inovonics®

White paper

Characteristics of RF Wireless in European Commercial Applications

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Introduction

Different kinds of RF have different characteristics; not all RF is suitable to every environment.

Almost every installer has had one bad experience with radio frequency (RF) technology, especially in commercial environments. They deployed a wireless solution for a given application and it wasn't adequate to the environment. Often this is a result of simple misunderstand of how wireless technology works.

This white paper will provide the characteristics of the different RF technologies, and explain why one kind of wireless will work in a given situation, and another wireless might not. We will also discuss the different types of wireless applications, and the importance of surveying wireless jobs.

The Electromagnetic Spectrum

Commercial wireless was pioneered by an Italian tinkerer, Guglielmo Marconi. He developed the first engineering-complete, commercially-successful radio transmission system: The wireless telegraph. In fact, there were operators with his telegraph company on the Titanic, without which there would have been no survivors, as there was no other way to send notifications or coordinates. Meaning, not only did Marconi pioneer commercial wireless as a whole, he was also one of the first to use it for a mission critical application.

Of course, now wireless has become truly ubiquitous. We live in a wireless world that provides our communication, information and entertainment. Our computers, cell phones, car door remotes and a whole host of other applications all operate using RF technology. We rely on RF nearly every minute of every day.

The one thing that all wireless devices have in common is that they all use some variation of the same kind of energy: The electromagnetic spectrum.

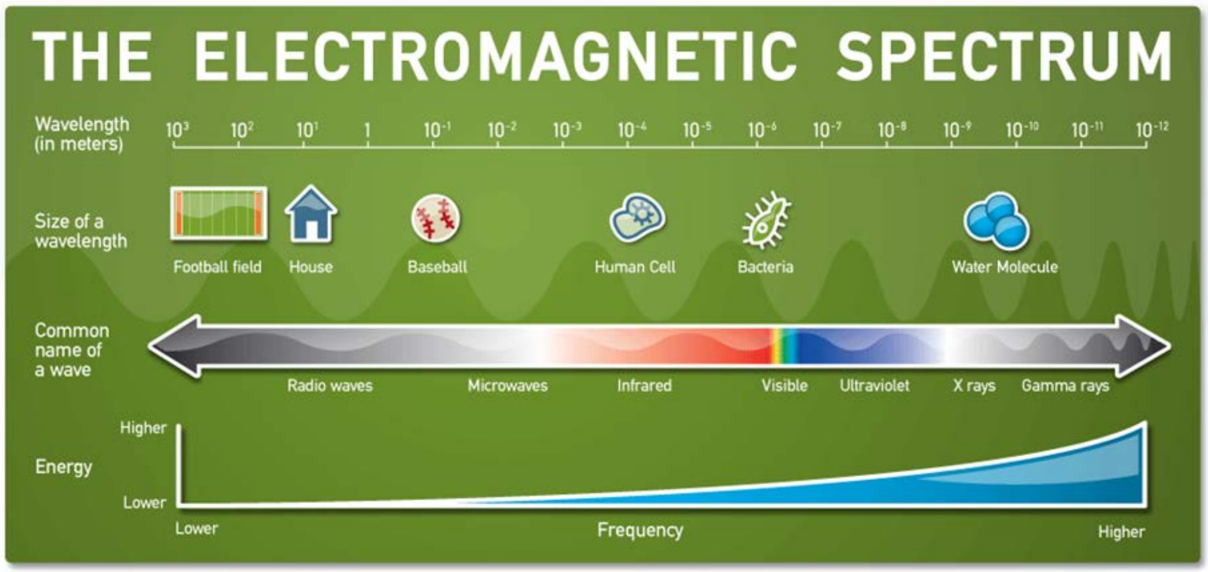


Figure 1 Electromagnetic spectrum wavelength and frequency

On the left side of Figure 1 are radio waves with long wavelengths and low frequency and energy; on the right side are radio waves with short wavelength and very high frequency and energy.

Gamma rays have the shortest wavelengths and highest level of energy — so much that they can cause cancer just by passing through your body.

Between those two extremes lies everything else, including visible light. In fact, your eyes happen to be a specialized receptor for that certain type of electromagnetic radiation.

The electromagnetic spectrum is the key to all wireless technologies. In this white paper, we will focus on radio waves, but they are only part of this larger spectrum.

Radio Spectrum Regulation

Being the inventor of wireless technology, Marconi had certain advantages that we don't. He didn't have to worry about regulatory oversight, for one thing. As the only person using wireless technology, if Marconi wanted to transmit with more power, he could just put more power through the antenna.

Obviously that’s no longer tenable. If every wireless manufacturer transmitted at whatever power they wanted and on whatever frequency, the entire spectrum would quickly become unusable. Every system would step on every other system, and they would all shortly fail.

As such, every country has a regulatory agency that individually manages the radio frequency spectrum, setting aside certain frequencies for different applications. There’s a section for BlueTooth, television, broadcast radio, and etc., and each section is tightly controlled.

For example, if a band is reserved for cell phones, then that band becomess extremely valuable and managed very tightly. As such, cell phone companies often have teams of technicians which do nothing but monitor for interference. If they locate a site of possible interference, they will travel to it with specialized equipment, and hone in on the cause.

Anything on the electromagnetic spectrum can cause interference with any other application if it does not meet regulatory guidelines; faulty lighting can even interfere with cell phone transmissions.

Any device that emits electromagnetic energy can be that cause of interference. For example, they might find a location with faulty lighting that is causing the problem. If they do, they will report it to the national regulatory agency, which can result in large fines for the offender.

Any system — whether it be residential or commercial wireless transmitters, WiFi, or broadcast radio — has to follow the rules laid down by the country it’s operating in. Those rules can include everything from frequency to output power to how long you're allowed to be on the air. As a manufacturer, you pick where on the electromagnetic spectrum you're going to operate and follow the regulations.

Characteristics of Wireless Technology

When we talk about the characteristics of wireless technology, there are three primary considerations: Range, data rate and battery life. All of them are intertwined such that prioritizing any single characteristic means a trade-off with the others.

Range

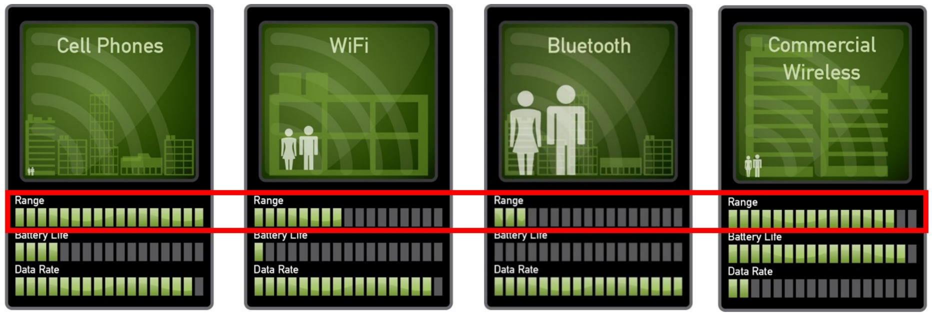


Figure 2 Range by application

In wireless technology, range is determined by four things:

- How loud you can shout, or transmitter power.
- How well physical obstacles are managed.
- How well interference by other kinds of electromagnetic energy is handled.
- How well you can hear — or receive sensitivity.

Transmission Power

Transmission power is fairly straightforward: The more power with which a message is transmitted, the further it will travel. However, transmission power also immediately impacts another wireless characteristic we will discuss later: Battery life.

Managing Physical Obstacles

Dry physical obstacles will not interfere with RF transmission. However, wet physical obstacles will attenuate the signals, and metal will reflect them.

In RF technology, anything that's dry — wood, glass, air, etc. — is invisible. A radio signal will go right through drywall as if it isn't even there. Anything wet, however, will cause attenuation, or a reduction in transmission power. Vegetation, human beings, cement and earthen berms will all allow the signal to pass through, but attenuated. Anything metal will reflect radio signals. This includes not only solid metal walls, but metal mesh that's smaller than the wavelength of the signal. Because so much of commercial construction is cement and metal, the physics of the radio waves themselves need to be considered.

A signal’s wavelength is determined by the frequency. An 868 MHz signal always has the same wavelength, as does a 2.4 GHz signal. As we saw in Figure 1, “Electromagnetic spectrum wavelength and frequency” on page 3, the lower the frequency of an RF transmission, the longer the wavelength; the higher the frequency, the shorter the wavelength.

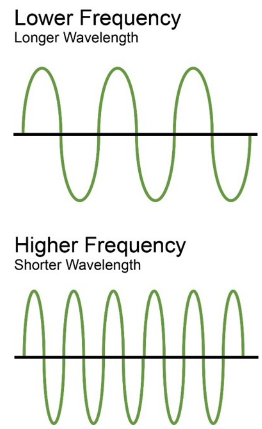


Figure 3 RF wavelength is determined by frequency

You don't need to capture the entire wavelength to get all the data, however. You only need a quarter of it: Half of the crest or trough of a wave.

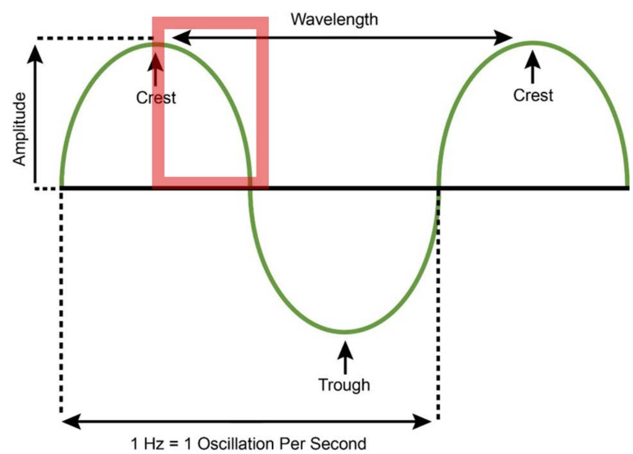


Figure 4 RF transmission wave

The ability to penetrate commercial construction materials is dependent on the size of the RF transmission's wavelength, which is determined by the frequency.

With residential construction, where most of the material is dry, wavelength is not much of an issue. Most of the materials are wood or glass which the RF transmission will ignore. But in commercial construction, where there's a lot of cement and metal, a shorter wavelength is preferred.

How short a wavelength? Well, an 868 MHz wave has a wavelength of approximately 34 centimeters. If you divide that by four, because we only need to catch a quarter of the wave, we end up with a quarter-wave that's roughly the long side of a business card. 868 MHz technology will be able to pass through gaps in construction material that are roughly the diameter of a tennis ball. Even in commercial construction, that's not too difficult to find.

Most residential wireless uses 433 MHz RF technology, which requires a quarter-wave that’s roughly the diameter of a basketball. That generally works fine for the materials used in residential construction, but has a harder time getting through commercial construction because of the metal and cement.

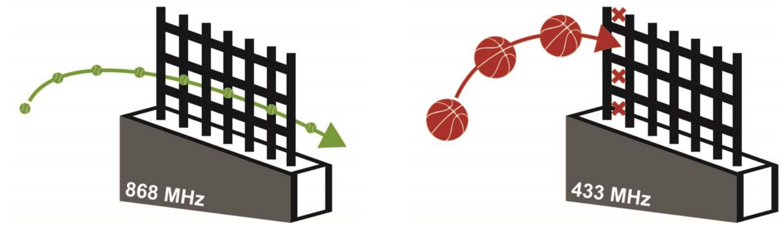


Figure 5 An 868 MHz signal penetrates commercial construction better than 433 MHz

Shorter wavelengths take more power to transmit a given distance. But that's only part of the story. As noted above, when you are picking a wireless technology, you're always making trade-offs. Shorter wavelengths also have higher data rates, which means they take more power to transmit. This is not an issue in line-powered devices, but must be a consideration with battery-powered devices.

Handling Interference

Just like trying to hear a conversation in a crowded restaurant, if there's too much background noise the content gets lost. The same principle applies in commercial wireless as well. If there is too much electromagnetic interference, the RF signal gets lost.

The interference in commercial facilities can cause RF data to get lost.

Interference is not usually an issue in residential installations, which is why most residential sites use narrow-band, single-channel systems. They operate on a single frequency and don't deviate from it.

Interference is a huge issue in commercial installations, however. Commercial lighting, electric motors and air handling units all give off electromagnetic radiation, or background noise, which interferes with the transmission. Because of this, commercial wireless requires a different approach from residential narrow band technology: Frequency-hopping, spread-spectrum technology.

Unlike narrow-band, single-channel systems, frequency-hopping spread-spectrum systems send the same signal repeatedly over multiple channels across an RF spectrum. If one part of the spectrum has high background noise, the signal will get through on another channel that doesn't.

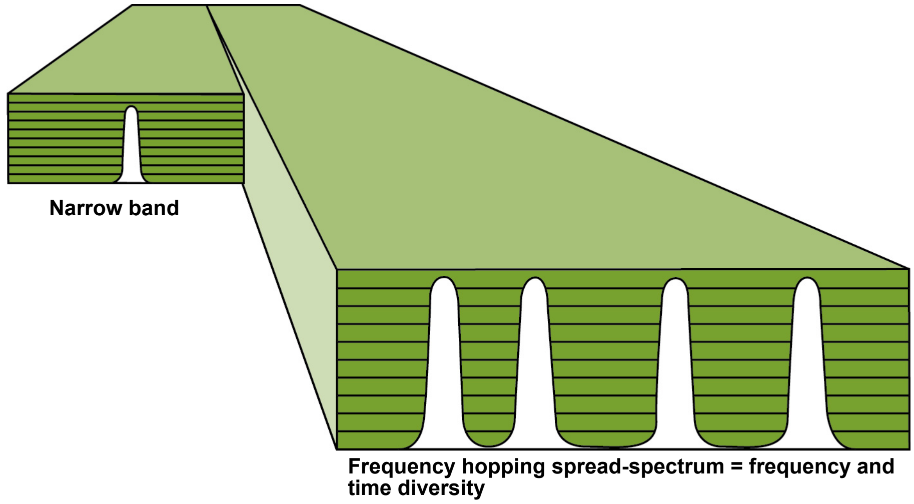


Figure 6 Frequency-hopping spread-spectrum technology

Frequency-hopping spread-spectrum technology was developed by the American military to ensure RF signals get through on the battlefield.

Commercial wireless systems should always use frequency-hopping spread-spectrum technology due to the many sources of interference found in commercial environments. Reliable coverage is a mission critical requirement, and frequency-hopping spread-spectrum technology ensures that it is met.

Receive Sensitivity

Like transmitter power, receive sensitivity seems fairly straightforward, but has a set of considerations that aren't immediately obvious. The number one consideration that impacts receive sensitivity brings us to our second wireless consideration: The data rate.

Data Rate

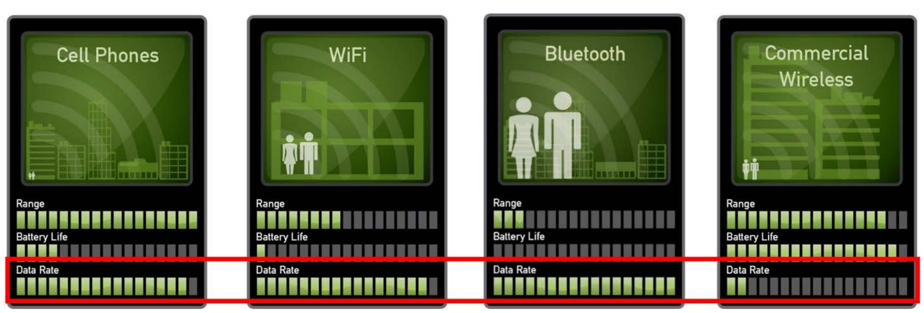


Figure 7 Data rate by application

The primary factor in receive sensitivity has to do with the data rate. The higher the data rate, the lower the receive sensitivity. A WiFi receiver will always be less sensitive than an 868 MHz commercial wireless receiver because of the application it's supporting.

Most commercial wireless applications don't need a high data rate. They only need to transmit a very small amount of data. That a contact opened or closed, for instance; or an environmental reading like temperature or humidity.

We have all experienced this in daily life, and negotiate it without thinking. If we're using WiFi and notice a weak signal, we just move until it improves. The same with our other applications that require a high data rate, from our cell phones to our BlueTooth headsets. But with a fixed system which supports mission critical applications that option doesn't exist.

In the case of cell phones or WiFi routers, a high data rate is essential for the application. That is not the case with most commercial wireless applications. Intrusion systems, for instance, typically don't need a high data rate; they just send an alarm if a contact is opened or closed.

Battery Life

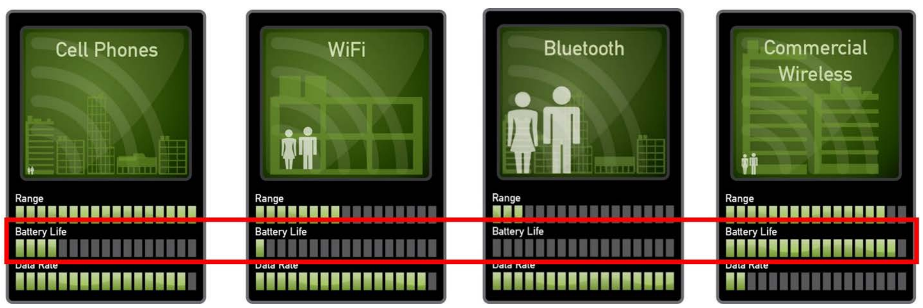


Figure 8 Battery life by application

The last thing to consider is battery life. We're all used to measuring battery life in hours, or, at most, days. We have grown accustomed to charging our cell phones or computers every night. But in most commercial wireless sensor systems, battery life has to be measured in years.

Imagine you're the facilities manager for a senior living community with 100 residents. To safeguard those residents, you've deployed 300 transmitters, ranging from panic buttons to smoke detectors. In such an environment, charging or changing batteries could become a full time job if the battery life is not adequate. The same holds true for any commercial wireless system.

As we know, as the frequency range increases, the energy in the wave itself increases, and that reduces battery life. 433 MHz and 868 Mhz bands require less energy to transmit signals the same distance as bands at higher frequencies. A

2.4 GHz signal has a smaller wavelength and can more easily pass through construction materials, but it takes more energy to transmit those signals a given distance. Which means that an extended battery life is more difficult in a 2.4 GHz system.

Choosing the Appropriate Wireless Technology by Application

An 868 MHz frequency-hopping spread-spectrum technology is the optimal RF technology for commercial wireless applications.

With all of the above considerations in mind, you will need to choose a wireless technology that is optimized for your application. Commercial wireless systems usually weigh the considerations as follows:

- It has to be approved by the regulatory agencies where it operates.
- It has to have an optimal penetration of commercial construction materials, meaning as short a wavelength as possible.
- However, an extended battery life is necessary, so the wavelength can't be too short.
- It has to handle interference well.

Which puts us at: 868 MHz frequency-hopping spread-spectrum technology.

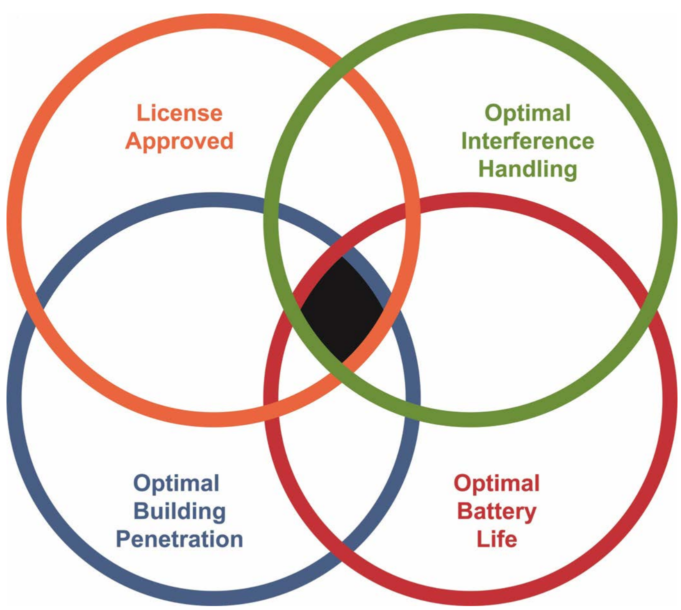
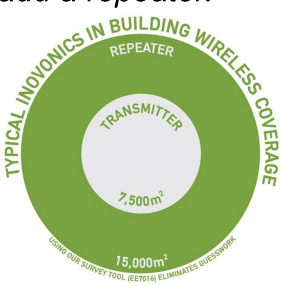


Figure 9 Wireless consideration for commercial wireless systems

You'll find that most systems used for commercial applications share these characteristics.

Repeaters

The guideline we use at Inovonics is that a transmitter is good for about 7,500 square meters, and for any distance beyond that, you will want to add a repeater.



Even with choosing the optimal RF technology, you may run out of range when trying to cover commercial facilities, or find physical obstacles which simply cannot be overcome. Which brings us to the repeater network.

Repeaters are 12v DC powered devices that retransmit signals from wireless transmitters to ensure they reach the receiver. Though repeaters may not always be required, the ability to use repeaters is a requirement for a commercial wireless system.

A repeater network is necessary to cover many commercial facilities, but also provides the ability to scale out the system. Likewise, a good repeater network provides multiple paths between the transmitter and the receiver, allowing the system to work around obstacles.

When weighing a commercial wireless repeater network, the following questions must be considered:

- How many square meters does each repeater cover? A reasonable standard is 15,000 square meters.
- How many repeaters can I use? Oftentimes the number of repeaters is limited by the system, and sometimes that number is as low as seven or eight. You will need to know how repeater limitations will affect facility coverage.
- How do I know where to put the repeaters? Meaning, what tools are available so that I have the right number and placement? Proper repeater placement ensures maximum system performance.
- How do I install them? Repeaters are typically line-powered to increase their output power. They usually have a battery backup, but can't be solely battery powered, because they're always on and listening. Some repeaters can be powered using solar energy.
- How do they function? Do they talk to each other, or do they only retransmit signals from transmitters?

Those are all questions that are important to ask, especially as you're quoting commercial installations.

You will also want to ensure that your repeater network is dedicated. For mission critical applications, this is essential. A WiFi system is not dedicated. It is a shared network, which makes it generally inadequate for mission critical applications. A WiFi system is usually the domain of the IT department. In many cases, in fact, the facility doesn't even own the WiFi network. If you put in a WiFi system that needs to be 99.99% percent reliable, you run the risk that changes can be made to the network that are entirely out of your control, and are irresolvable.

Survey Tools

Nearly every commercial wireless system has a way to help with installation, even if it's as simple as an LED on a transmitter that turns green to indicate connectivity with the receiver through the repeater network.

A complete RF survey kit is necessary for installing an effective commercial wireless system, and for correctly quoting jobs.

The most effective tool, however, comes in the form of an RF survey kit to help determine repeater placement. This offers a way of seeing signal strength in real time. It should be simple enough that it can be used both to install the system, and to demonstrate the coverage to the customer.

The most advanced of these can monitor coverage in real time, and can do so on the same cell phone you would use to check your WiFi coverage in your home. You can simply hang a survey transmitter where you're going to put the receiver, and walk outwards from it with a mobile survey receiver connected to your cell phone through an app. As you're walking, you can see the signal strength on an easy to read meter display. If the needle indicator stays in the green, the signal is fine and there's no need for a repeater; if it moves into the red, you start looking for a place to put a repeater.

Once you've determine the location of the first repeater, you start the process again, hanging the survey transmitter where you plan to place that repeater. This creates overlapping circles of coverage, ensuring that if a transmitter activates in a covered area, the signal will have multiple paths, and find the receiver.

Before any commercial wireless job is quoted, the installer must be able to walk the facility and see what the wireless coverage looks like. Without being able to properly survey a facility, there is the risk of incorrectly quoting the amount of equipment needed, or installing a wireless network that just doesn't work. This can result in costly call backs, re-bids and multiple site visits to perform post-installation troubleshooting.

Conclusion

Wireless systems are part of our everyday lives and benefit us in many ways. When it comes to mission critical systems in commercial facilities, we can get those same benefits as long as we choose the right system.

Choosing the right RF technology is the key to success when installing a commercial wireless system.

Choosing an RF technology optimized for your application is critical. For regular residential sites with RF-friendly construction, a commercial wireless system with a repeater network is probably overkill, and a narrow-band single-channel system will usually suffice.

Residential construction: Mostly dry materials invisible to RF signals

Commercial construction: Mostly materials that reflect or attentuate RF signals

Figure 10 Residential vs. commercial construction

But as you move to schools, hospitals, and other commercial facilities, commercial wireless becomes a necessity. The obstacles and interference involved simply won't allow anything less than 868 MHz frequency-hopping spread-spectrum technology with a dedicated repeater network.

Becoming comfortable with commercial wireless provides you number of advantages. You get more flexibility in competitive situations, you can get installs done faster, you reduce labor expenses, and can expand your service offerings. Commercial wireless is suitable for a host of applications, and multiple applications can even run on the same network.

Figure 11 Sample commercial wireless applications

Becoming comfortable with commercial wireless provides competitive advantages.

One of the other great advantages of a commercial wireless system is the ability to cover a multi-building campus with repeaters; multiple buildings can be covered without having to dig trenches through the parking lot. There is also the value of being able to maintain original architecture and preserve historical value.

Commercial wireless can also minimize bid risk. Installing a commercial wireless system is repeatable and predictable. The only point of consideration is really repeater placement. When choosing a wireless system for commercial applications, you will want to choose a system with good survey tools for determining and demonstrating RF coverage.

Inovonics has been developing and manufacturing commercial wireless products for thirty years. Our networks are designed and optimized to support mission critical security events such as mobile duress, intrusion, environmental monitoring, smoke detection, senior living e-call, and even submetering, and all in the most difficult commercial environments.

For more information about Inovonics commercial wireless solutions, contact us at sales@inovonics.com