July 11, 2022

Marlene Dortch
Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

Re: **ET Docket No. 18-295,** *Unlicensed Use of the 6 GHz Band*

Dear Ms. Dortch:

In the *Report and Order* in the above-referenced proceeding, the Commission encouraged the formation of an industry led multi-stakeholder group to study technical and operational issues for the 6 GHz band.[1/] The undersigned are the co-chairs of that multi-stakeholder group.

The multi-stakeholder group has produced and approved the attached report, which provides recommendations for best practices and procedures for interference detection, reporting, and resolution. We ask that you include this report in the record of this proceeding.

If there are any questions, please contact any of the undersigned.

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Attachment

cc: Ronald Repasi (by e-mail)

1/ *See Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd. 3852, ¶¶ 174-180 (2020).

Best Practices and Recommended Procedures for Interference Detection, Reporting, and Resolution to Protect Fixed Microwave Service Receivers in the 6 GHz Band

Version 1.0

Submitted to

the United States Federal Communications Commission

on July 11, 2022

Abstract

This Final Report is the result of a collective effort of the 6GHz Multi-stakeholder Group (MSG) consisting of industry participants chartered to provide best practices and recommended procedures for interference detection, reporting and resolution to protect fixed microwave service receivers in the 6GHz Band.

Revision History

Version #	Editor	Edit Date	Comments, Changes
0.1	Mark Poletti (CableLabs)	5-20-21	First draft, framework
0.2	Tim Godfrey, Jay Herman (EPRI)	6-1-21	Editorial cleanup and text expansion sections 4.1, 4.2, 5.1, 6.1, 7.1
0.3	Andy Scott (NCTA), Mark Poletti (CableLabs)	6-30-21	Text expansion in Section 2.1 and Annex A
0.4	Arnal Alphonso (Aviat)	6-30-21	Text expansion in section 5.1, 5.2
0.5	Doug Davies (Nokia)	7-28-21	Text expansion to sections 5.2, 5.3
0.6	Chris Szymanski (Broadcomm)	8-11-21	Editorial cleanup and text expansion to sections 2.1, 3.2
0.7	Guy Ball (APCO)	8-25-21	Text expansion in section 2.1, 4.0
0.8	Chris Szymanski (Broadcomm)	8-9-21	Addition of new section 5.0 (Characterization of RLAN Signals) and section 10 (Further Study)
0.9	WS1 Chairs	09-22-21	Consolidation and Clean Version
0.10	WS1 Chairs	09-23-21	Updates from WS1 Call 9-23
0.11	Tim Godfrey (EPRI), Jay Herman (EPRI), Chuck Lukaszewski (HPE)	11-02-21	Updates from off-line discussion on CBP in section 4.2. Also, new text to reporting section 7, and unresolved topics section 9
0.12	WS1 committee edits	11-04-21	Clean-up
0.13	WS1 Chair edits	11-15-21	Added Executive Summary, general cleanup to all sections.
0.14	David Hattey (Southern Company)	11-30-21	Expanded context in Section 10
0.15	WS1 Chairs	12-02-21	Edits from Dec 2 Call
0.16	WS1 Chairs	3-17-21	Added APCO content to section 4.1, Broadcom contribution to section 5, CableLabs/NCTA/APCO contribution to sections 7 and 8, added Annex C
0.17	WS1 Chairs	4-7-21	Accepted changes from APCO sections 6, 7, 8
0.18	WS1 Chairs	5-9-22	Accepted changes from Commscope, HPE, EEI, Southern in sections 6, 7, 8, 9, Annex C
0.19	WS1 Chairs	5-19.22	Per WS1 discussion, edits to sections 6, 8

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1 Executive Summary

This report summarizes the 6 GHz Multi-stakeholder Group (MSG) current understanding of the deployment issues faced in the 6 GHz band that includes incumbent and new unlicensed operation. The 6 GHz MSG formation was encouraged by the Federal Communications Commission (FCC) in its 6 GHz Report and Order (R&O)[1]. The 6 GHz MSG is comprised of a variety of industry participants with diverse background and views on the 6 GHz band.

The 6GHz MSG was tasked to develop best practices and recommended procedures for interference detection, reporting, and resolution to protect fixed microwave service receivers in the 6 GHz band that can be tailored to the situation of each of the incumbents. After review of the FCC R&O and related proceedings, industry standards, vendor-specific network measurement capabilities, the group was able to provide recommendations for best practices and procedures for interference detection, reporting and resolution. Finally, it is noted the 6GHz MSG was unable to address some topics, and some topics did not receive input contributions or did receive input contributions but a consensus among the 6GHz MSG could not be reached.

2 Background

2.1 Unlicensed Use In 6 GHz Band

On April 24, 2020, the Federal Communications Commission (FCC) released a Report and Order and Further Notice of Proposed Rulemaking (R&O), FCC 20-51, authorizing unlicensed use of the 5.925-7.125 GHz (6 GHz) band, with several mechanisms intended to ensure that the various incumbent users in the band are protected against harmful interference.

The rules adopted in the Report and Order authorize two types of unlicensed use in the 6 GHz band: 1) “standard-power” unlicensed operations (which include “access point” devices and associated “client” devices that connect to those access points) in specified portions of the band, where such unlicensed operations are only permitted under the control of an automated frequency coordination (AFC) system; and (2) “low-power indoor” operations (including access point devices and associated client devices) across the entire 6 GHz band.

In the Report and Order the FCC encouraged interested parties to establish an industry-led multi-stakeholder group (MSG) that could address technical and operational issues. A multi-stakeholder group convened and began meeting regularly in August 2020. The MSG is a consensus-based collection of interested industry parties and, according to its Terms of Reference, is structured to limit recommendations to best practices concerning unlicensed operations in the 6 GHz band, information for standards development organizations and, as appropriate, technical recommendations to the Commission’s Office of Engineering and Technology.

[1] *Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz, Report and Order and Further Notice of Proposed Rulemaking*, 35 FCC Rcd. 3852 (2020) (*R&O*).

The MSG considered processes for harmful interference detection, reporting and resolution. The FCC R&O in ¶71 fn.183 encouraged the formation of a multi-stakeholder group to "focus on complex technical and operational issues that provide valuable information and help promote the efficient ecosystem in the 6 GHz band." The FCC recognized in ¶174 that the group "could provide valuable insights into complex coexistence issues and provide a forum for the industry to work cooperatively towards efficient technical and operational solutions." ¶179 encouraged the development of "best practices and standards" that "will benefit all users of the 6 GHz band, both incumbents that desire additional protection and new unlicensed users that want to use the spectrum more intensely." Among the areas the FCC R&O identified for collaboration and information sharing were how to address situations in which an incumbent licensee "believes it may be experiencing harmful interference from standard-power or indoor low-power operations" or "has, or potentially has, an interference complaint." ¶176.

The FCC R&O explained in ¶84 that "[r]egardless of the processes that stakeholders may develop for addressing interference, … the Commission will be the final arbiter regarding cases of harmful interference." The FCC in 47 CFR §2.1(c) defines harmful interference as "[i]nterference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with ITU Radio Regulations." The FCC R&O applied these "criteria" to adopt rules for the 6 GHz band after "careful consideration of the incumbent services" to "ensure that unlicensed devices will not have a significant potential for causing harmful interference to the users authorized to operate in the 6 GHz band." ¶145. The AFC system "will protect incumbent fixed microwave operations from the potential of harmful interference from unlicensed standard-power operations in the U NII 5 and U NII 7 bands." ¶23. The FCC R&O specified in ¶71 an "I/N of -6 dB I/N" as the "specific interference protection criterion" for the AFC system, but explained that in doing so it was not "making a determination that any signal received with an I/N greater than -6 dB would constitute 'harmful interference.'" For indoor low-power operations, the FCC R&O adopted other restrictions and concluded that "the potential for harmful interference to incumbent services operating in the 6 GHz band is insignificant." ¶104.

2.1.1 Purpose of the Report

The purpose of this report by the 6GHz MSG is to facilitate cooperation regarding coexistence issues in the 6 GHz band so that both licensed incumbents and unlicensed users can make efficient and intensive use of the band consistent with FCC rules. It outlines a framework for coexistence activities including information sharing between incumbents and unlicensed users as well as assessing (i.e. detecting, measuring, identifying, reporting, and resolving) potential instances of harmful interference. These efforts are intended to result in a process for an environment where "industry can effectively address and resolve interference claims without necessitating involvement of the Commission's Enforcement Bureau." FCC R&O ¶176.

2.1.2 Scope of Work

The scope of work for 6 GHz MSG includes:

1) Creating a process for detecting harmful interference to licensed incumbents
    - Spectrum analyzer, Fixed Service (FS) radio, and sniffer
2) Outlining a process to measure and identify sources of harmful interference
3) Defining the characterization of U-NII device(s) signals to aid in processes above
    - Wi-Fi Channels, Wi-Fi is packet based, contains identifying information
    - Typical traffic patterns
4) Recommend a process for harmful interference reporting and for interference mitigation and resolution
5) Examine vendor equipment availability for testing

This report documents contributions by participants, takes into account the 6GHz MSG discussions, and identifies best practices available to all stakeholders. The report is considered a set of non-binding recommendations.

2.1.3 Membership

In discussing the formation of a multi-stakeholder group, the FCC indicated that, "[t]o ensure that all viewpoints are considered, we encourage stakeholders comprising all sectors of the 6 GHz ecosystem to participate, including: wireless service providers with interest in providing service through standard-power and indoor low power devices, RLAN and network equipment manufacturers, potential AFC operators, fixed service vendors and operators, existing 6 GHz band incumbent licensees, ultrawideband equipment manufacturers, academic experts, testing organizations, and other 6 GHz band stakeholders." As of July 11, 2022 there were 91 6GHz MSG participants involved in developing this document, including 6 GHz incumbents, organizations representing 6 GHz incumbents, and parties interested in deploying unlicensed services in the band. A full list of participants involved in developing this document is provided as [Annex B].

3 Approach and Report Structure

This section describes the approach followed in developing this document.

3.1 Approach

The approach consisted of:

- Discussing contributions from members on five topics outlined above in the Scope
- Creating report structure based on C-band Technical Working Group 4 5G/CBRS Coexistence (TWG4) final report
- Incorporating contributions into report structure
- The group making a concerted effort to bring the topics to conclusion by presenting detailed problem statement and a solution, when applicable.

- Criteria for consideration of topic included evaluation of technical feasibility, technical effectiveness, and deployment considerations.

The aim of the 6GHz MSG was to work towards consensus amongst members for topics the group was able to find agreement. For such topics, it was able to make recommendations for best practices and future action by stakeholders.

In cases where the group was unable to reach agreement, the topics and views presented by members are outlined in Section 9 and Annex C.

3.2 Call For Contributions

A call for contributions was made to the members at the beginning of the 6GHz MSG 's work early in August 2020 asking them to consider and address the following topics:

1) A process for detecting harmful interference to licensed incumbents
   - Review the definition of harmful Interference
   - Discuss approaches for detection
2) A process to measure and identify sources of harmful interference
   - Coordination with Fixed Service (FS) equipment vendors to define common metrics for interference measurement and assessment of impact
   - Discuss how to identify available data from FS radios and correlate to harmful interference
   - Discuss how to identify sources of interference
3) A process for harmful interference reporting and for interference mitigation and resolution
   - Define source and destination reporting
   - Define mitigation and resolution
4) Characterization of U-NII device(s) signals to aid in processes above
5) Examine vendor equipment availability for testing
   - Discuss options for device and equipment sourcing for (independent) test results, testing and analysis. Exchange of information and points of contact.

3.3 Report Structure

The report structure is based on addressing each of the scoped topics and addressing:

- Technical feasibility
- Best engineering practice

The findings, outcomes and discussions are summarized in each of the forthcoming sections. Where appropriate, each section will address a problem statement, findings, and conclusions (which may include outcomes, caveats, and discussion of alternative points of view).

4 Preventing Interference

The application of interference protection criteria for fixed microwave systems is defined under 47 C.F.R. §101.105(c). Guidelines for applying the criteria are specified in the Telecommunications Industry Association's, Telecommunications Systems Bulletin, ANSI/TIA-10, "Engineering Considerations for Fixed Point-to-Point Microwave Systems". The Commission defined the rules for 6 GHz unlicensed standard-power access points/devices under 47 C.F.R. 15.407.

The guidelines for frequency coordination among fixed microwave receivers employing digital modulation follow the procedures outlined in ANSI/TIA-10 and are based on receiver manufacturer data. For each potential case of interference, a threshold-to-interference ratio (T/I) shall be determined that would cause 1.0 dB of degradation to the static threshold of the protected receiver as defined in 47 C.F.R. §101.105, (i) (47 C.F.R. 15.407 also defines the -6 dB I/N ratio).

The guidelines for frequency coordination among fixed microwave receivers employing analog modulation follow the procedures outlined in ANSI/TIA-10. Manufacturer data or industry criteria will specify a baseband signal-to-noise requirement of the receiver that will result in acceptable signal quality for continuous operation. Following the procedures in ANSI/TIA-10 for each potential case of interference, a C/I objective shall be calculated to ensure that that this signal-to-noise ratio will not be degraded by more than 1.0 dB as defined in FCC §101.105, (ii).

Harmful interference is defined by the FCC as "[i]nterference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with ITU Radio Regulations." per 47 C.F.R. §2.1(c). The FCC adopted the "technical and operational parameters" in the R&O to "minimize the potential for harmful interference." ¶145. The R&O specified in ¶71 an "I/N of -6 dB I/N" as the "specific interference protection criterion" for the AFC system but explained that in doing so it was not "making a determination that any signal received with an I/N greater than -6 dB would constitute 'harmful interference.'" The FCC "will be the final arbiter regarding cases of harmful interference." R&O ¶84. Because the R&O does not provide an objective standard for detecting harmful interference, different stakeholders can have different views on whether interference is harmful, which could lead to both under and overreporting. An effective assessment should therefore include sufficient technical detail to determine whether U-NII device operations are a likely cause of harmful interference. An assessment must, for example, distinguish between the effect of nearby U-NII operations versus atmospheric effects, interference from other sources, or malfunctions in FS equipment.

4.1 AFC-managed Standard-Power Device Operation

4.1.1 Interference Protection Parameters

The FCC R&O in ¶71 specifies -6 dB I/N as the "specific interference protection criterion" for AFC purposes. As adopted, 47 C.F.R 15.407 (l) (2) (i) cites the -6 dB I/N as the Interference Protection Criteria for AFC co-channel exclusion zone determination and 47 C.F.R. 15.407 (l) (2) (ii) cites the same for AFC adjacent channel purposes. The FCC R&O explained that by using -6 dB I/N for AFC purposes it was not "making a determination that any signal received with an I/N greater than -6 dB would constitute 'harmful interference.'" R&O ¶84. It stated that the FCC "will be the final arbiter regarding cases of harmful interference." R&O ¶84. Harmful interference is "[i]nterference which endangers the

functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with ITU Radio Regulations." 47 CFR §2.1(c).

Note that Public Safety and other Fixed Station (FS) incumbents may request an Emergency Special Temporary Authority (STA) telephonically, or by email from the FCC for operation of new or modified microwave systems for emergency restoral of communications which have been disrupted as a result of hurricanes, floods, earthquakes, tornados, or similar disasters (See FCC Public Notice DA-21-1566 and § 101.205 Operation during emergency). Documentation of such operations need not be filed for a period of 10 days pursuant to FCC rules, 47 C.F.R. §§1.915(b)(1), and 1.931(b)(5). The MSG has not identified a mechanism to protect such links which lack an associated ULS record from harmful interference.

It is also noted that there is differentiation between an emergency STA and a temporary link in that emergency STAs can be granted telephonically (or by email) without filing technical documentation and therefore are not protected from interference in this timeframe.

4.1.2 AFC System Operation

The AFC design framework and operation are codified in the FCC Final Rules under 47 C.FAsR. 15.407 (k) "Automatic Frequency Coordinator (AFC) System" and 47 C.F.R. 15.407 (l) "Incumbent Protection by AFC System: Fixed Microwave Service." Additional framework was included in the AFC Public Notice[2] seeking guidance for AFC operation.

4.2 Low-Power Indoor Device Operation

4.2.1 Interference Protection Parameters

As with AFC operations, the FCC did not set a quantified harmful interference threshold for LPI operations. Harmful interference is "[i]nterference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with ITU Radio Regulations." 47 C.F.R. §2.1(c).

4.2.1 R&O Restrictions on LPI Operation

The FCC R&O in ¶99 outlines three restrictions below that are designed to prevent LPI devices from causing harmful interference. These restrictions are: "(1) limited to indoor operation; (2) required to use a contention-based protocol; (3) subject to low-power operation."

4.2.2 Limited to indoor operations

The FCC R&O in ¶100 details the reasoning that indoor operations protect incumbent FS because there is significant attenuation provided by the walls of buildings. The median signal loss for a traditionally constructed building of 17 dB is cited with footnote 254 referencing ITU-R P.2109.

4.2.3 Use of contention-based protocol

The FCC R&O in ¶101 details the reasoning for requiring LPI devices to employ a contention-based protocol, which is to "ensure efficient and cooperative shared use of the spectrum." It is noted that

[2] *The Commission Begins the Process for Authorizing 6 GHz Band Automated Frequency Coordination Systems*, Public Notice, FCC 21-100, ET Docket No. 21-352 (Sept. 28, 2021) (*AFC Procedures Notice*).

CableLabs, Comcast, Charter, and Cox (R&O footnote 255) suggest contention-based protocol "as a means of providing assurance that incumbent operation will not be harmed."

In ¶141 the FCC expands on the CableLabs study, noting "The data that CableLabs submitted collected from 500,000 Wi-Fi access points shows that 95% of access points have an activity factor of less than 2% and only 1% of access points are active more than 7% of the time. This illustrates that most of the time a particular access point will not be transmitting."

There is a discussion in ¶102 about the use of contention-based protocol to "avoid co-frequency interference with other services sharing the band" and how "this requirement can be leveraged to facilitate spectrum sharing with including incumbent fixed and mobile services..." In the case of the Fixed Service, ¶120, ¶141 and footnote 374 make clear that "Although indoor unlicensed devices may not always be able to detect the presence of microwave signals, the contention-based protocol requirement will still help prevent interference by ensuring that unlicensed devices do not transmit continuously."

4.2.4 Low Power Operation

Low-power operation is discussed in the FCC R&O Section B with the maximum EIRP of 30 dBm and a power spectral density of 5 dBm per 1 megahertz.

5 Characterization of RLAN signals

The FCC authorized unlicensed Standard Power Devices, Indoor Low Power Devices, and Client Devices under the U-NII rules. Wi-Fi and 5G NRU were specifically called out in the Report and Order, but any device that complies with 47 C.F.R. section 15.407 and is FCC certified, can be authorized to operate in the 6 GHz band. Wi-Fi is likely to be the prevailing UNII device type in the 6 GHz band. Wi-Fi is based on the IEEE 802.11 standard and has well understood technical characteristics and signaling. This section characterizes Wi-Fi signals, explains how such signals can be used to identify the device type, and provides typical Wi-Fi traffic patterns all of which can help in identifying a Wi-Fi transmitter.

5.1 Characterization of Wi-Fi signals

This overview explains that Wi-Fi is a packet-based device based on the IEEE 802.11 standard. These devices are often certified by the Wi-Fi Alliance so that any device, regardless of the device manufacturer, can communicate with any other Wi-Fi device. Only 802.11ax (Wi-Fi 6E) and soon 802.11be (Wi-Fi 7) are standardized to operate in the 6 GHz band. These standards identify specific required technical characteristics to be compliant with both Wi-Fi Alliance and IEEE, which is useful identifying if a transmission is Wi-Fi, and what type of Wi-Fi device it is. Information, such as the channel plan, the emissions mask, traffic patterns, packet size, and information contained in the packets can be used in identifying whether any observable interference is from a Wi-Fi based transmission.

5.1.1 Authorized Wi-Fi Device Types

The R&O authorized Low Power Indoor (LPI), Standard Power (SP), and Client Devices. IEEE 802.11ax specifies a convention that is used to identify which of these device types a transmission is coming from. Beacon and Probe Response frames sent by 6 GHz APs include the following Regulatory Info subfield which identifies the type of AP, i.e. LPI or SP AP.

Regulatory Info encoding in the United States

Value	Description
0	Indoor Access Point
1	Standard Power Access Point

In addition, Beacon and Probe Response frames sent by 6 GHz APs include Transmit Power Envelope (TPE) elements which specify the regulatory transmit power limits for client devices and (where applicable) Subordinate Devices. The transmit power limits are expressed as total transmit power EIRP and/or PSD EIRP as appropriate.

For example, an LPI AP in the US sends a TPE element where the Maximum Transmit Power Interpretation subfield indicates Regulatory Client EIRP PSD and the Maximum Transmit Power field indicates -1 dBm/MHz. A Standard Power AP in the US sends a similar TPE element except that the values in the Maximum Transmit Power field are obtained from an AFC System. In addition, if those AFC-derived PSD limits do not guarantee compliance with the total EIRP limit, an additional TPE element is sent where Maximum Transmit Power Interpretation subfield indicates Regulatory Client EIRP and the Maximum Transmit Power field indicates the total client EIRP limit of 30 dBm.

5.1.2 Wi-Fi Spectrum Use

IEEE 802.11 ax and 802.11be (draft) channel plan provides the fixed raster of center frequencies for all 20 MHz, 40 MHz, 80 MHz, 160 MHz, and (soon to be) 320 MHz transmissions. IEEE also defines the transmission mask for any 802.11ax and 802.11be compliant device.

Figure 1 shows IEEE 802.11ax (Wi-Fi 6E) and 802.11be (Wi-Fi 7) global 6GHz (5,925 MHz - 7,125 MHz) Channelization.

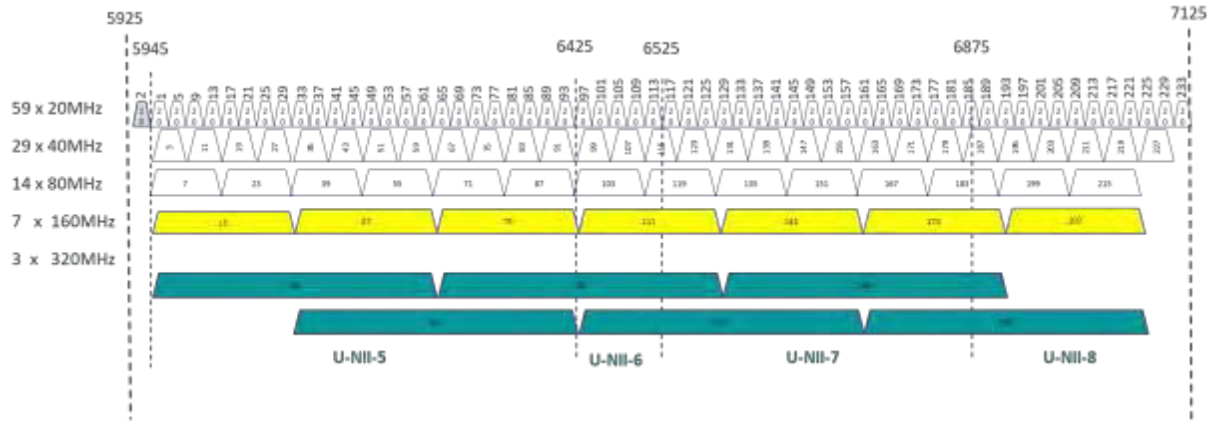
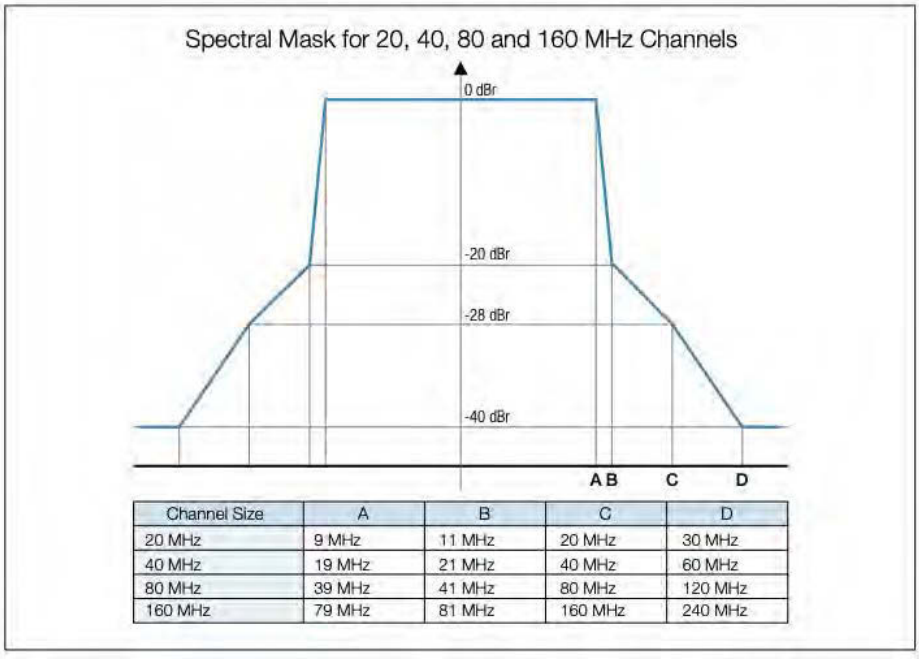


Figure 1. IEEE 802.11ax (Wi-Fi 6E) and 802.11be (Wi-Fi 7) Global 6GHz (5,925 MHz - 7,125 MHz) Channelization

Figure 2 shows the spectrum mask employed by the four different channel bandwidths used by current generation Wi-Fi 6E equipment.



Channel Size	A	B	C	D
20 MHz	9 MHz	11 MHz	20 MHz	30 MHz
40 MHz	19 MHz	21 MHz	40 MHz	60 MHz
80 MHz	39 MHz	41 MHz	80 MHz	120 MHz
160 MHz	79 MHz	81 MHz	160 MHz	240 MHz

Figure 2. IEEE 802.11ax (Wi-Fi 6E) Spectrum Mask

The channel plans and emissions mask are useful for identifying a Wi-Fi transmission via spectrum observation.

5.1.2.1 Wi-Fi Signal in the Frequency Domain

In order to identify a Wi-Fi device in a particular frequency range, start by first selecting the closest 160MHz Wi-Fi channel.[3] Using any widely available portable spectrum analyzer, run a sweep with a max-hold function across the entire bandwidth. Depending on the channel being used, the operator should see a shape similar to the graph shown below in Figure 3. In the first example, the image shows a 20 MHz Wi-Fi signal in a 40 MHz span.

[3] https://en.wikipedia.org/wiki/List_of_WLAN_channels#6_GHz_(802.11ax)

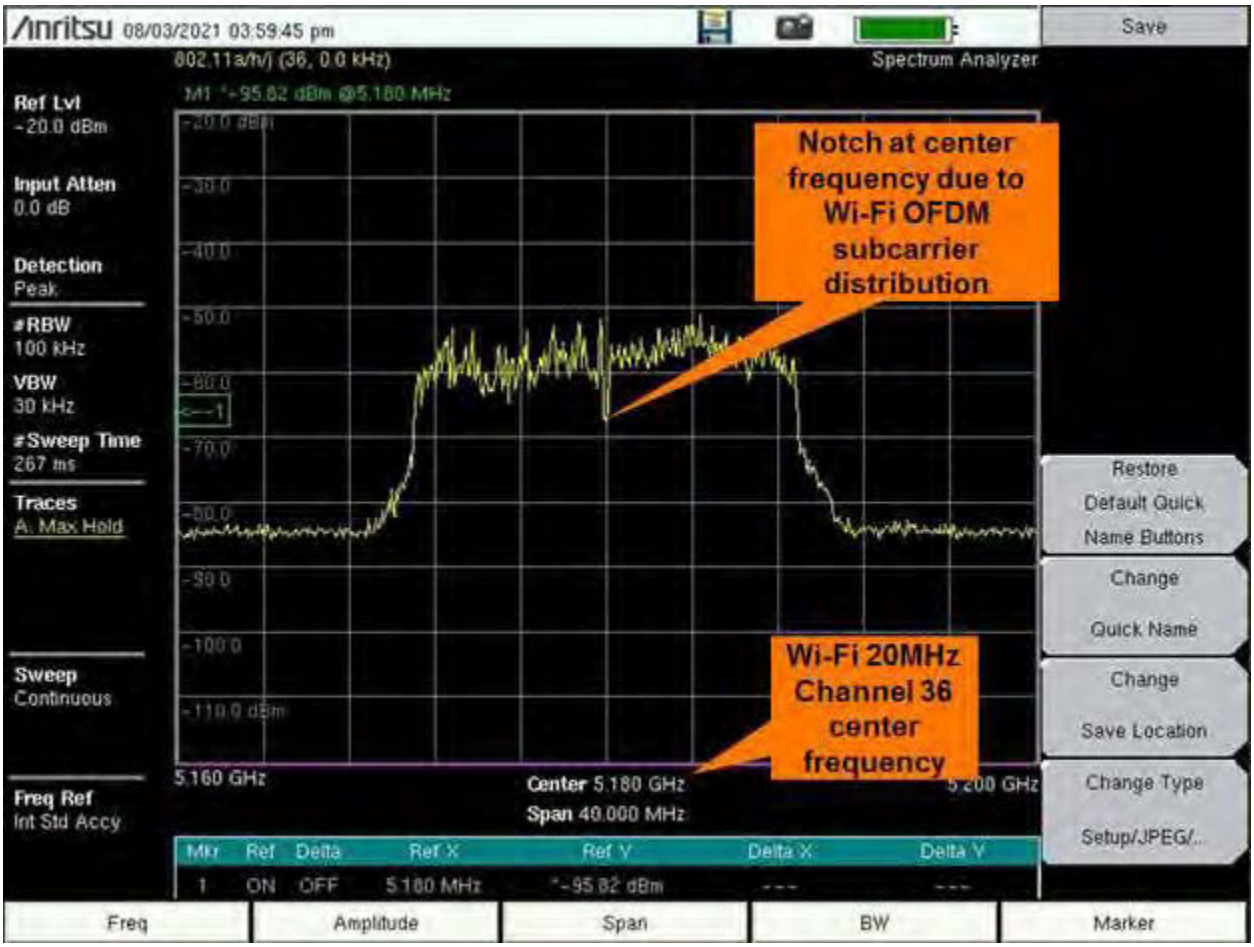


Figure 3. Spectrum Analyzer Frequency Domain FFT Plot of 20 MHz Wi-Fi Signal

In the second example below in Figure 4, the image below shows a 160 MHz signal in a 200 MHz span.

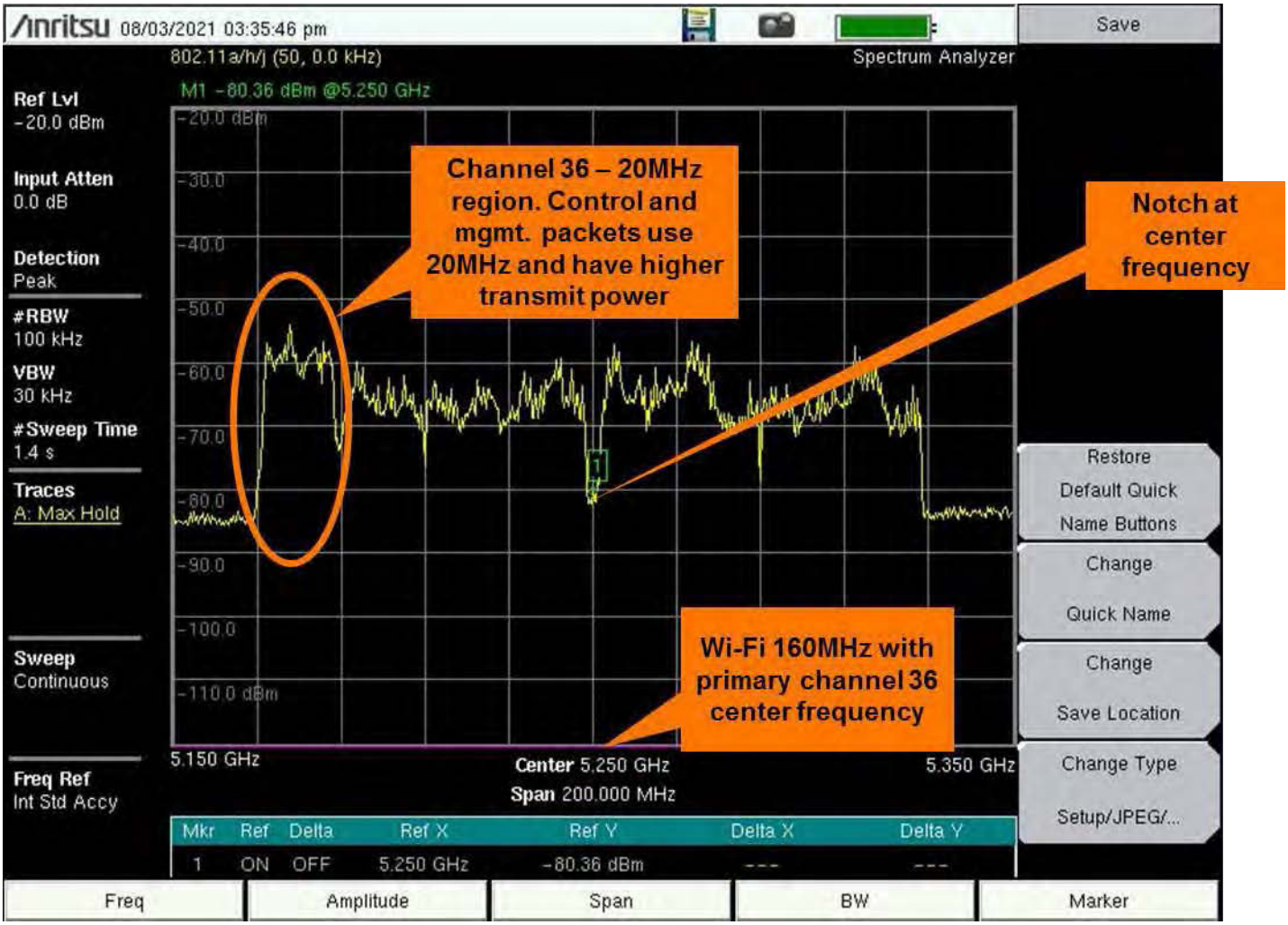


Figure 4. Spectrum Analyzer Frequency Domain FFT Plot of 160 MHz Wi-Fi Signal

5.1.2.2 Wi-Fi Signal in the Time Domain

Access Points (APs) broadcast beacon frames, typically every 100ms. Beacon frames are transmitted in a 20 MHz subchannel of the overall AP bandwidth known as the “primary”, whereas a data transmission is transmitted over the entire channel bandwidth in use. Beacons are typically transmitted at the lowest modulation, which means that they are most easily detectable. In the example above, the beacons are transmitted in the lowest 20 MHz channel, which has been designated as the primary.

To study the time domain, the measurement should use the zero-span setting on the spectrum analyzer to focus on a 100 KHz wide portion of the channel of the Wi-Fi signal and plot the signal strength seen in that frequency segment over time. The image below in Figure 5 captures the behavior of the beacon.

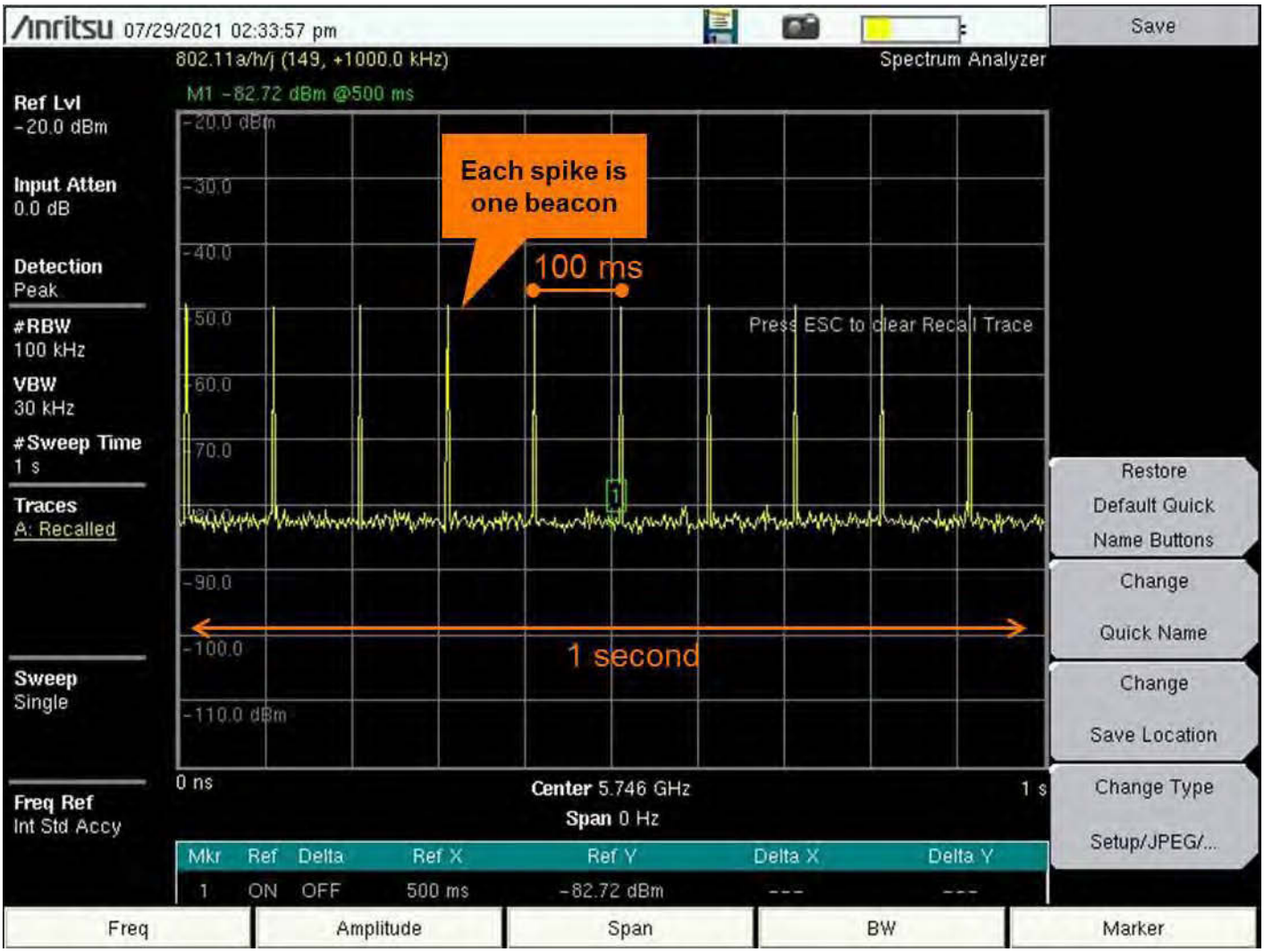


Figure 5. Spectrum Analyzer Time Domain Plot of Wi-Fi Signal Showing a Single Beaconing AP

While it is not uncommon for the receiver to only hear a single Access Point and therefore a single source of the beacon, we demonstrate below the common scenario where the receiver may hear more APs. In the three AP example below in Figure 6, there are now three overlapping 100 ms repeating patterns at different received power amplitudes.

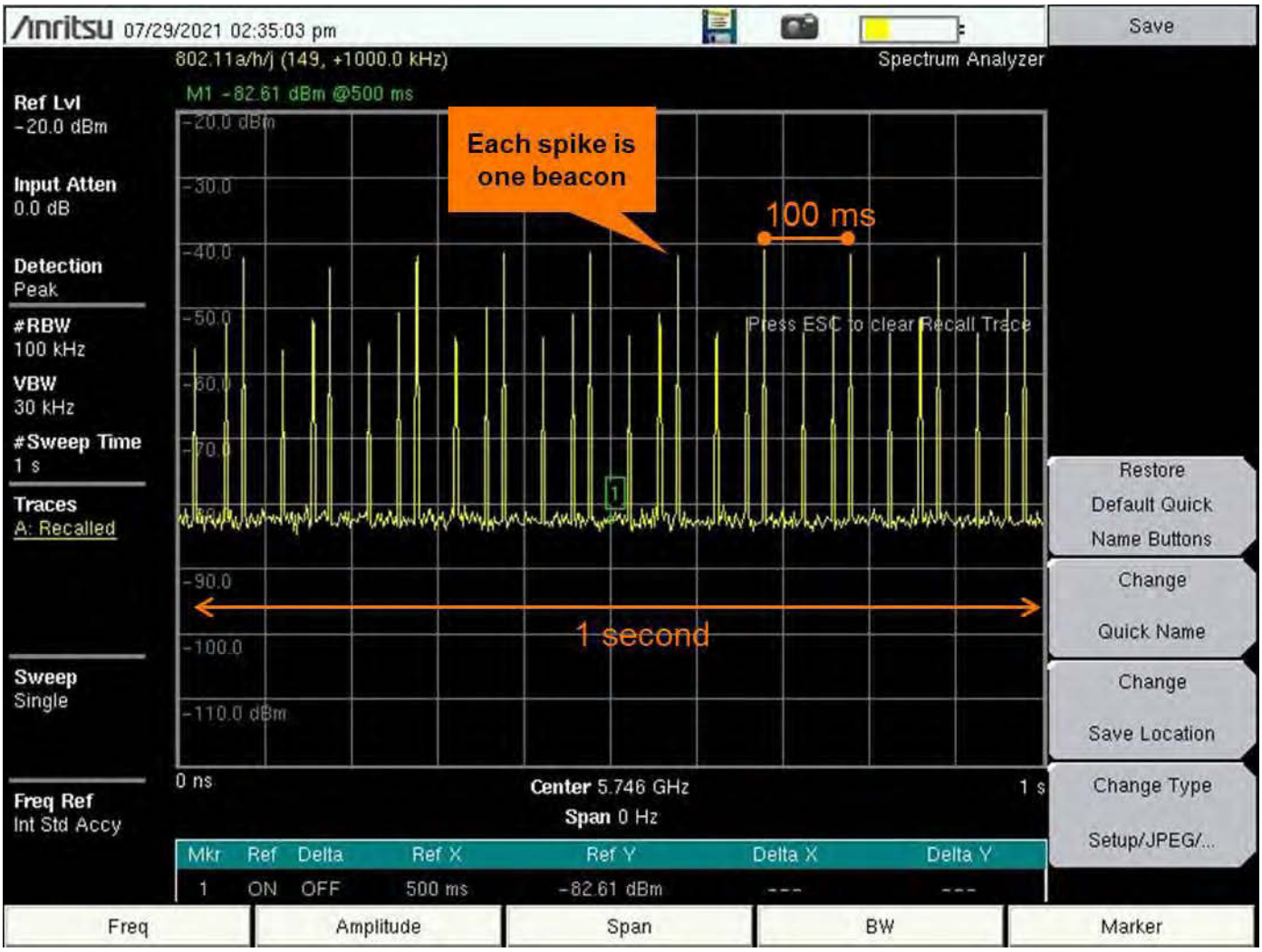


Figure 6. Spectrum Analyzer Time Domain Plot Showing Multiple Beaconing APs

Unlike beacon frames, data transmissions are sent at the highest supportable modulation. It is common in Wi-Fi equipment that high modulations use significantly reduced EIRP as compared with signaling frames like beacons to preserve signal linearity in the amplifier stage. For the highest 1024 QAM modulations supported by Wi-Fi 6E it is common to see as much as 6 dB power backoff. As a result, a very weakly received Wi-Fi source may only detect beacons and other signaling frames.

If the receiver is able to hear data traffic between the AP and the client, the time domain pattern will depend on the traffic pattern of the data being sent. As an example, we demonstrate a 5 Mbps continuous iPerf traffic stream in the graph below in Figure 7. Each spike in the plot is transmit opportunity (TXOP), which are occurring every 2 msec. The gap between the TXOPs is the medium returning to idle state, where no one is transmitting, and the channel returns to the noise floor.

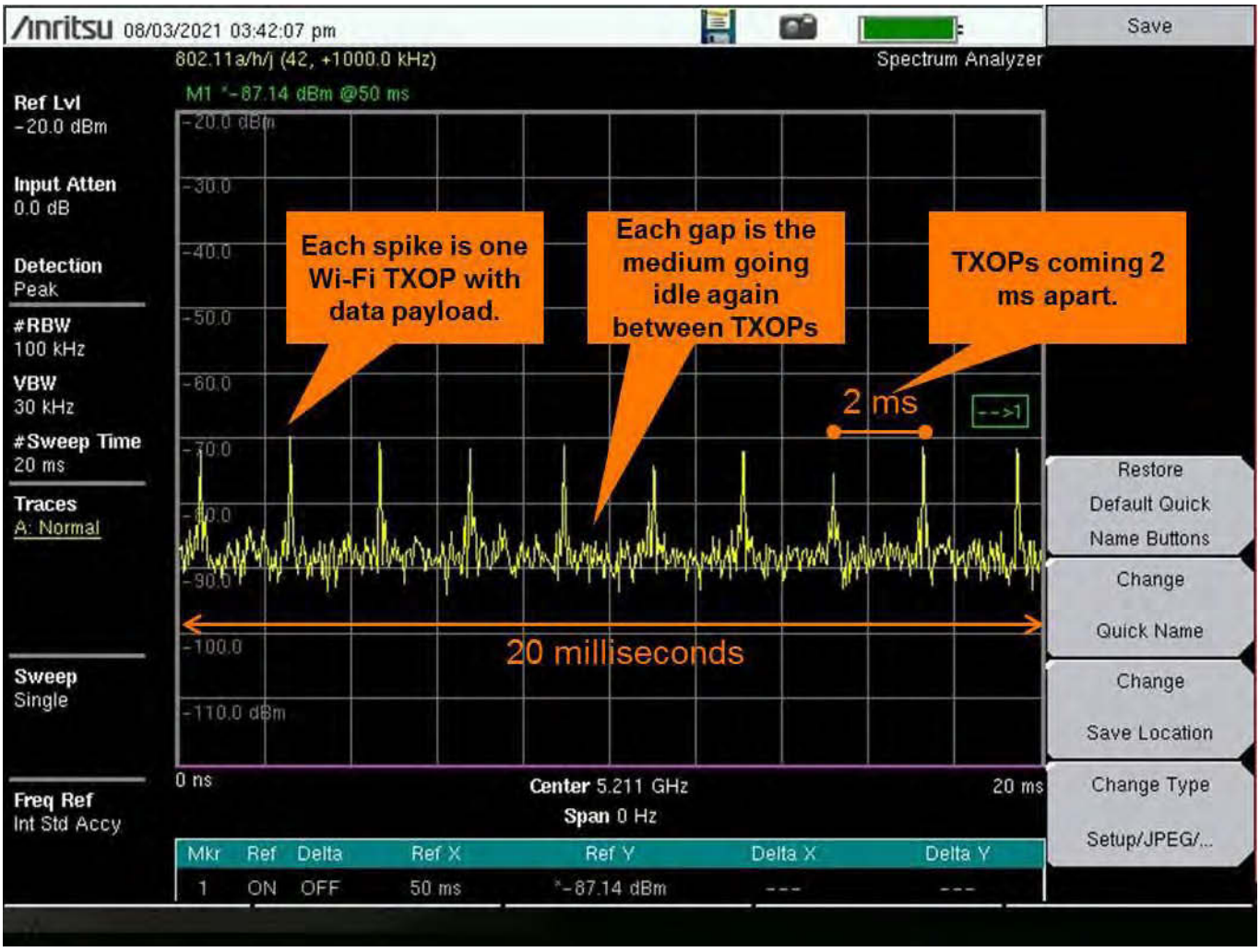


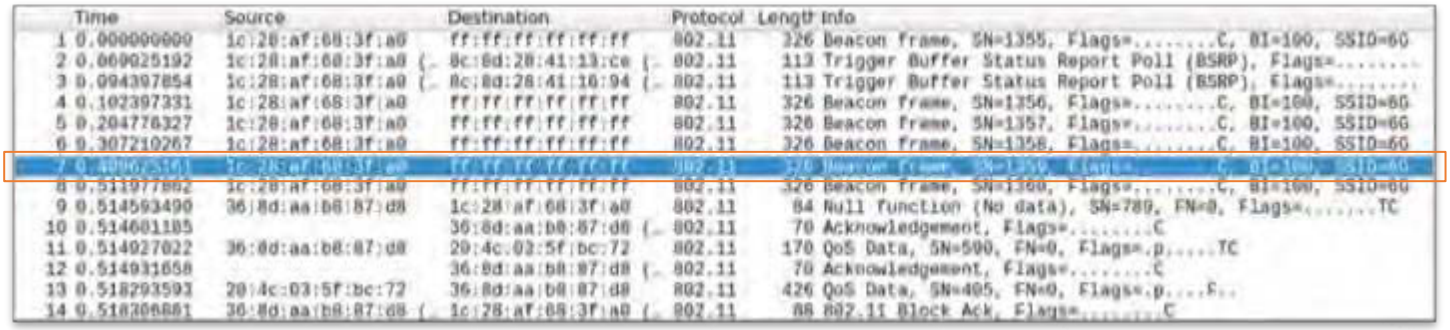
Figure 7. Spectrum Analyzer Time Domain Plot of Low Duty Cycle iPerf Data Transmission

5.1.3 Wi-Fi packet-based transmissions

This section explains how to interpret various types of Wi-Fi packets that have been captured with a protocol analyzer, such as control signaling (e.g., beacons) and data path signals, that have a maximum and minimum packet size and duration. Information contained in packets can be used to identify a specific Wi-Fi device type. These packets also contain a MAC Address/ID, which can be useful in identifying a specific Wi-Fi network. Packets can be captured using a sniffer and displayed with analyzer software such as the well-known and free Wireshark tool.

5.1.3.1 Identifying the 802.11 Access Point from the Beacon

An example capture is displayed below in Figure 8 with a beacon highlighted.



	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	1c:28:af:68:3f:a0	ff:ff:ff:ff:ff:ff	802.11	326	Beacon frame, SN=1355, Flags=.....C, BI=100, SSID=6G
2	0.000025192	1c:28:af:68:3f:a0	8c:8d:28:41:13:ce	802.11	113	Trigger Buffer Status Report Poll (BSRP), Flags=.....
3	0.094397854	1c:28:af:68:3f:a0	8c:8d:28:41:10:94	802.11	113	Trigger Buffer Status Report Poll (BSRP), Flags=.....
4	0.102397331	1c:28:af:68:3f:a0	ff:ff:ff:ff:ff:ff	802.11	326	Beacon frame, SN=1356, Flags=.....C, BI=100, SSID=6G
5	0.204776327	1c:28:af:68:3f:a0	ff:ff:ff:ff:ff:ff	802.11	326	Beacon frame, SN=1357, Flags=.....C, BI=100, SSID=6G
6	0.307210267	1c:28:af:68:3f:a0	ff:ff:ff:ff:ff:ff	802.11	326	Beacon frame, SN=1358, Flags=.....C, BI=100, SSID=6G
7	0.409625161	1c:28:af:68:3f:a0	ff:ff:ff:ff:ff:ff	802.11	326	Beacon frame, SN=1359, Flags=.....C, BI=100, SSID=6G
8	0.511977862	1c:28:af:68:3f:a0	ff:ff:ff:ff:ff:ff	802.11	326	Beacon frame, SN=1360, Flags=.....C, BI=100, SSID=6G
9	0.514593490	36:8d:aa:b8:87:d8	1c:28:af:68:3f:a0	802.11	84	Null function (No data), SN=789, FN=0, Flags=.....TC
10	0.514601185		36:8d:aa:b8:87:d8	802.11	70	Acknowledgement, Flags=.....C
11	0.514927022	36:8d:aa:b8:87:d8	20:4c:03:5f:bc:72	802.11	170	QoS Data, SN=500, FN=0, Flags=.p.....TC
12	0.514931658		36:8d:aa:b8:87:d8	802.11	70	Acknowledgement, Flags=.....C
13	0.518293593	20:4c:03:5f:bc:72	36:8d:aa:b8:87:d8	802.11	426	QoS Data, SN=495, FN=0, Flags=.p....F..
14	0.518306881	36:8d:aa:b8:87:d8	1c:28:af:68:3f:a0	802.11	88	802.11 Block Ack, Flags=.....C

Figure 8. Wireshark Packet Capture of Wi-Fi Traffic Including a Beacon

The beacon frame is then expanded to show the information contained within. A Wi-Fi beacon contains three different layer 2 addresses that can be used to identify specific devices and Wi-Fi networks. The transmitter/source addresses are the hardware identifier of the AP sending the beacon, while the Basic Service Set Identifier (BSSID) indicates a specific Wi-Fi SSID that is offered by the AP, as illustrated below in Figure 9. The first three bytes of the transmitter address usually (but not always) correspond to the device manufacturer organizationally unique identifier (OUI) which can be looked up in Google.

Figure 9. Wi-Fi Packet Header Showing Transmitter and Basic Service Set ID

Following the header information, a beacon is composed of a series of different information elements (IEs) that advertise the capabilities of the AP. This explanation will not cover every single IE you will find in a beacon – and it's common today to find as many as 20 or more IEs. We focus this discussion on those IEs that would be useful for an incumbent attempting to identify Wi-Fi signals and trace them to a source.

The first IE we will consider is the Service Set Identifier (SSID). This is the human-readable name of the network. It corresponds to the BSSID noted in Figure 9. This IE is used to populate the list of available Wi-Fi networks one sees when attempting to connect to a new Wi-Fi network. The SSID ("6G" in this example) is also visible, as shown below.

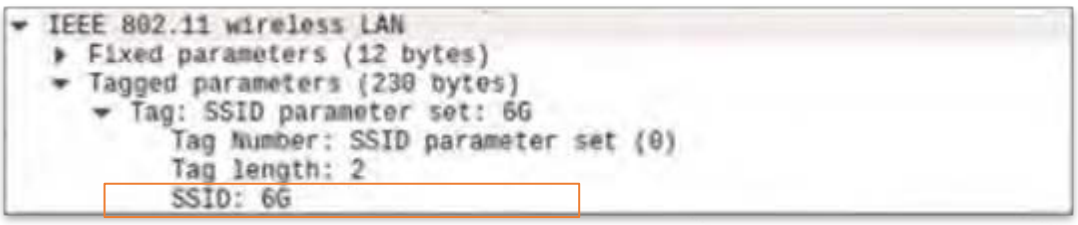


Figure 10. SSID Information Element Showing Human-Readable Wi-Fi Network Name

The next IE of interest to an incumbent radio engineer is called the Transmit Power Control (TPC) Report. This information element shows the configured EIRP level of the AP reported in dB, as shown in Figure 11. It can be used to verify that the AP is in compliance with regulatory maximum, as well as to estimate the path loss between the measurement point and the signal source.

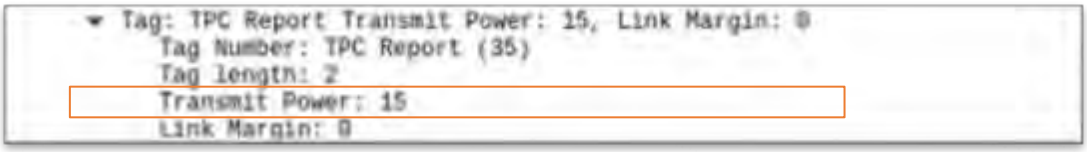


Figure 11. Transmit Power Control Report Information Element with AP EIRP

Another transmit power related element is Transmit Power Envelope (TPE). As compared with the TPC Report that provides the AP EIRP, the TPE IE communicates the maximum transmit power allowed by clients that are associated with this AP. In the case in Figure 12, the AP indicates in the first TPE element that client devices that fall under Max Tx Pwr Category = 1 may use a maximum PSD of 5 dBm/MHz. Category = 1 is defined as a 6 GHz Subordinate Device. In the second Transmit Power Envelope element the AP indicates that client devices that fall under Max Tx Pwr Category = 0 may use a maximum PSD of -1 dBm/MHz. Category = 0 is defined as a "default device".

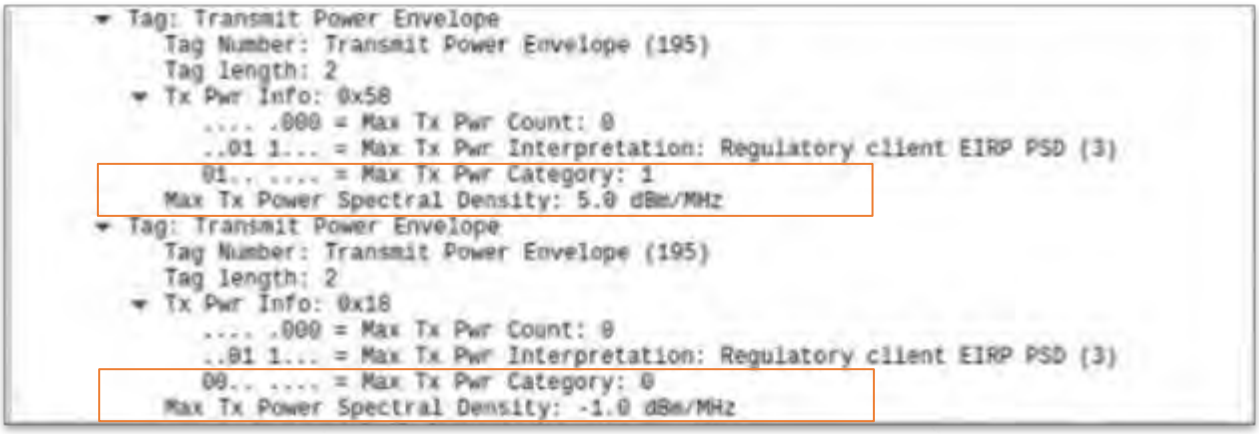


Figure 12. Transmit Power Envelope Information Element with Maximum Client PSD

When operating in 6 GHz, the AP will always include the 6 GHz Operation information element as shown in Figure 13. This includes the operating channel bandwidth (e.g. 20, 40, 80 or 160 MHz), the channel center frequency, and also an indication of whether it is operating as Low Power Indoor AP or Standard Power AP.

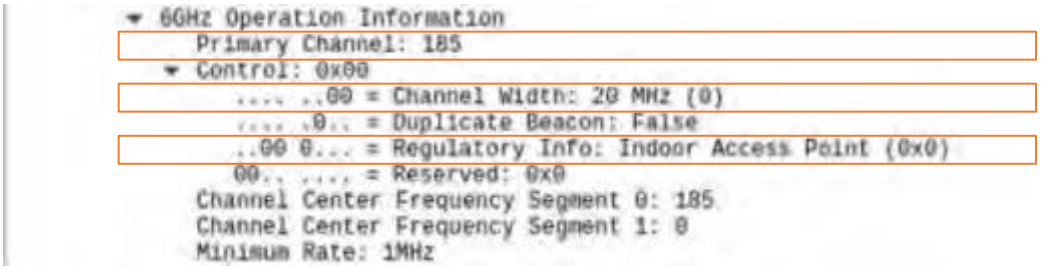


Figure 13. 6 GHz Operation Information Element with AP Type and Channel Bandwidth

5.1.3.2 Identifying 802.11 devices from Client Frames

In this section we consider the scenario where the packet capture receiver is unable to detect the AP itself, but is instead able to successfully decode transmissions from a Wi-Fi client device to the "hidden" AP. A Wi-Fi client device will transmit several different types of control frames in order to access the medium or in response to actions by the AP. The first example is the Clear-To-Send (CTS) to "self," as highlighted below in Figure 14.

The purpose of sending a CTS-to-self is to reserve the channel by informing all nearby Wi-Fi devices that this device has completed its random backoff process and now controls the medium. A CTS-to-self may be sent by both an AP and a client device. The destination address of a CTS-to-self is the same as the transmitter address. This acts as an implicit broadcast frame that is detected by all stations in the area using that channel, and causes them to adjust their backoff timers to wait until this station completes its transmission before attempting to access the medium.

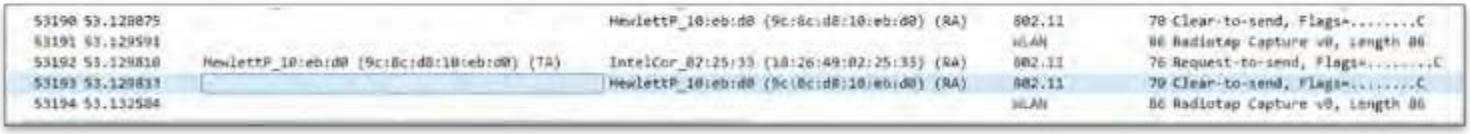


Figure 14. Clear to Send (CTS) Frame

Another very common control frame that will be transmitted by clients is the Block Acknowledgement (BA), as shown in Figure 15. As always in radio, transmissions must be acknowledged. If a packet capture system is hidden from an AP it will not be able to receive the downlink data transmissions but it may be able to detect the acknowledgements sent by the client in response.

Figure 15. Block Acknowledgement of Received Data Transmission

The BA contains a transmitter address, which is the client, and a receiver address, which is the AP, as shown in Figure 16. This can potentially be used to identify the manufacturer of an AP even if it cannot be directly detected by the packet capture system.

Figure 16. Receive & Transmitter Addresses in a Block Acknowledgement Frame

6 Interference Detection

PROBLEM STATEMENT:

Provide best practices and recommended procedures for interference detection that were not identified by the FCC.

FINDINGS:

There are two sections that address interference detection, namely (1) Best Practices and (2) Recommended Procedures. A set of Best Practices provides details on measuring licensed incumbent baseline performance and detecting/identifying a source causing reduction in performance. A set of Recommended Procedures includes a flow chart with step-by-step procedures to follow to detect harmful interference leading to the reporting of interference. Both can be tailored to the FS incumbent network operation.

6.1 Best Practices

6.1.1 Measuring Licensed Incumbent Baseline Performance

Non-Service Affecting

Most microwave radio vendors include various test procedures as part of the software in their current radios. Without disassembling waveguide or introducing test fixtures, it is possible to look at transmit and receive levels at both ends of a path. Point A can report its own receive and transmit power levels as well as the receive and transmit levels at Point B (the opposite end of the path). The same can be done from the point of view of Point B looking towards Point A, for confirmation of the first results by comparing the response in both directions. This type of information can be collected for periods of weeks or months prior to the introduction of potential sources of interference, and can be graphed, showing trends for the period of monitoring. In addition, radios that support adaptive modulation can provide reports showing the stability of the adaptive modulation level.

Weather and interference can both drive an adaptive modulation-capable radio to operate at a lower modulation (with less throughput), although at 6 GHz, rain does not play an important role in driving adaptive modulation changes. More typically, multipath and interference sources will be the deciding factors. For ACM (Adaptive Coding and Modulation)- capable radios, reports showing the modulation

levels as they vary with time should be created to establish the baseline typical modulation level prior to the introduction of new potential interference sources. These tests can be carried out at any time, but they will only show the difference between the typical modulation level at the time of the test and the future typical modulation level. Similarly, baseline Bit Error Rate (BER) tests can be carried out using software included with the radio. Some manufacturers offer path availability and throughput measurements as well. None of the tests that are included with the radio manufacturer's software require the disassembly of components in the radio path. For radios with fixed modulation, modulation tests are not applicable, although BER tests are available. In both cases, path availability reports and average throughput reports are available with some manufacturer's software. Longer outages with reduced average throughput can be indicators of interference.

Service Affecting

One example of a traffic-affecting test is the fade margin test. This section reviews the differences between indoor and outdoor radios for a fade margin test.

Many radios can modify their output power through software, although for most installations it will not be possible to reduce the transmit output power at one end enough to reach the 10-6 BER threshold at the receiver unless the radio operates at a high modulation (with a higher receiver threshold). For these radios, the difference between receiver threshold and received signal may be close enough that the range in transmitter power reduction may be enough to attenuate the received signal to threshold. Even then, it would be necessary to lock the radio into the highest modulation (for ACM radios) to prevent it from switching to a lower modulation with a lower receive threshold. For the rest, it will be necessary to introduce enough fixed attenuation into the path under test, that the software control of the transmit power will be enough to bring the receive level down to the 10-6 BER threshold. For indoor radios, adding fixed attenuators is fairly straight-forward. For outdoor radios, the task is more complex.

Outdoor radios have the transceiver mounted to the antenna. Transceivers can be directly mounted as part of an integrated antenna, connected through a coupler/combiner/OMT (Ortho Mode Transducer) or connected through waveguide. In the first two cases, it will not be possible to introduce fixed attenuation. Even in the case of transceivers connected to the antenna using waveguide, adding fixed attenuation is possible, but may require climbing to the antenna elevation to do so. For this reason, the fade margin test will probably be limited to indoor transceivers or outdoor transceivers connected by waveguide in easily accessible areas like rooftops. This is another test that must be carried out prior to the introduction of potential interferers in order to establish the baseline.

It is also possible to use software provided by the microwave radio manufacturers to provide a graphical representation of the spectrum in the radio receive pass band, similar to a spectrum analyzer sweep. The advantage of this type of software is two-fold. First, there is no requirement to insert a sampling point into the waveguide run, or to make measurements at the elevation of the antenna in the case of split package or outdoor radios. Second, the receiver sensitivity of the typical microwave radio is better than most spectrum analyzers and it is possible to detect interfering signals at lower levels than with a spectrum analyzer. Detecting co-channel interfering signals will require the transmitter of the system under test to be muted (turned off), so that underlying signals can be detected. Traffic will be interrupted as a result. The interfering carriers should be noted for later comparison with the post-introduction landscape.

For older radios not supporting software control and integrated test routines, waveguide transition sampling points, test fixtures, BER Test equipment and spectrum analyzers may be required to gather the baseline information. Introduction of transitions into waveguide paths or connection of in-line test equipment will be traffic-affecting Likely, adaptive modulation tests will not be required for these older radios as most did not support adaptive modulation.

Any baseline data collected should be compared to expected levels based on design documents and levels recorded at the time of the original installation. It is possible that a transmitter could be failing, an antenna is off-azimuth or waveguide is damaged if the levels are much different than the expected levels. If there are any differences from installation levels and design levels, these should be investigated and rectified prior to using the data for baseline comparison levels.

6.1.2 Detecting and Identifying a Source Causing Reduction in Performance

Using baseline data collected prior to the introduction of new wireless unlicensed mobile systems into the 6 GHz band, the baseline data can be compared to the newly collected data after the introduction of unlicensed devices. As low power devices are already being marketed and sold, the resulting impact to baseline data will need be considered. For an interference condition, it is unlikely that there will be any change to receive level. However, modulation levels may routinely be lower than the typical levels from the baseline, and BER may be higher. Interference levels that are below the noise floor may not be detected by traditional test equipment but can still be detected since their existence will create an increase in the MSE (Mean Squared Error) and this will reduce the modulation level. Some radios report LDPC (Low Density Parity Check) Code stress to indicate potential interference. Other parameters such as path availability and traffic throughput are key indicators of interference. For ACM radios, the interferers will drive the modulation state lower, decreasing throughput and this shows up in the modulation state report and average throughput report. For fixed modulation radios, interference can desensitize receivers and increase outage times. This will show up as lower annual path availability in the path availability report. These tests are indicators of interference, but do not identify the frequency of the interfering signal or source of the interference.

Once interference is suspected, the spectrum analyzer software provided by the radio manufacturer should be used. With the transmitter at the site experiencing interference turned off, it will be clear to see if there is another signal appearing in the FS channel. If the signal is above the noise floor, the frequency and signal level can be observed. One important thing to note is that the channel bandwidth of new unlicensed devices can be many times larger than the typical fixed services channel bandwidth. Radio manufacturer's software that uses the radio receiver, can only measure the signal coming into the radio through the filter system, so although it offers a spectrum analyzer measurement, it cannot capture the whole signal bandwidth when the signal is wider than the filter pass band. Since the purpose of using the radio receiver is to see signals with a lower signal level than can be captured with a regular spectrum analyzer, it may not be possible to identify the channel bandwidth of the interfering carrier unless the channel size of the interfering signal is less than the pass band of the radio filter. Peak hold may be required to capture signals that are sporadic in nature. Older radios may not be able to use this type of software and the user would have no other option than to use a traditional spectrum analyzer, test equipment and test fixtures.

6.2 Recommended Procedure

The flow chart in Figure 17 details a recommended procedure that can be used to detect harmful interference. A second option is also presented as a complementary set of procedures, that provides a set of recommended FS network parameters used to detect interference and severity of reduction in FS performance that can be tailored to the recommended procedure, based on vendor availability.

The step-by-step procedure is described in detail below and includes five steps, namely (1) Baseline Performance Measurement (2) Identify Performance Degradation (3) Troubleshoot (4) Determination of Equipment Issue (5) Proceed to Interference Reporting.

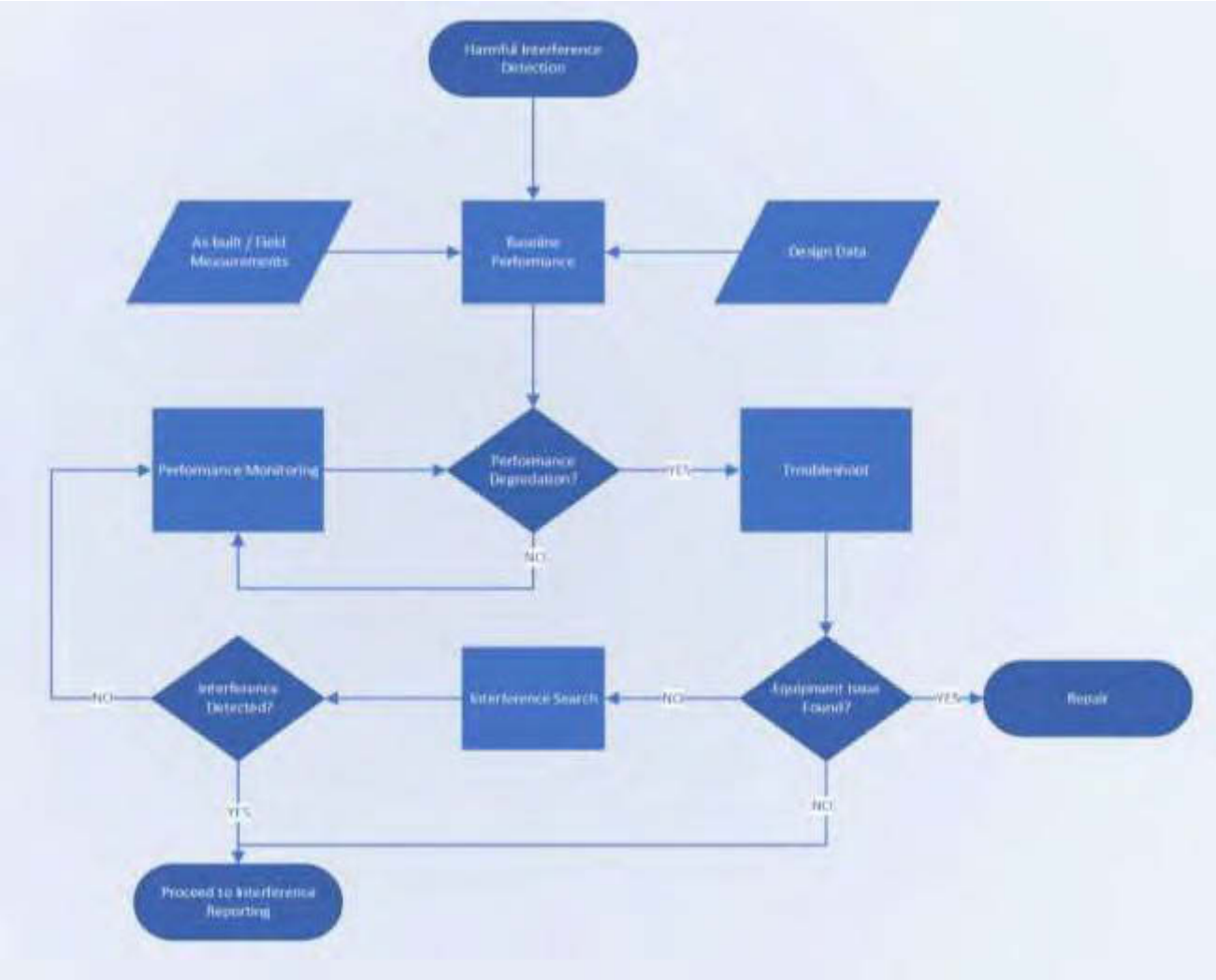


Figure 17. Recommended Procedure for Harmful Interference Detection

BASELINE PERFORMANCE (Step 1): Establish System RF baseline in advance of RLAN deployments for licensed paths. (Includes some out of service measurements and Bit Error Rate (BER) hits to path operation)

(Service-Affecting Approach)

- Perform transmit power measurements for all transmitters for path.
- Baseline existing interference environment for each path (if possible)
  - Requires turning off each paths' transmitters to take baseline measurements. (note: this is one option and may not be possible. An alternative non-service affecting method is described below)
  - Use adapters to connect spectrum analyzer to receive waveguide port. (note: Some systems could be using ODU's (Outdoor Units) in which case this may not be possible. Alternative would be to dismount ODU and attach waveguide flange to antenna feedhorn.)
  - Adjust analyzer to capture entire licensed bandwidth, as well as adjacent channels. (Note: Although test reports conclude that there were no adjacent channel interference issues found during their recent testing, that was specific to the radio under test, and not necessarily true for all manufacturers' radios – it is dependent on the receiver filtering mask of the particular receiver in use)
  - Save digital image of above referenced captured bandwidth
- Verify fade margins are consistent with original path design
  - May require taking path out of service, will impose bit errors on link.
  - Step attenuators can be used to simulate path fading, transmit power adjustment of far end transmitter is an alternative method. (note: Step attenuators cause interruption in the link every time a new attenuation level is selected. A vane variable attenuator would be recommended instead.)
  - Add attenuation or reduce transmit power until reaching a BER of 10^{-6} BER. Record and verify if this value is consistent with manufacturer's specs and path design.
- Signal to Noise Ratio (SNR), BER, Received Signal Level (RSL) and reliability percentage
  - Designed and engineered value
  - Measured values, mean and standard deviation – archive Network Management System data available (and used to calculate mean and deviation), preferably for 1 year to observe all seasonal effects.
  - Field measurements should be consistent with design or historical link performance. Any non-conforming results would require troubleshooting. Sub-standard links can be more difficult to accurately identify interference on.

(Non-Service Affecting Approach)

Note: This approach is based on FS systems with enhanced monitoring capabilities.

- Using FS craft-tool, Command Line Interface (CLI) or Network Management System (NMS) system capture current real-time key performance indicators, including:
  - Tx output power – for Automatic Transmit Power Control (ATPC) systems mean, min and max
  - RSL – current, min and max. Including protected or systems in branching configuration.
  - BER – current could take a while to register, so mean, min and max.

- SNR or Mean Square Error (MSE) – current, min and max.
- Fade Margin – targeted and current Fade Margin (FM) value.
- Modulation – for systems with Adaptive Code and Modulation (ACM) then current state and any recorded state changes.
- G.826 – errors currently observed or registered (preferably should be 0 errors).
- Spectrum Analysis – Snapshot of the Rx channel spectrum, including adjacent channels, if possible
- Forward Error Correction (FEC) – uncoded BER measurement (preferably should be none).

- Verification process
  - Measured values should be consistent with As-built reports or path calculation. This will usually include but not limited to Tx Power, RSL, & Fade Margin.
  - Consult vendor for other specific values or normal operating condition.
  - Any non-conforming link should be investigated and brought to optimal operating condition if possible.

IDENTIFY PERFORMANCE DEGRADATION (Step 2): Operational Indicators of Path performance issues (may not be associated with interference)

- Path/traffic performance degradation - BER drops to 10^{-6} or worse and traffic failures occur, or Adaptive Modulation drops path modulation level for no apparent reason.
  - Verify that there are no module failures at either site via the network monitoring system or site visit
  - Verify that the path RSL is consistent with original design parameters (note: RLAN Interference would not show up as a variance in RSL). If not:
    - Verify transmit power output is consistent original baseline of system
    - Switch between online and standby (A & B) sides of the radio equipment at both sites
    - Verify antenna/path alignment has not been compromised
    - Verify no issues with waveguide (visual, and if possible, sweep the waveguide)
    - For systems utilizing ACM, frequent non-weather/non-fading related switching may be indications of potential interference
- If no issues requiring remediation are found following above procedures, refer to next section. If remediation issues found, correct issues and repeat tests of this section.

DETERMINATION OF EQUIPMENT ISSUE (Step 3): Investigation into equipment performance must be undertaken to ensure equipment is fully operational, calibrated, within designed tolerance and configurations are set properly.

TROUBLESHOOTING (Step 4): Verification/ troubleshooting of Reportable Interference
(If possible – involves out of service measurements – if not possible, proceed to next section)

- Verify if interference is present for the affected path
  - Requires turning off each paths' transmitters to take measurements (note: this is one option and may not be required, there is a non-service affecting method described above)

- Use adapters to connect spectrum analyzer to receive waveguide port
- Adjust analyzer to capture entire licensed bandwidth, as well as adjacent channels
- Save digital image of above referenced captured bandwidth
- Compare this measurement with the previously baselined measurement to determine whether interference is now present

PROCEED TO INTERFERENCE REPORTING (Step 5): Once completion of steps 1 to 4 are verified and complete, proceed to interference reporting per the recommendations in Section 7.

6.2.1 Additional Options

The following parameters and procedures in Table 1 can also be used to detect interference and severity of reduction in FS performance.

Table 1. Recommended FS network parameters used to detect interference and severity of reduction in FS performance

Key Indicators	Desired Path	Minimal Impact	Moderate Impact	Major Impact	Severe Impact
RSL	Normal	Unchanged	Unchanged	**Unchanged or May Increase**	**Unchanged or May Increase**
SNR	Normal	**Slightly Degraded**	**Significantly Degraded**	**Significantly Degraded and fluctuating**	**Significantly Degraded to Total Loss**
Tx Power (Far End)	Normal	Normal	**Slightly Increasing**	**Increasing**	**Maxed**
BER	Better than $1x10^{-15}$	Better than $1x10^{-12}$	Better than $1x10^{-10}$	**$1x10^{-8}$ or Worse**	**$1x10^{-3}$ or Worse**
G.826	None	None	None	**ES or SES**	**ES, SES & UAS**
Link Status	Locked	Locked	Locked	Locked	**Intermittent to Loss**
FEC	Not Stressed	**Slightly Stressed**	**Stressed**	**Exhausted**	**Exhausted**

CONCLUSION:

The process outlined in this section provides a detailed set of best practices and recommended procedures for establishing a baseline and interference detection for incumbent FS radios. This model should permit identification of the baseline operations of the fixed links and detection and comparison of the effects of any harmful interference caused by unlicensed services in the 6 GHz band.

7 Interference Reporting

PROBLEM STATEMENT

Provide best practices and recommended procedures for interference reporting that were not identified by the FCC.

FINDINGS:

Consensus was not reached within the 6GHz MSG on a set of recommended procedures and recommended course of action for interference reporting by FS operators. Instead, two alternative viewpoints are presented that address procedures for reporting interference. In general, Viewpoint 1 is offered by FS incumbents and Viewpoint 2 is offered by the new entrants.

Under Viewpoint 1, the FS incumbents and new entrants (including AFC operators) are not co-equal, meaning that new entrants bear the responsibility to prevent, detect, and remedy interference they cause to incumbents. Further, incumbent microwave receivers did not need to be designed, and are not presently capable of, detecting interference or identifying the interfering source, including being able to delineate between a low power device and a standard power device under AFC control. Incumbents, particularly public safety, do not have the resources to dedicate to interference resolution – their main role is to carry out their public safety missions. The FCC should have a record of reports of interference to public safety communications. Therefore, the FS incumbents' views on interference reporting are guided by these realities.

Under Viewpoint 2, the FS incumbents would report suspected interference with detailed technical information directly to the AFC operators to allow for a more efficient process and faster resolution.

7.1 Recommended Procedure

VIEWPOINT 1

Upon experiencing potential interference, incumbent FS operators should report interference per the following steps:

1. Because 1) it is the statutory duty of the FCC to protect incumbent licensees from interference, the burden for identifying specific sources of standard-power deployments should be on AFC operators in conjunction with the FCC, 2) incumbent FS operators should not be responsible for keeping track of the various AFC operators and making individual, duplicative notifications, 3) it is unlikely that incumbent FS operators will know whether the interference is from a standard power device or low power device, and 4) the FCC should have a record of all interference reports, a single form or interface should enable the simultaneous notification to the FCC and AFC operators, through which incumbent FS Operators should provide:

- Call sign of affected station
- Affected receiver frequency
- Point of Contact (name, phone, email)

- Date/time interference first detected, with any additional information available that would assist AFC operators and the FCC with identifying the source of interference.
- The requirements for the initial report to trigger a response by the FCC and AFC Operators should not be overly prescriptive given the limited resources and information available to incumbents and sense of urgency for initiating the process to eliminate interference, particularly for public safety licensees.

2. If parties who have filed an interference report obtain additional information that would be helpful for resolving interference, they should be submitted using the same process described above.

VIEWPOINT 2

Upon experiencing suspected interference, incumbent FS operators should provide the following information to all AFC system operators:

1) Prepare documentation ("interference report") that demonstrates interference using interference detection methods per section 6 that follows the FCC Spectrum Enforcement Division[4] process for reporting interference including the following:
   - Point of Contact (name, phone, email)
   - FCC call sign
   - Latitude and longitude of the receive antenna
   - Affected receiver frequency
   - Detailed description of the nature of the suspected interference, including date and time the suspected interference was first detected, and the duration and frequency of the interference
   - Why it is believed that the interference is related to unlicensed operations
   - Any addition information that may be helpful in determining the cause of the suspected interference (e.g., equipment and methods used to detect interference, frequency or frequency range of interference, signal strength of the interference, etc.)

   It is also possible that an interference-reporting portal might be developed where reports of potential interference could be provided to all AFC operators and the FCC simultaneously through an online notification form such as the one used for CBRS. (https://docs.google.com/forms/d/e/1FAIpQLSd9Druyh011YjYQEep1RACVo1-HZBPvTuNKcHVyqzrXeynAIw/viewform?usp=sf_link).

2) Incumbent FS operator submits interference report to all AFC operators per publicly available contact information provided by FCC. Then proceed to interference resolution in section 8.

3) If deemed necessary, two optional approaches can be employed: (a) incumbent FS reports to a voluntary industry-native independent Working Group that creates a centralized framework to accept and evaluate reports (b) report to the FCC Spectrum Enforcement Division.

[4] https://www.fcc.gov/research-reports/guides/broadcast-interference

7.2 Recommended course of action per interference source

7.2.1 Interference Source is Low Power Device

Identifying the responsible party for an LPI device found to be the source of harmful interference is problematic since LPI devices do not interact with an AFC that would have information on the location and allowed frequency and maximum power. Therefore, either incumbents or the FCC Spectrum Enforcement Division would need to perform a field investigation to determine the location and owner of the device. LPIs can be located either through the use of radio direction finding equipment, or by capturing the MAC ID from the interfering signal and enlisting the help of internet service providers to cross-reference to a physical address. This may have limited effectiveness over time as the capability to introduce random MAC IDs is currently available and increasingly being adopted.

VIEWPOINT 1

In the above approach, given staffing as well as the anticipated growing numbers of unlicensed use of this spectrum, FS incumbents would necessarily have to rely upon the FCC Spectrum Enforcement Division to perform a field investigation to attempt to determine the location and owner of the device, which even if successful can take days if not weeks but also may not be technically feasible if these sources of interference are emitting from millions of devices throughout the nation.

VIEWPOINT 2

In the above approach, either incumbents or the FCC Spectrum Enforcement Division would be needed to perform a field investigation to determine the location and owner of the device. Measurement data and operational information from the FS network is considered important information to investigate and report interference.

7.2.2 Interference Source is AFC-Controlled Device

The FCC process for authorizing 6 GHz AFC systems is being defined in ET Docket No. 21-352. Contact information for AFC operators that are successful in being authorized and FCC certified for commercial AFC operation will be available from the FCC. Recommended actions taken by the AFC operator are addressed in section 8.

No difference in Viewpoint 1 and 2.

7.2.3 Enlisting Interference Identification Support of Internet Service Providers

Incumbents that are able to locate and identify the Ethernet MAC ID of the device causing the harmful interference should provide this information to internet service providers that operate in the vicinity. The purpose would be to enlist their help in locating the physical address of the device and contacting the responsible party to request turning the device off. This is described in further detail in section 8.

VIEWPOINT 1

In the above approach, given that FS incumbents are not staffed to perform field investigations necessary to locate the harmful interference, it is the FCC staff that are able to locate and identify the MAC ID of the device causing the harmful interference and who should provide this information to internet service providers that operate in the vicinity.

VIEWPOINT 2

In the above approach, it is the FS incumbents that are able to locate and identify the MAC ID of the device causing the harmful interference should provide this information to internet service providers that operate in the vicinity.

7.3 General - Licensed Incumbent Reports Interference to the FCC (all instances of reporting)

It is the statutory duty of the FCC to protect incumbent licensees from interference and the FCC Enforcement Bureau's Spectrum Enforcement Division, in conjunction with Regional Field Offices, is specifically responsible for responding to interference complaints involving FCC licensees. The Field Office functions include:

- Executing on-scene investigations, inspections, and audits;
- Immediately responding to safety of life matters;
- Investigating and resolving individual interference complaints;
- Investigation violation in all licensee and/or operator services;
- Coordinating with local and state public safety entities; and
- Carrying out special priorities of the FCC.

Contact information for the Spectrum Enforcement Division:

Federal Communications Commission
Enforcement Bureau
Spectrum Enforcement Division
45 L Street NE, Washington, DC 20554.

Phone: 1-888-225-5322

Directions for submitting complaints to the Spectrum Enforcement Division:

Complaints must be in writing and must include as much of the following information as possible: (1) the call sign and address of the station experiencing the interference, (2) the telephone number of a contact person for the station, (3) the frequency on which the complaining station operates; (4) a detailed description of the nature of the interference, including the duration and frequency of the occurrence of interference; (5) the call sign and address of the station believed to be the source of the interference; (6) the frequency on which the alleged interfering station operates; (7) the

provision of the Communications Act, Commission rule, order or station authorization believed to have been violated by the alleged source of the interference, and (8) any documentation supporting the alleged existence and cause of the interference.

VIEWPOINT 1

No change

VIEWPOINT 2

This Section 7.3 should be removed. It is understood by the industry that the FCC Spectrum Enforcement Bureau is always available to assist in interference issues.

CONCLUSION:

The process outlined in this section provides a detailed set of recommended procedures and recommended course of action for interference sources used for interference reporting by FS operators. Agreement on procedures for interference reporting could not be reached by the FS incumbents and new entrants. As a result, both viewpoints are included.

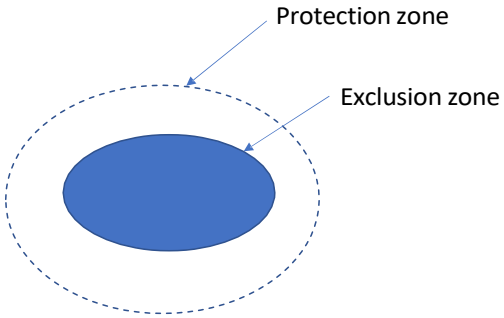
8 Interference Resolution

PROBLEM STATEMENT:

Provide best practices and recommended procedures for interference resolution that were not identified by the FCC.

Definitions:

- Exclusion zone: The area computed by the AFC using a specific interference protection criterion to prevent harmful interference to fixed microwave link receivers. (R&O paragraph 68)
- Protection zone: An added area around the exclusion zone as a result of interference detection as defined by the interference resolution process.



FINDINGS:

Consensus was not reached within 6GHz MSG on a set of recommended procedures and recommended course of action for interference resolution by FS operators. Instead, two alternative viewpoints are

presented that address procedures for resolving interference. In general, Viewpoint 1 is offered by FS incumbents and Viewpoint 2 is offered by the new entrants.

8.1 Recommended Procedure

VIEWPOINT 1

Under Viewpoint 1, the FS incumbents and new entrants are not co-equal, meaning that new entrants (including AFC operators) bear the responsibility to prevent, detect, and remedy interference they cause to incumbents. Further, incumbent microwave receivers did not need to be designed, and are not presently capable of, detecting interference or identifying the interfering source, including being able to delineate between a low power device and a standard power device under AFC control. Incumbents, particularly public safety, do not have the resources to dedicate to interference resolution – their main role is to carry out their public safety missions. The FCC should have a record of reports of interference to public safety communications. Therefore, the FS incumbents' views on interference resolution are guided by these realities.

- AFC operators' actions upon receipt of an interference report
  - Create a temporary 30-day effective exclusion zone around the affected station
    - 10 km extension of the prior exclusion zone being applied to the affected station
  - AFC operators do not issue or renew co-channel assignments in the temporary effective exclusion zone for frequencies contained in the interference report
  - Concurrently, the AFC operators will (1) work together to mitigate interference and to implement corrective actions to particular APs and (2) take an experimental approach to validate interference such as perform field interference testing (may be performed by reciprocity, i.e. measuring TX receive field strength via drive testing)
- AFC operators shall also experimentally determine a permanent effective exclusion zone if needed to correct the interference
- In the event interference is unable to be resolved by AFC operators, AFC operators will (a) report to a voluntary industry-native independent Working Group, and (b) report to the FCC Enforcement Bureau to assist the FCC's investigation and determination of appropriate action.

VIEWPOINT 2

Under Viewpoint 2, the FS incumbents would report interference directly to the AFC operators who would, in turn, work with all stakeholders to resolve. The exchange of detailed technical information between the FS incumbents and AFC operators allows for a more efficient process and a faster resolution. This is a collaborative, industry driven approach that allows AFC operators to resolve interference concerns depending upon the specifics of the situation.

- AFC operators' actions upon receipt of an initial interference report as documented per section 7.1.
  - AFC operators and incumbent FS review and validate interference report
  - Create a temporary (up to) 30-day effective protection zone around the affected station

    - AFC operators do not issue or renew co-channel assignments in the temporary effective protection zone for frequencies contained and demonstrated in the interference report
    - Concurrently, (1) the incumbent FS and AFC operators will work together to mitigate interference in good faith to eliminate protection zone or make it as minimal as possible (i.e. reducing new entrant power, channel availability, location, etc.) (2) an experimental approach can be used to validate interference such as perform field interference testing (may be performed by reciprocity, i.e. measuring TX receive field strength via drive testing). Interference measurement data may be provided to AFC operators to help identify and mitigate interference. There is no expectation that AFC operators will be required to perform field interference testing.
    - If mitigation techniques resolve the interference, the protection zone is removed.
- In the event interference is unable to be resolved, experimentally determine a permanent effective protection zone
    - May include isosceles triangle in front of the station and radius around the station for sidelobes and backlobes
    - Incumbent FS to provide a final harmful interference demonstration to all AFC operators per section 7.1.
    - Incumbent FS to present a permanent effective protection zone proposal to all AFC operators
- AFC operators' actions upon receipt of a final interference report
    - If it is determined that final harmful interference demonstration justifies proposed protection zone: temporary effective exclusion zone replaced with permanent exclusion zone for the affected station
    - If it is determined that final harmful interference demonstration does not justify proposed protection zone: temporary effective exclusion zone not replaced with permanent exclusion zone for the affected station
    - Fixed Service (FS) operators may file a harmful interference complaint with the FCC if they disagree with an AFC operator's determination that the proposed protection zone was not supported

CONCLUSION:

This section provides a set of recommended procedures for interference resolution. Agreement on procedures for interference resolution could not be reached by FS incumbents and new entrants. As a result, both viewpoints are included.

9 Topics where no consensus was reached

There are several topics where no consensus was reached. These are listed below with a description and viewpoints.

1) Interference resolution where interference source is either a Low Power Indoor or AFC-Controlled Device– addressing additional options for resolution for specific cases.

- Viewpoint 1: Further study is required to address interference resolution options for Low Power Indoor and AFC-controlled devices.

- Viewpoint 2: Section 8 provides interference resolution for Low Power Indoor and AFC-controlled devices.

2) Identification of costs involved during interference detection investigation (i.e. baseline performance measurements)
- Viewpoint 1: A division of responsibility between Licensed Incumbents and RLAN Manufacturers is recommended with an identification of costs involved.
- Viewpoint 2: Responsibility and identification of cost is out of scope of the6GHz MSG .

3) Division of responsibility and identification of costs involved with interference detection, reporting, and resolution due to operations of both low and standard power devices

- Viewpoint 1: A division of responsibility between Licensed Incumbents and RLAN Manufacturers is recommended with an identification of costs involved. Costs will clearly be incurred beginning with efforts to baseline the current environment prior to the introduction of unlicensed devices, and these costs should not be borne by incumbents.
- Viewpoint 2: Responsibility and identification of cost is out of scope of the 6GHz MSG .

4) Testing
- Viewpoint 1: The Report & Order in paragraph 177 encouraged the Multi Stakeholder Group to "work cooperatively to develop and test devices to aid in the goal of developing processes for introducing and operating devices across the 6GHz band".
- Viewpoint 2: Testing is outside the scope of the Work Stream 1 charter and should not be addressed.

10 Participant Contributions

Below is a list of participant contributions. Contributions are publicly available on the WInnForum website: https://groups.wirelessinnovation.org/wg/6GHz-MSG-WS1/document

- WS1 Final Report v0.18 (WS1 co-chairs)
- WS1 Final Report v0.17 (Commscope comments 4.18.22) r1 (Southern edits 4.20.2022).docx
- WS1 Final Report v0.17 (HPE comments).docx
- Comments on WS1 Final Report v0.17r1(AT&T).docx (AT&T)
- WS1 Final Report v0.17 (EEI comments).docx (EEI)
- WS1 Final Report v0.17 (Commscope comments 4.18.22) r1.docx (Commscope)
- WS1 Final Report v0.17 (WS1 co-chairs)
- WS1 Final Report v0.16 (working copy)-r7 hmg comments (Commscope)
- WS1 Final Report v0.16 (working copy)-r7 (WS1 co-chairs)
- Proposed edits to WS1 Final Report sections 7 and 8 (CableLabs/NCTA) (2.24.22)
- Summary of Concerns with MSG WS#1 Report (v0.15)-Section 10 (WFA) (2.10.22)
- Contribution to WS1 from Incumbent Companies on Non-Consensus Items (Southern) (2.10.22)
- CBRS Ix Reporting Procedure for MSG WS1 220127 (Commscope) (1.27.22)
- 'WS1 Final Report v0.15' (APCO) (12.16.21)
- Section 4 'RLAN Signal Characteristics' (Broadcom) (12.2.21)
- 'WS1 Final Report v0.14a' (Southern) (12.2.21)
- 'WS1 Final Report v0.13' (WS1 Co-Chairs)
- Contribution on Section 4.2.3 CBP (EPRI) (11.4.21)
- WS1 Final Report v0.11 (EPRI, HPE) (11.2.21)
- WS1 Final Report v0.10 WS1 Chairs (9.23.21)
- Contribution "Text Revision Section 4 Preventing Interference_092321" (Guy Ball, APCO)
- 'WS1 Final Report v0.9' (WS1 Chairs) 9-23-2021
- 'WS1 Final Report v0.7' (CableLabs) 9-9-21
- Contribution_ Proposed Revision of Text for WS1 Final Report v0.7 Section 4 (APCO) 9-9-21
- Update to Nokia contribution "WS1 Final Report v0.6_EPRI_081321.docx" incorporating WS1 discussion and comments during 8/12 meeting (Doug Davies) 8-26-21
- "WS1 Final Report v0.3_BRCM_25Aug2021_APCO Edits" (Guy Ball) 8-26-21
- Revision to Nokia contribution (6.30.21) to WS1 Report per WS1 comments from 7.29 meeting (8-12-21)
- Broadcom contribution to WS1 Report (WS1 Final Report v0.3_BRCM 8.11.21)
- Contribution to WS1 Final Report v0.4_Nokia_2021-06-30.docx (Nokia) (7.29.21)
- Follow-up contribution on LPI Field Testing in Columbus, GA (EPRI)
- WS1 Final Report v0.2_EPRI_06162 Aviat 062921 v2 (7.1.21)
- Contribution of section 2 for WS1 Final Report (NCTA, CableLabs) (7.1.21)
- WS1 Final Report (initial draft 0.2) (EPRI) (6.17.21)
- WS1 Final Report (initial draft 0.1) (Co-Chairs) (5.20.21)
- Preliminary update on LPI field testing (EPRI/Southern) (5.6.21)
- "Measurement methods and threshold that characterize a Fixed Service radio response to interference" (Nokia) (4.8.21)

- Considerations and Methodology for Interference Detection in Point-to-Point Microwave Links" (Aviat) (3.25.21)
- Contribution from APCO – "Edits to Draft Final Report Outline" (3.11.21)
- EPRI Workstream Report Outline (2.11.21)
- EPRI Peoria LPI interference test preliminary results (1.14.21)
- UTC Contribution on Testing Approaches (1.14.21)
- Southern additions to "Harmful Interference Detection, Reporting & Resolution" (12.15.20)
- Framework for "Harmful Interference Detection, Reporting & Resolution" procedure (EPRI) (11.19.20)
- Southern Submission on Harmful Interference and Detection (11.16.20)

11 ANNEX

11.1 ANNEX A: Abbreviations

Abbreviations

ACM	adaptive coding and modulation
AFC	automated frequency coordination
BER	1) bit error rate; 2) bit error ratio
dB	decibel
dBm	decibel milliwatt
CLI	Command-Line Interface
CSMA/CA	carrier sense multiple access with collision avoidance
EIRP	equivalent isotropic radiated power
FCC	Federal Communications Commission
FS	fixed service
GHz	gigahertz
I/N	interference-to-noise power ratio
ITU-R	International Telecommunication Union Radiocommunication Sector
km	kilometer
LPI	low-power indoor
MSG	multi-stakeholder group
NMS	Network Management System
RF	radio frequency
RLAN	radio local area network
R&O	report and order
RSL	receive signal level
SNR	signal-to-noise ratio
TWG	technical working group
U-NII	Unlicensed National Information Infrastructure

11.2 ANNEX B: MSG Work Stream 1 Membership

Participants listed below participated in developing this document .

- Tim Godfrey (EPRI) - Co-chair
- Mark Poletti (CableLabs) - Co-chair
- Guy Ball (APCO) – Co-chair - Technical Editor
- Prabodh Varshney (Nokia)
- Kasey Chow (Southern Company)
- Alan Tilles (APCO)
- Andy Scott (NCTA)
- Aryeh Fishman (EEI)
- Audrey Connors (Charter)
- Fabiano Chaves (Nokia)
- J. J. Stutler (Evergy)
- Jeff Cohen (APCO)
- Katz, Jeffrey H. (PSEG)
- Mike Bergman (CTA)
- Neeti Tandon
- Tom McPherson (AEP)
- Will Perkins (Comsearch)
- Thomas Willis (AT&T Labs)
- Chris Helzer (Cable Labs)
- Vikas Sarawat (Charter)
- Joe Attanasio (Comcast)
- Mark Gibson (Commscope)
- Rob Mitchell (Dominion Energy)
- Jay Herman (EPRI)
- Chuck Lukaszewski (HPE)
- Navin Hathiramani (Nokia)
- [Qualcomm] Tevfik Yucek
- Naotaka Sato (Sony)
- Sho Furuichi (Sony)
- Andrew Lynam (US Cellular)
- Iceflatline
- Sam Sambasivan (AT&T)
- Dhivya Kanthi (Cisco)
- Gordon Collins (Southern Company)
- Riku Pirhonen (NXP)
- Mark Reddish (APCO)
- Matt Mangriotis (Cambium Networks)
- Gerald Garnier (RED Technologies SAS)
- Yi-ling Chao (NXP)
- Peter Ecclesine (Cisco)
- Brett Kilbourne (UTC)
- Dave Hattey (Southern Company)
- Michael Tseytlin (Facebook)

- Tom Dombrowsky (Southern Company)
- Richard Burnhardt
- William Carney (Sony)
- Albert Petrick
- Benjamin Rolf (UWB)
- Chris Szymanski (Broadcom)
- Thomas Hervier (RED Tchnologies SAS)
- Kevin Gifford: University of Colorado-Boulder
- Indermeet Gandhi (Cisco)
- Don Root (NPSTC)
- Alex Roytblatt
- Tom Willis (ATT)
- Masoud Olfat (Federated Wireless, LLC
- George Hart (RCI)
- Christopher Richards (Ericsson)
- Eric Wagner (UTC)
- Jay Devadoss (SCE)

11.3 ANNEX C: Non-Consensus Items

The views contained within this Annex are from specific MSG participants, and do not represent the consensus of the MSG. An Annex is not normative to the MSG work product, is not a position of, or endorsed by or supported by the MSG. The MSG does not take any position on contents of this Annex. The MSG does not advocate for or against any regulations, including those based on this Annex.

There were four topics where consensus was not reached among the WS1 participants. This Annex was created in response to the concern that these topics either address a modification to existing FCC rules and regulations or directly respond to a subject of an open proceeding and are considered to be outside the scope of the 6 GHz MSG Terms of Reference (Annex D). The alternative view among participants is that the topics do not address FCC rules, or open proceedings, and are within the 6 GHz MSG scope as requested by the FCC, and therefore require further discussion. The topics presented in this Annex differ from Section 9. Section 9 addresses topics that are considered to be within the FCC R&O MSG intention and scope where consensus could not be reached.

This Annex provides the differing viewpoints of these topics. The 6 GHz MSG and WS1 do not advocate (1) any FCC R&O rule change and (2) any change to any open proceeding irrespective of the viewpoint or positions presented. This is strictly a record of the differing viewpoints.

FS Incumbents and associations representing FS incumbents that participated in the 6 GHz MSG and WS1 consider these topics to be an essential part of 6 GHz R&O MSG intention and should be documented in the WS1 report. New entrants and trade associations representing new entrants that participated in the 6 GHz MSG and WS1 consider these topics to be in conflict with existing FCC R&O rules, FCC open proceedings, 6 GHz Terms of Reference and out of scope of the WS1 objective to generate a report of procedures/best practices on detection of interference, resolution, reporting.

The four topics where consensus was not reached are described below. In general, the FCC R&O is presented as background and Viewpoint 1 is offered by the FS incumbents and viewpoint 2 is offered by the new entrants as described above.

1) Effectiveness of contention-based protocol (CBP) as a means to prevent interference to incumbents.

   - **6 GHz R&O para ¶101:** The FCC R&O in ¶101 "require[s] that the indoor low-power devices, both access points and their associated client devices, employ a contention-based protocol. Adopting such a requirement is suggested by CableLabs, Comcast, Charter, and Cox as a means of providing assurance that incumbent operations will not be harmed." The FCC requires contention-based protocol "to ensure efficient and cooperative shared use of the spectrum."
   - **Viewpoint 1**: ¶101 provides no analysis or conclusion regarding this statement. Also, there is concern about the FDD nature of incumbent operations (receive and transmit frequencies are offset) and the ability of CBP to effect operation of RLAN systems out of range of each other but still along the path of FS systems. Additionally, point to point transmissions of many licensed incumbents are continuous in nature and their equipment was never designed to be shared with other co-channel systems (unlike Wi-Fi equipment, where this is a fundamental requirement). Incumbent microwave system licensees sought to have technical discussions about how CBP would be implemented and how it would protect their systems to examine the effectiveness of CBP to prevent interference to incumbents.
   - **Viewpoint 2**: Agrees with FCC R&O and rules and believe no changes are necessary.

2) The effects of aggregate or additive interference from multiple unlicensed access point or client devices to incumbent systems.

   - **6 GHz FCC R&O para 72 *states:*** "*Aggregate interference*. The Commission did not propose, nor do we find that there is any need, to consider the effect of aggregate interference from multiple access points to point-to-point microwave links…" and notes that "the risk of interference from large numbers of standard power access points would not be due to signal aggregation from multiple unlicensed devices, but from a single standard-power access point in or near the main beam of a microwave link receive antenna with little or no intervening clutter."
   - **Viewpoint 1:** The Report & Order in paragraph 72 (among other mentions) dismisses the effects of multiple access points producing an aggregate interference level based on submittals from unlicensed proponents. Studies from Cable Labs and RKF were cited in multiple locations. Aggregate or Additive interference levels are real and driven by basic laws of physics and the probability of multiple RLAN networks in areas prone to interfere with licensed operations being driven by the small number of broadband channels combined with the large number of potential RLAN networks predicted by proponent's market forecasts and historical Wi-Fi penetration. Furthermore, the omission of beacon transmissions in all proponent submittals including the RKF and Cable Labs studies significantly understates interference probability.
   - **Viewpoint 2**: Agrees with FCC R&O and rules and believe no changes are necessary.

3) Fade Margin on licensed microwave links provides interference protection for those links and the effects of degradation of the fade margin are inconsequential.

- **6 GHz R&O, Footnote 179:** "We are cognizant of the Fixed Wireless Communications Coalition's claim that microwave links have no excess fade margin and that harmful interference will reduce the reliability of the microwave link. Because we have concluded based on the technical studies that harmful interference will not occur, permitting low-power indoor unlicensed devices will not reduce the reliability of the microwave links."
  - **Viewpoint 1:** The Report & Order in paragraph 21 and footnote 175 (among other mentions) agrees with the submissions of proponents that the large fade margins of licensed microwave links protect them from interference. Licensed microwave link fade margins are necessary to provide the high reliability required of these links (typically 99.999%.) Critical Infrastructure requirements are based on decades of experience and industry standards, notably ITU-R P.530. Fade Margins on microwave links were designed around impacts from weather conditions and multipath that result in signal fading and resulting in a loss of reliability. The further reduction in fade margin contributed by interference could greatly impact the number of minutes per year that weather or multipath will fade a path from operational service. Many licensed incumbents, design microwave paths with weather and multipath-induced fade margins that result in annual uptime of no less than 99.999% (5.25 outage minutes). The safe and reliable operation of the nation's electrical grid and public safety networks require large microwave fade margins to minimize communication interruptions over these licensed links. Furthermore, these licensed links are most critical during inclement weather, which is the precise time when the links are operating with the smallest margins. Licensees desired to conduct testing between systems to determine the interference effects to microwave systems under conditions that degrade the fade margin.
  - **Viewpoint 2**: Agrees with FCC R&O and rules and believe no changes are necessary.

4) Atmospheric Fades do not occur during Wi-Fi busy periods.

- **6 GHz R&O, para 143:** [on the issue of atmospheric fade] **"**we conclude that the likelihood of harmful interference to fixed service microwave links from indoor low power Wi-Fi access points is insignificant. " The Report & Order in paragraph 143 and footnote 377 (among other mentions) notes that licensed microwave link degradation will only occur if a deep atmospheric multipath fade occurs and that the time period of deep fades is the 8 hours after midnight which does not overlap with the Wi-Fi access point peak usage time.
  - **Viewpoint 1:** Real world experience and research by Bell Labs entered into the record before the Report & Order shows deep fades occur during a much broader time frame, especially in the southeast US, which overlaps with Wi-Fi peak use periods. Furthermore, post Report & Order real world testing and measurements demonstrated deep fades occurring commonly through 11AM. While fading may be more prevalent during certain times of the day or night from multipath, microwave path fades can and do occur at any time of the day or night during heavy rainfall. It is during storm conditions that reliable communications become even more critical to the utility industry and public safety networks for the safe and reliable operation of the electrical grid and public safety networks. To overlook these path fades that can occur at any time would be imprudent. Incumbent microwave system licensees sought to have a technical discussion and potentially engage in other testing to address this issue as part of WS1.
  - **Viewpoint 2**: Agrees with FCC R&O and rules and believe no changes are necessary.

11.4 ANNEX D: 6GHz MSG Scope of Work and MSG Terms of Reference

Scope of Work (agreed upon by participants in developing this document)

1) Process for detecting harmful interference to licensed incumbents
2) Process to measure and identify sources of harmful interference
3) Process for harmful interference reporting and for interference mitigation and resolution
4) Characterization of U-NII device(s) signals to aid in processes above
5) Vendor equipment availability for testing

Outcome

- Report(s) to document contributions, discussions, best practices available to all participants that is non-binding to all participants

6 GHz MSG Scope of Work for Developing this Document

- Process for detecting harmful interference to licensed incumbents
- Process to measure and identify sources of harmful interference
- Process for harmful interference reporting and for interference mitigation and resolution
- Characterization of U-NII device(s) signals to aid in processes above

6 GHz MSG Terms of Reference

1. 6 GHz MSG is an informal assembly of industry interests for the purpose to recommend best practices concerning unlicensed operations in the 5.925-7.125 GHz ("6 GHz band") in response to the 6 GHz R&O

    a. 6 GHz MSG shall have an open membership structure; participation is open to all pertinent stakeholder associations, trade groups and their members; 6 GHz MSG members must register and declare affiliation

    b. 6 GHz MSG shall have no legal responsibilities and its recommendations shall be nonbinding

2. 6 GHz MSG shall limit its recommendations to:

    a. Best practices concerning unlicensed operations in 5.925-7.125 GHz

    b. Information for standards development organizations

    c. As appropriate, technical and operational recommendations to the FCC's Office of Engineering and Technology

3. 6 GHz MSG shall not consider:

    a. Topics that directly respond to a subject of an open proceedings (e.g. 6 GHz FNPRM)

    b. Modifications to the existing FCC rules and regulations

4. 6 GHz MSG shall act by consensus. Consensus mean the general agreement of the participants. This means the process of the group requires consideration of all views, proposals and objections, and good faith endeavors to reconcile them. Where consensus is not possible, the group, including all working groups, should strive to make decisions that are supported by the available information and to document opposing views or abstentions. The achievement of consensus should be based on thorough examination of issues, including the discussion of dissenting opinions and the resolution of disagreement. If unanimous agreement cannot be achieved, then members shall have an opportunity to provide alternative views in its output without quantifying support for these views.
5. 6 GHz MSG will consider guidance from the FCC's Office of Engineering and Technology on the topics on which it would be most helpful for the Commission to receive input and a sense of the time frames in which such input would be helpful (see 6 GHz R&O para. 180)