

Deploying Unlicensed 6 GHz RLANs While Protecting the Fixed Service

George Kizer

Former President, National Spectrum Management Association
georgekizer@gmail.com



In the United States



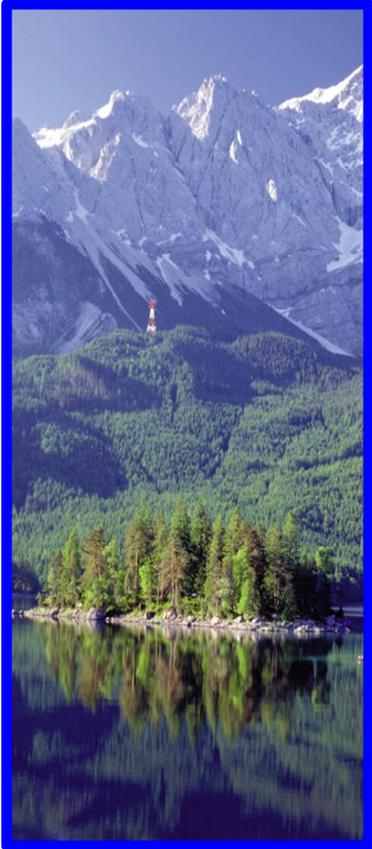
1934 – The Federal Communications Commission (FCC) was formed to regulate commercial spectrum

1978 – The National Telecommunications and Information Administration (NTIA) was formed to regulate federal spectrum

Both agencies adopted the Table of Allocations frequency allocation approach (divide the spectrum into segments and assign services to those segments)



The Table of Allocations Approach



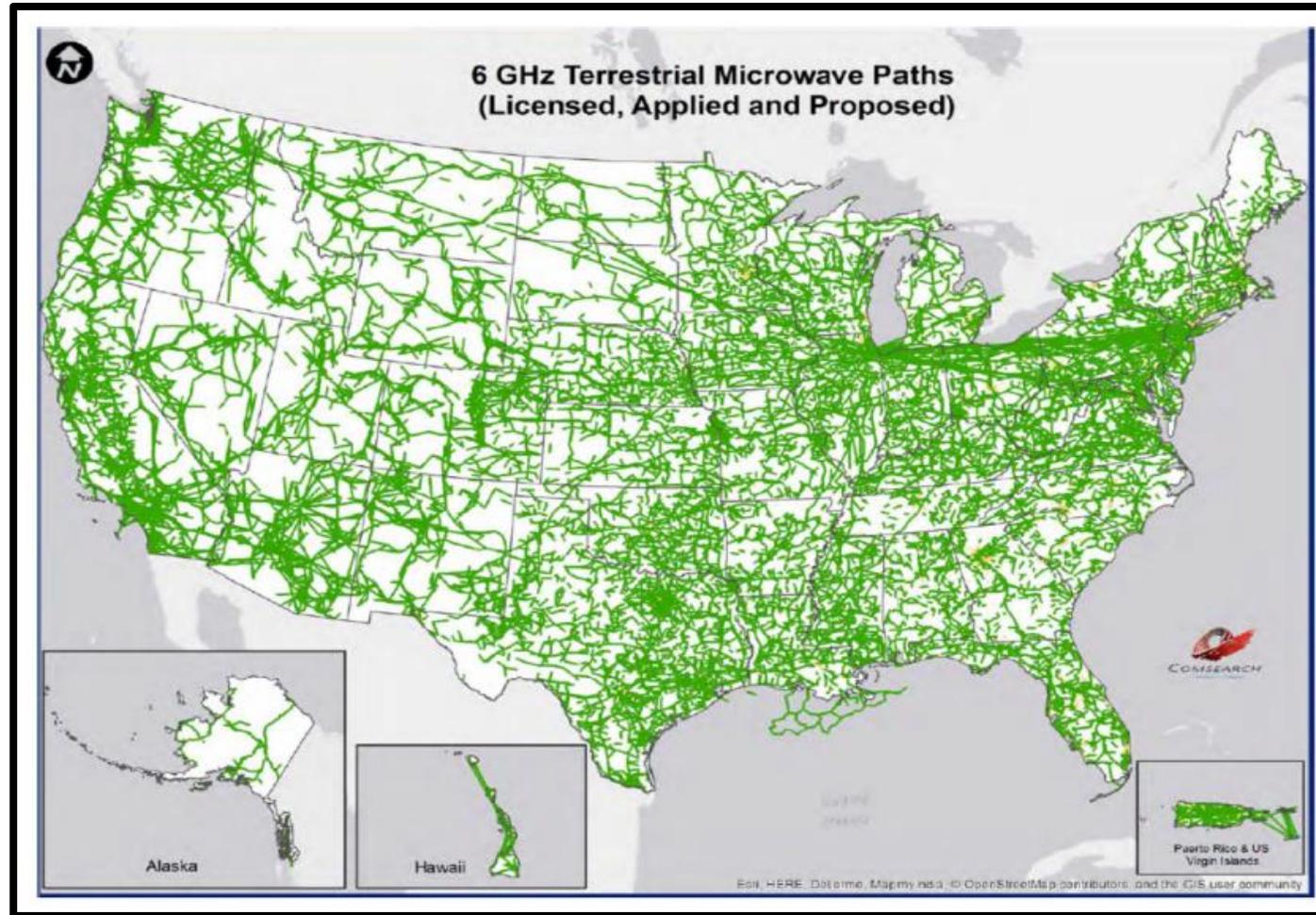
The basic idea is each band allocation is assigned to compatible services

The good news is this is administratively efficient

The bad news is spectrum usage density varies widely from allocation to allocation and therefore is not particularly spectrally efficient

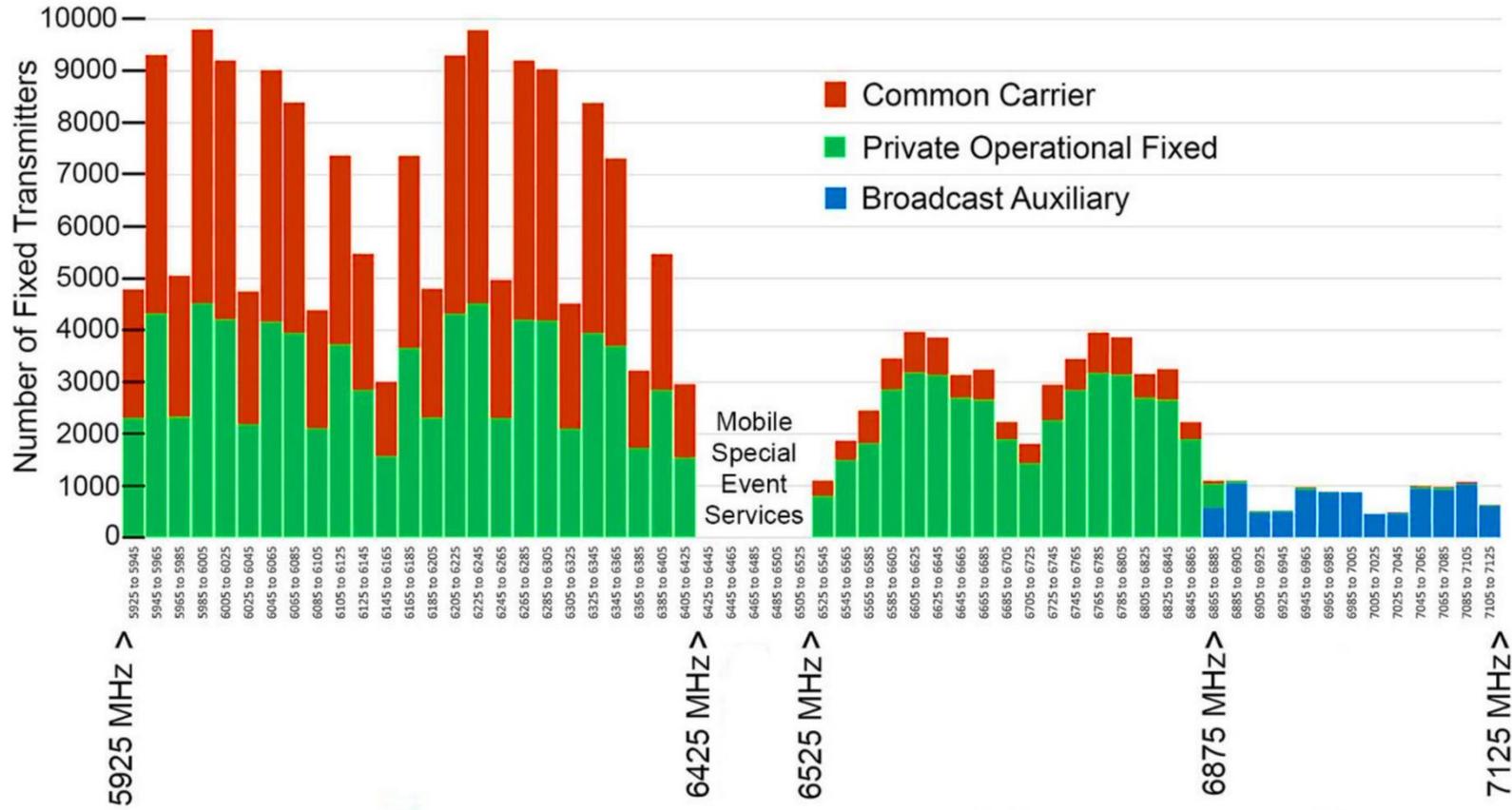


6GHz Networks Nationwide



Source: Comsearch as cited by AT&T, March 16, 2018, ET Docket 18-295 & GN Docket 17-183

Current Frequency Allocations at 6 GHz



66,324 Transmitters 30,280 Transmitters 5,051 Transmitters
Existing Fixed Co-channel Transmitters and Proposed Allocations per 20 MHz

data and graph provided by Comsearch

Political Pressure to Increase Spectrum Utilization

President Trump's Press Release, October 25, 2018

Subject: Developing a Sustainable Spectrum Strategy for America's Future

H.R. 4986: Ray Baum's Act of 2018

Especially section entitled "Making Opportunities for Broadband Investment and Limiting Excessive and Needless Obstacles to Wireless Act", also known as the "MOBILE NOW" Act.

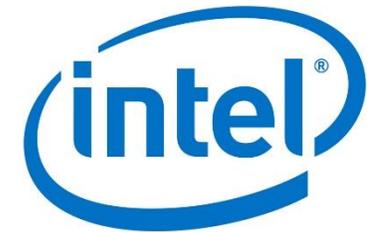
Statement of Chairman Pai, October 24, 2018

Especially "We look forward to ... acting quickly to make more 6 GHz spectrum available for unlicensed uses."

A Modest Proposal



In synchronization with current political thought, on January 25, 2018, Broadcom, Cisco, Facebook, Google, Hewlett Packard Enterprise, Intel, MediaTek, Microsoft and Qualcomm presented a proposal (based upon a study* by RKF Engineering Services) to the FCC proposing the introduction of unlicensed Radio LANs (RLANs) into the 6 GHz bands.



* Paul Margie, Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz, GN Docket No. 17-183, Harris, Wiltshire & Grannis, January 26, 2018, <[https://ecfsapi.fcc.gov/file/101261169015803/6%20GHz%20Ex%20Parte%20\(Bureaus\).pdf](https://ecfsapi.fcc.gov/file/101261169015803/6%20GHz%20Ex%20Parte%20(Bureaus).pdf) >

The RLAN Proposal

The RLAN group proposed 958,062,017 (\approx one billion) unlicensed devices spread across the United States in urban, suburban and rural areas by 2025.

Channel bandwidths ranged from 20 MHz to 160 MHz. Since only one channel was used, the modulation was assumed to be Time Domain Duplex (TDD) instead of Frequency Division Duplex (FDD) typically used by the fixed point to point service (FS).

The FCC Speaks



On October 24th, 2018, the FCC released a Notice of Proposed Rulemaking (NPRM), Unlicensed Use of the 6 GHz Band, ET Docket No. 18-295, GN Docket No. 17-183, <<https://docs.fcc.gov/public/attachments/FCC-18-147A1.pdf>>

On April 24th, 2020, the FCC released a [Report and Order \(R&O\)](#) and Further Notice of Proposed Rulemaking (FNPRM), Unlicensed Use of the 6 GHz Band, ET Docket No. 18-295, GN Docket No. 17-183, <<https://docs.fcc.gov/public/attachments/FCC-20-51A1.pdf>>

New 6 GHz Rules

- ❑ The FCC released their **Report and Order (R&O)** and Further Notice of Proposed Rule Making (FNPRM) on April 23rd.
- ❑ Unlicensed is authorized across the entire band of 5925-7125 MHz
- ❑ **Standard power** authorized for **indoor or outdoor use** under the control of an Automatic Frequency Coordination (AFC) system.
- ❑ **Low power indoor** and very low power devices are authorized with no AFC required.
- ❑ **Access Point:** The access point is the local network's access to the Internet. It can be either a standard power (indoors or outdoors) or low power (indoor access point). Similar function to today's Wi-Fi wireless router.
- ❑ **Client Devices:** Client devices can operate only under the control of an access point. Client to Client communication is prohibited.
- ❑ **AFC Operators:** The FCC's Office of Engineering and Technology will be charged with designating AFC operators and overseeing their operations.
- ❑ Supports formation of an industry-led **multi-stakeholder group** to further study technical and operational issues in the 6 GHz band such as resolving interference concerns.
- ❑ Supports industry testing
- ❑ FNPRM requests **comments** regarding increasing power of indoor devices and allowing very low power devices to be used outdoors without an AFC.
- ❑ **Fixed microwave retains its primary status.** Existing and new Fixed services systems have no coordination requirements towards unlicensed, and unlicensed services cannot cause interference to fixed services.

The Commission Created New Unlicensed Bands

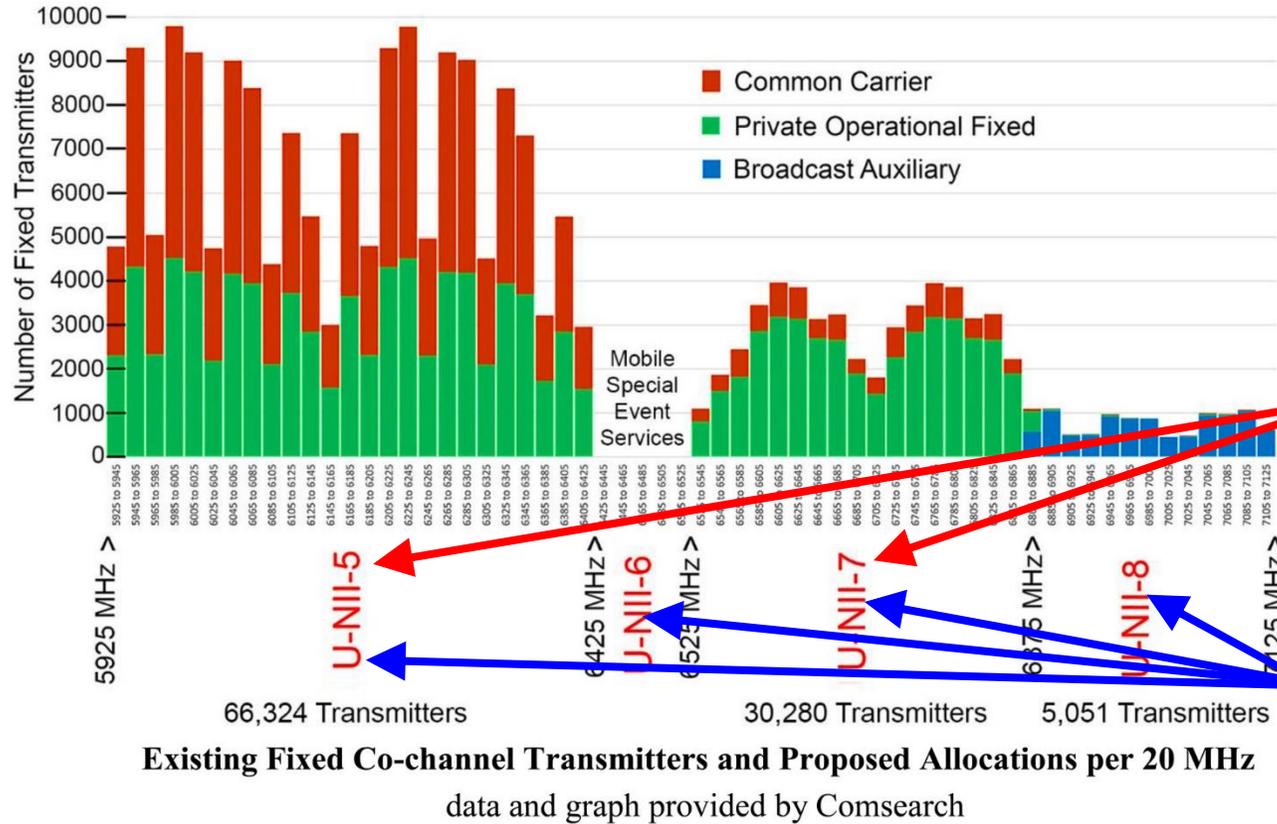
Currently the following unlicensed bands are **defined** (FCC Rules, Part 15):

U-NII-1:	5.150–5.250 GHz
U-NII-2A:	5.250–5.350 GHz
U-NII-2B:	5.350–5.470 GHz
U-NII-2C:	5.470–5.725 GHz
U-NII-3:	5.725–5.850 GHz
U-NII-4:	5.850–5.925 GHz

The NPRM and R&O introduce the following **new unlicensed bands**

U-NII-5:	5.925–6.425 GHz
U-NII-6:	6.425–6.525 GHz
U-NII-7:	6.525–6.875 GHz
U-NII-8:	6.875–7.125 GHz

New Services



An Automated Frequency Coordination (AFC) function is proposed for all outdoor devices.

Standard Power Outdoor Access Points and Clients can operate only on frequencies in the U-NII- 5 and -7 bands determined by an AFC.

Low-Power Indoor Access Points and Clients can operate on any frequency in the 6 GHz band without AFC.

Expected Types of Unlicensed RLANs

Expected Limiting Case: 98% Indoor and 2% Outdoor

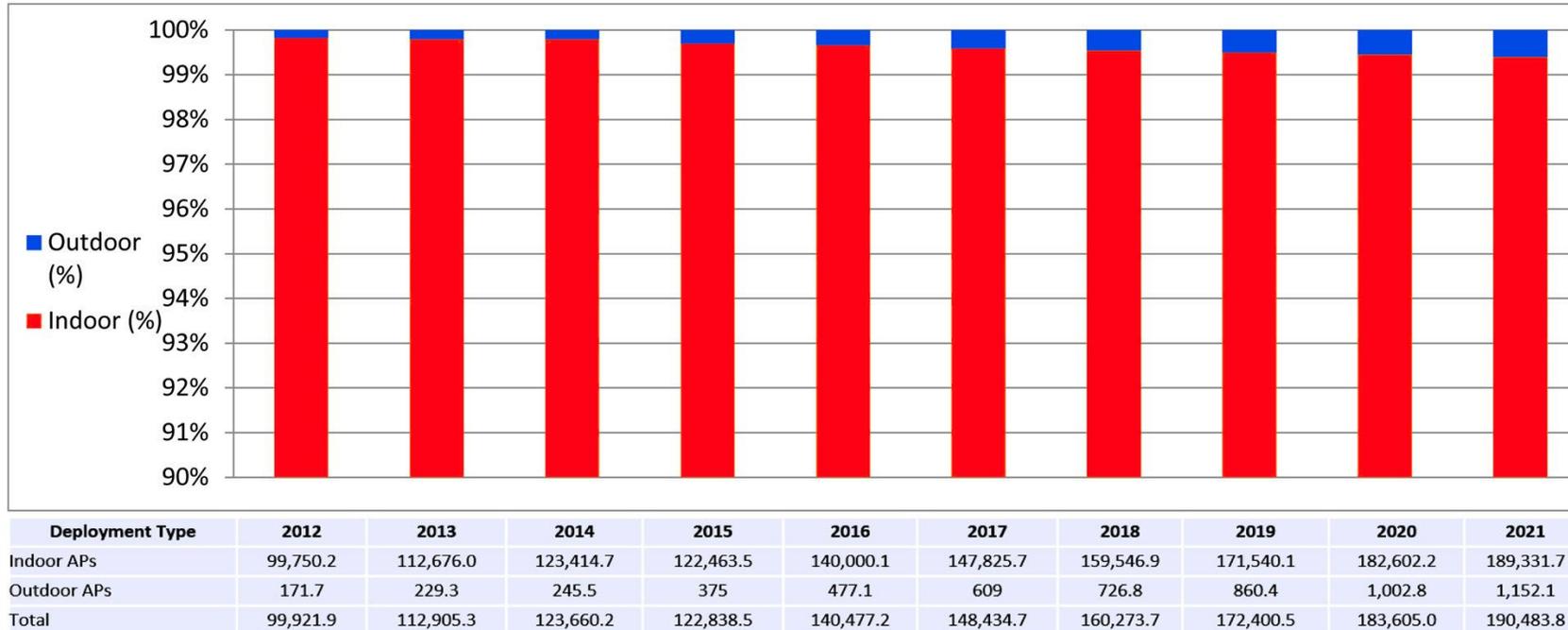
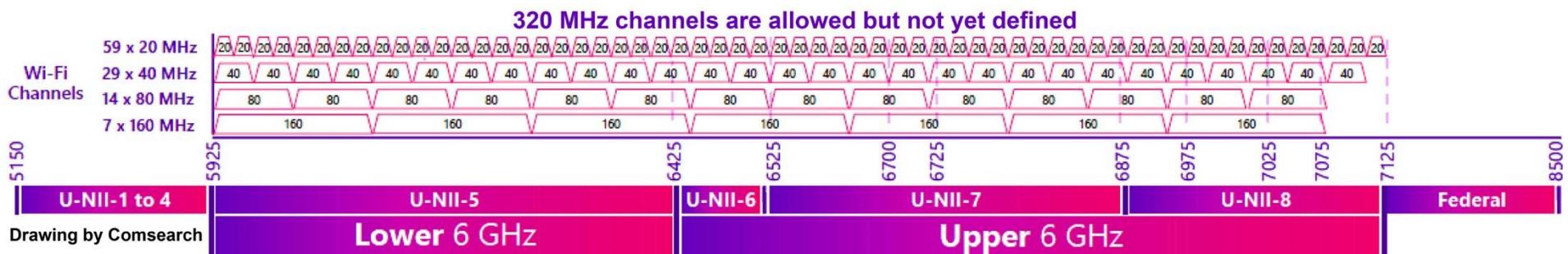


Figure 3-2 – Worldwide Indoor vs Outdoor Wi-Fi Shipments.

Source: Paul Margie, *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz*, GN Docket No. 17-183, Harris, Wiltshire & Grannis, January 26, 2018, page 14.

Expected RLAN Maximum Transmit Powers



Unlicensed Low Power Indoor RLAN Maximum Transmit Powers

RLAN Transmit Bandwidth (MHz)	20	40	80	160	320
Indoor Access Point EIRP (dBm)	18.0	21.0	24.0	27.0	30.0
Indoor Client Device EIRP (dBm)	12.0	15.0	18.0	21.0	24.0
Maximum Transmit Power into 30 MHz Channel					
RLAN Transmit Bandwidth (MHz)	20	40	80	160	320
Indoor Access Point EIRP (dBm)	18.0	19.8	19.8	19.8	19.7
Indoor Client Device EIRP (dBm)	12.0	13.8	13.8	13.8	13.7

Unlicensed Standard Power Indoor/Outdoor RLAN Maximum Transmit Powers

RLAN Transmit Bandwidth (MHz)	20	40	80	160	320
Indoor/Outdoor Access Point EIRP (dBm)	36.0	36.0	36.0	36.0	36.0
Fixed Indoor/Outdoor Client Device EIRP (dBm)	36.0	36.0	36.0	36.0	36.0
Mobile Indoor/Outdoor Client Device EIRP (dBm)	30.0	30.0	30.0	30.0	30.0
Maximum Transmit Power into 30 MHz Channel					
RLAN Transmit Bandwidth (MHz)	20	40	80	160	320
Indoor/Outdoor Access Point EIRP (dBm)	36.0	34.8	31.7	28.7	25.7
Fixed Indoor/Outdoor Client Device EIRP (dBm)	36.0	34.8	31.7	28.7	25.7
Mobile Indoor/Outdoor Client Device EIRP (dBm)	30.0	28.8	25.7	22.7	19.7

Transmit Power Activity Factor

Today RLANs use one channel and Time Division Duplex (TDD) for data transmission in a point to multipoint architecture. An Access Point is the center of the architecture with Client devices communicating with the Access Point.

The Access Point and Client take turns transmitting on the communications channel.

The average transmit power for each device is less than maximum transmit power.

The difference between maximum power and average power is termed Activity Factor (or Duty Cycle).

The FCC quotes results from a CableLabs simulation report*:

Activity Factor $\leq 7\%$ for 99% of 500,000 RLANs

Activity Factor $\leq 2\%$ for 95% of 500,000 RLANs

Activity Factor $\leq 1\%$ for 90% of 500,000 RLANs

Activity Factor $\leq 0.4\%$ for 50% of 500,000 RLANs

In the UK, the Activity Factor is generally taken as 1.97%**.

The reduction in effective transmit power would be $10 \log_{10}(\text{Activity Factor}/100)$.

The FCC is of the opinion that effective transmit power should be used for interference estimates rather than peak (maximum) transmit power.

Peak interference would “punch holes” in transported data but receivers would probably remain working.

RLANs broadcast “beacons” at full power ten times a seconds regardless of transmission activity.

The effect on networks of infrequent transmission peaks is not yet clear.

The effect of RLAN Activity Factor on Fixed Service operation is unknown

* 20191218_6GHz_InterferenceSimulation_final (CableLabs, Dec 18 2020).pdf

** Ofcom Report: *Improving Spectrum Access for Wi-Fi / Spectrum Use in the 5 and 6 GHz Bands*, 2020, Table A7.6, page 53 and Electronic Communication Committee (ECC of CEPT), *Sharing and compatibility studies related to Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) in the frequency band 5925-6425 MHz*, May 2019, Table 13, page 23.

Transmit Power Activity Factor

Time Division Duplex (TDD) transmission uses a single channel to communicate both directions on a duplex path.

Due to the periodic need to stop transmitting one direction to allow transmission the other direction, TDD typically experiences transmission latency of several milliseconds.

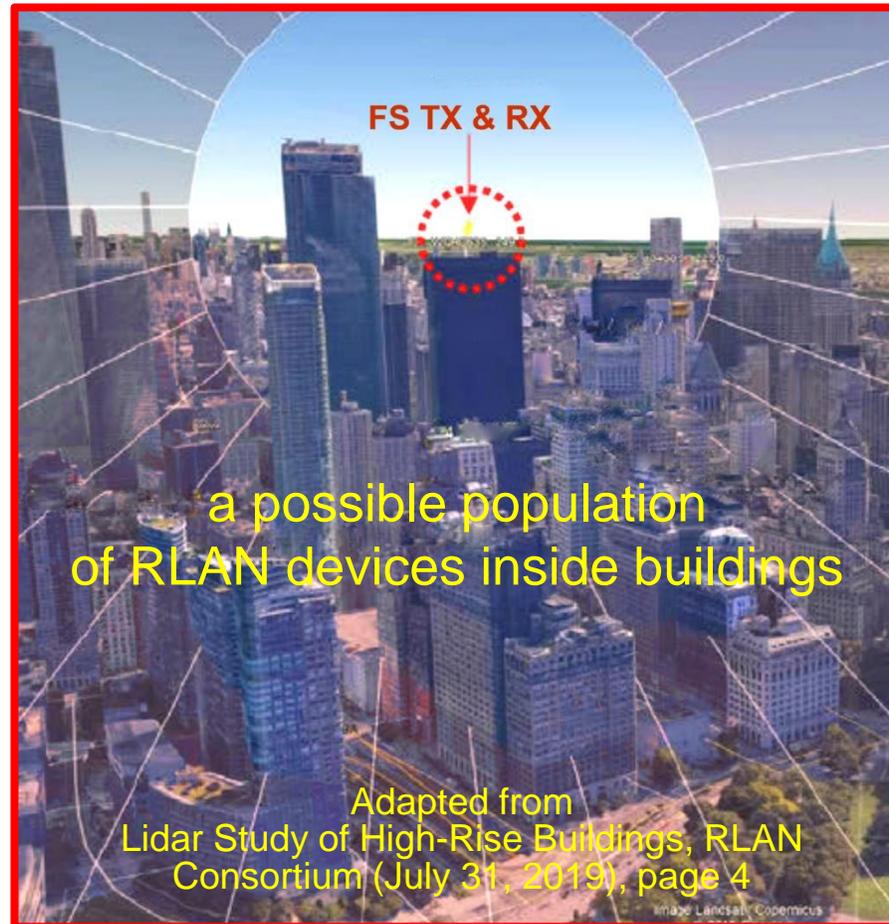
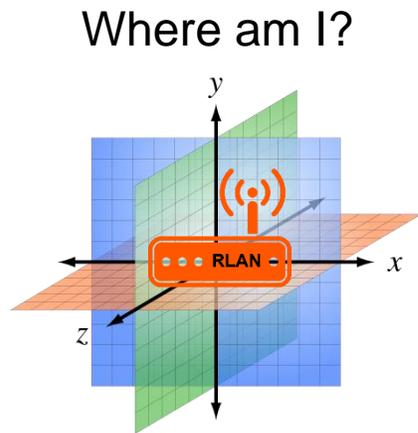
When RLANs are introduced to 6 GHz, the multiple wide bandwidth channels will allow the RLANs to use Frequency Division Duplex (FDD) transmission.

In this case, transmission each direction is accomplished using a different channel and latency could be reduced to the microsecond range (a goal of 5G and augmented/virtual reality environments).

Of course, Transmission Activity Factor will be essentially 100% and average interference will be on the order of 20 dB worse than for TDD systems.

In the future, Activity Factor may not be a factor.

Unmanaged Indoor RLANs



BEL varies from 2 to > 40 dB

Old or new construction
significantly different

Reflections, resonances and
window and wall composition
variation significant

Loading docks, covered
balconies, picture window
conference rooms and corner
offices of concern

BEL can be measured
Contact Rich Lee, iPosi
303.475.2493, rlee@iposi.com

Building Entry Loss (BEL) will vary widely – as will potential interference

RLAN physical location significantly affects interference

National Spectrum Management Association

AFC Managed Outdoor RLANs

The Automatic Frequency Coordination (AFC) process is a misnomer. No coordination is offered.

The process is actually Automatic Frequency Assignment (AFA). The license holder does not get a vote in the process.

Propagation loss between RLAN transmitter and Fixed Service receiver must be calculated using WINNER II and ITM propagation models using 1 arc-second digital terrain data and clutter from ITU-R P.452-16 and ITU-R P.2108-0. If building and terrain data is not available, a probabilistic model must be used.

The interference protection criteria is -6 dB I/N but how I is calculated is not defined. The FCC believes Activity Factor must be considered.

Fixed Service radio characteristics are taken from the FCC's Universal Licensing System (ULS) database.

Presumably the AFC will be funded by the RLAN operators.

Will the AFC do the appropriate thing from the Fixed Service perspective?

Interference Mitigation



Interference Mitigation

Unexpected circumstances are inevitable. RLAN transmitters will be numerous and typically invisible. How will you find the interfering one?

How many AFC systems will have to be queried to determine who controls the interfering transmitter?

Will **Interference Bounty Hunter** become a new job description?



As a Fixed Service Operator, What Should You Do?



- Verify and/or update your microwave paths data in the FCC's ULS database
- Perform a risk analysis of your 6 GHz paths using realistic path parameters
- Monitor your paths' data performance and be prepared to take action if interference occurs



Work with Your Frequency Coordinator to Verify Your ULS data

Comsearch

Laura Fontaine, 703.772.4090, lfontain@comsearch.com

Micronet

Brad Youngblood, 972.422.7200 x105, brad@micronetcom.com

Radyn

Thu Nguyen, 301.728.2813, thu@radyn.com

Wireless Applications Corporation

Arman Kolukcija, 425.643.5000, Arman.Kolukcija@wacorp.net

Perform a Risk Assessment of Your Network



What is the probability of your paths being degraded if RLANs were deployed in office or residential buildings?

Be Prepared

Monitor path performance and be prepared to take action.

Monitor the availability of your radio paths and **establish a baseline**.

Received Signal Level (RSL) history will not tell the story.

Historical Severely Errored Seconds or Frame Loss Seconds will tell the tale.

More Severely Errored Seconds one direction than another is indicative of an interference case.

For Adaptive Coded Modulation (ACM) radios, modulation state switching without corresponding receive signal level changes is also indicative of interference.

Consider taking the path out of service and running a standard fade margin test or a spectrum analyzer sweep of the channel during periods of suspected interference.

If necessary, consider periodically flying a spectrum analyzer along a suspect path
(RadioSiteTest.com, Tom Brinkoetter, 408.592.3759, tom.brinkoetter@radiositetest.com)
<<https://www.youtube.com/watch?v=VdZLCFSMiYM>>

Take Action

Monitor path performance and **be prepared to take action.**

Attempt to resolve your issues locally. If that does not work, involve the FCC Enforcement Bureau's Spectrum Enforcement Division.

Get your facts together:

The call sign and address of the station experiencing the interference;

The telephone number of a contact person for the station;

The frequency on which the complaining station operates;

A detailed description of the nature of the interference, including the duration and frequency of the occurrence of interference;

The owner and contact information for the source of the alleged interference;

The frequency on which the alleged interfering facility operates;

The provision of the Commission rule believed to have been violated by the alleged source of the interference (§15.5 (b) Operation of an intentional, unintentional, or incidental radiator is subject to the conditions that no harmful interference is caused and §15.3 (m) Harmful interference. Any emission, radiation or induction that endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunications service operating in accordance with this chapter.)

Any documentation supporting the alleged existence and cause of the interference.

John Schauble, Deputy Chief, Broadband Division, Wireless Telecommunications Bureau, recommends you submit interference complaints through the FCC Enforcement Bureau's online portal: <https://fccprod.servicenowservices.com/psix-esix>.

It has separate paths for public safety, enterprise licensees (most commercial licensees), and consumer complaints.

John (202.418.0797, john.schauble@fcc.gov) also would appreciate a heads up if you become aware of a complaint being filed.

His engineers are interested in tracking any problems if they occur.

Take Action

You may need to follow-up with FCC management

Key Headquarters Personnel

Elizabeth Mumaw, (202.418.1381, elizabeth.mumaw@fcc.gov), Chief
JoAnn Lucanik, (202.418.0873, joann.lucanik@fcc.gov), Deputy Chief
Ricardo Durham, (202.418.1154, ricardo.durham@fcc.gov), Deputy Chief

Regional and Field Offices

Region One covers Connecticut, District of Columbia, Delaware, Iowa, Illinois, Indiana, Massachusetts, Maryland, Maine, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Virginia, Vermont, Wisconsin, and West Virginia.

Region One Field Offices: Boston 617.786.7746, Chicago 847.813.4672, Columbia (MD) 301.725.1996, Detroit 248.471.5661, Kansas City (MO) 816.316.1248, New York 212.337.1865, Norfolk 757.546.0896 and Philadelphia 215.741.3016

David Dombrowski, (215.880.1161, david.dombrowski@fcc.gov), is Regional Director.

Region Two covers Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Puerto Rico, Tennessee, Texas, and the Virgin Islands.

Region Two Field Offices: Atlanta 770.935.3370, Dallas 214.575.6361, Houston 713.983.6096, New Orleans 504.219.8999, San Juan 787.766.5568 and Tampa 813.348.1602

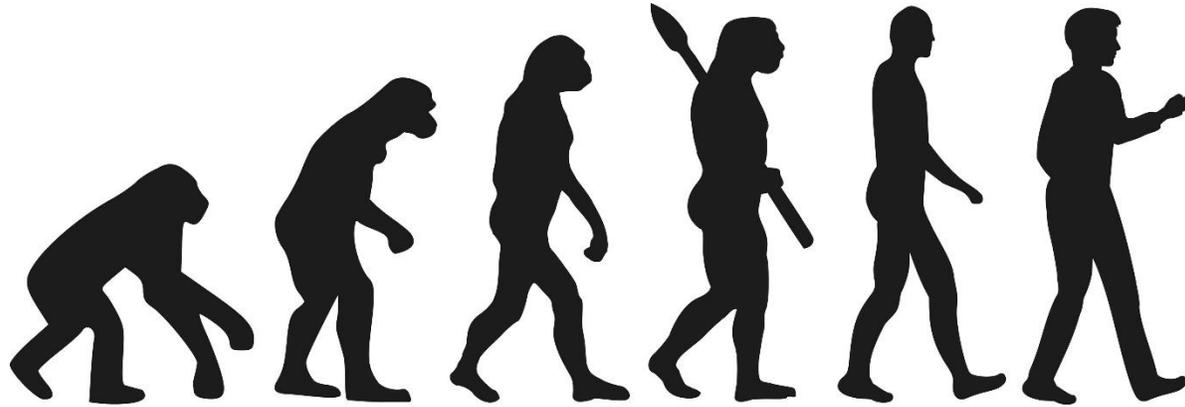
Ronald Ramage, (678.293.3194, ronald.ramage@fcc.gov), is Regional Director.

Region Three covers Alaska, American Samoa, Arizona, California, Colorado, Guam, Hawaii, Idaho, Kansas, Montana, North Dakota, Nebraska, New Mexico, Nevada, Oregon, South Dakota, Utah, Washington, and Wyoming.

Region Three Field Offices: Anchorage 907.271.6342, Denver 303.231.5212, Honolulu 808.675.7021, Los Angeles 562.860.7474, Portland (OR) 360.696.6707, San Diego 858.496.5111, San Francisco 925.416.9717, and Seattle 425.820.6271

Lark Hadley, (562.865.0235, lark.hadley@fcc.gov), is Regional Director.

Evolution ?



Today we stand at the threshold of significant change.

If we are successful, we will make a major step in the evolution of frequency management

Let us strive to be successful!

Want to get involved in defining
the radio networks of the future?



Join us!

<https://nsma.org/>