



Emergency Responder Communication Enhancement Systems (ERCES) for



Derek Case, Dir. of Marketing & Business Dev.
September 22nd, 2023



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Agenda

- Overview of Public Safety Radio Systems
- Introduction to the ERCES / BDA Solution
- Code Requirements – IBC, IFC, NFPA 72, NFPA 1221
- UL 2524 Standard and UL Listing Requirements
- Avoiding Interference & Assuring Code Compliance
- FCC Registration Requirements
- Review of AHJ Specification
- How to Inspect and Certify a BDA / ERCES System
- Compliance Assurance



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ERCES / BDA Systems / Public Safety DAS

Introduction to Emergency Responder Communication Enhancement Systems

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**Reliable radio
coverage is not
a luxury.**

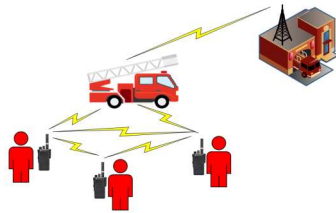
It is a necessity.

***Lives Depend
Upon It!***

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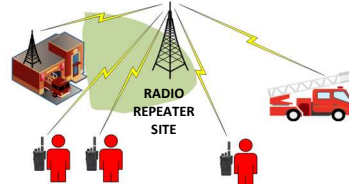
Two-Way Radio Communications

DIRECT Radio to Radio or “**Simplex**” Radio Communications where radios “talk” directly and there is no need for a central radio site.



Advantage: Simple and Reliable for short-range
Disadvantage: Short-range; only acceptable for smaller buildings

REPEATED or “**Duplex**” frequency systems where all communications go through the repeater site. All transmissions are received & rebroadcasted with higher power by the repeater.

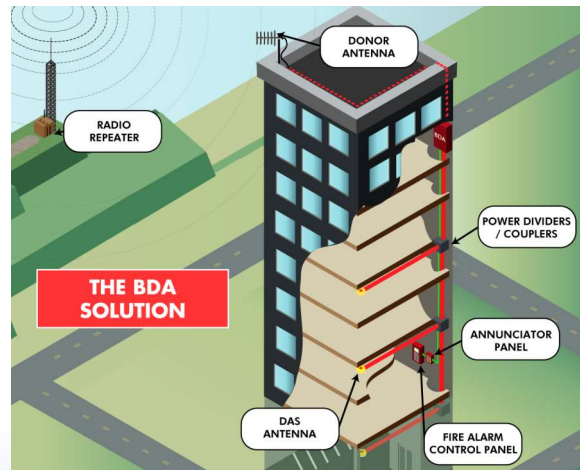
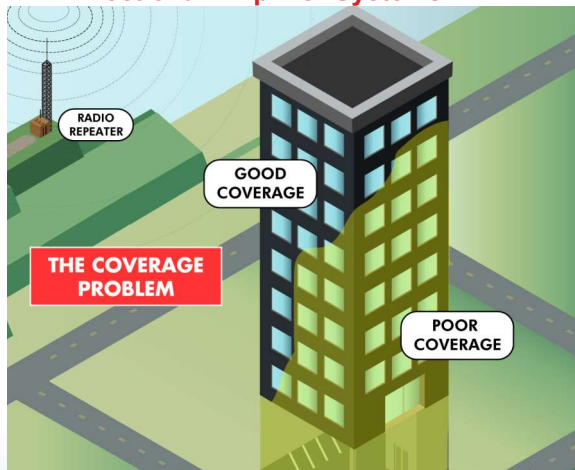


Advantage: Good radio coverage over wide area
Disadvantage: Radio signals must reach repeater site to work



Emergency Responder Communication Enhancement Systems (ERCES)

• Bi-Directional Amplifier Systems



BDA System Components

EMERGENCY RESPONSE RADIO (BDA)

- AC POWER NORMAL
- AC POWER LOSS
- BATTERY LOW
- ANTENNA PROBLEMS
- BATTERY CHARGER TROUBLE
- BATTERY LOW

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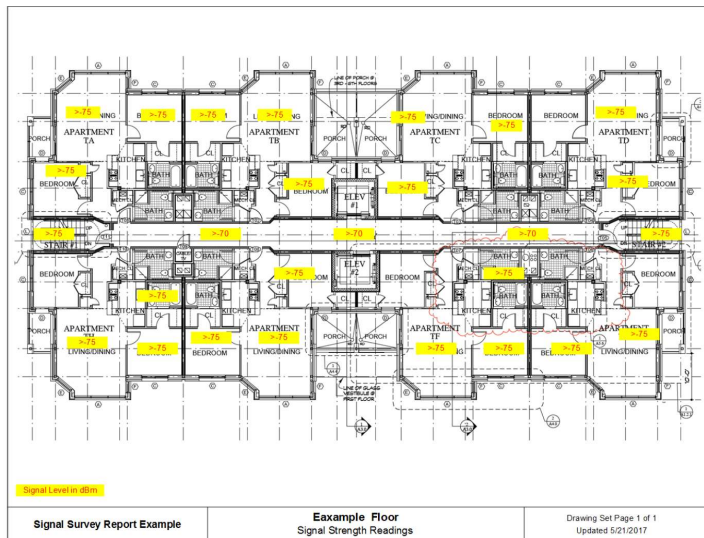
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Typical RF Site Survey = 20 Equal Grids

Another simple DL noted right on plan.

This surveyor used a 7x4 pattern for 28 grids. The geometry is neater and the survey looks more complete this way. It also helps the system designer ensure complete coverage.

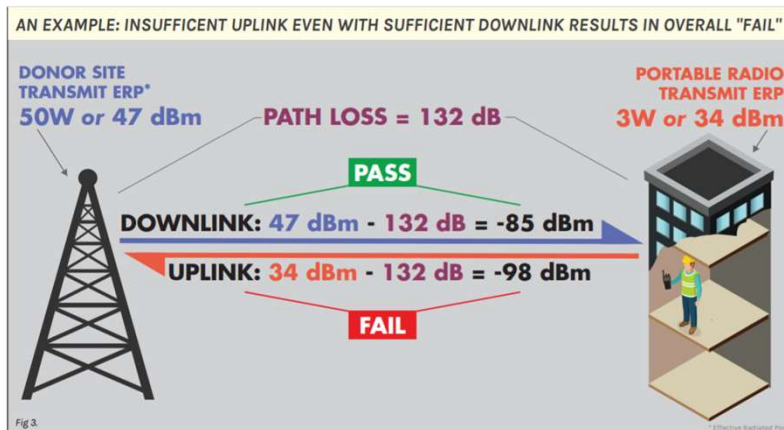
- Surveys are done by an FCC GROL-certified technicians.
- Minimum 20 readings per floor.
- Test all critical areas.
- Report submitted to AHJ.



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Minimum Inbound / Outbound Signal Strength



-85dBm is the inbound signal strength, and 13 dB is the signal strength difference (47 dBm – 34 dBm)

The outbound signal strength, in this example, would only be -98 dBm (-85 dBm – 13 dB), which does not meet code.

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Delivered Audio Quality

Signal strength is quantified by measuring signal with spectrum analyzer at **-95 dBm** (which leaves 15 dB margin in case of adverse conditions).

Radios will receive signals as weak as -120 dBm +/- 3dB

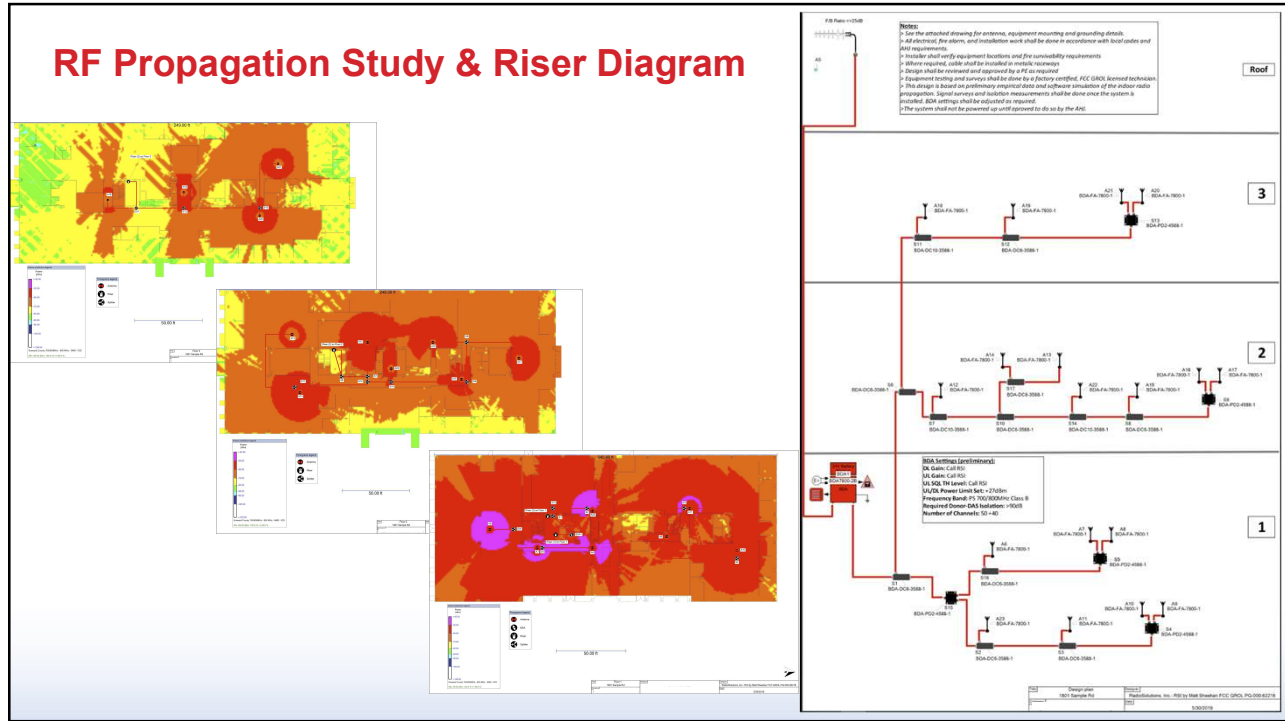
Biggest issue with DAQ testing 3.0 (in perfect conditions vs. real life conditions) is that communication may fail in borderline conditions.

NFPA 1221 2016 Edition

Delivered Audio Quality Metrics (DAQ):

- 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.
- DAQ 5** Speech easily understood.




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Typical Deployment Process

- **DESIGN** documents are submitted to the electrical engineer and/or architect and then to the AHJ for review & approval.
- **PERMIT** for installation of a BDA system is obtained by the BDA vendor, as required by the AHJ.
- **INSTALL** Electrical Contractor installs cable, connects power, and the Fire Alarm Technician makes connections to the fire alarm system. Engineered Systems Integrator installs the antennas, terminations and other RF components.
- **TEST** ERCES Systems Integrator commissions, tests and documents the system in accordance with NFPA specifications.
- **FINAL REPORT** is submitted to the AHJ along with a request for inspection.
- **INSPECT** AHJ inspects the system and does several radio checks from different parts of the building and all critical areas.
- **COMPLIANCE** AHJ signs off on the system and provides a compliance certificate.

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Code Requirements

Codes & Standards for Emergency Responder Communication Enhancement Systems

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Code Requirements

 <p>IBC 916 / 918 IEBC IFC 510 IFC 907 IFC 1103.2</p>	 <p>NFPA 1, 101 NFPA 72 NFPA 1221 NFPA 1225</p>	 <p>Federal</p>	 <p>State & Local</p>
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Pennsylvania ERCES Codes & Standards



2018 International Building Code – 918.1 Emergency responder radio coverage shall be provided in all new buildings in accordance with Section 510 of the *International Fire Code*



2018 International Fire Code

Adopted only to the extent referenced in Chapter 35 of the International Building Code 2018

510.1 Emergency responder radio coverage in new buildings

510.2 Emergency responder radio coverage in existing buildings Existing buildings shall be provided with approved radio coverage for emergency responders as required in Chapter 11

510.3 Permit required

510.4 Technical requirements

510.5 Installation requirements

510.6 Maintenance Requirements



NFPA 72 2016 Edition
24.9* Two-Way Radio Communications Enhancement Systems.
(References NFPA 1221 Chapter 9.6)



NFPA 1221 2016

9.6 Two-Way Radio Communications Enhancement Systems.

9.6.1 General

9.6.2 Pathway Survivability

9.6.3 Lightning Protection

9.6.4 Testing Requirements

9.6.5 Non-Interference and Non-Public Safety System Degradation

9.6.6 Approval and Permit

9.6.7 **Radio Coverage (99% Critical Areas; 90% General Areas)**

9.6.8 **Signal Strength** Inbound/Outbound DAQ >=3.0 analog or digital

9.6.9 Donor Antenna Isolation >20 dB above system gain

9.6.10 System Radio Frequencies

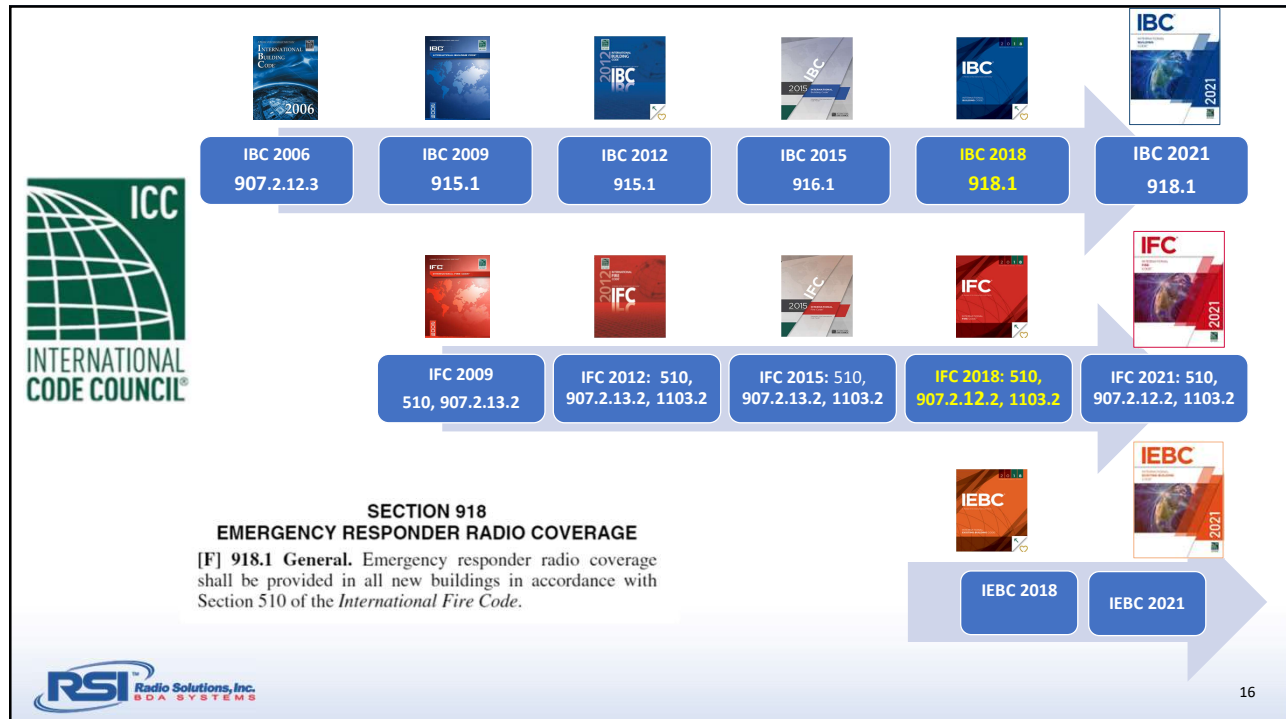
9.6.11 System Components

9.6.12 Power Supplies

9.6.13 System Monitoring

9.6.14 Technical Criteria

11.3.9 Operational Testing





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510.1 Emergency responder radio coverage in new buildings.
 New Buildings shall have approved radio coverage for emergency responders within the building based on existing coverage levels of the public safety communication systems utilized by the jurisdiction, measured at the exterior of the building. This section shall not require improvement of the existing public safety communication systems.

Exceptions:

1. Where approved by the building official and the fire code official, a wired communication system in accordance with Section 907.2.12.2 shall be permitted to be installed or maintained instead of an approved radio coverage system.
2. Where it is determined by the fire code official that the radio coverage system is not needed.
3. In facilities where emergency responder radio coverage is required and such systems, components or equipment required could have a negative impact on the normal operations of that facility, the fire code official shall have the authority to accept an automatically activated emergency responder radio coverage system.

510.2 Emergency responder radio coverage in existing buildings.
 Existing buildings shall be provided with approved radio coverage for emergency responders as required in Chapter 11.

510.3 Permit required.
 A construction permit for the installation of or the modification to emergency responder radio coverage systems and related equipment is required as specified in Section 105.7.6. Maintenance performed in accordance with this code is not considered a modification and does not require a permit.

510.4 Technical Requirements.
 Systems, components and equipment required to provide the emergency responder radio coverage system shall comply with Sections 510.4.1 through 510.4.2.8.

510.4.1 Emergency responder communication enhancement system signal strength.
 The building shall be considered to have acceptable emergency responder communications enhancement system coverage when signal strength measurements in 95 percent of all areas on each floor of the building meet the signal strength requirements in Sections 510.4.1.1 through 510.4.1.3.

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510.4.1.1 Minimum signal strength into the building.

The minimum inbound signal strength shall be sufficient to provide usable voice communications throughout the coverage area as specified by the fire code official. The inbound signal level shall be sufficient to provide not less than a Delivered Audio Quality (DAQ) of 3.0 or an equivalent Signal-to-Interference-Plus-Noise-Ratio (SINR) applicable to the technology for either analog or digital signals.

510.4.1.2 Minimum signal strength out of the building.

The minimum outbound signal strength shall be sufficient to provide usable voice communications throughout the coverage area as specified by the fire code official. The outbound signal level shall be sufficient to provide not less than a DAQ of 3.0 or an equivalent SINR applicable to the technology for either analog or digital signals.

510.4.1.3 System performance.

Signal strength shall be sufficient to meet the requirements of the applications being utilized by public safety for emergency operations through the coverage area as specified by the fire code official in Section 510.4.2.2.

510.4.2 System design.

The emergency responder radio coverage system shall be designed in accordance with Sections 510.4.2.1 through 510.4.2.8 and NFPA 1221.

510.4.2.1 Amplification systems and components.

Buildings and structures that cannot support the required level of radio coverage shall be equipped with systems and components to enhance the public safety radio signals and achieve the required level of radio coverage specified in Sections 510.4.1 through 510.4.1.3. Public safety communications enhancement systems utilizing radio-frequency-emitting devices and cabling shall be approved by the fire code official. Prior to installation, all RF-emitting devices shall have the certification of the radio licensing authority and be suitable for public safety use.



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510.4.2.2 Technical criteria.

The fire code official shall maintain a document providing the specific technical information and requirements for the emergency responder communications coverage system. 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, the applications being used and other supporting technical information necessary for system design.

510.4.2.3 Standby power.

Emergency responder radio coverage systems shall be provided with dedicated standby batteries or provided with 2-hour standby batteries and connected to the facility generator power system in accordance with Section 1203. The standby power shall be capable of operating the emergency responder radio coverage system at 100-percent system capacity for a duration of not less than 12 hours.

510.4.2.4 Signal booster.

If used, signal boosters shall meet the following requirements:

1. All signal booster components shall be contained in a National Electrical Manufacturer's Association (NEMA) 4-type waterproof cabinet.
2. Battery systems used for the emergency power source shall be contained in NEMA 3R or higher-rated cabinet.
3. Equipment shall have FCC or other radio licensing authority certification and be suitable for public.
4. Where a donor antenna exists, isolation shall be maintained between the donor antenna and all inside antennas to not less than 20dB greater than the system gain under all operating conditions.
5. Bi-Directional Amplifiers (BDAs) used in emergency responder radio coverage systems shall have oscillation prevention circuitry.
6. The installation of amplification systems or systems that operate on or provide the means to cause interference on any emergency responder radio coverage networks shall be coordinated and approved by the fire code official.



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510.4.2.5 System monitoring.

The emergency responder radio enhancement system shall be monitored by a listed fire alarm control unit, or where approved by the fire code official, shall sound an audible signal at a constantly attended on-site location. Automatic supervisory signals shall include the following:

1. Loss of normal AC power supply.
2. System battery charger(s) failure.
3. Malfunction of the donor antenna(s).
4. Failure of active RF-emitting device(s).
5. Low-battery capacity at 70-percent reduction of operating capacity.
6. Failure of critical system components.
7. The communications link between the fire alarm system and the emergency responder radio enhancement system.

510.4.2.6 Additional frequencies and change of frequencies.

The emergency responder radio coverage system shall be capable of modification or expansion in the event frequency changes are required by the FCC or other radio licensing authority, or additional frequencies are made available by the FCC or other radio licensing authority.

510.4.2.7 Design documents.

The fire code official shall have the authority to require "as-built" design documents and specifications for emergency responder communications coverage systems. The documents shall be in a format acceptable to the fire code official.

510.4.2.8 Radio communication antenna density.

Systems shall be engineered to minimize the near-far effect. Radio enhancement system designs shall include sufficient antenna density to address reduced gain conditions.

Exceptions:

1. Class A narrow band signal booster devices with independent AGC/ALC circuits per channel.
2. Systems where all portable devices within the same band use active power control features.



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510.5 Installation requirements.

The installation of the public safety radio coverage system shall be in accordance with NFPA 1221 and Sections 510.5.1 through 510.5.4.

510.5.1 Approval prior to installation.

Amplification systems capable of operating on frequencies licensed to any public safety agency by the FCC or other radio licensing authority shall not be installed without prior coordination and approval of the fire code official.

510.5.2 Minimum qualifications of personnel.

The minimum qualifications of the system designer and lead installation personnel shall include both of the following:

1. A valid FCC-issued general radio operators license.
2. Certification of in-building system training issued by an approved organization or approved school, or a certificate issued by the manufacturer of the equipment being installed.

These qualifications shall not be required where demonstration of adequate skills and experience satisfactory to the fire code official is provided.

510.5.3 Acceptance test procedure.

Where an emergency responder radio coverage system is required, and upon completion of installation, the building owner shall have the radio system tested to verify that two-way coverage on each floor of the building is not less than 95 percent. The test procedure shall be conducted as follows:

1. Each floor of the building shall be divided into a grid of 20 approximately equal test areas.
2. The test shall be conducted using a calibrated portable radio of the latest brand and model used by the agency talking through the agency's radio communications system or equipment approved by the fire code official.
3. Failure of more than one test area shall result in failure of the test.
4. 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. Failure of not more than two nonadjacent test areas shall not result in failure of the test. If the system fails the 40-area test, the system shall be altered to meet 95% coverage requirement.



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5. A test location approximately in the center of each test area shall be selected for the test, with the radio enabled to verify two-way communications to and from the outside of the building through the public agency's radio communications system. Once the test location has been selected, that location shall represent the entire test area. Failure in the selected test location shall be considered to be a failure of that test area. Additional test locations shall not be permitted.

6. The gain values of all amplifiers shall be measured and the test measurement results shall be kept on file with the building owner so that the measurements can be verified during annual tests. In the event that the measurement results become lost, the building owner shall be required to rerun the acceptance test to reestablish the gain values.

7. As part of the installation, a spectrum analyzer or other suitable test equipment shall be utilized to ensure spurious oscillations are not being generated by the subject signal booster. This test shall be conducted at the time of installation and at subsequent annual inspections.

8. Systems incorporating Class B signal-booster devices or Class B broadband fiber remote devices shall be tested using two portable radios simultaneously conducting subjective voice quality checks. One portable radio shall be positioned not greater than 10 feet (3048 mm) from the indoor antenna. The second portable radio shall be positioned at a distance that represents the farthest distance from any indoor antenna. With both portable radios simultaneously keyed up on different frequencies within the same band, subjective audio testing shall be conducted and comply with DAQ levels as specified in Sections 510.4.1.1 and 510.4.1.2.

510.5.4 FCC compliance.

The emergency responder radio coverage system installation and components shall comply with all applicable federal regulations including, but not limited to, FCC 47 CFR Part 90.219.

510.6 Maintenance.

The emergency responder radio coverage system shall be maintained operational at all times in accordance with Sections 510.6.1 through 510.6.4.



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510.6.1 Testing and proof of compliance.

The owner of the building or owner's authorized agent shall have the emergency responder radio coverage system shall be inspected and tested annually or where structural changes occur including additions or remodels that could materially change the original field performance tests. Testing shall consist of the following:

1. In-building coverage test as described in Section 510.5.3.
2. Signal boosters shall be tested to verify that the gain is the same as it was upon initial installation and acceptance or set to optimize the performance of the system.
3. Backup batteries and power supplies shall be tested under load of a period of 1 hour to verify that they will properly operate during an actual power outage. If within the 1-hour test period the battery exhibits symptoms of failure, the test shall be extended for additional 1-hour periods until the integrity of the battery can be determined.
4. Other active components shall be checked to verify operation within the manufacturer's specifications.
5. At the conclusion of the testing, a report, which shall verify compliance with Section 510.5.3, shall be submitted to the fire code official.

510.6.2 Additional frequencies.

The building owner shall modify or expand the emergency responder radio coverage system at his or her expense in the event frequency changes are required by the FCC or other radio licensing authority, or additional frequencies are made available by the FCC or other radio licensing authority. Prior approval of a public safety radio coverage system on previous frequencies does not exempt this section.

510.6.3 Nonpublic safety system.

Where other nonpublic safety amplification systems installed in buildings reduce the performance or cause interference with the emergency responder communications coverage system, the nonpublic safety amplification system shall be corrected or removed.

51.6.4 Field testing. Agency personnel shall have the right to enter onto the property at any reasonable time to conduct field testing to verify the required level of radio coverage.



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24.9 Two-Way Radio Communications Enhancement Systems.

24.9.1 General.

24.9.1.1 Non-Interference. No amplification system capable of operating on frequencies or causing interference on frequencies assigned to the jurisdiction by the FCC shall be installed without prior coordination and approval of the authority having jurisdiction. The building manager/owner shall suspend and correct other equipment installations that degrade the performance of the public safety radio system or public safety radio enhancement system.

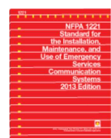
24.9.1.2 Approval and Permit. Plans shall be submitted for approval prior to installation. At the conclusion of successful acceptance testing, a renewable permit shall be issued for the public safety radio enhancement system where required by the authority having jurisdiction.

24.9.2 Installation and Design. All in-building two-way radio communications enhancement systems shall be designed, installed, and maintained **in accordance with NFPA 1221.**



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9.6 Two-Way Radio Communications Enhancement Systems.

9.6.1 All system components shall be designed, installed, tested, inspected, and maintained in accordance with the manufacturers' published instructions and the requirements of Section 9.6.

9.6.2 Pathway survivability levels shall be as described in Section 5.10. [72:24.3.13.1]

9.6.2.1 Two-way radio communications enhancement systems shall comply with 9.6.2.1.1 through 9.6.2.1.4. [72:24.3.13.8]

9.6.2.1.1* Where a two-way radio communications enhancement system is used in lieu of a two-way in-building wired emergency communications system, it shall have a pathway survivability of Level 1, Level 2, or Level 3. [72:24.3.13.8.1]

Exception: Where leaky feeder cable is utilized as the antenna, it shall not be required to be installed in metal raceway.
[72:24.3.13.8.1]

9.6.2.1.1.1 The feeder and riser coaxial cables shall be rated as plenum cables that match the building's fire rating and pathway survivability.

9.6.2.1.1.2 The feeder coaxial cables shall be connected to the riser coaxial cable using hybrid coupler devices of a value determined by the overall design. [72:24.3.13.8.1.2]

9.6.2.1.2 Where a two-way radio communications enhancement system is used in lieu of a two-way in-building wired emergency communications system, the design of the system shall be approved by the AHJ. [72:24.3.13.8.2]

9.6.2.1.3* Riser coaxial cables shall be rated as riser cables and routed through a 2-hour-rated enclosure. [72:24.3.13.8.3]

9.6.2.1.4 The connection between the riser and feeder coaxial cables shall be made within an enclosure matching the building's fire rating and pathway survivability, and passage of the feeder cable in and out of the enclosure shall be fire-stopped to the building's fire rating and pathway survivability.

9.6.3* Systems shall have lightning protection that complies with NFPA 780.

9.6.4 Systems that are used to comply accordance with 11.3.9 and 11.3.9.1.

9.6.5 Non-Interference and Non-Public Safety System Degradation.

9.6.5.1 No amplification system capable of operating on frequencies or causing interference on frequencies assigned to the jurisdiction by the licensing authority of the country of jurisdiction shall be installed without prior coordination and approval of the AHJ.



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9.6.5.2 The building manager/owner shall suspend and correct equipment installations that degrade the performance of the public safety radio system or public safety radio enhancement system.

9.6.5.3 Systems that share infrastructure with non-public safety services shall ensure that the coverage and performance of the public safety communications channels are not degraded below the level of performance identified in 9.6.7 and 9.6.8, regardless of the amount of traffic carried by the non-public safety services.

9.6.6 Approval and Permit.

9.6.6.1 Plans shall be submitted for approval prior to installation.

9.6.6.2 At the conclusion of successful acceptance testing, a renewable permit shall be issued for the public safety radio enhancement system where required by the AHJ.

9.6.7* Radio Coverage.

9.6.7.1 Radio coverage shall be provided throughout the building as a percentage of floor area as specified in section below through section on amplification components.

9.6.7.2 The system shall adhere to the maximum acceptable propagation delay standard provided by the AHJ.

9.6.7.3 Radio coverage shall be determined by the AHJ.

9.6.7.4 Critical Areas. Critical areas, including fire command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by the AHJ, shall be provided with 99 percent floor area radio coverage.

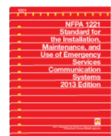
9.6.7.5 General Building Areas. General building areas shall be provided with 90 percent floor area radio coverage.

9.6.7.6 Amplification Components. Buildings and structures that cannot support the required level of radio coverage shall be equipped with a system that includes RF emitting devices that are certified by the radio licensing authority to achieve the required adequate radio coverage.



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9.6.8* Signal Strength

9.6.8.1* Inbound. A minimum inbound signal strength sufficient to provide usable voice communications, as specified by the AHJ, shall be provided throughout the coverage area. The inbound signal level shall be sufficient to provide a minimum of DAQ 3.0 for either analog or digital signals.

9.6.8.2 Outbound. A minimum outbound strength sufficient to provide usable voice communications, as specified by the AHJ, shall be provided throughout the coverage area. The outbound signal level shall be sufficient to provide a minimum of DAQ 3.0 for either analog or digital signals.

9.6.9 Isolation. If a donor antenna exists, isolation shall be maintained between the donor antenna and all inside antennas to a minimum of 20 dB under all operating conditions.

9.6.10 System Radio Frequencies. The public safety radio enhancement system shall be capable of transmitting all radio frequencies, as required by the AHJ assigned to the jurisdiction, and be capable of using any modulation technology in current use by the public safety agencies in the jurisdiction.

9.6.10.1 List of Assigned Frequencies. The AHJ shall maintain a list of all inbound/outbound frequency pairs for distribution to system designers.

9.6.10.2* Frequency Changes. Systems shall be upgradeable to allow for instances where the jurisdiction changes or adds system frequencies to maintain radio system coverage as it was originally designed.

9.6.11 System Components.

9.6.11.1* Component Approval. RF emitting devices and cabling used in the installation of the public safety two-way radio communications enhancement systems shall be approved by the AHJ, and all RF emitting devices shall have the certification of the radio licensing authority and be suitable for public safety use prior to installation.

9.6.11.2 Component Enclosures. All repeater, transmitter, receiver, signal booster components, external filters, and battery system components shall be contained in a NEMA4- or NEMA4X-type enclosure(s).



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9.6.11.3 RF Emitting Devices. RF emitting devices shall meet the following requirements in addition to any other requirements

- (1) RF emitting devices shall have the certification of the radio licensing authority prior to installation.
- (2) All RF emitting devices shall be compatible with both analog and digital communications, as required to be used by the radio licensing authority and the AHJ, simultaneously at the time of installation.

9.6.12 Power Supplies. At least two independent and reliable power supplies shall be provided for all RF emitting devices and any other components of the system: one primary and one secondary.

9.6.12.1 Primary Power Source. The primary power source shall be supplied from a dedicated branch circuit and comply with *NFPA 72*.

9.6.12.2 Secondary Power Source. The secondary power source shall consist of one of the following:

- (1) A storage battery dedicated to the system with 12 hours of 100 percent system operation capacity
- (2) An alternative power source of 12 hours at 100 percent system operation capacity as approved by the AHJ

9.6.12.3 Monitoring Integrity of Power Supplies. Monitoring the integrity of power supplies shall be in accordance with 9.1.2.2.

9.6.13 System Monitoring.

9.6.13.1 Fire Alarm System. The system shall include automatic supervisory signals for malfunctions of the two-way radio communications enhancement systems that are annunciated by the fire alarm system in accordance with *NFPA 72*, and shall comply with the following:

- (1) Monitoring for integrity of the system shall comply with *NFPA 72*, Chapter 10.
- (2) System supervisory signals shall include the following:
 - (a) Donor antenna malfunction
 - (b) Active RF emitting device failure
 - (c) Low-battery capacity indication when 70 percent of the 12-hour operating capacity has been depleted
 - (d) System component failure

continued...



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(3) Power supply supervisory signals shall include the following for each RF emitting device and system component:

- (a) Loss of normal ac power
- (b) Failure of battery charger

(4) The communications link between the fire alarm system and the two-way radio communications enhancement system must be monitored for integrity.

9.6.13.2 Dedicated Panel.

(1) A dedicated monitoring panel shall be provided within the fire command center to annunciate the status of all RF emitting devices and system component locations. The monitoring panel shall provide visual and labeled indications of the following for each system component and RF emitting device:

- (a) Normal ac power
- (b) Loss of normal ac power
- (c) Battery charger failure
- (d) Low battery capacity (to 70 percent depletion)
- (e) Donor antenna malfunction
- (f) Active RF emitting device malfunction
- (g) System component malfunction

(2) The communications link between the dedicated monitoring panel and the two-way radio communications enhancement system must be monitored for integrity.

9.6.14 Technical Criteria. The AHJ shall maintain a document of technical information specific to its requirements that shall contain, as a minimum, the following:

- (1) Frequencies required
- (2) Location and effective radiated power (ERP) of radio sites used by the public safety radio enhancement system
- (3) Maximum propagation delay (in microseconds)
- (4) List of specifically approved system components
- (5) Other supporting technical information necessary to direct system design.



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ERCES / BDA System Codes & Standards (continued)

Code Requirements	NFPA*			IFC		
	NFPA 72 (2013)	NFPA 1221 (2016)	NFPA 1221 (2019)	IFC 510 (2015)	IFC 510 (2018)	IFC 510 (2021)
In-Building Solution Required	§ 24.5.2	§ 9.6	§ 9.6	§ 510.1	§ 510.1	§ 510.1 510.4 Mandates UL 2524 Listing
Level 1, 2 or 3 Path Survivability	2 Hour for Riser Coaxial Cable § 24.3.6.8.1	2-Hour for Riser Coaxial Cable § 9.6.2.1.1	Enclosures for backbone & antenna cables match bldg. 9.6.2.3 & 9.6.2.4	Not Addressed in § 510. Referenced in 24.3.6.8.1 of NFPA 72-2013	Yes, § 510.4.2. Reference to NFPA 1221	Shall be approved by the AHJ § 510.4.2.1
Plenum Rated Coaxial Cable Required	Yes, Riser & Feeder Coaxial Cable § 24.3.6.8.1.1	Yes, Riser & Feeder Coaxial Cable § 9.6.2.1.1.1	Yes, Backbone, Antenna, Radiating or fiber optic cables § 9.6.2.1	Not Addressed in § 510. Referenced in 24.3.6.8.1.1 of NFPA 72-2013	Yes, § 510.4.2. Reference to NFPA 1221	Shall be approved by the AHJ § 510.4.2.1
Lightning Protection Required	Not addressed in § 24.5.2	Yes, In accordance with NFPA 780 § 9.6.3	Yes as per NFPA 780 9.6.3*	Not Specifically Addressed in § 510	Yes, § 510.4.2 Per NFPA 780 as Referenced in NFPA 1221	Yes, § 510.5.1
Isolation of Donor Antenna Required	Yes, 15 dB § 24.5.2.3.3	Yes, 20 dB § 9.6.9	Yes, 20 dB § 9.6.9	Not Specifically Addressed in § 510	Yes, 20 dB - § 510.4.2.4 (4)	Yes, 20 dB - § 510.4.2.4 (4)
Secondary Power Source	12 Hours § 24.5.2.5.2	12 Hours § 9.6.12.2	12 Hours § 9.6.12.2	24 Hours - § 510.4.2.3	12 Hours - § 510.4.2.3 or 2-Hour Battery w/ Emergency Generator	12 Hours - § 510.4.2.3 or 2-Hour Battery w/ Emergency Generator
Signal Strength & Area Coverage Required	-95 dBm - § 24.5.2.3 90% General - § 24.5.2.2.2 99% Critical - § 24.5.2.2.1	DAQ 3.0 - § 9.6.8 90% General - § 9.6.7.5 99% Critical - § 9.6.7.4	DAQ >=3.0 § 9.6.8.1.2 90% General § 9.6.7.4 99% Critical - § 9.6.7.3	-95 dBm - § 510.4.1 95% General - § 510.4.1 99% Critical - Not Specifically Addressed in § 510	DAQ 3.0 - § 510.4.1.1 95% General - § 510.4.1 99% Critical - § 510.4.2 (Ref. NFPA 1221)	-95 dBm - § 510.4.1.1 DAQ 3.0 - § 510.4.1.1 95% General - § 510.4.1 99% Critical - § 510.4.1
Monitoring By Fire Alarm Required	Yes - § 24.5.2.6	Yes - § 9.6.13	Yes - § 9.6.13	Yes - § 24.5.2.6 NFPA 72 -2013	Yes - § 9.6.13 NFPA 1221-2016	Yes - § 9.6.13 NFPA 1221-2016
Cabinets for Equipment & Battery Backup	Yes, NEMA 4/NEMA 4X - § 24.5.2.5.2	Yes, NEMA 4/NEMA 4X - § 9.6.11.2	Yes, NEMA 4/NEMA 4X - § 9.6.11.2	Yes, NEMA 4 - § 510.4.2.4 (1) & (2)	Yes, NEMA 4 / NEMA 3R - § 510.4.2.4 (1) & (2)	Yes, NEMA 4 / NEMA 3R - § 510.4.2.4 (1) & (2)
Monitor Antenna Malfunction Required System Acceptance / Testing	Yes, Donor Antenna - § 24.5.2.6(2)(a) § 24.5.2.1.2	Yes, Donor Antenna - § 9.6.13.1(2)(a) § 9.6.4, 11.3.9 & 11.3.9.1	Yes, Donor Antenna - § 9.6.13.1(2)(a) § 9.6.4, 11.3.9 & 11.3.9.1	Yes, § 24.5.2.6(2)(a) NFPA 72-2013 § 510.5.3	Yes, Donor Antenna - § 510.4.2.5 § 510.5.3	Yes, Donor Antenna - § 510.4.2.5 (3) § 510.5.4 510.4 Mandates UL 2524 Listing



* NFPA 1 § 11.10: In all new and existing buildings, minimum radio signal strength for fire department communications shall be maintained at a level determined by the AHJ. Where required by the AHJ, two-way radio communication enhancement systems shall comply with NFPA 1221. (Safer Buildings Coalition, 2019)

In-Building 2-Way ERCES UL 2524

- Creates a Performance Standard for BDA Manufacturers
- UL 2524 requirement is introduced in the 2021 edition of IFC 510.
- “Independent 3rd Party Verification NFPA 1221 & IFC 510 Requirements *Are Met*”



Are ERCES / BDA Systems Regulated?

FCC-Certification Requirements:

- Signal Boosters must be FCC-certified
- Manufacturer product brochures and product labels must include FCC ID number
- The end-user and the licensee must ensure that all equipment is FCC-certified
- BDA systems shall be designed & installed by manufacturer-trained, FCC GRO-Licensed Personnel
- Building owner and anyone else who intends to operate a BDA must first obtain a consent from the licensee of the frequencies for which the device or system is intended to amplify. Consent is not required from third party unintended licensees whose signals are incidentally retransmitted.
- Signal Booster operation is on a non-interference basis and must not create harmful interference to other unintended licensees.



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Assuring Compliance

Avoiding Interference with Municipal Emergency Communications Systems

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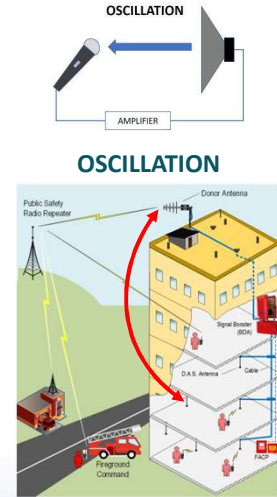
Concerns About Non-Compliant BDA Systems

#1 – OSCILLATION Interference

Improper installation or a failure could lead to Oscillation (donor antenna signal feeds back into the DAS), creating harmful interference to Public Safety Radio System.

THE SOLUTION: Oscillation Suppression

1. BDA Detects Oscillation & Reduces Gain until the oscillation is neutralized
2. BDA Sends Trouble Signal to Fire Alarm Control Panel
3. BDA Indicates Trouble on Remote Annunciator / Monitor
4. BDA Continues normal operation with the maximum allowable gain



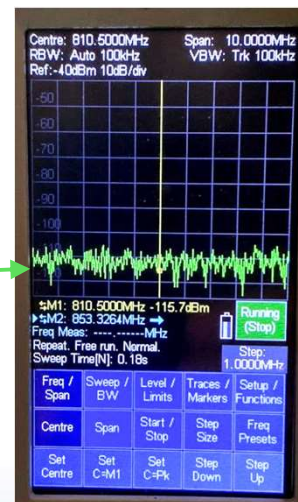
Concerns About Non-Compliant BDA Systems

#2 - NOISE Interference:

Noise on uplink can potentially add up & cause signal degradation for fire radio systems.

THE SOLUTION- Noise Suppression Feature:

1. Most BDAs normally generate a small amount of noise when idle.
2. This small amount of noise can negatively affect donor or receiver sites that are very close to the BDA.
3. Uplink noise can be mitigated with proper design and by using BDA with uplink noise suppression (a.k.a. squelch) feature.



Concerns About Non-Compliant BDA Systems

#3 - SUPERVISION:

Failure of a System Component may go unnoticed without proper monitoring & supervision (required by NFPA 72 / 1221 / 1225), resulting in the system NOT being available when you need it the most.

THE SOLUTION – Code-Compliant Supervision and Monitoring:

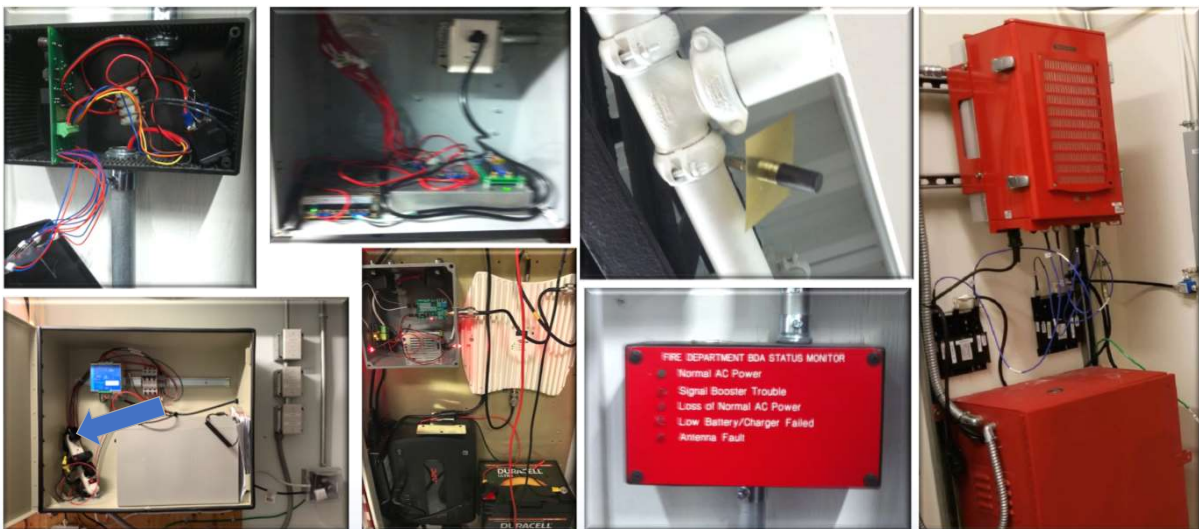
1. Supervision as required by IBC / IFC and NFPA
2. SUPERVISED Dedicated Monitoring Annunciator Panel
3. Dedicated connections for Fire Alarm Panel Supervisory
4. Monitoring Of:
 - Battery
 - Power Supplies (Primary & Secondary)
 - Antenna
 - BDA Diagnostics



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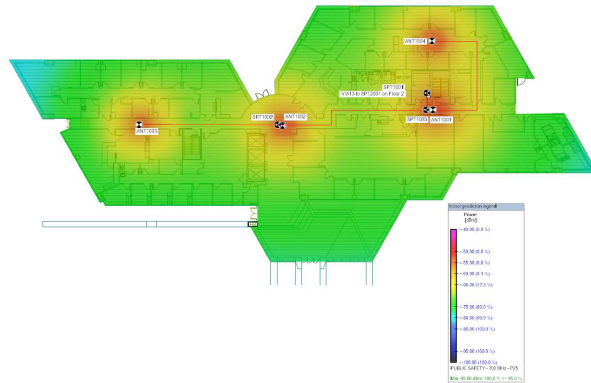
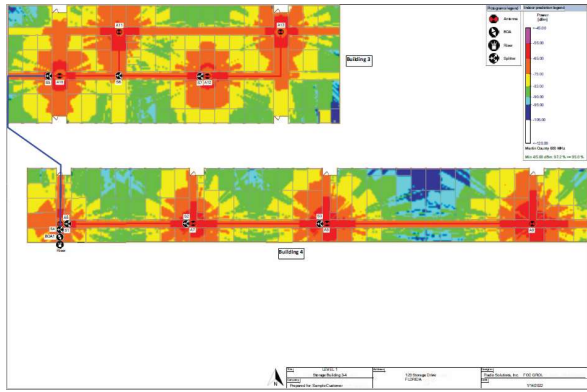
What About Code Compliance, Reliability & Safety?



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What About Code Compliance, Reliability & Safety?

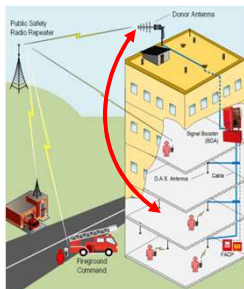


Which RF Propagation Model would you trust to provide code-compliant communications for First Responders?



Impact on Municipal Emergency Comm's Systems

OSCILLATION PREVENTION



FCC-LICENSED TECHNICIANS



In-Building Public Safety Communications (IBPSC)



MANUFACTURER TRAINING

NON-INTERFERENCE



CODE-REQUIRED SUPERVISION



Specification, Inspection & Enforcement

Authorities Having Jurisdiction (AHJ) and Architect & Engineer (A&E) Requirements

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EXAMPLE Fire Department
**Specification and Requirements for Emergency Responder
Radio Coverage in Buildings**

The **EXAMPLE Fire Department** has developed this specification in conjunction with the requirements of the Code requirements in the state of Pennsylvania, including **IFC Section 510** 2018 edition, **NFPA 72 Chapter 24.9** 2016 edition, **NFPA 1221 Chapter 9.6** 2016 edition:
510.4.1.1: The minimum inbound signal strength shall be sufficient to provide usable voice communications throughout the coverage area as specified by the fire code official.

510.1 Where required by the AHJ, two-way radio communication enhancement systems shall comply with **IFC 510 2018** edition.

Two-way Radio Communications Enhancement systems shall comply with NFPA 1221 2016 Edition

The installation and operation of radio-based emergency responder communication systems must comply with this document.

Property owners who maintain compliance with this specification are granted permission to operate the signal boosters on frequencies licensed to the **Town of EXAMPLE** Fire and Police Departments by the Federal Communications Commission.

Failure to maintain compliance with this specification will result in the automatic withdrawal of said permissions.

Prior to the construction of an Emergency Responder Communication System, a permit must be applied for and submitted to:

Fire Prevention Office
EXAMPLE Fire Department
EXAMPLE St, EXAMPLE TOWN, PA Zip

Effective Date: September 1, 2023

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Approval and Permit

1. Prior to the installation of a fire fighter Communication system, a permit for the Installation of a signal booster must be submitted to:
 - Fire Prevention Office
Example Fire Department
Example St, Example Town, PA Zip
2. The permit application shall include:
 - a. Detailed Drawings showing the location of the amplification equipment and associated antenna systems which include a view showing building access to the equipment.
 - b. Schematic drawings of the electrical system, backup power, antenna system and any other associated equipment relative to the amplification equipment including Panel Locations and labeling.
 - c. Manufacturer's data sheets on all equipment to be installed.
3. Upon approval, a permit for the installation of a signal booster will be issued. Any field changes that occur during construction shall be incorporated into a new As-Built plans, including any manufacturer's data sheets for any equipment changes not submitted in the original submittal. As- Built plans, if required due to system changes, shall be submitted for approval.
4. The EXAMPLE Fire Department assumes the responsibility of registering approved Signal Boosters with the FCC.
5. Property Owners who maintain compliance with this document are granted permission to operate a signal booster on frequencies licensed to the EXAMPLE Fire Department by the Federal communications commission. The failure to maintain compliance with this specification will result in the automatic withdrawal of said permissions.

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Fire Fighter Communication System Specification

1.0 General

All new and existing buildings shall have approved radio coverage for Fire Fighters within the building based upon the existing signal levels of the EXAMPLE Fire Department communication systems at the exterior of the building. This section shall not require improvement of the existing public safety communication systems.

Exceptions:

- A. Buildings that have sufficient levels of radio coverage to satisfy the requirements of this specification may request a waiver with the following constraints:
 1. A radio survey as described in this specification must be submitted and signed by a qualified radio vendor. (Building must be substantially completed with all walls, windows, roof, interior partitions completed prior to the survey)
 2. The survey shall be submitted with the waiver request.
 3. If approved, the waiver will only be valid for a 5-year period at which time a new radio survey must be submitted.
 4. If at any time it is determined that radio coverage does not meet this specification, the waiver will be withdrawn, and the property owner is then required to provide radio coverage as required by this specification.
- B. One and 2 family dwellings
 - 1.1 Buildings and structures that cannot support the required level of radio coverage shall be equipped with a distributed antenna system and FCC-certified, listed signal boosters, or systems otherwise approved in order to achieve the required adequate radio coverage.

2.0 Signal Strength

- 2.1 The in-building radio system is an integral component of the life safety equipment of a building or structure. The primary function is to provide reliable firefighter communications at the required signal strength within the specified areas.
- 2.2 Critical Areas such as emergency command center, fire pump room, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations and other areas deemed critical by the AHJ shall be provided with 99% floor area radio coverage.
- 2.3 General Building Areas shall be provided with 95% floor area radio coverage as specified in the 2018 version of the IFC Section 510.4.1.
- 2.4 In-building radio systems required by this ordinance must provide the following signal strengths:

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Downlink – The inbound signal level shall be sufficient to provide not less than a Delivered Audio Quality (DAQ) of 3.0 or an equivalent Signal-to-Interference-Plus-Noise Ratio (SINR) applicable to the technology for either analog or digital signals.

Uplink – The outbound signal shall be sufficient to provide not less than a DAQ of 3.0 or an equivalent SINR applicable to the technology for either analog or digital signals.

3.0 Radio Surveys:

3.1 Acceptance test procedure. Where an emergency responder radio coverage system is required, and upon completion of installation, the building owner shall have the radio system tested to verify that two-way coverage on each floor of the building is not less than 90 percent. The test procedure shall be conducted as follows:

1. Each floor of the building shall be divided into a grid of 20 approximately equal test areas.
 2. The test shall be conducted using a calibrated portable radio of the latest brand and model used by the agency talking through the agency's radio communications systems.
 3. Failure of not more than two nonadjacent test areas shall not result in failure of the test.
 4. In the event that three 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. Failure of not more than four nonadjacent test areas shall not result in failure of the test. If the system fails the 40-area test, the system shall be altered to meet the 90-percent coverage requirement.
 5. A test location approximately in the center of each test area shall be selected for the test, with the radio enabled to verify two-way communications to and from the outside of the building through the public agency's radio communication system. Once the test location has been selected, that location shall represent the entire test area. Failure in the selected test location shall be considered failure of that test area. Additional test locations shall not be permitted.
 6. The gain values of all amplifiers shall be measured, and the test measurement results shall be kept on file with the building owner so that the measurements can be verified during annual tests. In the event that the measurement results become lost, the building owner shall be required to rerun the acceptance test to reestablish the gain values.
 7. As part of the installation a spectrum analyzer or other suitable test equipment shall be utilized to ensure spurious oscillations are not being generated by the subject signal booster. This test shall be conducted at the time of installation and subsequent annual inspections.
 8. Systems incorporating Class B signal-booster devices or Class B broadband fiber remote devices shall be tested using two portable radios simultaneously conducting subjective voice quality checks.
- 3.2 RF plots indicating the enhanced coverage shall be submitted at the time of acceptance testing.
- 3.3 The FD is to be notified prior to any testing.
- 3.4 Unattended operation of the in-building radio system is not permitted until the completion of acceptance testing.

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4.0 Technical Specifications and Component Installation:

- 4.1 Assembly and installation of all components of the Fire Fighter Communication System shall comply with all applicable sections of the National Electrical Code.
 - 4.2 Signal boosters and other active components of the system shall be listed for the intended purpose.
 - 4.3 Pathway Survivability levels shall be as described in NFPA 72 version 2016 §24.3.13.1.
 - 4.4 The system must comply with all applicable sections of FCC rules. Signal booster shall have FCC certification prior to installation.
 - 4.5 Aftermarket add-on filters, attachments or other modifications of the original equipment shall not be permitted.
 - 4.6 All signal booster components, power supplies and chargers shall be contained in a NEMA4 type approved waterproof cabinet. All enclosures shall be painted red and shall include a locking mechanism.
 - 4.7 The signal booster system shall include built-in automatic alarming of malfunctions of the signal booster and battery system as per §9.6.13.1 NFPA 1221 version 2016. Aftermarket equipment add-ons and field modifications of the OEM equipment to achieve compliance with this specification will not be accepted.
 - 4.8 Maximum Propagation delay of the signal booster system is 14us (microseconds)
 - 4.9 Antenna isolation shall be maintained between the donor antenna and all inside antennas (D.A.S.) to a minimum of 20dB under all operating conditions.
- 4.10 Frequencies:**
- The systems shall be capable of supporting simultaneous transmissions of the following frequencies:
- Downlink frequency (mobile receive) Fire Channel 1: 159.300 MHz
 - Downlink frequency (mobile receive) Fire Channel 2: 159.300 MHz
 - Downlink frequency (mobile receive) Police: 155.5275 MHz
 - Uplink frequency (mobile transmit) Fire Channel 1: 151.385 MHz
 - Uplink frequency (mobile transmit) Fire Channel 2: 159.0675 MHz
 - Uplink frequency (mobile transmit) Police: 159.0675 MHz
- Signal surveys shall include all the specified frequencies.

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4.11 To reduce the possibility of unwanted interference affecting the operation of the system, signal boosters shall be band or channel selective type. Wide-band signal boosters shall not be accepted.

4.12 Signal Boosters shall have oscillation prevention circuitry to protect the public safety radio system in case of signal booster malfunction.

4.13 The cabinet shall be labeled (in bright yellow):

EXAMPLE FIRE DEPT. RADIO

Serviced by: vendor name and telephone number

5.0 System Monitoring:

5.1 The In-Building Radio system shall include automatic supervisory and trouble signals for malfunctions of the signal booster(s) and power supplies that are annunciated by the fire alarm system as specified in §9.13.1 of NFPA 1221 version 2016. Trouble signals must be immediately reported to the radio service provider.

5.2 The integrity and supervision of the circuits monitoring the signal boosters, power supplies and the dedicated monitoring panel shall comply with §10 of NFPA 72 version 2016.

5.3 System and Signal booster supervisory signals shall include Antenna Malfunction and Signal booster failure as per §9.6.13.1 of NFPA 1221 version 2016

5.4 Power supply supervisory signals shall include loss of normal AC power, Failure of battery charger, and low battery capacity (alarming at 70% of battery capacity and 30% of the charge remaining). The operation of the low battery alert function shall either be demonstrated to the AHJ, or third party verified with a Listing to the applicable UL / ANSI standard.

5.5 A dedicated monitoring panel* shall be provided within the emergency command center or other location specified by the fire department, to annunciate the status of all signal boosters. The monitoring panel shall provide visual and labeled indication of the following for each signal booster:

- (1) Normal AC power
- (2) Loss of normal AC power
- (3) Battery charger failure
- (4) Low battery capacity
- (5) Donor antenna malfunction
- (6) Active RF emitting device (Signal booster) failure
- (7) System component malfunction (if applicable)

5.6 A sign will be located at the dedicated monitoring panel with the name and telephone number of the service provider.

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6.0 Distributed Antenna System:

6.1 The distributed antenna system may utilize a radiating cable, conventional cable, fixed antennas or a Combination of all three.

6.2 Notice will be made to the **EXAMPLE** Fire Department as part of the permit application if the DAS will have frequencies other than those specified in section 4.9. All secondary users of the distributed antenna system (DAS) must comply with all requirements of the **EXAMPLE** Fire Department so as not to degrade the operational standards of the system.

7.0 Power Supply:

7.1 At least 2 independent and reliable power supplies shall be provided (§510.4.2.3 of IFC 2018)

7.2 The primary power source shall be supplied from a dedicated branch circuit and comply with (§510.4.2.3 of IFC 2018)

7.3 The emergency responder radio coverage system shall be equipped with a secondary source of power. The secondary source of power shall be a battery system with a listed dedicated battery charger. The secondary power supply shall automatically switch over and power the device when the primary power source is lost. The secondary source of power shall be capable of operating the emergency responder radio coverage system for a period of at least 12 hours. The battery charging system shall automatically charge in the presence of external power input. Battery charger and all other electronic components must be fully enclosed in a non-vented NEMA4 enclosure. Batteries shall be enclosed either in a separate, vented NEMA3R or sealed NEMA4 type approved enclosure of appropriate size. (§510.4.2.4 (1) & (2) IFC 2018)

8.0 Acceptance Testing:

8.1 Delivered audio quality (DAQ) testing will be conducted by FD radio personnel to ensure that two-way radio coverage, on each floor of the building, meets the minimum coverage requirements of Section 2 above.

8.2 The radio service vendor shall certify that the in-building radio system was installed and tested in accordance with the requirements of the current In-Building Radio Coverage Specification.

8.3 A radio service company shall certify that a maintenance contract is in effect that provides 24-hour by 7-day response within 2 hours of notification of a problem. This contract must be for a period of at least 1 year.

8.4 RF plotting (grid tests) results, gain values of all amplifiers, as built drawings which include BDA Manufacturer, Model #, Serial #, FCC Certification #, Listing Certificate and a link budget must be submitted.

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9.0 Annual Test:

9.1 The owner shall check all active components of the in-building radio system, including but not limited to amplifier, power supplies, and back-up batteries, a minimum of once every twelve (12) months.

9.2 Amplifiers shall be tested to ensure that the gain is the same as it was upon initial installation and acceptance. The original gain shall be noted and any change in gain shall be documented.

9.3 Back-up batteries and power supplies shall be tested under load to verify that they will operate during an actual power outage.

9.4 Active components shall be checked to determine that they are operating within the manufacturer's specifications for their intended purpose.

9.5 Documentation of the test shall be maintained on site and a copy forwarded by the radio service company to the **EXAMPLE Fire Department** upon completion of the test.

9.6 Radio coverage test shall be conducted a minimum of once every year to ensure that the radio system continues to meet the requirements of this ordinance. The procedure set forth in Section 3 shall apply to such tests. Any gaps in coverage shall be promptly remedied or reported to the fire department.

10. Service Provider Responsibilities:

10.1 All tests shall be conducted, documented, and signed by a person in possession of FCC General General Radio Telephone Operators License.

10.2 All testing personnel shall be certified and authorized by the BDA manufacturer in the installation and operation of their equipment.

10.3 Submit annual testing report to the fire department.

10.4 Fire department shall be promptly notified of any system failures that have not been rectified during the initial service call.

10.5 FD shall be notified in writing at least thirty (30) days prior to cancellation of a maintenance contract.

10.6 FD shall be notified in writing upon the procurement of contractual agreements relating to in-building radios covered by this specification.

11. Modifications:

11.1 Any modification of an existing BDA System will require a written request to FD.

11.2 After completion of any modification to a BDA, a full acceptance test as required in this specification will be conducted and submitted for review.

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12. Fire Department Inspections:

12.1 Fire Department Radio personnel, after providing reasonable notice to the owner or there representative, shall have the right to enter onto the property to conduct field testing to be certain that the required level of radio coverage is present.

13.0 Property Owner Responsibilities:

13.1 Upgrades to system as directed by the **EXAMPLE Fire Department**.

13.2 Maintenance contract maintained with a qualified radio service contractor, who will provide a 24 hour by 7-day emergency response within two (2) hours after notification



Information Sheet Emergency Responder Radio Coverage System

An Emergency Responder Radio Coverage System (ERRCS) is required in accordance with the direction set forth by the Philadelphia Fire Department and Section of Licenses and Inspections in [Code Bulletin, E-1002](#).

The system must be designed in accordance with Section 510 of the 2018 Philadelphia Fire Code, NFPA 70-16 National Electrical Code, NFPA 72-16 National Fire Alarm and Signaling Code and NFPA 1221-16 Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems.

The system must be installed and accepted by the Philadelphia Fire Department prior to the issuance of a Certificate of Occupancy. The system shall NOT be activated until final acceptance.

This information sheet establishes application and testing requirements for new systems.

Design Criteria

The in-building wireless system shall provide coverage throughout the entire building and must be designed utilizing signal propagation analysis software.

The radio operating frequencies and radio sites for the 800MHz City Wide Simulcast System are listed in Exhibit A.

Application Requirements

Installation of an ERRCS shall require an Electrical Permit.

Permit Application

Permit application shall be submitted through the online portal.

A separate electrical permit application is required for this work and the combination permit application may not be utilized.

Designer

The application shall include proof of the following for the system designer:


- Valid FCC general radio operators license
- Certification of in-building system training issued by a nationally recognized agency, or a certificate issued by equipment manufacturer.

Plan

Design plans must be sealed by a licensed PA Professional Engineer and comply with [Electrical Permit, Plan requirements](#), and include the following information:

- Layout of Communication Equipment
- Radio Signal Strength Evaluation
- Amplification System Configuration
- Signal Booster Location(s)

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Standby Power Configuration

- Detailed single line plan with device settings, equipment and device specifications, and circuiting conductor sizes and types for fire alarm systems.
- Component cut sheets

A copy of design files shall be furnished upon request.

Contract

A copy of the executed contract for system installation must be submitted before the billing statement is generated.

Contractor

The licensed Philadelphia Electrical Contractor must be named on the permit application.

The lead installer of the wireless system must also possess the following credentials:

- Valid FCC general radio operators license
- Certification of in-building system training issued by a nationally recognized agency, or a certificate issued by equipment manufacturer.

Permit Processing

L&I will review permit documents for compliance with NFPA 70 and NFPA 72. Permit application will also be forwarded to the City of Philadelphia Office of Information and Technology (OIT), Emergency Operations Division for review of wireless network.

Applications are reviewed by L&I within 20 business days. Additional time may be required for OIT review.

Permit Fees

The permit fee is \$25 for each 51000 or fraction thereof of estimated construction cost. Minimum fee of \$51 and maximum fee of \$15,825.

Additional permit fees: \$4.50 State surcharge; \$3.00 City surcharge.

Inspection

The licensed Electrical Inspection Agency named on the electrical permit shall be responsible to inspect and certify compliance with NFPA 70 and NFPA 72.

The Electrical Permit and associated Building Permit shall not be released until the ERRCS has been tested and accepted by the Philadelphia Fire Department as set forth below. The approval letter must be uploaded to the [Local Demand Compliant on the Building Permit](#).

Testing and Acceptance

Upon completion of installation and after building is permanently enclosed, the installer shall certify that two-way coverage is not less than 95 percent in critical areas, including fire command centers, fire pump rooms, and stairs, exit passageways, elevator lobbies, standpipe cabinets, and sprinkler sectional valve locations, and coverage is not less than 95 percent in all other areas of the building.

Testing shall be performed in accordance with Section 510 of the Philadelphia Fire Code, including the following:

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EXHIBIT A

System

The Philadelphia Public Safety Radio System is a PDS Phase II simulcast system using ten radio sites geographically placed about the city.

Operating Frequencies

The simulcast system uses 42 frequency pairs in the 800MHz Public Safety band. The details are in the table below:

TX	RX	TX	RX		
1	801.0125	809.0125	27	802.0875	807.0875
2	801.5000	809.5000	28	802.4125	807.4125
3	801.2875	809.2875	24	802.8375	807.8375
4	801.3375	809.3375	30	803.0625	807.0625
5	801.3025	809.3025	26	802.0375	807.0375
6	801.5125	809.5125	27	802.0125	807.0125
7	801.6875	809.6875	28	803.0000	808.0000
8	801.6875	809.6875	29	803.0625	808.0625
9	801.7075	809.7075	30	803.0875	808.0875
10	801.8000	809.8000	31	803.2875	808.2875
11	801.8125	809.8125	32	803.3125	808.3125
12	801.8375	809.8375	33	803.3375	808.3375
13	802.0125	807.0125	34	803.0375	808.0375
14	802.0225	807.0225	35	803.0500	808.0500
15	802.0875	807.0875	36	803.0625	808.0625
16	802.1000	807.1000	37	803.0875	808.0875
17	802.1125	807.1125	38	803.1875	808.1875
18	802.2000	807.2000	39	803.0125	808.0125
19	802.0125	807.0125	40	803.8375	808.8375
20	802.0625	807.0625	41	802.7375	812.7375
21	802.0750	807.0750	42	808.7375	813.7375

Site Information

The ten radio sites that could be assessed as donors are listed in the table below along with coordinates and ERP for each site.

Site Address	LAT	LONG	Antenna 1	Antenna 2	Antenna 3	ERP (watts)
Phila City Hall, 1400 JFK Blvd.	39-57-08.0 N	75-09-40.0 W	19	16	16	
129 Summit Lane	40-03-30.0 N	75-14-21.0 W	16	16	16	
4040 Whittaker Avenue	40-00-11.1 N	75-27-16.8 W	205	205	204.2	
2489 Southampton Road	40-06-53.8 N	74-59-23.0 W	44	44	44	
1851 State Road	40-02-32.1 N	75-00-21.8 W	182	182	182	
3059 Grays Ferry Avenue	39-56-22.7 N	75-11-41.4 W	204	204.2	204.2	
4925 Fort Mifflin Road	39-43-34.6 N	75-12-27.2 W	115	115	115	
1000 Germantown Avenue	40-02-18.0 N	75-11-06.0 W	115	115	114.8	
4300 Ford Road	40-00-04.9 N	75-13-06.0 W	155	155	154.9	
8225 Bocton Avenue	40-03-53.1 N	75-03-00.4 W	188	188	186.2	

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BDA Permit


Permit is part of the Project Submittal Package for the AHJ (with Plans, Equipment Specifications, etc.)

Permit to Install a BDA System Signed by:

- Property Manager
- BDA System Installer

“Property Owner *understands and has agreed to comply with the current* _____ Fire Department Signal Booster Specification”

Note whether Fire AND Police Frequencies are included (also consider E.M.S., Public Works, etc.)



FIRE DEPARTMENT
Permit to Install and Maintain a Signal Booster

Installation Address: _____ Zip: _____

Name of Bldg (if applicable): _____

Property Owner Name: _____ Address: _____

Property Manager Name: _____ Address: _____

Radio System Installer Name: _____ Address: _____

New Fire Radio Installation

New Fire and Police Radio Installation

Modification of existing system

5-Year Waiver (survey required with permit application)

Floors

Above Grade _____

Below Grade _____

Shared (M study required with permit)

Not Shared

Signature: _____ Note: Not to be signed by contractors

Electician's License # _____

I certify that the property owner understands and has agreed to comply with the current _____ Fire Department Signal Booster Specification. If a conflict should result with any of these specifications it will be my responsibility to resolve it.

The property owner has also acknowledged that upon final system acceptance, permission will be granted to operate a signal booster on frequencies licensed to the _____ Fire Department, by the Federal Communications Commission (FCC) and that failure to maintain compliance with the _____ Fire Department Signal Booster specifications will result in the withdrawal of this permission.

Radio Service Provider Name: _____ Address: _____

FCC License # _____

Signature: _____ Phone: _____

Email: _____ Fax: _____ Date: _____

For fire use only

Permit Number: _____ FCC Signal Booster Registration # SB _____

Issued by: _____ Signal Booster Specification Version: _____


Revision Date _____

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AHJ Acceptance

Customized to the Municipality:

- A. Plans & Permits
- B. System Components
- C. Fire Alarm System Monitoring
- D. Signal Booster Dedicated Panel
- E. Critical Areas Radio Signal Coverage Test
- F. Closeout Documentation Requirements



ERCES Acceptance Check List
Emergency Responder Communications Enhancement Systems State of _____

Plans and Permits

- If required, a permit shall be issued by the AHJ for the ERCES System (NFPA-1221 §9.6.6.2)
- BDA Plans submitted for approval prior to installation (NFPA-1221 §9.6.6.1)
- Valid FCC GRGL license for technician and equipment manufacture training (IFC §510.5.2)
- Signal Survey Report of completed system, showing signal levels of all floors in building (NFPA-1221 §9.6.7)

System Components.

- Signal booster components shall be contained in a NEMA 4 enclosure (NFPA-1221 §9.6.6.1)
- Permanent external filters and attachments shall not be permitted (NFPA-1221 §9.6.11.2)
- Signal boosters shall have FCC certification prior to installation (NFPA-1221 §9.6.11.1)
- Systems shall be capable of upgrade, if the jurisdiction changes frequencies (NFPA-1221 §9.6.10.2)
- AC power source shall be supplied from a dedicated branch circuit (NFPA-1221 §9.5.12.1)
- Storage battery with at least 12 hours of 100 percent system operation capacity (NFPA-1221 §9.6.12.2)
- Storage batteries shall be marked with the month and year of manufacture (NFPA-72 10.6.10)
- ERCES Active Components shall be UL 2524 listed (NFPA-72 10.3.1)

Fire Alarm System Monitoring

- Antenna malfunction supervisory signal at FACP (NFPA-1221 §9.6.13.1)
- Signal booster failure supervisory signal at FACP (NFPA-1221 §9.6.13.1)
- Low-battery capacity supervisory signal at FACP (NFPA-1221 §9.6.13.1)
- Loss of normal ac power supervisory signal at FACP (NFPA-1221 §9.6.13.1)
- Failure of battery charger supervisory signal at FACP (NFPA-1221 §9.6.13.1)

Signal Booster Dedicated Panel

- Normal ac power status at Dedicated Panel (NFPA-1221 §9.6.13.2)
- Signal booster trouble status at Dedicated Panel (NFPA-1221 §9.6.13.2)
- Donor Antenna Trouble (NFPA-1221 §9.6.13.2)
- Loss of normal ac power status at Dedicated Panel (NFPA-1221 §9.6.13.2)
- Failure of battery charger status at Dedicated Panel (NFPA-1221 §9.6.13.2)
- Low-battery capacity status at Dedicated Panel (NFPA-1221 §9.6.13.2)

Critical Areas Radio Signal Coverage Test

- Fire command center (NFPA-1221 §9.6.7.4)
- Fire pump room (NFPA-1221 §9.6.7.4)
- Exit stairs (NFPA-1221 §9.6.7.4)
- Exit passageway (NFPA-1221 §9.6.7.4)
- Elevator lobbies (NFPA-1221 §9.6.7.4)
- Standpipe cabinets (NFPA-1221 §9.6.7.4)
- Sprinkler sectional valve locations (NFPA-1221 §9.6.7.4)
- Other critical function areas as determined by fire official (NFPA-1221 §9.6.7.4)


Closeout Documentation Requirements


- As-built Documents containing at a minimum: Riser diagram, Equipment Locations, Cable Paths
- Equipment Technical Specifications (Manufacturer Spec. sheets)
- FCC ID Number, UL 2524 Listing Certification
- Signal Survey Report as specified
- Maintenance Contract / Annual Inspection Certification, Proof of Compliance
- Minimum Qualifications – Design, testing and installation performed by qualified personnel (FCC GRGL License Number and Manufacturer Training Certification Required)
- Compliance Certification (Inspection report)

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FCC Registration

- A. AHJ inputs FCC Registration # & Password
- B. Location of the Signal Booster
- C. Frequencies Included
- D. Call Sign
- E. Filer's Company Info. & Contact Info.
Usually the Licensee (AHJ Responsibility)
- F. Signature





PART 90 CLASS B SIGNAL BOOSTER REGISTRATION TOOL

In accordance with Federal Communications Commission's rule under Section 90.219(d)(5), all existing and future Class B Signal Boosters must be registered through the FCC.

Signal Booster Registration:

1. Visit: www.fcc.gov/signal-boosters/registration
2. Enter your (FRN) FCC Registration Number and password in the upper right-side fields of the web page.
 - a. If you do not have an FRN number, you may register for one by visiting: www.fcc.gov/cores
3. Reverify the location of the desired Signal Booster Location by either:
 - a. Entering the Address, City, and state on the Signal Booster Information Page, and clicking the "Get Lat/Long" button.
 - b. Or entering the Latitude and Longitude, in decimal degrees, on the Signal Booster Information Page, and clicking the "Get Address Info" button.

*It is important to note, that each Signal Booster must be registered separately. Once registration is complete, there will be an opportunity to submit another booster.
4. Once the desired location appears correctly on the Map, check the frequencies **box(es)** within the signal booster's operating range
5. Enter one call sign, at minimum, associated with the Signal Booster
6. Enter the filer's Company Information. And enter the Contact Information, if different from the previous information entered
7. Enter Signature Information then click Submit to finish the registration
8. On the confirmation, a Signal Booster ID number will be available to print or save, for your records. Each registration will be available the day it was filed.

Access Past Signal Booster Registrations:

1. Visit: www.fcc.gov/signal-boosters/registration. On the Part 90 Signal Booster Registration and Discovery Page, click "View All Boosters"
2. Registrations can be searched by Booster ID Numbers, name of Filer, city, county, state, zip code, latitude/longitude, or call sign

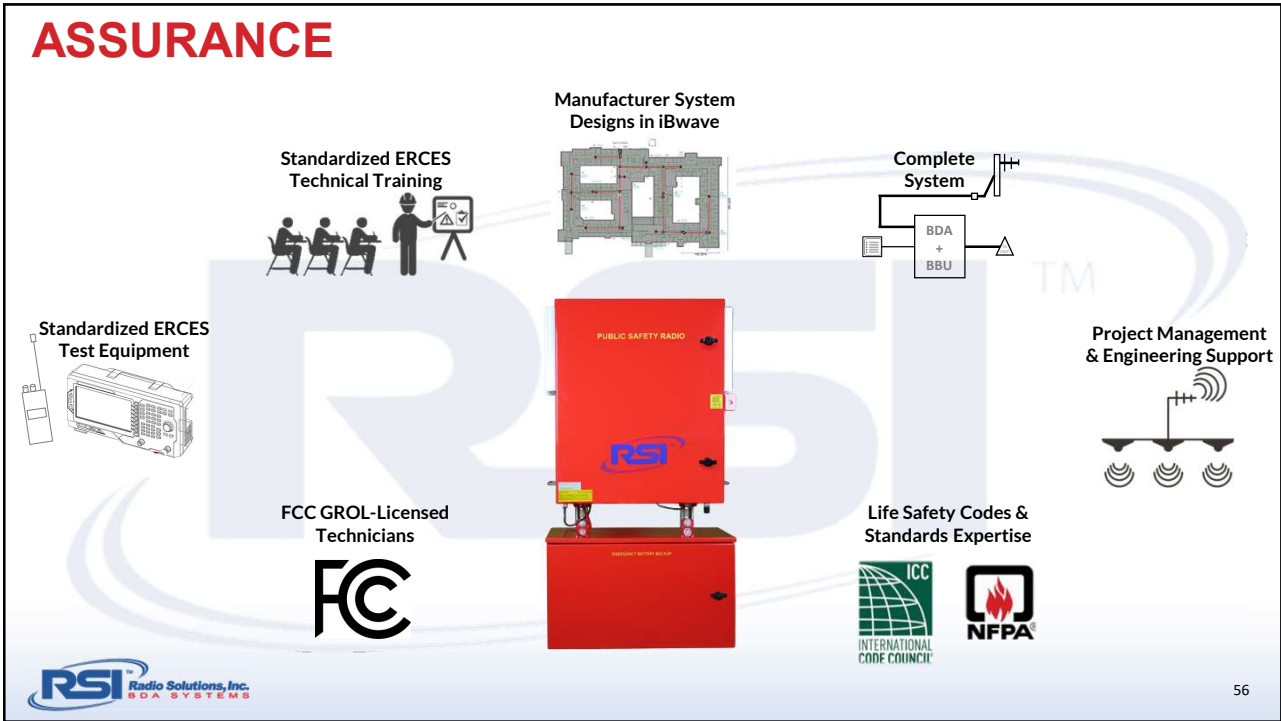
For any Further Questions, the FCC Licensing Support Hotline can be reached at: (887) 480-3201 or at <https://esupport.fcc.gov/online/request.htm>.

*Federal Communications Commission. (2014). WIRELESS TELECOMMUNICATIONS BUREAU ANNOUNCES AVAILABILITY OF PART 90 CLASS B SIGNAL BOOSTER REGISTRATION TOOL (Public Notice). Retrieved from <https://www.fcc.gov/documents/part-90-class-b-signal-boosters-creation-tool-now-available> was referenced in the making of this document.

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Compliance Assurance

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QUESTIONS & ANSWERS



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Question 1:

I'm an Authority Having Jurisdiction, and my municipality does not currently have a Specification for E.R.C.E.S. / BDA Systems.

How can I best develop a Specification for my municipality?

- a. RSI can provide the ERCES Specification Development Tool that we reviewed in today's presentation.
- b. We can also provide examples of excellent BDA Specifications from other municipalities.
- c. Based on the Fire Codes that are enforceable in your municipality, you can develop your own functional specification the components, functionality, and inspection requirements of these systems.



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Question 2:

How can I tell if the Authority Having Jurisdiction has a specification for ERCES? And whether they're required in my city?

- a. Radio Solutions will most likely have a copy of the AHJ Specification if one exists.
- b. If NFPA & IFC Requirements are enforceable in your area, then testing the radio signal strength and delivered audio quality (DAQ) in the critical areas of the building will confirm whether a system is required.



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Question 3:

How can I tell if my building project that is in the DESIGN PHASE will need a BDA System?

- a. Your local Life Safety Integrator can take radio signal strength readings at the site before construction is even begun.
- b. RSI can predict (based on the building's location, design & construction materials) whether a BDA System will be required.
- c. It's best to include stacked 2-hour rated spaces for the BDA System in the design, especially if initial readings are weak.
- d. Final RSSI measurements will be taken when walls & windows are installed to confirm whether radio signal strength enhancement is required.



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Question 4:

As a Specifying Engineer for a Building Owner, how do I ensure consistent Quality & Code-Compliance of the ERCES Systems installed in my building projects?

- a. Radio Solutions ensures Consistent Quality and Code-Compliance is through our CERTIFIED-ERCES Specialist Program.
- b. We use standardized manufacturer's training, FCC GROL-licensed technicians, standardized test equipment and tools, manufacturer design of every ERCES system, and standardized components.
- c. The combination of process control, with expert design by the manufacturer, and installation by Life Safety Experts assures Building Owners, Specifying Engineers, and AHJs of consistent quality nationwide.



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Speaker Contact Information



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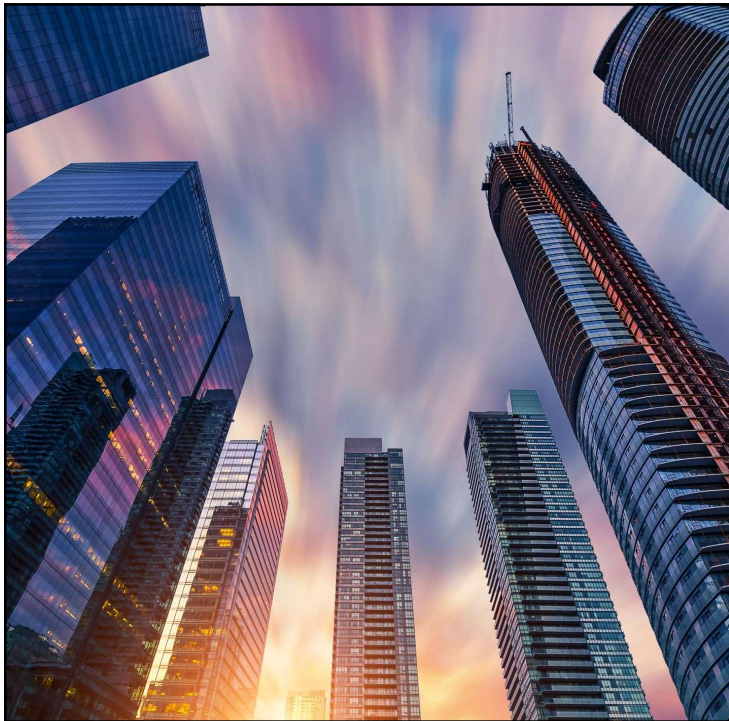
62



Thank You!



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Are your Projects Compliant with ERCES Codes?

AHJs are ramping up enforcement of the recently introduced in-building communications (ERCES) codes throughout the US.

- How to avoid delays and surprise cost overruns on the new building projects
- Learn the fundamentals of ERCES Systems, how to specify them, how to ensure code compliance, how to reduce your liability & protect yourself from non-compliant systems
- Delivering superior value to your clients through optimized Engineering Specifications & RFQs



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Engineering Specification

- **GENERAL**
 - Bi-Directional Amplifiers (Signal Boosters)
 - Coaxial Cable
 - Antennas
 - Cable Taps
 - Connectors
 - Power Dividers
 - Other Components
 - Includes Specific Fire Code References
- **DESIGN REQUIREMENTS**
- **TECHNICAL SPECIFICATIONS & PERFORMANCE REQUIREMENTS**
- **INSTALLATION REQUIREMENTS**
- **ACCEPTANCE & TEST PROCEDURES**



<p>1.1 EMERGENCY RADIO COMMUNICATION ENHANCEMENT SYSTEM (BDA SYSTEM)</p> <p>A. General</p> <ol style="list-style-type: none"> 1. Provide an in-building radio signal amplification system to provide complete coverage in the building for the public safety agencies as required by the local AHJ (Authority Having Jurisdiction). System users shall receive and transmit radio signals from their portable radio units within the building. This shall be accomplished utilizing the following components: <ol style="list-style-type: none"> a. Bi-Directional Amplifiers (Signal Boosters) b. Coaxial Cable c. Antennas d. Cable taps e. Connectors f. Power dividers g. Other components and interconnecting circuitry as required 2. The system shall comply with the requirements of UL2524 In-building 2-Way Emergency Radio Communication Enhancement Systems, NFPA 72, 2013 Edition, NFPA 1221, 2016 Edition and IFC 2015, as referenced. 3. The entire system shall meet the requirements of the Fire Department, the Building Department and all other agencies and authorities having jurisdiction (AHJ). 4. The work in this section shall include the responsibility for all permit requirements with the AHJ. Where filings require engineer's signature, documents shall be submitted for his or her review and signature. This responsibility shall include furnishing of required quantities of floor plans, descriptive notes and/or specifications, wiring diagrams, shop drawings and amendment forms. 5. Early completion of the in-building emergency radio communication enhancement system will be required as to permit a Certificate of Occupancy to be obtained in a timely manner 6. Any permits necessary for the installation of the work shall be obtained prior to the commencement of the work. All permit costs and inspection fees shall be included 7. The in-building emergency radio communication enhancement system shall use a UL2524 Listed, NFPA 72, NFPA 1221 and IFC 2018 compliant signal booster or approved equal. <p>B. Design requirements</p> <ol style="list-style-type: none"> 1. In-building emergency radio communication enhancement systems for emergency responders are an integral component of the life safety equipment of a building or structure. The primary function is to provide reliable emergency responder communications at the required signal strength within the specified areas. 2. Critical Areas such as emergency command center, fire pump room, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations and similar critical areas shall be provided with 100% floor area radio coverage. 3. General building areas shall be provided with 95% radio coverage, or as specified by AHJ. 	<p>65</p>
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Engineering Specification

- **GENERAL**
 - Bi-Directional Amplifiers (Signal Boosters)
 - Coaxial Cable
 - Antennas
 - Cable Taps
 - Connectors
 - Power Dividers
 - Other Components
 - Includes Specific Fire Code References
- **DESIGN REQUIREMENTS**
- **TECHNICAL SPECIFICATIONS & PERFORMANCE REQUIREMENTS**
- **INSTALLATION REQUIREMENTS**
- **ACCEPTANCE & TEST PROCEDURES**

<ol style="list-style-type: none"> 4. The in-building emergency radio communication enhancement systems must provide the following signal strengths: <ol style="list-style-type: none"> a. Downlink - Minimum signal strength of -95 dBm throughout the coverage area. b. Uplink - Minimum signal strength of -95 dBm received at the AHJ Radio System. c. OR As otherwise required by the AHJ. 5. The system shall be complete with all components and wiring required for compliance with all applicable codes and regulations, and for its operations described hereinafter. 6. An approved manufacturer or a qualified and approved vendor shall supply, test and determine locations of components which are required for proper operation as well as to supply, install, test and certify the performance of the complete system. Vendor qualifications must be acceptable to the AHJ. 7. Design may include iBwave software-simulated radio propagation modeling with heat maps showing predicted signal coverage levels within the building. The iBWave design shall be done by iBWave certified personnel. 8. All tests shall be conducted, documented, and signed by a person in possession of an FCC General Radio Telephone Operators License. All testing personnel shall be certified and authorized by the signal booster manufacturer in the installation and operation of their equipment. Personnel qualifications must be acceptable to the AHJ. 9. The system design shall be based on the Radio Solutions, Inc (Norwell, MA) line of Public Safety Signal Boosters UL2524, NFPA 72, NFPA 1221, IFC and FCC certified to establish standards of quality for materials and performance. The naming of a specific manufacturer or a catalog number does not waiver any requirement or performance of individual components described in the specifications. 10. Assembly and installation of all components of the Emergency Responder Radio Communication Enhancement System shall comply with all applicable sections of the National Electrical Code. 11. Survivability from attack by fire shall meet requirements of NFPA 72, NFPA 1221, IFC or as required by the local jurisdiction. 12. The system must comply with all applicable sections of the FCC rules. Signal booster shall have FCC certification prior to installation. 13. Antenna isolation shall be maintained between the donor antenna and all inside antennas (D.A.S.) to a minimum of 20dB under all operating conditions. <p>C. Technical Specifications and Performance Requirements</p> <ol style="list-style-type: none"> 1. The system specified shall be based upon Radio Solutions, Inc (Norwell, MA) line of Public Safety UL2524 Listed and NFPA72, NFPA 1221, IFC compliant signal boosters 2. The signal booster shall be a Class B Public Safety type as designated by the FCC or as required by the AHJ. 	<p>66</p>
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Engineering Specification

- GENERAL
 - Bi-Directional Amplifiers (Signal Boosters)
 - Coaxial Cable
 - Antennas
 - Cable Taps
 - Connectors
 - Power Dividers
 - Other Components
 - Includes Specific Fire Code References
- DESIGN REQUIREMENTS
- TECHNICAL SPECIFICATIONS & PERFORMANCE REQUIREMENTS
- INSTALLATION REQUIREMENTS
- ACCEPTANCE & TEST PROCEDURES

3. The secondary power supplies, battery chargers and system monitoring shall be fully compliant with NFPA 72, NFPA 1221 and IFC. The signal booster shall have both the primary and the secondary power supplies within a waterproof, type-4 approved enclosure.
4. All signal boosters and other active system components must have FCC certification prior to installation. The equipment FCC ID must be shown on the product datasheets and technical submittals. The ID must also be displayed on the product as required by the FCC.
5. The signal booster shall be pre-set by the equipment manufacturer for the frequencies specified by the AHJ. Field tuning of RF filters and duplexers is not allowed.
6. UHF and VHF signal boosters shall be band selective type with a maximum 3dB channel bandwidth of 200KHz (Fc +/- 100KHz) per band. Non-selective wide-band signal boosters shall not be accepted, unless required to cover multiple channels within the same band.
7. Signal Boosters shall have oscillation suppression circuitry to protect the public safety radio system in case of system malfunction or other causes. The oscillation suppression circuit shall not disable the system operation. Systems that automatically disable the signal booster upon oscillation detection shall not be allowed.
8. Signal Boosters shall have uplink noise suppression function to eliminate uplink noise while in standby (i.e. no radio transmission from within a building). Systems that produce any measurable level of uplink noise while in standby shall not be allowed.
9. Signal Booster gain shall be rated at minimum of 80dB and the gain shall be adjustable in a minimum of 30dB range. System gain shall be set and documented at the time of the final system test.
10. Maximum Propagation delay of the signal booster system shall be the lesser of 14µs (microseconds) or as specified by AHJ.
11. The signal booster system shall include built-in automatic supervision of malfunctions of the signal booster and battery system as per NFPA 1221 NFPA 72 and IFC. Non-OEM equipment add-ons and modifications to comply with this specification shall not be allowed.
12. A dedicated supervised monitoring panel shall be provided within the emergency command center next to the fire alarm panel / annunciator or other location as designated by AHJ to annunciate the status of all signal booster locations. The monitoring panel shall provide visual and labeled indication of the following for each signal booster:
 - a. Normal AC power
 - b. Signal booster trouble
 - c. Antenna Failure
 - d. Loss of normal AC power
 - e. Failure of battery charger
 - f. Low battery capacity
13. The vendor shall verify the system monitoring requirements and the required annunciator location with the AHJ prior to system installation. System monitoring shall be fully compliant with the AHJ requirements.
14. Non-OEM External filters, duplexers, power supplies or other non-OEM additions or modifications of the original equipment shall not be allowed.

Engineering Specification

- GENERAL
 - Bi-Directional Amplifiers (Signal Boosters)
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 - Connectors
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- DESIGN REQUIREMENTS
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- INSTALLATION REQUIREMENTS
- ACCEPTANCE & TEST PROCEDURES

15. All signal booster components shall be contained in a type-4 approved and UL 50c listed watertight enclosure. All enclosures shall be painted red with external labeling as required by the AHJ.
- D. Installation Requirements
1. Installation of all components of the Emergency Responder Communication Enhancement System shall comply with all applicable sections of the National Electrical Code NFPA-70, NFPA-72, NFPA 1221, IFC and / or as required by the local AHJ.
 2. At least 2 independent and reliable power supplies shall be provided as specified in NFPA 72, NFPA 1221 and IFC.
 3. The primary power source shall be supplied from a dedicated twenty (20) ampere branch circuit and comply with NFPA-70 National Electrical Code, NFPA 72 and NFPA 1221 2016 edition.

The signal booster shall be equipped with a secondary source of power. The secondary source of power shall be a battery system with a dedicated battery charger powered by a separate, dedicated twenty (20) ampere branch circuit. The secondary power supply shall power on automatically when the primary power source is lost. The secondary source of power shall be capable of operating the emergency responder radio coverage enhancement system for a period of at least 24 hours. The battery system shall automatically charge in the presence of external power input. Battery charger and all other electronic components must be fully enclosed in a waterproof Type-4 approved enclosure. Batteries shall be enclosed in a separate, vented Type-3R or Type-4 approved enclosure. External UPS (Uninterruptible Power Supplies) are not acceptable.
 4. RF Coaxial Cable shall be a listed, CMP plenum. The cable classification shall be clearly marked on the outer surface of the cable regular intervals.
- E. Acceptance and Test Procedures
1. Acceptance testing of an in-building radio system is required upon completion of installation.
 2. The coverage testing shall be done in accordance with NFPA 72, NFPA 1221, IFC and as required by the local AHJ.
 3. All tests shall be conducted, documented, and signed by a person in possession of a current FCC General Radio Operator License.
 4. All test records along with system diagrams, iBWave design, equipment specifications, user manuals, RF link budget calculations, battery backup calculation and other design data shall be submitted upon completion of the project, and as required by the AHJ.

Appendix A - DETAILED CODE REFERENCES



I – Code Adoption

International Codes-Adoption by State (JAN 2023)

X = One or more state or local agencies/jurisdictions have adopted an edition of the specific code. However, the particular code is not used as a standard for all buildings.
 Blank = The specific code has not been adopted by any state or local jurisdiction in the state. *15* = Number indicates the specific code edition that is adopted as a mandatory state minimum.

Edition 21 = 2021 18 = 2018 15 = 2015 Edition 12 = 2012 Edition

Jurisdiction	IBC	IFC	IEBC
Alabama	21	21	21
Alaska	21	21	21
Arizona	X	X	X
Arkansas	12	12	X
California - 2021 Edition	21	21	21
Colorado	X	X	X
Connecticut - 2021 Edition	21	21	21
Delaware	X		X
District of Columbia	15	15	15
Florida	18		18
Georgia	18	18	18
Hawaii	18		18
Idaho	18	18	18
Illinois	X	X	X
Indiana	12	12	
Iowa	15	15	15
Kansas	X	X	X
Kentucky	15	12	15
Louisiana	15	X	15
Maine	15		15
Maryland	18		18
Mass = 2021 NFPA 1, 1221	15	X	15
Michigan	15	X	15
Minnesota	18	18	18
Mississippi	18	18	18

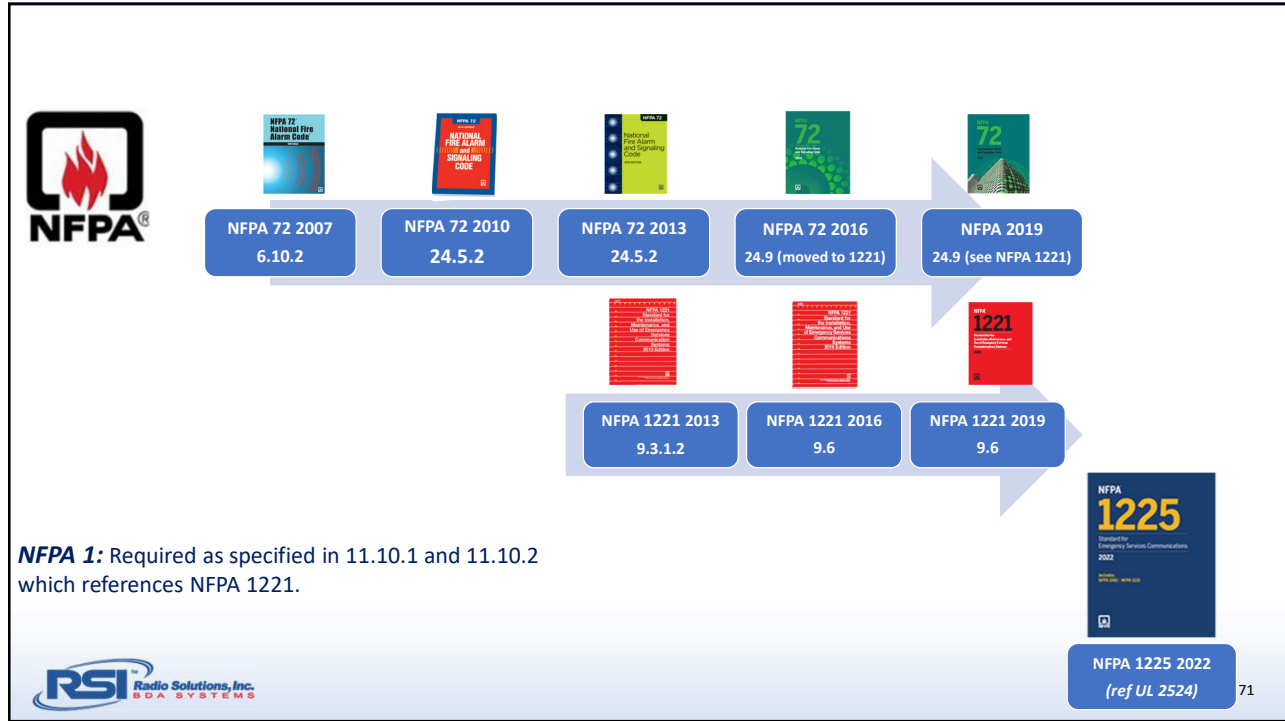
International Codes-Adoption by State (JAN 2023)

X = One or more state or local agencies/jurisdictions have adopted an edition of the specific code. However, the particular code is not used as a standard for all buildings.
 Blank = The specific code has not been adopted by any state or local jurisdiction in the state. *15* = Number indicates the specific code edition that is adopted as a mandatory state minimum.

Edition 21 = 2021 18 = 2018 15 = 2015 Edition 12 = 2012 Edition

Jurisdiction	IBC	IFC	IEBC
Missouri	X	X	X
Montana	21	12	21
Nebraska	18	X	18
Nevada	X	X	X
New Hampshire	18		18
New Jersey	21	15 (IBC)	
New Mexico	15	15	15
New York	18	18	18
North Carolina	15	15	15
North Dakota	21	21	X
Ohio	15	15	
Oklahoma	18	18	18
Oregon	21	18	
Pennsylvania	18	18	18
Rhode Island	18		
South Carolina	21	21	X
South Dakota	21	15	21
Tennessee	12	12	12
Texas	12	X	X
Utah	18	18	18
Vermont	15		15
Virginia	18	18	18
Washington	18	18	18
West Virginia	18		18
Wisconsin	15	X	15
Wyoming	21	21	21





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NFPA 72 2007
6.10.2 Two-Way In-Building Radio Communications Enhancement Systems.


6.10.2.1 Installation of two-way in-building radio communications enhancement systems shall be permitted.

6.10.2.2 Two-way in-building radio communications enhancement systems shall be permitted to be monitored by the building fire alarm system.

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NFPA 72 2010 & 2013


24.5.2* Two-Way Radio Communications Enhancement Systems.


- 24.5.2.1 General.
 - 24.5.2.1.1 Non-Interference.
 - 24.5.2.1.2 Approval and Permit.
 - 24.5.2.2 Radio Coverage.
 - 24.5.2.2.1 Critical Areas.
 - 24.5.2.2.2 General Building Areas.
 - 24.5.2.2.3 Amplification Components.
 - 24.5.2.3 Signal Strength.
 - 24.5.2.3.1 Inbound.
 - 24.5.2.3.2 Outbound.
 - 24.5.2.3.3 Isolation.
 - 24.5.2.4* System Radio Frequencies.
 - 24.5.2.4.1 List of Assigned Frequencies.
 - 24.5.2.4.2* Frequency Changes.
- 24.5.2.5.1 System Components
 - 24.5.2.5.1 Component Approval
 - 24.5.2.5.2 Component Enclosures
 - 24.5.2.5.3 External Filters 'Permanent external filters and attachments shall not be permitted'
 - 24.5.2.5.4 Signal Booster Components
- 24.5.2.6 System Monitoring
 - 24.5.2.6.1 Fire Alarm System
 - 24.5.2.6.2* Dedicated Panel
- 24.5.2.7 Technical Criteria
- 24.5.2.8 Inspection and Testing




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NFPA 72 2016

24.9 Two-Way Radio Communications Enhancement Systems.

- 24.9.1 General.
 - 24.9.1.1 Non-Interference.
 - 24.9.1.2 Approval and Permit.
- 24.9.2 Installation and Design. All in-building two-way radio communications enhancement systems shall be designed, *installed, and maintained in accordance with NFPA 1221*


Moved to NFPA 1221 in 2016

NFPA 1221 2016

9.6 Two-Way Radio Communications Enhancement Systems.

- 9.6.1 General
- 9.6.2 Pathway Survivability
- 9.6.3 Lightning Protection
- 9.6.4 Testing Requirements
- 9.6.5 Non-Interference and Non-Public Safety System Degradation
- 9.6.6 Approval and Permit
- 9.6.7 Radio Coverage (99% Critical Areas; 90% General Areas)
- 9.6.8 Signal Strength Inbound/Outbound DAQ >=3.0 analog or digital
- 9.6.9 Donor Antenna Isolation >20 dB above system gain
- 9.6.10 System Radio Frequencies
- 9.6.11 System Components
- 9.6.12 Power Supplies
- 9.6.13 System Monitoring
- 9.6.14 Technical Criteria

11.3.9 Operational Testing



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NFPA 72 2019

24.9 Two-Way Radio Communications Enhancement Systems.

24.9.1 Non-interference.

24.9.1.1 "No ERCES installations without prior AHJ approval"

24.9.1.2 "Building owners must suspend & correct equipment...."

24.9.2 Installation and Design. All in-building two-way radio communications enhancement systems shall be designed, installed, and maintained *in accordance with NFPA 1221.*



NFPA 1221 2019

9.6 Two-Way Radio Communications Enhancement Systems.

9.6.1 General

9.6.2 Approval

9.6.3 Lightning Protection

9.6.4 Testing Requirements

9.6.5 Non-Interference & Non-Public Safety System Degradation

9.6.6 Approval and Permit

9.6.7 Radio Coverage (99% Critical Areas; 90% General Areas)

9.6.8 Signal Strength In/Outbound DAQ >=3.0 analog or digital

9.6.9 Donor Antenna Isolation >20 dB above system gain

9.6.10 Frequencies

9.6.11 System Components

9.6.12 Power Sources

9.6.13 System Monitoring



9.6.14 Technical Criteria



NFPA 1225 2022

Requires all ERCES to be Listed to the UL 2524 (ANSI) Standard



**SECTION 918
EMERGENCY RESPONDER RADIO COVERAGE**

[F] 918.1 General. Emergency responder radio coverage shall be provided in all new buildings in accordance with Section 510 of the *International Fire Code*.

IBC 2006
907.2.12.3

IBC 2009
915.1

IBC 2012
915.1

IBC 2015
916.1

IBC 2018
918.1

IBC 2021
918.1

IFC 2009
510, 907.2.13.2

IFC 2012: 510, 907.2.13.2, 1103.2


IFC 2015: 510, 907.2.13.2, 1103.2

IFC 2018: 510, 907.2.12.2, 1103.2

IFC 2021: 510, 907.2.12.2, 1103.2


IEBC 2018

IEBC 2021
Refers to IFC 510




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2006 IBC - 907.2.12.3 Fire Department Communication System. An approved two-way, fire department communication system designed and installed in accordance with NFPA 72 shall be provided for fire department use....




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2009 IBC - 915.1 Emergency responder radio coverage shall be provided in all new buildings in accordance with Section 510 of the *International Fire Code*.





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2012 IBC - 915.1 Emergency responder radio coverage shall be provided in all new buildings in accordance with Section 510 of the *International Fire Code*.



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2015 IBC - 916.1 Emergency responder radio coverage shall be provided in all new buildings in accordance with Section 510 of the *International Fire Code*




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2018 IBC - 918.1 Emergency responder radio coverage shall be provided in all new buildings in accordance with Section 510 of the *International Fire Code*




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2009 IFC – 510
510.1 Emergency responder radio coverage in buildings.
All buildings shall have approved radio coverage for emergency responders within the building based upon the existing coverage levels of the public safety communication systems of the jurisdiction at the exterior of the building. This section shall not require improvement of the existing public safety communication systems.
Exceptions: 1. Where approved by the building official and the fire code official, a *wired communication system* in accordance with Section 907.2.13.2 shall be permitted to be installed or maintained in lieu of an approved radio coverage system.




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2012 IFC – 510
510.1 Emergency Responder Radio Coverage in Buildings All buildings shall have approved radio coverage for emergency responders within the building based upon the existing coverage levels of the public safety communication system of the jurisdiction at the exterior of the building. This section shall not require improvement of the existing public safety communication system.
Exceptions: 1. A wired communication system shall be permitted in lieu of an *approved* radio coverage system. 2. Where the Fire Code Official determines the radio coverage system is not needed.
510.2 Radio Signal Strength 95% coverage for All Areas on Each Floor
510.2.1 Minimum signal strength into the building -95 dBm
510.2.2 Minimum signal strength out of the building -100 dBm
510.3 Emergency Responder Radio Coverage in Existing Buildings
 1. When a wired communication system can't be repaired
 2. Within a timeframe established by the adopting authority
1103.2 ERRC in existing buildings: Require coverage if existing wired system cannot be repaired, unless AHJ determines system is not needed



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2015 IFC – 510

510.1 Emergency responder radio coverage in new buildings

510.2 Emergency responder radio coverage in existing buildings Existing buildings shall be provided with approved radio coverage for emergency responders as required in Chapter 11


510.3 Permit required

510.4 Technical requirements

510.5 Installation requirements



510.6 Maintenance Requirements

1103.2 ERRC in existing buildings: Require coverage if existing wired system cannot be repaired, unless AHJ determines system is not needed



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2018 IFC – 510

510.1 Emergency responder radio coverage in new buildings

510.2 Emergency responder radio coverage in existing buildings Existing buildings shall be provided with approved radio coverage for emergency responders as required in Chapter 11


510.3 Permit required

510.4 Technical requirements DAQ 3.0 or Signal-to-Interference-Plus-Noise-Ratio (SINR), 12 hour battery backup, isolation > 20dB, oscillation prevention, monitoring,

510.5 Installation requirements FCC GROL + Mfgr. Certificate, 95% 20-grid testing,

510.6 Maintenance Requirements Annual Testing, performance optimization

1103.2 ERRC in existing buildings: Require coverage if existing wired system cannot be repaired, unless AHJ determines system is not needed



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2021 IFC – 510 Emergency Responder Radio Coverage

510.1 ERRC in new buildings

510.2 ERRC in existing buildings

510.3 Permit Required

510.4 Technical Requirements

Equipment required to provide emergency responder radio coverage shall be listed in accordance with UL 2524. Systems, components and equipment required to provide the emergency responder radio coverage system shall comply with Sections 510.4.1 through 510.4.2.8.

510.4.1 ERCES Signal Strength

95% General Areas & 99% Critical Areas

510.4.1 Minimum Signal Strength into the building

-95 dBm DAQ \geq 3.0 or equivalent SINR

510.4.2 Minimum Signal Strength out of the building

DAQ \geq 3.0 or equivalent SINR

510.5 Installation Requirements


510.6 Maintenance

1103.2 ERRC in existing buildings: Require coverage if existing wired system cannot be repaired, unless AHJ determines system is not needed




2018 IEBC – Section 904 Fire Protection

No mention of Emergency Responder Communications Enhancement Systems




2021 IEBC – 101.2.1 Application of fire code.
Where work regulated by this code is also regulated by the construction requirements for existing buildings in Chapter 11 of the International Fire Code such work shall comply with applicable requirements in both codes.



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IFC 1103.2 ERRC in existing buildings: Require coverage if existing wired system cannot be repaired, unless AHJ determines system is not needed



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