At noon on April 28, 1852, Moses Farmer and William Channing placed the first public fire reporting system into service in Boston, Massachusetts. That system utilized publicly accessible street boxes located around the city. When occupants saw a fire, they could report that fire by turning the hand crank located in the box. The dispatcher could then correlate the box number to a street address and dispatch a fire company to that location.

Signals on the system were transmitted by a technology similar to telegraphs. This meant that overhead wires were strung throughout the city to transmit alarms to the fire dispatcher. Some residents likened the wires to a massive spider’s web. The first Boston telegraph fire reporting system was in service for almost 20 years before being replaced by a more modern version of the same technology.

There have been many improvements in transmission technology since 1852. But many public fire reporting systems are still in service, primarily throughout the Northeastern United States and some government facilities. In communities with public fire reporting systems, many businesses are still required to connect to this system through a “master box” arrangement.

More recent changes involved the use of directly connected systems, especially in large cities, using leased telephone lines. In this arrangement, the leased lines were used to transmit data between protected premises and the supervising station or public fire dispatcher. Leased lines have all but disappeared since the breakup of AT&T in 1984, leaving customers to develop better ways of transmitting signals.

Digital Alarm Communicator Systems (DACS) were another significant improvement to fire alarm transmission between the protected premises and the supervising station or fire department dispatcher. This arrangement requires ordinary telephone service to transmit the data.

But all of these methods require the use of metallic conductors to transmit alarm signals. Cellular telephony, radio frequency (RF), and other wireless methods have recently revolutionized the industry. Unlike wireless technology, every metallic conductor based transmission method is prone to ground faults, shorts, and open circuits. There have been cases, such as the Hinsdale, Illinois Fire in 1988, where the telephone exchange was destroyed by a fire, rendering the local telephone system inoperable. Other events such as the Pacific Bell software glitch in 1991 have caused outages in large geographic areas.

We’ve finally come full circle. Modern fire alarm transmitters use wireless technology to send signals to responders. The first fire alarm “systems” were wireless, too. However, they used firefighter’s rattles and church bells to alert residents of a fire. Conductor-based technology actually started a revolution in the industry more than 150 years ago. This article explores some of the more modern technologies and their salient requirements.

Wireless Technologies
Of course, public fire reporting systems are extremely reliable and operate under a variety of fault conditions. However, public fire reporting systems do not transmit trouble or supervisory signals. For interior fire alarm systems, Radio Frequency (RF) transmitters, cellular telephony, microwave transmission, and other methods were developed to prevent some of the problems associated with conductor failures. Collectively, these methods are called “wireless” transmission.

NFPA 72-2007, National Fire Alarm Code, provides many requirements for these technologies. Chapter 8 provides requirements for supervising stations and the means of communicating signals between protected premises and the supervising station. Wireless public fire reporting systems are covered by Chapter 9, and apply to street box systems and auxiliary systems (master boxes).

Coded Radio Boxes
One significant improvement in public fire reporting systems is the use of radio transmission through the use of coded radio boxes. Coded radio boxes are often used by municipalities when there is no copper-based infrastructure in place, or where conductor maintenance has become prohibitively expensive. Coded radio boxes can be used as master boxes to transmit alarms from protected premises, just like hard wired public fire alarm reporting systems. Section 9.4.2.3 of NFPA 72 provides specific requirements for coded radio boxes used on public fire reporting systems.

Coded radio boxes can be powered by a utility distribution system, photovoltaic power system, user power, or batteries. There are a variety of requirements for each type of primary power scheme, but all involve some sort of backup power to be provided, as a trouble signal is sent to the public fire service communications center.

Section 9.4.2.3.3 requires coded radio boxes to transmit test, tamper, and fire signals to the public fire service communications center. At least one repetition of each signal must be transmitted.

Coded radio networks offer a way of circumventing physical problems and high costs associated with metallic conductors. However, there are additional requirements that must be met in order to ensure an equivalent reliability. For example, Section 9.5.3.1.1 requires two
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receiving networks for each frequency on a Type A network. Each network requires the following:
• Antenna
• RF receiver
• Signal processing equipment
• Time/date alarm printer
• Audible alerting device
• Power supply

Both receiving networks must be installed at the public fire service communications center. However, Type B networks do not require this level of redundancy.

Public fire alarm reporting systems are not the only type of system that can take advantage of wireless technologies. Other available technologies for protected premises systems include the following:
• Digital Alarm Communicator Systems (DACS)
• Digital Alarm Radio Systems (DARS)
• Two-Way Radio Frequency (RF) Multiplex Systems
• One-Way Private Radio Alarm Systems
• Private Microwave Radio Systems

NFPA 72 does not offer any particular preference on one method or another because each of these technologies has roughly equal reliability. In fact, most technologies require transmission of alarm signals in 90 seconds or less.

Digital Alarm Communicator Systems (DACS)

Digital Alarm Communicator Systems (DACS) are the most common type of transmission means between a protected premises fire alarm system and a supervising station. They are most often used with dual telephone lines, but they can also be used with wireless transmission technologies.

DACS are required to use two means of transmission between the protected premises and the supervising station. At least one of the means must be land-based telephone line (individual loop start line) as the primary means of transmission, but the secondary means can be any one of the following means:
• A cellular telephone connection
• A one-way radio system
• A one-way private radio system
• A private microwave radio system
• A two-way RF multiplex system

These means are all available for use with DACS, but cellular telephones are the most prevalent means of wireless communications on a DACS. Cellular telephone transmitters have limitations. They must have a signal from a nearby tower, which is not always possible in remote areas, and may not be available from all providers.

Cellular Transmitters

Cellular transmitters essentially use the same network as the cellular telephones used for voice communications. They act as radio transmitters, which may offer some resistance against the problems associated with land line transmission. These transmitters must be listed for use with DACS. There are three basic types of cellular transmission: circuit switched, control channel, and cellular digital packet data. Each method offers advantages in terms of price, availability, and reliability.

DACS using a cellular transmitter, paired with a land line, offer a good way of providing enhanced reliability against land based telephone outages. Telephone outages are very rare, but a cellular transmitter offers resistance against an arsonist or vandal who cuts telephone lines to prevent transmission of signals. The monthly cost of a cellular DACS is comparatively priced with land-based copper lines, and may be a better option in some applications. DACS also have the advantage of a small antenna, which can be located indoors away from damage.

Radio Frequency (RF) Transmission

There are other methods of communicating between the protected premises and the supervising station. These include One-Way Private Radio System, and Two-Way RF multiplex systems. One-way private radio systems only transmit alarms from protected premises to the supervising stations, and cannot receive alarms. Two-way RF systems transmit data in both directions, as they are multiplexed. This makes them more secure and somewhat more reliable.

In the two-way RF multiplexed network, a supervising station uses RF
transceivers (repeaters) spread across a large geographic area. The transceivers must be located in the geographic area so that each transmitter can communicate with one or more transceiver. RF systems are ideal for campus style arrangements, and other similar dense urban settings with a high density of protected premises in a relatively small area.

A typical RF arrangement is to install a network of transceivers across the area served, so that there are multiple redundant pathways. Figure 1 is an illustration of such a network. Section 8.6.3.4 of NFPA 72 provides requirements for two-way RF multiplexed systems.

The reporting times required by NFPA 72 for RF technologies are similar to other technologies, and require alarm signals to be transmitted in 90 seconds or less. There are two basic categories of RF technologies: Type 4 and Type 5.

Section 8.6.3.4.4.1 contains the requirements for Type 4 systems. Type 4 systems are required to be provided with the following features:

- Each site has an RF receiver connected to the supervising station by a separate channel.
- Each RF receiver at the protected premises can access at least two receiving sites.
- The system has at least two RF transmitters that are located at one site and have the capability of interrogating all RF transmitters/receivers on the premises, or two transmitters dispersed with capability to be interrogated by two different transmitters.
- Each RF transmitter allows immediate use, and every transmitter is operated at least once every 8 hours.

Type 4 systems have more reliability because of the redundancy of transmitters and receivers. This redundancy is provided as a means of mitigating failures caused by lightning strikes. Because Type 4 systems are more reliable, the maximum loading is significantly higher than for Type 5 systems. Table 8.6.3.4.5.2 permits loadings of approximately four times of those for Type 5 systems.

A possible drawback with RF systems is that antennas are often struck by lightning and are subject to wind and ice damage. However, land based transmission methods are subject to the same problems.

Digital Alarm Radio Systems (DARS)

Digital Alarm Radio Systems (DARS) provide a means of two-way communication, but do not require dedicated transceivers located in the geographic area. Instead, the transceivers at each protected premises act as repeaters for other transmitters, and vice versa. This arrangement makes for a very reliable system because signals have multiple pathways back to the supervising station. DARS may be slightly more reliable when widespread telephone outages occur, because they do not rely on cellular technology, which eventually switches signals to land-based lines. This technology is sometimes referred to as “adaptive network systems”, and is often used on burglary systems because of their ability to withstand faults on land lines. Figure 2 illustrates this type of network.

DARS are sometimes used with DACS as a means of providing another means of transmission in the event of a DACS failure. Section 8.6.3.2.3 provides requirements for DARS. Specifically, the DARS must transmit the alarm signal if the DACS transmission by telephone land line is not successful. In this case, the DACT must continue to attempt to connect with its receiver. DARS must transmit a signal at least once daily to ensure reliability of the systems.

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Private Microwave Radio Systems

Private microwave radio systems are rarely used and can be very expensive. They are primarily used on military facilities or by public utilities, and can be used to transmit data over long distances. The infrastructure for microwave transmission requires line-of-sight transmission, usually between hilltops. The initial cost of this technology is very high, and it is not widely used for alarm transmission.

Summary

So, what transmission method is best? Some technologies have distinct advantages in some extreme circumstances. But as previously stated, the reliability is approximately equal for all transmission technologies. The method that suits the cost/benefit ratio is usually the preferred method of transmission. Campus arrangements and cities have an advantage for RF technologies. But two-line DACS may have an advantage in many settings. The designer must also evaluate the availability of the technologies, where the project is located, and the likelihood of a loss of communications.

Different protected premises can benefit from different technologies. For example, Highly Protected Risk (HPR) occupancies may require much more risk management than a small mercantile occupancy. In this case, a prudent designer might wish to use multiple technologies, rather than “placing all the eggs in a single basket”. The designer must also decide which application is best suited to the project needs, to include cost and reliability. In all cases, the owner must be consulted to determine what type of costs and benefits are acceptable. It is, however, the designer and not the AHJ who selects the method of communications.

Most occupancies are not required by any building code to have off-premises monitoring, or “emergency forces notification”. Some local codes require certain occupancy types or use groups to be protected in this manner. Many supervising station connections are provided at the owner’s request or by insurance interests. However, if a system is installed, it must meet code, using equipment listed for the purpose.

What’s on the horizon? While not truly a wireless connection, many manufacturers are now producing internet gateways. These gateways allow worldwide access to a fire alarm system. It will be interesting to watch the development of this technology and how it affects the fire alarm industry in the coming years.

According to Art Black, the Chair of the NFPA Technical Committee on Supervising Stations, the committee is poised to reduce or eliminate many of the requirements in Section 8.6 of NFPA 72 in the 2010 code cycle. According to Black, it doesn’t make sense to micromanage the requirements of all these technologies when Underwriter’s Laboratories and others do that.

Black says the goal of the technical committee is to simplify the Code so that all the authority having jurisdiction needs to do is to verify the transmission equipment is listed for fire alarm use. That should make the AHJ’s job somewhat easier, but that involves trust in the equipment listings.

Fire alarm transmission technology has come a long way since 1852. Choosing the best wireless technology can be complicated, but wireless technology can make for more reliable fire alarm systems, and safer properties.

Merton Bunker is a principal member of Merton Bunker and Associates of Stafford, VA. Please visit our web site at: www.mertonbunker.com.

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NPSTC brings issues to national attention, adds Aiken. “Industry knows that when they appear at NPSTC they are exposed to all of public safety. Many issues over the past years have become issues because of the unity of support that is NPSTC.”

Jackie Siegel is the editor of npstc spectrum, the quarterly newsletter at NPSTC. To learn more about NPSTC, visit www.npstc.org.

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