Photos courtesy Phoenix Fire Department

The Right Radio Fit

The Phoenix Fire Department transitioned to digital trunked radio communications, but researched options and made adjustments.

By Doug Mummert and Mike Worrell

Phoenix is the fifth-most populous city in the United States, covering about 518 square miles and home to around 1.5 million residents. The Phoenix Fire Department (PFD) has 57 fire stations and responds to more than 160,000 incidents a year. The department also runs a regional fire dispatch center and participates in an automatic-aid consortium with 20 other jurisdictions. The Phoenix Fire Regional Dispatch Center automatically dispatches the closest appropriate fire service resource, regardless of jurisdictional boundaries. This provides the highest level of life safety for the citizens of Phoenix and for all those who live in communities served by automatic aid partners. It is a more effective system than mutual aid, which is far less transparent or seamless. Located in the 12th-largest metropolitan area in the United States, serving four counties, the automatic-aid consortium covers more than 2,000 square miles and includes 178 response locations (fire stations) that respond to more than 315,000 incidents per year (2009).

For the past 30 years, the PFD has used analog simplex communications in the VHF band to support the communications needs of the automatic-aid system. The range of simplex communications via portable radios is limited to a few miles. However, simplex communications via mobile radios can provide a reliable range of 10 – 25 miles.

The main advantage of simplex is it maintains direct communications between firefighters and the incident commander without depending on external infrastructure. Supported simplex communications refers to communications to and from the dispatch center. This is provided by high-powered transmitters from the dispatch center to the emergency scene and a system of diversity receivers (voted) from the emergency scene to the dispatch center.

Upgrade Path

In the 1980s, the city of Phoenix began researching available options to upgrade or replace multiple radio systems in use by different city departments, some of which used separate radio infrastructures. A few of the systems, based on 1950s technology, had overloaded frequencies and no available new frequencies. They didn't support secure operations, and proposed FCC changes created other risks.

Although the PFD had a strong, reliable system with sufficient capacity, as a result of leveraging automatic-aid partners' assets, most city departments felt the current systems didn't meet their needs. It was decided to transition the city's voice radio systems into one trunked radio system. In 2000, at a cost of more than $120 million, the city of Phoenix purchased a Project 25 (P25) digital trunked 700/800 MHz multizone radio system. Taking into consideration the fire automatic-aid consortium, the new system was regional, covering the 2,000-square-mile automatic-aid service area as it was at the time of construction. Extremely robust and efficient, the trunked radio system features multiple simulcast zones and several intelli-repeater sites; 117 frequencies; 95-percent coverage with varied coverage levels designed to 12, 17 and 23 dB of structural signal degradation to a portable radio on the hip; and a 2 percent grade of service or reliability. Built as the Phoenix Regional Wireless Network (PRWN), it's now known as the Regional Wireless Cooperative (RWC).

During the system's design and

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buildout, there were few entities with systems already in place that could be called on to share their experiences. The vast majority of the systems were analog trunked systems. Phoenix Fire had only operated on VHF analog simplex and had no experience with either repeated or repeated trunked systems. The transition team was tasked with researching digital radios and trunked systems to determine their effects on fire ground communications.

Digital and Trunked Research

The research into digital radios occurred during 2000 – 2001. The New York City Fire Department (FDNY) had just deployed and subsequently recalled digital radios based on some lost transmissions on an incident. It was found that the units on the incident didn't hear distress calls, while units farther away from the incident did. This prompted the Phoenix Fire transition team to research digital radios with simplex channels. During the research, PFD officials learned that when two radios transmitted simultaneously, the digital information was corrupted and no transmissions were heard, but if another radio was away from the incident and received a strong signal from one of the radios, it would receive the transmission. The near radios received strong signals from both radios corrupting the data. Conversely, the distant radio captured only the strong signal, allowing reception of valid data that could be converted to voice. Another issue discovered was that use of a self contained breathing apparatus (SCBA) or loud background noises made communications difficult. These digital characteristics were shared, and many people disputed the findings based on the advertised advantages of digital radios.

From 2006 to 2007 after the deployment of more digital systems, reports of poor intelligibility prompted the International Association of Fire Chiefs (IAFC) and the National Institute of Standards and Technology (NIST) to study fire ground noise effects on digital radios. Digital vocoders in use at the time, as well as the newest vocoders, didn't meet National Fire Protection Association's (NFPA) 1981: Standard on Open-Circuit SCBA for Emergency Services. Intelligibility with the SCBA mask on, in digital and analog, was greatly decreased. Analog was able to pass the intelligibility standard of 80 percent.

During the same period, testing trunked radio system effects on the fire ground became a priority. This effort was more critical because Phoenix has no in-building ordinances for bidirectional amplifiers, and the city was growing rapidly. To complicate matters, the service area was divided into in-building penetration zones. This was determined by the predominate construction in a geographic area. The five subsystems and intellirepeaters were also designed with different traffic loading capabilities.

A testing process was developed to test buildings in each of the in-building penetration zones — heavy construction/high-rise, large industrial and residential. To select the types of buildings to be tested, the NFPA building classifications were used: fire resistive, noncombustible, ordinary construction, heavy timber (not tested because this material is minimal in Phoenix) and wood frame. Each NFPA building type was tested in each in-building penetration zone. A standard fire response for each building type was developed, and personnel were deployed inside the building to test radio communications.

The tests found that analog simplex communications provided the most reliable, intelligible communications. This was based on the ability of personnel on the interior communicating with an incident commander on the exterior. There were times while using the trunked system that one interior position could see another interior position but couldn't communicate because the trunked system wasn't providing coverage.

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Established Requirements

Testing provided the needed information to determine what the requirements for fire ground communications for the Phoenix Fire Department would be. A labor/management group was formed to decide the best option and the requirements for fire ground communications. During this time, NFPA 1221 (2002 Edition): Standard for the Installation, Maintenance and Use of Emergency Services

Communications Systems was in effect, greatly influencing the decision to remain simplex and analog.

NFPA 1221 2002

8.3.1.3 A separate simplex radio channel shall be provided for on-scene tactical communications. This section refers to Appendix A.8.3.1.3.

8.3.4.1.26 Tactical Communications. Trunked system talk groups shall not be used to fulfill the requirement for the provision of a simplex radio channel for on-scene communications.

NFPA 1221 has since been changed to allow the use of trunked channels.

Meanwhile in Phoenix, the decision to remain analog simplex was reinforced by economic factors that limit funding to provide in-building coverage and system expansion or enhancements. In addition, ongoing difficulties with digital intelligibility as noted by the IAFC and NIST and digital not meeting intelligibility with an SCBA mask as defined in NFPA 1981 were factors.

After it was determined that simplex was the best option for fire ground communications, another study to define communications requirements for the fire ground was initiated. This study concluded that in typical firefighting situations, once an operational area is defined by the initial emergency responder(s), the need for wide-area operations to other radio users diminishes for the individuals involved in the immediate emergency tactical response. These local area and on-scene incident operations need a functionally simple and operationally predictable communications system to support emergency service providers. Reliable communications are critical to the safety of personnel for any fire department response that involves hot/hazard zone operations or other hazardous emergency conditions. The PFD and labor representatives developed the following communications requirements:

■ To provide uninterrupted communications on the fire ground in a contaminated atmosphere for the following:

1. Radio unit to radio unit (crew-to-crew operations);
2. Radio unit (crew) to incident commander; and
3. On-scene incident radio units (crew and incident commander) to and from the PFD alarm room/dispatch center location.

■ Radio unit to radio unit communications at all times, without changing channels to ensure firefighter safety.

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The next step was to select a technology that best meets the communications requirements. The department is nearing the end of a long, labor-intensive process in which simplex and trunked technologies were analyzed. Simplex with receiver infrastructure, with digital vehicular repeater (DVR) and without infrastructure was examined.

Each technology was scored on meeting the requirements, cost, availability of the technology and longevity. Additional considerations were added. Regulatory constraints and in-band interference in the 700/800 MHz band were seen as difficult to overcome. The introduction of dual-band radios may provide added flexibility to leverage current VHF infrastructure for fire ground use and have the benefit of the wide-area capabilities of the trunked system. This scenario may provide the opportunity to phase in the new dual-band radios on an as-needed basis. The deadline to make the selection is fast approaching and reaching a critical time frame to meet FCC narrow-banding requirements.

Dual-band radios also make the DVR more viable by creating large frequency splits that minimize interference problems. In addition, no waivers are required for analog operation or to operate 30-watt mobile radios for in-building penetration. A new power output-related issue to deal with relates to recently proposed guidelines that would substantially lower the power output of new “intrinsically safe” portable radios. This could be problematic for safe fire ground operations, as well as routine communications.

System expansions or enhancements don’t always mean an increase in coverage area. When enhancements are needed to improve coverage in an area, it can take years to procure funding, design and build if a new site is required.

Trunked radio systems are large computer networks with an RF component to transfer voice messages to and from digital portable radios. Networks require constant care and maintenance to keep them performing to public-safety standards. This often requires the implementation of subscriber fees to use the system. Depending on the jurisdiction, the fees provide all or part of the funding needed to maintain the system. At some point, similar to the computer world, software upgrades will require hardware upgrades to run the new software. The cost for Phoenix’s upgrades was in the millions of dollars.

The PFD successfully transitioned to digital trunked radios for nonhazard zone incidents in 2009. This includes most calls where firefighters are unlikely to wear an SCBA, such as most EMS incidents. Automatic-aid partner jurisdictions are transitioning their nonhazard zone incidents to the new system as resources allow, with a goal of transitioning all partners in the near future.

Trunked radio systems were

specifically developed to promote the efficient use of available spectrum and they also excel at enabling a large number of disparate users to talk across long distances. Although these attributes don't promote reliable or predictable hazard zone communications, they work well for nonhazard zone communications. The PFD will complete its evaluation of available solutions for hazard zone communications in 2010 and continue further planning for voice and data radio communications for the future. ■

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