HWG | HARRIS, WILTSHIRE & GRANNIS LLP

April 12, 2018

Ex Parte

Marlene 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:

On April 10, representatives from Apple Inc., Broadcom Corporation, Cisco Systems, Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Microsoft Corporation, Qualcomm Incorporated, and RKF Engineering Solutions, LLC met with representatives of the Office of Engineering and Technology, the Wireless Telecommunications Bureau, and the International Bureau. A complete list of participants in this meeting is attached to this letter.

In these meetings, we discussed the attached presentation and addressed filings by fixed-wireless companies operating in the 6 GHz band. A comprehensive written response to the recent filings by fixed-wireless companies is forthcoming.

Pursuant to the FCC's rules, I have filed a copy of this notice electronically in the above referenced docket. If you require any additional information, please contact the undersigned.

Sincerely,

Paul Margie
Counsel to Apple Inc., Broadcom Corporation, Facebook, Inc., Hewlett Packard Enterprise, and Microsoft Corporation

Enclosures

cc: meeting participants

MEETING ATTENDEES

Julius Knapp (OET)
Bahman Badipour (OET)
Michael Ha (OET)
Walter Johnston (OET)*
Nicholas Oros (OET)
Aspasia Paroutsas (OET)
Robert Pavlak (OET)
Barbara Pavon (OET)
Jamison Prime (OET)
Paul Murray (OET)
Karen Rackley (OET)

Steve Buenzow (WTB)*
Tom Derenge (WTB)*
Ariel Diamond (WTB)
Paul Powell (WTB)*
Becky Schwartz (WTB)*
Blaise Scinto (WTB)*
Aole Wilkins El (WTB)*

Jose Albuquerque (IB)
Diane Garfield (IB)

Mark Neumann (Apple Inc.)
Chris Szymanski (Broadcom Corporation)
Mary Brown (Cisco Systems, Inc.)
Michael Tseytlin (Facebook, Inc.)
Austin Schlick (Google LLC)
Chuck Lukaszewski (Hewlett Packard Enterprise)
Peter Pitsch (Intel Corporation)
David Horne (Intel Corporation)*
Paula Boyd (Microsoft Corporation)
John Kuzin (Qualcomm Incorporated)
James Boughton, RKF Engineering Solutions, LLC
Ted Kaplan, RKF Engineering Solutions, LLC*
Tann Pinney, RKF Engineering Solutions, LLC*
Paul Margie, Harris, Wiltshire & Grannis LLP
Paul Caritj, Harris, Wiltshire & Grannis LLP

* Participated telephonically.

FS-RLAN Coexistence in the 6 GHz Band

April 10, 2018

Overview

- FS incumbent interests focus on situations where RLANs operate in the main beam of an FS link.
- RKF concluded that this situation will be extremely rare.
- Even in the rare instances when an RLAN is in the main beam, it will not necessarily cause harmful interference.
  - Mitigation techniques can resolve these occurrences.
  - Through an NPRM, the Commission can assess if such mechanisms are necessary.
- This presentation discusses the main issues raised by FS incumbents and shows that RKF's conclusions are correct, while the incumbents' criticisms are invalid.

Discussion topics

1. The objectives of the RKF study
2. FWCC mischaracterizes main-beam RLAN operations
3. FS incumbents' criticisms of the RKF study are unjustified
4. Additional mitigation mechanisms can be considered in an NRPM
5. Conclusion

FS commenters’ criticisms of the RKF study are misplaced

- RKF evaluated nationwide RLAN deployment in 6 GHz using the UNII rules as a baseline, to quantify the probability of interference *without* additional mitigation.
    - RKF did not evaluate specific mitigation techniques beyond those in the UNII rules, but recognized their potential.
- The FS incumbents make fundamental errors and do not undermine RKF's demonstration that nationwide RLAN deployment is feasible.
- Consistent with the RKF study, the FCC should consider mitigation in an NPRM.
    - Several techniques can deal with different interference scenarios in sub-bands or geographic areas, or even for particular service categories.
    - We have provided on the record candidate mitigate techniques and potential tools to protect incumbents from harmful interference.

Main-beam RLAN operation will be extremely rare

- RKF demonstrated that instances where RLANs operate in the main beam of an FS link will be *extremely rare*
- The FS incumbents' criticisms are misplaced
  1. Statistical analysis
  2. Modeling RLAN-FS interference models
  3. Multipath fading
  4. Path loss, clutter, and building entry loss
  5. Antenna patterns and FS modeling
  6. Simultaneous RLAN transmission assumptions
  7. Outdoor RLAN transmissions and EIRP assumptions
  8. RLAN and FS channelization

FWCC's claim that every RLAN operating in a main beam will cause harmful interference is incorrect

- FWCC ignores real-world conditions including clutter blocking line of sight, antenna discrimination, and polarization mismatch.
- For short periods an FS link with no excess margin can tolerate an I/N of +36.8 dB.*
- A link with excess fade margin can tolerate higher levels of interference.
    - For any given link, if excess fade margin is available, the IPC may be relaxed dB-for-dB.*

*NTIA Report 05-432, INTERFERENCE PROTECTION CRITERIA, Phase 1 - Compilation from Existing Sources

RKF properly used statistical analysis

- RKF placed representative RLANs randomly by population, and separately analyzed the interference potential between each RLAN and potentially affected FS links.
- A time-sensitive, statistical approach is appropriate because RLAN traffic is bursty.
  - Probabilistic modeling accurately reflects real-world conditions.
  - Differs from coordination between high duty-cycle FS systems, where minimum coupling loss is key with no reference to time domain.
- The FCC's TAC recommends statistical analysis for "thorough interference assessment."*
  - Worst-case analysis useful "to determine consequences of harmful interference."

*ET Docket 17-340 Public Notice, December 2017, at 3

RKF used appropriate techniques and models

- 10 simulations on 91,187 FS links, representing 911,870 different RLAN-to-FS morphologies in CONUS.
  - All RLANs operating within 150 km of the receiver were considered.
- From a single simulation RKF identified 165 worst-case links where I/N exceeded -6 dB, then subjected these worst cases to an additional 1,000 random RLAN drops (representing another 165,000 RLAN-to-FS morphologies).
  - Link availability measured at five 9s or six 9s continued to meet those standards.
- RKF properly used ITU-R Rec. P.530 to calculate link unavailability.
  - The Barnett-Vigants (B-V) model is over 40 years old, whereas P.530 is revised every few years to reflect latest research on fading and propagation
  - The B-V model urged by FWCC "overestimates worst month unavailability for link length greater than 25 km."*
  - "A major drawback of B-V model is the choice of C factor which is somewhat subjective. ITU-R P. 530 model is more appropriate to design detailed links."*
  - B-V's use of a single generic "C factor" makes the model less precise than P.530, which replaces C factor with parameters for link inclination, antenna altitude, and specific geoclimatic factors.

*Agba, Morin & Bergeron, "Comparison of Microwave Links Prediction Method: Barnett-Vigants vs. ITU Models."

RKF conservatively addressed multipath fading

- Assuming that multipath fade and interference occur randomly includes the possibility that they occur at the same time.
  - Multipath fading most often occurs after midnight when RLAN activity is low.
    - FWCC's expert confirms this in a paper he submitted to TIA TR45.*
    - NTIA report referenced by RKF states that FS system multipath usually occurs after midnight and this multipath fade margin can be used to reduce IPC between 8:00 am and midnight.**
- RKF's study *did not* apply unused multipath fade margin, which would have reduced a link's susceptibility to interference.

*Kizer, George, "Abnormal Propagation," submitted to TIA TR45 Working Group on Microwave Systems, Doc. No. TR45.WGMS-170112-377 at 11 ("Flat multipath fading usually occurs daily between midnight and 9 AM during the summer and early fall."); *id*. at 12 ("When the transmission path is near the central part of a large, high-pressure cell (inside the central isobar on the weather map) and clear skies are predicted, expect heavier than usual fading during the period from shortly before sunset to an hour or so after sunrise. This rule applies primarily to the slow-moving weather systems in the warmer months. The air near the surface should be relative moist and winds light (less than 6 knots) or calm.").

**See RKG report, Section 3.2.5.2 and fn. 22.

RKF used appropriate models for loss and clutter

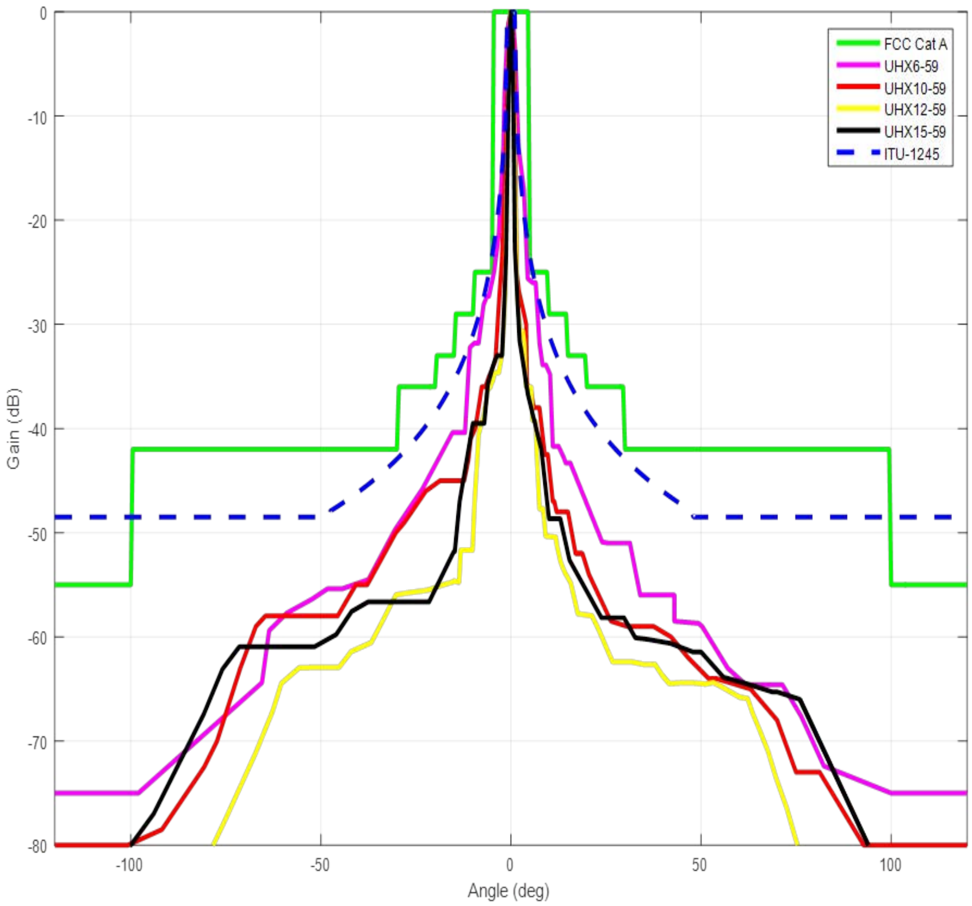
- WINNER II Model
  - Developed empirically from large number of measurements; stochastic across wide variety of parameters.
  - Urban and suburban NLOS models match widely accepted COST-Hata at 2 GHz.
  - RKF used WINNER II for only a fraction of scenarios.
    - E.g., Used more conservative ITM, STRM and P.2108 models for distances >1 km, even though WINNER II is valid to 5 km.
  - RKF did take base station and terminal heights into account.
    - Assumed LOS for transmitters >10m.
  - FWCC confuses RKF's propagation model comparison chart with actual implementation.
- Clutter Model
  - FWCC assumes free space and ignores that clutter dramatically reduces interference.
  - AT&T's recommendation of 3GPP 3D Uma is not appropriate.
    - Covers only part of the 6 GHz band.
    - Requires street widths and building heights, which is not realistic for nationwide study.

RKF’s antenna patterns and FS modeling are conservative

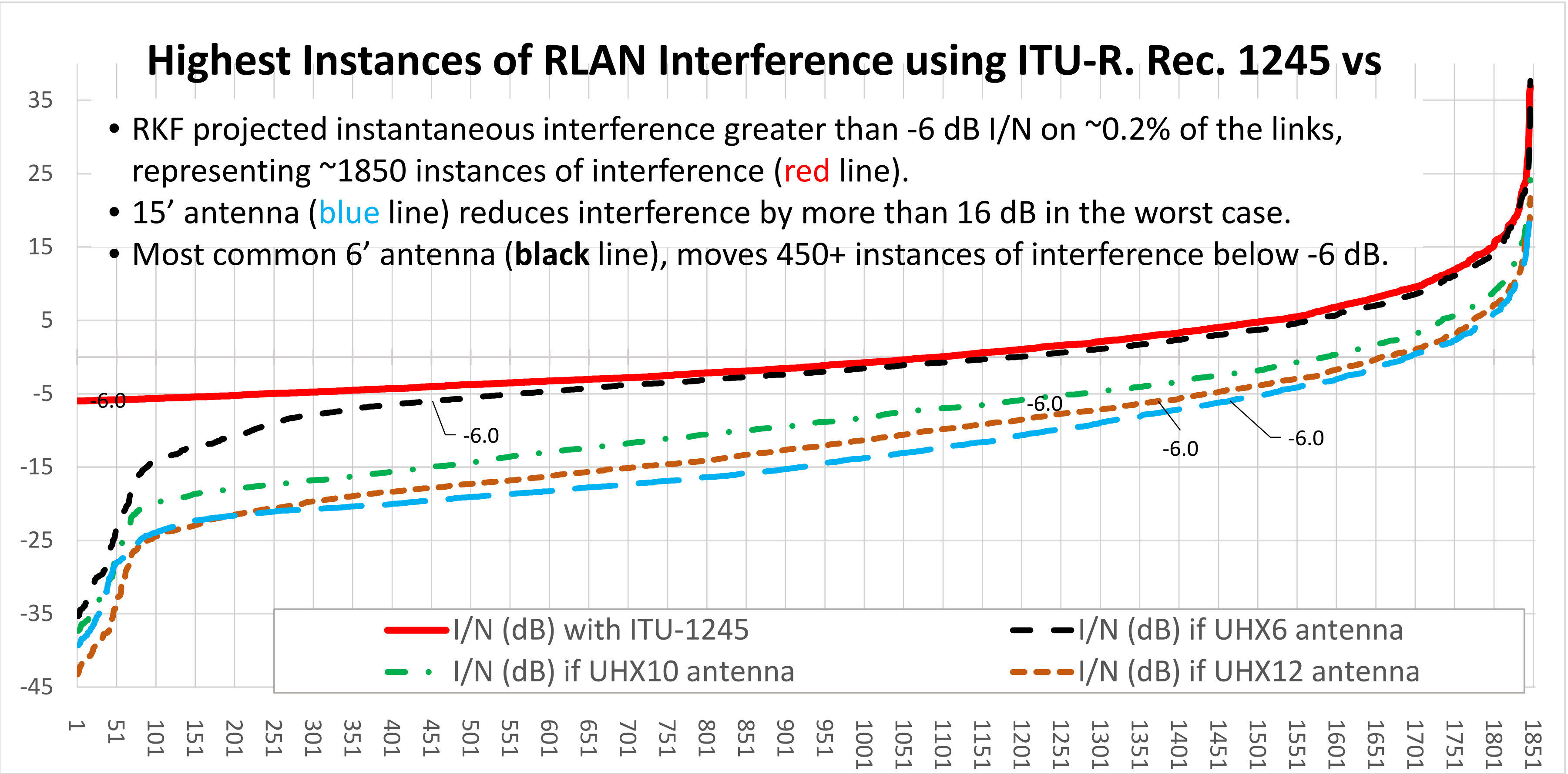
- RKF used the ITU-R 1245 pattern, and the antenna gains listed in ULS, which overestimates interference.
- Replacing the ITU-R 1245 pattern with real-world antenna patterns as suggested by FWCC (keeping gain the same) *reduces* the probability of interference.*

*FCC catA is an envelope pattern similar to ITU-R P.699, not appropriate for statistical interference analyses.

Antenna Pattern	Interferers w/ 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%



Using UHX antenna patterns as FWCC recommends *reduces* projected interference



RKF's traffic assumptions are conservative

- RKF's calculations for assumed unlicensed use of 6 GHz:
  - 240 GB/person-month during 4 busy hours.
  - 32% of traffic occurs during the busy hours.
  - Therefore, 750 GB/person-month.
  - 90% of projected 2025 U.S. population (i.e., 312.3m people) use 6 GHz band.
  - 750 GB/month X 312,300,000 = **234,225 PB/month**.
- Starting with Cisco's VNI 2021 North American traffic forecast and assuming continued 20% growth suggests 112,865 PB/mo for wireless in 2025.
  - RKF's assumption for U.S.-only unlicensed traffic is 2X this assumption for *licensed & unlicensed* wireless across *all of North America.*

FWCC's simulation fatally ignores channel assignment and duty cycle

- FWCC places all RLANs co-channel instead of spreading across 59 channels.
  - RKF realistically distributed RLANs across 1,200 MHz.

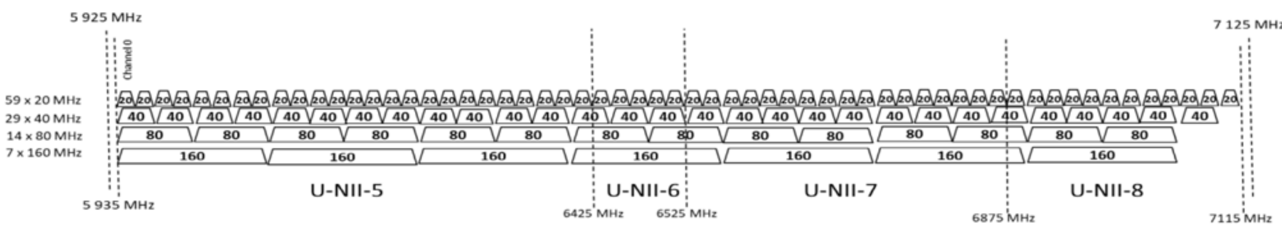


Figure 3-10 - Proposed RLAN Channel Plan

- FWCC assigns a duty cycle of 100% to every outdoor RLAN.
  - Applying RKF's realistic 0.44% duty cycle, only 13.2 of the 3,000 outdoor RLANs dropped by FWCC should have been transmitting at any given time.
- Correcting these errors yields 0.0011 instantaneously transmitting, co-channel RLANs per km2, instead of the 15 RLANs/ km2 FWCC assumed.

FWCC greatly overstates the EIRP of outdoor RLANs

- FWCC assumes that every outdoor RLAN will be operating at or near the 35 dBm max power permitted in 5 GHz band.
  - Relatively few devices operate at maximum power.
  - FWCC itself acknowledges clients @ 19dBm and low-power outdoor APs @ 24dBm.
- RKF properly used an EIRP distribution.
  - RKF's weighted average is 22.73 dBm, which is 4dB higher than U.S. submitted to ITU-R.*
  - RKF's method of isotropic antenna with EIRP distribution also is used by NTIA, the ECC, and WP5A.

		Weighted EIRP Distribution (mW)							
Outdoor Use Case	**Weight**	**4000**	**1000**	**250**	**100**	**50**	**13**	**1**	**Total**
High Power AP	20%	2.83%	1.77%	6.04%	4.21%	3.55%	1.44%	0.17%	20.00%
Low Power AP	30%	0.00%	0.25%	3.41%	1.33%	5.73%	16.87%	2.41%	30.00%
Client	50%	0.00%	0.00%	0.00%	3.46%	22.85%	23.68%	0.00%	50.00%
Sub-Total	**100.00%**	**2.83%**	**2.02%**	**9.45%**	**9.00%**	**32.13%**	**41.99%**	**2.58%**	**100%**

Table 3-8 - Outdoor RLAN Source EIRP Distribution (mW)

- Because it ignores power distribution, the FWCC study is not a true Monte Carlo simulation.

*USJTG-05/04r3, *Sharing analyses between maritime radars and RLAN systems at 5350-5470 MHz* (Jan. 2013) (proposing a weighted average EIRP of 18.73dBm for outdoor RLAN population of 5%).

FWCC overstates PSD at FS receivers

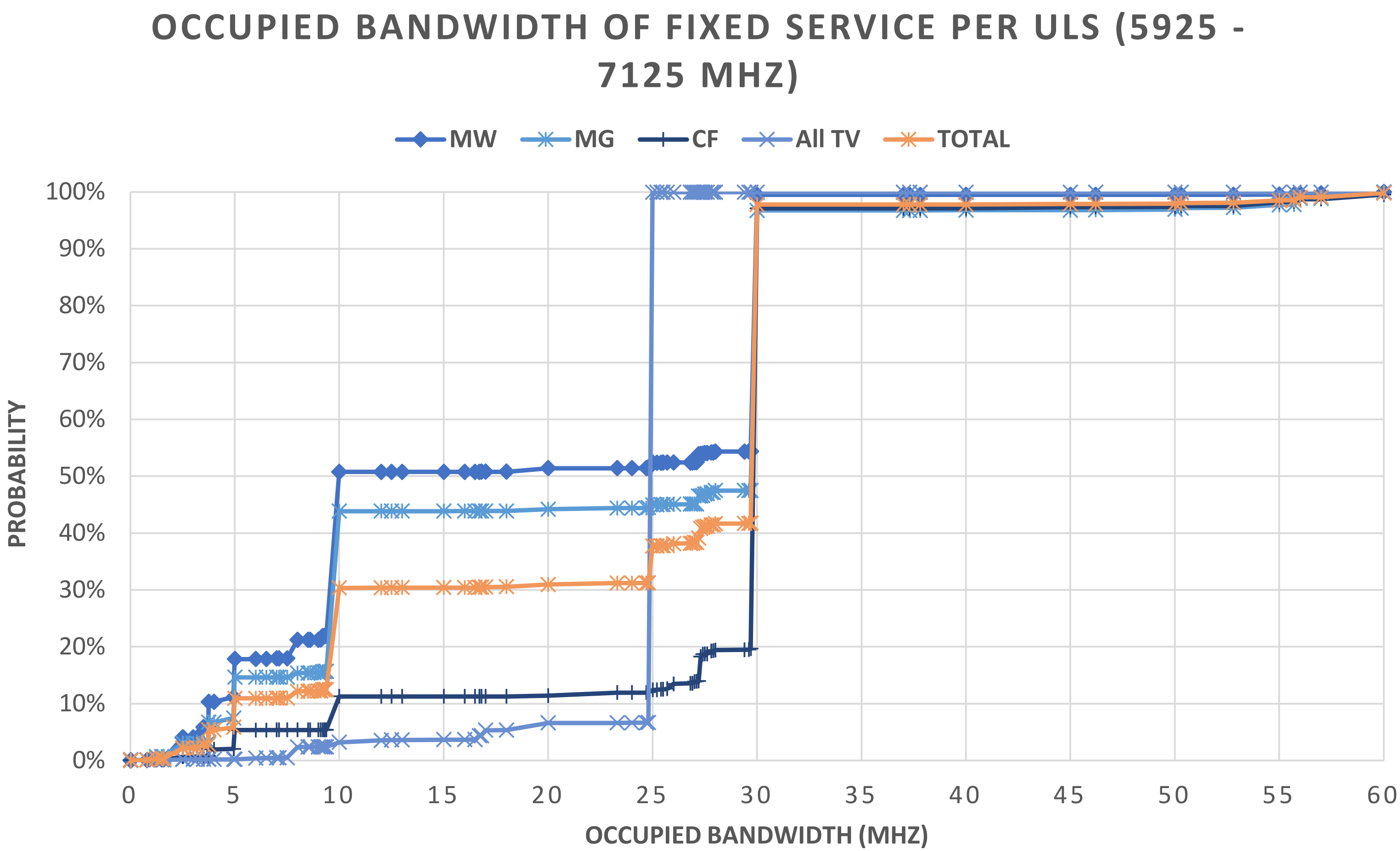
- FWCC assumes 100% of RLAN channels are 20 MHz.
  - Consistent with U.S. & ITU studies, RKF assumed 10% are 20 MHz.

Bandwidth	20 MHz	40 MHz	80 MHz	160 MHz
Percentage	10%	10%	50%	30%

Table 3-9 - RLAN Bandwidth Distribution

- FWCC uses worst-case FS bandwidth and fails to account for partial RLAN overlap.
  - Smaller FS channelizations of 400 KHz – 10 MHz are >30% of population
    - >41% of all 6 GHz FS links are less than 30 MHz.
    - 50.7% of MW Service FS links are 10MHz or less.
- RKF properly used randomized RLAN bandwidths and actual bandwidth and gain for each FS receiver.

Narrow FS channelizations are common



Mitigation can be addressed through an NPRM

- In the rare cases when main-beam RLAN operation occurs, link design and attenuation generally will render it inconsequential to FS.
- If the FCC nevertheless determines that mitigation is appropriate for outdoor RLANs in the main beam, solutions are available.
    - Coordination is relatively straightforward.
        - Outdoor RLANs that potentially interfere have a clear view of FS and likely can get a clean GPS fix.
    - The RLAN industry has advanced several ideas in NOI comments.
    - An NPRM is the right venue to address this issue.

Conclusion

- Main-beam RLAN operations will be very rare.
- Few of these rare instances actually will create *harmful* interference.
- If mitigation is needed to address these extraordinary instances, a range of options exist.
- The FCC has the record it needs to move to an NPRM, where it can decide on the need for mitigation rules.