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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*
***Ex Parte* Communication**

Dear Ms. Dortch:

On July 13, 2018, representatives of the Fixed Wireless Communications Coalition (FWCC) made a presentation to Commission staff on the requirements for effective mitigation of interference from unlicensed RLAN devices into Fixed Service (FS) receivers in the 6 GHz bands.[1]

In discussions since then with RLAN representatives, we have modified and relaxed some of these requirements, albeit with qualifications.

The purpose of this letter and its attachment are to inform the Commission as to the evolution of the FWCC's views on the mitigation issues, and to present two particular concerns: the threat of interference from non-coordinated indoor RLANs, even at low power; and the unsuitability of the ULS database for RLAN coordination.

A. REVIEW OF MITIGATION REQUIREMENTS

Following is the list of requirements we presented on July 13, annotated to reflect developments.

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[1] *6 GHz RLAN Mitigation Issues* (slide deck), attached to Letter from Cheng-yi Liu, Counsel for the Fixed Wireless Communications Coalition, to Marlene H. Dortch, Secretary, FCC (July 17, 2018).

Requirement: prior coordination for all RLAN devices of any power, indoors and outdoors.

> RLAN Group agrees to prior coordination for all outdoor RLANs and for indoor RLANs above some (unspecified) power level, but it wants to operate indoor RLANs below that power level without coordination.[2] The attachment here, summarized in Part B below, shows that indoor RLANs even at very low power pose an interference threat. All RLANs require coordination.

Requirement: interference criterion of 1 dB fade margin degradation (I/N = – 6 dB).

> RLAN Group agrees.[3]

Requirement: an RLAN's initial request for authorization must be made outside the 6 GHz bands.

> RLAN Group appears to disagree.[4]

Requirement: the coordination system assumes line-of-sight for every link.

> The FWCC is open in principle to coordination based on databases that incorporate blocking by terrain and buildings, if the databases are shown to be accurate and kept up to date. We are not aware of specific databases that qualify. **Propagation models that assume clutter losses without specific path-by-path evidence must not be used.**

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2 *6 GHz: Additional FS Protection Discussion* (slide deck) at 7, attached to Letter from Paul Margie, Counsel to Apple Inc., *et al*. to Marlene Dortch, Secretary, FCC (filed Aug. 2, 2018) (*RLAN Group August 2 slide deck*); *see also A 6 GHz FS & FSS-Incumbent Protection Approach* (slide deck) at 2, attached to Letter from Paul Margie, Counsel to Apple Inc., *et al*. to Marlene Dortch, Secretary, FCC (filed June 15, 2018).

3 *RLAN Group August 2 slide deck* at 4; *See also 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").

4 *Comparison of 6 GHz AFC with TVWS & CBRS Spectrum Management Database Systems* (single slide), attached to Letter from Apple Inc. *et al*. to Marlene Dortch, Secretary, FCC (filed Aug, 23, 2018) ("Non-service transmissions for network discovery are permitted.")

Requirement: the coordination system assumes worst-case elevation at any RLAN location regardless of building height (but accounts for curvature of the Earth).

> The FWCC is open in principle to coordination based on terrain elevation, again assuming an accurate database. We are also open to coordination based on elevation within buildings, if that can be determined accurately and reliably.

Requirement: coordination based on a complete, accurate, and frequently updated FS receiver database.

> We explain in Part C below why ULS is not adequate for this purpose.

Requirement: periodic refresh of each RLAN authorization.

Requirement: an RLAN must shut down if its refresh does not succeed on schedule.

Requirement: protection of adjacent channels in every case, and protection of second-adjacent channels where necessary.

> The FWCC is open in principle to operation on adjacent channels based on evaluation of individual FS receiver characteristics.

Requirement: when authorizing a client RLAN through a master, allowing for cases where the master is at a safe location but the client is at an interfering location.

> RLAN Group agrees.[5]

Requirement: prohibition of operation on aircraft or drones

Requirement: successful testing of the coordination system under realistic conditions with participation of FS operators.

B. INTERFERENCE RISK FROM INDOOR LOW-POWER RLAN OPERATION

The RLAN Group has repeatedly signaled its wish to operate low-power devices indoors without coordination, on the assumption that such devices will "operate at maximum powers sufficiently low that they pose no material risk of harmful interference to incumbent links."[6]

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5 *RLAN Group August 2 slide deck* at 5.

6 *6 GHz: Additional FS Protection Discussion* (slide deck) at 7, attached to Letter from

We show that RLAN powers low enough to pose no material risk to the FS are also too low to be useful.

The main threat of FS interference from RLANs is the case of a single RLAN, perhaps indoors on an upper floor, located within the boresight of an FS receive antenna under free-space conditions—that is, with only the building wall between the RLAN and the FS antenna. The RLAN Group's numbers suggest 469 million low-power indoor "clients" concentrated into urban and suburban areas.[7] In the presence of 90,000+ FS receivers, most of which are likewise located in urban and suburban areas, some RLANs are all but certain to appear in receiver boresights.

The attached technical study, *Determining the Impact of Non-Coordinated Indoor 6 GHz RLAN Interference on Fixed Service Receivers*, analyzes the interference from an indoor RLAN transmitter into a FS 6 foot receive antenna boresight. (A larger FS receive antenna would result in more restrictive RLAN transmitter power.) The analysis conservatively assumes 20 dB attenuation through the building wall. The results are in Table 1.

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

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

From the table, an indoor RLAN at any workable power poses an unacceptable interference threat to FS receivers. RLAN Group has proposed 18.5 dBm for indoor client RLANs.[8] If one of these happens to fall in an FS receiver boresight, it will cause interference out to a distance of 10.2 km.

Paul Margie, Counsel to Apple et al., to Marlene H. Dortch, Secretary, FCC (Aug. 2, 2018).

[7] We calculate this from a total of 958 million RLANs, RKF Study at 13, of which 98% are indoors, *id*. at 22, with 50% of those being low-power clients. *Id*. at 22, Table 3-5. RLAN Group expects most of its units to operate in the 5% of the country that is urban or suburban. RKF Study at 16 & Table 3-3.

[8] RKF Study at 18, Table 3-4.

The conclusion is inescapable: Every indoor RLAN, at any power lever, must be subject to frequency coordination.

The FWCC is open to discussing arrangements in which indoor devices need not be individually coordinated if RF-tethered to a fixed device, such as an access point, whose location is known.

C. FS DATABASE FOR RLAN COORDINATION

The RLAN group proposes to frequency coordinate RLANs using the FCC's ULS database to determine the FS receiver locations and characteristics.[9] ULS is a poor choice for two reasons. Receiver coordinates, antennas, and radio types in ULS are incomplete and unreliable—subject to end users' frequent typos and idiosyncratic descriptions of equipment, with no easy mechanism for correcting errors.[10] (ULS primarily serves administrative rather than technical purposes.)

The frequency coordinators have access to FS databases with complete and accurate receiver information, and that show all coordinated links. We urge the Commission to require that 6 GHz RLAN coordination use databases that correctly reflect all of the FS receivers in operation or successfully coordinated.

Respectfully submitted,

Cheng-yi Liu
Mitchell Lazarus
Counsel for the Fixed Wireless
Communications Coalition

cc (by email): Paul Margie, Counsel for Apple Inc. *et al*.

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9 Letter from Paul Margie, Counsel to Apple et al., to Marlene H. Dortch, Secretary, FCC at 3 (June 12, 2018).

10 Worse: most users must pay a $305 filing fee to correct an error.

Determining the Impact of Non-Coordinated Indoor 6 GHz RLAN Interference on Fixed Service Receivers

George Kizer
August 28, 2018

The RLAN Group proposes to exempt from frequency coordination indoor RLAN systems below some (unspecified) power level, on the incorrect assumption that low-power indoor devices pose no threat of interference to 6 GHz Fixed Service (FS) receivers.[1] We demonstrate below that indoor RLANs at any useful power will risk unacceptable levels of interference into FS receivers, and so will require coordination.

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: I/N = -6 dB.[2]

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

Receiver front end noise N is given by the following:[3]

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

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,[4] and I/N = –6 dB, so the allowable foreign system interference I would be the following.

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

The channel bandwidths having commercial significance are the following:

[1] *6 GHz: Additional FS Protection Discussion* (slide deck) at 7, *attached to* Letter from Paul Margie, Counsel to Apple *et al*., to Marlene H. Dortch, Secretary, FCC (Aug. 2, 2018) ("Low Power Indoor (LPI) devices operate at maximum powers sufficiently low that they pose no material risk of harmful interference to incumbent links").

[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] Kizer, G., *Digital Microwave Communication*, page 674, formula (A.54), Hoboken: Wiley and Sons, 2013.

[4] RKF Study at 29.

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:

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:

$$RFM = \{10 \log_{10} [\, 10^{N/10} + 10^{I/10} \,] \} - N \qquad (3)$$

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,[5] 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.

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

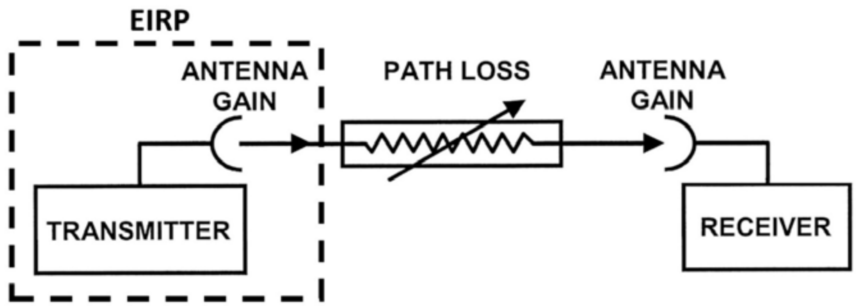

Figure 1 – Typical Radio Path

For the typical radio path, transmission line losses may be ignored. They are insignificant relative to the other losses in the path. If both antennas are operating in their far fields,[6] 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. RLAN Group estimates there will be 469 million low-power indoor "clients."[7] Concentrated into urban and suburban areas, in the presence of 90,000+ FS receivers, some of these are virtually certain to fall into receiver boresights.[8]

A conservative estimate for signal loss through a building wall at 6 GHz is 20 dB.[9] Based upon this information, we may write an equation for FS receiver interference from an indoor RLAN:

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[6] 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.

[7] This number follows from a total of 958 million RLANs, RKF Study at 13, of which 98% are indoors, *id*. at 22, with 50% of those being low-power clients. *Id*. at 22, Table 3-5.

[8] Similarly, the ITU-R suggests using free space loss when analyzing interference of ubiquitous RLANs into FS systems. ITU-R Recommendation F.1706, *Protection Criteria for Point-to-Point Fixed Wireless Systems Sharing the Same Frequency Band with Nomadic Wireless Access Systems in the 4 to 6 GHz Range*. Geneva: International Telecommunication Union, Radiocommunication Sector, January 2005.

[9] 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, Institute for Telecommunication Sciences, National Telecommunications and Information Administration, U.S. Department of Commerce, September 1995.

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) (4)

Building Penetration Loss (dB) = 20 (see above)
Receive Antenna Gain (dBi) = 38.0 (boresight, 6 foot Cat. A or B1 parabolic antenna)[10]
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) - 20 + 38.0 - 5 - 3 (5)

Assume Path Loss is free space.

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

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)]
- 20 + 38.0 - 5 - 3

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

= -1.7 + 20 Log [Path Distance (kilometers)] (7)

From equation (7), Table 3 gives the maximum RLAN power that limits interference to the I/N = -6 dB criterion specified by RLAN Group, for various path lengths between the RLAN and the FS receiver:

Path Distance (km)	RLAN EIRP (dBM)
1	-1.7
3	7.8
6	13.9
10	18.3

Table 3 – Indoor RLAN Power Limits for FS Boresight Antennas

[10] §101.115 (b) (table) (antenna standards).

CONCLUSION: Even indoor RLANs at very low power pose an unacceptable interference threat to FS receivers, unless they operate under control of a coordination system.