TECHNICAL BULLETIN for Operators of 6 GHz Microwave Systems

Suggested baseline measurements in preparation for expected interference from unlicensed devices

To: Public Safety Operators of 6 GHz Fixed Point-to-Point microwave systems

Purpose: The purpose of this Technical Bulletin is to advise public safety agencies operating 6 GHz point-to-point microwave systems of the importance of managing/archiving baseline performance measurements in preparation for expected harmful interference that may be caused by new unlicensed operations in the band and to update those measurements on an as needed basis. Baseline measurements document current system operating parameters/measurements in advance so that future operating parameters can be compared to the archived operating parameters in the event of a degradation of system performance.

Background: In 2020, the FCC adopted rules for the 6 GHz band that will allow hundreds of millions of unlicensed devices to operate across the entire band. The FCC authorized two distinct types of these new Wi-Fi devices: “standard power” devices that are subject to automated frequency coordination (AFC), and “low power indoor” (LPI) devices. We are concerned that these devices present an interference risk to public safety because despite our requests, the FCC did not require testing in advance, ensure effective measures are in place to prevent interference, or adopt measures to quickly detect, identify, and eliminate interference when it occurs.

The FCC encouraged the establishment of a voluntary multistakeholder group (MSG) to address several technical issues. In a recent report filed with the FCC, the MSG

identified the need to conduct baseline performance measurements for all existing incumbent microwave receivers.[1] LPI devices are already being marketed and sold to consumers, which means public safety microwave receivers could be impacted already, degrading link performance parameters and the true baseline by the day. Neither the MSG nor the FCC accounted for the costs and impacts to service that will result. Yet it is critical to protect mission critical operations by maintaining and securely storing system "baseline" data records. Baseline data can be useful when performing regularly scheduled maintenance as well as troubleshooting interference (i.e., due to an unlicensed device).

Fixed Station Microwave Systems at Higher Risk: Microwave receivers installed on rooftops (or towers) in urban and/or suburban areas with large buildings (i.e., apartment buildings or hotels) within the boresight of the antennas are at the highest risk of experiencing interference from unlicensed devices (See Figure 1).

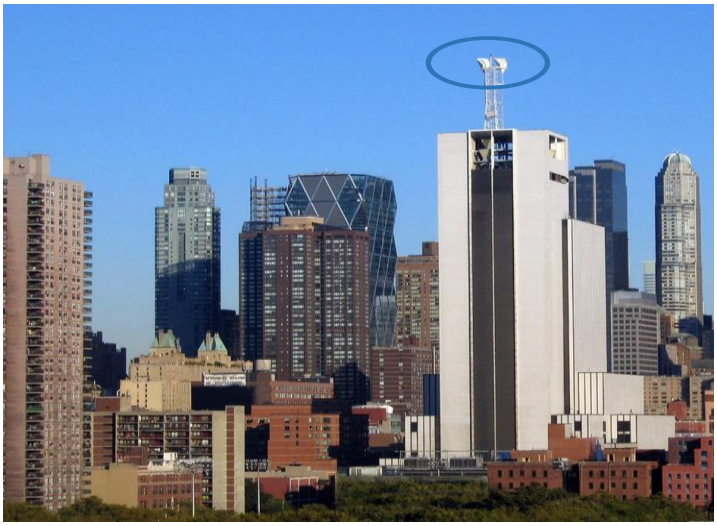

Figure 1. Microwave antennas in Brooklyn, NY

An outdoor unlicensed device at ground level a half a mile away can be within the boresight of the microwave antenna installed on a 100-foot tower and can cause interference up to tens of miles away (See Figure 2).

[1] Letter from Richard Bernhardt, Don Root, Edgar Figueroa, and Brett Kilbourne, Chairs of the 6 GHz Multi-Stakeholder Group to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 18-295 (filed July 11, 2022), *attaching* "Best Practices and Recommended Procedures for Interference Detection, Reporting, and Resolution to Protect Fixed Microwave Service Receivers in the 6 GHz Band."

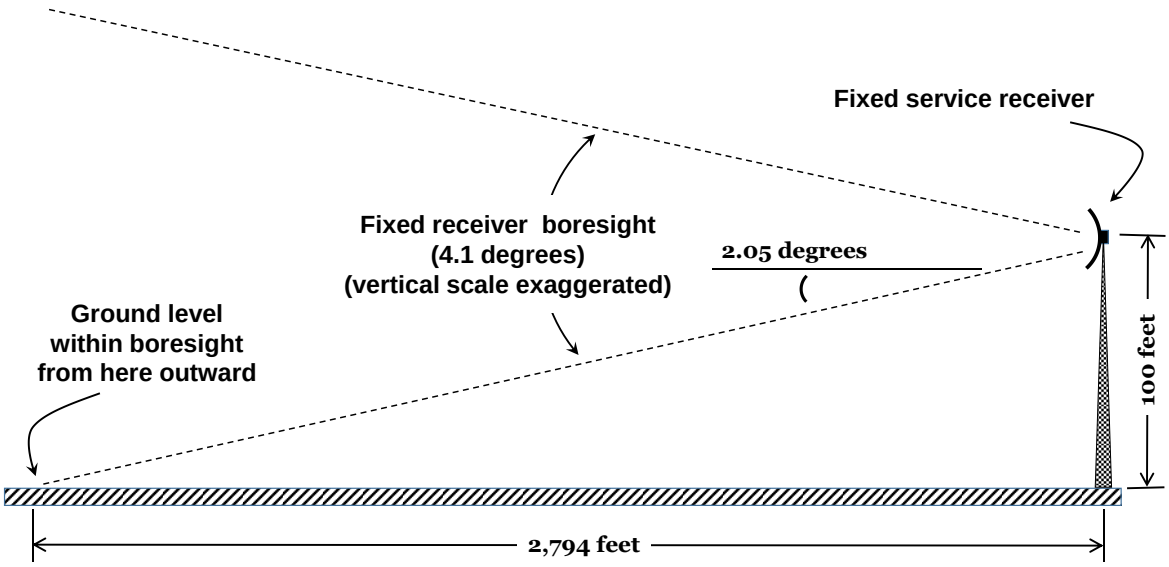

Figure 2: FS receiver boresight reaches ground level 0.53 miles from 100 ft. tower

Furthermore, LPI devices operated in a tall residential or office building, or nearby house, could threaten interference at a very short distance if it is within the boresight of the microwave antenna (See Figure 3).

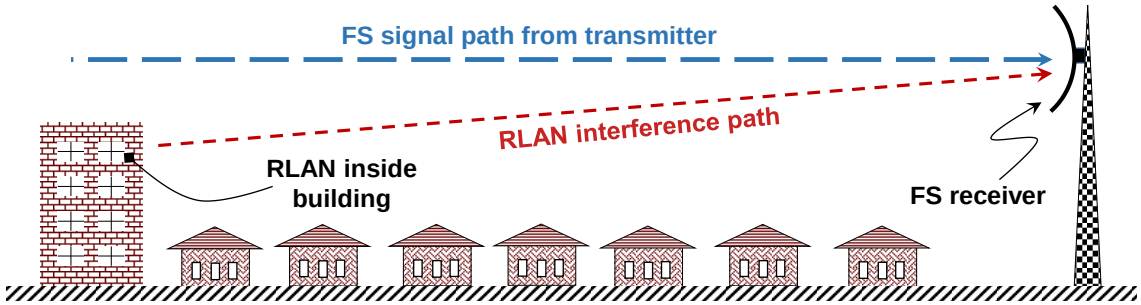

Figure 3: RLAN interference from indoor operation building (horizontal scale compressed)

Suggested Baseline Performance Measurements for a new microwave path: Measurement of baseline performance indicators can be obtained using a variety of methods. The preferred method of acquiring the measurements for a new radio path is to include them in the contractor scope of work to be performed during link commissioning immediately following installation. A copy of the baseline measurements as well as the path design should be obtained and archived for future reference.

Some suggested baseline parameters to be measured at the time of installation and compared to the path design at both sites of a microwave link are:

1. RSL (dBm): The measured receive level should be within +/- 3dB of the design level.
2. Transmit Power (dBm)
3. Modulation Type: If ACM (Adaptive Coding and Modulation) is in use document the highest QAM level.
4. Throughput (Mbit/s)
5. Measured Bit Error Rate
6. Transmit and Receive Frequencies
7. Fade Margin Test
8. Measurement of the Noise Floor (dBm)

Suggested Baseline Performance Measurements for an existing microwave path: Agencies with existing microwave paths that do not have baseline performance measurements available can perform them using either the non-Service or Service affecting methods. Older microwave radios that do not have modern software may be required to use the service affecting method to perform the measurements.

Non-Service Affecting Method: Most modern microwave radio vendors have integrated software that can measure internal baseline parameters and include recommended test procedures. For example, it is possible to measure transmit and receive levels at the near end site as well as the far end site of a radio path without disassembling waveguide or introducing test fixtures. Additionally, critical baseline parameters can be downloaded for periods of weeks (or months), and then graphed to show trends during a defined test period. Furthermore, radios supporting adaptive modulation can provide reports showing the stability of the adaptive modulation level over time. Stability of a radio system in the 6 GHz band is typically affected by interference or fading of the radio signal through the atmosphere (i.e., due to multipath, reflections, ducting, etc.) resulting in a down-shift from a higher to a lower modulation (i.e., 4096QAM to 1024QAM) resulting in less data throughput.

Below are some suggestions to measure a baseline using non-service affecting integrated software in the radio. The tests can be initiated at any time and report

the stability of the current system performance so that it can be compared to system performance at some future date.

1. ACM Stability Tests: Reports showing the modulation levels as they vary in time can be prepared prior to the introduction of future unwanted interference for radios employing ACM (Adaptive Coding and Modulation).
2. Bit Error Rate Tests: Bit Error Rate test can be carried out and documented for future reference.
3. Receive Level: The receive level can be measured and documented for future reference.
4. Path Availability and Throughput: Some manufacturers' software offer the ability to measure the current Path Availability and Data Throughput. Longer system degradation with a reduced average throughput can be an indication that the system is receiving unwanted interference from an external source.
5. Signal to Noise Ratio (SNR) or Mean Square Error: Current, min, max.
6. Fade Margin: Targeted and Current Fade Margin (FM) value.

Suggested Service Affecting Method: The Fade margin test is an example of a service affecting test. The purpose of the test is to determine the Receiver Threshold of a near end receiver by incrementally attenuating the far-end transmitter until a bit error rate of 10E-6 is achieved and measuring the corresponding receive level (dBm). The measured receive level (dBm) is the actual receiver threshold (dBm) value and can be compared to the receiver threshold as documented in the manufacturer's specification. The receiver threshold is degraded if the value is higher than the manufacturer's specifications. The final step would be to turn off the far end transmitter and measure the noise floor (dBm). An analysis of the test results and path engineering can be used to determine if the antennas require re-alignment, or if unwanted interference is being received from an external source.

The exact test procedure will vary depending on the make, model, and equipment configuration, as well as the operating parameters of the link. Therefore, it is recommended to consult the equipment manufacturer regarding baseline measurements for the radio system in use. For example, some agencies deploy

all-indoor radios with the equipment and active components installed in an indoor shelter. Alternatively, some agencies utilize split-mount radios consisting of an indoor unit (IDU) mounted in an indoor shelter, and an outdoor unit (ODU) which connects directly to an antenna on a tower or rooftop. Testing of Split-Mount systems may be limited to those installations with the outdoor unit installed at ground level or on a rooftop if fixed attenuators are required to be inserted between the ODU and antenna.

If a copy of the Fade Margin Test is not currently available, we suggest using the integrated software of the radio and Non-Service Affecting methods to perform baseline measurements as previously described. Agencies with older radio systems without integrated software and enhanced monitoring capabilities may be required to perform the Service Affecting fade margin test to measure the necessary baseline parameters.

Annex:

The annex contains some suggested baseline testing examples using the Non-Service Affecting and Service Affecting Methods.

Non-Service Affecting Method

It is possible for agencies using integrated software and enhanced monitoring capabilities to perform baseline performance measurements without affecting service:

1. Using the Fixed Station craft-tool, Command Line interface (CLI), or Network Management system (NMS), capture the 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 Coding 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).

2. Verification Process
   - Measured values should be consistent with as-built reports or path calculation. This will usually include but not be 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.

Service-Affecting Method

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.)

1. Perform transmit power measurements for all transmitters for path.
2. Baseline existing interference environment for each path (if possible)
   - Requires turning off each path's transmitters to take baseline measurements. (Note: this is one option and may not be possible.)
   - Use adapters to connect spectrum analyzer to receive waveguide port. (Note: some systems could be using ODUs (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.
   - Save digital image of above referenced captured bandwidth.
3. 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.

4. 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.