PCTEL

Ensuring Public Safety Emergency Communications:

Verifying Indoor Network Performance

ICC INTERNATIONAL CODE COUNCIL®

NFPA®

SAFER BUILDINGS COALITION Feel Safe Inside

P25 DIGITAL WIRELESS · SANS FILL · NUMERIQUE · INALÁMBRICO

TCCA 25

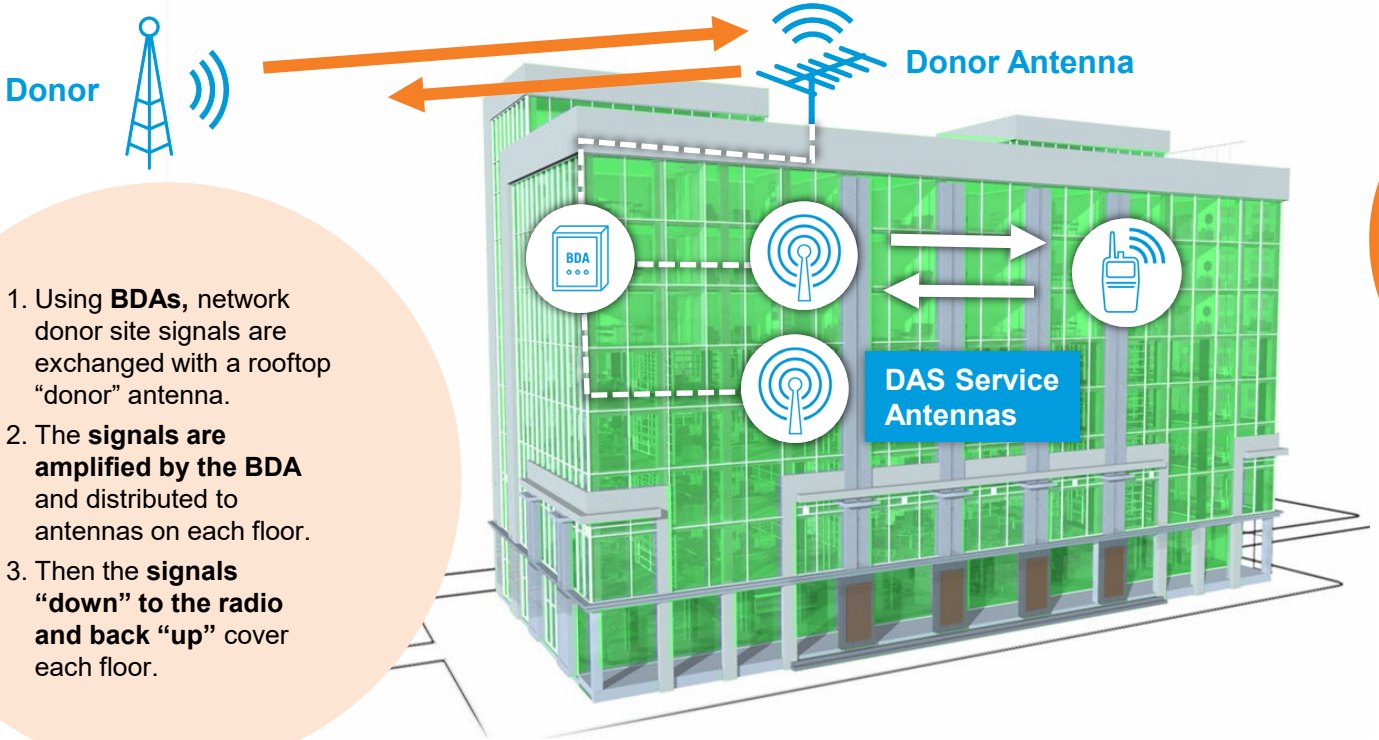
David Adams
Director of Business Development

FierceTelecom FierceWireless FIERCE INNOVATION AWARDS TELECOM EDITION 2019

Indoor Signal Coverage: Technical Solutions

The technical Solution is known: an inbuilding radio system

In Public Safety, called an *Emergency Responder Communication Enhancement System* (ERCES) in IFC 510 2021



1. Using **BDAs,** network donor site signals are exchanged with a rooftop “donor” antenna.
2. The **signals are amplified by the BDA** and distributed to antennas on each floor.
3. Then the **signals “down” to the radio and back “up”** cover each floor.

Only **building owners** can deal with indoor coverage

What is the Motivation?

Jurisdictions Create and Enforce Building Codes

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Multiple Stakeholders Related to Codes

Many parties *influence* these requirements…

Jurisdictions

Emergency Services
- Fire Dept.
- Police
- EMS

Government Agencies
- Fire Marshals
- Code Officials
- Permit Dept.

IT Engineering License Holders
- Approve Designs / Review Tests / Approve Turnup
- Networks Maintain Gov. Buildings

Examples of Codes

NFPA72

1221, 1225

IFC 510

Updated Editions

Adopted by AHJs

Wireless Industry
- Vendors
- Industry Organizations (TSB, Safer Buildings, etc.)

and are *directly affected* by them

Industry

Building Owner
- Responsible for Performance
- Contract Out
- Test / Maintain

Contractors
- General
- Electrical
- Alarm / Fire Room

Radio Systems / Services
- Survey Tests
- Design / Deploy
- Test / Report

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Testing: Which Organizations Care?

	Coverage ***The radio signal works well for enough of the building***	System Commissioning ***The inbuilding system does not degrade other communications***
AHJs ***Fire Marshals***	Primary concern: **First Responders are safe** with good communications Occupants able to communicate	Outside their realm of responsibility and expertise; historically not included in building permit
FCC Licensees ***Radio Shops***	Not required by their license to provide full indoor coverage	Primary concern: **licensed frequencies work well; approve all transmitters** based on “no harm caused”

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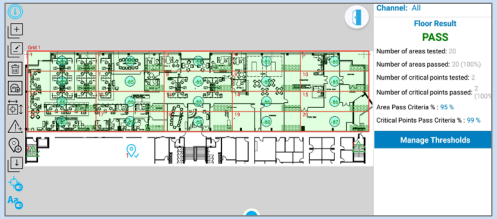
Comparing Test Approaches and Applications

TEST STYLES HAVE DISTINCT DIFFERENCES

Path Based Testing	Grid Based Testing
Rapid evolution of technologies, bands	Older, stable, non-cellular, fewer bands
Wide range of technologies and services	Primarily for emergency voice service
Coverage, capacity, handovers, etc.	Primarily coverage
Voice, data throughput, interference, etc.	Minimum voice quality level
Allows for a fine granularity for analysis	Automatic, standardized “Pass/Fail”
Requires higher degree of engineering capability, time	Enables less experienced users, non-technical consumption
Commercial Cellular Networks	Public Safety LMR Networks



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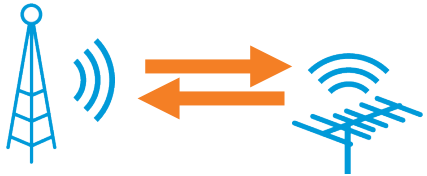
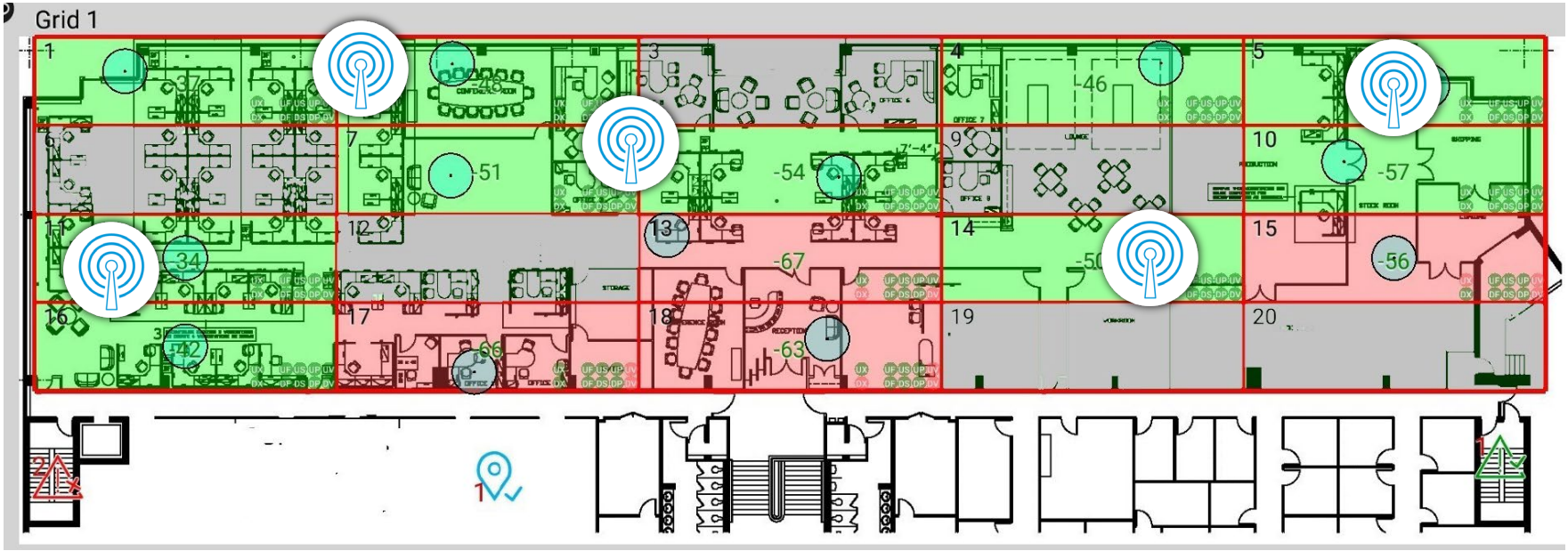
Determining “Good” Indoor Radio Coverage

The codes specify how good the radio signals need to be to provide good coverage…testing is required to “know” for sure

- The codes require testing all areas in a building based on a grid system





Approval is based on sufficient measurements “passing”

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Summarizing the Code Test Requirements

Typical AHJ Requirements
Test all channels/technologies used by AHJ
Grid of “20 equal areas” on ***each floor plan***
Test each area in the “center” ***only***
Test critical areas with different criteria
Minimum ***signal strength level sufficient for DAQ 3.0***, or ***SINR*** both in and out
Grade each area pass/fail based on thresholds for test items
Grade the building: x% tested areas
Create signed report by AHJ approved person
Using Radio or AHJ approved equipment
Annual retests, compared to first test

- Drawing from NFPA and IFC
- Changes over the regular updates (historically every 3 years)
- Across version adapted by numerous AHJs
- Interpreted differently
- Some aspects are not consistently enforced

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Frequencies / Channels to Test

Typical AHJ Requirements

Test all channels/technologies used by AHJ

NFPA 1221 **2016 9.6.10**
"…transmitting all radio frequencies, as required by the AHJ assigned to the jurisdiction, and be capable of using any modulation technology…upgradeable to allow for instances where the jurisdiction changes or adds system frequencies"

IFC 2018 **510.4.2.2 Technical criteria**
"This document shall contain, but not be limited to, the various frequencies required, the location of radio sites, the effective radiated power of radio sites, the maximum propagation delay in microseconds..."

Multiple networks, different channel types

County Fire Control	County Police Traffic	City Fire Control	Cellular
454.125	853.7125	753.7125	ATT B17 5780
451.0	850.5	750.5	Ver B13 5130
462..325	861.125	761.125	FN B14
….	….	….	….

Project Workspace

CF CC 451.0
CP TC 853.7125
CP TC 850.5
CP TC 861.125
City 761.125
ATT B17 5780
Ver B13 5130 FN B14

Create a list of all channels / frequencies of all channels that need to be tested ("Workspace")

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Defining the Grids

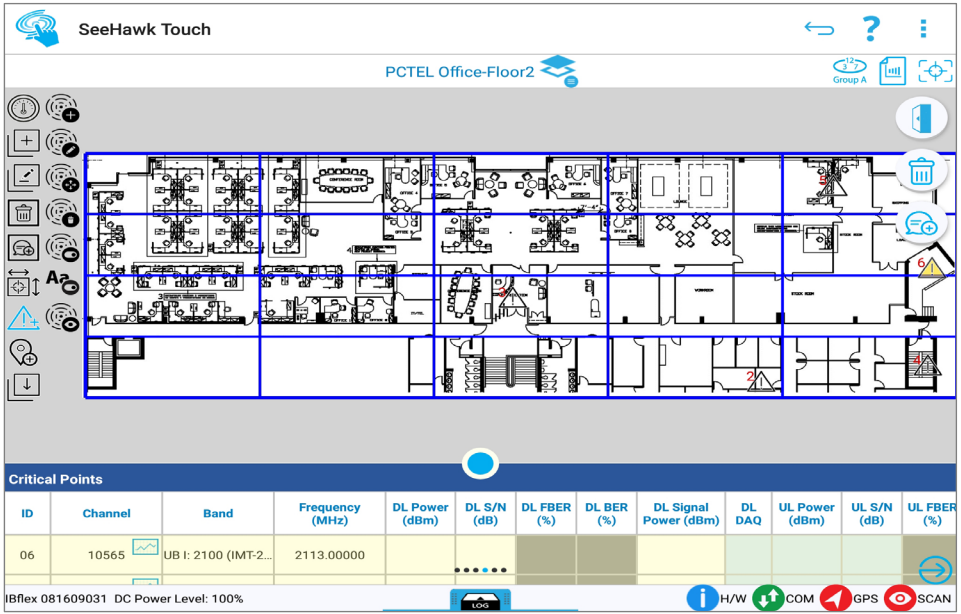
Typical AHJ Requirements

Grid of “20 equal areas” on **each floor plan**

NFPA 1221 2016 **A.11.3.9 Test Procedures**
“…20 grid cells…min. 20’…max 80’…exceeds 128K’…multiple 20 area grids…not more than 2 adjacent can fail…decrease to half the dimension (80 areas)”

IFC 2018 **510.5.3 Technical criteria**
“…Each floor of the building shall be divided into a grid of 20 approximately equal test areas…In the event that two of the test areas fail the test, in order to be more statistically accurate, the floor shall be permitted to be divided into 40 equal test areas”

Maximum size of grid and grid areas



Add the grids to cover the floor plan

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Fitting the Grid

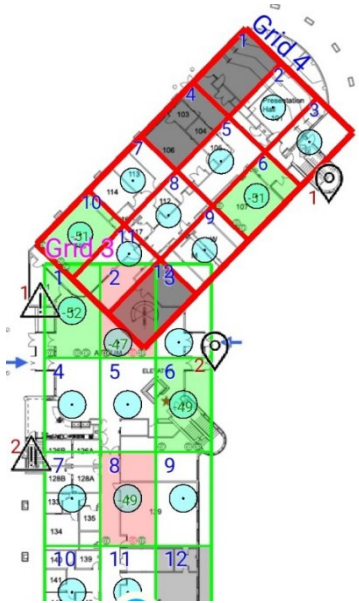
- “Rectangular” areas forming the grid
- Flexible size, number and arrangement
- Adapt color, intensity based on floorplan

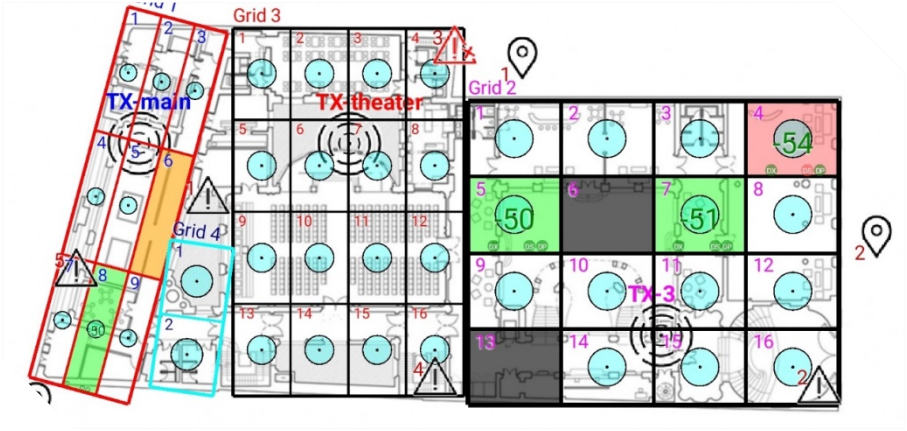
Grid Areas:

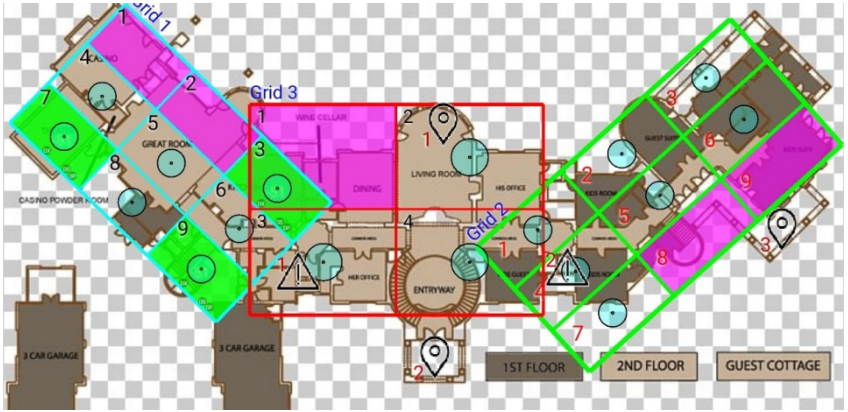
- Cover all floor space
- Uniform Size
- < specified max
- Add more as needed

Exactly “20” seems less important in practice

More areas when failing % or “adjacent” rule







Test Points in Each Grid Area

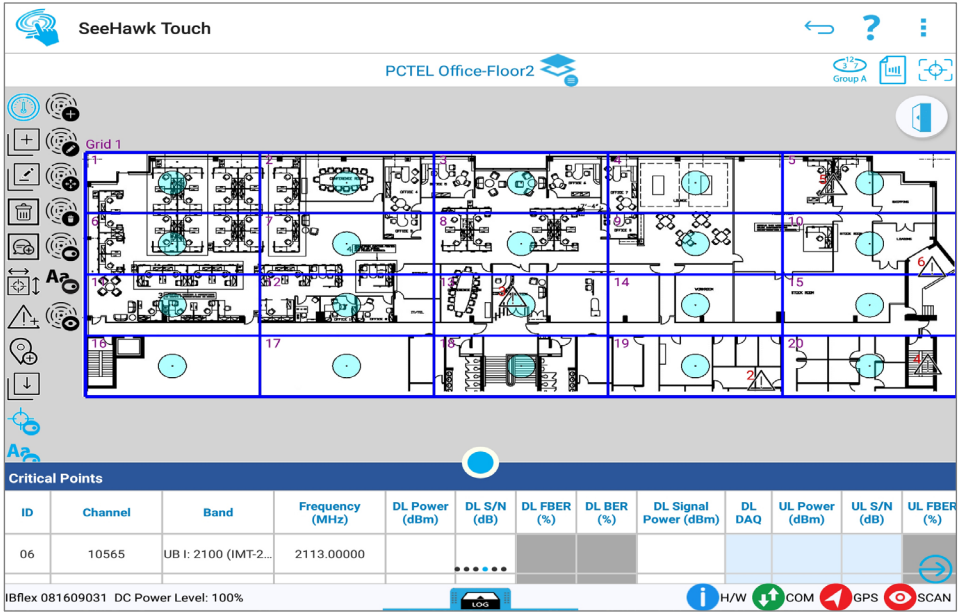
Typical AHJ Requirements

Test each area in the “center” ***only***

NFPA 1221 2016 **A.11.3.9 Test Procedures**
“…taken at the center… walking an “X”… minimum length of 10’…”

IFC 2018 **510.5.3 Technical criteria.**
…A test location approximately in the center of each test area shall be selected for the test… that location shall represent the entire test area…

- Most AHJs **do NOT** require moving through the grid area
- Calculating an “average” is **CRITICAL**



- **Identify the test locations**
- **Adjust locations for furnishings**
- **“Stand Still” or “Move in an ‘X’ ”**

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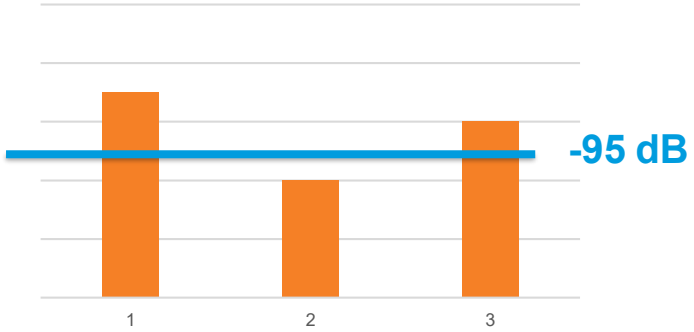
Metrics to Measure

Typical AHJ Requirements
Minimum ***signal strength level sufficient for DAQ 3.0***, or ***SINR*** both in and out
510.4.1.1 Minimum signal strength into the building…provide usable voice…provide not less than a Delivered Audio Quality (DAQ) of 3.0 or an equivalent Signal-to-Interference-Plus-Noise Ratio (SINR)…
510.4.1.2 Minimum signal strength out of the building. Similar ***IFC 510 2018***
510.4.1.1 Minimum of -95dBm…DAQ of 3.0 or an equivalent SINR…(outbound the same) ***IFC 510 2021 Proposed***



- **RSSI (signal power):** most common historically (being restored in next version)
- **Accurate "Averaging" and Test Method** (antenna usage, movement, etc.) are important
- **Voice Quality test:** graded based on DAQ
- **"Signal Quality":** some local AHJs adding SINR/BER; under consideration for national
- **In Practice?** Power at a minimum with radio or SA; some require 2-way voice; starting to add/substitute with signal quality; a few require power/SINR/BER at the radio site

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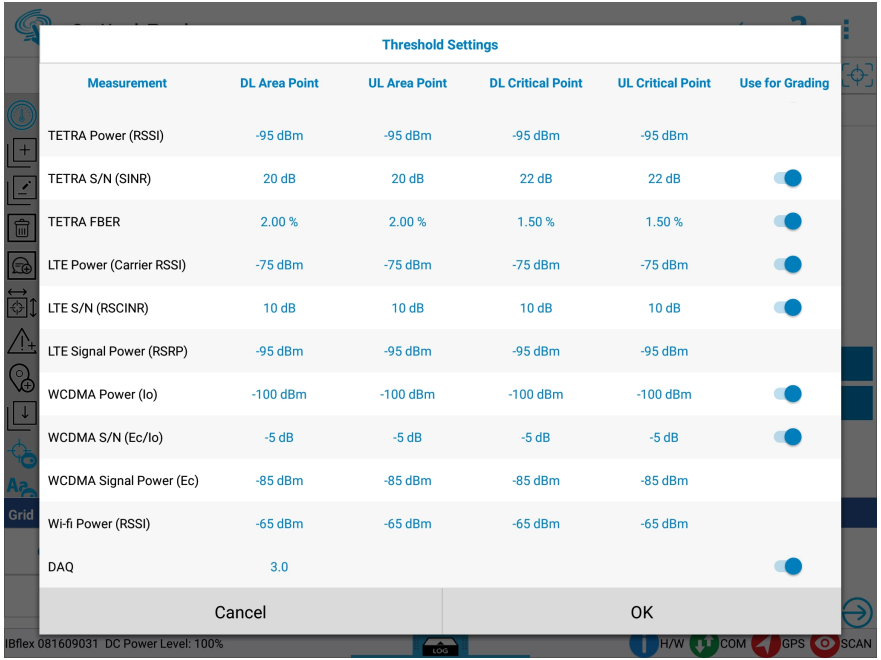
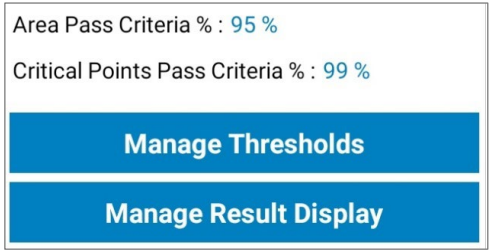
Pass / Fail Criteria: Thresholds

Typical AHJ Requirements
Grade each area pass/fail based on thresholds for test items
Grade the building: x% tested areas
NFPA 2016 **A.11.3.9 Test Procedures** “three (out of 20) of the areas fail the test, or if two adjacent areas fail” - 90% is not stated but is implied
IFC 2018 **510.5.3 Technical criteria.** …signal strength measurements in 95 percent of all areas on each floor of the building meet the signal strength requirements…

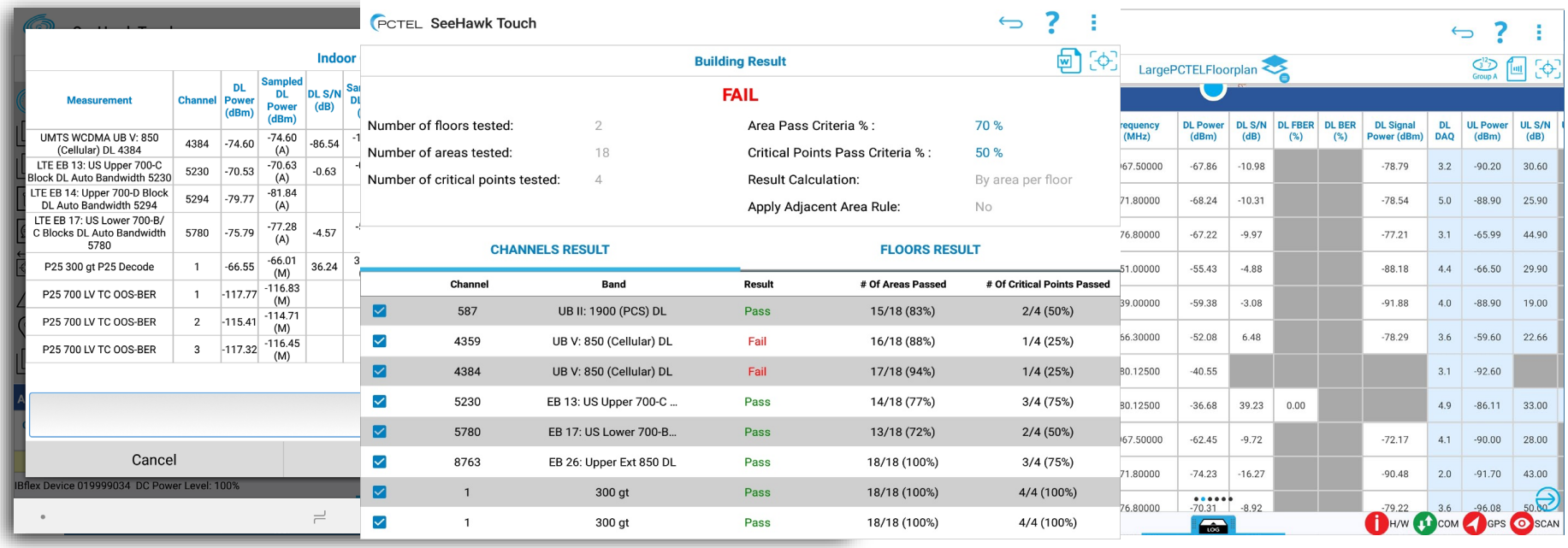
AHJs may use different criteria for “pass/fail”





Configure the test criteria

Execute Tests, Gather/Grade Results

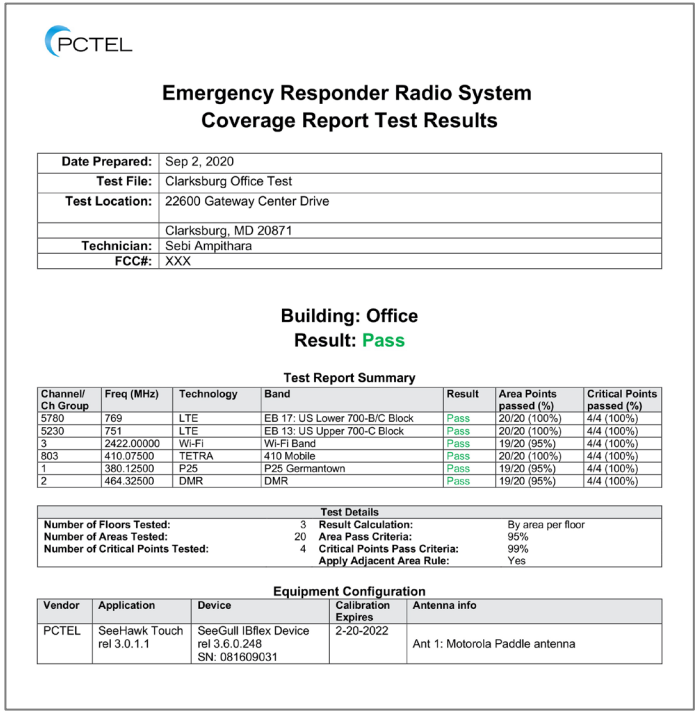


- **Execute the test** at each test location – stand still or walk the “X”, create average
- **Record** the measurements **and grade by threshold**
- **Real time display of progress** is important

NFPA 2016 “Acceptance test procedures and requirements should be as directed by the AHJ”

Reporting to the AHJ and Building Owner

Typical AHJ Requirements
Create signed report by AHJ approved person
Using Radio or AHJ approved equipment
NFPA 2016 **A.11.3.9 Test Procedures** "…information required from the DAQ level and commissioning tests, including a full report with grid locations, DAQ measurements…"
IFC 2018 **510.6.1** "…a report, which shall verify compliance with Section 510.5.3, shall be submitted to the *fire code official*…"



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Emergency Responder Radio System
Coverage Report Test Results

Date Prepared:	Sep 2, 2020
Test File:	Clarksburg Office Test
Test Location:	22600 Gateway Center Drive
	Clarksburg, MD 20871
Technician:	Sebi Ampithara
FCC#:	XXX

Building: Office
Result: Pass

Test Report Summary

Channel/ Ch Group	Freq (MHz)	Technology	Band	Result	Area Points passed (%)	Critical Points passed (%)
5780	769	LTE	EB 17: US Lower 700-B/C Block	Pass	20/20 (100%)	4/4 (100%)
5230	751	LTE	EB 13: US Upper 700-C Block	Pass	20/20 (100%)	4/4 (100%)
3	2422.00000	Wi-Fi	Wi-Fi Band	Pass	19/20 (95%)	4/4 (100%)
803	410.07500	TETRA	410 Mobile	Pass	20/20 (100%)	4/4 (100%)
1	380.12500	P25	P25 Germantown	Pass	19/20 (95%)	4/4 (100%)
2	464.32500	DMR	DMR	Pass	19/20 (95%)	4/4 (100%)

Test Details

Number of Floors Tested:	3	**Result Calculation:**	By area per floor
Number of Areas Tested:	20	**Area Pass Criteria:**	95%
Number of Critical Points Tested:	4	**Critical Points Pass Criteria:**	99%
		Apply Adjacent Area Rule:	Yes

Equipment Configuration

Vendor	Application	Device	Calibration Expires	Antenna info
PCTEL	SeeHawk Touch rel 3.0.1.1	SeeGull IBflex Device rel 3.6.0.248 SN: 081609031	2-20-2022	Ant 1: Motorola Paddle antenna

Prepare Report for the Building by Floor/Channel

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Additional Considerations

Building Codes	
510.1	New buildings shall have approved radio coverage …
510.2	Existing buildings…
510.6.1	inspected and tested annually or where structural changes occur
510.5.4	FCC 47 CFR Part 90.219
510.4.2.7	“as-built” design documents…
510.5.2	minimum qualifications of the system designer and lead installation personnel…A valid FCC-issued general radio operators license… Certification of in-building system training…
510.4.1.3	applications being utilized…for emergency operations…(such as in FirstNet)
510.1	New buildings shall have approved radio coverage …
510.2	Existing buildings…
510.6.1	inspected and tested annually or where structural changes occur

IFC 510 2018

- New buildings, major renovations, or all existing buildings?
- Annual retesting? Or some other period?
- FCC compliance
- Voice tests? Radios? Who is allowed?
- Final documentation?
- “Pre-approval”
- Licenses (FCC, etc.)? Certifications?
- Network for fire? Or others included?
- FirstNet?

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Commissioning Tests: Equipment Performance

Design and Installation Integrity

This verifies the amplifier and antenna installation and configuration produces good performance

Performed in the equipment room

- Power in/out to BDA toward donor (per channel)
- Power in/out of BDA toward the DAS (per channel)
- Uplink and downlink spectrum noise
- Spurious oscillations
- Verify BDA Filter configuration*
- Isolation – multiple points to measure *
- Proper BDA Squelch *

Performed in coverage area

- Antenna Verification “Test Signal” *
  - Performed without being “on air” with the live “donor system”
- Antenna Verification “Live”
  - Performed while connected to a live network
- Signal “Leakage” *
- Near / Far (“Two Radio”)*
- Updated design documentation (“As Built”)

** Uses a Test Transmitter to conduct*

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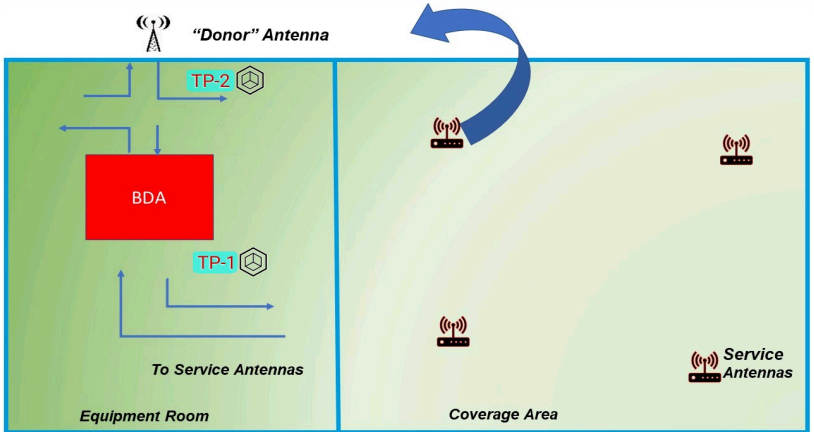
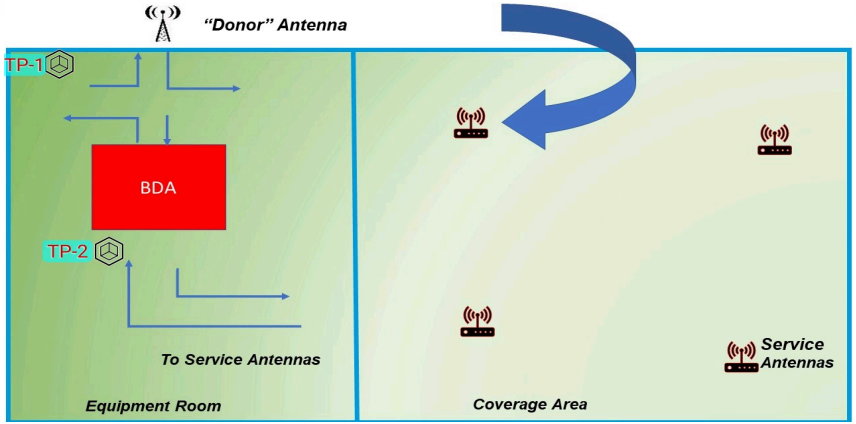
Commissioning Tests: Isolation

Verifies proper design, installation and configuration of the equipment





Test TX at TP-1, Measure at TP-2

Downlink Isolation: Measurements to ensure that the indoor antenna signals do not feedback through the donor antenna

Uplink Isolation: Measurements to ensure that signals from the Donor Antenna do not feedback through the indoor antenna system

Perform a test with a Test Transmitter at TP1, and measure level and verify sufficient loss at TP-2

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Commissioning: “Near/Far Test” (Two Radio Test)

Verifies that there is sufficient antenna density and ensures the portable radio with the *weaker* signal is not overpowered by the *stronger* radio

Donor Repeater

Repeater Sites

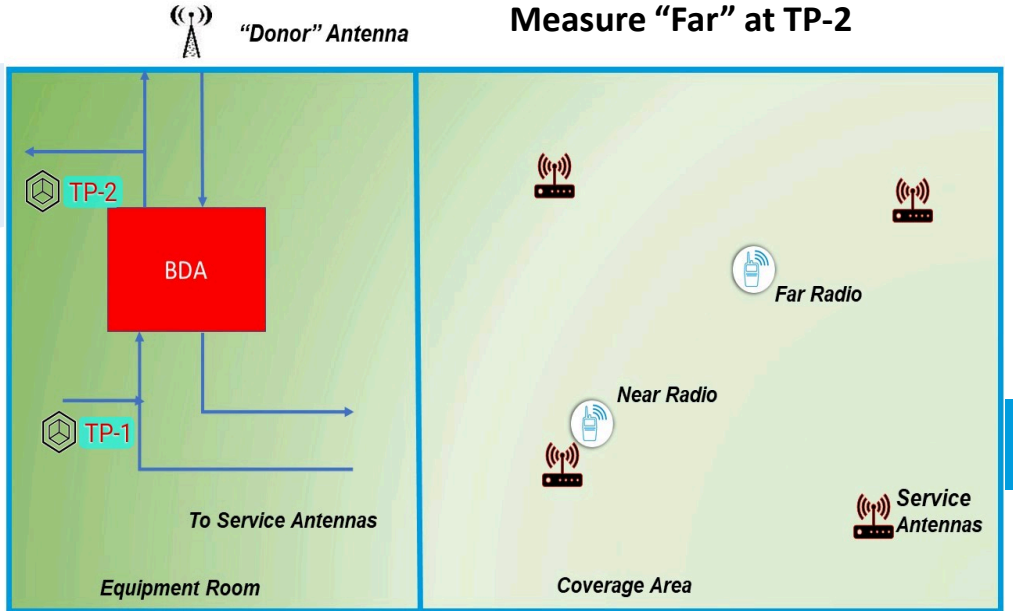
IFC 510 2018

510.4.2.8 “…minimize the near-far effect…”

510.5.3 “… two portable radios simultaneously conducting subjective voice quality checks…”

Test TX at TP-1 to mimic “Near”

Measure “Far” at TP-2



Perform a **voice test on the Far radio while the Near is active** or **measure power and SINR** to ensure good performance

“Farthest” (lowest power) from any antenna

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Summary

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Test all channels/technologies used by AHJ
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Grade each area pass/fail based on thresholds for test items
Grade the building: x% tested areas
Create signed report by AHJ approved person
Using Radio or AHJ approved equipment
Annual retests, compared to first test

- Get to know the AHJ – radio/IT departments and fire marshals
- Get to know their codes – which national code they are based on and the year of
- Understand their specific requirements: what they enforce and what they do not enforce
- Requirements beyond the code
- Consider getting “pre-approval” of the test plan

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Thank You.
Questions?

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Resources:
pctel.com/public-safety-testing-solution/

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