BAPCO 2020

The Annual Event for Public Safety Technology

10 - 11 MARCH 2020
RICOH ARENA, COVENTRY
BAPCO-SHOW.CO.UK

Ensuring Indoor Radio Coverage: Code Compliance Based on Signal Quality

Industry Leading Wireless Network Test and Measurement Tools

IB*flex*®, HB*flex*™ and MX*flex*® Scanning Receivers | CW Transmitter | SeeHawk® Touch Software with Signal Analyzer
SeeHawk Engage™ User Experience Testing | Public Safety Testing Solution | SeeWave® Interference Locating System

Public Safety Indoor Performance: What Is the Problem?

Indoor Signal Penetration: Challenges

The jurisdictions are responsible for "outdoor" networks used by Public Safety agencies

… but the radio signals penetrate "in building" poorly – the radio signal degrades

These challenges apply to cellular and business critical radio networks

The signals are attenuated and create multiple paths

Indoor Signal Coverage: Solution

Technical Solution: an inbuilding radio system (Emergency Responder Radio Coverage System)

… but the motivation? The jurisdictions have no role in solving problems inbuilding

Only building owners can deal with indoor coverage

May use a BDA system, passive or active DAS, small cell, etc.

Jurisdictional solution: Building Code Enforcement

Stakeholders Involved with Public Safety

Many parties *influence* these requirements ….. and are *directly affected* by them

Emergency Services
- Fire Dept.
- Police
- EMS

Government Agencies
- Fire Marshals
- Adopt Codes
- Permit Dept.

IT Engineering
- Review Tests
- Approve Designs
- Maintain Gov. Buildings
- Outdoor Networks

NA Code Examples

NFPA72 1221 ***IFC 510***

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

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

Contractors
- General
- Electrical
- Alarm/Fire Room

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

Indoor Systems: Good Radio Coverage?

Outdoor network signals exchanged with roof top antenna and amplified

The signals are distributed to antennas on each floor

Then the signals "down" to the radio and back "up" cover each floor

Both "downlink" and "uplink" performance is critical

Indoor Systems: Testing Radio Coverage?

The codes specify how good the radio signals have 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 in sufficient measurements "passing"

Testing Commercial Cellular vs. Public Safety LMR

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
Cellular Network Industry	**Public Safety Industry**

Grid Testing
Applying Code Requirements and The Test Process

Channels to Test

Typical AHJ Requirements
Test all channels/technologies used by AHJ
Grid of "20 equal areas" on ***each floor***
Test each area in the "center" ***only***
Minimum ***signal strength level***
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
Test critical areas with different criteria
Grade the building: x% tested areas
Signed record, AHJ approved person
Radio or AHJ approved equipment
Annual retests, compared to first test

County Fire Control
454.125
451.0
462..325
....

County Police Traffic
853.7125
850.5
861.125
....

City Fire Control
753.7125
750.5
761.125
....

Cellular
ATT B17 5780
Ver B13 5130
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"

Power Measurements: Any Radio Technology

Channelized Power (RSSI) Measurements

- Create “saved” lists for other technologies – no re-entering frequencies
- Easily specify center frequency, bandwidth and number for any channel of interest
- Applies to any test mode using workspaces
- Some TETRA channels “predefined” (spec)

Custom Channel lists address any technology that does not have full decoding support

Applications

- Outdoor driving tests
- Indoor walk and antenna verification tests
- Grid tests

PROTOCOL	BAND
GSM	380 Mobile
UMTS WCDMA	380 Base
CDMA2000	410 Mobile
EV-DO	410 Base
TD-SCDMA	450 Mobile
LTE	450 Base
TD-LTE	870 Mobile
Wi-Fi	870 Base
LTE-LAA	
TETRA	

P25 Measurements: Power and Quality

Decodes P25 signals for enahnced

- Supports Phase 1 and 2 with automatic detection of Phase, modulation and NID
- Power (RSSI) and SINR
- Frame BER for “in service” signals
- Full frame BER for “out of service” signals

Applications

- Outdoor driving tests
- Indoor walk and antenna verification tests
- Grid tests

Channel	Band	Frequency (MHz)	DL Power (dBm)	DL S/N (dB)	DL FBER (%)	DL BER (%)
5780	EB 17: US Lower ...	739.00000	-64.04			
14	100 IWN Rockvill...	173.90000	-65.87	30.03	0.00	
15	100 IWN Rockvill...	168.73750	-106.71	3.62		
2	300 FCC GT CC	380.12500	-91.68	4.93	25.62	

Floorplans

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Import the floor plan

Defining the Grids

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Add the grids

Defining the Grids

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

Test Points in Each Grid Area

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Identify the test locations
Adjust locations for furnishings

Critical Areas: Separate Tests, Different Grading

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Mark the “Critical Points” for special tests

Items to Measure

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Historically used various power levels (being restored in next version)

Voice Quality based on DAQ

Some local AHJs Adding “Signal Quality” (SINR, BER), under consideration for national

Practically? Some combination

How to Measure "Good" Radio Coverage

The priority is to ensure voice communication throughout the building for first responder in emergency situations

Two individuals speak to each other over radios and assess the "delivered audio quality" (DAQ)

Delivered Audio Quality Metrics:

DAQ 1 Unusable. Speech present but not understandable.
DAQ 2 Speech understandable with considerable effort. Requires frequent repetition due to noise/distortion.
DAQ 3 Speech understandable with slight effort. Requires occasional repetition due to noise/distortion.
DAQ 3.4 Speech understandable without repetition. Some noise/distortion present.
DAQ 4 Speech easily understood. Occasional noise/distortion present.

Real speech assessment up and down

Subjective, individual opinion, expensive

Reliable equipment measures the radio power (signal strength, RSSI) and quality (signal relative to the radio noise)

Radio	DAQ 3.0	DAQ 3.0	DAQ 3.4	DAQ 3.4
	BER %	SINR	BER %	SINR
P25 C4FM	2.6	17.4	2	19
P25 CQPSK	2.6	15.7	2	17

Source: TSB-88

Focus on the radio signal

Objective, uniform, repeatable, accurate

Ideally up link measurements as well

Signal To Noise Measurement

RF Noise and Interference is the Primary Contributor to Poor Voice Quality

Channel + Noise

RSSI ~ -80 SINR ~ 45

Excellent Voice Quality Expected

Channel + High Noise

RSSI ~ -80 SINR ~ 15

Poor Voice Quality Expected

Channel + Interferer

RSSI ~ -80 SINR ~ 5

Poor Voice Quality Expected

NOTE: while the noise is shown separately, it is really combined with channel power and not visible without a SINR measurements

Bit Error Rate Measurement

The number of bits in error and the rate they occur is correlated to noise and SINR

"Out of Service" Measurement

- **A channel must be put into the out of service state at the radio site**
- **A continuous test pattern is transmitted repeatedly**

Comparison

- **Uses every bit in measurement, producing an accurate average quicker**
- **But utilizes a channel that cannot be used**

"In Service" Measurement

- **A channel is still used (control or traffic)**
- **The fixed information (frame pattern and overhead) is examined for error**

Comparison

- **Channel is still used**
- **Much fewer bits in measurement, accurate average takes more time**

To accurately measure to 2% BER, 3 "In Service" samples are sufficient

Pass / Fail Criteria: Thresholds

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Threshold Settings

Measurement	DL Area Point	UL Area Point	DL Critical Point	UL Critical Point	Use for Grading
P25 Power (RSSI)	-95 dBm	-95 dBm	-95 dBm	-95 dBm	
P25 S/N (SINR)	18 dB	18 dB	20 dB	20 dB	
P25 FBER	5.00 %	5.00 %	5.00 %	5.00 %	
LTE Power (Carrier RSSI)	-100 dBm	-100 dBm	-100 dBm	-100 dBm	
LTE S/N (RSCINR)	5 dB	5 dB	5 dB	5 dB	
LTE Signal Power (RSRP)	-95 dBm	-95 dBm	-95 dBm	-95 dBm	
DAQ	3.0				

Area Pass Criteria % : 95 %

Critical Points Pass Criteria % : 99 %

Manage Thresholds

Manage Result Display

Configure the test criteria

Execute Tests, Gather Results

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Execute Test, Grade By Threshold

Create Report Automatically, Real Time is Best

Automated Reports

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Emergency Responder Radio System
Coverage Report Test Results

Date Prepared:	Jan 6, 2020
Test Location:	PCTEL Office Germantown
Technician:	David Adams
FCC#:	xxxxx

Building: PCTEL Office Germantown
Result: Fail

Test Report Summary

Channel/ Ch Group	Freq (MHz)	Technology	Band	Result	Area Points passed (%)	Critical Points passed (%)
587	1967.50000	UMTS WCDMA	UB II: 1900 (PCS) DL	Fail	1/18 (5%)	1/4 (25%)
4359	871.80000	UMTS WCDMA	UB V: 850 (Cellular) DL	Fail	4/18 (22%)	0/4 (0%)
4384	876.80000	UMTS WCDMA	UB V: 850 (Cellular) DL	Fail	6/18 (33%)	0/4 (0%)
5230	751.00000	LTE	EB 13: US Upper 700-C Block DL	Fail	0/18 (0%)	0/4 (0%)
5780	739.00000	LTE	EB 17: US Lower 700-B/C Blocks DL	Fail	0/18 (0%)	0/4 (0%)
8763	866.30000	LTE	EB 26: Upper Ext 850 DL	Fail	2/18 (11%)	0/4 (0%)
1	380.12500	P25	300 gt	Fail	6/18 (33%)	3/4 (75%)
1	380.12500	P25	300 gt	Fail	5/18 (27%)	4/4 (100%)

Test Details

Number of Floors Tested:	2	**Result Calculation:**	By area per floor
Number of Areas Tested:	18	**Area Pass Criteria:**	90%
Number of Critical Points Tested:	4	**Critical Points Pass Criteria:**	99%
		Apply Adjacent Area Rule:	No

Equipment Configuration

Vendor	Application	Device	Calibration Expires	Antenna info
PCTEL	SeeHawk Touch rel 2.9.0.3	SeeGull IBflex Device rel 3.4.0.243 SN: 081407041	2-1-2019	

Prepare Report – For Building By Floor/Channel

Sample Test Report

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Summarizes the entire test

- Each Channel Fails/Passes independently
- Building Passes if all channels pass
- Summarize the entire test approach
- Document the Equipment

Sample Test Report: Hotel Test with Genwave

Floor: Hotel_Floor1
Channel: 2025
Result: Fail

Areas Tested:	10	**Area Points Pass Criteria:**	95 %
Critical Points Tested:	0	**Critical Points Pass Criteria:**	99 %
Total Grid Size:	59622.3 sq. ft	**Frequency (MHz):**	2117.5000

Sample Test Report: Hotel Test with Genwave

Grid	Area	DL Power (dBm)	DL S/N (dB)	DL Signal Power (dBm)	DL DAQ	UL Power (dBm)	UL S/N (dB)	UL Signal Power (dBm)	UL DAQ	Result	DL Loss (dB)	Comment
1	1	NT	NT	NT	NT	NT	NT	NT	NT	NT		
1	2	NT	NT	NT	NT	NT	NT	NT	NT	NT		
1	3	NT	NT	NT	NT	NT	NT	NT	NT	NT		
1	4	NT	NT	NT	NT	NT	NT	NT	NT	NT		
1	5	NT	NT	NT	NT	NT	NT	NT	NT	NT		
1	6	NT	NT	NT	NT	NT	NT	NT	NT	NT		
1	7	-73.79	31.61	-93.36						Pass		
1	8	-65.77	26.04	-88.64						Pass		
1	9	-74.64	18.19	-97.50						Fail		
1	10	NT	NT	NT	NT	NT	NT	NT	NT	NT		
1	11	-81.53	8.53	-112.46						Fail		
1	12	-70.18	19.29	-92.62						Pass		
1	13	-71.20	30.66	-90.39						Pass		
1	14	-61.47	28.83	-84.20						Pass		
1	15	-69.31	11.37	-92.51						Pass		
1	16	NT	NT	NT	NT	NT	NT	NT	NT	NT		
1	17	-70.63	18.66	-92.47						Pass		
1	18	-60.46	25.79	-80.19						Pass		
1	19	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Public Safety Grid Testing Automation

Preparation

Frequencies
Grids
Pass/Fail Criteria

Automated Grid Creation

Execution

Click and Collect
Simultaneous Measurements
Real-Time Results

Simple Test Execution

Reporting

One-Click Reporting

Real-Time

Ready for Submission

PCTEL’s Public Safety Network Testing Solution

PCTEL® Public Safety Testing Solution

Solution Features

- Automated Grid Testing
- Automated Reporting
- Portable & Easy to Use
- Upgradable
- Performs Related Testing

Solution Components

- SeeHawk® Touch Software
- IB*flex*® Scanning Receiver
- Walk Testing Kit

Addresses cellular and business "mission" critical network testing

SeeHawk Touch

Android Tablet Application

Five Test Modes

Perpetual License

Annual Maintenance Plan

First Year included

Walk Test for baseline surveys, planning data, and design validation

Grid-Based Test for Public Safety building assessment and final approval

Spectrum Analysis for Equipment Room, Troubleshooting

Antenna Verification for Commissioning of new builds

Drive test outdoor macro deployments

IB*flex*® Scanning Receiver Features

Support simultaneous data collection across all major wireless network bands and beyond.

In-building focused with hot swappable battery system, small form factor, lightweight, and lower power consumption.

Multiple platform support for Windows® laptop and Android™ tablet.

Simultaneously collect data across 12 technologies
5GNR, LTE FDD, TD-LTE, LTE-LAA, NB-IOT, WCDMA, GSM, CDMA, EV-DO, TD-SCDMA, P25, DMR, TETRA, and Wi-Fi.
Include channelized power measurements for any technology
Analog, older digital technologies

Connect with Bluetooth® and USB.

Support for 4x2 and 2x2 MIMO measurements.

Easy data storage on hard drive, external USB drive, SD drive on scanner.

Fully field upgradable for SW and options
2 year calibration

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PCTEL

Assuring Public Safety Communications: Verifying Indoor Network Performance