A Mid America Consultants, Inc.
White Paper

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Industrial Radio System Design Guide

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Contents

Introduction	**2**
Problem Statement	**2**
Other Communication Options	**2**
Industrial Radio Solution	**3**
Implementation	**3**
Summary	**5**

Introduction

Industrial radio networks are a great alternative to provide communication between locations that are separated by great distances, but how do you select the right radio for your application?

Problem Statement

Should I use a licensed or unlicensed radio? What protocol should the radio run? What types of antennas? How does the terrain and vegetation affect the system?

These are just a few of the dizzying array of choices that have to be made to create a functional radio network.

Other Communication Options

There are other means to communicate with other sites. For many years, the phones system was used, either with a phone number for every site, or a leased line between every site. Although generally very reliable, these systems carried a month to month expense and you are placing your mission critical operations in the hands of someone else, plus phone systems have evolved so that very few technicians exist inside the phone companies that can maintain or service these types of systems.

What about cellular? Yes this is an alternative, but some of the same problems that exist in the hardwired arena, exist also in cellular systems, monthly expense, depending on another entity to keep your system operational, plus cellular technology is changing rapidly, that as soon as you invest in cellular modems and get your system operational, you will be notified that

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the phone company is implementing the next generation in technology, and you have to upgrade your modems to continue to operate on the cellular network.

Fiber optic cable is an option, but you have a huge expense in trenching in miles and miles of cable, plus someone could dig up the cable at any time.

A satellite network is another option, but again it is very expensive to implement, has monthly charges associated with it, and you are depending on another company to maintain service for you.

Industrial Radio Solution

Installing your own radio network to connect the many sites in your system is a very attractive alternative to the above options..

Benefit 1

You own your own equipment, and you are not dependant on anyone to provide service or keep their system in operation to keep your system working.

Benefit 2

There are no monthly costs associated with owning your radio network. Granted there are some initial capital costs, but in general there is a less than two year payback from the monthly charge savings.

Benefit 3

If you choose an Ethernet based radio, there are great benefits for remotely monitoring and programming your PLC equipment from a central location over your radio network.

Implementation

The first question to ask is how far apart are your sites. Unlicensed radios have a range of 20 to 30 miles (typically 1 watt of power), where the licensed radios have a range of 50 miles (typically 5 watts of power). The range can be extended longer than these distances by adding in repeater units.

Licensed radios typically operate in four frequency ranges, 130-174 MHz, 216 – 235 MHz, 330 – 512 MHz, and 800 -960 MHz. You have to apply and receive a license from the FCC to own and operate a radio network in any of the above ranges. This license will give you the right to broadcast on a specific frequency in a certain geographical area. In some cases you are granted a transmit and a receive frequency.

Unlicensed radios operate in two bands, 902 – 928 MHz, and the 2.4 – 2.5 GHz. In these radios, they do spread spectrum frequency hopping, where the transmitted message is broken up into small parts, with each part transmitted on a single frequency, which jumps around in a seemingly random pattern. The transmit and receive radios are synchronized to this pattern. This allows multiple radio systems to operate within the same geographical area, as any received data that does not match the predefined sequence will be ignored. This frequency hopping has another great advantage, it makes the radio system very secure, especially when you enable the encryption algorithms.

The lower the frequency, the less it is absorbed by objects in its path, which means that you will get better radio performance if you have a lot of vegetation in your path.

The next question to answer is do you have line of sight between each site or what will it take to get line of sight. Radios operate best when there is a clear unobstructed radio path between the sites. At this point it is best to perform a radio path study of the network to see if you have any major obstructions in the system. You can hire a company like Mid America Consultants to perform this study, or depending on whose radios you use, some of the radio manufacturers will perform this service for free.

Information that will need to be gathered to perform the radio path study is the GPS location of each site with its elevation and the expected height of the antenna at each site. Loaded with that information, the radio path study software will produce a report that will give you the signal strength from your central site to each of the remote sites and provide a cross section of path, showing any major obstructions (like hills) in that path.

The radio path study can then be used in the next stage of the design process. As mentioned before, signal strength is the backbone of what makes a successful radio installation, and the biggest component of signal strength is line of sight between locations. The radio path study software can be used to play with antenna heights to try to achieve the line of sight, or help you determine where you need to add repeater stations to get the line of sight needed.

Another component of the signal strength is accounting for the gains and losses in your radio network. Especially with the unlicensed radios, where you are working with only one watt of power, it is very critical to manage this. Losses occur primarily in the feedline between the radio and the antenna, where excessive feedline length, too small of a feedline, or too many or bad connections, can all rob your ability to communicate. These losses can be counteracted by selecting antennas that will increase the gain in the system, and correctly sizing the feedline.

The radio path study software can assist you in selecting the correct antenna and feedline combination to minimize your system losses.

There are two types of antennas that are typically used in industrial radio networks. The first is an omnidirectional antenna. As the name suggests, this antenna broadcasts its signal in a 360 degree pattern from the antenna. This type of antenna is used in a point to multipoint system where you have a central location talking to multiple remote sites, scattered in different directions from this central location.

The other type is a directional antenna called a Yagi antenna. These antennas transmit in a very narrow, focused direction, and are typically used in remote sites where you

point the antenna at the central omnidirectional antenna, or they are used on each end in a point to point configuration.

Serial radios typically have to be configured in a Master / Slave relationship, where one PLC acts as the Master, and the remaining PLC's in the network being Slaves. Data is communicated in this model via a poll / response, where the master sends out a poll packet to all radios, and the one PLC in the radio network that the address matches, replies with data. This is a slower way to obtain data, because each slave is polled in sequence, and if they are not responding, generally have retries.

Under this model, all data is concentrated into the master PLC, so if something is wrong with the master PLC or Master radio, no information is updated.

Alternatively, the unlicensed radios with Ethernet connectivity are really LAN extensions. This means that all functionality (online programming and edits, simultaneously receiving data from multiple PLC's, etc.) that is available for a hardwired system, is available for the over the air system. This means that data is received faster, and typically the loss of a component is the loss of only one PLC's data, and not the whole system.

Summary

Designing an industrial data network has many components, and things to be careful about with your selection. They have great advantages over other alternatives, primarily because you own your equipment, and you are not dependant on another company or service provider to keep your information and control systems up and operational. In addition, not having recurring monthly costs saves on expenses, and shifts the cost typically into a capital budget as opposed to a maintenance budget.

If you do choose a radio network, most of our current customers are choosing the unlicensed radios because they do not have to deal with the government, and they pick up faster throughput and all of the maintenance and configuration benefits of the Ethernet network.