iBwave

A Complete Guide to Surveying and Grid Testing Public Safety Networks

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A Complete and Accurate Survey Paves the Way for Optimal Network Design

Public safety networks in buildings empower first responders and emergency workers to share potentially life-saving information with each other, with central command staff, and with other agencies at critical times. These networks are considered so essential to saving lives, they're now mandatory in new buildings and renovation projects in many jurisdictions around the world.

Because indoor public safety networks are designed and built to support mission-critical communications, they're different from a standard distributed antenna system (DAS) in several ways.

Indoor Public Safety Networks Have Unique Requirements

To ensure they provide the highest possible availability, indoor public safety networks must meet pathway survivability standards and adhere to stringent backup power standards. The network must also cover all areas of the building, including those that are often a low priority or difficult to cover with a DAS. These areas include escape routes such as elevators and stairwells as well as critical areas such as the fire command center, fire pump room, standpipe cabinets, and sprinkler sectional valve locations that are often buried deep within buildings.

From a communications perspective, the public safety network is for the exclusive use of first responders and emergency workers who communicate using Project 25 (P25) two-way radio communications, private LTE cellular communications, or analog system . The network uses spectrum dedicated to public safety communications, and is the full financial and legal responsibility of the building owner.

P25 and LTE Public Safety Networks

P25 public safety networks are used for land-mobile radio (LMR) voice communications and low-bandwidth data communications. In some cases, a private LTE public safety network that supports faster speeds, higher capacity, and lower latency complements the P25 network. This guide focuses on surveys for P25 networks.

The Survey Reduces Risks Related to Coverage, Costs, and Approvals

A complete and accurate network survey ensures these mission-critical networks are fully optimized for coverage, costs, and jurisdictional requirements. The survey is the only way to:

- Confirm the extent and quality of outdoor public safety network coverage so the building owner isn't paying to duplicate coverage
- Guarantee the indoor network provides adequate coverage, quality, and signal strength to support instant, clear emergency communications, and to override signals from outdoor public safety networks that can introduce communications delays and interference
- Create the comprehensive, detailed reports required to obtain network approvals from the local Authority Having Jurisdiction (AHJ)

Overcoming Common Challenges with Public Safety Network Surveys

Like any task, surveys for indoor public safety system networks come with challenges. However, taking time upfront to thoroughly understand survey requirements and choose the right survey solution helps to overcome those challenges.

The challenges associated with surveying Public Safety Networks

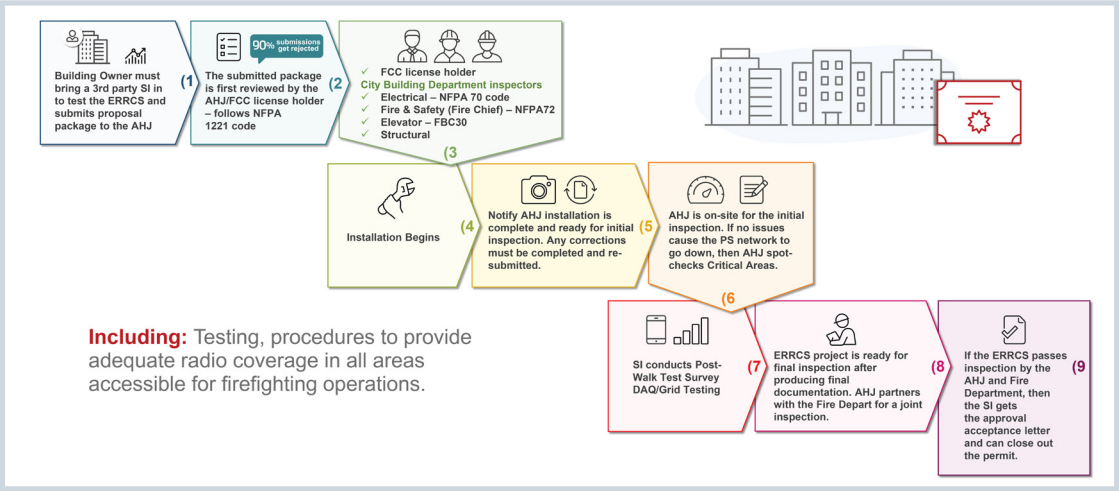
Reviewing AHJ Requirements

Each AHJ has unique and specific requirements for in-building public safety network surveys and reports. Before starting the survey, it's extremely important to carefully review those requirements as they will determine how the survey is executed. AHJs typically specify the critical areas in the building that must be covered, how and where measurements must be taken, and the drawings and data that must be included in the survey report. They may also dictate the technologies that can and cannot be used to take measurements.

Getting the survey right the first time reduces the risk of inadequate network performance, project delays, and unexpected costs:

- If the network is under-designed based on the survey results, it won't provide the full coverage and high network quality needed for reliable public safety communications throughout the building and it won't meet regulatory requirements.
- If the network is over-designed based on the survey results, network costs are unnecessarily increased for the building owner.

The steps shown in the image below reflect the AHJ requirements for public safety networks deployments.



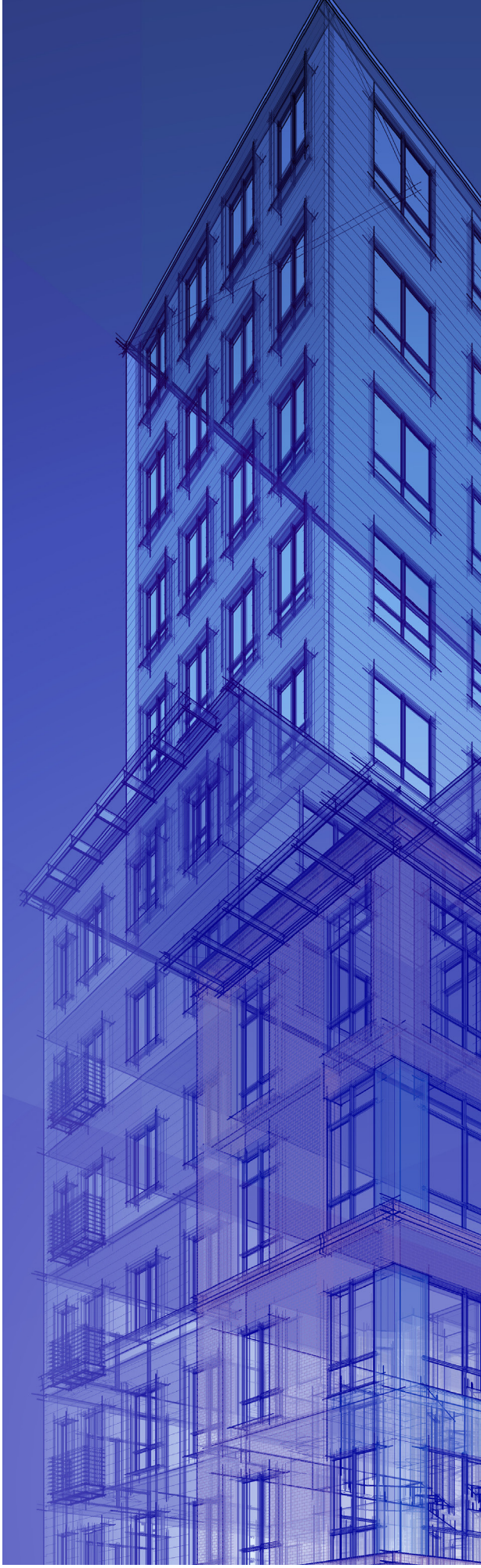
AHJ established requirements for design, installation, operation and maintenance of inbuilding systems

Choosing the Right Survey Solution

Historically, environment and RF measurement survey details were captured using pen and paper. However, this manual approach significantly increases the risk of errors and misunderstandings when data is transferred to network design engineers. The manual approach also considerably elevates the cost and involves more time spent since field engineers have to write a document to report site surveys and grid test measurements.

Survey solutions that eliminate the need to manually capture and share data are available but must be carefully evaluated to ensure they don't introduce other issues. For example, **it's important to avoid survey solutions that are:**

- Heavy, and that require extensive configuration and substantial training as these flaws make surveying difficult, time-consuming, and costly
- Slow and complicated-to-use as these flaws make it challenging to get comprehensive, real-time, and accurate insights into coverage, interference, and anomalies
- Limited in capabilities as this flaw makes it difficult to share survey data and site documentation, and to collaborate with other team members and design engineers
- Built to use manual processes for reporting and data collection, which can lead to missing information, misinterpretations, and project delays



Understanding RF Propagation Basics in Buildings

Every building has a different RF propagation profile so it's crucial to survey for coverage in a comprehensive way with no assumptions. For example:

- A single-story building has a very different RF propagation profile than a high-rise building where lower floors may be poorly covered by outdoor public safety networks while higher floors have comprehensive coverage.
- Building areas that are often used to escape — stairwells, elevators, emergency and everyday entrances — often suffer from the worst RF propagation characteristics, a flaw that can be fatal.
- Buildings that contain large numbers of electronic systems and devices have complex and highly variable RF propagation patterns, and interference may be an issue. Hospitals, manufacturing facilities, and the offices of high technology companies are good examples of these types of buildings.

Spectrum and Building Materials Influence Signal Penetration and Attenuation

The frequencies used for public safety communications affect how well signals penetrate into buildings and how likely it is that interference from other networks, systems, and devices will be an issue.

Overall, RF signals at lower frequencies penetrate into buildings and through dense materials better than signals at higher frequencies. Because signal penetration from outdoor public safety networks heavily influences indoor network requirements, it's important to know which frequency is being used for public safety communications. In the U.S., public safety channels are available across a wide range of frequency bands:

- VHF band
- 220 MHz band
- UHF band
- T-Band
- 700 MHz narrowband
- 700 MHz broadband
- 800 MHz band
- 4.9 GHz band
- 5.9 GHz band

The materials used on the outside and inside of the building also affect signal penetration and attenuation, and must be considered during surveys. For example, at 900 MHz:

- A single-pane window can reduce signal strength by 10 dB. When that same window includes single-layer sun protection and silver reflective coating, signal attenuation can increase to 25 dB.
- Standard-sized lumber and bricks typically result in signal attenuation of 5 dB and lower, while thick concrete and large masonry blocks can easily increase signal attenuation to 20 dB and higher.

People, furniture, electronics, and infrastructure such as water conduits and wiring also influence RF signal propagation in buildings.

RF Propagation Influences Network Equipment Choices and Costs

When RF signal penetration into and throughout the building is poor, the public safety network must include boosters, amplifiers, and repeaters that strengthen and disseminate RF signals indoors. These elements increase network costs and may need to meet very specific AHJ requirements. As a result, it's extremely important to know which types of materials are present in different areas of the building, and to take signal strength readings in each area. Readings taken near windows often differ considerably from readings taken near central elevator shafts, stairwells, support columns, and infrastructure stacks.

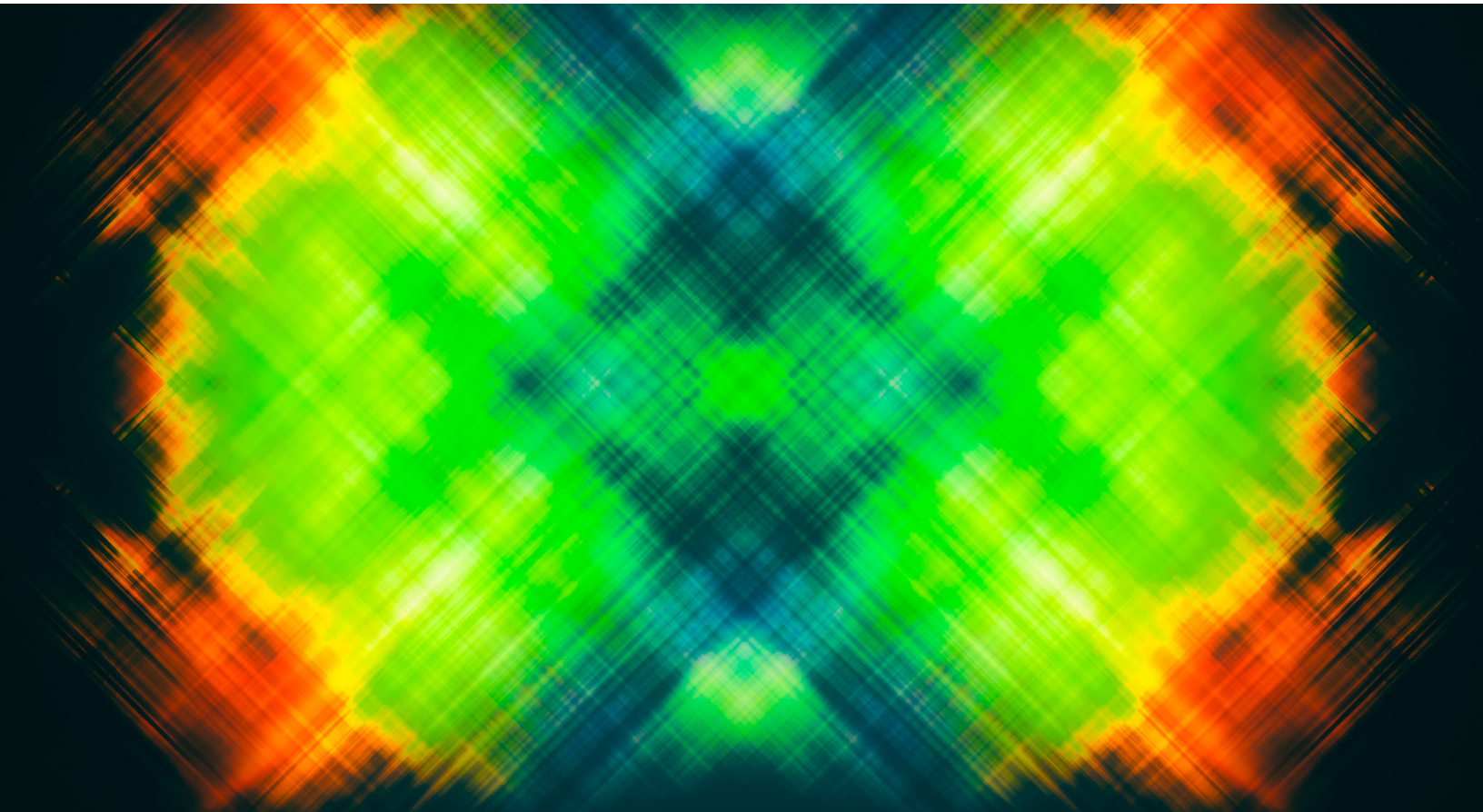
Boosters, amplifiers, and repeaters may also be required to ensure in-building RF signals are stronger than macro public safety network signals, particularly on higher floors where macro network signals can be quite strong. Capturing the differences in macro signal strength throughout the building determines how much additional equipment is needed to ensure public safety radios don't jump from the indoor public safety network to the outdoor network as first responders move through the building.

Streamlining the Network Survey and Report Submission

Using the right survey solution simplifies and accelerates each stage of the grid and environment survey process, making it fast and easy for technicians to generate comprehensive and accurate survey reports that meet AHJ requirements.

To streamline the survey and report creation process, survey solutions must provide the following characteristics and capabilities:

- **Lightweight and handheld:** An easy-to-use and -carry solution that leverages the power of smart, mobile devices, while minimizing the burden on technicians.
- **Integrated:** A survey solution that seamlessly integrates a collection of measurement data and visual information eliminates the need for multiple disjointed tools that increase complexity and survey time.
- **Comprehensive data collection:** A survey solution that can collect a wide range of survey data for different network technologies, as well as a variety of key performance indicators (KPIs) for cellular networks, reduces the costs for building owners.
- **Advanced grid test capabilities:** Advanced capabilities make it fast and easy to create, add, and edit grids, capture measurement data, identify critical areas, and automatically generate pass/fail reports to submit to the AHJ. For maximum flexibility, the solution should allow technicians to set thresholds for each measurement type, choose which measurements to include in grid testing, and set the percentage of general and critical areas that must pass grid tests.
- **Image and video capture:** To ensure survey data and reports are supported with visuals, technicians must be able to easily capture images and videos as they walk the building. For clarity and completeness, they must also be able to save visuals to geo-located identifiers on floorplans and annotate them with text or voice notes.
- **Easy sharing of survey data:** When survey data and pass/fail reports can be easily shared with external and internal teams, the survey process is faster and easier, and the integrity of captured data is maintained from grid test and environment survey through design. To accelerate AHJ approvals, the survey solution should be able to quickly generate and submit test result reports while the technician is still on-site. It should also allow technicians to easily share survey data and test results with team members, network design engineers, and building owners.



Conducting an Indoor Public Safety Network Survey

An indoor public safety network survey that is efficient, cost-effective, and meets AHJ requirements includes key activities before, during, and after the survey.

Before the Survey: Verify the Basics

We can't over-emphasize the importance of reviewing the AHJ survey and report specifications before starting the survey. In particular, review the AHJ requirements for grid sizes, measurement locations, and inclusion of calculations for inbound and outbound signal strength.

To reduce the risk of unnecessary and unexpected delays, it's also important to confirm logistics associated with the job. Before heading to the site, verify:

- The building location and most efficient way to get there
- The contact person for the job
- How the building and its various areas should be accessed, including secure and sensitive areas
- Whether an escort is required as the survey is conducted

During the Survey: Take a Methodical Approach

There are no hard and fast rules for the survey process, but it often makes sense to start with **grid testing**.

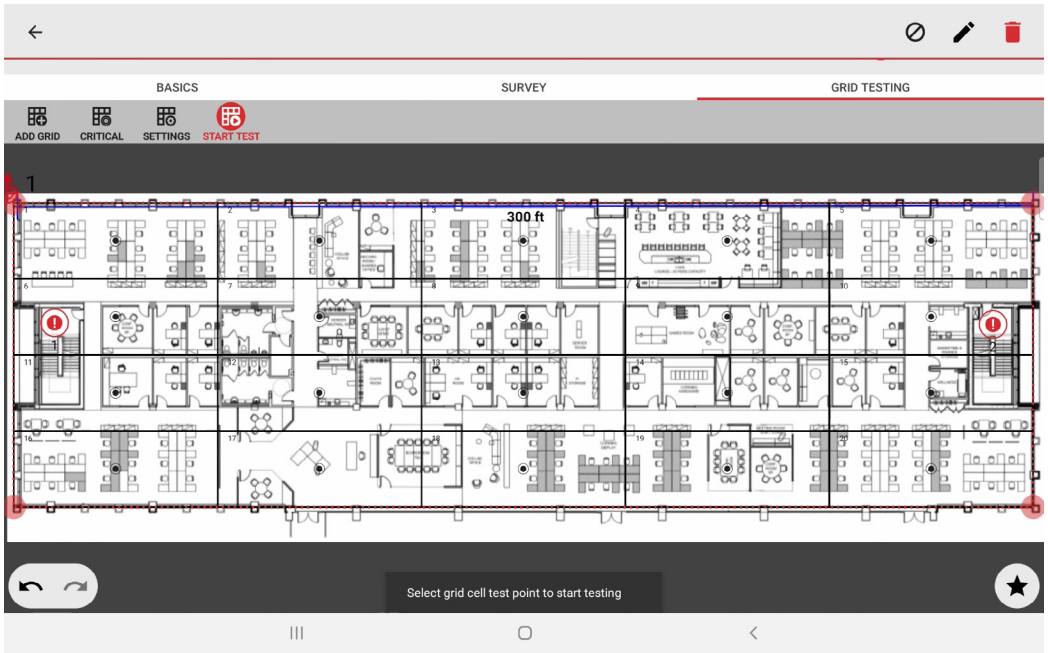
1 Start With Grid Testing

Before starting the test, add scaled grids that meet AHJ requirements over the floorplan and thresholds for each measurement type.

Then, walk every floor taking the required measurements, annotating images and videos with notes about what is being captured and building materials used in the area.

Once you capture the measurement data, you will see which grids passed or failed the test based on the set thresholds and generate a report that you will then submit to AHJs for approval.

iBwave has integrated NFPA constraint rules that users can enable or disable. These rules warn users when their drawn grid doesn't comply with the size or number of grids.



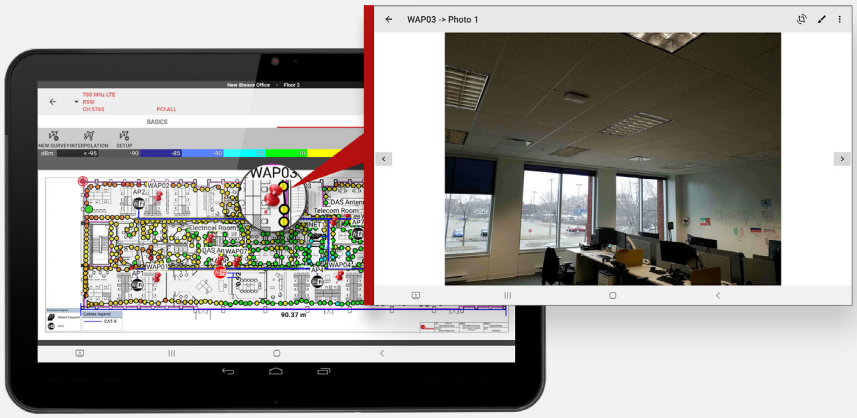
Adding a grid to a floorplan and performing grid test

❷ Perform Environment Survey

The next step is the environment survey, which determines where the donor antenna, bi-directional amplifier (BDA), riser cables, and antennas are located.

Identifying the optimal rooftop location for the donor antenna is particularly important as expensive rooftop alterations may be required to accommodate the installation. To determine the best location for the donor antenna, start by identifying the tower the antenna will communicate with and the strength of signals from that tower. This information is also important to network designers because it influences the indoor equipment used in the network. For example, if signal strength is low on the building rooftop, network designers will need to choose a BDA with higher gain than other models.

It's also critical to consider where in the building the BDA will be installed as the location also affects network costs and signal propagation. BDAs are often installed in the fire life safety or fire pump rooms, which are typically located in basements. These locations can require very long riser cable runs to the donor antenna and additional antennas to ensure adequate high-quality signals in areas far from the BDA. To identify the optimal antenna locations, walk each floor of the building and consider the materials used in each area as well as the distance from the BDA.



Capturing and annotating images of the site areas and equipment

With iBwave, you can pushpin text, image, audio or video annotations to the floor plan with your cables, access points and any other information you want to annotate to your survey to help you better understand your network coverage.

❸ Test Network Coverage

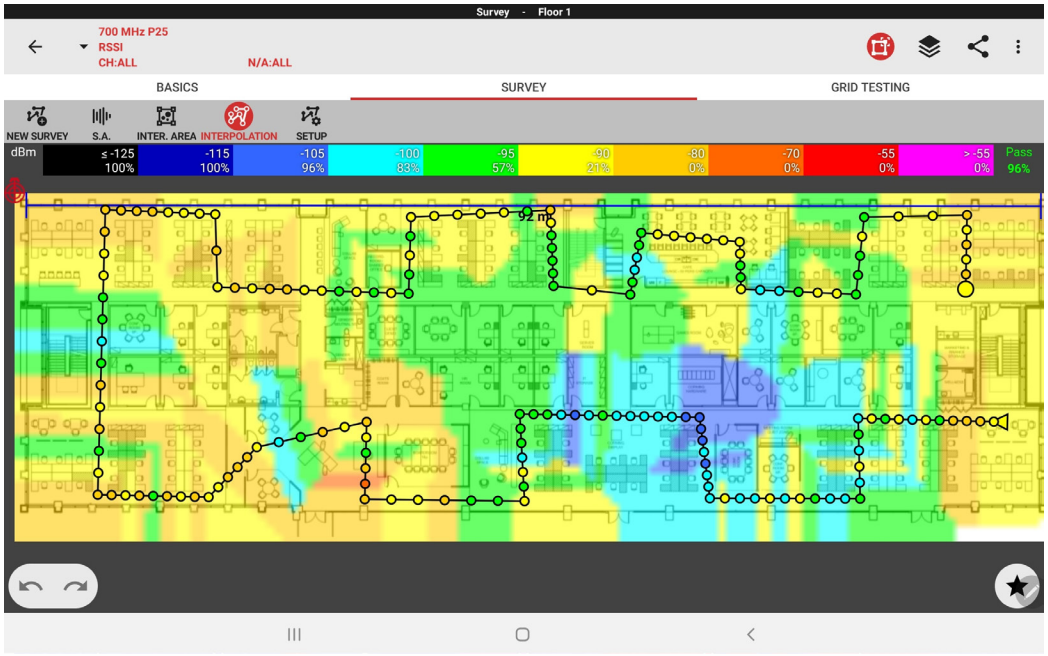
To ensure reliable and adequate network coverage for the public safety network, it is crucial to test its performance. Here are the key steps involved:

Perform a Walk Test: Walk through the building while measuring signal strength and quality. Capture important metrics like Received Signal Strength Indicator (RSSI), Signal-to-Interference-plus-Noise Ratio (SINR), and Bit Error Rate (BER) to assess network performance.

Capture P25 Measurement Data: Collect specific measurement data for P25 networks, including RSSI, SINR, and BER. These measurements provide insights into the quality and reliability of P25 signals throughout the building.

Interpolate Results: Create a coverage map by interpolating the collected data. This map visualizes signal strength and quality across the building, helping identify coverage gaps, overlaps, and potential interference areas.

By conducting a walk test, capturing P25 measurement data, and interpolating the results, you can evaluate network coverage comprehensively. This information is vital for optimizing the system, identifying areas that need improvement, and ensuring compliance with AHJ requirements (image in next page).



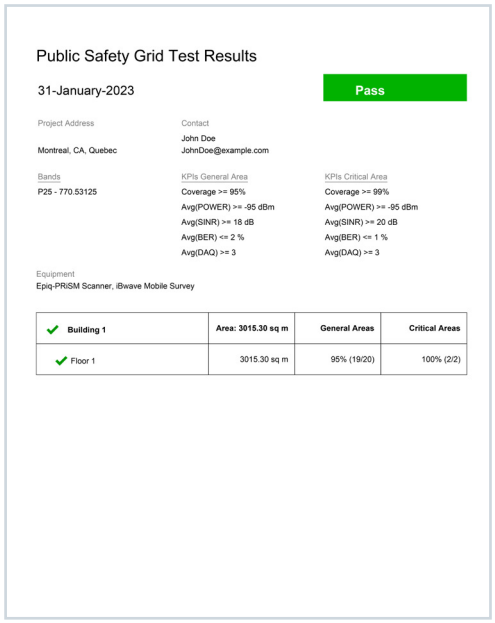
Performing P25 network coverage test

After the Survey: Submit the Report and Follow Up

The final step is to generate a report that can be immediately submitted to the AHJ, building owner, and network designers. To ensure the complete picture is provided, be sure to include higher level insight such as:

- Whether the building needs additional coverage or is adequately covered by outdoor public safety networks
- Where in the building additional coverage is required
- The signal strength on the rooftop from the towers in the area

Being on-site is also a good opportunity to verify details related to the network deployment, including construction details, installation timing, and restrictions that could affect deployment costs. This insight helps to prevent costly delays and surprises at later stages of the project, particularly if significant rooftop alterations are required to accommodate the donor antenna.


Public Safety Grid Test Results

31-January-2023

Pass

Project Address
Montreal, CA, Quebec

Contact
John Doe
JohnDoe@example.com

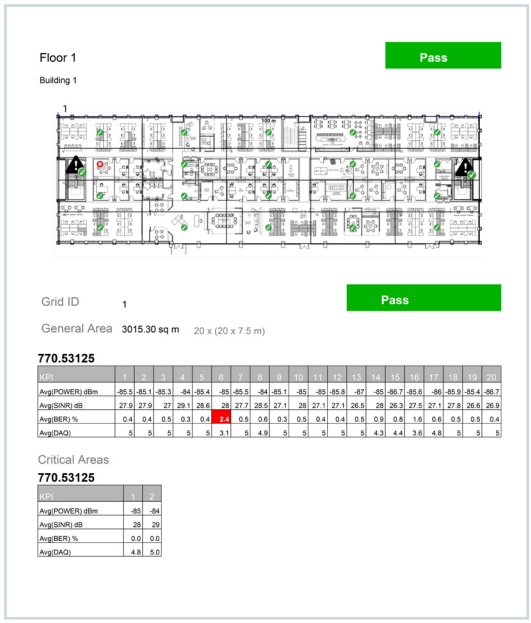
Bands
P25 - 770.53125

KPIs General Area
Coverage >= 95%
Avg(POWER) >= -95 dBm
Avg(SINR) >= 18 dB
Avg(BER) <= 2 %
Avg(DAQ) >= 3

KPIs Critical Area
Coverage >= 99%
Avg(POWER) >= -95 dBm
Avg(SINR) >= 20 dB
Avg(BER) <= 1 %
Avg(DAQ) >= 3

Equipment
Epiq-PRiSM Scanner, iBwave Mobile Survey

✔ Building 1	Area: 3015.30 sq m	General Areas	Critical Areas
✔ Floor 1	3015.30 sq m	95% (19/20)	100% (2/2)


Floor 1

Pass

Building 1

Grid ID 1

Pass

General Area 3015.30 sq m 20 x (20 x 7.5 m)

770.53125

KPI	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Avg(POWER) dBm	-85.5	-85.1	-85.3	-84	-85.4	-85	-85.5	-84	-85.1	-85	-85	-85.8	-87	-85	-86.7	-85.6	-86	-85.9	-85.4	-86.7
Avg(SINR) dB	27.9	27.9	27	29.1	28.6	28	27.7	28.5	27.1	28	27.1	27.1	26.5	28	26.3	27.5	27.1	27.8	26.6	26.9
Avg(BER) %	0.4	0.4	0.5	0.3	0.4	2.4	0.5	0.6	0.3	0.5	0.4	0.4	0.5	0.9	0.8	1.6	0.6	0.5	0.5	0.4
Avg(DAQ)	5	5	5	5	5	3.1	5	4.9	5	5	5	5	5	4.3	4.4	3.6	4.8	5	5	5

Critical Areas

770.53125

KPI	1	2
Avg(POWER) dBm	-85	-84
Avg(SINR) dB	28	29
Avg(BER) %	0.0	0.0
Avg(DAQ)	4.8	5.0

Generating grid test results for a cell and a floorplan

Integrating the Network Survey Into the End-to-End Process

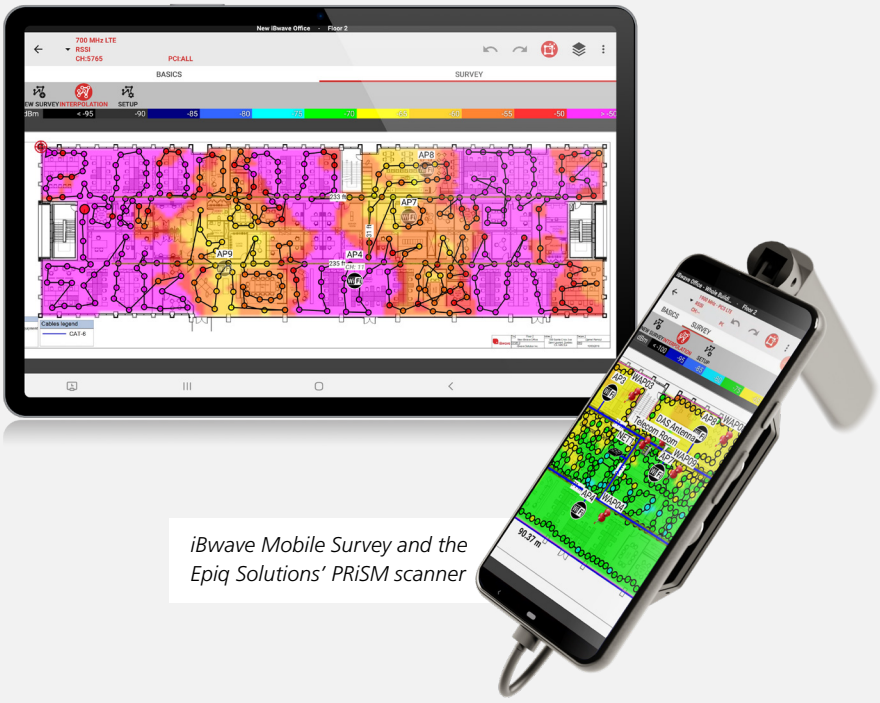
For maximum efficiency, network quality, and cost control, the network survey must be part of the end-to-end network process, rather than a standalone activity.

At iBwave, we understand the challenges, constraints, and requirements associated with indoor public safety network surveys. Our survey solution simplifies and accelerates the survey process, and contributes to higher quality, more cost-effective public safety networks in buildings.

Public Safety Network Surveys Made Simple

The **iBwave Mobile Survey for Public Safety** solution gives technicians a simple, lightweight, and affordable way to test, verify, and document public safety networks in buildings. They can simply attach the lightweight and power-efficient **Epiq Solutions' PRiSM™ scanner** to their Android device to quickly and easily:

- Scan and analyze building coverage, interference, and anomalies
- Perform grid test and quickly generate your report to submit to AHJs
- Create accurate wireless coverage maps that include photos, videos, and annotations, as well as heatmaps that illustrate site coverage to meet AHJ requirements
- Share survey data, visuals, and reports with a variety of audiences

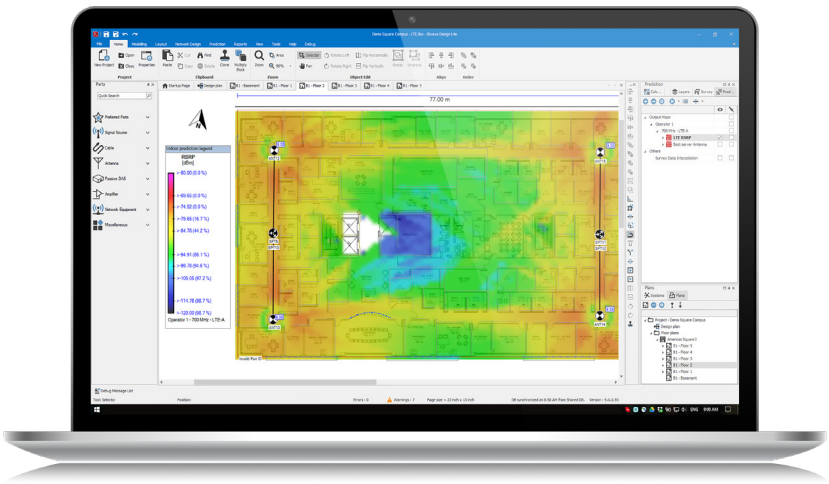


iBwave Mobile Survey and the Epiq Solutions' PRiSM scanner

The compact **PRiSM scanner weighs only 6 ounces** (under 170 grams) and easily snaps onto mobile devices using a magnet. The seamless integration between the scanner and the mobile app means technicians never have to struggle with heavy, complicated, and disjointed survey solutions that are expensive to purchase and time-consuming to learn.

Grid test with iBwave Mobile Survey and the Epiq Solutions' PRiSM scanner

Because the iBwave Mobile Survey for Public Safety solution also integrates with the **iBwave Public Safety design solution**, the integrity of captured data is maintained throughout the end-to-end process. Network designers don't have to waste time struggling to interpret handwritten data, and there is significantly less risk of human errors on the survey and design sides of the equation.



iBwave Public Safety – Public safety network design software

The **iBwave Mobile Survey for Public Safety** solution also provides value beyond the initial site survey. It can be used to measure year-over-year changes in signal coverage and quality. These comparisons can be used to verify the in-building public safety network is performing as expected and to troubleshoot reported issues.

Learn More

To learn more about the **iBwave Mobile Survey for Public Safety** solution and the **Epiq PRiSM scanner**, visit our **website** or contact us

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