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March 2004
WIRELESS VOICE AND DATA FOR MOBILE AND REMOTE MISSION-CRITICAL OPERATIONS
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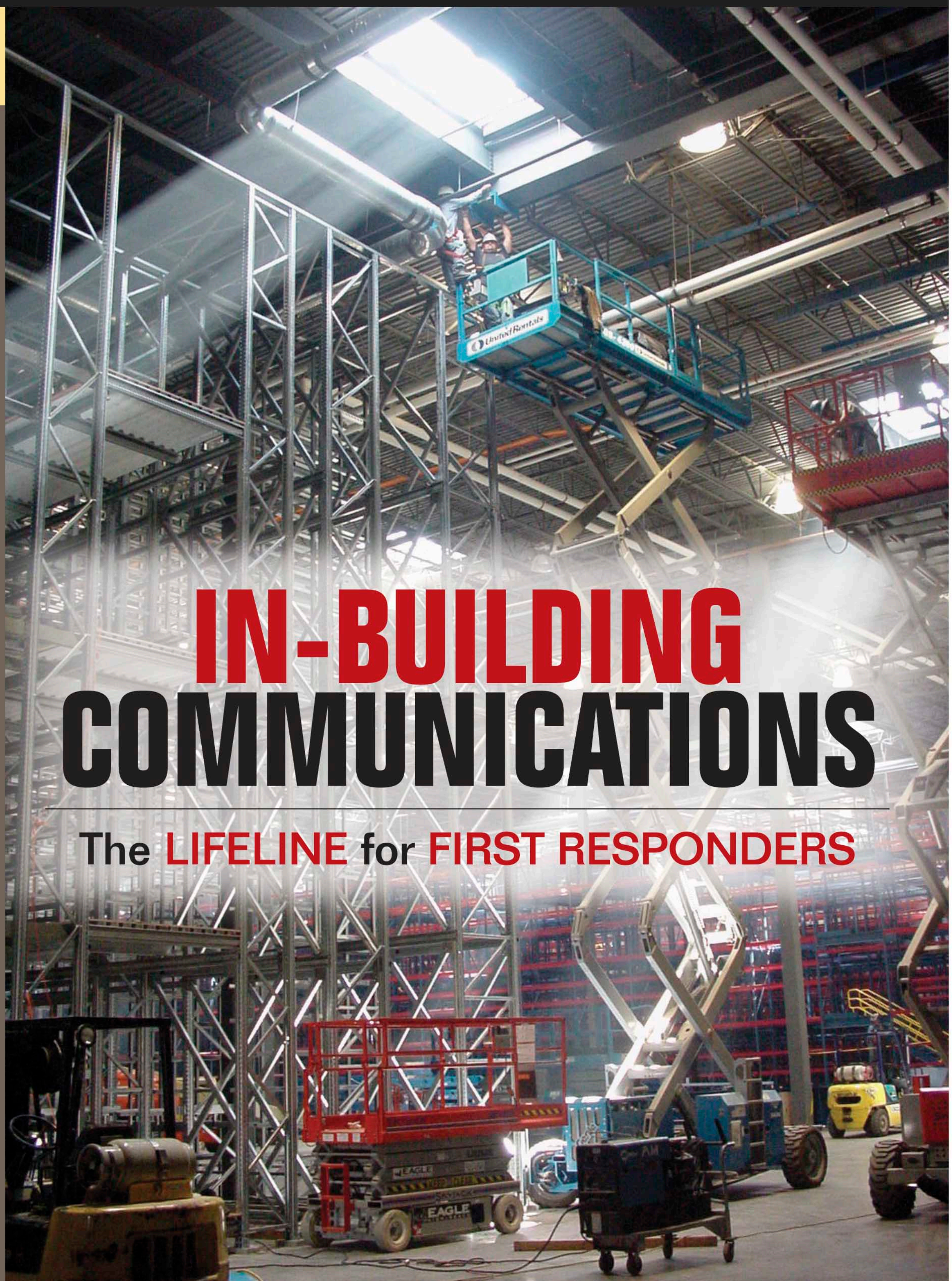

IN-BUILDING COMMUNICATIONS

The LIFELINE for FIRST RESPONDERS

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BY JACK DANIEL

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Public safety wireless communications is evolving from vehicular-mounted mobile radios to handheld portable radios. This trend, which is especially pronounced in urban areas, is transforming the way public safety radio systems are used and expected to perform. First responders expect to be able to communicate wherever they go, including basements, high-rise buildings, and subways.

These expectations have made providing reliable radio communications inside obstructed areas a mandatory requirement for new public safety communications systems. This need is supported by a number of recent horror stories: the unfortunate maintenance worker in Los Angeles who suffocated in a high-rise elevator during a fire; the firefighter who couldn't call for help on his radio after falling through a fire-weakened floor; and the solo policeman facing an armed suspect.

While some fingers point to the 800 MHz band and digital radios as the cause of today's poor indoor coverage, they are only partially to blame. Rather, it was the combination of portable radios becoming a primary communications device along with the adoption of 800 MHz and digital radios that made in-building coverage an absolute necessity. In fact, VHF and UHF portables aren't reliable underground

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or deep inside buildings either. While some users say that lower frequency bands penetrate buildings better, others have found that higher frequencies actually work better. Actual performance depends on many case-by-case factors.

New radio systems usually include additional signal-level strength to at least provide coverage inside residential and smaller structures. It is not economically feasible, however, to provide 100 percent indoor coverage through repeater sites alone. Additionally, unforeseen operational changes as well as the expanding responsibility of some agencies due to forces such as suburban growth, agency expansion, and increased interference can create a need for signal boosters in existing systems.

Benefits of Dependable Indoor Coverage

In-building coverage is a life-saving necessity. First responders should be confident that their communications lifeline will be there when they need it most.

Dependable indoor coverage enables public safety personnel to work more efficiently in both routine and emergency situations. Inconsistent and unpredictable radio coverage creates apprehension and duplication of system users' efforts, which is reflected in higher department costs.

It is a well-known fact that the rapidity and completeness of first responder actions during the first minutes of an incident directly affects the resources and time needed to get control of the situation. Any delay in the initial efforts can multiply the losses and costs.

The need for in-building coverage has driven many proactive jurisdictions to enact ordinances and codes that mandate building owners to take corrective action when public safety communications coverage within their facilities is inadequate. These codes are usually enacted at the city or county level and may be either building or fire codes. At least two statewide codes are pending as well.

Ordinances and codes assure that in-building requirements are being met, although they vary in complexity and methodology. A white paper on this subject can be found at www.RFSolutions.com/sbwp.htm.

In-Building Technology for Public Safety

While much attention has focused recently on in-building reception for consumers using cellular or PCS handsets, adequate public safety in-building systems are an entirely different issue.

Although it can be argued that in some situations cellular coverage is critical, systems designed for public safety *must* operate reliably, even under the greatest traffic loads and worst possible conditions.

The most basic method for enhancing in-building coverage is to use a "passive" antenna system, where an outside antenna is connected to an inside antenna with a coaxial cable. This approach may work when the donor site (the repeater or base tower) is only a few miles away and the inside coverage area is very small.

In most cases, however, a passive system is not able to provide an adequate signal within a building. Technically, the signal delivered to the handset in a passive system is typically 40 dB to 60 dB less than the signal received at the outdoor antenna, mainly due to the space loss between the inside antenna and the portable's

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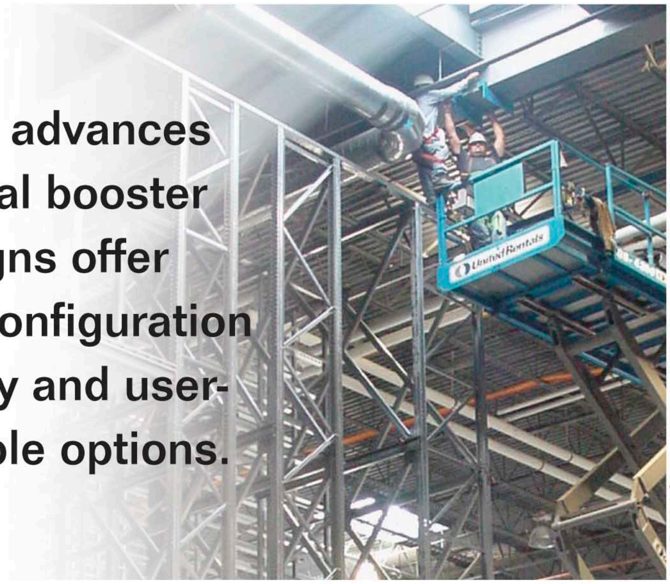

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antenna. If it appears a passive system may work, it is wise to route the coaxial cable through an equipment closet so a signal booster can be added later if needed.

Public safety in-building systems can be interfaced with base stations or repeaters in the building or, more commonly, with signal boosters. Other techniques such as portable repeaters offer some improvement of on-scene communications, but they may be inadequate for the size and construction of certain structures. Buildings must be individually surveyed to establish the best, most dependable solution.

Signal Booster Technology

Signal boosters, also known as bi-directional amplifiers (BDAs), are specialized RF amplifiers that are often highly effective for meeting the demands of in-building coverage. BDAs operate within very specific FCC guidelines and require FCC certification, even if they are operated underground.

The FCC restricts the use of these devices to FCC licensees authorized to operate on the frequencies processed by the signal boosters. Public safety agencies give their permission to operate a signal booster on the public safety channels when they enact ordinances. They may also grant permission on a site-by-site basis.

Signal boosters are available in a wide range of frequencies and designs. They also vary according to the amount of amplification (gain) and the level of reliability/survivability needed.

The RF filtering in a signal booster is important for maintaining stable operation and maximum rejection of undesired channels that could degrade performance. For example, a high-performance public safety signal booster operating in the 821-824/866-869 MHz bands also has adjacent band rejection filters that minimize interference from cellular and Nextel cell sites operating in adjacent frequency bands.

Mass-produced, consumer-grade 800 MHz signal boosters designed for non-critical Nextel/cellular uses are sometimes installed for public safety applications. This is not always a wise decision, since public safety users need signal boosters to continue to provide service during extreme, abnormal conditions. Additionally, consumer-grade signal boosters are generally smaller in size and offer minimal filtering and the lowest filter cost designs.

Almost indestructible signal boosters designed specifically for public safety can provide reliable service even in the most extreme conditions. These devices cost more than consumer-grade products, however, due to their larger, high-performance RF filters, modularity, options, and built-on service features.

Public safety signal boosters are generally built like a battleship and housed in watertight NEMA 4 enclosures, even when installed indoors. This not only protects the equipment from contaminants, rodents, and tampering, but it also allows the signal booster to survive a firefighter's wash-down during a fire.

For similar reasons, many public safety signal boosters are designed to *not* shut down in the event of high temperatures or power surges and interruptions. Common wisdom says it is better to let the signal booster operate as long as possible under adverse conditions, even if the performance degrades or the signal booster suffers damage. During an extreme emergency, it is more important to save the first responders than the signal booster.

Recent advances in signal booster designs offer greater configuration flexibility and user-selectable options. Some designs provide software control of bandwidths and channels. Alarms and monitoring can be done locally as well as remotely, even via the Internet. Problems that once required a technician to visit the site can be corrected remotely, including bypassing amplifier stages to correct excessive gain or a failed stage.

Some models even maintain a retrievable performance log, allowing an engineer at a remote site to review momentary events (such as intermittent high-level interference events) and optimize the gain settings remotely.

Public safety models include decoupled RF test points that allow engineers to do performance testing without taking the equipment off-line or unplugging coaxial cables. The RF distribution system consists of the cables and antennas that take the RF signals in and out of the desired coverage areas throughout the structure.

Some users may want to use the same distribution system for both public safety and non-public safety systems. Although certain combinations may technically work, these two user categories should be kept separate. In most cases, sharing a distribution system will result in the public safety agency losing some or all control over it. Adjustments and modifications within a shared distribution system (also known as a "neutral host system") made to satisfy non-public safety communications can be detrimental to public safety and may only be discovered during an emergency.

New Distribution Options

Modern in-building systems are designed to fit specific structures and meet the unique communications needs of the user through a combination of antennas, radiating cable, and other components. No one approach is best for all situations.

While special components such as radiating coaxial cables, broadband antennas, multiband power dividers, and fiber-optic cable systems have been available for signal booster applications for some time, newer developments such as broadband or multiband antennas and power dividers allow the same distribution system to carry VHF, UHF, and 700-900 MHz bands simultaneously. This can be helpful in jurisdictions where police and fire operate on different bands.

Radiating cable favors linear coverage like hallways and tunnels, while multiple indoor antennas (also called distributed antenna systems or DAS) work well for larger open areas. An experienced in-building system designer will look at these alternatives and select a combination that best matches an agency's requirements.

A relatively new distribution option is RF over fiber. Fiber systems for 800 MHz to 900 MHz distribution are well developed, and VHF/UHF systems are starting to be implemented.

One benefit of fiber is that it is very efficient. Standard single-mode fibers are capable of carrying the complete public safety spectrum over a distance of 10 miles with no net loss. This makes it a good candidate for use inside very large buildings, long tunnels, and campus-like building complexes. One "head-end" can feed the whole distribution network, with RF boosters added where needed at the distant ends of the fiber. And since fiber cannot radiate RF, it neither picks up nor emits interference.

Did You Know?

Cellular engineers use the term "passive" differently than land mobile engineers. In cellular jargon, passive means there are no in-line amplifiers in the internal RF distribution network. However, a passive cellular system has base stations and/or signal boosters driving the RF distribution network.

It is crucial that first responders have radio communications where they most need it, and that coverage holds up during an incident. Sooner or later, most agencies will need signal boosters, especially as higher frequencies and lower powered systems are deployed. Not all signal boosters are adequate for public safety use, however. It is important that agencies carefully research and evaluate signal boosters before any purchase to make sure their specific needs will be met. ■

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RadioResource MissionCritical Communications is published by the RadioResource Media Group. Pandata Corp., 7108 S. Alton Way, Building H, Centennial, CO 80112, Tel: 303-792-2390, Fax: 303-792-2391, www.radioresourcemag.com.