District of Columbia's Public Safety In-Building Radio Systems

Existing Coverage Testing

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Version 1.0

GOVERNMENT OF THE DISTRICT OF COLUMBIA
Office of Unified Communications, Washington, DC

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1 Introduction

Increasingly, public safety entities, commercial wireless service providers, and wireless users require reliable communications inside buildings and inside tunnels. For public safety, reliable two-way communications are essential throughout the whole geographical area of a jurisdiction including on-street, in tunnels and within buildings.

Effective January 2015, the District of Columbia has adopted a legislation mandating radio coverage for newly constructed buildings as recommended by the International Fire Code (see http://dcregs.dc.gov/Gateway/RuleHome.aspx?RuleNumber=12-H510). This legislation therefore results into the deployment of numerous in-building radio systems repeating signals from the District public safety radio network (host network) into the depth of the city's buildings. While the Bi-Directional Amplifiers (BDA) and Distributed Antennas Systems (DAS) that make up in-building radio systems do effectively enhance coverage, they also have the potential to negatively affect both in-building and overall radio network coverage if not properly designed, installed, and maintained. Furthermore, without proper BDA/DAS records management, locating in-building systems that interfere with the network can be very challenging.

The code specifies that "emergency responder radio coverage systems and related equipment shall comply with all additional requirements, specifications and criteria established by the District of Columbia Office of Unified Communications to satisfy the operational needs of emergency responders and to prevent adverse impact on the District of Columbia's public safety communications". The set of documents that constitutes the additional requirements, specifications and criteria established by the District of Columbia Office of Unified Communications is available at https://ouc.dc.gov/page/oucs-public-safety-building-radio-systems-requirements. It includes:

- A presentation giving an overview of the process
- A document describing in detail the process for the District validation of public safety in-building repeater systems.
- A document describing the OUC technical requirements for those systems
- A document describing the OUC systems acceptance testing process
- A document describing the annual testing requirements
- Various forms supporting the process

The purpose of this set of documents is to serve as a reference guide to outline how in-building BDA and DAS Systems shall be designed and deployed to provide emergency responders radio coverage in buildings throughout the District of Columbia. Those documents are provided to relevant organizations to facilitate the process of implementing and operating BDAs and DAS that will provide the required radio services and not adversely affect the mission critical radio network that the Office of Unified Communications (OUC) of the District of Columbia.

This specific document describes the process for testing coverage in buildings that have no BDA installed. This process is required to determine if a BDA is required in the building. Process of the Public Safety In-building Radio Systems in the District of Columbia.

2 Procedure Overview

2.1 Tasks outline

This acceptance test is limited to radio functions and does not assess if the system installation complies with the Fire Code, that task being the Fire department's and DC Regulation Authority responsibility. The system shall stay "off" and not transmitting until the next steps are completed. The objective is to ensure that the first responders obtain the required quality of service while ensuring the public safety radio network is not degraded by the implementation of the in-building repeater system. The acceptance process includes the following steps:

1. PRE-REQUISITES
2. REVIEW DOCUMENTATION PROVIDED BY THE VENDOR
3. ACCEPTANCE TEST PREPARATION
4. REMOTE ACCESS CHECK:
5. SITE INSPECTION
6. BDA COMPLIANCE AND CONFIGURATION CHECK
7. UPLINK NOISE CONTRIBUTION EVALUATION
8. BDA GAIN ADJUSTMENT
9. UPLINK NOISE CONTRIBUTION EVALUATION
10. UPLINK SQUELCH ADJUSTMENT
11. ISOLATION TEST
12. FREQUENCIES AVAILABILITY VERIFICATION
13. AUDIO TEST
14. COVERAGE TEST AND DATA COLLECTION

2.2 Building Owner/Manager Responsibilities

The owner of the building is responsible for:

- Fund the testing and any troubleshooting and repairs costs if necessary
- Contract one of the OUC approved vendors to perform the testing
- Schedule with the approved vendor and the OUC the testing itself
- In case of deficiencies, investigating the cause of the issue(s)
- Fixing deficient equipment or configurations until meeting requirements.

A significantly number of buildings are built to be occupied by offices or for commercial use.

It might take a few months, sometimes years to rent all floors out. Meanwhile, some of the building interiors might not be completed when coming to perform a Public safety DAS test (floors without interior walls, no ceilings, etc.)

In that case the building is not complete i.e. the whole building still needs to be tested. The testing staff shall note which floors are not physically complete.

The transmission authorization letter sent by the OUC will specifically include which floors were complete when testing occurred and which floors were not. The letter will also explain that when significant modification will be made to the building affecting radio waves propagation and/or levels of interference, the building owner shall perform again a public safety BDA/DAS test at his cost using one of the OUC approved vendors. A non-exhaustive list of modifications affecting radio propagation includes:

- adding interior/exterior walls, ceiling, partitions,
- extending the Distributed Antennas System
- implementing additional wireless systems (internal systems or cellular systems for instance)

The extent of the test will depend on the modifications made to the building. It will be determined on a per case basis.

2.3 Deliverables

1. Updated OUC Uplink Budget spreadsheet:
    1. Design modifications need to be included in the “Designer ‘s Settings” tab
    2. Measurements need to be included in the “Objectives vs. Measurements” tab
2. Acceptance Test Checklist & results (see document 6.6 Acceptance testing checklist on this web page: https://ouc.dc.gov/page/oucs-public-safety-building-radio-systems-requirements)
    1. Information requested in the header tab
    2. Checks and values included in the checklist tab. Comment as necessary.
    3. Remote checks (at least one if copper DAS)
    4. Coverage baseline values
    5. Coverage plots (grid) & associated statistics
    6. Audio test results.

3 Acceptance Testing Prerequisites

Before scheduling a site acceptance test with the OUC or its approved vendor, the building owner technical representative will ensure that the following prerequisites are completed. The vendor shall provide the information below **ahead** of the scheduling of the testing.

1. Documentation

    a. Building Manager contact information
    b. Plan describing what parts of the building:
        i. Are completed (including interior walls and ceilings)
        ii. What parts of the building are targeted for immediate occupancy
        iii. IMPORTANT NOTE: All rooms of the building will be tested
    c. As built drawings including the following files:
        i. floor plans

That documentation shall be sent to das.ouc@dc.gov.

2. Site completion

    a. Verification that the building completion actual status matches the description in section 1.
    b. All spaces are clear for walking with a test cart.

4 Acceptance Test Process

4.1 Review documentation provided by the vendor.

The vendor MUST provide the information listed in the **Error! Reference source not found.**~~Acceptance Testing Prerequisites~~ section above prior to the acceptance test. If the information provided is not complete, do NOT schedule the test.

4.2 Acceptance test preparation

Before heading to the building for testing, the OUC approved testing company shall make sure that:

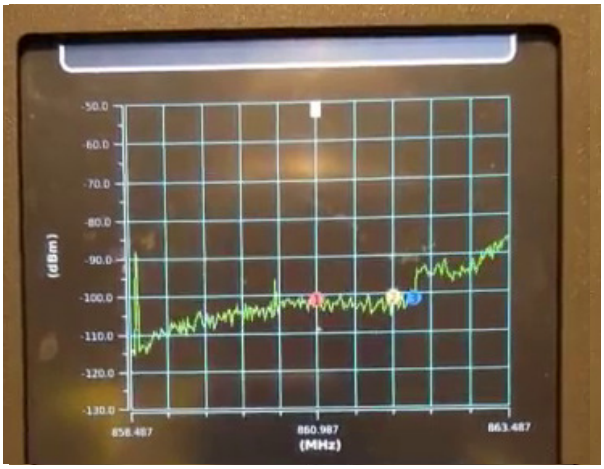
1. It checked with the OUC System Manager the system is available for testing during the test time period.
2. It has scheduled the test with the building POC and the OUC system manager. The OUC system manager will take the necessary steps to make sure that measurements and read received levels at all potentially affected host sites can be collected.
3. It has the data collection equipment ready. Preferably a tool that allows you to plot on the floor plan RSSI and other parameters
4. It had defined a grid according to the following guidelines:
    a. Building drawings for each floor will be reviewed and test locations marked to determine these test locations as part of a test plan prior to actual testing. Grids must be created such that the long length of the grid is under 125% of the length of the short length of the grid. For example, a 40x50 grid is acceptable; a 20x26 grid is not acceptable.
    b. For floors less than 32,000 sq. ft., each floor of the building shall be divided into grids of 20ft x 20ft each.
    c. For floors between 32,000 sq. ft. and 128,000 sq. ft., each floor of the building shall be divided into 20 Grids.
    d. For floors over 128,000 sq. ft., each floor shall be subdivided into 40 grids.
5. You have two portable radios fully charged, calibrated, and programmed with in-building testing code plug.
6. You have another voice communication device like your mobile telephone in case radio communication is not possible.
7. The remote access to the BDA will be performed by the OUC

4.3 Commercial DAS Level of Interference Verification (if Applicable)

In some cases, commercial cellular systems deployed in a building can create interference with the public system. This is in particular true if the distributed antennas are not shared between the public safety frequencies and the cellular system. To check if such interference exists,

- Make sure the commercial DAS and its feed are on.
- Take a spectrum analyzer under the cellular DAS antenna in an expected poor coverage antenna.
- Verify that the public safety band is free of interference, see pictures below. The first one is with the commercial BDA off. No interference shows in the public safety band (red marker). The second one shows that with the commercial BDA on the noise raises significantly.

Commercial BDA:



4.4 Coverage Test and Data Collection

To perform this test, you will make measurements on the control channel. Control channels are listed in Section 6.2. Please check with the system manager which one is active (default is channel 2):

1. Then collect the RSSI data in dBm received with a spectrum analyzer or similar tool.
2. All floors, stairwells and areas of the building need to be measured
3. Critical areas include stairwells, headend room and emergency and standby power rooms
   A Central location with low signal level such as an elevator lobby, or mechanical room shall be selected on all floors. 2-4 critical areas per floor.
   a. A P25 Audio test shall be performed at all critical areas.(see Appendix)
   b. Measure RSSI level and log on recording chart.
   c. Measure RSSI and throughput levels (both ways) and log on recording chart.
4. The measurements shall be grid based, the grid being developed as described in a previous section.
5. As per NFPA, the measurements within a grid will be recorded :
   a. while walking an “X” pattern with the center of the pattern located approximately in the center of each grid area
   b. The linear distance of each side of the “X” equal to at least 10% of the length of the grid side and a minimum length of 10 ft.
   c. Measurements sampled in an averaging mode to include a minimum of 1 sample per each 5 ft. travel recorded with no less than 10 samples per measurements per side of the ”X”
6. The results need include the following:
   a. A Map that color code the received levels (the map needs to demonstrate that all floors, stairwells elevators have been tested exhaustively).
   b. The map shall identify clearly the critical areas and the corresponding measured parameters
   c. Statistics that demonstrate that the criteria passed (95% per floor)
   d. An Excel table that shows the RSSI values and indicates the floor and location of the measurement. This table will clearly identify the critical areas and fringe areas of measurements. This table will serve as a baseline for annual testing.
   e. The location and identification of at least 5 fringe areas with lowest signal level.
7. Fringe Areas testing
   a. Audio Test on all 25 trunked audio channels.
   b. Measure RSSI level and log on recording chart.
   c. Measure RSSI and throughput levels (both ways) and log on recording chart.
   d. At the host receiver(s), the signal to noise ratio is equal to 18 dB

Appendix 1 : Audio Test-P25 Only

Even though signal strength and BER measurements are providing good evaluations of the quality of the coverage, the audio quality gives a sense of the ultimate quality of service perceived by the end-user.

To test the audio quality you need to:

1. Use radios with code plug installed where all 26 channels are programmed to be tested individually.

You can use the following phrase to test the uplink:

*"This is OUC doing in building test. Counting 1, 2,3,4,5 do you co*py?"

2. Evaluate the audio call quality using the following table:

DAQ Values	Subjective Performance Description
1	Unusable, speech present but unreadable.
2	Understandable with considerable effort. Frequent repetition due to noise / distortion.
3	Speech understandable with slight effort. Occasional repetition required due to noise / distortion.
3.4	Speech understandable with repetition only rarely required. Some noise / distortion.
4	Speech easily understood. Occasional noise / distortion.
4.5	Speech easily understood. Infrequent noise / distortion.

3. Test at each test location both talk-out and talk-in will for both 700 and 800 MHz talk-groups.

4. Repeat the same process throughout each floor of the building including stairways and elevator machine rooms

5. A maximum of 5% non-adjacent areas shall be allowed to fail the test for a given floor.

6. For talk-out tests, voice calls shall be made to a portable radio at hip level.

7. For talk in tests, voice calls shall be made from a portable radio at hip level (with a shoulder mike). At a given test location, rekeying will be allowed if an initial PTT does not receive a channel grant.

8. Note the locations where the test failed.