Undergraduate Journal of Mathematical Modeling: One + Two

Volume 11 | 2021 Spring 2021 Article 5

2021

Emergency Communications Deficiency Locator

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Recommended Citation

Collins, Austin (2021) "Emergency Communications Deficiency Locator," *Undergraduate Journal of Mathematical Modeling: One + Two*: Vol. 11: Iss. 2, Article 5.
DOI: https://doi.org/10.5038/2326-3652.11.2.4933
Available at: https://digitalcommons.usf.edu/ujmm/vol11/iss2/5

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Emergency Communications Deficiency Locator

Abstract

The Bi-Directional Amplifier (BDA) is the newest edition to Life Safety in the state of Florida. The Florida Fire Prevention Code (NFPA 1) section 11.10.1 states that "In all new and existing buildings, minimum radio signal strength for fire department communications shall be maintained at a level determined by the authority having jurisdiction (Committee *NFPA 1: Fire Code 2018*). That authority having jurisdiction for our local Tampa Bay area is the Hillsborough County Fire Rescue department and they have posted their own requirements along with the Florida Senate for emergency communication standards. All existing "Hi-rise" buildings, 75 feet tall or more, must comply by Jan. 1st 2022, all existing apartment complexes must comply by 2025, and all existing buildings that do not comply with the Hillsborough County Fire Rescue department standards were supposed to have applied for permit by December of 2019 (Senate *Florida Legislature*) . Several building owners are unaware of the aforementioned changes and it is extremely important to efficiently identify the buildings that do not comply with the latest regulations.

To begin determining the best fix for soft spots in public safety radio transmissions I considered three separate FCC callsigns that cover the emergency radio channels around Hillsborough County. Next, I recorded the amount of Watts each tower is using to then convert to decibel gain (dB) that each tower produces. I determined that greater the power (Watts) that you push through a tower has a decreasing rate of decibels produced per watt and therefore not an option to solve the problem at hand. Then I derived an expression for "Free Space Path Loss (FSPL) in dB" that shows the dissipation of radio signal over a given distance. Using this formula, I realized I may not be able to provide an overall solution for the lack of radio signal, but I would be able to locate areas that will require the installation of a radio amplification system. Therefore, using derivative and integration techniques, I have designed a precise method for mapping areas of radio propagation around Hillsborough County, which in turn, show areas that do not receive the minimal -95dB radio strength and must have a BDA installed.

Keywords

fire prevention control, fire rescue department standards, radio wave propagation, bi-directional amplification system(BDA)

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PROBLEM STATEMENT

Bi-directional Amplification systems are now mandated in the state of Florida, per the Florida Fire Prevention Code, and Fort Knox Fire and Communications needs a solution to provide public safety radio coverage at a more efficient rate.

MOTIVATION

The evolving Life Safety code is one of the most important progressions in society today. Fire alarm systems, suppression systems, radio communication systems, etc. play a critical role in ensuring public safety under extreme circumstances. These new “two-way radio communications” systems allow firefighters, police, and EMT’s to have immediate access to communication to one another during an emergency within a building. And that is why the Bi-Directional Amplification systems, BDA, were introduced in the last updated Florida Fire Prevention Code. From an engineering aspect, when a new project is being drawn up, engineers must list out a set of specifications required to be implemented in the building design by hired contractors. Now the new radio communications code can be tricky to decipher when it comes to new construction. In an existing building, the building owner can hire a company to take radio strength readings to determine if the building has sufficient emergency communication signal. But for new construction, there is no building to do these readings in! And sure, you may take readings from the ground level where construction will take place, but that leaves out too many uncalculated variables like radio wave diffraction, decibel dissipation, and the effect of decibel gain from initial transmission. On the other side of that coin, the general contractor will not want to make the site owner pay for unnecessary building additions, like a BDA system, if they will fall within the acceptable decibel levels for clear two way radio communication. So, how do we predetermine radio strength for a given location without ever stepping foot on site? Through deriving a formula that gets down to the core understanding of radio wave propagation, accounting for as many variables as possible, and pinpointing where the edge of the curve that lies between areas within code and which are not.

MATHEMATICAL DESCRIPTION & SOLUTION APPROACH

Since it was important to investigate how exactly FCC Callsigns transmit public safety frequencies, through RadioReference.com, I retrieved data from three specific tower sites that transmit into the same general area. Figure 1 shows a map of FCC callsign (Uniquely designated

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government agency frequencies) locations that cover the same intermediate area within the Hillsborough County limits. I will be using these same tower locations throughout the project.

Figure 1

(*Hillsborough County (EDACS) - Site Map*)

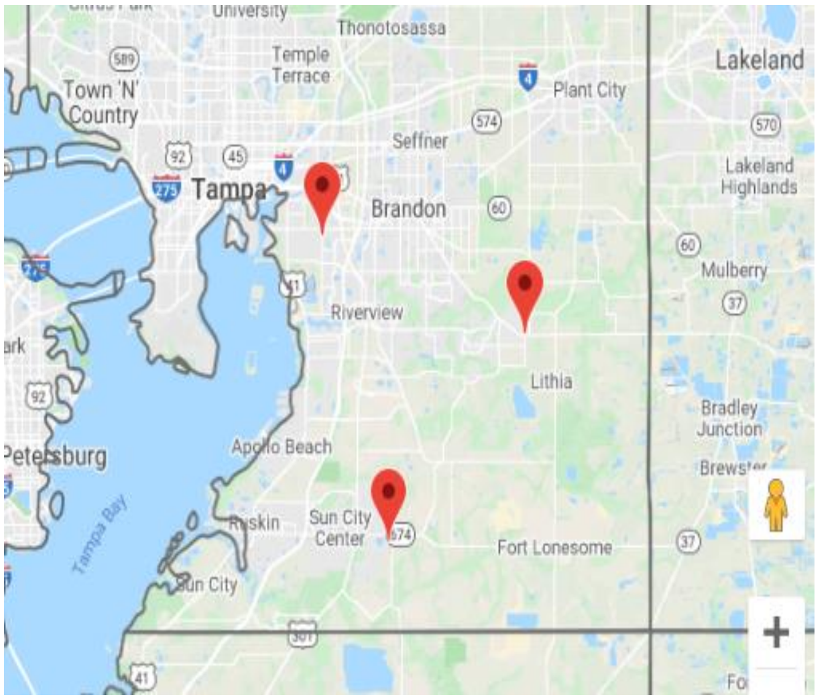

Figure 2 states the FCC Callsign addresses along with miscellaneous tower information.

Figure 2 (*FCC Callsign WPDV262 (Hillsborough Co. Sheriff's Office)*)

#	Tower ID	Type	Ant Height	Struc Height	Elevation	Address
1	1054317	TOWER	121.9	126.5	6.0	3212 S 78TH STREET
2		TOWER	54.9	58.8	26.0	1120 7TH STREET
3		TOWER	54.9	57.3	32.0	6766 LITHIA PINECREST ROAD

These three FCC Callsign locations operate under the Hillsborough County Sheriff's Office FCC license "WPDV262". All locations use an analog system voice and can be transmitted and received by Fire, EMT, and Police officers. Figure 3 shows the frequencies in which these officers communicate over for emergencies.

Figure 3 Site Frequencies

(*Hillsborough County (EDACS)*)

851.125	851.375	851.5625	851.700	851.825	852.3125	852.550	852.650	852.800	852.9125
853.250	853.275	853.575	853.600	853.825					

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DOI: https://doi.org/10.5038/2326-3652.11.2.4933

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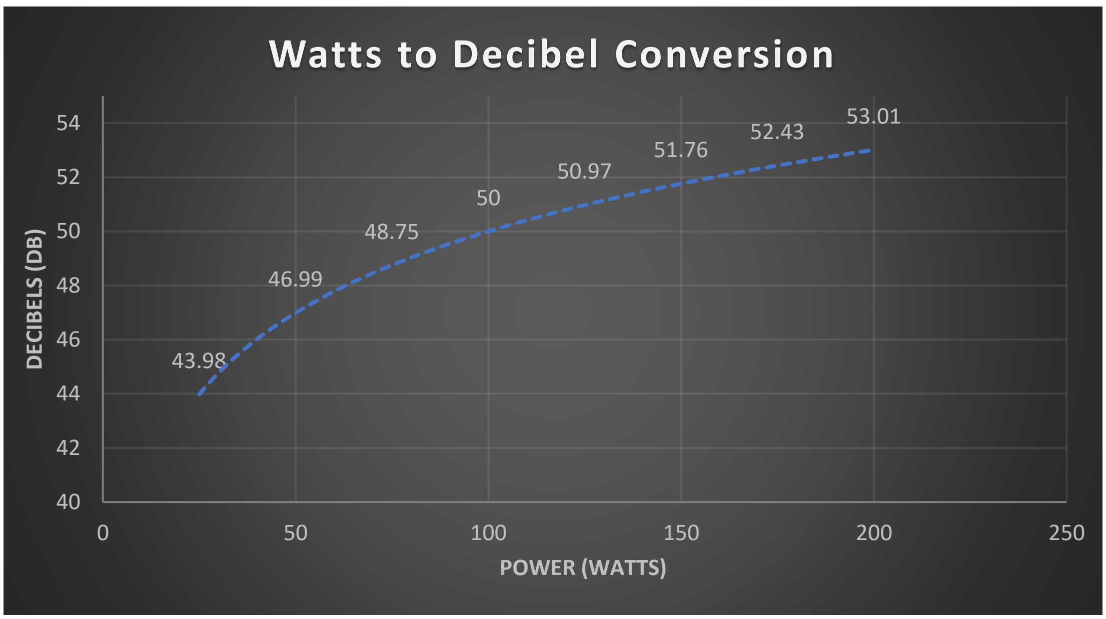
*for my project I will be using frequency 851.125 mHz

Power in Watts to Decibels conversion

1. Through the following link you will see that each tower in Hillsborough County operates at an output power of 100 watts. (ULS License *FCC*)
2. The watts to decibel conversion formula: $g(x) = 10 \cdot \log_{10}(1000 \cdot x)$
3. Input "x" will be in watts and "$g(x)$" will be in decibels or dB's.
4. The goal of this calculation and the following graph (Figure 4) is to see the number of decibels that 100 watts puts off as well as how subtracting or adding more power will affect the number of decibels produced.

Figure 4 $g(x) = 10 \cdot log_{10}(1000 \cdot x)$



To further investigate the watts to decibel conversion I decided to take the derivative of the formula $g(x) = 10 \cdot \log_{10}(1000 \cdot x)$ which gave me $g'(x) = 10/(x \ln 10)$. Based on the derivative of the watts to decibel conversion formula we can determine if adding wattage to the tower transmitter locations is a viable solution for public safety radio coverage in the intermediate areas.

Derivative of Power in Watts to Decibel conversion

1. Derivation formula: $g'(x) = \frac{10}{x \ln 10}$
   Input "x" will be in watts and "$g'(x)$" will be in dB/watt.

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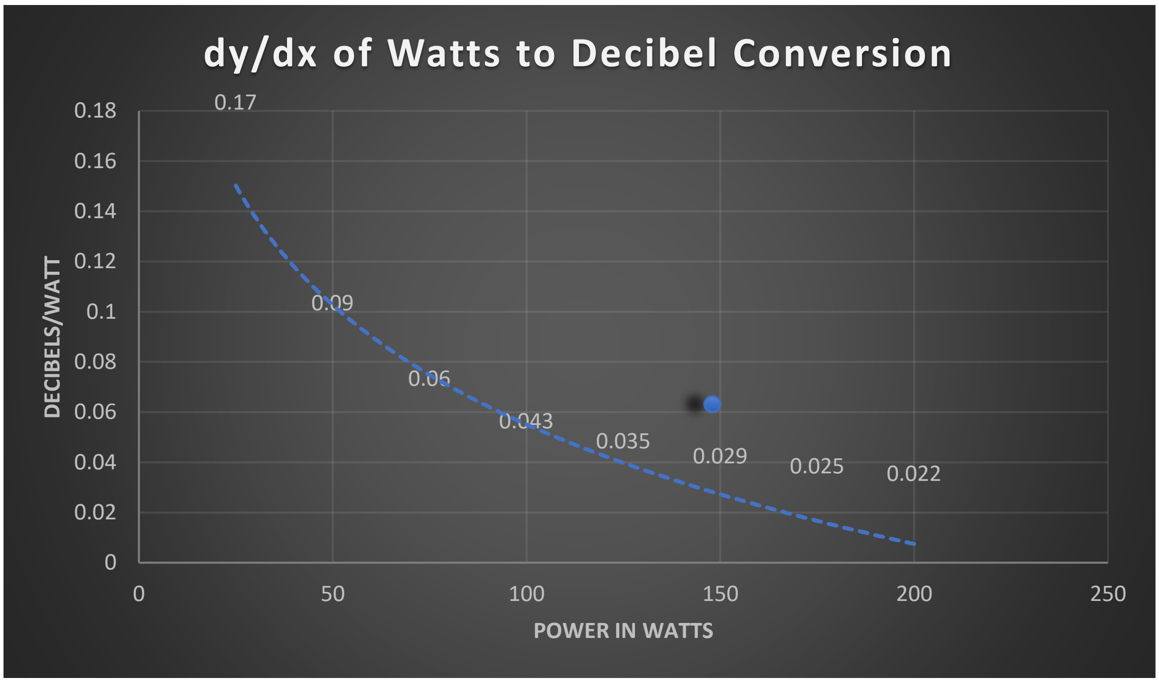
2. The goal of this calculation and the following graph (Figure 5) is to determine if $g(x)$ is increasing or decreasing as you apply more wattage to the transmitter tower.

Figure 5 $g'(x) = 10/(x \ln 10)$



The $g'(x) = \frac{10}{x \ln 10}$ graph has produced *y*-values that are above the *x*-axis and this tells us that $g(x) = 10 \cdot \log_{10}(1000 \cdot x)$ is still increasing as you add more power to the tower. But, is this enough evidence to prove that adding more power will be a viable solution to public safety radio transmission? Let us take the second derivative to determine the overall trend of $g(x)$.

The second derivative of Power in Watts to Decibel conversion

1. Second Derivation Formula: $g''(x) = -\frac{10}{x^{2} \ln 10}$
2. The input "*x*" will be in watts and $g''(x)$ will be dB's/(watt)^2.
3. The goal of this calculation and the following graph (Figure 6) is to test the concavity of $g(x)$ in order to determine if increasing power produces an increased or decreased rate of dB's/watt.

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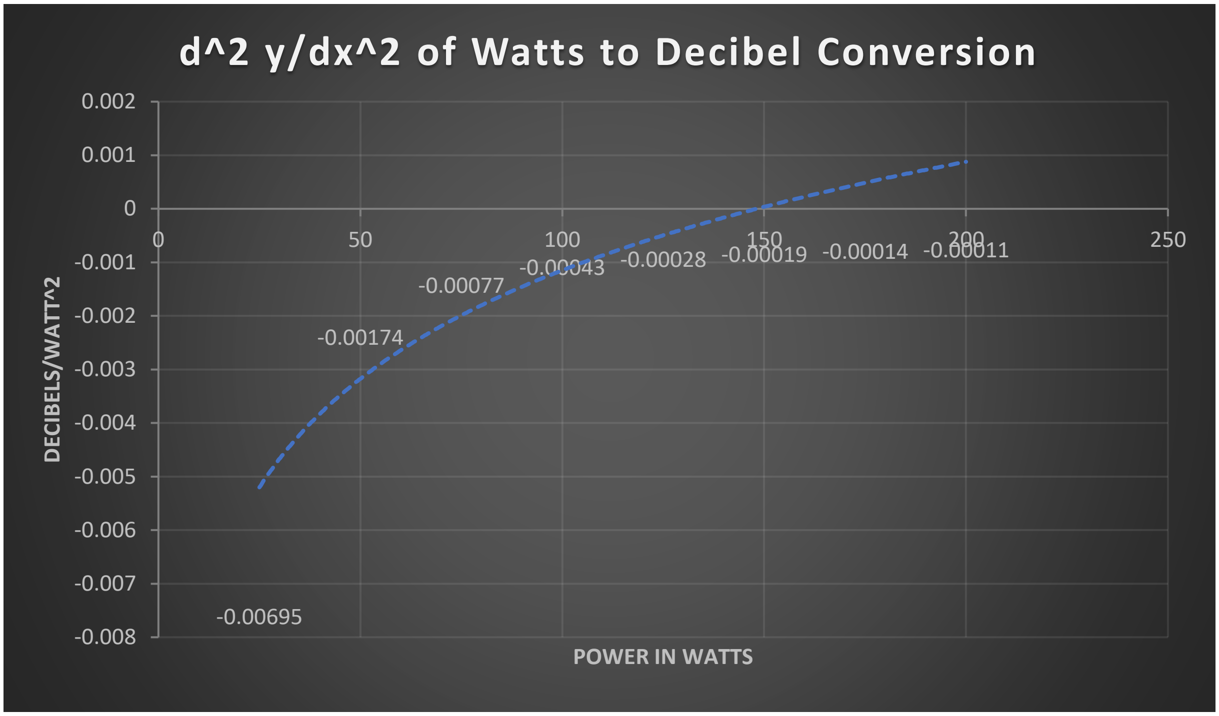
Figure 6 $$g''(x) = -\frac{10}{x^2 \ln 10}$$



*Ignore the trend line eclipsing the *x*-axis, the *y*-values become infinitesimally small with the $\lim_{x\to\infty} g''(x) = 0$.

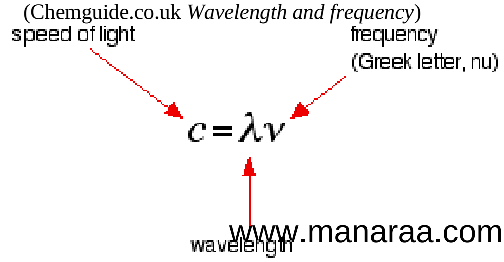
The $g''(x)$ graph has produced all values below the *x*-axis which tells us that $g(x) = 10 \cdot \log_{10}(1000 \cdot x)$ is concave downward. Ultimately, these derivations of our initial power to decibel conversion formula prove that as you add more power you get less decibel gain per watt added. Therefore, increasing transmitter tower power provides insignificant decibel gain and is not a viable solution for public safety radio coverage.

Now I will focus to devising an efficient process for locating "soft spots" in public safety radio coverage within my selected FCC callsigns intermediate area. This will allow my company to either locate existing buildings that will need a BDA system to be brought up to code, or to inform engineers on whether or not their new construction projects will need a BDA system transcribed into their specifications. Free Space Path Loss, or "FSPL", is a term used to define the dissipation of radio wave propagation over a given distance in space. I will first show how FSPL is derived, then, using a constant of 851.125 megahertz (mHz) and an input of distance in kilometers (km) as a variable, I will determine various decibel loss over a given distance.

Deriving the Free Space Path Loss formula for dB's

- Radio wave propagation path loss model:

(Chemguide.co.uk *Wavelength and frequency*)



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$$L(x) = \left(\frac{4\pi x}{\lambda}\right)^2$$

*where $\lambda = c/\nu$

$$L(x) = \left(\frac{4\pi x\nu}{c}\right)^2$$

*where "c" is the constant of the speed of light; "ν" stands for frequency

$$L(x) = \left(4\pi x\nu \cdot \frac{1 \cdot 10^6}{3 \cdot 10^5}\right)^2$$

*for distance (x) in kilometers; for (ν) in megahertz

- Now to get the dB version of the path loss model we must take the log of both sides of the equation multiplied by -10:

$$f(x) = -10 \log\left(4\pi x\nu \cdot \frac{1 \cdot 10^6}{3 \cdot 10^5}\right)^2$$

- Finally, we get the final equation for the dB version of the radio wave propagation path loss model as follows:

$$f(x) = -(32.44 + 20\log_{10}(\nu) + 20\log_{10}(x))$$

(Kuo, *Derivation the dB version of the Path Loss Equation for Free Space*)

The FSPL Formula for dB's

1. FSPL formula: $f(x) = -(32.44 + 20\log_{10}(\nu) + 20\log_{10}(x))$
2. The input "x" will be distance in kilometers and "$f(x)$" will be in decibels. "ν" will be a constant of 851.125 megahertz.
3. The goal of this calculation and the following graph (Figure 7) is to determine free space path loss in decibels at various distances from the transmitter tower.

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DOI: https://doi.org/10.5038/2326-3652.11.2.4933

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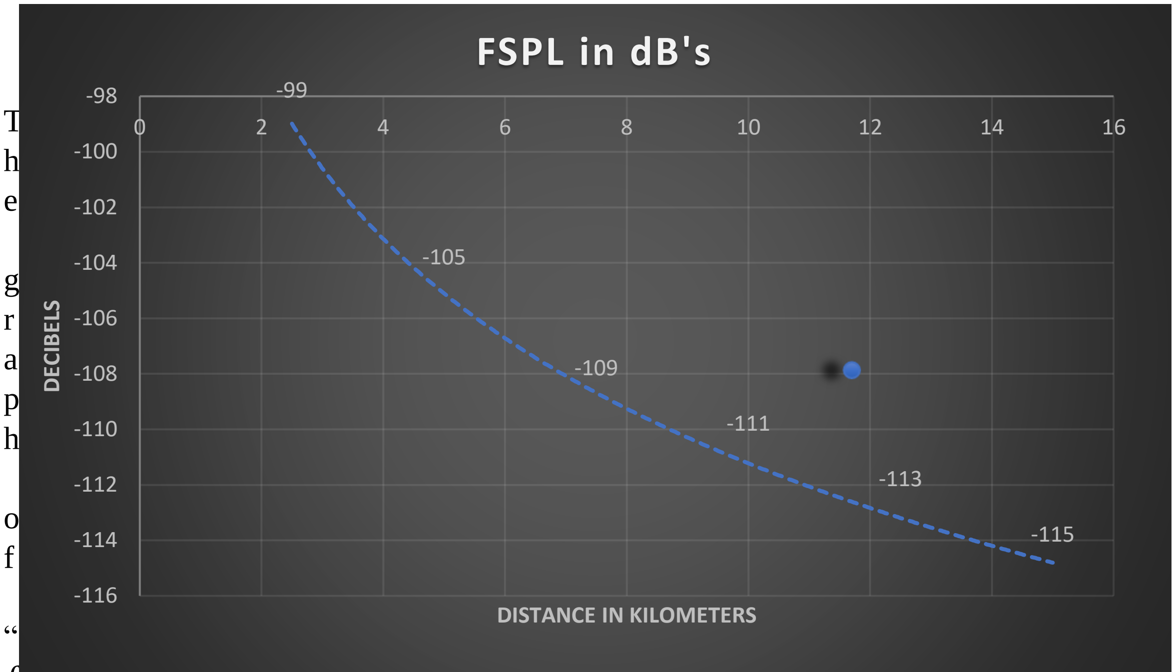
Figure 7 $f(x) = -(32.44 + 20\log_{10}(v) + 20\log_{10}(x))$



T h e g r a p h o f

“ $f(x)$ ” produces all negative values for decibels because this shows the “loss” of radio signal over a given distance. To further investigate the rate at which decibels are lost per kilometer we can take derivative of $y = f(x)$.

<u>dy/dx of the FSPL Formula</u>

1. Derivation Formula: $f'(x) = -\frac{20}{x \ln 10}$
2. The input “x” will be distance in kilometers and “$f'(x)$” will be in dB’s/km. Notice that your constant “v” is not longer apart of the formula. This tells us the impact of frequency is insignificant to the overall decibel loss per kilometer.

3. The goal of this calculation and graph (Figure 8) is to determine decibel loss per kilometer as you travel further away from the transmitter tower and whether or not “$f(x)$” is increasing or decreasing in lost decibels.

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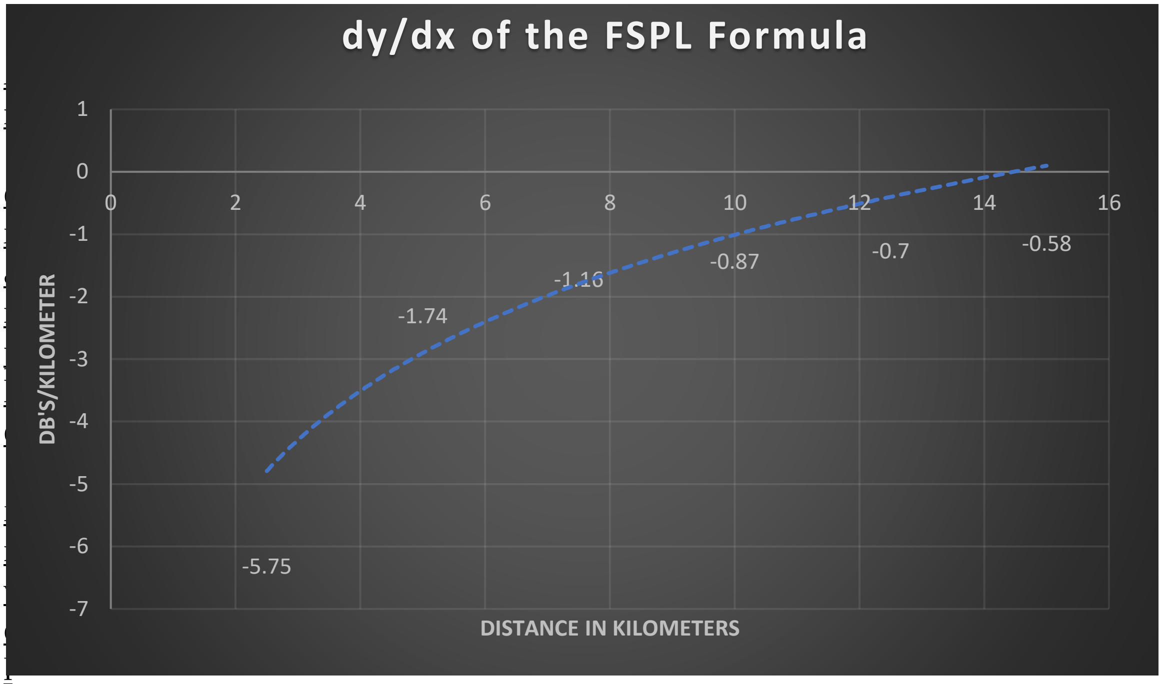
Figure 8



ving $f'(x) = -\frac{20}{x \ln 10}$ and the Fundamental Theorem of Calculus

$$\text{Take } \int_{2.5}^{15} f'(x)\,dx = \int_{2.5}^{15} -\frac{20}{x \ln 10}\,dx$$
$$= -[8.69 \ln x]_{2.5}^{15}$$

$$= (-(8.69 \ln 15) + (8.69 \ln 2.5)) = -15.57$$

Now, if you take $f(15) - f(2.5)$ you get the same answer of -15.57.

As you can see from $f'(x)$, as you travel further from the transmitter tower you are still losing decibels per kilometer and therefore this graph shows that $f(x)$ is still increasing in decibel loss. If you take $f''(x)$ you would find that $f(x)$ has an upward concavity because of the negative sign, but if we ignore this negative sign the graph is actually concave down. Which means the rate at which your losing decibels/kilometer is slowing down the further you travel from the transmitter tower. Now this may seem confusing for someone who does not understand radio signal and the Free Space Path Loss formula. The reason you lose decibels at a slower rate the further you travel from a transmitter tower, is that as you approach -120dB's communication becomes non-existent and this takes longer distance to develop. Remember, the standard that the Florida Fire prevention Code has set for acceptable dB loss for downlink (receive) and uplink (transmit) readings is -95dB's. Understanding the difference between a downlink value

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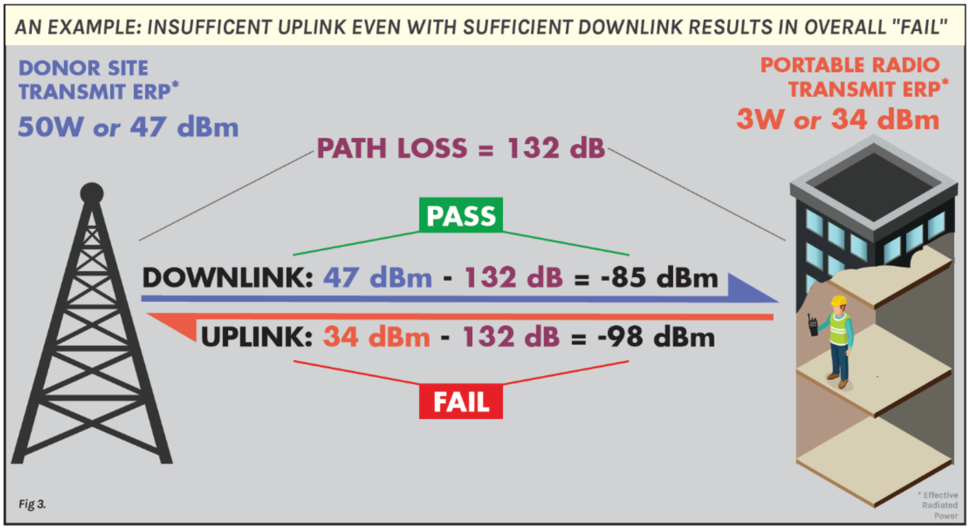
and an uplink value is very important to this project and the public safety radio standards. Figure 9 will help put this into perspective.

Figure 9



(B. *Technical & Sales Resources for RSI Distributors*)

A downlink is a value of dBm, or "decibel milliwatts", coming from the transmitter tower to the location in which you may be taking radio strength readings at to determine if the site is within code. Typically, this dBm value is being powered by 50-200 watts depending on the transmitter tower. Keep in mind, Figure 9 is using a 50-watt transmitter tower versus we are using 100-watt towers. Now, the uplink value is produced by a public safety portable radio that is only powered on average by 3-watts. Which has much less dBm output than the 100 watt towers we are using for this project. Therefore, for the uplink value ≥ (-95dB's) you must have a downlink value ≥ (-79dB's).

Difference in downlink vs. uplink value = (50dB's – 34dB's) = 16dB's

Building Material Decibel Loss Constants

So far, we have calculated the number of decibels a 100-watt tower produces and various free space path loss decibel values for a range of distance. The last variable I would like to account for before putting together the final formula is how different types of building material affect decibel loss. I have chosen to use three most common types of building material to create my "Emergency Communication Deficiency Locator" maps.

- Concrete Building Constant: $(C) \approx -25dB's$
- Brick Building Constant: $(B) \approx -20dB's$
- Wood Building Constant: $(W) \approx -15dB's$

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*All constants have been determined based on emergency communication site surveys carried out by myself for Fort Knox Fire and Communications, examples can be found in the Appendices. Readings taken outside the walls of the site versus readings taken on the insides of those walls gave me an approximation for these constants.

Emergency Communications Deficiency Locator Formulas

Base Formula

$$(Tower\ dB\ Gain) + (FSPL + Building\ Material\ Constant) \geq -79dB's$$

Extended Formulas

$$((10 \cdot \log_{10}(1000(100))) + (-(32.44 + 20\log_{10}(851.125) + 20\log_{10}(distance)) - (C)) \geq -79dB's$$

$$((10 \cdot \log_{10}(1000(100))) + (-(32.44 + 20\log_{10}(851.125) + 20\log_{10}(distance)) - (B)) \geq -79dB's$$

$$((10 \cdot \log_{10}(1000(100))) + (-(32.44 + 20\log_{10}(851.125) + 20\log_{10}(distance)) - (W)) \geq -79dB's$$

Acceptable Distances per Building Material Types and their Coverages

*Area of a circle: πr^2

1. Building type: Concrete Buildings
   a. Acceptable Distances per dB readings ≥-79dB's: 5.0 km
      i. $\pi(5.0km)^2 = 78.5km^2$
2. Building type: Brick Buildings
   a. Acceptable Distances per dB readings ≥-79dB's: 7.5 km
      i. $\pi(7.5km)^2 = 176.7km^2$
3. Building type: Wood Buildings
   a. Acceptable Distances per dB readings ≥-79dB's: 15 km
      i. $\pi(15km)^2 = 706.9km^2$

*All calculations can be found in the Appendices.

DISCUSSION

My work has produced coverage maps in which represent three local FCC Callsigns in the Hillsborough County area and their intermediate areas. My project name, "Emergency Communication Deficiency Locator", is represented by the space in between each propagation coverage shown in these maps. Propagation of radio waves spreads from a central location into the area of a circle, hence the reason I used the area of a circle formula to gather my coverages in the previous section.

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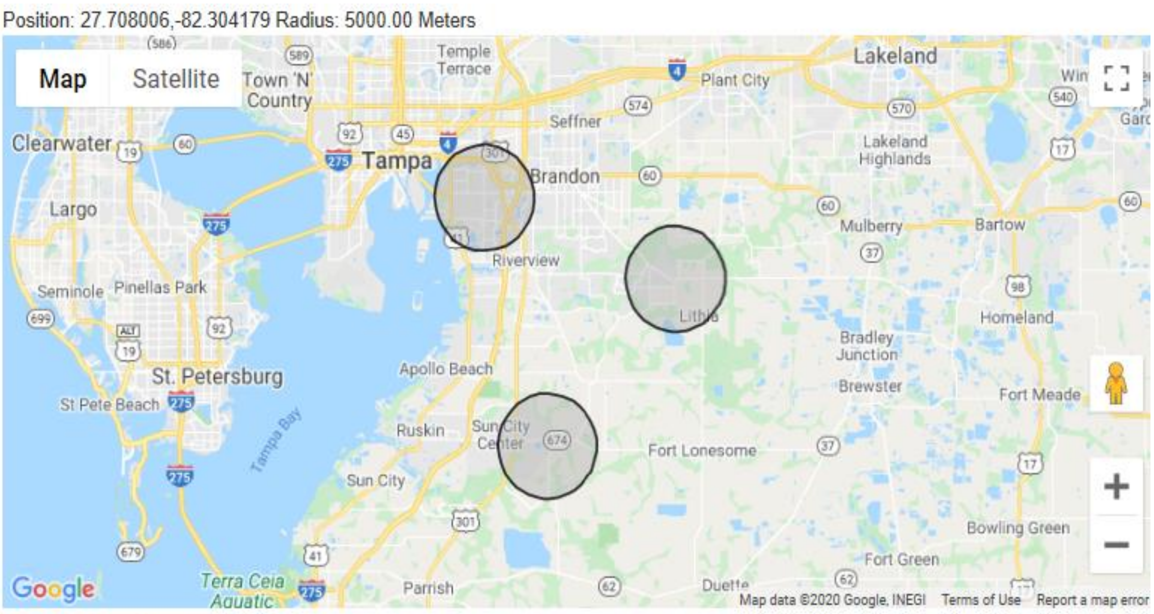
Emergency Communication Deficiency Locator Maps

1. Concrete Buildings: https://www.mapdevelopers.com/draw-circle-tool.php?circles=%5B%5B5000%2C27.918688%2C-82.368623%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%2C%5B5000%2C27.850123%2C-82.173469%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%2C%5B5000%2C27.7080057%2C-82.3041788%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%5D



(Collins *Map Developers* Concrete buildings)

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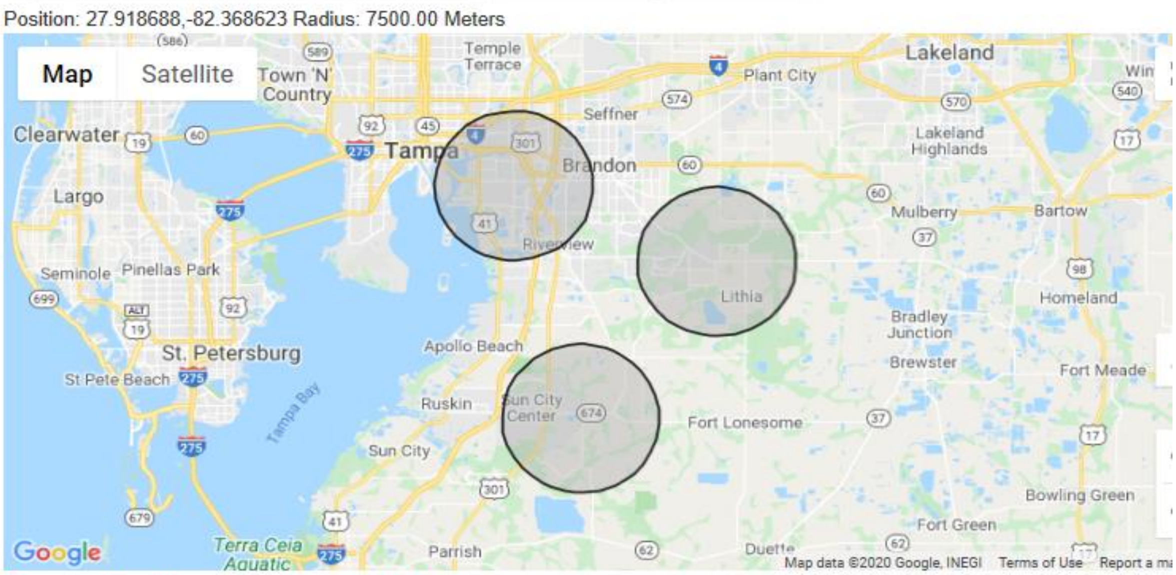
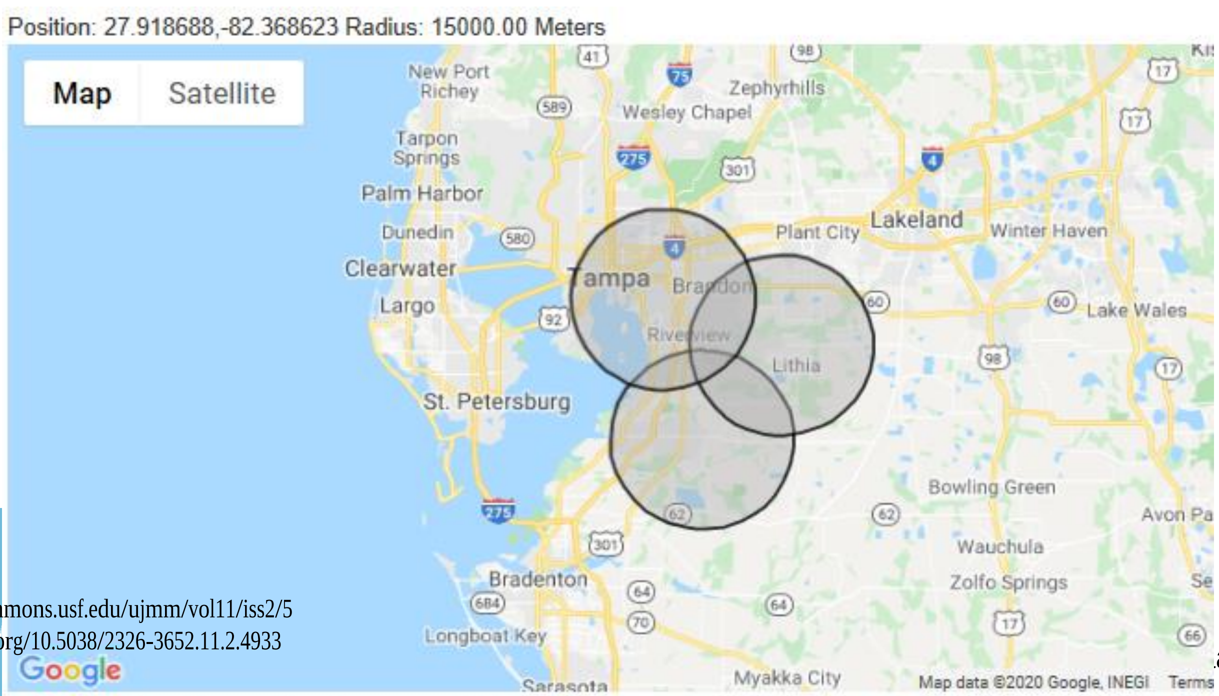
2. Brick Buildings: https://www.mapdevelopers.com/draw-circle-tool.php?circles=%5B%5B7500%2C27.7080057%2C-82.3041788%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%2C%5B7500%2C27.850123%2C-82.173469%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%2C%5B7500%2C27.918688%2C-



82.368623%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%5D

(Collins *Map Developers* Brick Buildings)

3. Wood Buildings: https://www.mapdevelopers.com/draw-circle-tool.php?circles=%5B%5B15000%2C27.7080057%2C-82.3041788%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%2C%5



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DOI: https://doi.org/10.5038/2326-3652.11.2.4933

B15000%2C27.850123%2C-
82.173469%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%2C%5B
15000%2C27.918688%2C-
82.368623%2C%22%23AAAAAA%22%2C%22%23000000%22%2C0.4%5D%5D

(Collins *Map developers Wood Buildings*)

Radio waves have obvious distinction in their capability to travel through different building materials. Each map illustrates this distinction with wood structures having the greatest radio wave transparency, whereas, brick and concrete buildings are more stifling. This project has allowed me to explore emergency communication coverages in our local area. My project has several implications for engineering, with respect to radio communications and life safety. Accurately predicting emergency communication coverages at a location could revolutionize the Bi-Directional Amplifier industry as it significantly reduces time and resources spent on site surveys. Moreover, it is helpful for engineers in dealing with BDA systems when listing specifications for their new construction projects.

Conclusions & Recommendations

The Bi-Directional Amplifier (BDA) is the newest edition to Life Safety in the state of Florida. The Florida Fire Prevention Code (NFPA 1) section 11.10.1 states that “In all new and existing buildings, minimum radio signal strength for fire department communications shall be maintained at a level determined by the authority having jurisdiction. Unfortunately, several building owners are unaware of the updated fire prevention codes and therefore, risk closure of their businesses. The largest issue for the Life Safety Industry today, is being able to decisively determine which buildings are not within code at an efficient rate. The goal of this project was to investigate different strategies to enhance emergency radio communications. The first formula I analyzed was the power in watts to decibel conversion. I chose this formula to start my project because if we could boost the decibel coverage from its origin of transmission then we would arrive at an overall solution with more ease. Unfortunately, through deriving the first and second derivatives of the power to decibel conversion, I came to the conclusion that as you add more power to the formula you receive less decibel gain per watt and therefore an impractical strategy for my problem statement. The next strategy I decided to investigate was finding a way to produce radio frequency coverage maps that are adequate per the Florida Fire Prevention Code. This led me to derive a formula for Free Space Path Loss in decibels using megahertz and kilometer units. With the FSPL formula I was able to graph a set of distances and their produced decibel losses. Next, I analyzed the FSPL graph by taking its derivative to see how distance affected decibel loss per kilometer. Lastly, I added building material loss constants to hone in on accurate results and to provide a variety of coverage maps. Using the formula of the area of a circle I was able to produce emergency radio communication coverage maps in kilometers squared. If someone would like to approach the same project, I would suggest looking in to providing coverage maps of different areas across the United States. It is only a matter of time before other states adopt these Life Safety regulations and with new locations will come new sets of variables for the formulas. For example, transmitter power levels, building materials, and emergency frequencies could all be different and these need to be taken account for. For new

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project ideas, I would suggest deriving a formula for variables that account for inside wall building materials as well as surrounding obstructions that cause radio wave diffraction. These may prove to be difficult, but with the right calculus tools employed, solutions are inevitable.

Nomenclature

$g(x)$	Watts to dB conversion
$g'(x)$	dB/watts
$g''(x)$	dB/(watts)^2
$f(x)$	Free Space Path Loss (FSPL) in dB
$f'(x)$	FSPL(dB)/km
$f''(x)$	FSPL(dB)/(km)^2
C	Concrete building constant
B	Brick building constant
W	Wood building constant
w	Watts
Km	Kilometers
dB	Decibels (short for dBm)
dBm	Decibel milliwatt
λ	Wavelength
c	Speed of Light constant
ν	Frequency
FSPL	Free Space Path Loss
r	Radius
$\pi(r)^2$	Area of a circle
FCC Callsign	Unique government designated tower
x	Input variable
$\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$	Leibniz Notation

*Metric Units used throughout the project and for results.

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DOI: https://doi.org/10.5038/2326-3652.11.2.4933

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APPENDICES

Code Reference

(17) The authority having jurisdiction shall determine the minimum radio signal strength for fire department communications in all new high-rise and existing high-rise buildings. Existing buildings are not required to comply with minimum radio strength for fire department communications and two-way radio system enhancement communications as required by the Florida Fire Prevention Code until January 1, 2022. However, by December 31, 2019, an existing building that is not in compliance with the requirements for minimum radio strength for fire department communications must apply for an appropriate permit for the required installation with the local government agency having jurisdiction and must demonstrate that the building will become compliant by January 1, 2022. Existing apartment buildings are not required to comply until January 1, 2025. However, existing apartment buildings are required to apply for the appropriate permit for the required communications installation by December 31, 2022.

https://digitalcommons.usf.edu/ujmm/vol11/iss2/5
DOI: https://doi.org/10.5038/2326-3652.11.2.4933

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Code Reference

SAFER BUILDINGS COALITION

CODE ADVISORY – UPDATED November 8, 2018 SBCA-110818

Florida Fire Code: Existing Buildings Timetable

Florida Fire Prevention Code (NFPA 1) requires in-building coverage. Some building type have been granted an extension.

DISCUSSION:

Florida Fire Prevention Code provides that AHJ (Authority Having Jurisdiction) can require maintaining adequate fire department radio signal strength inside any building (new or existing). Florida Statute § 633.202 provides for compliance extensions for certain building types.

KEY DATES:

- **Existing hi-rise buildings** are required to comply by the Florida Fire Prevention Code beginning **January 1, 2022**
- By **December 31, 2019**, an existing building that is not in compliance with the requirements for minimum radio strength for fire department communications must apply for an appropriate permit and must demonstrate that the building will become compliant by January 1, 2022
- **Existing apartment buildings** are not required to comply until **January 1, 2025**. However, existing apartment buildings are required to apply for the appropriate permit for the required communications installation by **December 31, 2022**

NEXT STEPS:

1. Determine if sufficient fire department radio signal exists in your building. Qualified in-building wireless systems integrators (and others) can assist with this testing.
2. Contact your local Fire Code Official (AHJ, Authority Having Jurisdiction) to find out how this code is being enforced in your jurisdiction.
3. If coverage is insufficient and the AHJ is enforcing this requirement, prepare a plan (design, permits, etc.) by the deadline listed for your property type.
4. Visit Safer Buildings Coalition website www.saferbuildings.org to locate professionals who can assist and to stay up to date on fire codes pertaining to in-building radio communication enhancement systems.

CODE EXCERPTS

Florida Fire Prevention Code (NFPA 1)

11.10 Two-Way Radio Communication Enhancement Systems.

11.10.1 In all new and existing buildings, minimum radio signal strength for fire department communications shall be maintained at a level determined by the AHJ

11.10.2 Where required by the AHJ, two-way radio communication enhancement systems shall comply with NFPA 72.

§ 633.202 Florida Statute

18) The authority having jurisdiction shall determine the minimum radio signal strength for fire department communications in all new high-rise and existing high-rise buildings. Existing buildings are not required to comply with minimum radio strength for fire department communications and two-way radio system enhancement communications as required by the Florida Fire Prevention Code until January 1, 2022. However, by December 31, 2019, an existing building that is not in compliance with the requirements for minimum radio strength for fire department communications must apply for an appropriate permit for the required installation with the local government agency having jurisdiction and must demonstrate that the building will become compliant by January 1, 2022. Existing apartment buildings are not required to comply until January 1, 2025. However, existing apartment buildings are required to apply for the appropriate permit for the required communications installation by December 31, 2022.

§ 718.1085 (EXCERPT)

...the term "high-rise building" means a building that is greater than 75 feet in height where the building height is measured from the lowest level of fire department access to the floor of the highest occupiable level.

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Site Survey Example 1

Point	Hand Held Gain (dBm)	Donor Tower Gain (dBm)	Frequency	Inbound Downlink RSSI (dBm)	PASS/FAIL	Path Loss	Outbound Uplink RSSI(dBm)	PASS/FAIL
OUTSIDE SE Corner	34	51.76	02 851.700	**-75**	PASS	126.76	**-92.76**	PASS
OUTSIDE NE Corner	34	51.76	02 851.700	**-70**	PASS	121.76	**-87.76**	PASS
OUTSIDE SW Corner	34	51.76	02 851.700	**-76**	PASS	127.76	**-93.76**	PASS
OUTSIDE NW Corner	34	51.76	02 851.700	**-85**	PASS	136.76	**-102.76**	FAIL
Fire Pump Room	34	51.76	02 851.700	**-100**	FAIL	151.76	**-117.76**	FAIL
Sprinkler Riser 1	34	51.76	02 851.700	**-85**	PASS	136.76	**-102.76**	FAIL
Sprinkler Riser 2	34	51.76	02 851.700	**-85**	PASS	136.76	**-102.76**	FAIL
Electric Room / FACP	34	51.76	02 851.700	**-95**	PASS	146.76	**-112.76**	FAIL
ROOF SE Corner	34	51.76	02 851.700	**-67**	PASS	118.76	**-84.76**	PASS
ROOF NE Corner	34	51.76	02 851.700	**-60**	PASS	111.76	**-77.76**	PASS
ROOF SW Corner	34	51.76	02 851.700	**-64**	PASS	115.76	**-81.76**	PASS
ROOF NW Corner	34	51.76	02 851.700	**-64**	PASS	115.76	**-81.76**	PASS

Site Survey Example 2

10	3/12/2020	34	51.76	**-78**	PASS	129.76	**-95.76**	FAIL
11	3/12/2020	34	51.76	**-75**	PASS	126.76	**-92.76**	PASS
12	3/12/2020	34	51.76	**-79**	PASS	130.76	**-96.76**	FAIL
13	3/12/2020	34	51.76	**-74**	PASS	125.76	**-91.76**	PASS
14	3/12/2020	34	51.76	**-80**	PASS	131.76	**-97.76**	FAIL
15	3/12/2020	34	51.76	**-70**	PASS	121.76	**-87.76**	PASS
16	3/12/2020	34	51.76	**-78.5**	PASS	130.26	**-96.26**	FAIL
17	3/12/2020	34	51.76	**-75**	PASS	126.76	**-92.76**	PASS
18	3/12/2020	34	51.76	**-78.5**	PASS	130.26	**-96.26**	FAIL
19	3/12/2020	34	51.76	**-74.5**	PASS	126.26	**-92.26**	PASS

https://digitalcommons.usf.edu/ujmm/vol11/iss2/5
DOI: https://doi.org/10.5038/2326-3652.11.2.4933

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