# THE IMPORTANCE OF KNOWING THE ERCES RULES OF ENGAGEMENT

PRESENTED AT THE
53RD ANNUAL CAFAA CONFERENCE

FEBRUARY 8, 2024

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**(ret.) CFO, FM**
Safer Buildings Coalition

# THE IMPORTANCE OF KNOWING THE ERCES RULES OF ENGAGEMENT

## Seminar Objective

This interactive presentation will provide insights on the critical rules of engagement integrators must understand to properly deploy an ERCES. Topics for discussion will center around:

- Fire codes/standards
- FCC requirements
- Engagement of the Frequency License Holder
- Competency
- Key aspects of the Complete ERCES Handbook.

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**Safer Building Coalition is the only advocacy group and resource for everything related to solving for In-Building Wireless "Dead Zones".**

**Our Scope includes all In-Building Technologies:**
Commercial Cellular (LTE / 5G) • LMR (Land Mobile Radio) • Emergency Responder Communications Enhancement Systems (ERCES) • Private LTE • Future Technologies.

*Membership is always free for Gov't / Public Safety Staff*

The **Safer Buildings Coalition** is an independent, not for profit organization.

www.saferbuildings.org





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Clip Courtesy NBC
NBC
CHICAGO FIRE
2021 SEASON 9 TRAPPED!

# First Responder Communications Must Work

*The Portable Radio is one of the most important pieces of an Emergency Responders Personal Protective Equipment!*

**Radio signals failed firefighters scaling Charlotte high-rise**

First responders couldn’t communicate while rescuing people stranded in elevators






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## *The Importance of Critical Communications, ERCES Installation and Maintenance…*

- **Incident: #24-0004182 / High-Rise Electrical Problem**
- **Weather: Hot and Humid**
- **Time: Dispatched: 18:57:21**
- **On-Scene: 19:00:03**
- **Primary Complete: 20:47:36**
- **Secondary Complete: 22:45:47**
- **Units in service: 23:24:07**
- **Resources: Engines 04, 02, 01, 05, 06, 08, 07, 43, Ladders 04, 02, 01, 18, Rescue 10, Battalions 01, 03, 04, 08, Safety 1, Rehab 01, Cars 01, 10, 15, 19, 313, 342**
- **Building Construction: *51-story office building***
- **Conditions upon arrival: Fire alarms present on three floors with reports of smoke on some floors along with multiple people trapped in elevators**

**Communications: Understand that communications are always going to be an issue. A repeater system was supposedly in this building, but it failed to help. We ended up using channels for operations, water supply, and staging. The ops channel was very spotty once companies entered the stairwells and on most of the floors. The talk around channel was utilized for most communications but this channel was quickly overloaded with transmissions. The original plan was to assign different channels for each group but only the talk around channel allowed for contact so that plan was scrapped. We requested the field comm unit but were told that it was deployed to Vermont. Every NIOSH LODD report mentions communications as a factor. This goes up exponentially in buildings of this type.**





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# NIOSH LODD Reports

The National Institute for Occupational Safety and Health top 5 casual factors of firefighter deaths and injuries on the fireground:

1. Improper Risk Assessment
2. Lack of Incident Command
3. Lack of Accountability
4. Inadequate Communications
5. Lack of SOPs or failure to follow established SOPs

## Key Recommendations Included:

- ***Provide all fire fighters with radios and train them on their proper use***






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# Key Takeaway:

*When we are disconnected – we are less safe*





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- Competency of the Industry


## Alan Perdue – Executive Director

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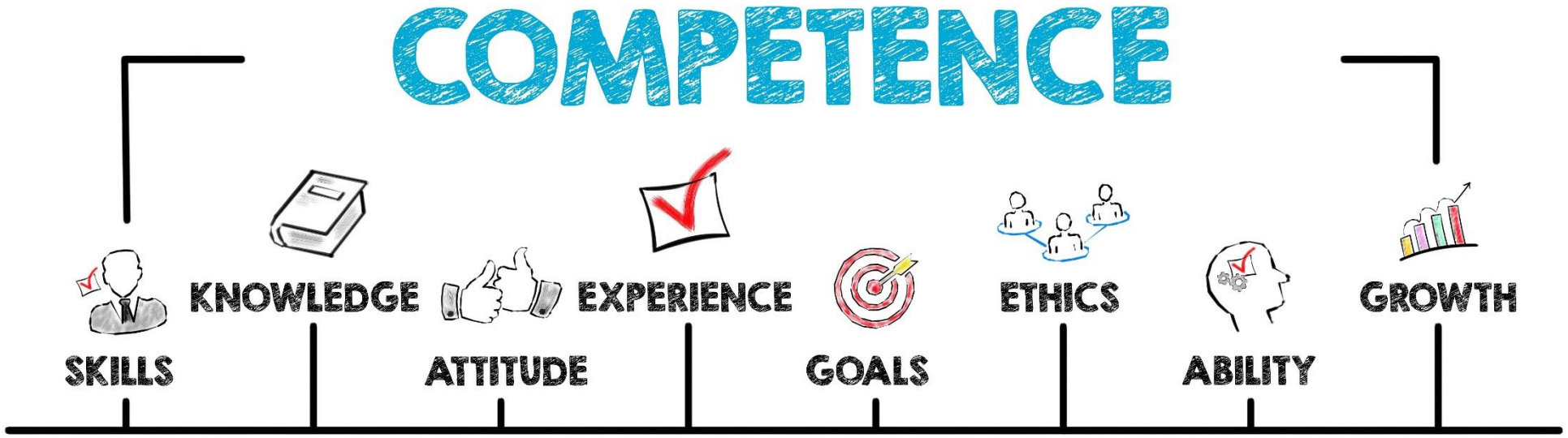
# The Case for Competency

***QUESTIONS TO CONSIDER***

- Are Emergency Responder communications capabilities inside buildings important?
- Are ERCES considered part of the Life Safety eco system of a building?
- Does ERCES need to work when needed?
- Do the ERCES Stakeholders need to know what they are doing?

# The Case for Competency

## So, What is Competence?



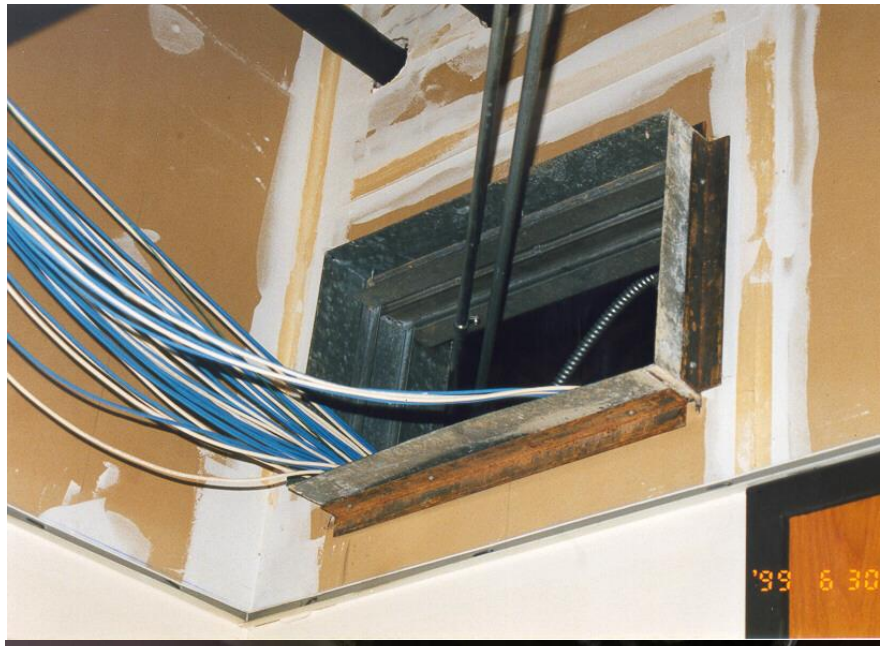
# Increasing the Competency of the Industry

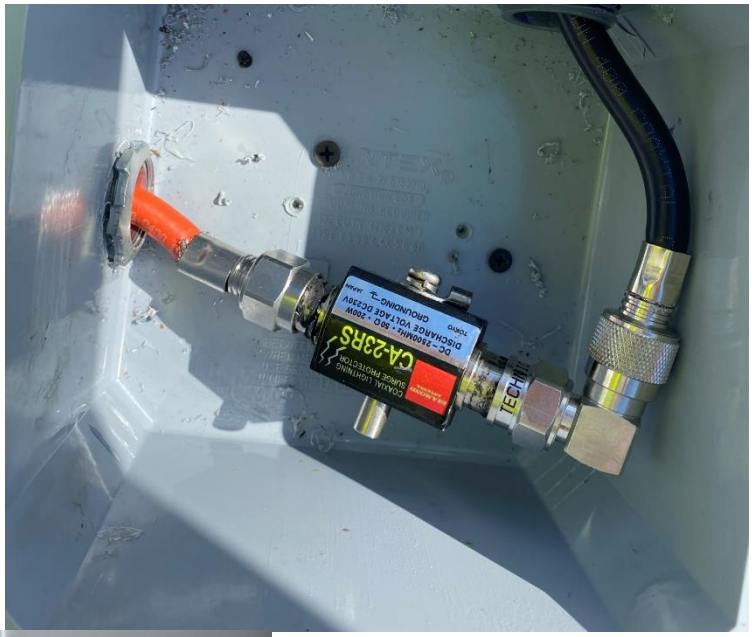
**IFC 510.5.3 Minimum Qualifications of Personnel.**

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

1. A valid FCC-issued general radio operator's 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.




# What Not To Do!!!





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# Competency of the Industry


## AHJ's: Do you want the Individual or the Organization Certified?

**Regular Season Team Record**

| | |
|---|---|
| 2022 14-3 | 2022 14-3 |
| 2023 11-6 | 2023 11-6 |

**Sports Teams & ERCES Integrators are only as good as their *Individuals Talents*…**

# NFPA 1225 – 2022 Edition


**18.2* Approval.**
Where an in-building emergency responder communications enhancement system is used, the design of the system shall be performed by an **RF system designer** and shall be approved by the AHJ and the **frequency license holder(s).**

**3.3.115* RF System Designer.**
**An individual who has the education, experience, training, and understanding of RF theory and application to design an in-building emergency responder communications enhancement system (ERCES) that complies with this standard and the requirements of the licensing authority of the country of jurisdiction.**





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**www.myflorida license.com. Florida permits several specialty contractors to work on ERCES systems:**

# KNOW YOUR SCOPE

## KEEP IT LEGAL

## WORKING WITHOUT A PROPER LICENSE IS AGAINST THE LAW

| Electrical Contractors' Licensing Board LICENSE CATEGORIES<br>Certified = State Examination<br>Registered = Local License | | Statewide Contractor | Limited to Specific Jurisdiction | Electrical -All Types- | Electrical Excluding Alarms | Fire Alarms, Burglar Alarms | Burglar Alarms ONLY | Specific Specialties See Definition 61G6-7,FAC | Residential Burglar See Definition 489.505,F.S. | Limited Energy CCTV Central Music & VAC, Intercom, Electric Locks and Fiber Optic | Two-Way Radio Communications Enhancement Systems |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EC | Certified Electrical Contractor | ✔ | | ✔ | | ✔ | | ✔ | | ✔ | ✔ |
| ER | Registered Electrical Contractor | | ✔ | | ✔ | | | ✔ | | ✔ | |
| EF | Certified Alarm System Contractor I | ✔ | | | | ✔ | | | | ✔ | ✔ |
| EG | Certified Alarm System Contractor II | ✔ | | | | | ✔ | | | ✔ | |
| EJ | Registered Residential Alarm System Contractor (489.537) | | ✔ | | | | | | ✔ | ✔ | |
| EY | Registered Alarm System Contractor I (489.537) | | ✔ | | | ✔ | | | | ✔ | ✔ |
| ES | Certified Two-Way Radio Communications Enhancement Systems Specialty | ✔ | | | | | | ✔ | | | ✔ |

Figure 9.2.6 **Example of trade license matrix (State of Florida)**[2]

# NICET ERCES Certification

## In-Building Public Safety Communications (IB-PSC)

For more info about NICET certification:

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| Level I | Level II | Level III | Design |
|---|---|---|---|
| Examination- *Pass the:* | | | |
| Level I Exam | Levels I and II Exam | Levels I, II, and III exams | Design exam |
| Performance Verification- *Obtain supervisor verification of:* | | | |
| All Level I Performance Measures | All Levels I and II Performance Measures | All Levels I, II, and III Performance Measures | All Design Performance Measures |
| Work History- *Provide complete, detailed position descriptions and time allocations showing[1]:* | | | |
| A minimum of 6 months of technical experience in Emergency Responder Communication Systems (ERCS), which MUST include: | A minimum of 2 years of technical experience in Emergency Responder Communication Systems (ERCS), which MUST include: | A minimum of 5 years of technical experience in Emergency Responder Communication Systems (ERCS), which MUST include: | A minimum of 2 years of technical experience in Emergency Responder Communication Systems (ERCS), which MUST include: |
| At least 6 months direct | At least 12 months direct | At least 4 years of direct | At least 12 months of direct |

# Increasing the Competency of the Industry

**NICET In-Building Public Safety Communications Certification (IB-PSC)**

## What does this certification program mean for Industry?

- Go beyond GROL and Manufacturer Training
- Drive Workforce Development and Best Practices
- Distinguish Your Business from Unqualified Competition

## What does this certification program mean for the AHJ?

- Protect your PS Networks – Enhance, Not Harm
- Distinguish the Pros from the Newbies
- Skills Validation and Continuing Education Requirements

# Increasing the Competency of the Industry

AHJ Adoption of Competency Benchmark Example:

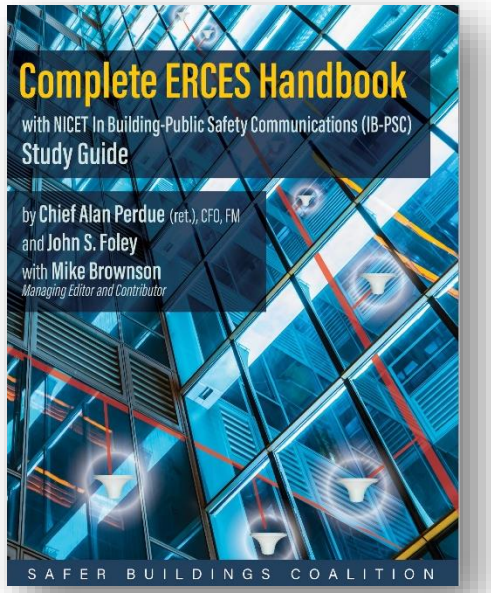
Beginning in June 2024, all installation technicians who are servicing any ERRCS projects must have a minimum NICET IB-PSC Level 1 certification. Technicians which have 6 months or less of in-building experience, must be overseen by a NICET IB-PSC Level 2 certified technician. Projects leads are required to possess a minimum NICET IB-PSC Level 2 certification. Project leads must be on site during commissioning and testing of the system. All ERRCS project designers are required to have the NICET IB-PSC Design certification.

# Increasing the Competency of the Industry

## What should an AHJ look for in a certification Process?

| | NICET | Others? |
|---|---|---|
| Specifically created for ERCES? | ✓ | ? |
| Certification Body is Known and trusted by AHJs? | ✓ | ? |
| Skills Validation? | ✓ | ? |
| Individual Employment history validation? | ✓ | ? |
| Certification revocation / appeal process? | ✓ | ? |
| Continuing Education Requirements? | ✓ | ? |
| Built in collaboration with the Safer Buildings Coalition? | ✓ | NO |

# IB-PSC Curriculum and Learning:
# Complete ERCES Handbook

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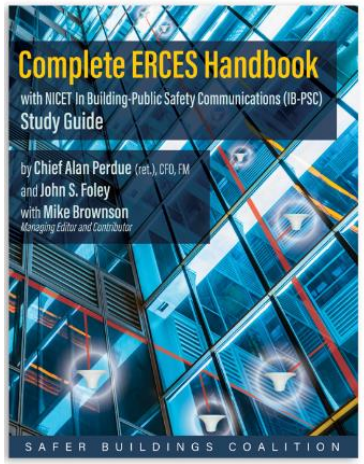
"As the current President of NASFM, I am proud of our role in helping to bring this important handbook to all ERCES stakeholders, and I highly recommend this handbook as an essential guide for achieving in-building public safety communications competency.

I encourage public safety and industry professionals alike to rely upon it as a trusted source of objective ERCES facts, and to incorporate it into their training programs."

**Michael Desrochers**
Vermont State Fire Marshal
**President, National Association of State Fire Marshals (NASFM)**

# SBC ERCES HANDBOOK with NICET Study Guide – THE MATH

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## 7 THE MATH

**About this chapter: What it is, and what it isn't.**
This chapter is *not* an RF engineering reference with advanced mathematics and design guidance. There are excellent references available for such a purpose, such as the ARRL Handbook for Radio Communications, Microwave and RF Engineering by Giovanni Bianchi and Roberto Sorrentino, RF and Microwave Engineering: Fundamentals of Wireless Communications by Prof. Frank Gustrau, Fundamentals of Microwave and RF Design by Michael Steer, and others.

What this chapter does attempt to provide is an understanding of many of the math concepts used in wireless. Central to these concepts is an understanding of Decibels and link budgets. Decibel (dB) is used to measure both absolute power as well as fractions and multiples of power. Decibel math is then used to simulate the actual RF environment for use in predictions.

*This chapter is an effort to make RF math accessible to readers who already possess basic to intermediate math skills, and who have a need to understand the essential mathematical concepts that pertain to wireless communications.*

When we think about how RF signals behave in the physical world, we need some way of predicting and measuring these behaviors. We do this with mathematics. This chapter presents an overview of the basic mathematical units and formulas used in the wireless industry that describe how RF behaves in the physical world. When taken as a whole, these functions allow us to create an important model called the **Link Budget**.

The Link Budget is the heart and soul of RF design. So, what is a Link Budget? The Link Budget is an accounting of all the gains and losses in an RF transmission system to provide an expected RF signal level at the receiver.

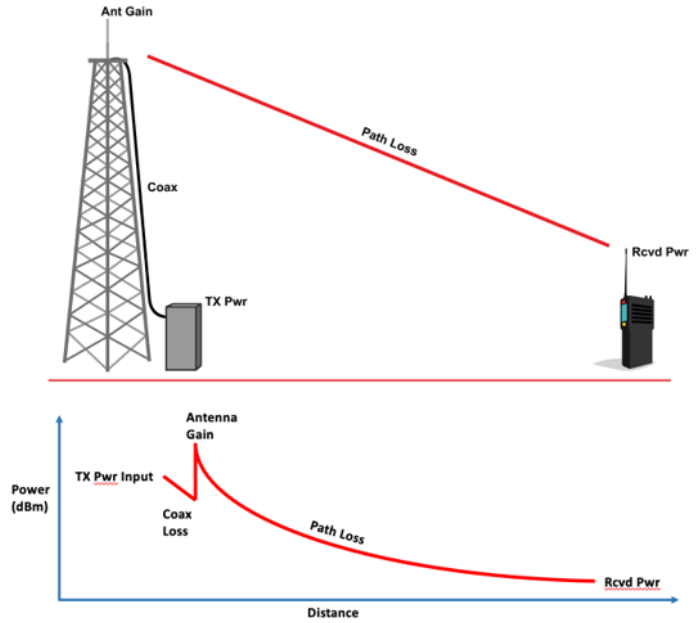


***Figure 7, Simple link budget example***

We will go much deeper into the elements that make up a Link Budget further on in this chapter, and ever further in subsequent chapters. But before we can do this, we must *first* understand the basic units of measurement used in RF mathematics.

Let's take this moment to introduce the reader to Safer Building Coalition's online resource site related to this handbook. At www.erceshandbook.com you'll find a variety of resources related to this handbook. Pertinent to this





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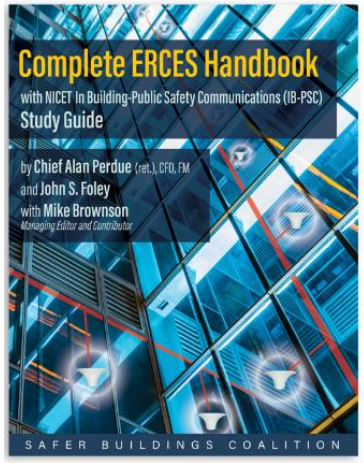
# SBC ERCES HANDBOOK with NICET Study Guide – THE SCIENCE

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Managing noise is an important topic for RF technicians. As an example, if you are trying to have a conversation at a loud party, you need to either raise your voice to be heard over the noise or move to a quieter place. The same thing happens with radio receivers. If background noise is too high (interference) the receiver can't distinguish the desired transmitter signal from the noise and the communication link fails. If that noise (interference) happens at the public safety radio site, transmissions from all the mobiles and portables in the field will be negatively impacted.

In this chapter we will also explore various methods for transmitting information using radio frequency (RF) signals. Newer, more complex techniques such as LTE have dramatically improved the amount of information that can be transmitted as well as improved the efficiency of the limited amount of radio spectrum available to us. But newer technologies also add a level of complexity to the measurements and testing of these systems.

## 8.1 WHAT IS SPECTRUM?

When defining a very wide range of frequencies, spectrum is the common term. A common example of the use of spectrum is to describe light. We may refer to the visible spectrum of light, or the infrared spectrum which causes our skin to feel warn or the infrared spectrum which causes sunburn. The spectrum of light is at a MUCH higher frequency than radio spectrum used for communications though. See Illustration 8.1a of the Electromagnetic Spectrum.

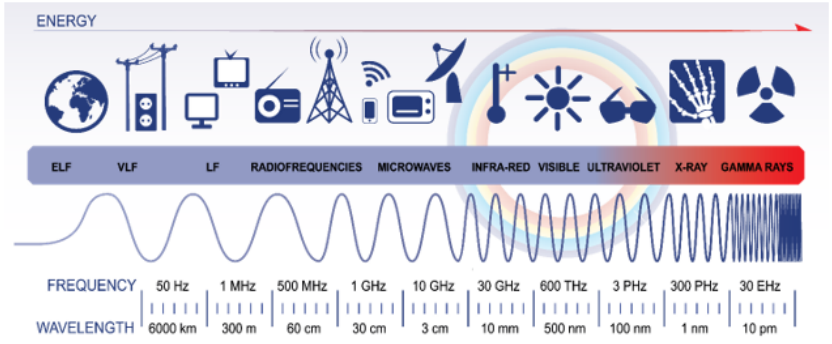


*Figure 8.1a, Electromagnetic Spectrum*

The *radio spectrum* includes the typical frequencies used to transmit information over the air, from short wave radio used for very long-distance communications to microwaves used to transmit large amounts of data between two points. Spectrum in then divided into specific *frequency bands*, each with their own defined use and characteristics.

Figure 8.1b below shows the radio spectrum between 3MHz and 3GHz and identifies the frequency bands within this spectrum used by public safety for their two-way radio communications (excluding most cellular bands).

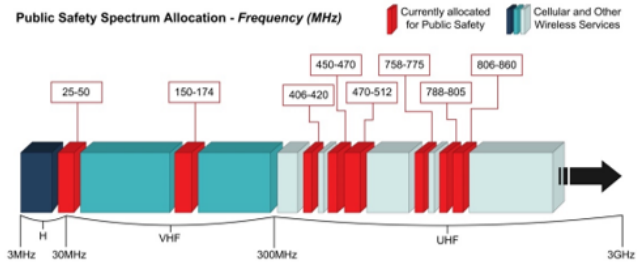


*Figure 8.1b Public Safety Spectrum Allocation*

## 8.2 FREQUENCY BANDS

A frequency band of is smaller range frequencies within the radio spectrum that the licensing authority has designated for a specific purpose. The table below shows the range of frequencies assigned within the US by the FCC for use by the public safety community.

| Frequency Bands | Frequencies | Comments |
|---|---|---|
| VHF Low Band | 25-50 MHz | Not applicable to IB-PSC, rarely used by public safety anymore. Can operate over large distances. |
| VHF High Band | 150-174 MHz | Commonly used by older technology radio systems or for wide area coverage |
| UHF | 402-420 MHz | Federal government band, used by federal security services |
| UHF | 450-470 MHz | This band is shared with commercial users and becoming less commonly used by public safety due to lack of available frequencies and congestion |





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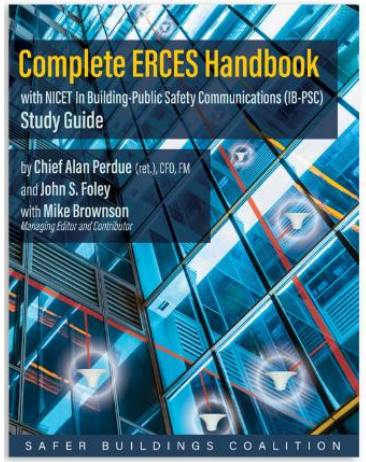
# SBC ERCES HANDBOOK with NICET Study Guide – BEST PRACTICES

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network applications may need more hands because cable for ERCES is stiffer, heavier, and more susceptible to damage from bends, strains, or mishandling. If the cable is damaged in any way that results in the outer shield getting dented, crimped, deformed, twisted, or stretched, it will be necessary to remove the damaged cable and pull a new one.

## 20.8 CABLE SUPPORT

Cable support is designed for immediate installation (hold the cable in place today) and long-term stability (prevent the cable from bending or deforming over time). Here are a few standard guidelines:

- **Cables should be supported every 3-10 feet.** It is best to vary the distance slightly (6 inches to 1 foot) between support points to avoid waveforms. Cables should be supported within 1 foot of termination points. NEC states:

  **NFPA 70, 2020 edition**
  800.110 Raceways, Cable Routing Assemblies, and Cable Trays.
  (C)(1) Horizontal Support.
  Cable routing assemblies shall be supported where run horizontally at intervals not to exceed 900 mm (3 ft) and at each end or joint, unless listed for other support intervals. In no case shall the distance between supports exceed 3 m (10 ft).

  *Always refer to the manufacturer's specifications for cable support requirements.*

- **Cables must be supported by J-Hooks with a flat base of at least one-and-a-half-inch width.** Bridle rings may not be used. Although an installation with bridle rings may look fine on the day it is completed, a few weeks, months, or years later, the weight of the cable will gradually deform the outer shield creating a dent that degrades performance. If there is a deformation at every support point, overall cable performance can degrade by as much as 50%.

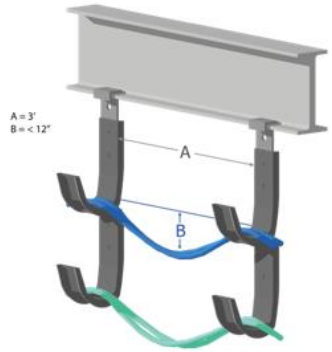


*Figure 20.8, Example of cable hangers (J-hooks)*

*Figure 20.8.1 Note the properly supported black coaxial cable.*

- **Consult the GC, building owner, or Engineer regarding acceptable support attachments.** In many projects, low-voltage installers are forbidden to attach to anything except the building structure.





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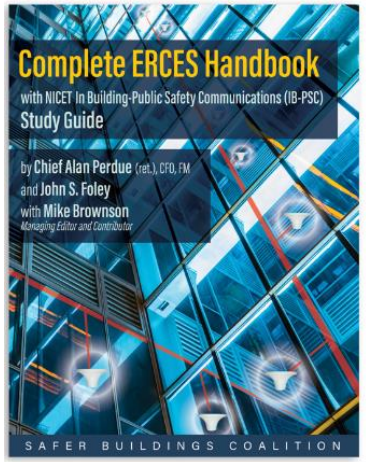
# SBC ERCES HANDBOOK with NICET Study Guide – ACCEPTANCE TEST

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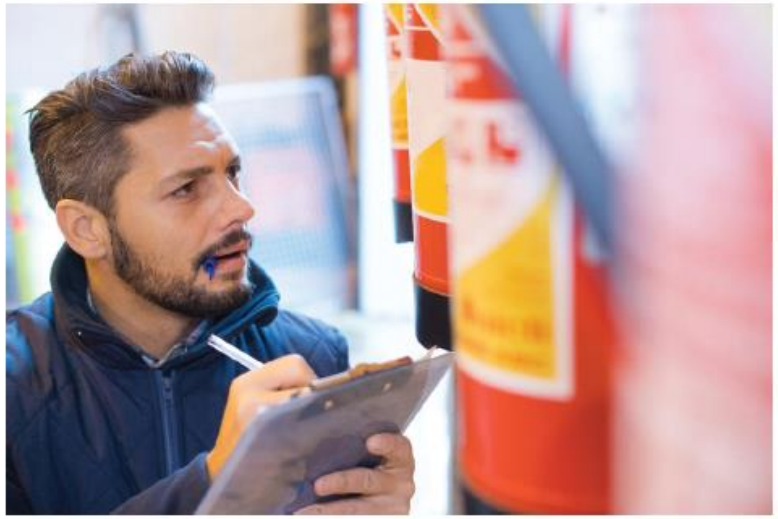
CHAPTER 23

## THE ACCEPTANCE TEST

The goals of the Acceptance Testing phase of an ERCES project are to:

- Assure that the ERCES meets all project and jurisdiction requirements
- Document the final, accepted conditions of the ERCES

You would think that the preparations necessary for an ERCES acceptance test should be a simple task: just follow the codes and standards. However, over the past 13 years that ERCES has been included in model codes and standards, this is a very optimistic wish.



The model code for ERCES was first introduced in IFC 510 in 2009, NFPA® 1 Annex in 2009, and NFPA 72® in 2010. Compared to the fire sprinkler codes and standards (*NFPA* 13) (which has been around for over 100 years) ERCES requirements are extremely new and in the earliest stages of development, interpretation, standardization, and best practice development. This creates many challenges for both the code official and the System Integrator.

Another challenge is the complexity of RF transmissions. For example, just walking through the building with the code official saying, "Can you hear me now?" on radio may result in an ERCES that works well within the building but might cause substantial noise and interference to outdoor radio users or radio networks. We can't expect every code official to fully understand the physics of RF transmission, therefore it is vital that the system integrator ensure that the solution





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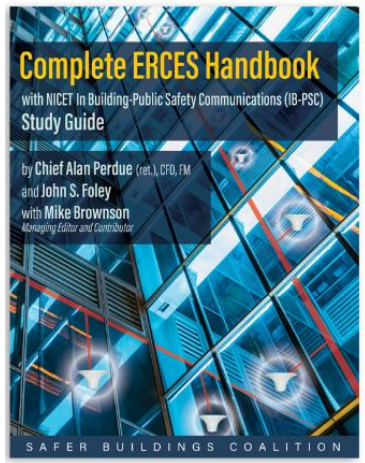
# SBC ERCES HANDBOOK with NICET Study Guide – SAFETY

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*Note: Within ERCES, the acronym BBU stands for Battery Backup Unit. In cellular Radio Access Networks BBU stands for Baseband Unit.*

For advanced private network and cellular system testing where the BBU communicates with the RRH over fiber using CPRI protocol, CPRI test capability is desired.

## 14.6 SAFETY / ENVIRONMENTAL TOOLS AND EQUIPMENT

Job site safety reduces the risk of work-related injuries, but also decreases the risk of injuries to the public. According to OSHA (Occupational Safety and Health Administration),

The following were the top 10 most frequently cited standards by Federal OSHA in fiscal year 2021 (October 1, 2020, through September 30, 2021)[1], including the section of US Department of Labor regulations that pertain to each category:

1. Fall Protection, construction (29 CFR 1926.501)
2. Respiratory Protection, general industry (29 CFR 1910.134)
3. Ladders, construction (29 CFR 1926.1053)
4. Hazard Communication, general industry (29 CFR 1910.1200)
5. Scaffolding, construction (29 CFR 1926.451)
6. Fall Protection Training, construction (29 CFR 1926.503)
7. Control of Hazardous Energy (lockout/tagout), general industry (29 CFR 1910.147)
8. Eye and Face Protection, construction (29 CFR 1926.102)
9. Powered Industrial Trucks, general industry (29 CFR 1910.178)
10. Machinery and Machine Guarding, general industry (29 CFR 1910.212)

The section following details many of the tools and practices that reduce these risks. It leverages info found at osha.gov.

## 14.7 PERSONAL PROTECTIVE EQUIPMENT [PPE]

**OSHA PPE RULES**
PPE falls into these categories (Listed with the OSHA 29 CFR 1910 Subpart I and 1926 Subpart E: [see www.osha.gov]

[1] Source: www.osha.gov

- 1910 Subpart I - Personal Protective Equipment [Occupational Safety and Health Standards]
- 1926 Subpart E - Personal Protective and Life Saving Equipment [Safety and Health Regulations for Construction]

***Figure 14.7, Personal Protective Equipment***

From www.osha.gov :

What is personal protective equipment?

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests, and full body suits.

What can be done to ensure proper use of personal protective equipment?





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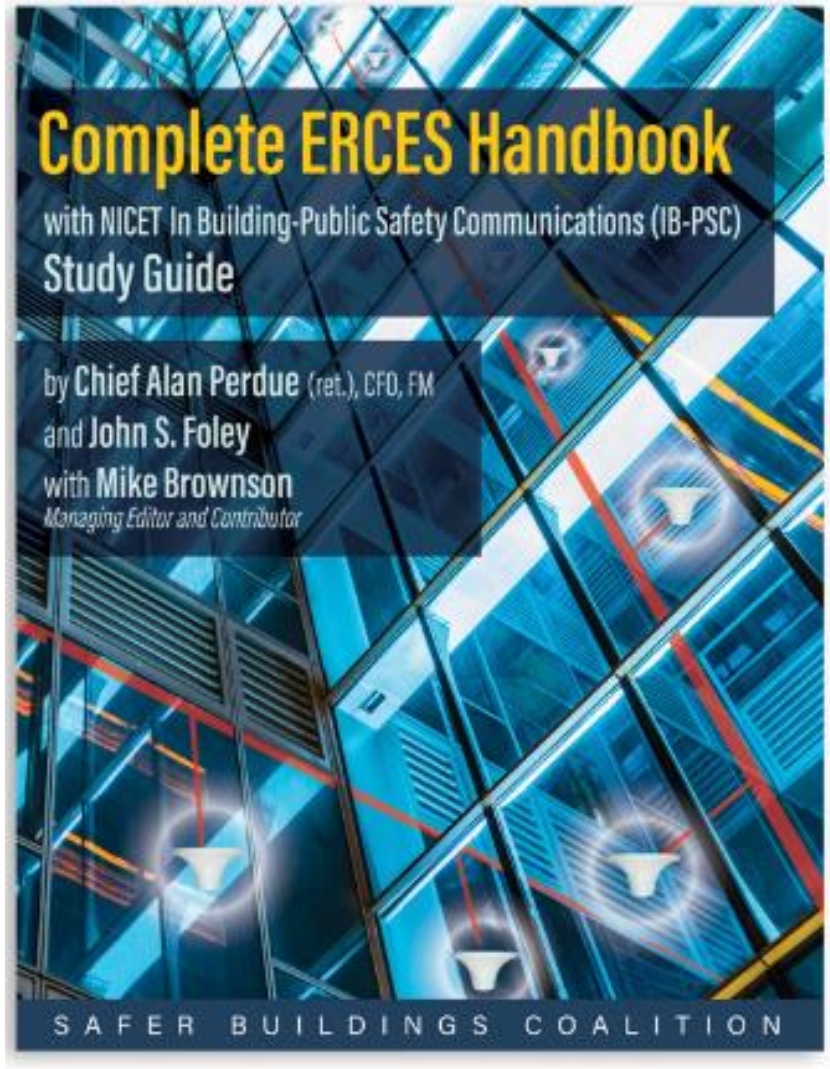


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# KEY TAKEAWAYS FOR THE JURISDICTION

Radio frequency is a very specialized knowledge set. Installers that are new to RF or have otherwise not yet acquired the necessary skills can cause serious interference to the public safety radio network.

- Require installers to present a certificate from a nationally recognized certification for individuals not the organization (such as NICET or others that are based on the individuals skills and knowledge).
- Improperly commissioned and installed BDAs can cause serious harm to the public safety radio network.
- Even with excellent signal level within a building the signal quality may be insufficient for reliable communications.
- If a building under inspection has both a public safety DAS and a cellular DAS, the cellular DAS should be fully operational if possible. If not, then testing the PS DAS should be repeated once a cellular DAS is turned on.

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# Federal Communication Commission (FCC) Rules


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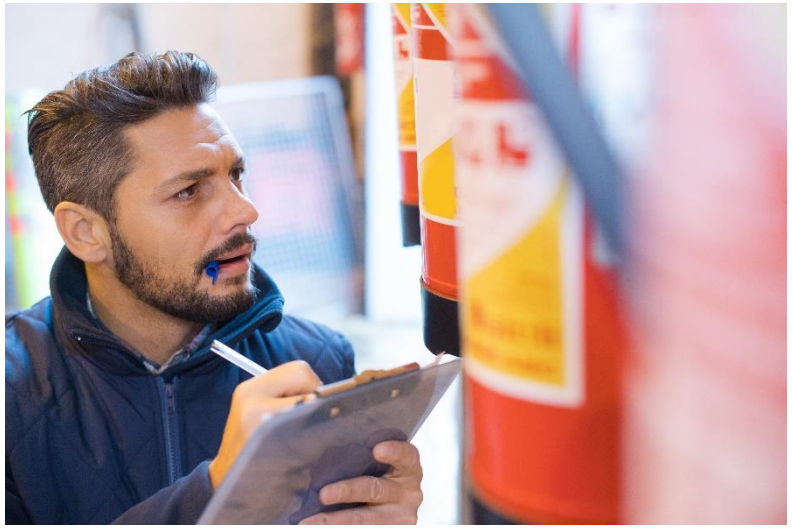
# Every ERCES Project is a Shared Responsibility



Code Enforcement - AHJ

- Fire Codes, Electrical Codes, Building Codes

Building Owner and
Their Vendor:
The System Integrator

Frequency(s) License Holder

# There are three elements that identify the key Jurisdiction Radio Operations point of contact:

1. They understand how their radio system works and can convey the necessary technical details to the System Integrator

2. They are responsible for making sure the system works and for resolving any problems or interference.

3. They have the authority to grant permission to rebroadcast the public safety frequencies licensed to them.

For this reason, we refer to them as the **Frequency License Holder (FLH).**

## 3.3 Frequency License Holder (AKA The "Other" AHJ)

The FCC license holder is responsible for the end-to-end operation of all systems and services pertaining to their licensed frequencies within their defined service contour. A service contour (or protected contour) refers to the area in which the FCC allows coverage from its communications network. System integrators and building owners wishing to operate equipment capable of rebroadcasting on the license holder's frequencies must have permission from the license holder. License holders have the right to direct any party to cease transmissions on their licensed frequencies within their defined service contour.

Note the use of the term "service contour". This indicates that organizations operating licensed frequency networks are Service Providers.

For ERCES, Land Mobile Radio (LMR) systems have been the predominant technology as detailed in the codes and standards. While for many years the codes and standards contained language that implied that other forms of communications (besides two-way radio) were covered by the code, it was not until the 2021 edition of the International Fire Code (IFC) and the 2022 edition of NFPA 1225 that it was made clear that other modes of public safety communications (such as cellular services) are covered by these codes and standards.

So, who are the frequency license holders then?

For two-way radio systems, the Frequency License Holder is typically the "radio system owner", "radio administrator", "radio shop", etc. under the management and control of the jurisdiction. The jurisdiction could be a municipality, a county, a state, or other region. In some cases, jurisdictions may band together to create a cooperative radio network managed as a unified entity.

For cellular services, the Frequency License Holder is the wireless carrier (i.e. AT&T, Verizon Wireless, T-Mobile, US Cellular, others) who operate the cellular frequencies licensed to them by the FCC.

Two-way radio system owners and cellular carriers are both correctly referred to as "Service Providers".

The rules regarding the authority and responsibility of the FCC Licensee pertaining to LMR public safety radio coverage are defined in FCC section 90.219.

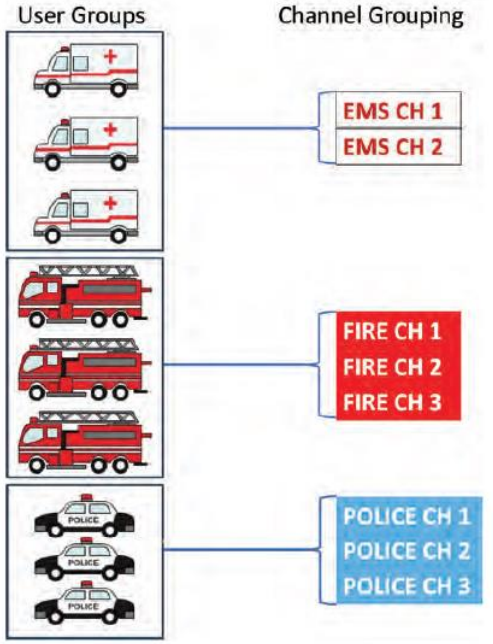



Figure 8.3.5a **Simple Channel Organization (Conventional)**

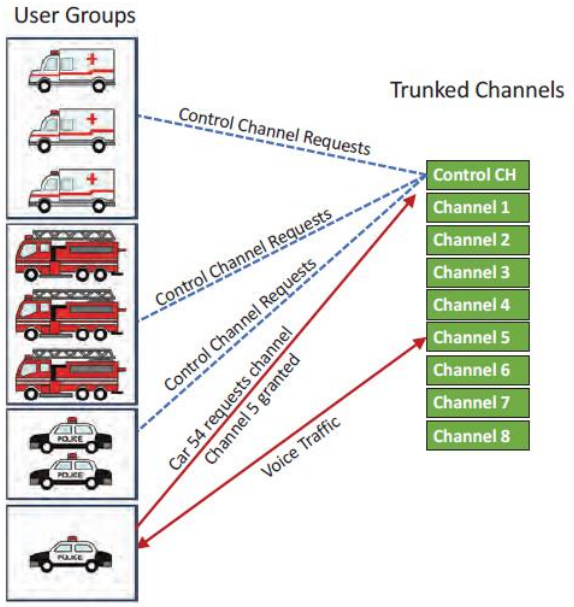


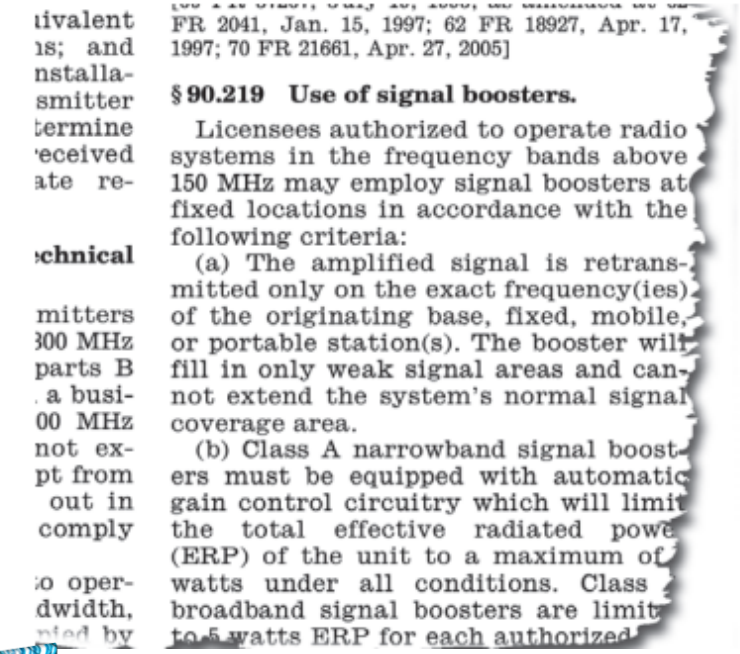

Figure 8.3.5b **Shared Channel Organization (Trunking)**

## 3.5 Federal Communications Commission (FCC)

Whether an ERCES is enhancing Land Mobile Radio, Cellular Service, or any other frequency band licensed by the Federal Communications Commission (FCC), the rules and regulations of the FCC apply in every case, without exception.

With ERCES, much emphasis has been placed on fire and building codes, and the professionals who interpret and enforce these codes. In order for ERCES systems to perform safely, effectively, *and lawfully*, FCC rules must be followed. The FCC License Holder[3] is the ultimate authority and has the ultimate responsibility for how ERCES systems function and interact with their communications systems.

The FCC is the US government agency that reports directly to Congress with a mission to provide the people of the United States with the best communications capabilities possible in support of national interests and defense and promote the safety of life and property. The FCC regulates all radio communications spectrum within the borders of the US and its territories. The agency processes applications and issues licenses for spectrum operation, facilitates cooperation among license holders, provides oversight, regulates commercial and public safety radio services, analyzes complaints, conducts investigations, and develops, implements, and enforces regulations.



FR 2041, Jan. 15, 1997; 62 FR 18927, Apr. 17, 1997; 70 FR 21661, Apr. 27, 2005]

**§ 90.219 Use of signal boosters.**

Licensees authorized to operate radio systems in the frequency bands above 150 MHz may employ signal boosters at fixed locations in accordance with the following criteria:

(a) The amplified signal is retransmitted only on the exact frequency(ies) of the originating base, fixed, mobile, or portable station(s). The booster will fill in only weak signal areas and cannot extend the system's normal signal coverage area.

(b) Class A narrowband signal boosters must be equipped with automatic gain control circuitry which will limit the total effective radiated power (ERP) of the unit to a maximum of watts under all conditions. Class broadband signal boosters are limit to 5 watts ERP for each authorized

FCC 47 CFR § 90 covers Private Land Mobile Radio Services, while sub-part 90.219 describes the use of Signal Boosters in Private Land Mobile Radio Networks. FCC 47 CFR Part 20 covers Commercial Mobile Services such as cellular radio networks. While the predominance of public safety communications systems utilize Land Mobile Radio (LMR) systems, commercial cellular services (such as FirstNet by AT&T) are increasingly used by Public Safety agencies and will be covered in this handbook where appropriate. (Like LMR services, FirstNet Band 14 is FCC Part 90 spectrum.)

The rules that describe Part 20, Part 90, consumer, and industrial signal boosters are addressed later in Chapter 4, THE RULES.

The United States isn't the only country requiring reliable in-building communications for first responders. Each country has an equivalent government agency doing similar work. If performing ERCES work in another country, it's important to understand

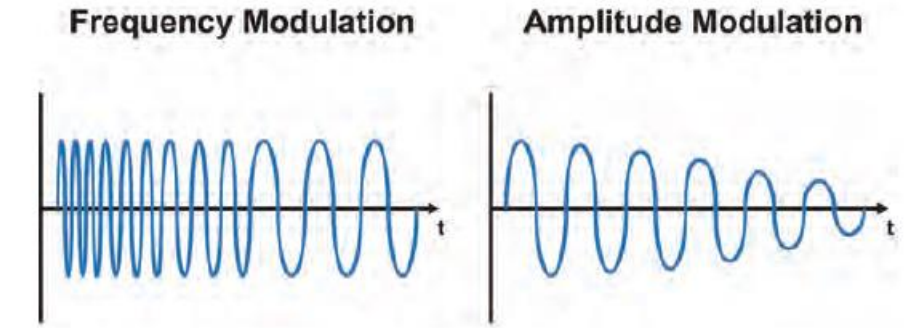



Figure 8.4.1 **Analog modulation techniques**

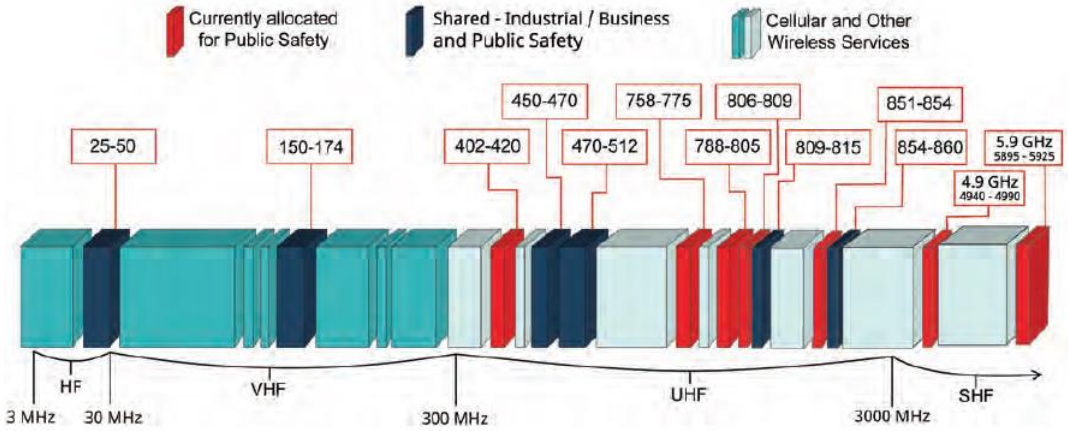



Figure 8.1b **Public safety spectrum**

# FCC 47 CFR § 90.219 - Use of Signal Boosters

The FCC recognizes the importance of in-building coverage for first responders, as they related in their 2013 comments on the record:

***"Signal booster systems play a crucial role in allowing public safety first-responders to communicate in buildings, tunnels and other areas where signals would normally be blocked." and, "We find that allowing third parties to operate signal boosters with express licensee consent serves the public interest by promoting reliable communications, particularly reliable public safety communications."***[1]

There are several sections of FCC rules that pertain to in-building communications. These include the more general sections:

- 47 CFR Subchapter D - SAFETY AND SPECIAL RADIO SERVICES: Part 90 - PRIVATE LAND MOBILE RADIO SERVICES
- 47 CFR Subchapter B - COMMON CARRIER SERVICES: Part 20 - COMMERCIAL MOBILE SERVICES

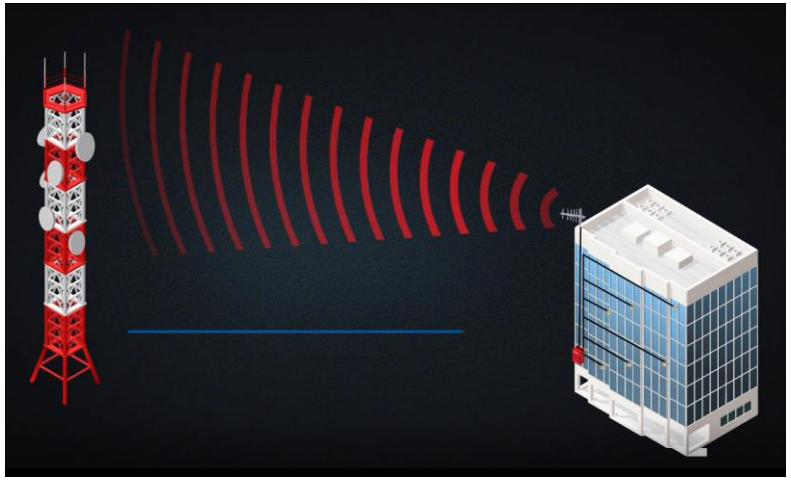
# Deployment Rules and Good Engineering Practices

A BDA straight out of the box may exceed certain FCC RF emission limits if the system integrator is unaware of these FCC rules or careless in the installation. FCC part 90.219 states that BDAs shall not radiate more than −43 dBm of noise within the band of operation and no more than −70 dBm of noise outside the band of operation. The key word here is “radiate.”

This refers to RF emissions from an antenna or network of antennas. Since an ERCES solution is a design/build and unique to every building, the FCC has no way to regulate the noise radiated other than make it the signal booster **owner’s responsibility**. As most Signal booster owners are building owners with little or no RF expertise, they rely upon their system integrator to manage such concerns.

# FCC Part 90 Signal Booster Rules

**FCC Rule Section 90.219**
**Authority to operate.**



Non-licensees seeking to operate signal boosters must obtain the **express consent of the licensee(s)** of the frequencies for which the device or system is intended to amplify.

The consent must be maintained in a **recordable format** that can be presented to an FCC representative or other relevant licensee investigating interference. ***= Written Consent***

# NFPA 1225 – 2022 Edition


**18.7 Approval and Permit.**

**18.7.1**
Plans, including , but not limited to, specifications, link budget, and other information required b the AHJ and **frequency license holder(s),** shall be submitted for approval prior to installation.

**3.3.64 Frequency License Holder(s).**
**The person(s) or entity(ies) that hold the license from the licensing authority of the country of jurisdiction for the frequencies being used by both the in-building emergency responder communications enhancement system and the emergency services communications system that it enhances.**

**18.7.2**
**Written authorization by the frequency license holder** shall be required upon initial installation and prior to activation of the emergency responder communications enhancement system.





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# FCC Part 90 Signal Booster Regulations: Class A vs Class B

**Class A Signal Booster**

Boosters in this class are designed to transfer on one or more specific channels. DAS and high-powered boosters often fit into this classification, as they have a higher power and a more narrow signal filter. Class A has no passbands exceeding 75 kHz. (Narrow banding)

**Class B Signal Booster**

Class B boosters have passbands that exceed 75 kHz (Wide banding), and are generally limited to under 500K sq ft because of power limitations. These are generally less expensive than class A boosters.

**Part 90 Rule: (5)** Class B signal booster installations must be registered in the FCC signal booster database that can be accessed at the following URL: *www.fcc.gov/signal-boosters/registration.*

| **Part 90 Signal Boosters** |
| --- |
| WARNING. This is NOT a CONSUMER device. It is designed for installation by FCC LICENSEES and QUALIFIED INSTALLERS. You MUST have an FCC LICENSE or express consent of an FCC Licensee to operate this device. You MUST register Class B signal boosters (as defined in 47 CFR 90.219) online at *www.fcc.gov/signal-boosters/registration.* Unauthorized use may result in significant forfeiture penalties, including penalties in excess of $100,000 for each continuing violation. |

***Figure 4.2b, Example of FCC Part 90 warning label***

# Express Consent

## Remember - FCC Rules Require Express Consent for ERRCS

### WHY THIS MATTERS:

- **Improper design and operation** of ERRCS systems can interfere with the proper operation and performance of public safety radio networks, placing the public and first responders at risk.
- **Where are the systems installed?** It is critical that the location and immediate contact information for all installed ERRCS systems be available to the frequency license holder to quickly locate sources of interference and insure correct continued operation.
- Fire Code authorizes Code Officials to require public safety radio signals be present within a building, but **FCC rules govern who can authorize turning on and operating such a system.** This is the Frequency License Holder, and not the AHJ (unless the AHJ is both).

| Materials | Attenuation @ 860 MHz |
|---|---|
| Free Space (Air) 10 feet | 40.8 dB |
| Free Space (Air) 100 feet | 60.8 dB |
| Free Space (Air) 1 mile | 95.3 dB |
| Glass 0.25” (6 mm) | 0.8 dB |
| Glass 0.5” (12 mm) | 2.0 dB |
| Low-E / Green Glass (Double Pane) | 23-38 dB |
| Lumber 3” (76 mm) | 2.8 dB |
| Brick 3.5” (89 mm) | 3.5 dB |
| Brick 7” (178 mm) | 5.0 dB |
| Brick 10.5” (267 mm) | 7.0 dB |
| Masonry Block 8” (203 mm) | 12.0 dB |
| Masonry Block 16” (406 mm) | 7.0 dB |
| Masonry Block 24” (610 mm) | 28.0 dB |
| Concrete 4” (102 mm) | 12.0 dB |
| Brick Faced Concrete 7.5” (192 mm) | 14.0 dB |
| Concrete 8” (203 mm) | 23.0 dB |
| Reinforced Concrete 3.5” (203 mm) | 27.0 dB |
| Concrete 12” (305 mm) | 35.0 dB |

**Construction materials that make up the obstructions are the largest attenuators.**

**-3.0 dB = ½ Power**
**-6.0 dB = ¼ Power**
**-10.0 dB = 1/10 Power**

This reduction in power is known as *attenuation*. Look at Table 7.3a and notice that the attenuation of the RF signal after passing through 12" of concrete (35 dB) is greater than the attenuation after passing through 3.5" of brick (3.5 dB).

| dB | Power Reduction |
|---|---|
| −1.0 | 20.60% |
| −2.0 | 37.00% |
| −3.0 | 50.00% |
| −3.5 | 55.30% |
| −6.0 | 75.00% |
| −9.0 | 87.50% |
| −10 | 90.00% |
| −12 | 93.70% |
| −20 | 99.00% |
| −30 | 99.90% |
| −35 | 99.97% |
| −40 | 99.99% |
| −50 | 99.999% |
| −60 | 99.9999% |

Table 7.3b **dB to Percent Power Reduction**

Looking at this you might think the power attenuation through concrete is ten times greater than the attenuation through brick (3.5 dB × 10 = 35 dB??). But remember, we are using a

*logarithmic scale*.

On a logarithmic scale, 35 dB is actually *1,400 times more attenuation* than 3.5 dB!

Take a look at the Table 7.3b to see the ratio of change (in dB) expressed as a percentage of power reduction.

Notice that a −3 dB change results in a 50% decrease in power.

A −6 dB change results in a 75% decrease in power (or half again from 3 dB).

A −35 dB change results in a 99.97% decrease in power.

| | |
|---|---|
| Brick 3.5" (89 mm) | 3.5 dB |
| Brick 7" (178 mm) | 5.0 dB |
| Masonry Block 8" (203 mm) | 7.0 dB |
| Masonry Block 16" (406 mm) | 12.0 dB |
| Masonry Block 24" (610 mm) | 28.0 dB |
| Concrete 4" (102 mm) | 12.0 dB |
| Brick Faced Concrete 7.5" (192 mm) | 14.0 dB |
| Concrete 8" (203 mm) | 23.0 dB |
| Reinforced Concrete 3.5" (203 mm) | 27.0 dB |
| Concrete 12" (305 mm) | 35.0 dB |


# Signal Strength/Quality – Per NFPA

## NFPA 1225 - 2022 Edition

**18.9 Signal Strength and Quality**

**18.9.1*** Downlink**.**

A minimum downlink signal shall be sufficient to provide a minimum of DAQ 3.0 for voice communications using either narrowband, analog, or digital P25 signals or wideband LTE digital signals throughout the coverage area. (*See A.20.3.10.*)

**A.18.9.1**

*Downlink* refers to the signal from the base station to the portable. Although DAQ 3.0 is required as a minimum, it is recommended that systems be designed for DAQ 3.4 to provide a safety factor.

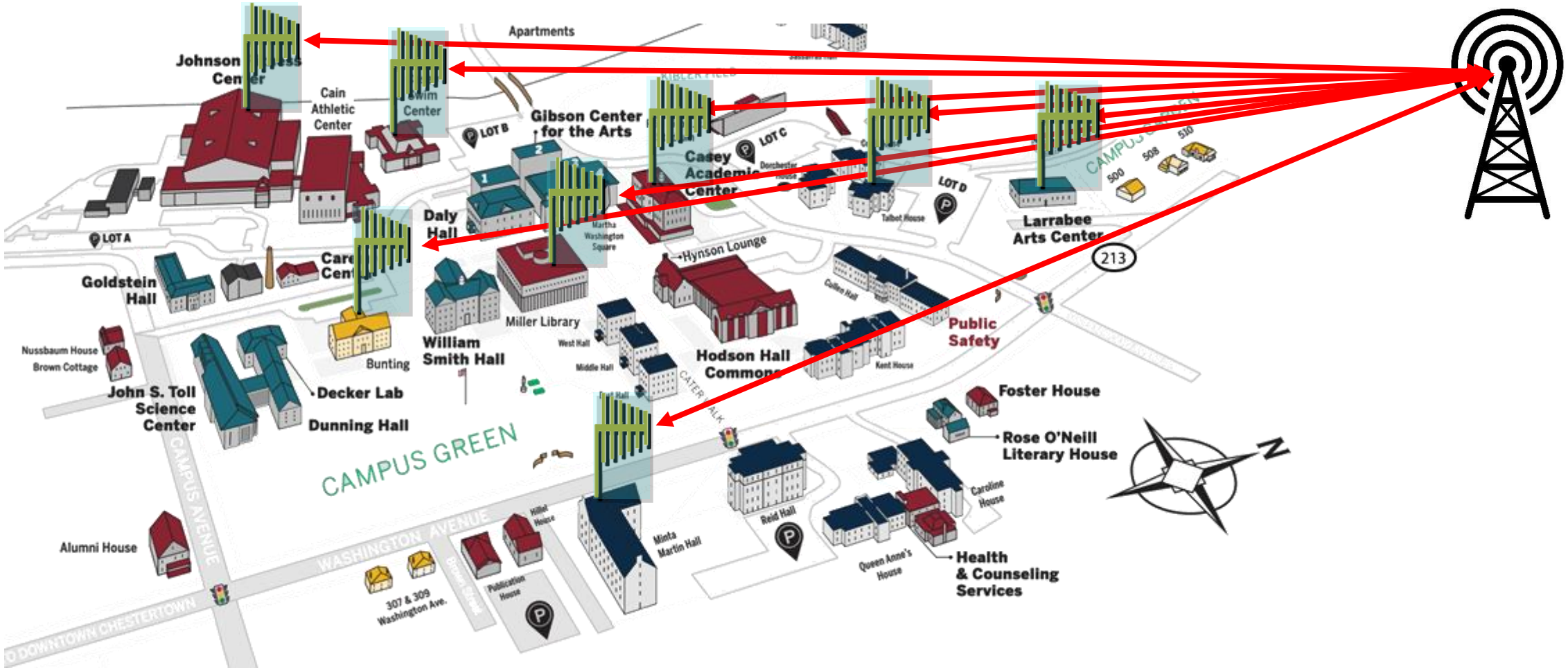
**18.9.2*** Uplink**.**

The uplink signal shall be sufficient to provide a minimum of DAQ 3.0 for voice communications using either narrowband, analog, or digital P25 signals or widespread LTE digital signals. (*See A.20.3.10.*)

**A.18.9.2**

*Uplink* refers to the signal from the portable to the base station.

# Campus & Multi-Building Site Considerations




*Multiple Signal Boosters and Donor Antennas, with overlapping RF Paths?*





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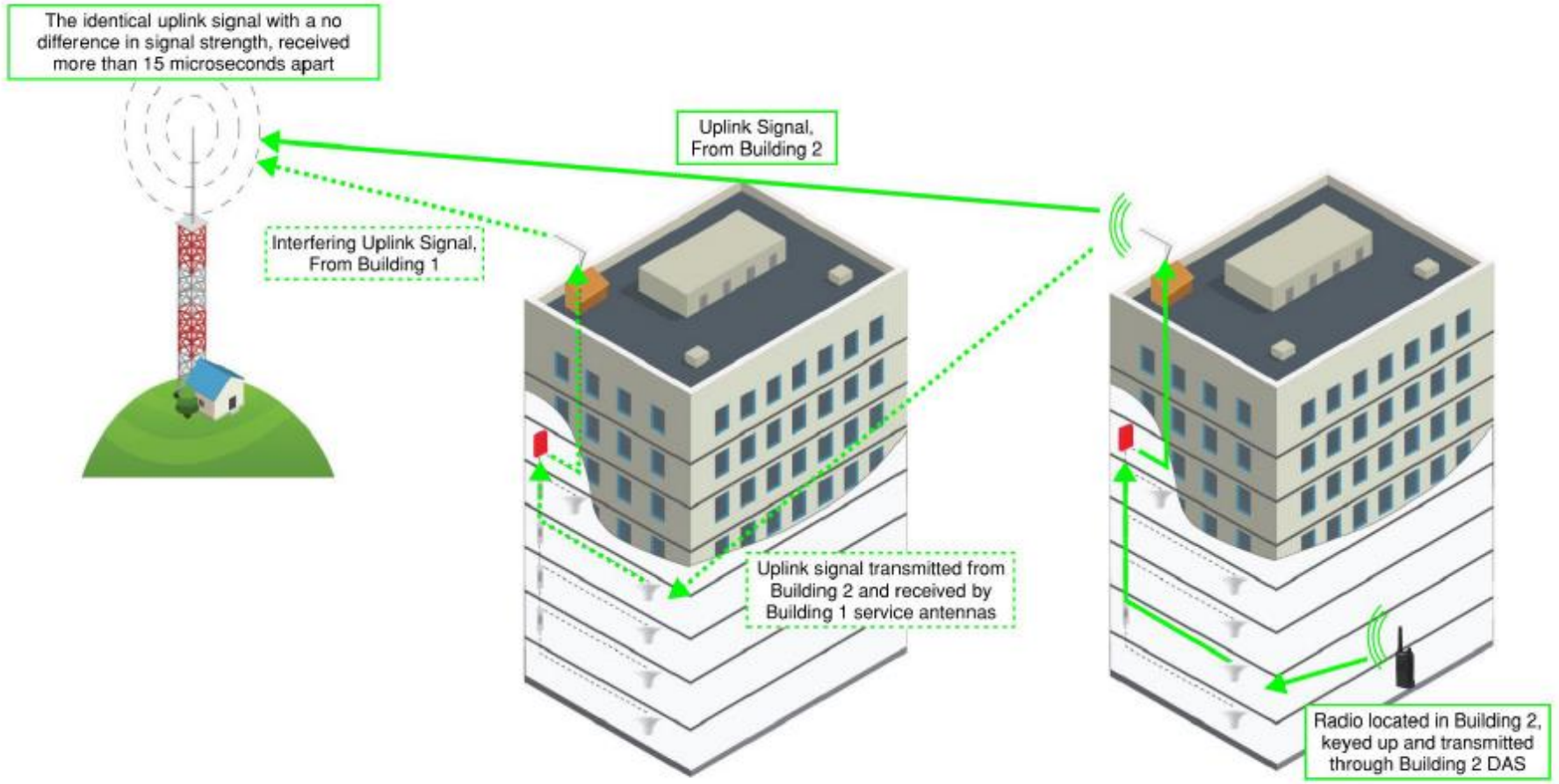
# Campus & Multi-Building Site Considerations




*Multiple Signal Boosters and Donor Antennas, with overlapping RF Paths?*





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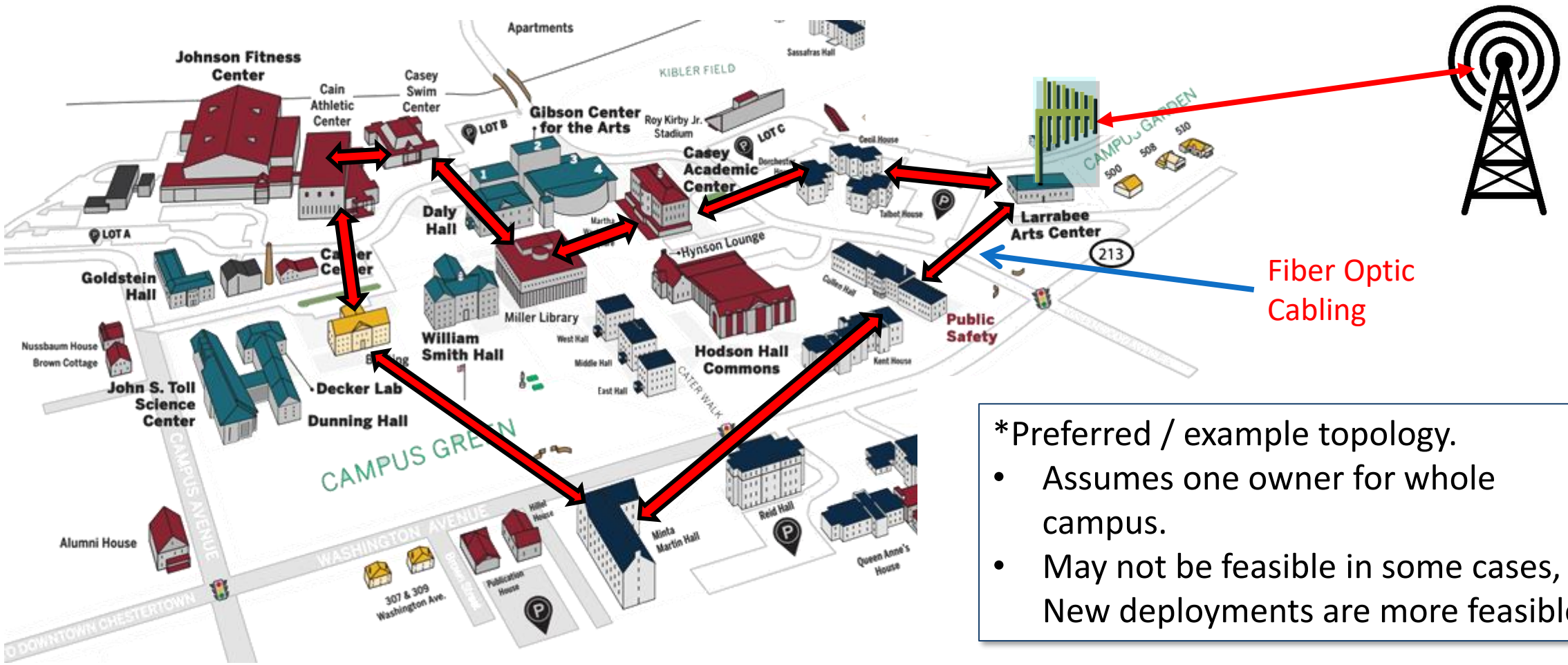
# Campus & Multi-Building Site Considerations




*Preferred / example topology.

- Assumes one owner for whole campus.
- May not be feasible in some cases, New deployments are more feasible

*Or a Master Signal Booster and Donor Antenna Hubbed to other buildings using Fiber?*





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- Noise and Interference
- Calculating Noise Floor


**Alan Perdue – Executive Director**

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# *Types of Interference*

According to the International Telecommunication Union's (ITU) Radio Regulations (RR), there are three types of RF interference:

• **Permissible interference** (*RR, No. 1.167*): "Observed or predicted interference which complies with quantitative interference and sharing criteria contained in these [ITU RR]…or in ITU Radiocommunication Sector (ITU-R) Recommendations or in special agreements as provided for in these Regulations"[5];

• **Accepted interference** (*RR, No. 1.168*): "Interference at a higher level than defined as permissible interference and which has been agreed upon between two or more administrations without prejudice to other administrations"[6]; and

• **Harmful interference** (*RR, No. 1.169*): "Interference which endangers the functioning of a radio[-]navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radio…communication service operating in accordance with RR"[7].

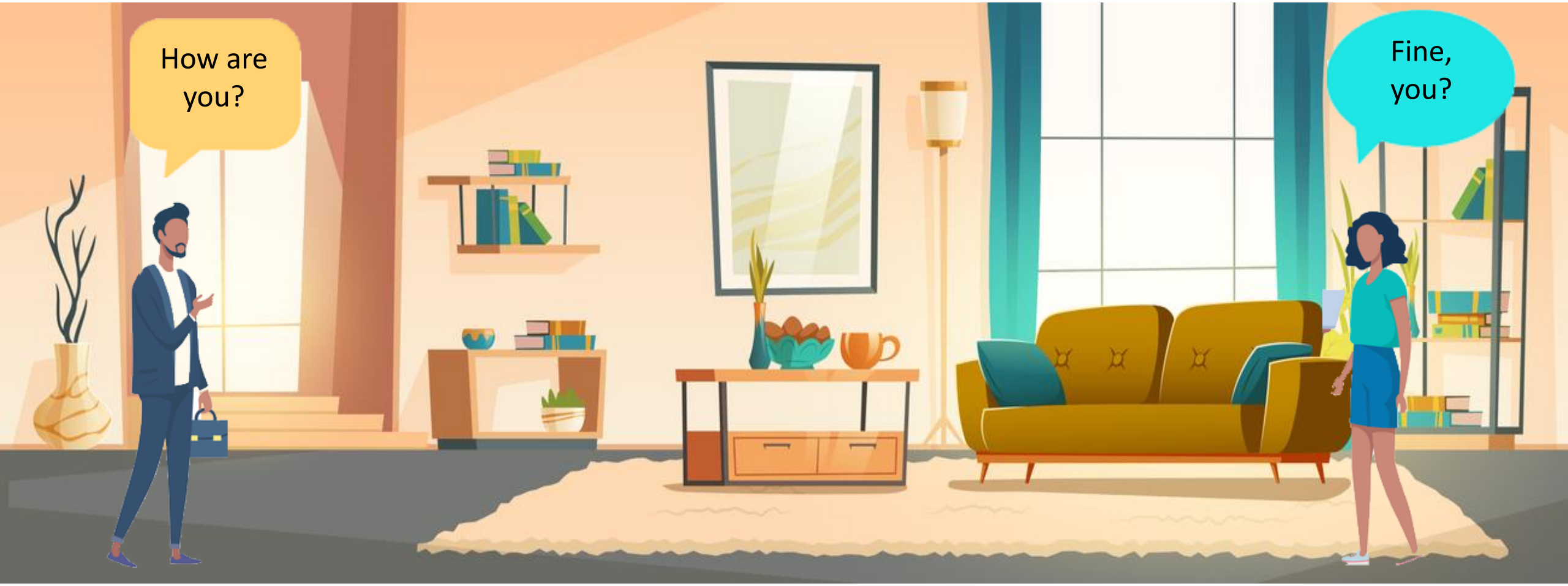
# *Sources of Interference*

There are two sources that can result in harmful interference:

- **Intentional interference sources**, which include illegal jamming devices, radios programmed to use unauthorized frequencies, or other purpose-built solutions; or

- **Unintentional interference sources**, which include low-quality foreign-made electronics (e.g., Universal Serial Bus [USB] chargers, baby monitors transmitting on public safety frequencies); outdated, degraded, or improperly installed signal boosters; lighting ballasts; and solar flares

# Signal to Noise Ratio





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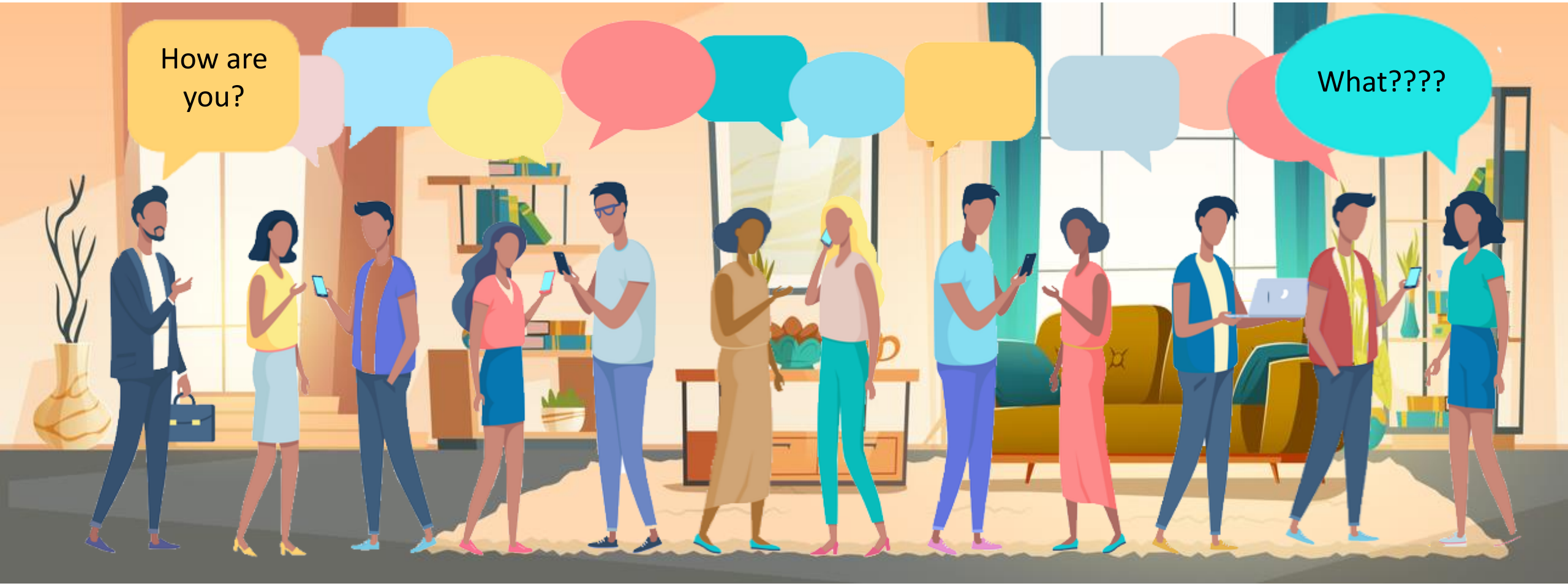
# Signal to Noise Ratio





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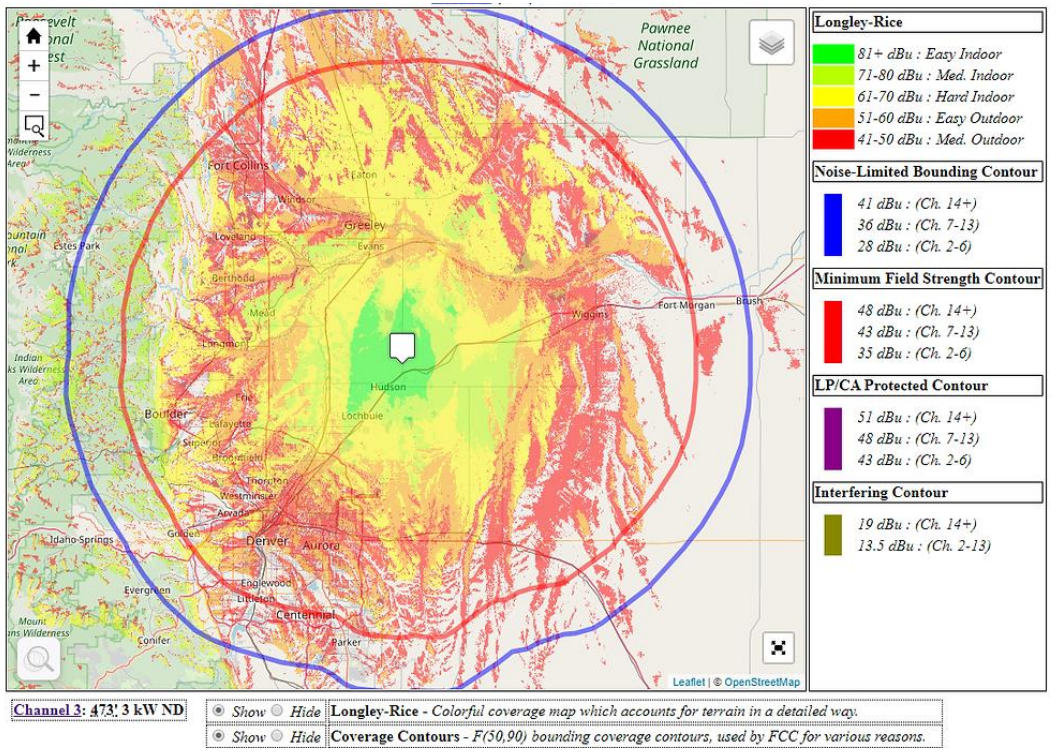
# Impact of Noise and Interference

## How does noise or interference affect public safety agencies and radio users?

1. **Coverage area shrinking.** Imagine a broadcast tower serving an area of 30 square miles, then being affected by noise. The users at the edges of that service area may now find themselves without emergency communications. The worse the noise, the more the coverage area shrinks.

2. **Reduction of call capacity for the radio system**. Contemporary radio systems support the ability to have numerous users talking concurrently. If the radio system detects noise it may disable some portion of itself, allowing for fewer users.





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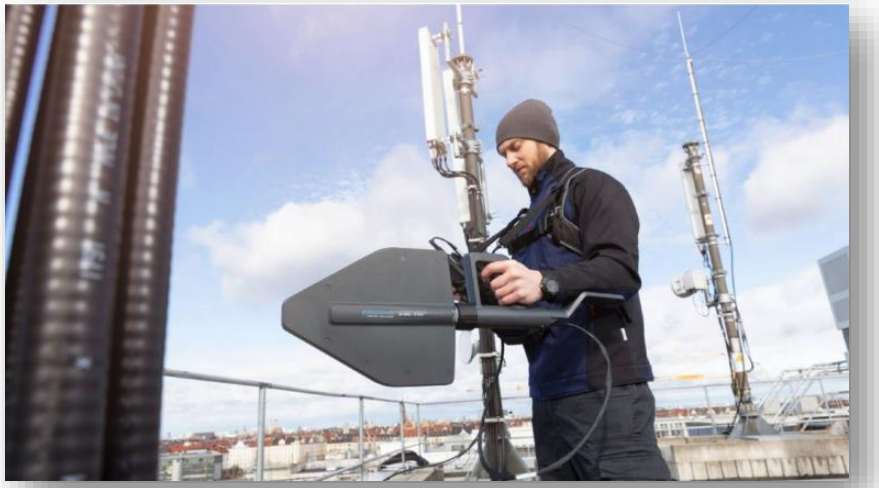
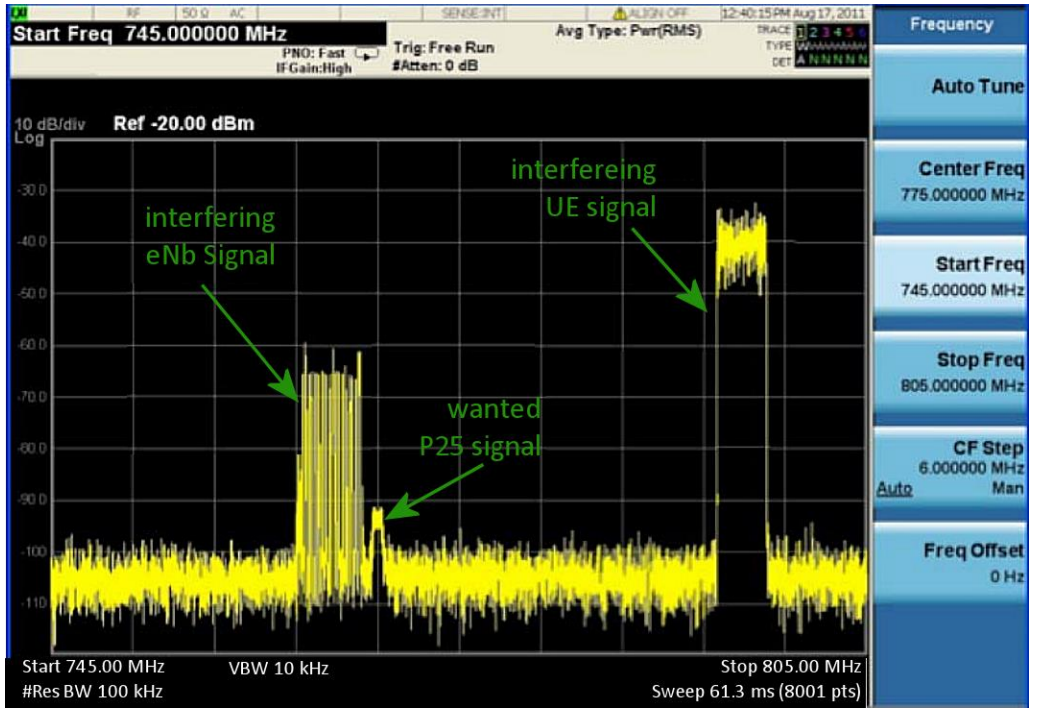
# Impact of Noise and Interference

## How does noise or interference affect public safety agencies and radio users?

**3. Dead Channels – Or entire systems knocked out of service!**

**4. Diversion of public safety resources to identify and resolve the problems.**







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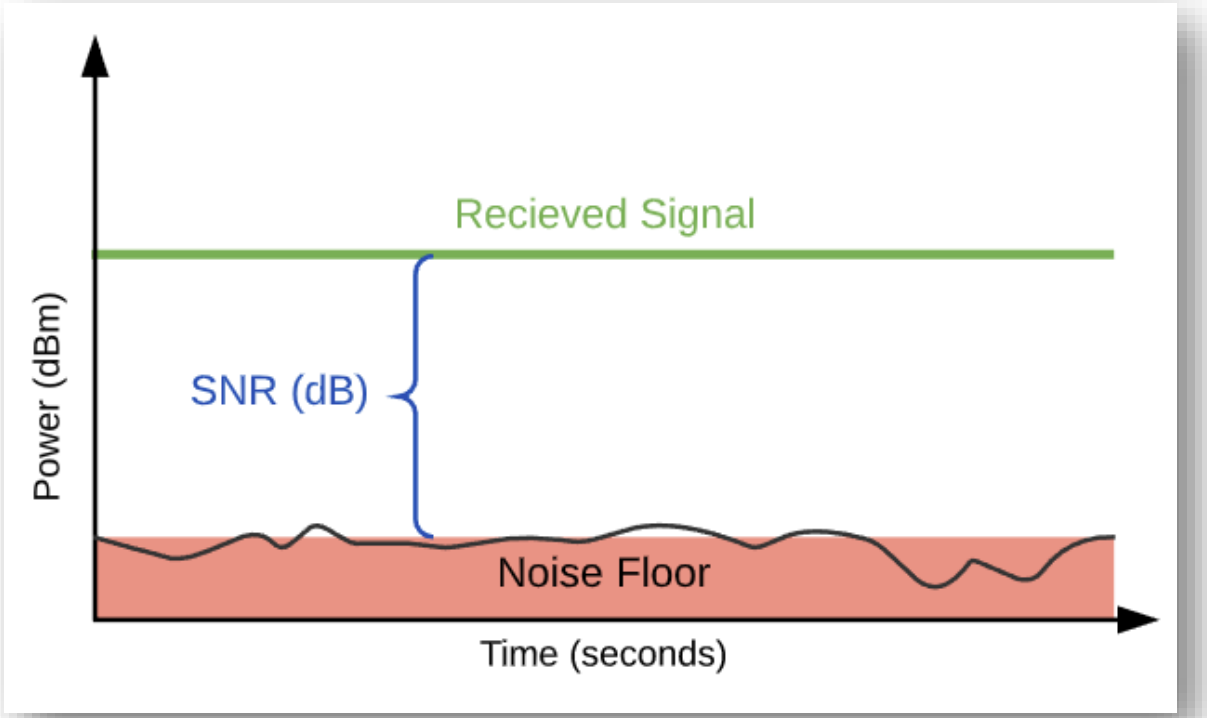
# Signal to Noise Ratio

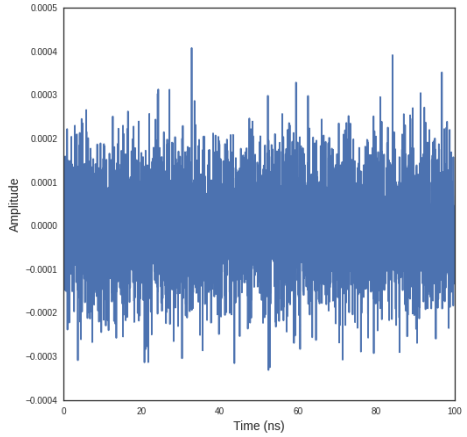
RF ***Noise*** can generally be regarded as any RF energy that is not the desired signal.

***Signal-to-Noise Ratio*** is a measure that compares the level of a desired signal to the level of background noise. When the noise level is as high or nearly as high as the desired signal level, radio systems cannot function correctly.

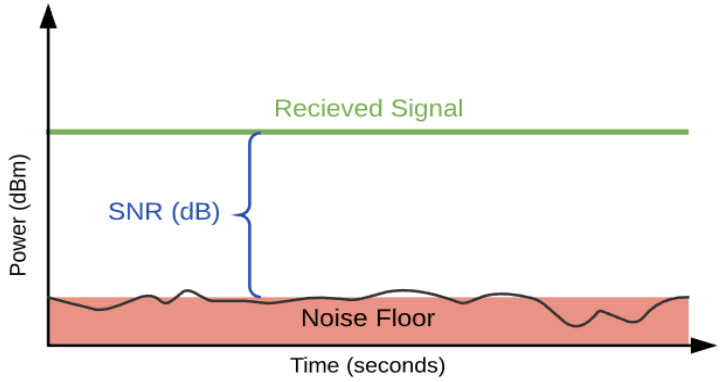


# Some Key Terms:

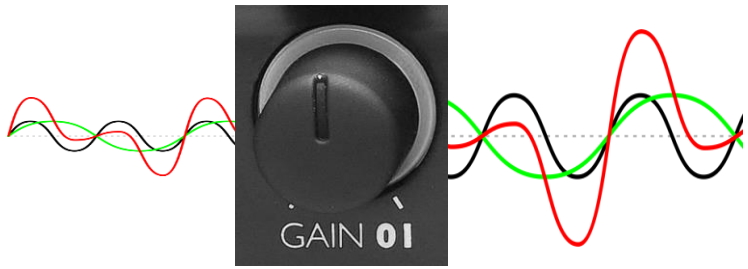
- **Thermal Noise** - Thermal noise is a noise that is a result of the thermal agitation of electrons. The thermal noise power depends on the bandwidth and temperature of the surroundings.




- **Noise Floor** - The Noise Floor is the signal created from adding up all the unwanted signals within a measurement system.




- **BDA Gain** - Gain is a measure of the ability of the Bi-Directional Amplifier (BDA) to increase the power of a signal from the input to the output





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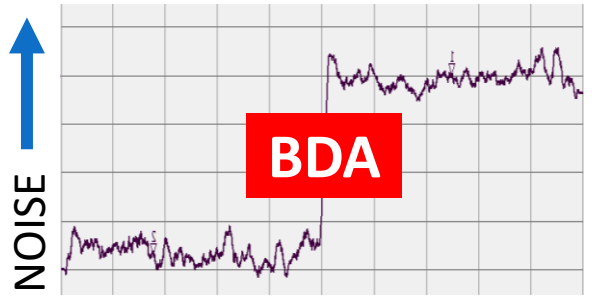
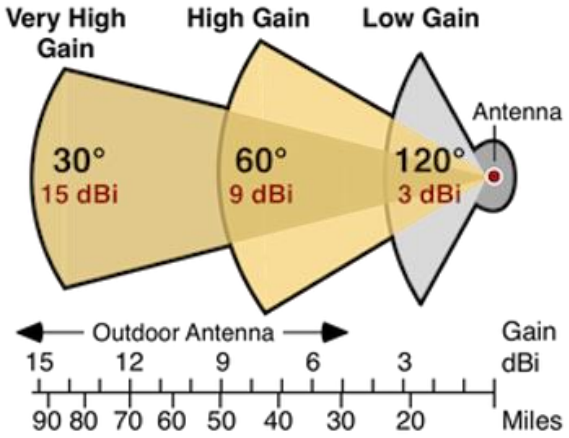
# Some Key Terms:

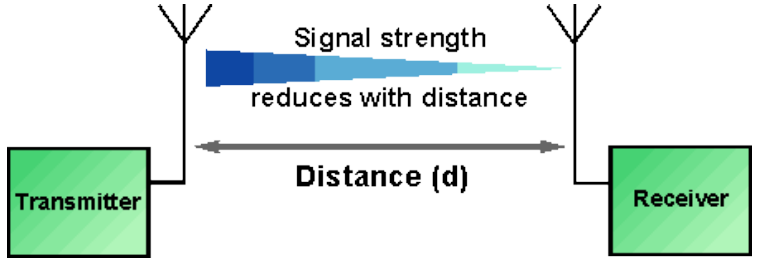
- **BDA Noise Figure** - The Noise Figure defines the amount of noise an element (like a BDA) adds to the overall system.




- **Antenna Gain** - Antennas don't create radio energy, they can only divert, direct, or concentrate it in some direction. This is called Antenna Gain.




- **Free Space Path Loss (FSPL)** - Free Space Path Loss is the attenuation (reduction) of signal strength between two antennas. Assumes the space between the antennas is an obstruction free, line-of-sight straight path through the air.





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# Thou Shalt Not Raise the Noise Floor….


**18.9.3* Noise Floor.**

If the design of the in-building emergency responder communications enhancement system (ERCES) requires the use of a signal booster, then the maximum uplink RF noise (noise crown) created by any signal booster or signal booster booster-based ERCES **shall not raise the noise floor at the public safety communications site closest to the ERCES or any receive site within the public safety communications network that the ERCES is intended to operate with.**





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# Link Budget

An accounting of all the gains and losses in a transmission system.

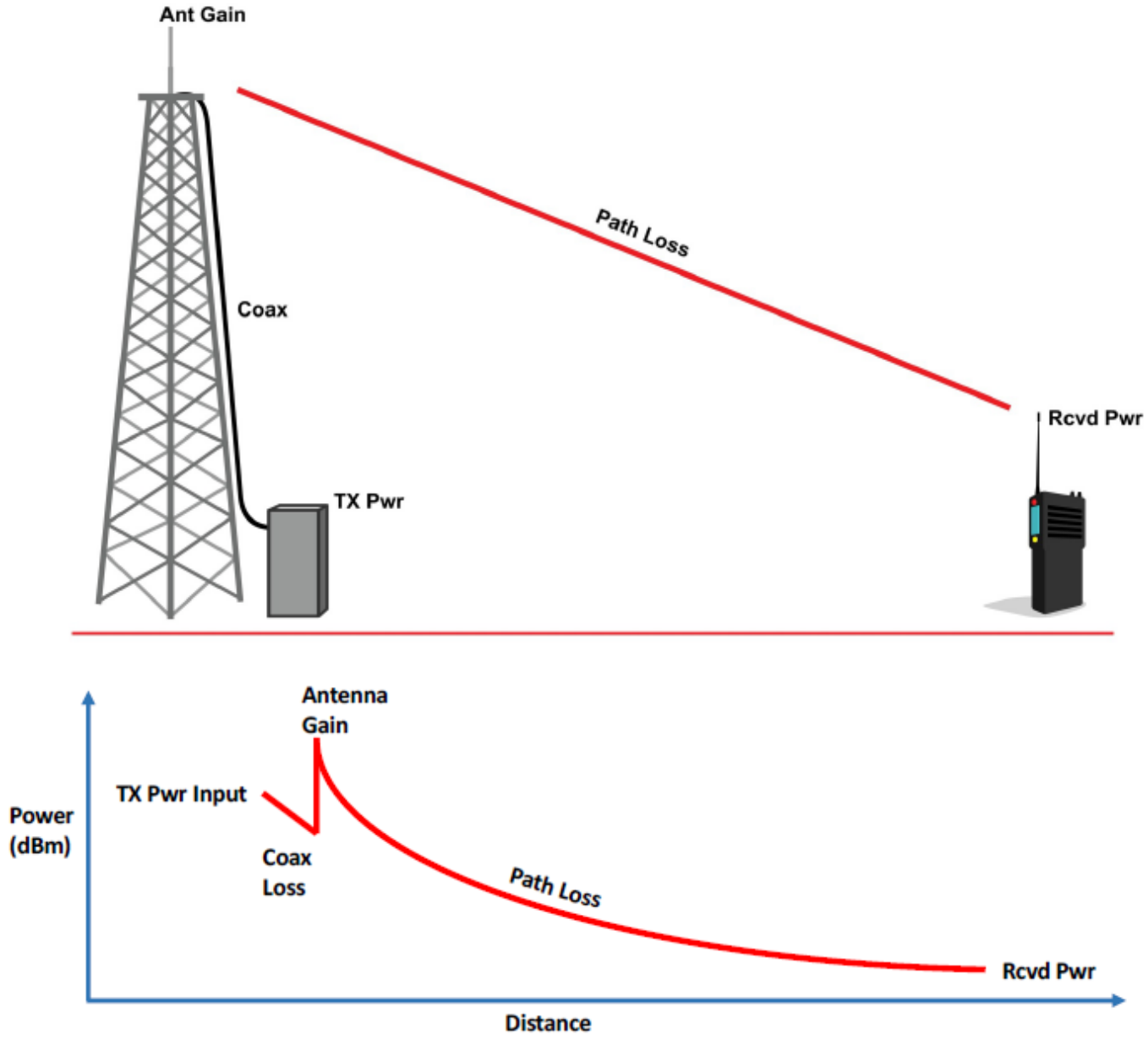



Figure 7.9 **Simple Link Budget**
**[TX Pwr – Coax Loss + Antenna Gain – FSPL = Rcvd Pwr]**

# Simplifying RF Math: Rule of 3's and 10's

## +dB = Multiply Power

## -dB = Divide Power

| |
|---|
| +3dB = double ( x2) |
| -3dB = half ( ÷2) |
| +10dB = ten times greater ( x10) |
| -10dB = one-tenth as much (÷10 ) |

| dB | Power Reduction |
|---|---|
| -1.0 | 20.60% |
| -2.0 | 37.00% |
| -3.0 | 50.00% |
| -3.5 | 55.30% |
| -6.0 | 75.00% |
| -9.0 | 87.50% |
| -10 | 90.00% |
| -12 | 93.70% |
| -20 | 99.00% |
| -30 | 99.90% |
| -35 | 99.97% |
| -40 | 99.99% |
| -50 | 99.999% |
| -60 | 99.9999% |

# RF Math – Decibels and the Logarithmic Scale

Question:

How much attenuation is - 27dB?

| | |
|---|---|
| Reinforced Concrete 3.5” (203mm) | 27.0 dB |

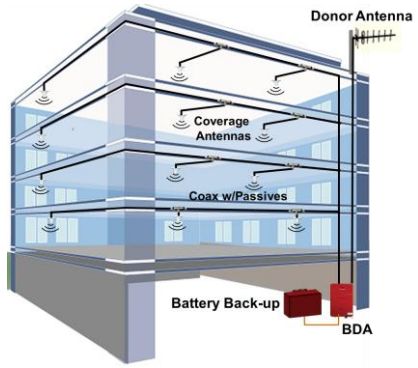
| Material | Attenuation @ 900 MHz |
|---|---|
| Free Space (Air) 10 Meters | 72.5 dB |
| Free Space (Air) 100 Meters | 92.5 dB |
| Free Space (Air) 1000 Meters | 112.5 dB |
| Glass 0.25” (6mm) | 0.8 dB |
| Glass 0.5” (13mm) | 2.0 dB |
| Lumber 3” (76mm) | 2.8 dB |
| Brick 3.5” (89mm) | 3.5 dB |
| Brick 7” (178mm) | 5.0 dB |
| Brick 10.5” (267mm) | 7.0 dB |
| Concrete 4” (102mm) | 12.0 dB |
| Masonry Block 8” (203mm) | 12.0 dB |
| Brick faced concrete 7.5 “ (192mm) | 14.0 dB |
| Masonry Block 16” (406mm) | 7.0 dB |
| Concrete 8” (203mm) | 23.0 dB |
| Reinforced Concrete 3.5” (203mm) | 27.0 dB |
| Masonry Block 24” (610mm) | 28.0 dB |
| Concrete 12” (305mm) | 35.0 dB |

$$-3dB - 3dB - 3dB - 3dB - 3dB - 3dB - 3dB - 3dB - 3dB = -27dB$$

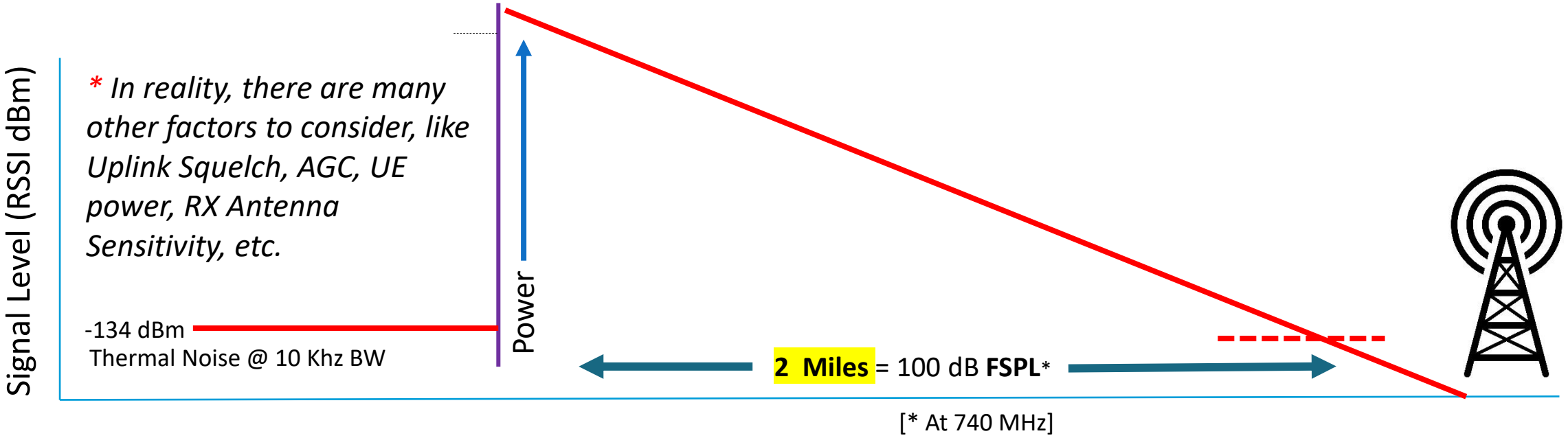
$$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 1/512$$

1/512 is a 99.8% reduction in power!

# Don’t Raise the Noise Floor at the Tower – a *simplified** example




- 134 dBm Noise Floor
+ 75 dB BDA Uplink Gain - 59
+ 5 dB BDA Noise Figure - 54
+ 8 dB Donor Antenna Gain - 46
- 46 dBm leaving the building donor antenna
- 100 dB FSPL -146
- 146 dBm BDA System Noise at Tower* *Actually, Can’t go lower than Thermal Noise @ -134 dBm*





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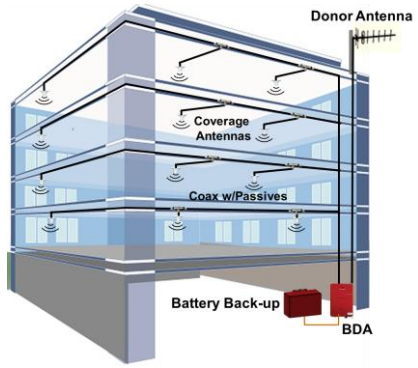
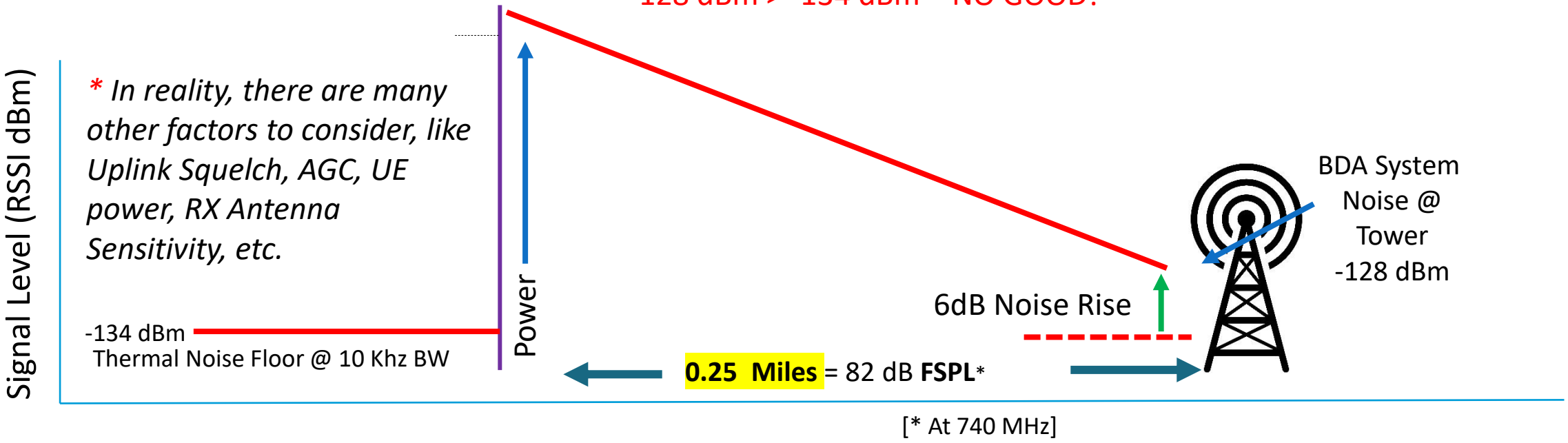
# What if the Tower is Closer to the Building? a *simplified** example




| | |
|---|---|
| - 134 dBm Noise Floor | |
| + 75 dB BDA Uplink Gain | - 59 |
| + 5 dB BDA Noise Figure | - 54 |
| + 8 dB Donor Antenna Gain | - 46 |
| - 46 dBm leaving the building donor antenna | |
| - 82 dB FSPL | -128 |
| - 128 dBm BDA System Noise at Tower | |

-128 dBm > -134 dBm – NO GOOD!





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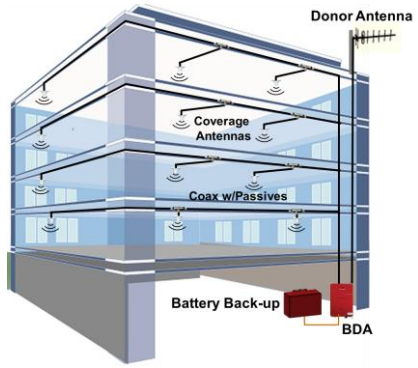
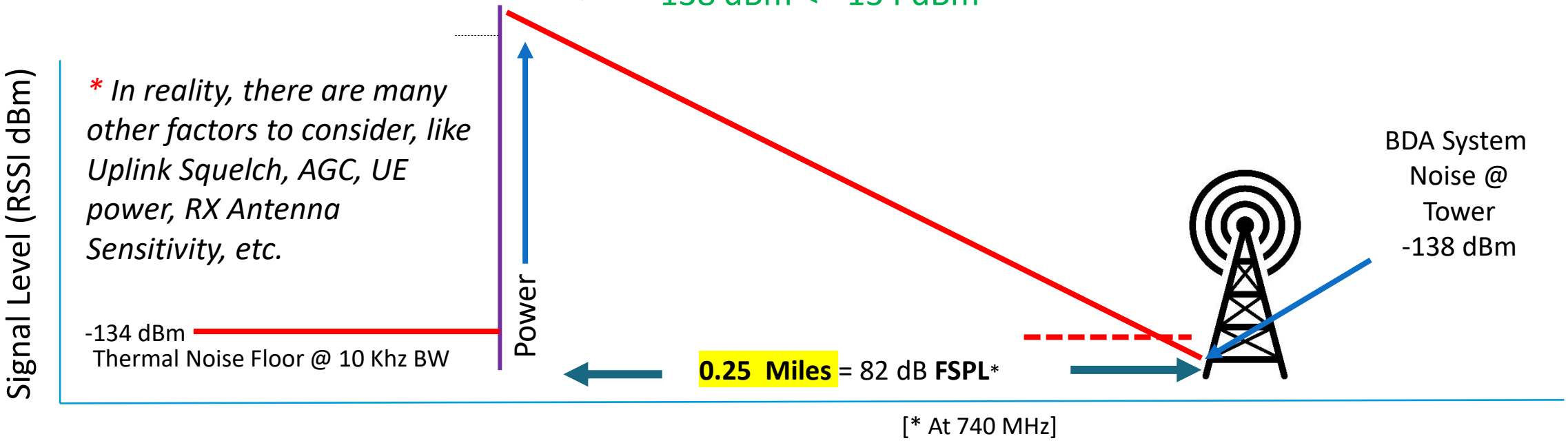
# Don’t Raise the Noise Floor at the Tower – a *simplified** example




- 134 dBm Noise Floor
+ 65 dB BDA Uplink Gain *[adjust gain down by 10 dB]* - 69
+ 5 dB BDA Noise Figure - 64
+ 8 dB Donor Antenna Gain - 56
- 56 dBm leaving the building donor antenna
- 82 dB FSPL - 138
- 138 dBm BDA System Noise at Tower

✓ - 138 dBm < - 134 dBm





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# Interference Example: Band 14 and LMR Conflicts

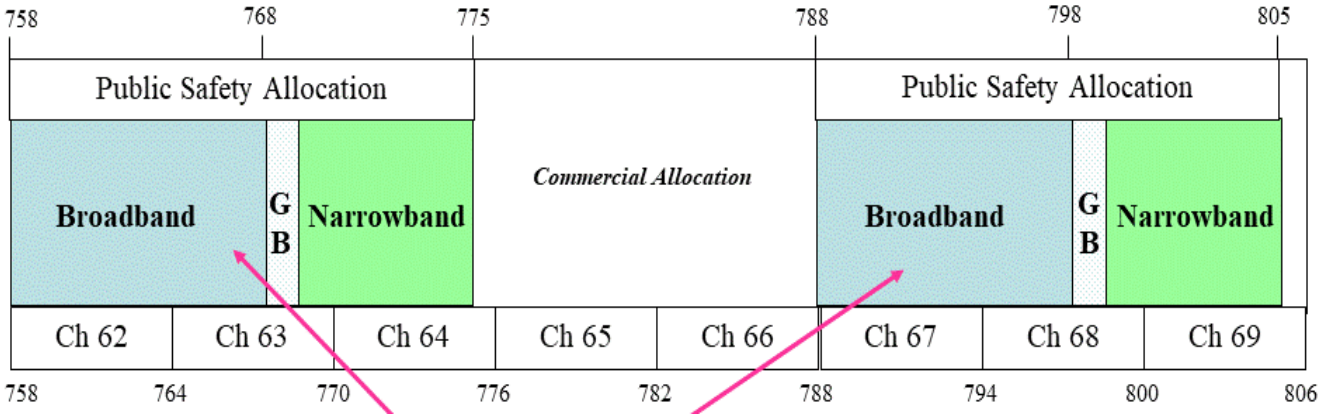



Chart by FCC

- FirstNet Band 14 public safety LTE utilizes two 10-MHz-wide blocks of spectrum at 758 MHz to 768 MHz (downlink) and at 788 MHz to 798 MHz (uplink).
- These bands are adjacent to existing in-use public safety narrowband spectrum (769 MHz to 775 MHz and at 799 MHz to 805 MHz) *(only a 1 MHz Guard Band)*

# Good Engineering and Notch Filters can help…

**Example Notch Filters**

**Dimension Ranges:** From about 9” x 9” to about 12” x 12” or 12” x 13”

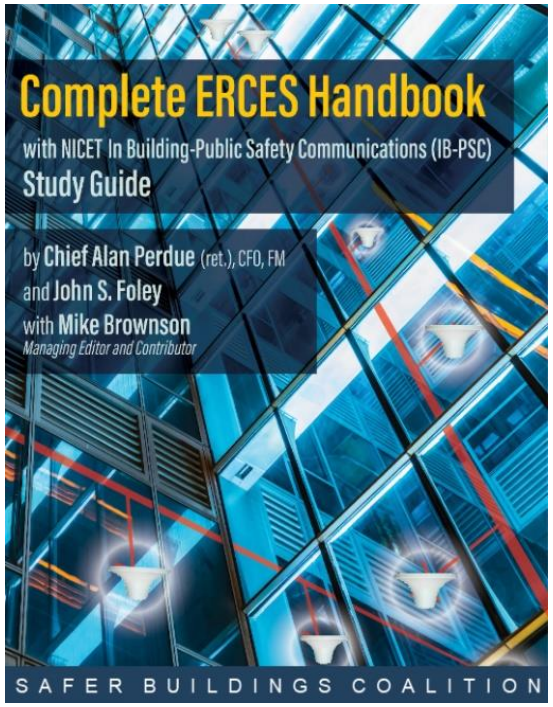
- FirstNet has reported interference from existing ERCES / Signal Boosters that are improperly amplifying FirstNet licensed bands.
- This can be avoided with good engineering design practices and careful frequency planning. For example, *notch filters* may be added to ERCES / Signal Boosters to prevent such interference.

# FCC Rules defines whose responsibility it is to fix any conflicts…

- Signal booster operation is on a non-interference basis and buildings using BDA's may be required to cease or alter the BDA's operating parameters due to a request from an FCC representative or a licensee's *[PS Radio Agency or FirstNet]* request to resolve interference.
- Therefore, it is the responsibility of building owners and their Systems Integrator contractors to resolve conflicts.
- Best practice is to engineer to avoid any conflicts to begin with.
- OEMs – Quality Products, proper labeling, documentation, training

# QUESTIONS?

## CAFAA Special

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