Real People
Make Up Life Safety

Public Safety Network Testing Solution

David Adams
Director of Business Development
PCTel

Agenda

- **Public Safety Indoor Performance: What is the Problem?**
- **PCTEL – Public Safety Testing Solution**
- **Grid Testing Process & Requirements**
- **Case Study**
- **Conclusion**

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

PCTEL First Responder Antenna Systems

Public Safety Police, Paramedics, Firefighters, Command Units

Applications

- Fleet management
- Asset tracking and monitoring
- Mobile Wireless Hot Spots
- Video streaming
- Voice communications

Product Offering

- GNSS/LTE/Wi-Fi multiband antennas
- Full spectrum/Wideband LMR antennas
- 802.11 ac Wi-Fi MIMO capability
- Multi-carrier LTE for FirstNet
- Permanent, glass & magnetic mounts
- Low profile, small footprint solutions
- Covert designs

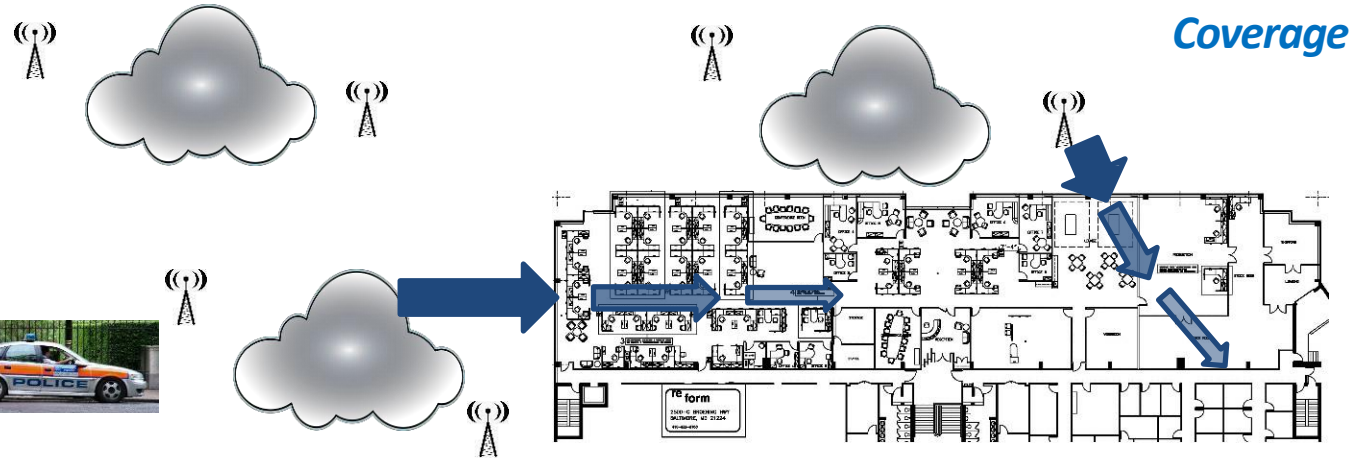
Courtesy of Los Angeles Sheriff's Department

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



Technical Solution is known: Emergency Responder Radio Coverage System (ERRC)

Indoor Signal Coverage: Solution

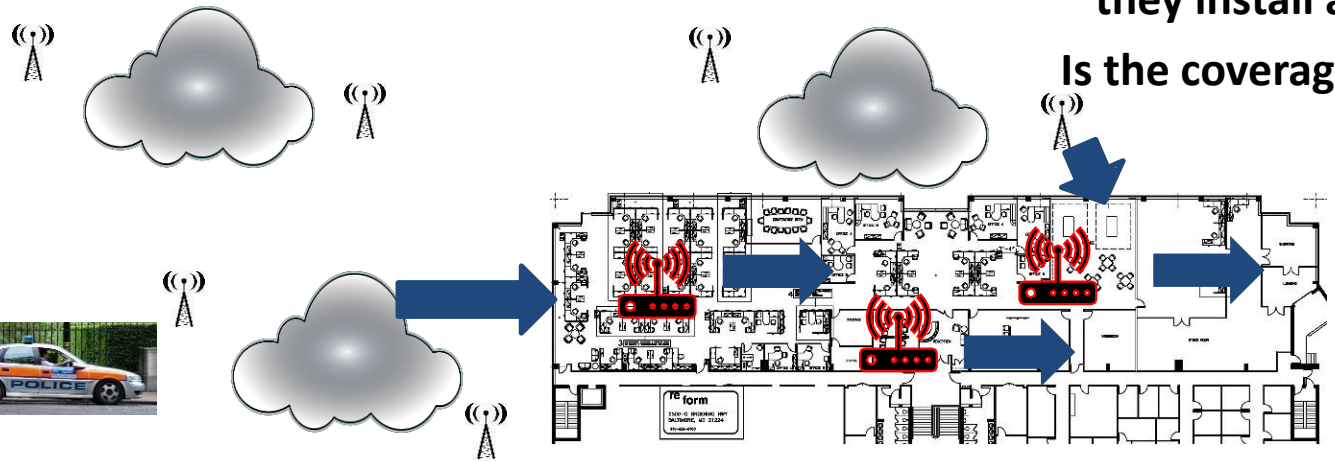
The technical Solution is known: Emergency Responder Radio Coverage System (ERRC)

… but the jurisdictions have no role in solving problems inbuilding

Only building owners can deal with indoor coverage

If they need an ERRC, will they install a BDA system?

Is the coverage good enough?



Jurisdictional solution: Building Code Enforcement

Multiple Stakeholders

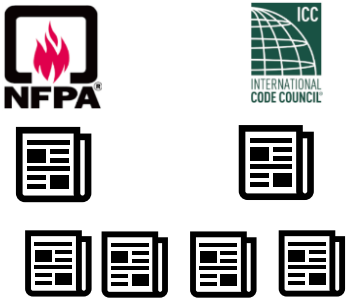
Many parties *influence* these requirements ….. and are *directly affected* by them

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

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

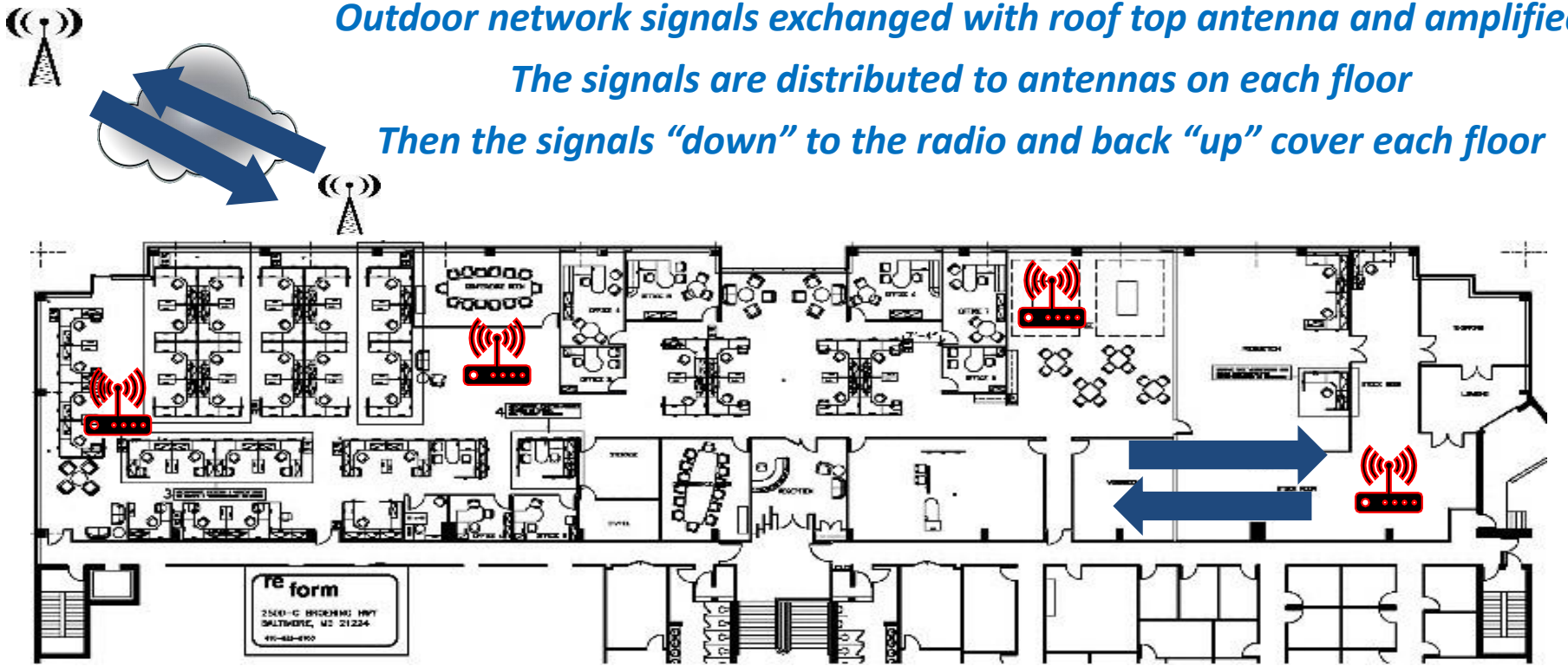
Radio Systems/ Services
- Survey Tests
- Design/Deploy
- Test/Report

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



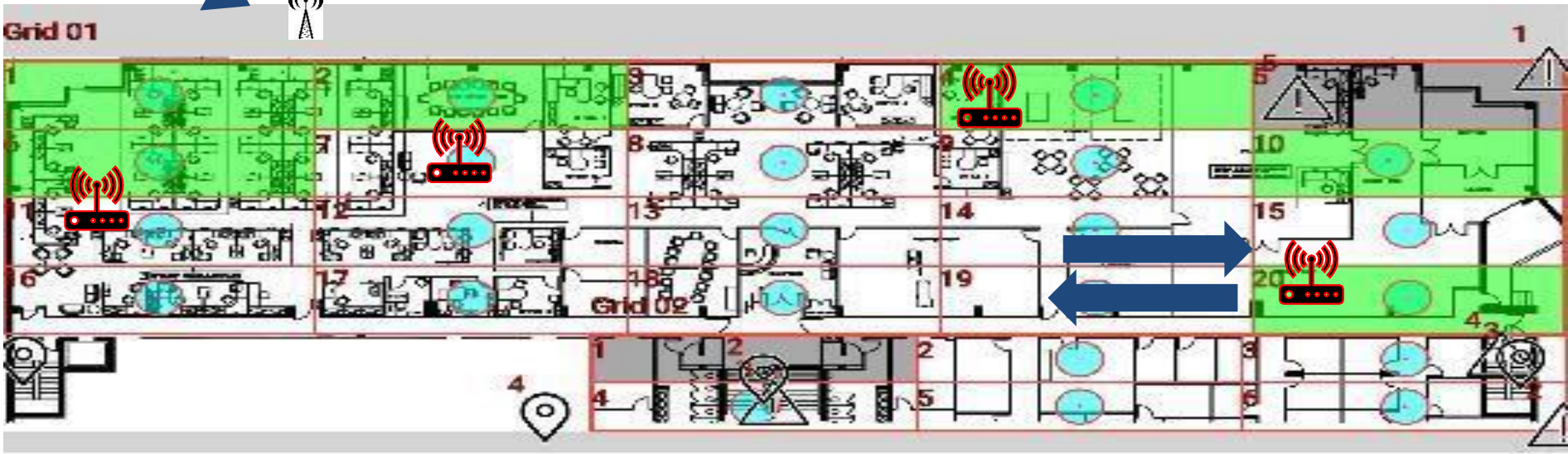
Both "downlink" and "uplink" performance is critical

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

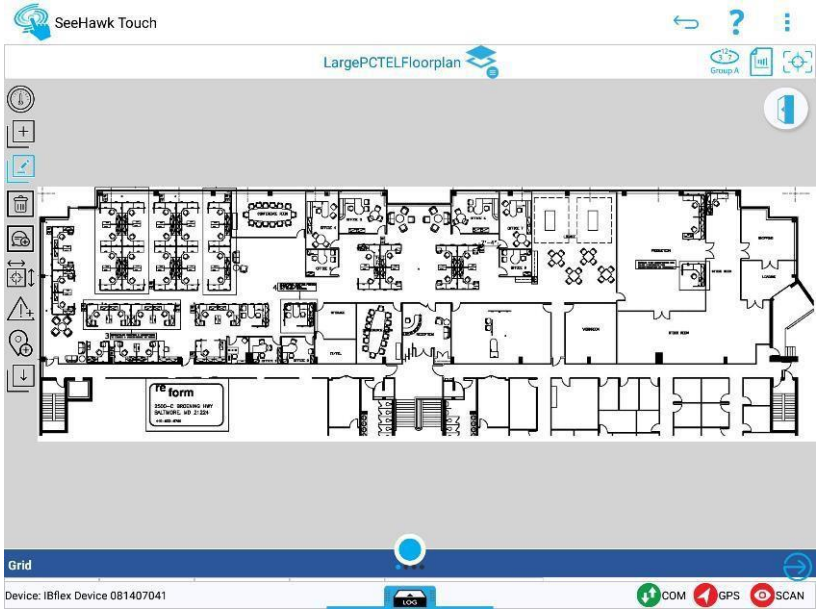
Public Safety has distinct differences from historic "cellular operator" testing

Cellular Network Industry	Public Safety Industry
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"
Leverage and requires higher degree of engineering capability, time	Enables lesser experience, quicker
Path Based Testing	**Grid Based Testing**

Grid Testing
Process and Requirements

Floorplans

Typical AHJ Requirements
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



Import the floor plan

Digital Grids

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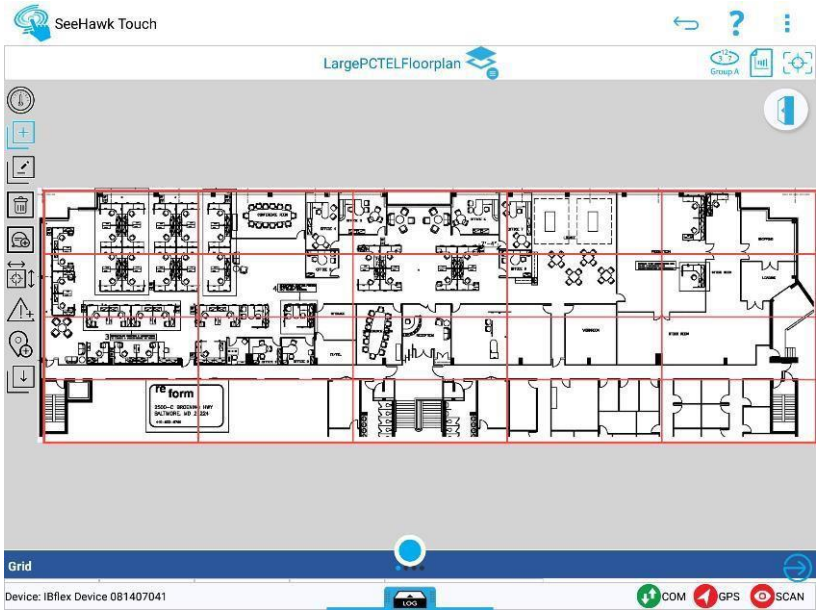

Add the grids

Test Points

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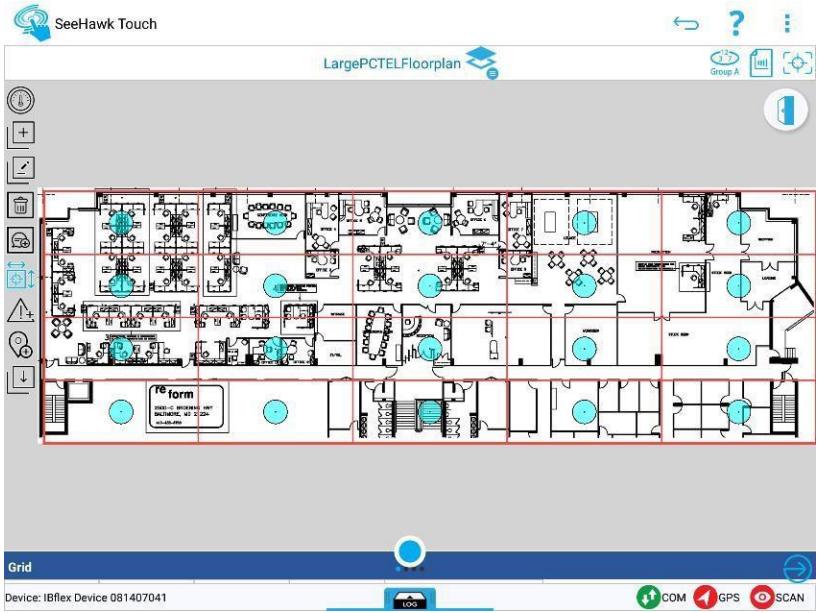

Identify the test locations

Do-Not-Test Areas

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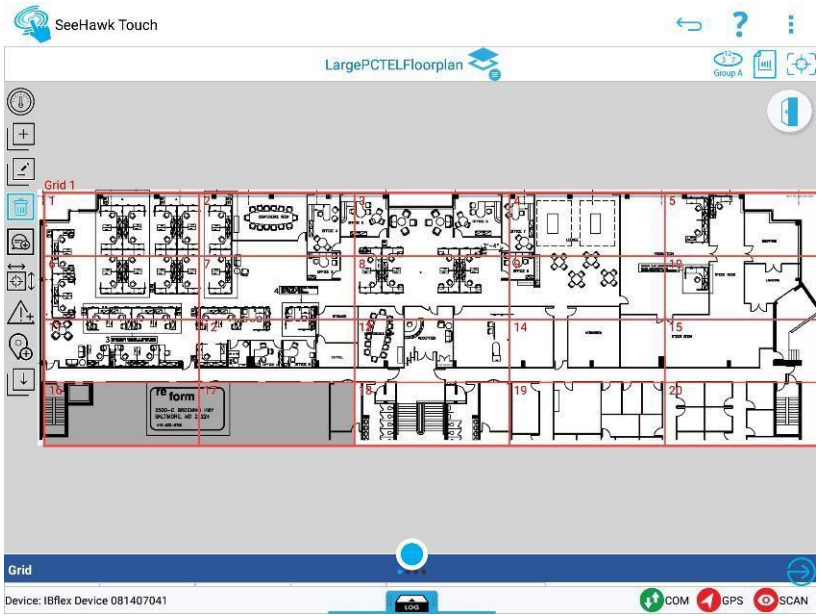

Identify the “Do Not Test” areas

Critical Points

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Mark the “Critical Points” for special tests

Reference Points

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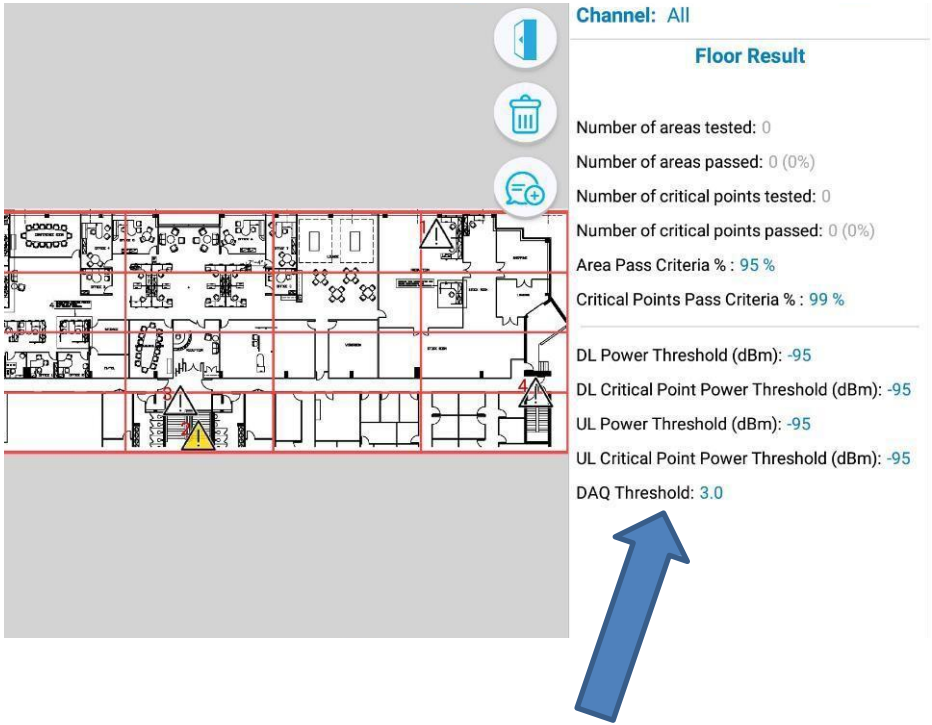

Configure the test criteria

Test Results

Typical AHJ Requirements
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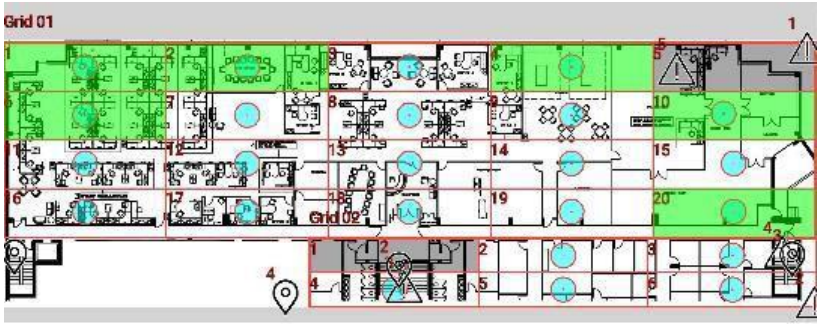
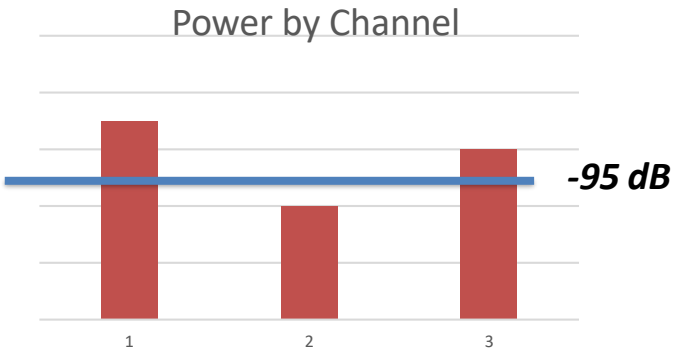


Execute Test, Grade By Threshold
Create Report Automatically, Real Time is Best



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

Automated Reports

Typical AHJ Requirements

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- Annual retests, compared to first test

Emergency Responder Radio System
Coverage Report Test Results

Date Prepared:	Sep 24, 2018
Test Location:	MK Tunnel
Technician:	Dave Copeland
FCC#:	

Building: MK Tunnel
Result: Fail

Number of Floors:	1	**Grading Approach:**	By area per floor
Number of Areas Tested:	94	**Area Pass Criteria:**	95%
Number of Critical Points Tested:	20	**Critical Points Pass Criteria:**	99%

Equipment

Vendor	Application	Device	Calibrated Date	Antenna info
PCTEL	SeeHawk Touch rel 2.3.0.0	SeeGull IBflex Device rel 2.2.3.0 SN: 081803015	3-9-2018	

Test Report Summary

Channel/Group	Freq (MHz)	Result	Areas passed (%)	Critical Points passed (%)
1	860.26250	Fail	19/94 (20%)	5/20 (25%)
2	851.41000	Fail	12/94 (12%)	4/20 (20%)
3	858.71000	Fail	2/94 (2%)	1/20 (5%)

Prepare Report – For Building By Floor/Channel

Variations Across AHJs: What Are the Differences? How?

- **A Grid is a Grid… or is it?**
  - NFPA: 20 “Areas” of generally equal size (20-80 ft per side)
  - If a floor is > 128K sf, add 20 more
  - If adjacent areas fail, use 80 areas (IFC 40 areas)
  - … or, every area is ~ 50x50 ft., or some other size

Solution is able to customize the grid

- **Test each area in a grid, but how?**
  - IFC: Must be in the center (not allowed to move, or retest)
  - NFPA: move in an “X” through the center (10% of the side)
  - Measurement device 3-4ft, vertical antenna (NFPA); some “on hip”

Solution is flexible in recording measurements

- **Test the network, but what channels exactly?**
  - List of channels from AHJ… but not always
  - Multiple systems: state, county, city, fire, police may be separate
  - P25: analog/digital, CC or TC, 150/450/750/820, Phase 1/Phase 2
  - FirstNet LTE, Combine project with Cellular Networks

Solution handles all required combinations in one test

PCTEL®
Performance Critical

Variations Across AHJs: What Are the Differences? How?

- **What is a "passing" grade?**
  - Historically, down link power
  - NFPA: 90% of the areas are > -99 dB (but not 2 adjacent)
  - IFC: 95% of the areas are > -95 dB
  - NFPA: Includes critical points - 99% of the points > -90 dB, (not in IFC)
  - Recent: Up link added– but every area? Where is the measurement taken? How it is executed?
  - Recent: changed to a signal strength level sufficient for DAQ 3.0
  - IFC: ***"…or a SINR equivalent"*** to DAQ 3.0 (not NFPA)
  - IFC: "Near/Far"; NFPA "Two Radio"; downlink only? Power or DAQ
- **SINR or DAQ (or BER): recognizable speech is the important point…**
  - But DAQ is subjective, time intensive, and not reproducible
  - SINR is accurate, can be automated, and quick to measure
  - BER: out of service? In service BER on the framing message?

Solutions that can automate the testing of all parameters, grade real time and automate the SNR tests

Variations Across AHJs: What Are the Differences? How

- **Which measurement approach?**
  - NFPA: Average, 5 samples per side of “X” – works for Control Channels; Max for Traffic Channels? What about DAQ?
  - TSB 88 sample rate for “confidence” in some AHJs
- **New buildings only? “In building” system if you fail? Yes, but**
  - Some AHJs require for all new buildings, others existing buildings
  - Give a date for testing, for a plan, and for completion
  - Most “repeat” the outdoor system using a “donor”… but some have “separate channels” for indoor only
- **Uplink?**
  - No guidance n where to measure, what criteria to use
  - Very few AHJs are requiring this today: a better solution is needed
- **Certifications for tester:** FCC; Test Equipment; Special certifications
- **Test when:** before ERRC, commission install, AHJ supervised, annually

Solution that can automate the testing of all parameters, grade real time and automate the SNR tests

Indoor Test Requirements: What Is the Need (US only)?

Assumptions: Automated test solutions, US only, Indoor only, P25/FirstNet combined w/ Cellular 2018>2022

- ~6M Commercial buildings meeting the criteria, 50K new every year
- % of AHJs requiring new buildings (35>80%) and existing buildings(2>15%)
  - AHJs require annual retest once tested
- 147K > 1M buildings tested annually (*enforcement is far from complete*)
- Time to plan/execute/report: Manual 5 hours per floor > 2h with automated; Average building can be reduced to 3 days
- # of tests for each person: 100/year (*conservatively growing to 200*)
- From 1000 to 3000 people involved in testing, ***assuming highly efficient, automated test solution***

PCTEL's Public Safety Network Testing Solution

PCTEL® Public Safety Testing Solution

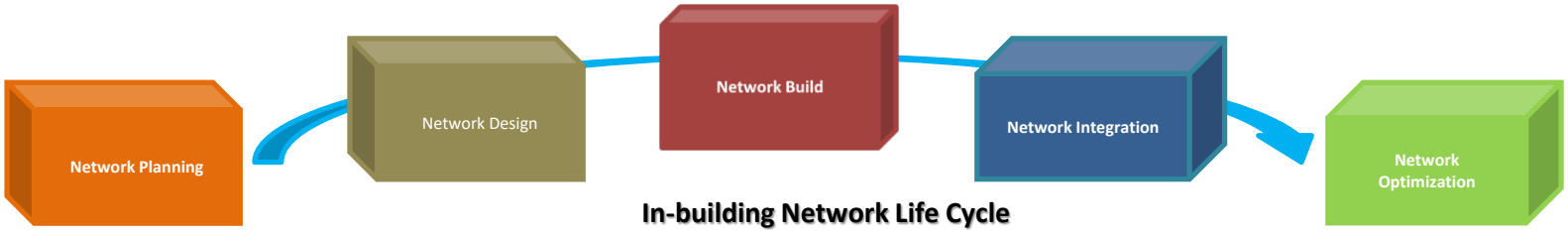
Solution Requirements

- 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

Complete Project Requires Multiple Tests



In-building Network Life Cycle

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

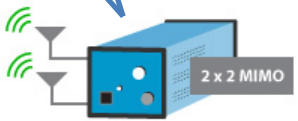
Support simultaneous data collection across all major wireless network bands and beyond.

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

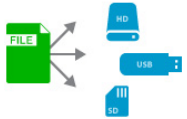
Multiple platform support for Windows® laptop and Android™ tablet.

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

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.

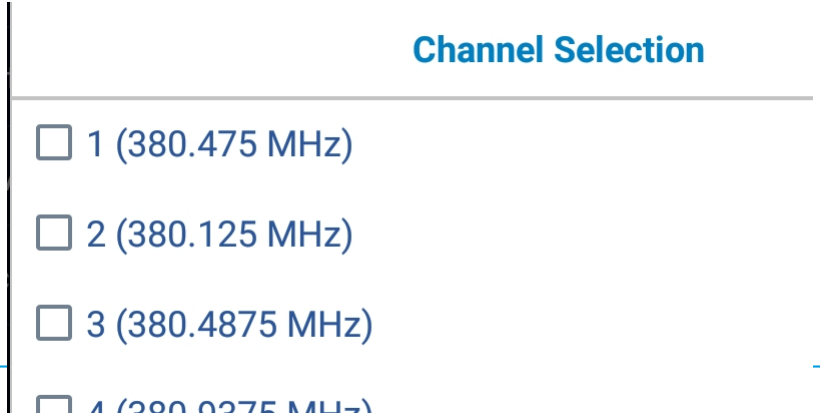
Fully field upgradable for SW and options
2 year calibration

Power Measurements: Any Radio Technology

Channelized Power (RSSI) Measurements

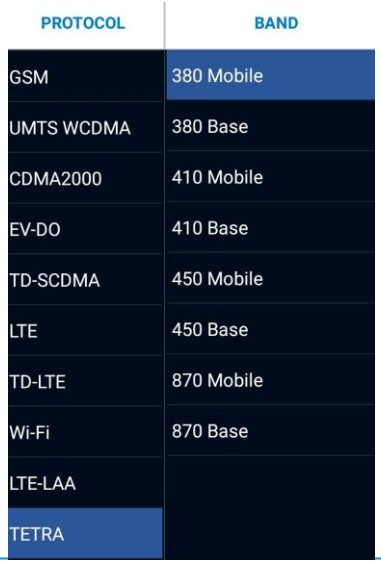
- TETRA channels are “predefined” per the spec
- Create “saved” lists for other technologies – no re-entering frequencies
- Easily specify center frequency, bandwidth and number for any channel of interest
- Applies to any test mode using workspaces

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



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	

Complete Kits for a Range of Applications

	IB*flex*® Scanner	SeeHawk® Touch	Accessories
Public Safety Network Testing Solution – P25	Measurements across 140-990M, P25 SINR/BER, Power on any Technology	Grid Test, Walk Test and Signal Analyzer	Battery Pack, Back/side pack, charger, PS antenna, carrying case
Public Safety Network Testing Solution – P25 and ATT/Verizon LTE	Adds LTE, Layer 3 for LTE and all bands used by ATT and Verizon for FirstNet	Adds Outdoor Drive Test and Antenna Verification	Adds car charger, roof top antennas for cellular
Public Safety Network Testing Solution – P25 and Cellular	Adds additional cellular technologies with Layer 3, and all bands		
Options	Upgrade from any kit, Certification Training	Additional licenses for office support	Additional batteries or battery pack

One Click Reporting

Emergency Responder Radio System
Coverage Report Test Results

Date Prepared:	September 21st, 2017
Test Location:	PCTEL RF Solutions Group
	20410 Observation Dr.# 200 Germantown, MD 20876
Technician:	David Adams
FCC#:	455

Building: PCTEL Germantown
Result: Pass

Number of Floors:	1	**Grading Approach:**	By Floor
Number of Areas Tested:	10	**Area Pass Criteria:**	95%
Number of Critical Points Tested:	10	**Critical Points Pass Criteria:**	99%

Equipment

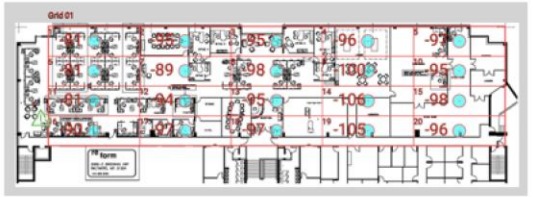
Vendor	Application	Device	Calibrated Date	Antenna info
PCTEL	SeeHawk Touch rel 2.1.1.1	SeeGull IBflex rel 2.1.1.1 SN: 12345678	12/31/2017	Ant 1 Ant 2

Test Report Summary

Channel/Group	Freq (Mhz)	Result	Areas passed / %	Critical Points passed / %
10	751.000	Pass	9/10 (90%)	10/10 (100%)
15	451.000	Pass	9/10 (90%)	10/10 (100%)
120	151.000	Pass	9/10 (90%)	10/10 (100%)
Group 5		Pass	9/10 (90%)	10/10 (100%)
11	752.000			
12	753.000			

Floor: Floor 1
Channel 10
Result: Pass

Areas Tested:	9/10 (90%)	**Area Threshold:**	-95 dBm
Critical Points Tested:	2/2 (100%)	**Critical Points Threshold:**	-90 dBm
Total Grid Size:	10000 sq.ft	**Frequency (MHz):**	750.00



Comment Grid 1: Executive Suite
Comment Grid 3: Fire Room

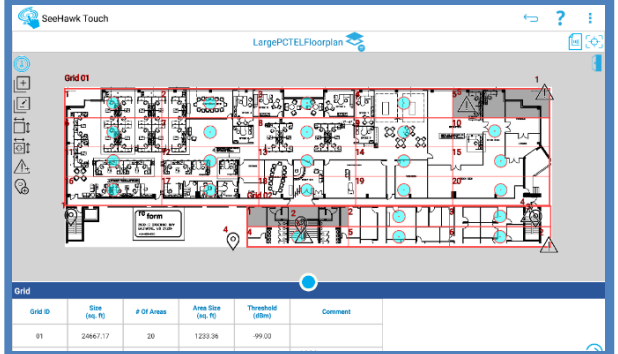
Prepare Final Report for Submission

Building Summary ***By Floor/Channel***

Public Safety Grid Testing Automation

Preparation

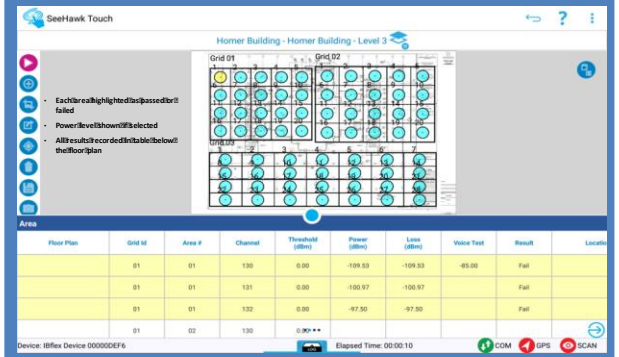
Frequencies
Grids
Pass/Fail Criteria



Automated Grid Creation

Execution

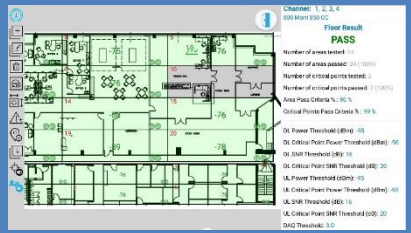
Click and Collect
Simultaneous Measurements
Real-Time Results



Simple Test Execution

Reporting

One-Click Reporting



Real-Time

Ready for Submission

Design Tool Integration

iBWave

iBWave
Mobile Note
Option 1

SeeHawk Touch

Completed Data via cloud to PC

3. Return

4. Analyze

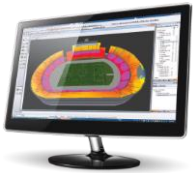
OR

iBWave
Ranplan

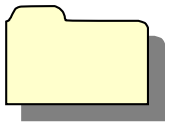
1. Design

Design File

2. Test



Option 2



4. Analyze

Completed Data File

3. Export

Integration Use Cases

Planning Tool

SeeHawk Touch

1. ***Network Planning and Design*: Baseline Survey and Model Tuning CW**
   Receive floor plans and information on existing networks. Test for coverage and quality of DAS, small cell, and macro.

2. **Network Build and Acceptance: UL/DL Tests, Coverage CW Tests**
   Receive new design info. Test for coverage in in-building walk test or in Antenna Verification Mode.

3. ***Commissioning:* Antenna Verification (DL/UL), Additive Noise, etc.**
   Receive updated design info. Test for coverage, configuration, quality, HE, and Antenna Verification Tests.

4. ***Optimization*: Coverage and Interference**
   Receive “as built” design info. Test for coverage and capacity of DAS, small cells, and macro.

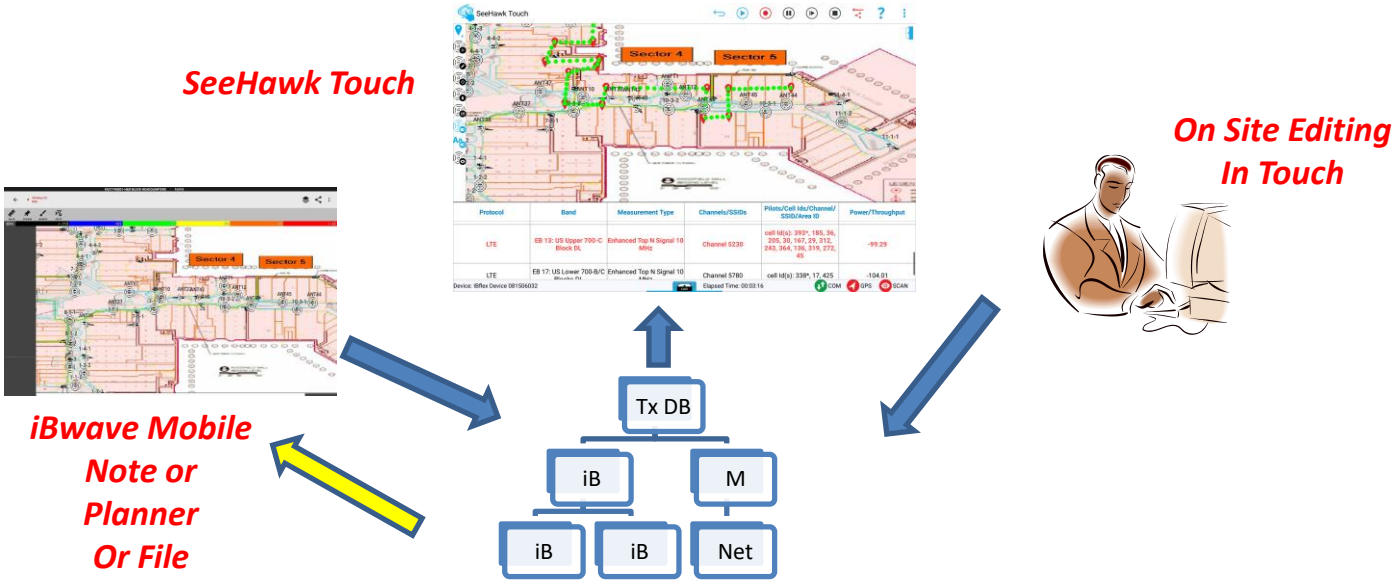
Transmitter Information During Collection

Transmitter Information available while Collecting on site

- ***Transmitter Info*** with iBwave design import (file or mobile application)
- ***All information can be edited***

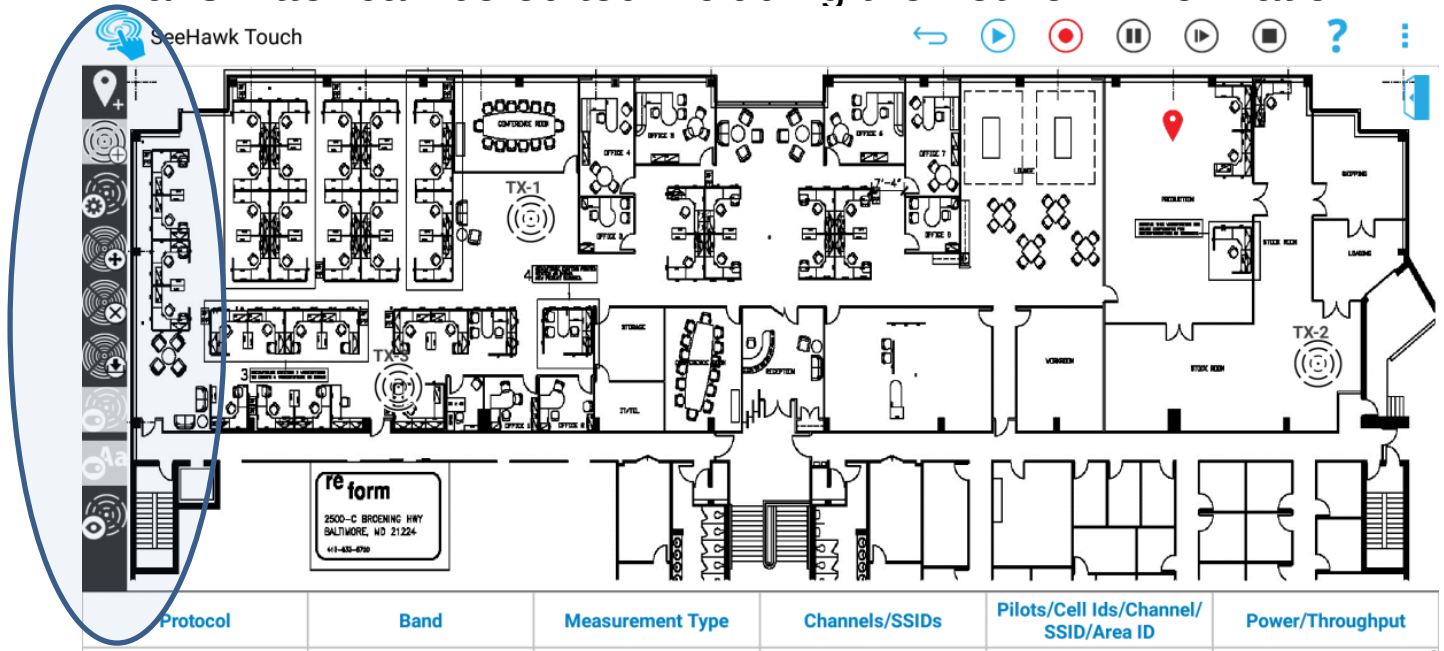
New Features in Planning

- Import from Network info (SON updates), return updated info to iBwave



Transmitter Information Manual Editing

Transmitter can be edited including the network information



Protocol	Band	Measurement Type	Channels/SSIDs	Pilots/Cell Ids/Channel/ SSID/Area ID	Power/Throughput
UMTS WCDMA	UB II: 1900 (PCS) DL	Top N	Channel 487		
UMTS WCDMA	UB IV: 2100 (AWS) DL	RSSI 200 KHz (CW)	Channel 2087		
UMTS WCDMA	UB V: 850 (Cellular) DL	RSSI 200 KHz (CW)	Channel 4359		
	FB 12: US Lower 700-A/B/	Enhanced Top N Signal 10			

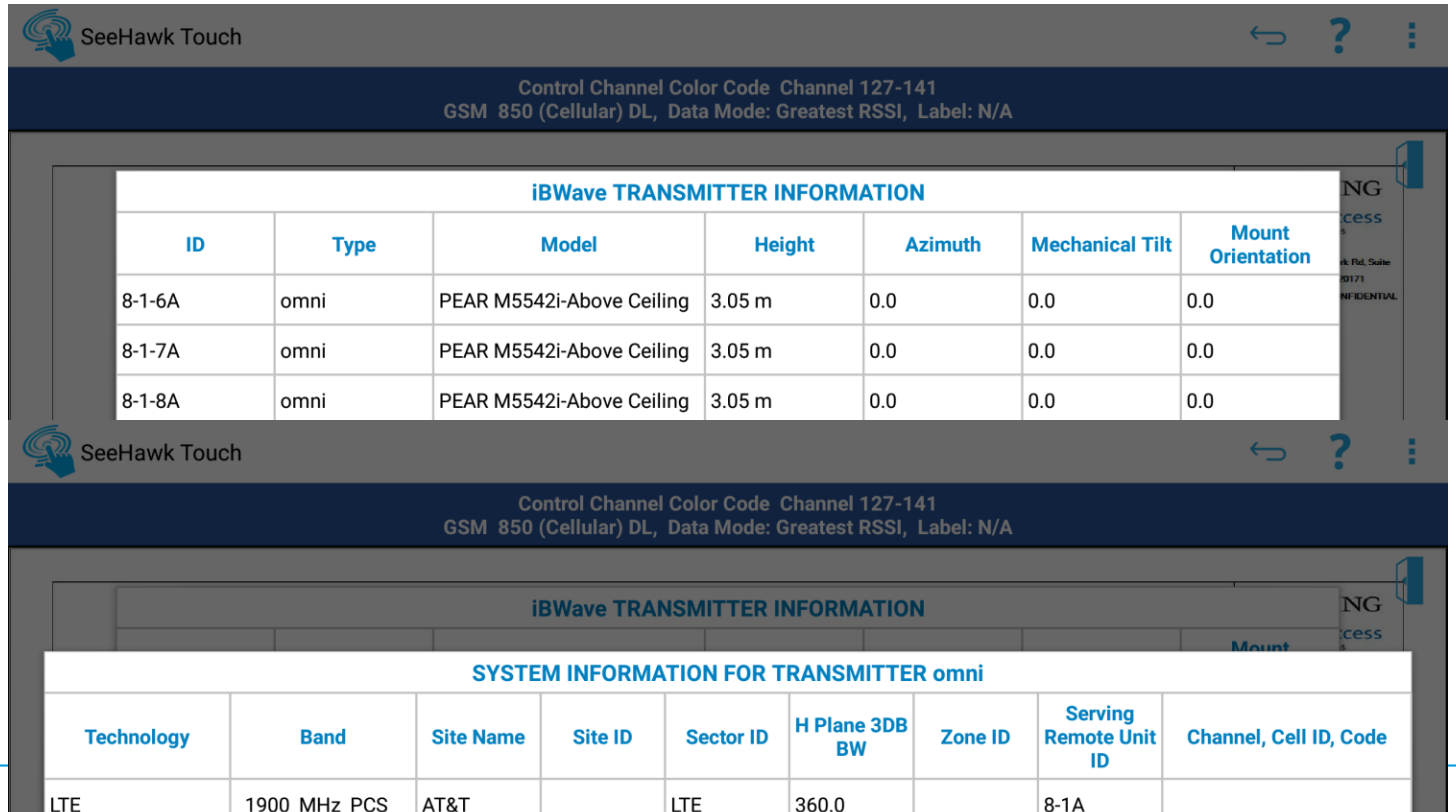
Device: IBflex Device 081506032(expires January 31, 2017 18:59 EST)

LOG

COM GPS SCAN

Transmitter Information Details Table

Full Transmitter information display for reference



Case Study

Case Study: System and Test Methods

System to be Tested

- Two “Sister” Tunnels w/ three lanes of traffic per tunnel
- Two independent Public Safety BDA/DAS fed by 5 Donors
- Baseline and Fire Code Compliance required for each system

Tunnel #1

- 3 Techs and 5 test devices per shift (2 shifts)
- Required lane closures on major highways – government truck
- 36 man-hours consumed for On-Site Coverage Testing
- Manual recording of 600 signal levels (handwritten) for test grids
- 20 admin hours for report

Tunnel #2

- 2 Techs and 1 test tool (1 shift)
- NO lane closures required; safety vehicles & personnel (lead/trail) not required ($$’s saved)
- 7 man-hours consumed for On-Site Coverage Testing
- 600 signal levels auto-recorded for test grids
- Report now automated

Case Study: Benefits of New Solution

Accuracy of data and quality of reporting far exceeding requirements

Efficiency gains: <20% of time/costs

“In order to be truly successful and fully engaged in providing the best Distributed Antenna Systems (DAS) service to our customers, we had to invest in the best tools and software. We did our research and it was the best decision we made.”

Scott Umemoto, Day Wireless Systems

Summary - PCTEL Testing Solution

Features

- ✓ Automated setup, test and report
- ✓ Ergonomics – light, discrete
- ✓ Fast, simultaneous, accurate measurements
- ✓ Easy to use
- ✓ Real-time results
- ✓ Robust development roadmap that is customer driven
- ✓ Spectrum analyzer included
- ✓ Drive test walk test, and antenna verification tools available

Benefits

- ✓ Reduces preparation, testing and reporting time (by 80% in case study)
- ✓ Consistency in the measurement and methodology
- ✓ Cost effective use of personnel
- ✓ Real-time troubleshooting
- ✓ Walk out of the building with report ready
- ✓ Use for drive testing, walk testing, design, and other tasks
- ✓ Future proof (FirstNet, cellular, CBRS, NB-IoT, Multefire, LAA, 5G)

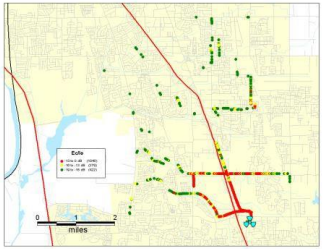
Conclusion

Thanks

SeeHawk® Touch Software Tools

Multiple Capabilities

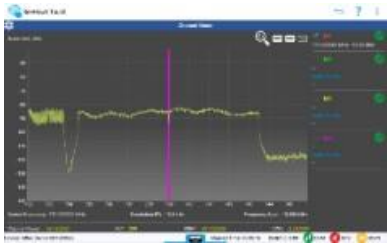
Tightly integrated tools "built in" one solution for the variety of tasks



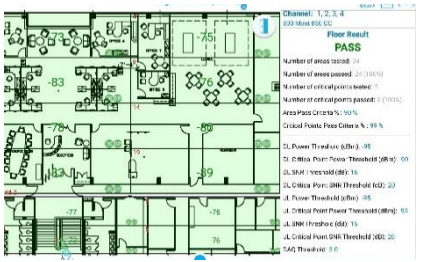
Drive test outdoor macro deployments

Commissioning: antenna verification

Walk test DAS and small cells



Spectrum Analysis for Equipment Room, Troubleshooting



Grid-based test for public safety

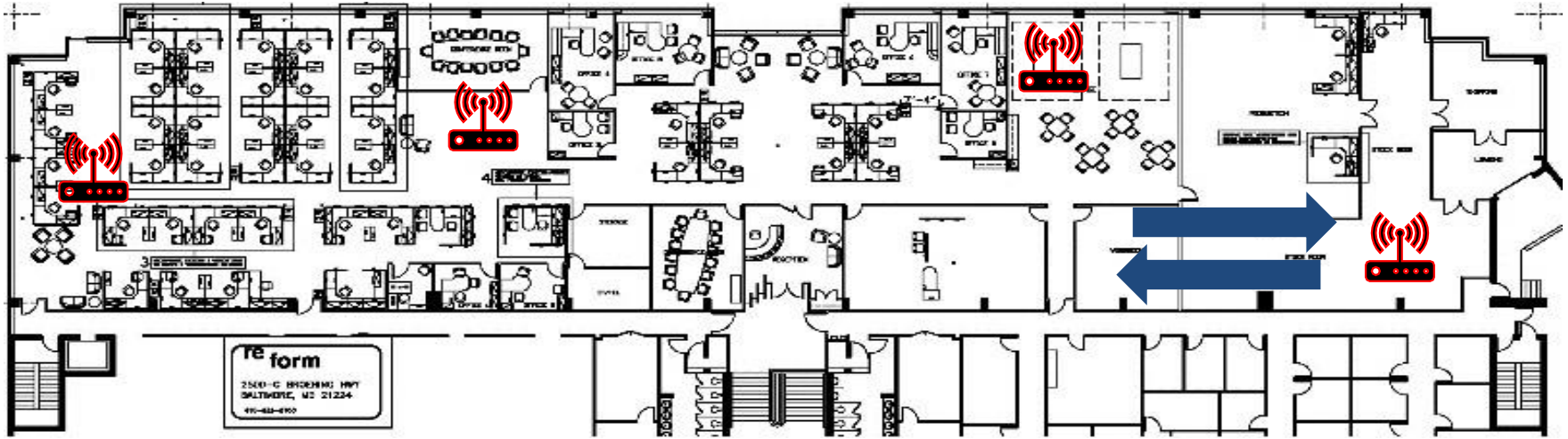
Indoor Signal Testing: Good Coverage?

The codes specify how good the radio signals have to be to provide good coverage

… testing is required to "know" for sure

Outdoor network signals exchanged with roof top antenna and amplified

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



Jurisdictional solution: Building Code Enforcement