from Paul Margie, Counsel to Apple Inc., *et al*. to Marlene Dortch, Secretary, FCC (filed Jan. 26, 2018) ("RKF Study").
[3] Wi-Fi Alliance Letter at 2.
[4] Kizer, G., *Digital Microwave Communication*, page 674, formula (A.54), Hoboken: Wiley and Sons, 2013.
[5] RKF Study at 29.

| Channel Bandwidth (MHz) | Receiver Noise N (dBm) | Allowable Interference I (dBm) |
|---|---|---|
| 60 | -91 | -97 |
| 30 | -94 | -100 |
| 10 | -99 | -105 |
| 5 | -102 | -108 |

**Table 2 – Receiver Front End Noise and Allowable Interference Power**

Receiver path performance is a direct function of path fade margin. Fade margin is limited by the combined power level of receiver front end noise and external interference, given by the following formula:

$$RFM = \{10 \log_{10} [ 10^{N/10} + 10^{I/10} ] \} - N \qquad (4)$$

RFM = Reduction in Fade Margin (dB)
N = Receiver Front End Noise (dBm)
I = External Interference (dBm)

If we relate I to power relative to N, we can set N = 0 and I as the dB level of power relative to N. Using this approach with equation (3), and the RLAN Group's (I/N) of -6 dB,[6] gives an equivalent reduction in fade margin of 1 dB.

At the 6 GHz frequencies, path fading is multipath only, caused by changing refractions from atmospheric layers that can interfere destructively with the direct signal. An FS receiver under stress from atmospheric fading may need all of its fade margin to maintain communication at an acceptable level of availability.

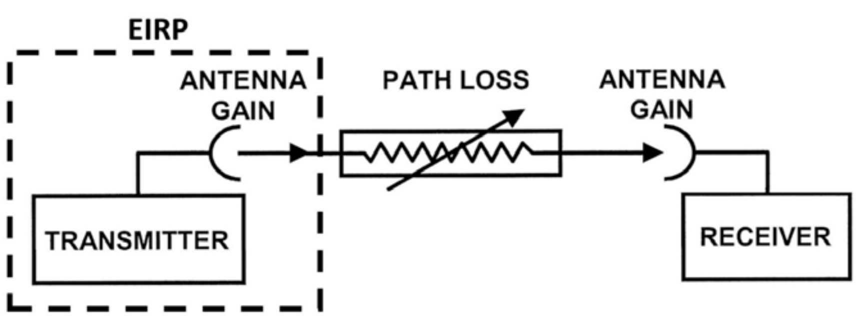


**Figure 1 – Typical Radio Path**

For the typical radio path, transmission line losses may be ignored. They are insignificant

[6] RKF Study at 5, 6, 11.

relative to the other losses in the path. If both antennas are operating in their far fields,[7] the propagated power appearing at the receiver is simply the sum of transmitter power (dBm) and transmit antenna gain (dBi) (in combination termed EIRP), minus the free space and atmospheric losses (dB), plus the receive antenna gain (dBi). Atmospheric losses for the frequencies under consideration are insignificant and may be ignored.

The main interference threat from indoor RLAN operation is a unit, perhaps on an upper floor, located within the boresight of an FS receive antenna under free-space conditions with only the building wall between the RLAN and the FS antenna.

Wi-Fi Alliance estimates signal loss through a building wall at 6 GHz to be 30 dB.[8] Wi-Fi Alliance provides no documentation for this number, which is at least 10 dB higher than those in the literature. Nevertheless, based upon this assumption, we may write an equation for FS receiver interference from an indoor RLAN:

Interference (dBm) = RLAN EIRP (dBm) – Path Loss (dB)
– Building Penetration Loss (dB) + Receive Antenna Gain (dBi)
– Antenna Side Lobe Rejection (dB) – Near Field Loss (dB)
– Bandwidth Mismatch Loss (dB) - Polarization Decoupling Loss (dB) (5)

Building Penetration Loss (dB) = 30 (see above)
Receive Antenna Gain (dBi) = 38.0 (boresight, 6 foot Cat. A or B1 parabolic antenna)[9]
Antenna Side Lobe Rejection (dB) = 0 (for boresight case)
Near Field Loss (dB) = negligible for the cases we are considering (beyond 0.5 km)
Bandwidth Mismatch Loss (dB) = 10 Log (94 MHz (RLAN weighted average) / 30 MHz)
= 5
Polarization Decoupling Loss (dB) = 3

This gives:

Interference (dBm) = RLAN EIRP (dBm) – Path Loss (dB) - 30 + 38.0 - 5 - 3 (6)

Assume Path Loss (other than building penetration loss) is free space.

Free Space Path Loss (dB) = 92.5 + 20 Log [Frequency (GHz)]
+ 20 Log [Path Distance (kilometers)] (7)
= 108.3 + 20 Log [Path Distance (kilometers)] (assumes lower 6 GHz mid-band frequency of 6.175 GHz)

[7] Kizer, G., *Digital Microwave Communication*, pages 265-274. Hoboken: Wiley and Sons, 2013 and Kizer, G., "Microwave Antenna Near Field Power Estimation," *4th European Conference on Antennas and Propagation (EuCAP) Proceedings,* April 2010.
[8] Wi-Fi Alliance Letter at 4**.**
[9] §101.115 (b) (table) (antenna standards).

The allowable interference for a 30 MHz FS channel is -100 dBm (from Table 2 above):

–100 = RLAN EIRP (dBm) – 108.3 - 20 Log [Path Distance (kilometers)]
- 30 + 38.0 - 5 - 3

RLAN EIRP (dBm) = -100 + 108.3 + 20 Log [Path Distance (kilometers)]
+ 30 - 38.0 + 5 + 3

= + 8.3 + 20 Log [Path Distance (kilometers)] (8)

From equation (8), setting RLAN EIRP to 30 dBm and solving for path distance gives 12.2 km.

**CONCLUSION:** Indoor RLANs within 12.2 km of an FS receiver threaten interference, under Wi-Fi Alliance's assumptions of power and building penetration loss. Even indoor RLANs must operate under control of an automatic frequency coordination system.