Digital Radio in the Americas

A Guide for New Deployments and System Upgrades

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The Importance of Digital Radio Standards

By Sandra Wendelken, Editor

The past few years have seen the development of several new digital radio technologies and the continued maturity and evolution of other digital radio standards, some of which have been on the market for more than 20 years. This e-book serves as a guide for four of the most typical standards in the Americas — Digital Mobile Radio (DMR), NXDN, Project 25 (P25) and TETRA. In addition, digital Private Mobile Radio (dPMR) technology is beginning to expand into some South American markets.

With the new digital radio standards and the established technologies, interoperability and competition have become more central for users. From industries such as utilities, energy and private wireless to public-safety systems, open standards are allowing users to buy equipment from the vendor that best meets their needs for each component of the network.

Mission-critical voice networks continue to be one of the most important tools for mission-critical companies and agencies. New broadband initiatives are on the horizon, but those networks are years away and likely won't have mission-critical voice capability for a decade or more. In fact, many users take advantage of the mission-critical data capabilities available through the digital radio standards highlighted in this e-book.

This e-book covers the features and specifics of each of the four technologies, along with articles on system upgrades, interoperability and open procurements. In addition, each vertical industry has a case study that demonstrates how a particular digital radio standard worked to fulfill that user's needs and requirements. Following an overview section with general information on the standards and how users can take advantage of their various features, the next three sections each highlight a digital vertical market — critical infrastructure industries (CII), private wireless/enterprise and public safety.

Each sponsor of this resource contributes to one or more of the digital radio platforms in some way so take a close look at their offerings when you are ready to move forward with your next digital radio technology purchase. Each sponsor is a leader in its market and would welcome a chance to explain its products and services.

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Section 1: Overview

The Technical Differences of Digital Standards

Photo courtesy Hytera Communications

Several digital technologies are now available for transportation, utilities, public-safety agencies and other mission-critical communications users. These products are rich in features, but it is difficult to compare different brands and models without knowing the specific application and spectrum.

FDMA and TDMA

Three technologies — NXDN, Digital Mobile Radio (DMR) Tier 1 and Project 25 (P25) Phase 1 — operate in FDMA mode, and several technologies, including DMR Tiers 2 and 3, Project 25 Phase 2 and TETRA, use TDMA mode. RF channel bandwidths are 6.25 and 12.5 kilohertz for NXDN, DMR and P25 Phase 2; 12.5 kilohertz for Project 25 Phase 1; and 25 kilohertz for TETRA.

All FDMA and TDMA products can offer the equivalent of one voice channel per 6.25 kilohertz of RF channel bandwidth. FDMA can be programmed to use either 6.25- or 12.5-kilohertz channels, TDMA typically offers only a set of two 6.25-kilohertz voice channels carried inside a 12.5-kilohertz channel, and TETRA offers a set of four 6.25-kilohertz voice channels carried inside a 25-kilohertz TETRA channel. NXDN, P25 and

DMR radios use a similar AMBE 2+ voice encoder-decoder (vocoder). TETRA uses the Algebraic Code Excited Linear Prediction (ACELP) vocoder.

FDMA and TDMA each have certain advantages for specific uses. For instance, an NXDN voice radio using a single 6.25-kilohertz RF channel has an extra 3 decibels (dB) of sensitivity and less noise than other offerings in 12.5 or 25 kilohertz. If there is a need to operate a voice channel over a long distance and in a noisier-than-normal RF environment, a single 6.25-kilohertz FDMA NXDN channel will outperform the other radios in range and noise tolerance. Wider RF bandwidth TDMA radios in 12.5 and 25 kilohertz will not be able to reach as far or be as noise tolerant.

If the requirements include mostly data communications, a TDMA TETRA radio will offer the highest data bandwidth by aggregating the four voice channels into a single 25-kilohertz data channel. TETRA can also operate with simultaneous combinations of voice and data channels. DMR Tier 2 and 3 radios can aggregate two voice channels into a single 12.5-kilohertz data channel, which is also matched by NXDN FDMA radios operating in 12.5-kilohertz mode.

Regarding real-world FDMA and TDMA operation and issues, FDMA is perceived as a less-intrusive technology to be deployed next to existing analog FM radio systems in operation. Some TDMA radios are considered more aggressive, capable of generating interference to other radio channels nearby. However, all TDMA and FDMA radios are certified and meet FCC rules on interference to other radios or systems. Furthermore, every radio manufacturer is continually improving its products, and what might have been a concern in the past may no longer be an issue.

The best purchasing approach is to define well the needs and technical specs of a radio system to be procured, then conduct a small pilot test to determine if the chosen radio can operate satisfactorily in the real-world environment where it will be deployed. This applies to both FDMA and TDMA systems.

NXDN

Kenwood and Icom designed NXDN as an open standard introduced in 2006. An NXDN manufacturers association was formed, and NXDN radios are available from several vendors. NXDN radios are available for conventional and trunked voice and data operation using FDMA technology. NXDN radios have advanced security and encryption options including advanced encryption standard (AES).

NXDN radio systems are offered for the VHF, UHF and 800 MHz bands

from Kenwood and Icom. The radios are fully interoperable in conventional mode, and in early 2014, both companies announced plans to offer products that support both trunking protocols in the NXDN technical standard.

NXDN provides transmission control protocol/IP (TCP/IP) interfaces between radio sites, simplifying system architecture and providing strong functionality. The established radio system is suitable for mission-critical applications and for medium- to large-sized systems. NXDN is being deployed across North America with conventional and trunked systems for voice, data, telemetry and remote monitoring/command operation by the Class 1 freight railroads, which have more than 80,000 miles of track and 20,000 locomotives. Many of the railroad RF engineers and managers who developed positive train control (PTC) digital radio systems and radios are the same people who used similar mission-critical criteria to evaluate radio systems from various manufacturers and selected NXDN for their mission-critical railroad mobile voice and data network. NXDN has built-in redundancy in its network to ensure continuous operation.

dPMR

Digital Private Mobile Radio (dPMR) is a digital radio protocol specifically targeting highly functional solutions by using low-cost and low-complexity technology. dPMR is a narrowband 6.25-kilohertz FDMA technology that offers many forms of voice and/or data applications. The protocol is specified in both TS102 490 and TS102 658 European Telecommunications Standards Institute (ETSI) standards and complies with the European Harmonised Standard EN301 166-2 for use in 6.25-kilohertz channels.

dPMR exists in a range of functional levels: dPMR446 is the license-free product for use in peer-to-peer operations without base stations or repeaters in the 446 MHz UHF band. This technology is covered by the ETSI standard TS102 490.

dPMR Mode 1 is the general purpose peer-to-peer application of dPMR for all forms of licensed PMR use. Mode 1 is part of the ETSI standard TS102 658. dPMR Mode 2 is the licensed PMR version that includes all base station and repeater functionality, allows interfaces via gateways and is part of ETSI standard TS102 658. dPMR Mode 3 is full-functionality dPMR and can be offered by managed access multisite complex systems including all the same interfaces and gateways as Mode 2.

The standard hasn't been deployed in the United States, but there are some deployments in South America.

TETRA

TETRA is a mature and established TDMA digital voice trunked and data radio technology used around the world and recently in North America. The TETRA standard was finalized in 1995, and TETRA was introduced in the market in 1997. Millions of TETRA radios are deployed in more than 125 countries globally. TETRA equipment is available in the VHF, UHF and 800 MHz bands. TETRA also provides TCP/IP interfaces between various radio sites, simplifying system architecture and providing strong functionality.

A unique characteristic of TETRA technology is that many radio manufacturers developed a set of common standards for TETRA within the ETSI. These standards confer interoperability between radio equipment from multiple vendors.

TETRA offers an impressive array of features and functionality and includes a redundant network architecture. For example, TETRA offers unique features such as a vehicular radio that can be software upgraded and programmed to operate as a direct mode operation (DMO) repeater gateway. This gateway automatically repeats the network traffic to and from a person who left the vehicle and is working in the field, using a low-power handheld radio to talk to and from the TETRA network via the vehicular DMO gateway. The DMO gateway can detect the presence of other DMO gateways in other vehicles nearby and avoid simultaneous transmissions through two or more DMO gateways. For customers with large numbers of workers in the field, this feature could mean significant cost savings by not having to design and build the entire network infrastructure and deploy more base stations to support communications with low-power handheld radios anywhere in the system.

Similar to NXDN, TETRA is suitable for large mission-critical networks and is used outside North America for large mission-critical systems that include public-safety agency users across Germany and operation as a European PTC radio system carrying vital signal data and commands on freight railroads.

DMR

DMR is a European standard developed under ETSI, the same organization that developed the TETRA standard. DMR was developed with three sub-standards or tiers aimed at smaller commercial networks that didn't require the higher-end functionality and features of TETRA.

DMR Tier 1 operates in FDMA and 400 MHz, while DMR Tiers 2 and 3

Technology selection depends mainly on the type of application and operation.

operate in TDMA and in the VHF, UHF and 800 MHz bands. Similar to NXDN and TETRA, DMR provides TCP/IP interfaces between various radio sites, simplifying system architecture and providing strong functionality. DMR has no redundant network infrastructure. The standard offers features such as an AMBE 2+ vocoder and the ability to operate in simulcast mode, which TETRA doesn't have. Many DMR Tier 2 features map to similar features in NXDN and TETRA, but no direct, honest comparison would be possible.

DMR Tier 1 technology can be used in a simple conventional implementation of unlicensed spectrum radio in the UHF band that in many aspects is similar to the family radio system (FRS) used in the U.S. Tier 1 technology is the only DMR technology that uses FDMA. DMR Tier 2 is a TDMA conventional radio system developed around 2005 to provide a lower-cost alternative, with less features, for non-mission-critical use in small commercial networks. Similar to MPT 1327, DMR Tier 2 was not developed for high-reliability, mission-critical, large multisite radio systems, which require other higher-end technologies.

However, DMR is far more advanced than MPT 1327, and DMR manufacturers have made a significant effort to guarantee that a certain number of DMR radio features are compatible across different manufacturers through interoperability tests. Some manufacturers have been certified as having that basic number of DMR features interoperable between vendors, and more manufacturers will pursue and obtain similar certifications in the future.

DMR Tier 3 is an advanced implementation of DMR Tier 2 with added trunked radio functionality. DMR Tier 3 interoperability tests announced by the DMR Association showed interoperability compliance with selected features among several manufacturers.

MOTOTRBO is a different implementation of the DMR standard developed and implemented by Motorola Solutions. Many features/functionalities are not compatible with other DMR original equipment manufacturer (OEM) products. However, the manufacturer has participated in DMR interoperability tests demonstrating its products offer a set of DMR interoperable features. MOTOTRBO is available in single-site and multisite versions. Both versions have a single point of failure in the master repeater.

Project 25

The initial phase of P25 focused on the Common Air Interface (CAI) and vocoder as its baseline. Phase 1 included the specifications for 12.5-kilohertz FDMA equipment and systems that could interoperate with multiple vendors' radios in conventional or trunked mode, as well as legacy analog FM radio systems.

The CAI standard was completed in 1995. Since then, additional Phase 1 standards have been developed to address trunking; security services, including encryption and over-the-air-rekeying (OTAR); network management and telephone interfaces; and the data network interface. Additionally, there have been ongoing maintenance revisions and updates to the existing standards.

P25 Phase 2 was designed to satisfy public safety's need to transition to a 6.25-kilohertz or equivalent occupied channel bandwidth and maintain backward compatibility to Phase 1 technology, allowing for graceful migration toward greater spectrum efficiency. Although the need was identified for standards to address additional interfaces and testing procedures, the primary focus for the Phase 2 suite of standards was defined by a two-slot TDMA approach to spectrum efficiency as opposed to a 6.25-kilohertz FDMA technology. The Phase 2 suite of standards addressing TDMA trunking technology was completed and published in 2012, but the standards allowing initial product development were published in 2010.

A significant number of standards documents addressing the P25 Inter-RF Subsystem Interface (ISSI) have been developed and published. The standards for the Conventional Fixed Station Interface (CFSI) and Console Subsystem Interface (CSSI) have also been completed and successfully deployed. Additionally, standards have been developed and published to address a number of interfaces relevant to security services, to include the Inter-Key Management Facility Interface (IKI).

The P25 Compliance Assessment Program (CAP) is a voluntary program that allows suppliers of P25 equipment to demonstrate that their respective products are compliant with P25 baseline requirements reflected in the suite of standards. The federally funded and developed program provides the user community assurance that the communications equipment it is implementing meets the standards for performance, conformance and interoperability. The charter for the P25 CAP was executed in April 2008, and eight laboratories were accredited to conduct performance and interoperability tests relevant to the P25 Phase 1 CAI.

The user community has repeatedly emphasized the need for expanded P25 CAP testing.

Final Conclusions

Technology selection depends mainly on the type of application and operation. A customer requiring simulcast or VHF operation will most likely select DMR. A small network operator with remote data needs might select NXDN. But a customer that needs to reach out to workers who are away from their vehicles and network infrastructure might select TETRA. A North American customer that plans a large, complex public-safety network will most likely select P25 technology.

All the technologies and digital radios described can be more or less suitable depending on the intended application. There is no radio technology or digital radio product that stands head and shoulders above the rest. And for some applications, the right solution could be with some of the simplest technologies and implementations.

Digital Technologies Comparison Chart

Feature	Digital Mobile Radio (DMR)	digital Private Mobile Radio (dPMR)	NXDN	Project 25 (P25)	TETRA
Technology	2-slot TDMA	FDMA	FDMA	Phase 1: FDMA Phase 2: TDMA	4-slot TDMA
Frequencies	VHF, UHF; 800, 900 MHz	VHF, UHF	VHF, UHF, 800 MHz	VHF; UHF; 700, 800, 900 MHz	VHF, UHF, 800 MHz
Channel Bandwidth	6.25 and 12.5 kHz	6.25 kHz	6.25 and 12.5 kHz	Phase 1: 12.5 kHz Phase 2: 6.25 kHz	25 kHz
Data Rate (kilobits per sec.)	9.6 kbps	4.8 kbps	6.25: 4.8 kbps 12.5: 9.6 kbps	9.6 kbps	28 kbps
Modulation	4-level FSK	4-level FSK	4-level FSK	C4FM	$\pi/4$ DQPSK
Analog Compatibility?	Yes	Yes	Yes	Yes	No
Conventional Option?	Yes	Yes	Yes	Yes	No
Vocoder	AMBE + 2	AMBE + 2	AMBE + 2	AMBE + 2	ACELP
Encryption	AES	Yes	AES/DES	AES/DES	TETRA Encryption Algorithm (TEA) ciphers
More Information	DMR Association dmrassociation.org	dPMR Association dpmr-mou.org	NXDN Forum nxdn-forum.com	P25 Technology Interest Group (PTIG) project25.org	TETRA + Critical Communications Association tandcca.com

Critical Steps for a System Upgrade

By Mike Stanley


Photo courtesy Selex

When it comes to mission-critical communications systems — purchasing new systems or upgrading — it takes an extremely focused effort to do it correctly. Advancements in communications networks during the past few years are more significant than in the previous 20 years. These changes have also altered the way we approach new system purchases, upgrades and life cycle management. This article's focus is about issues that impact long-term system planning, avoiding the minefields and managing expectations by engaging key stakeholders early in the project.

How do our immediate decisions provide a positive first step toward taking our core communications needs forward and providing the best value and the longest product life cycle possible? Lessons learned, best practices, existing industry talent, and hands-on and technical resources in project planning and execution are important issues to consider. The end result of these efforts is to provide first responders a communications system that is dependable and provides the best support for working in the dangerous environments they encounter every day.

Measure Twice, Cut Once

As the old proverb defines, double-checking before taking action often avoids the need to cut again and lose valuable time and resources. One way this can be accomplished in system planning is to move the focus from five years to 10 years. Life cycles of equipment used to be 15 – 20 years; today it is maybe 10. If you don't look at a system life cycle with this

Forget five-year strategic planning — go for 10 years. This will force the team to think about technology long term from acquisitions to disposition.

perspective, then stock up on parts or you will be in trouble. And remember, some parts of the system become obsolete before others. Forward-thinking strategy engages stakeholders to think through what the system should look like, how it should perform, the cost to maintain, timelines for projected upgrades, technologies that will support growth and budgeting.

One successful planning tip is engaging experts from the user community, both technical and hands-on, who will be impacted by the project. Carefully identify and engage your best and brightest in a forward-looking process. System users understand what their needs and issues are and can provide valuable information. There are excellent processes available for doing this in a methodical way that gets you the best focus, buy-in and ownership of the project. One successful practice in data gathering is to invite key representatives from multiple disciplines and departments to work together with an expert facilitator and explore common and unique needs. There will be tradeoffs, but this activity gets the attention of the user community that the project is not a top-down mandate, but a shared process that supports the interests of all stakeholders. Some issues that can be explored include:

- Coverage needs
- Fleet mapping and talk groups
- Tactical channels
- Dispatch locations and priorities
- Interoperability
- Encryption
- Mobile data
- In-building coverage

For example, in-building coverage is often a requirement in system designs. But the reasons that law enforcement or structural fire may need to visit a building can be different. Use of a bi-directional amplifier (BDA) can enhance signal strength that is attenuated because of frequency, structural design or location of the nearest tower. But if the BDA is damaged in a fire, the coverage is gone. The user would then use talk-around channels, which may require training or a portable BDA or vehicular repeater. Regardless, this user involvement engages stakeholders early and ensures project success.

Rules of Engagement

Maureen Rhemann, senior strategist at Trends Digest, adds some valuable advice for working through a strategy for good decision-making:

- Align the acquisition cycle with technology. Many acquisition cycles are getting longer, not shorter, while technology life cycles are getting shorter.
- Forget five-year strategic planning — go for 10 years. This will force the team to think about technology long term from acquisitions to disposition.
- Don't be blindsided by technology fads or slick marketing. Even though a technology may be hot, the proof is in the implementation. What is the percentage of market penetration and the success rate with the implemented customer sets?
- Don't let overzealous technical staff wanting to be on the leading edge thwart sound business judgment. Get second opinions and engage in due diligence before making a technology investment. There are numerous cases of buying into the leading edge only to have it fail miserably and result in a rapidly depreciating investment.

An additional point is evaluating change as a forcing function. Change energizes, but the goal is to get that energy going in the right direction. Gaining buy-in and ownership from those most affected by system changes is a vital key to project success.

Consultants

If it is financially feasible, there is value in finding a consulting organization with the right credentials to support a system purchase or upgrade. Typically, the larger the project, the more important it becomes to hire consulting services. Knowledge from people who have firsthand experiences implementing or upgrading systems of similar size and complexity will provide value. Identification of the key users and technical resources can be helpful and effective and ease a consultant into the process. Consultants also provide multiple connections that the customer needs for accountability and support of the project from beginning to end.

Consultants can be a valuable resource for governance models, project planning, system baselining, technical evaluations and design initiatives. They can also support request for proposal (RFP) development and vendor evaluations. However, multiple connections in the user and technical community still must be involved in the process. Besides avoiding the top-down perception, user involvement will provide an invaluable asset and put the right infrastructure in place.

While a model is only as good as the participation of the people engaged, lessons learned demonstrate that the absence of governance is even worse.

Selecting the right consultant requires some homework and a careful evaluation of past performance and customer satisfaction ratings. Hiring the most expensive consulting organization may not be the best choice or the best value. There are many good, small consulting organizations with excellent past performance that can provide the right level of service for a system purchase or upgrade. It takes the consultant's ability to work successfully with all the stakeholders at various levels for a successful outcome.

Multiple Users

It is not uncommon for a new system that is being developed to finally get the attention of other agencies such as natural resources, a local sheriff's department, an administrative office or a school system. If multiple users will be operating on the new system, opportunities for resource sharing are possible.

Sharing resources could potentially involve a tower collocation opportunity, shared costs for a new tower build or leasing space to offset operations and maintenance (O&M) costs. For example, designing a system for mobile coverage and later having another department that needs portable coverage request access to the system can be problematic. It is not impossible to overcome, but portable coverage means other types of technical requirements and potentially new tower sites. To mitigate these issues, collect the requirements from key stakeholders while the project is in its earliest stage. This will provide insight to the technical parameters, advantages and limitations. Perhaps in the planning phase, enhancements to design parameters could result in improvements to the coverage for all users, if representative members of the stakeholders were involved. This is where a governance model is important.

Governance as Control

The Interoperability Continuum by Safecom places governance at the beginning of a list of five critical areas — governance, standard operating procedures (SOPs), technology, training and exercises, and usage. There are multiple governance models for local, regional, state, federal and tribal agencies, but essentially its focus provides structure and support for engaging multiple stakeholders with diverse needs and specific

expectations. The continuum provides a framework for decision-making and who is ultimately responsible for managing and maintaining assets. While a model is only as good as the participation of the people engaged, lessons learned demonstrate that the absence of governance is even worse. Another function of governance is to support the development of a mutual vision for a new system or upgrade and move independence to interdependence among agencies and departments. System participation T&Cs, interoperability needs, decision-making, accountability, committee development and future system upgrade requirements all need a model of governance to guide stakeholder involvement.

It is not impossible for public-safety disciplines and jurisdictions to work together to find a common resolution to problems. When proper governance is in place, resolution to issues will be less burdensome, and all interested parties can find an acceptable path forward. Human interfaces should not be supplanted by technology — they should work in harmony.

A Final Thought

There is no perfect answer. We should start with lessons learned, best practices, existing industry talent and include hands-on and technical resources in project planning and execution. A system purchase and implementation or a system upgrade is expensive, time consuming and a detailed undertaking. Nothing can undermine a project of this nature more than not engaging key stakeholders early and thus allowing negative perceptions to develop, including the following common complaints:

- This project is just a top-down mandate.
- What value can I offer? Nobody asked me for my input.
- A consultant was hired, but I too can add valuable information.
- It is your project, not mine.
- When things go wrong, just remember I told you so.

It is often the soft side that gets overlooked, but engaged participants and committed stakeholders drive a project's success.

Mike Stanley is the director of business development for Mindbank Consulting Group. Stanley has worked in LMR since 1996, supporting federal, state, local and tribal system purchases and upgrades.
In addition, Stanley specializes in user group facilitation and needs analysis in support of system designs, implementation and training.

How Standards Drive Interoperability

Mission-critical interoperability cannot be resolved by broadband alone. Project 25 (P25) and other digital radio technologies will continue to provide the primary push-to-talk (PTT) voice solution for public-safety agencies for years to come. Much of the recent attention regarding mission-critical communications has been captured by the future nationwide public-safety broadband network that will hopefully provide the capabilities that public-safety practitioners need to support all of their operational needs.

Until that network is realized, digital radio technologies will continue to provide that capability to mission-critical communications companies throughout the world. During the past 20 years, P25 has improved interoperability among those agencies and continues to increase operability by working with the P25 User Needs Subcommittee (UNS) to increase the features and functions available for mission-critical communications. Broadband may eventually provide the flexibility public safety needs, but that may be years to come.

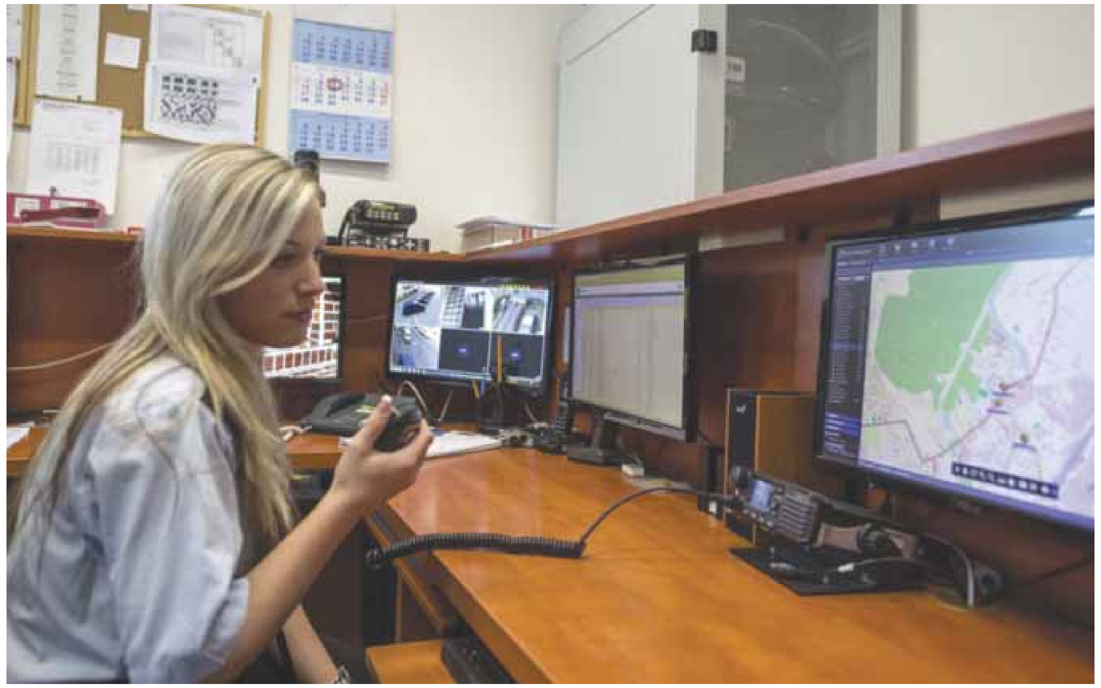
Broadband is ideal for data-intensive applications in infrastructure-rich areas of the country, but broadband may not provide a workable, reliable, secure mission-critical PTT solution in the near or mid-term. Users who look to broadband to solve communications gaps should think in terms of the evolution of LMR as it relates to interoperability, not the revolution that broadband represents. Most agree that mission-critical PTT voice is an essential requirement that now can only be satisfied with some form of digital radio technology that supports radio-to-radio direct, repeater and trunked solutions, which is why it is important to support the standards for the foreseeable future, to enhance interoperability and provide multiple sources with standards-compliant technology. In other words, LMR will be with us for a long time, and we need to continue with a working technology that provides interoperability and cost effectiveness.

Interoperability has changed considerably during the past several decades. Prior to the introduction of trunked communications and digital technologies, interoperability was as simple as sharing frequencies between neighboring jurisdictions. The introduction of digital, trunked communications technologies dramatically changed the way agencies operate. As deployments began in the 1980s, an interoperability gap was created when agencies could no longer communicate with each other depending on the technology they chose. Unfortunately, interoperability took a back seat to new features and expanded capabilities, and the new digital technologies sometimes made communications between agencies more difficult. As technologies improved and more digital systems were introduced, less thought was given to interoperability contributing to the divergence of compatible digital systems, until the introduction of digital standards.

Digital radio standards have created a competitive environment that has improved cost benefits in the digital land mobile marketplace. Users now have more options for competitive procurements of standardized equipment. For example, in 2014, more than 35 companies provided P25 equipment and services, and the manufacturers continue to add standardized features and functions to serve the user needs.

Other digital radio standards are performing interoperability tests among vendors to ensure all products work together. Check the websites of the various forums and associations that promote each technology to ensure one vendor’s equipment has been tested to be compatible with another vendor’s equipment within the same standard.

Dispatch Considerations for Digital Systems



By Sandra Wendelken

One important development in digital radio technology during recent months involves interfaces to connect radio infrastructure to dispatch consoles. Digital radio standards bodies and manufacturers have recognized that the key to interoperability is allowing one radio infrastructure vendor's equipment to work with another vendor's dispatch consoles.

Users have driven demand for console interoperability, along with a 2010 congressional inquiry specific to the Project 25 (P25) standard. With the ability to purchase communications consoles from a different supplier than the company supplying base stations for a network, the system operator can reduce costs.

However, ensuring interoperability between different vendors for infrastructure and consoles isn't always easy. Analog radio interfaces were simple, but digital interfaces have call alerting and encrypted audio so the interfaces are more complex to enable those advanced features.

Radio infrastructure from a hardware standpoint is typically the same but trunked infrastructure includes some additional hardware that enables the trunking features. Console vendors generally have the flexibility to interface with a number of technology platforms. Intellectual property comes into play, and the console vendors must control that issue. Once a manufacturer has the proper license to enable the console technology, it becomes a control feature of conventional or trunked systems.

All the main digital radio technologies are based on Internet Protocol (IP). Extending IP to radio infrastructure can be difficult when a supplier starts to provide the same level of capability available in the analog world. With console products based on an IP backbone, digital radio technology users gain an end-to-end IP connection.

For the buyer, IP technology fosters fewer proprietary hardware procurements. The IP and console interfaces allow more choice and flexibility in terms of which vendors the buyer selects. The operator can pay for only the features it wants to buy. However, the buyer is playing the role of system integrator.

That is where interoperability testing comes in; buyers want to know that all the pieces work together before they buy. There is not a standardized console testing process in the marketplace for any of the standards, however, many radio and console vendors are working together to test their equipment and ensure it is interoperable.

Avtec successfully completed interoperability testing between its Scout 3.2 software and Tait Communications' Digital Mobile Radio (DMR) and P25 trunked radio systems. Omnitronics' RediTALK dispatch console also received interoperability certification after passing DMR Tier 3 tests with Tait. Zetron and Hytera Communications announced successful joint testing of their systems using an interface based on the DMR Association Applications Interface Specification (AIS). The testing involved Zetron's Advanced Communications (AcomEVO) system using the interface with Hytera's Tier 2 DMR system.

On the P25 front, Zetron completed successful testing with its AcomEVO system using the P25 Console Subsystem Interface (CSSI) with Harris' P25 Phase 2 and EF Johnson Technology's P25 radio infrastructure. Zetron, Relm Wireless and Spectra Engineering completed successful joint testing using the P25 Digital Fixed Station Interface (DFSI) to connect to Relm Wireless and Spectra Engineering's DFSI-based repeaters and base stations. Zetron and Simoco completed joint testing of Zetron's MAX Dispatch system using the DFSI with Simoco's P25 conventional network.

Airbus DS Communications has a defined set of P25 tests that go beyond Compliance Assessment Program (CAP) testing, said Marty Christensen,

Airbus DS Communications product area business manager. Those tests include 180 test cases for consoles.

Kenwood and Icom America are the main vendors of the NXDN standard, and Avtec has console interfaces to both of the vendors' NXDN products. TETRA vendors have invested heavily in infrastructure-to-console testing as well.

User Examples

More users are beginning to realize the benefits of the various digital radio console interfaces. Zetron's dispatch system using the P25 CSSI was deployed at the Greater Toronto Airports Authority (GTAA). The new 26-position Acom EVO system installed for the GTAA is serving as the master dispatch console for an Airbus DS Communications three-site, 12-channel simulcast P25 radio solution deployed at the GTAA's Integrated Operations Control Center (IOCC). The result is an open-standards-compliant solution that allows airport personnel to communicate with each other and with emergency responders on other networks in nearby municipalities.

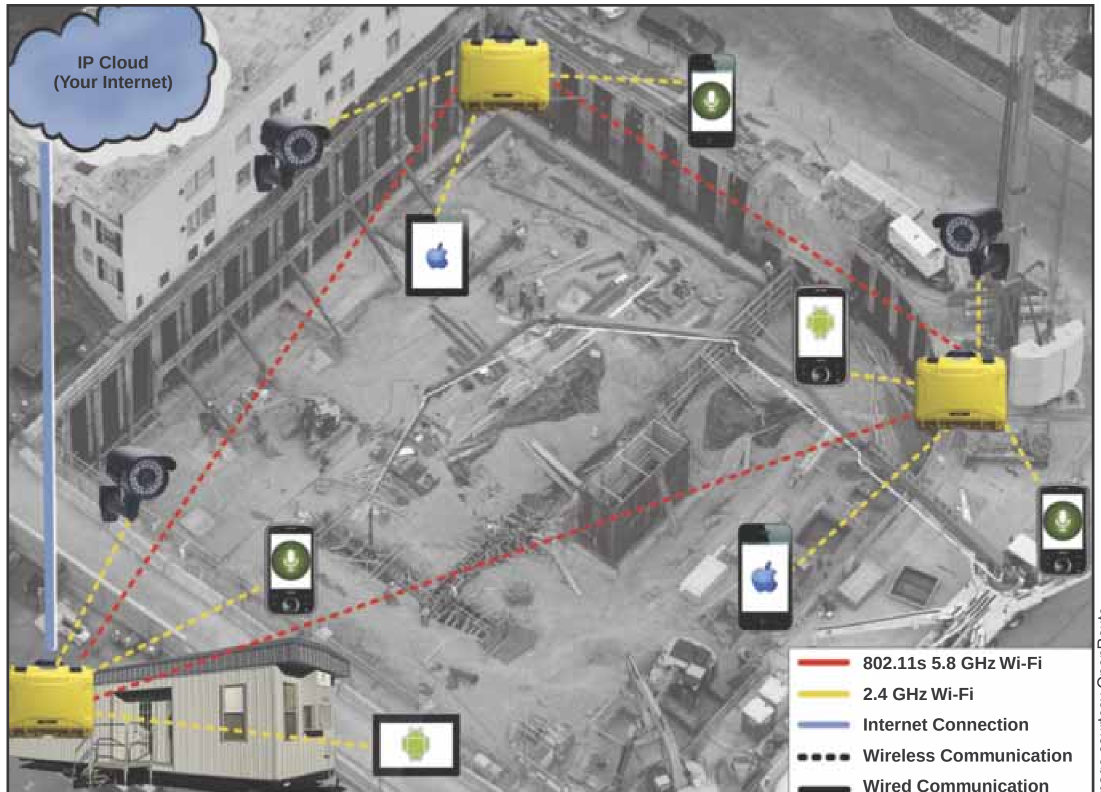
Tait Communications won a multimillion-dollar contract to supply Manitoba Hydro, the province's major energy utility, with an 80-site DMR Tier 3 VHF network. The deal includes about 40 Zetron dispatch consoles, as well as Eventide recorders.

Avtec was granted a contract by Airbus DS Communications to supply 63 consoles that will be used to provide emergency dispatching services for the more than 3 million residents who live in the city of Montréal and surrounding suburbs.

More multivendor networks and interoperability tests will continue in the future. Suppliers have seen the importance of assuring buyers that their products work seamlessly with other manufacturers' equipment. The expanding market for interoperable console equipment will only increase the markets for mission-critical digital radio technologies.

Sandra Wendelken is editor of MissionCritical Communications *magazine.*

The Market for Digital Radio Apps



Open standards make it easy to temporarily extend wireless networks with products such as OpenRoute OnSite Wi-Fi, add surveillance cameras, create on-site communications and bring cloud-based applications direct to the incident site. OpenRoute for the construction industry makes it easy to set up a temporary onsite Wi-Fi network with Android-based applications that support users in positioning the access points for optimum coverage.

By Nickie Petratos

Interchangeable peripherals and software-enabled devices have given consumers and enterprise customers the ability to personalize how they receive media information, communicate with others and configure their homes, workplaces and automobiles. The majority is interoperable because of open standard technologies such as Bluetooth, USB, Wi-Fi and published software development kits (SDKs). These standards expanded the market to thousands of developers and initiated the proliferation of specialized products and information.

LMR serves many diverse industries with users performing a variety of roles in various environments. The user and team requirements can also differ because of geographic regulations or service availability, increasing the need for local support. The descriptors — local, geographic, regional and niche — appear in many LMR customer requirements documents. The industry is diverse and fragmented in its age — analog radios have been used for more than 50 years; its customer base — public safety, manufacturing, utilities, education and any industry with work teams; and its geographic penetration — multiple standards bodies, protocols and regulatory agencies around the world. The need for specific solutions and information has existed for many years and is implemented through "specialty" products requiring costly, unique hardware.

The LMR industry business model offers customization and service by local businesses and vendors, but is based on proprietary interfaces. Therefore many of these applications are limited, use expensive hardware and lock the customer to a single manufacturer. Upgrades, new technologies and new features are less costly to implement as peripherals, accessories and applications. Obviously it is less expensive to purchase applications and accessories than to change out a network or portable/mobile. Each customer's unique situation provides niche opportunities for local, market knowledgeable providers.

There is an increase of application developers and peripheral suppliers at various exhibits and within advertising space. The market need, user demand and vendor innovation for LMR market/customer-targeted applications are acknowledged. There are indications within the standards' committees of initial cooperation among manufacturers.

- The TETRA + Critical Communications Association (TCCA) recognized that a standard interface would best serve customers and has established an application working group.
- The Digital Mobile Radio (DMR) working group includes short data messages as part of the DMR Tier 3 interoperability test features, although optional.
- Project 25 (P25) manufacturers tested and confirmed that their radios could recognize other manufacturers' programming feature sets.

The progression from analog to digital technologies enables software to create customer-specific solutions. Another change is the inclusion of the same hardware, such as embedded GPS, Bluetooth, Wi-Fi, USB and large high-resolution color displays, found in cellular phones. A well-defined software and hardware interface is essential to make this possible. An interface standard will define how the application software will access the command and control functionality of the radio.

The expansion of providers and solutions will have a positive impact on all stakeholders, customers, providers and the industry. A common interface standard would make it lucrative for small, local companies to develop niche devices and applications. The potential LMR applications based on an open, well-defined interface would advance personal and work team preferences, in-service information and cross-team operations.

Custom(er) Solutions

Differentiated solutions are required because of the diverse customer, geographic markets, and operating procedures and situations. LMR users have important jobs and rely on their communications devices. Devices can personalize the experience for an individual or can improve the effectiveness, safety and well-being of a team. Prospective solutions can also link multiple teams.

No matter what the vertical market or industry, an individual has preferences and physical differences. Just as in the consumer world, personal devices and applications can enhance the user's five senses to adapt to a working environment. Popular audio applications such as hands free, voice recognition, audio enhancement, noise reduction and speech to text must be hardened for the harshest of LMR markets. Peripheral devices and applications can be customized for the LMR environment. These solutions can be effective by enhancing performance or removing constraints found in various environments. The common detractor, background noise, is a great example of how a noise-reduction application would be unique for each LMR user even within a vertical market. The surroundings vary among manufacturing equipment, rail yards, airport tarmacs, accident scenes, construction and entertainment events. The most flexible, least expensive, most effective implementation would be at the user level.

Applications can also transform information that an individual doesn't normally sense into a perceptible indicator for the individual, team leader or dispatcher. For example, hazardous material or temperature indicator transforms into an audible piercing alarm and message to the monitoring station; an intruder in a defined locality sends an alarm to a dispatcher; and an accelerometer turns a man-down alert into an emergency call to the commander with location coordinates. These devices and applications will also transform the information exchange into whichever sense the user or situation prefers. Examples are audible to visual, such as text, in

case of surveillance, or visual to audible in case of darkness.

All individuals and teams have unique operating procedures, job equipment, vehicles, work group size, hierarchy and location. The peripheral devices and applications adapt the LMR products to each user's requirements. Every action, detection, function and observation can be enhanced through technologies enabled by a standard interface. With an open, well-defined interface, the creativity of many developers will ensure innovation.

Operational Information

Collected data, such as environmental conditions, location, proximity, health of equipment and personnel, is only useful when it is interpreted and available. Applications turn data into information for the right people at the right time. Application providers understand how users and teams operate and create the information to be most effective. Superior products deliver information to integrate service and perform with the reliability and clarity specific to each team's requirements. Applications can interpret the data into operating instructions for the user or work team or into records for reports, history or logs. Location data can be turned into asset tracking, people tracking and site management. Equipment control data can be turned into status monitoring of trains and work vehicle systems including air conditions, lighting, wheel and brake wear. Subject matter experts in the various markets best develop these applications.

LMR work sites are environments where interactions between people and equipment are highly intensive. Particularly in a stressful environment, the availability of information ascertained from real-time data allows a user to focus on the critical aspect of a job. Tactical information provides intelligence from multiple sources to better understand and manage operations. Applications developed on an open standard would not only increase information to teams, but would also provide collaboration between teams on different devices.

A common interface standard enables service interoperability and fleet management across multiple vendors' products and provides for connectivity to other machine and data devices. Data and service interoperability are important and implementable at a user level. A standard interface allows usability between man and machine, and provides operational and service management usability between different vendors' LMR equipment.

User Interoperability

Vendors have cooperated to design network system interface standards. A natural extension would be to provide interface standards for devices and applications. User applications provide the most flexible, lowest cost and fastest path to interoperability between technologies.

LMR migration from analog to digital trails other industries. Voice interoperability is stressed as a primary objective within each of the digital technologies, but migration has induced friction by the lack of analog legacy features that many institutions built into their operating procedures. Having a standard interface would allow fast-moving developers to create some of these talk management features in the digital technologies. Other impediments to migration are the geographic regional differences in occupational regulations —audio mask and sound pressure levels (SPL) — vehicular standards, energy provisions and intrinsic safety. The majority of these can be addressed at the device user level. A standard interface would expedite geographic-specific solutions. Re-creating the legacy features with the addition of the new capabilities incents migration to digital technology.

The current path to interoperability through purchase of a new network is limited and works for self-contained organizations that use one form of communications technology. Surveys show that the majority of organizations use multiple communications technologies within their operations. In addition to LMR, they have cellular, satellite and wireless LANs. Furthermore, interteam and interagency cooperation is often required. Interface standards targeted at the user and team level could provide a path for interoperability between technologies.

Developers have created applications that provide interconnect between telephony and LMR devices, but these applications are based on proprietary interfaces and are specific to one manufacturer's equipment. Interoperability between teams using different vendor devices is not effectively supported. The capabilities of the digital standards substantially improve the potential of universal equipment compatibility. Because of the nature of digital technology, user-based interoperability may be solved through either voice or data exchange.

The Standard Interface

The benefits that a universal interface offers the market are the reason for its success. Device interfaces adopted by the digital radio standards bodies will enable creation of user-friendly devices and applications that increase the value of LMR products. The customer will have multiple market-specific applications for increasing efficiency using the same peripherals and applications across mixed product fleets. The providers will have new revenue streams. And a standard interface across manufacturers' products makes it easy for small, local vendors to participate in the creation of market-specific solutions.

Within the same technology, there are multiple user roles with different personal and team requirements, operating within different environments. A standard interface allows the use of the same system with multiple devices each customized to these roles.

Interoperability has been stressed as a primary objective of the major protocols — TETRA, P25, NXDN and DMR. A device interface standard would support the interoperability objective. A standards-developed interface would be designed with quality of service (QoS) built in and certified to be interoperable.

Why not change LMR from a technically mature, stable market to a growth market? An interface standard could be the key to making the digital migration a growth opportunity for LMR rather than just a replacement triggered by the useful life of the hardware or regulatory amendments. Instead of keeping it proprietary and taking share, establishing a standard interface that can provide voice and data solutions would make LMR grow beyond the typical voice-centric user.

With the majority of surveyed readers expecting a minimum of 15 years before broadband will replace LMR, a standard interface that fosters third-party applications on current networks is necessary. The creation of solutions on current equipment will expose the greatest numbers of users to operating information and improving effectiveness.

Nickie Petratos is president of SpheraTek, a provider of business and technology services. Prior to 2012, Petratos was vice president, Motorola Solutions. Her contributions include several LMR business and market firsts, including two-way radios designed for the Radius dealer channel and Digital Mobile Radio (DMR) systems and terminals. Additionally, she established and managed global design centers with a population of more than 2,000. These engineering centers supported Project 25 (P25), TETRA, DMR, WiMAX and multiple analog technologies.

Section 2: Critical Infrastructure Industries

The Case for DMR Tier 3

Images courtesy Radiodata

By Max Zerbst and Winfried Schultz

Apart from their core business, utility companies often operate LMR networks to control and supervise their mobile workforces. Especially during power outages, it is essential for an electric utility to have a radio system that still remains available for its work. In some cases, the radio network is also exploited to support wireless supervisory, control and data acquisition (SCADA) applications.

Many of these radio networks used to be conventional or trunked analog systems. However, many new digital deployments are based on the Digital Mobile Radio (DMR) standard and others. DMR is a TDMA radio technology

A DMR Tier 3 trunked radio network owns and administers a number of base station sites as radio cells, and within a radio cell, a number of radio channels.

with two time slots as logical communications channels within a radio channel bandwidth of 12.5 kilohertz. As a specification of the European Telecommunications Standards Institute (ETSI), it is free and publicly available. While the radio coverage area of an LMR network normally will match the service area of a company, capacity requirements are more difficult. Capacity depends on the number of technical facilities, such as electricity, transformer and switching substations, which are distributed over the service area and likely coincide with the population or customer density. Thus, the required capacity will be higher in urban and suburban areas and considerably lower in rural areas.

Scalability is understood as the maximum number of base station sites that can be integrated in an LMR network and the maximum number of transceivers equipped at a site. Other factors contribute to scalability — for example, the control channel in its operating modes in a trunked radio network and whether standard and simulcast sites can be mixed within the same radio network. Furthermore, the availability of spectrum has a strong impact on the design of a radio network. Spectrum is a scarce resource, and regulators normally are reluctant to generously allocate frequencies.

Conventional vs. Trunking

In contrast to a conventional digital system, a trunking air interface offers a larger scope of functionality that simplifies, facilitates and even enforces certain control and monitoring functions of the radio network. Deciding in favor of a trunking air interface, such as DMR Tier 3, is inevitably a decision based on the specific structure and mode of operation for a radio network.

A DMR Tier 3 trunked radio network owns and administers a number of base station sites as radio cells, and within a radio cell, a number of radio channels. The channels are logically divided into a control channel and a number of payload channels for voice and data communications. Mobile stations are using the control channel to register in the radio network, to set up voice and data calls, and to transfer certain data telegrams required for roaming in a multisite network. Because the call setup includes automatic allocation of a payload channel, there is no need for manual channel selection at the mobile station in a trunked radio network.

When using a control channel to coordinate traffic on multiple channels, the trunking effect is an important aspect, which allows serving more mobile subscribers per channel than in a conventional configuration. However, in a radio network with a small number of subscribers in a large area, this effect is of minor importance. The advantages of structure and mode of operation of a DMR Tier 3 trunked radio network prevail.

Nevertheless, the control channel of the DMR Tier 3 air interface is a key feature because of its several modes of operation:

- A dedicated control channel is firmly assigned to this function, operates permanently and is used for a site with a larger number of channels;
- A composite control channel is non-dedicated and may also be used as a payload channel on demand. It is applied if the peak capacity requirement is anticipated to exceed the payload capacity installed; and
- An in-active control channel is operating asynchronously. In this operation mode, all signaling on the control channel is completely suspended, and it requires the mobile station to send a “wake-up” call prior to setting up a call.

The control channel also opens special options to perform data transfers. Data transfer over the control channel secures fastest delivery. Up to 127 status messages with pre-defined meanings can be exchanged between mobile subscribers in a radio network. Also, short data messages up to a maximum of 367 bits (equal to about 45 bytes) can be transferred via the control channel.

A further advantage of a trunked radio network is its switching function and its interfacing capabilities, incorporated in a switching subsystem that controls and monitors the entire radio network and handles the integration of a mobile workforce into the voice and data communications of an organization. Most important is interfacing to a private branch exchange (PBX) for voice — via four-wire E&M, integrated services digital network (ISDN) and VoIP — and to a local area network (LAN) for applications such as fleet management and interconnecting to control centers. Access to the public-switched telephone network (PSTN) can normally be facilitated via a PBX.

Finally, a trunked radio network provides network management functions designed for all technical and organizational purposes of a radio network.

When the density of mobile users in an area is low, there is a trade-off cost of base station equipment against the number of frequencies to apply for.

Hence, it serves to establish the operability of the radio network and ensures its availability during operation. In general, it provides tools for configuring all components of the radio network, monitoring the operation of the radio network, fault management, and administering mobile stations, mobile subscribers and mobile talk groups.

Fault management permits the fast detection and localizing of faults by means of alarms and information about the operational status of network components. All important operational events, including access to network management as well as all call data, may be recorded and retrieved at any time and used for statistical purposes. Most functions and features of a trunked radio network show a clear predominance over a conventional system.

Radio Coverage vs. Frequencies

A DMR Tier 3 trunked radio network may be operated in all commonly used frequency bands, from low VHF up to UHF. When replacing an existing analog radio system with a DMR Tier 3 system, some regulators even allow allocated frequencies to be kept. This can substantially reduce cost when re-using existing sites with power supplies and antenna installations. Apart from this cost advantage, it is generally beneficial to operate the radio network using lower frequencies because this can minimize the number of radio sites required for a given coverage area.

Capacity Requirements

The number of mobile users and their calling behavior determines the required capacity for the coverage area of a site. Depending on call type (individual, dispatch and group call) and mode of operation (semi-duplex or duplex), the duration of a call on average may differ between 15 seconds and several minutes. This directly influences the number of radio channels and the operational mode of the control channel at a base station site. In practice, a base station site is scalable between one and eight radio channels, i.e. transceivers receiving the uplink and transmitting on the downlink frequency. Thus, a pair of frequencies separated by the duplex distance is needed to operate a single radio channel.

When the density of mobile users in an area is low, there is a trade-off

cost of base station equipment against the number of frequencies to apply for. So it depends on the regulator and its allocation decision whether standard or simulcast equipment must be installed. The cost for simulcast is almost twice as high as standard equipment.

Nevertheless, for a larger area of low mobile user density, a user can either install sites with just one radio channel with a nondedicated or inactive control channel all configured with different frequencies, or for the same number of sites, install simulcast equipment, each with an identical set of frequencies. The control channel may then either be dedicated or nondedicated.

It is important to understand that both standard and simulcast equipment use the same air interface protocol. With a DMR Tier 3 trunked radio network, all simulcast sites together will be handled as one logical cell. In an urban area with a higher mobile user density, standard equipment for base station sites is generally the preferred choice. Facilitating a maximum of eight radio channels at a base station site, including a dedicated control channel, even high urban capacity requirements can be fulfilled.

Service and Safety

Radio coverage always is first when discussing radio service availability. In addition, redundancy measures must be taken to maintain operation of the network in case of technical failures. That includes, for example, a second switching subsystem as hot stand-by and linking to base station sites in a ring configuration. Both measures can substantially improve service availability.

Usually mobile stations for VHF frequencies are built into vehicles and are used in them. To enhance the coverage outside the vehicle, a digital enhanced cordless telecommunications (DECT) solution connected to the mobile station can be used. The cordless DECT phone with almost the same user interface as the mobile station enables mobile users to enter hazardous workplaces without waiving voice communications.

Most important is the emergency call function. An emergency call must work under all circumstances, as long as radio coverage is provided. This must be independent from the availability of the control channel and must work when a site is equipped with only one transceiver and both logical communications channels are in use. In this case, one logical channel will be cleared and allocated to the emergency call.

Frequency allocations have a strong impact to what extent standard sites or simulcast sites have to be deployed, therefore again challenging scalability.

Conclusions

When going digital, a DMR Tier 3 trunked radio network is a good choice to replace an existing analog conventional or trunked system. Control channels at each base station site process roaming data and call setup requests of mobile users in the network. The versatile modes of operation facilitate the fine-tuned adaptation to capacity requirements and thus contribute to scalability. Call setup includes automatic allocation of a payload channel, avoiding any manual channel selection at the mobile station by a mobile user.

Frequency allocations have a strong impact to what extent standard sites or simulcast sites have to be deployed, therefore again challenging scalability. Technique, control channel mode and number of transceivers equipped are chosen site by site. However, simulcast sites with the same set of frequencies are handled by the trunked radio network as one large single cell.

A DMR Tier 3 trunked radio network comprises base station sites and a switching subsystem with interfaces to PABX/PSTN and LAN and integrated network management functions. The structure and network management functions facilitate full control and supervision of the entire radio network, maintaining its operability and high level of radio service availability.

Finally, safety-related features are important aspects in the design of a DMR Tier 3 trunked radio network. Apart from good radio coverage provided for mobile stations built into vehicles, coverage may be enhanced by an integrated DECT solution permitting users to leave the car without losing radio contact. The emergency call is pre-emptive in case all channels are in use, and with sufficient radio coverage, will work under all circumstances, even without a control channel.

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Winfried Schultz is sales and marketing director at Radiodata located in Berlin and chair of the Marketing Working Group of the DMR Association. He has a degree in electrical engineering and more than 20 years of experience in professional mobile radio (PMR) and the electronics industry.

TETRA Takes Flight at LAX

By Sandra Wendelken

Photo courtesy Bill Arthur of Arinc

When Los Angeles International Airport (LAX) announced that the new Tom Bradley International Terminal would be located between the tower site of the airport's mission-critical communications system and the network's users, interference was just one in a set of challenges for the iDEN network.

"The construction of the new international terminal was creating interference issues with the signal," said John Monto, Rockwell Collins director of radio technology solutions. Rockwell Collins, which acquired Arinc in 2013, supplies the airline and aviation ground-based mission-critical communications network for the Los Angeles airport, along with 22 other airports across the country.

"Our customer base is primarily those that support flight operations," he said. "We really need to have good coverage at the gates. The new terminal is situated between our current LAX site and our customers, which really concerned me. Reliable service is important, so this situation was a big driver in investing in a second site."

The new Tom Bradley International Terminal opened in September, and the new 800 MHz TETRA network went live in December following system testing. The network replaces iDEN technology, which Motorola Solutions is phasing out. The 800 MHz iDEN system was deployed in 2001 to support multiple users, including airline ramp area personnel, airline passenger services, ground handlers, terminal security teams and all airport ground support staff, such as baggage handlers and caterers.

"Our current site is located on the east side of the airport," Monto said. "Since we elected to put TETRA in, we used the opportunity to expand our coverage and added a second site on the west side of the airport. This really gave us a nice footprint, which covers the whole airport."

LAX is one of the largest airports that Rockwell Collins services, while the San Juan, Puerto Rico, and Honolulu airports are two of the smallest. Selecting a new technology was necessary for LAX, and the air transportation communications firm is now investigating options at the other 22 airports.

"We do currently hold spectrum at 22 other airports; however, each location is different so we will evaluate what makes sense for each, but we have not established a timeframe," Monto said.

The Los Angeles upgrade is part of a partnership with TETRA supplier PowerTrunk. The partnership represents the first North American deployment of the technology in the aviation market. TETRA's benefits for LAX included voice clarity for radio communications, improved RF spectrum efficiency with multiple simultaneous conversations and an open standard that optimizes total cost of ownership.

"While TETRA is not a new technology, there is a learning gap here in the United States," Monto said. "PowerTrunk has been very helpful in closing that gap, and helping us get to where we are with LAX.

"For those considering TETRA, a point to remember is that the technology is not new. It's been around since the 1990s and is deployed in 140 countries around the world. The robustness of the system and the successful performance history made it a low-risk proposition for LAX."

NXDN-Based SMR Targets Oil and Gas

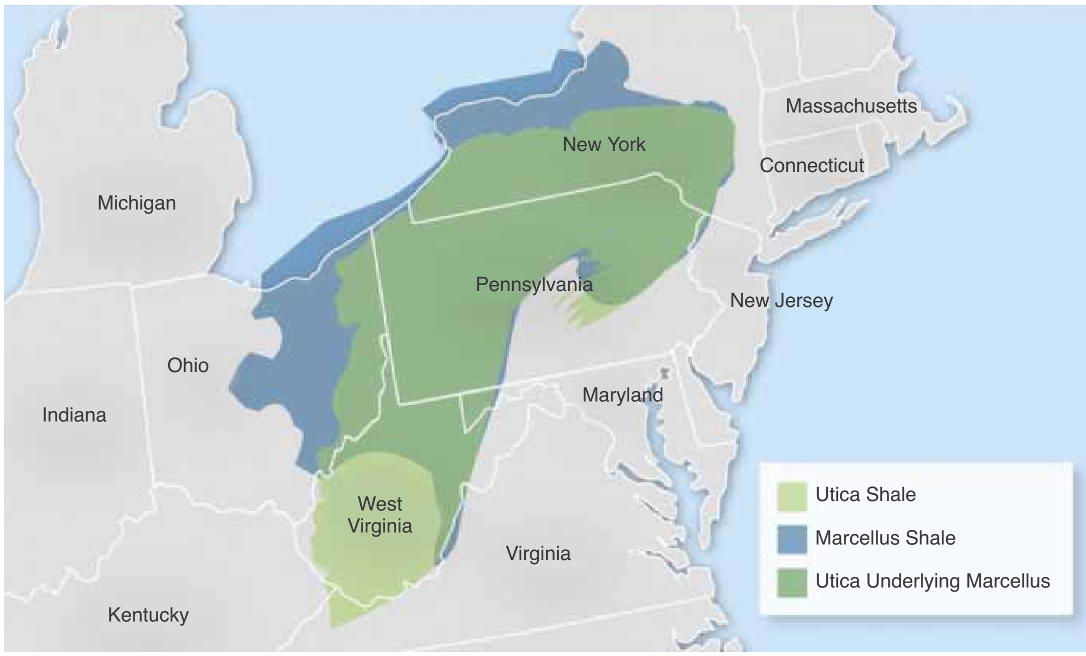


Photo courtesy Marcellus Shale Coalition (MSC)

By Bruce Barton

A Pennsylvania company needed to develop a cost-effective system to provide mission-critical communications covering multiple counties and states, many of which don't have cellular phone coverage. The system needed to communicate 24/7 with near public-safety quality of service and provide reliable 24/7 service with backup power and redundancy on key elements.

The Keystone Digital Network (KDN) was developed from an existing network of two-way radio dealers that were in the areas to be covered. In the end, Deployed Communications and Technologies (DCAT) built the system with assistance and cooperation of Long Communications, another two-way radio dealer in the Troy, Pennsylvania, area.

During a two-year period beginning in 2011, eight primary mountaintop repeater sites were installed in northern Pennsylvania. Three of the sites were Internet connected using DSL from a local phone company. Because of the remote locations, some sites were connected by a 5.8 GHz microwave radio system to the hub location in Troy. After fighting with poor DSL connections, a phone company at one of the major sites provided a fiber connection to support the system in that area. With a single point with a good Internet connection,

Wide-area trunked digital radio systems can now be offered in the $15 – $20 per month range for many companies, making two-way radios again attractive to many businesses.

staff expanded the microwave backhaul system to connect five of the repeater sites.

However, two of the sites had no DSL, cable or other Internet access available. After testing several different 3G and 4G Internet modems, Cradlepoint cellular modems were deployed to two sites with Verizon Wireless service and one site on the AT&T network, and one site operates via a cable modem. The modems proved effective and relatively cost efficient using only a couple of Gigabits per month of data access. There is also a portable trailer site with Verizon 4G data access.

Customers and Coverage

The NXDN equipment is providing wide-area multitrunk digital radio coverage to the three primary counties — Bradford, Tioga and Wyoming counties in Pennsylvania — where the Marcellus Formation of shale gas deposits are found. The gas companies use a variety of contractors to locate the best places to drill for the gas, and drilling rigs are required to drill wells. Companies that perform the fracturing of the wells, site development and build the pipelines to take the gas to the market are among the clients of the network.

The hardest part of selling a system to the oil and gas industry is that because many of the companies and workers come from other states where gas and oil production has been a staple for years, reaching these companies and their decision-makers proved to be a daunting task. Local gas-related trade shows helped open a few doors into the industry.

The gas industry recognizes the need for two-way radios because coverage in many of the areas that hold the Marcellus gas are remote and have little or no cellular coverage. The NXDN-based network with its interconnected trunked radio sites meets the needs of the gas industry clients. The network is still expanding to cover western Pennsylvania and Ohio gas and oil areas.

Because many of the gas companies and their subcontractors had to provide coverage across a multicounty area, their offices could be as many as 100 miles from where their employees are working. The multiple Internet-connected trunked repeater sites provided coverage in their home area, as well as areas as far as 100 miles away. Some companies' home offices are located in areas outside of the radio system coverage, but they can still connect to the areas where employees are working via IP-connected virtual consoles on computers, allowing the same functionality as if a radio was placed in their offices on the network.

KDN's largest gas company client had a unique situation and wanted its employees to communicate on a portable when out of the vehicle at a compressor or gas well site and to send a lone worker alert if an employee didn't respond within a given amount of time.

The network was built as primarily a mobile coverage system, and portables didn't have coverage in many of the areas where the gas wells were being drilled. The solution was to use Pyramid Communications mobile in-band repeaters in the company's fleet of pickup trucks, and this allowed an employee to carry a portable that would talk to a truck's Pyramid radio, which was then relayed back through the truck's radio into the trunked radio system. The portables had to include a lone worker feature because many workers are on the sites alone for many hours. This required the operator to reset the radio every hour to prevent an automatic emergency signal being sent to the company's dispatch center that can result in an additional worker being sent to the location. After a few months of testing, a satisfactory working interface with the mobile repeater was achieved, overcoming problems with the audio and a reliable triggering of the lone worker function from the portable to the trunked mobile, which allowed for the portables to function in a manner that met the client's safety department's satisfaction.

Changes and Challenges

A few changes in the industry have driven the need for businesses to return to the use of two-way radios. Several years ago, the cost of cellular phones was at an all-time low with businesses able to get a cell phone for as little as $10 or even free and monthly service in the $10 – $15 range with shared pools of minutes. That trend has now swung the other direction where the cost of an employee phone is averaging $25 – $45 a month depending on its options and capabilities. Wide-area trunked digital radio systems can now be offered in the $15 – $20 per month range for many companies, making two-way radios again attractive to many businesses. The gas and oil industries in areas such as northern and western Pennsylvania where cell-phone coverage is virtually nonexistent have returned to two-way radios as a primary means of contacting their employees in the field and providing communications during an emergency.

Several challenges were addressed over the years as the system was built. The first and biggest challenge was that the multitrunk system was new

technology, based on the NXDN protocol. KDN was one of the first major systems built in the United States with the new technology, so staff had to help resolve growing pains and developmental issues in the technology.

Another major issue that developed within the first year was that the Cisco small office virtual private network (VPN) solution used to connect the sites developed issues with its battery use for memory and the way it handled the traffic between the sites. Within about a year of the installation of the VPNs, the batteries died and lost connections. The solution developed with ICS Technologies was a custom-owned VPN server designed and tweaked for radio over IP traffic. The system used a centralized VPN server at a commercial server farm to connect each of the Mikrotik VPN routers to each other. A major side advantage to developing the VPN system was that it's able to negotiate its connection from behind virtually any kind of Internet connection and has been tested with both 3G and 4G, DSL, cable and multiple types of satellite Internet connections. This allowed the company to run one of the trunked repeater sites off a permanent satellite connection because of the lack of Internet providers or even cellular Internet service in the area of the site. An additional advantage to the VPN system is that the locations don't have to have static IPs assigned by the Internet provider.

The NXDN trunked system offers business and industry the capability of communicating across multiple locations in multiple states — even on different continents — with the use of Internet linking. The network covers parts of Pennsylvania, New York, New Jersey, Ohio and West Virginia. Interconnected trunking allows the user to have multiple talk groups dividing larger businesses into clusters based on functionality, location and the importance of their business activities. Such things as lone worker, man down, GPS tracking and remote PC-based consoles all add to the attraction of digital trunked repeater systems.

Bruce Barton started his communications career 42 years ago in high school using CB radios and installing them in cars as a land development salesman for a local Radio Shack dealer. He expanded into commercial communications in the early 1970s as a civil defense communicator and member of search and rescue (SAR) team. He has developed interoperability and disaster communications training programs.

Section 3:
Private Wireless/Enterprise







NXDN Serves Private Wireless Firms

By Sandra Wendelken

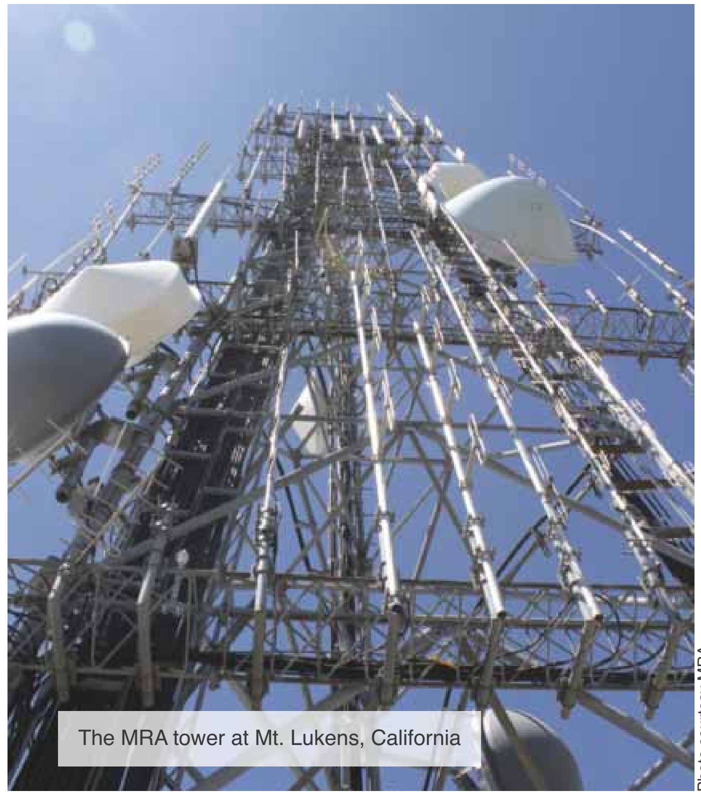

The MRA tower at Mt. Lukens, California

Photo courtesy MRA

SMR networks, which offer commercial two-way radio service to customers across mission-critical vertical markets, ramped up in the 1980s. However, subscriber numbers began to decline during the 1990s and 2000s. As cellular operators offered monthly flat-rate pricing and included features such as caller ID and messaging, many SMR subscribers jumped ship to commercial services. In addition, Nextel Communications purchased many SMR operators and stole customers from those that remained with its push-to-talk (PTT) service and nationwide coverage.

The situation has reserved itself in many ways in recent years. Sprint acquired Nextel, and the Nextel Direct Connect service, which once had the highest average revenue per user (ARPU) in the industry, no longer exists. Digital technologies have had a deep impact across the mobile radio communications industry in recent years, but an unexpected effect has been on the SMR market. Digital trunked technology allowed analog SMR operators to upgrade to digital and connect sites and networks to offer area-wide services, along with enhanced features that customers are accustomed to with mobile phones.

Two SMR operators, Mobile Relay Associates (MRA) in California, and Diga-Talk operated by A Beep in the Chicago area, have built digital networks using NEXEDGE technology from Kenwood. Both operators are experiencing growth by increasing customer numbers, adding sites and extending coverage areas.

"The radio does fit that industry that used to depend on the Nextel Direct Connect. There is a lot of Direct Connect business that is coming back to radio."
— Frank Anderson, Diga-Talk

The Diga-Talk network has increased to 25 sites in Illinois, and the company recently agreed with five dealers in Wisconsin that offer NXDN services through 15 sites to marry the systems and offer a contiguous footprint across the two states. Users from Illinois can seamlessly roam on the Wisconsin networks, says Frank Anderson, partner with A Beep.

"The technology is so good, we're able to add these sites and make this large geographic footprint that never existed before in the SMR business," Anderson says. "It was all single-site stuff before."

MRA's California network has coverage from Ventura to Palm Springs and from Bakersfield to the Mexican border with 24 sites. The company plans to expand to 30 sites by the end of the year. There are some gaps in the coverage area, in Santa Barbara and San Luis Obispo for example, but the system has 170 channels on the air.

Both operators use Kenwood equipment exclusively, although both executives are intrigued by the announcement from Icom and Kenwood to offer products under each other's NXDN trunking protocol. The NXDN suite of standards includes two trunking protocols. Type C, offered by Kenwood under the NEXEDGE brand, is a control channel-based trunking architecture. Type D, offered by Icom under the IDAS brand, is a distributed logic-based architecture.

The Customers

The customer bases are where the largest differences lie between the two businesses. The state of Illinois enacted laws that ban cellular phone use in commercial motor vehicles and in all vehicles in construction and school zones. And in January 2012, the U.S. Department of Transportation (DOT) enacted rules prohibiting commercial drivers from using handheld mobile phones while operating commercial trucks or buses. These new laws have heavy fines not only for the driver of a commercial motor vehicle but also for the company owner.

The Diga-Talk unit is exempt from the laws because it is classified as a two-way radio, Anderson says. "Business users are coming back to radio because it makes more sense," he says. "Two-way radio is legal. You can't

"It's a very different market than it used to be in the 1980s when SMRs first came into existence. The level of expectation from customers has grown with the advent of cellular networks and smartphone applications."
— Mark Abrams, Mobile Relay Associates

have a cell phone in your hand [while driving]."

Diga-Talk has also enjoyed an influx of customers from small companies such as heating, venting and air conditioning (HVAC) and landscaping firms, in addition to schools, ambulances and limousine firms.

"The radio does fit that industry that used to depend on the Nextel Direct Connect," Anderson says. "There is a lot of Direct Connect business that is coming back to radio."

MRA serves a large number of towing and cement companies, as well as construction, trucking and ambulance firms. In California, the federal DOT law isn't being enforced yet, so MRA hasn't seen as many customers coming to its SMR network for that reason. However, states must begin enforcing the law by January 2015 to keep federal funding.

"We know enforcement is going to ramp up; it's been lax to this point," Mark Abrams, MRA partner, says. "A lot of people have the attitude of 'When they start enforcing it, I'll worry about it.' "

MRA hasn't yet enjoyed a mass transition from the cell-phone industry either. "We expect that there is going to be more of an exodus from cellular to two-way radio, not that we expect a landslide, but we expect it to increase," Abrams says. "We aren't in the cellular business, and we didn't have contact with those companies with Nextel phones, so we didn't have the opportunity to sell to those people."

Regardless, both networks continue to add subscribers with numbers in the thousands. "It's a very different market than it used to be in the 1980s when SMRs first came into existence," Abrams says. "The level of expectation from customers has grown with the advent of cellular networks and smartphone applications out there. What worked perfectly in the 1980s, still works perfectly but customers don't want it because it doesn't have enough bells and whistles."

The Applications and Marketing

Voice is certainly still king for SMR customers, but many are using GPS

and AVL data applications to track fleets. One MRA customer is running credit card data with the NXDN system through a custom interface. NXDN radios have an RS232 serial interface, and the credit card transactions require IP connections. A software programmer who was familiar with IP and radio wrote a program to convert the serial connection to IP and back, as well as account for the data speeds of the NEXEDGE system.

Some Diga-Talk customers with CAD systems are sending dispatch messages directly to the radios. A portion of Diga-Talk subscribers also take advantage of AVL and GPS tracking with the network.

Word of mouth is an important marketing tool, but postcards have also worked well for Diga-Talk. The company also does cross marketing with other dealers. MRA uses Internet advertising and some phone book ads.

One feature and customer expectation that both SMRs copied from cellular operators is flat-rate pricing with unlimited airtime. "We don't have any telephone interconnection, so it's really a PTT device, but it is very easy to compete because we're offering flat-rate monthly bills and unlimited airtime," Anderson says. "We have private users and group communications. The dependability is there. The fact that the driver doesn't have to think about switching sites or systems is key. The radio is automatically controlled by the system, and it just works."

Both companies anticipate further geographic expansion. Market dynamics are helping put SMRs back on the map, and operators are enjoying the revival.

Sandra Wendelken is editor of MissionCritical Communications *magazine.*

Georgia Utilities Embrace TETRA

Photo courtesy Diverse Power

By Sandra Wendelken

After years of waiting for TETRA technology to become a reality in the United States, the first SMR network based on the European-originated standard launched in western Georgia. The network, a joint venture between a regional utility and a mobile radio communications dealer, will service the utility's workers, as well as public-safety and other users.

Diverse Power, based in LaGrange, Georgia, is a member-owned electric cooperative that provides electric energy to Troup, Harris, Heard, Meriwether, Muscogee and Coweta counties in Georgia and Chambers County in Alabama. The utility worked with Dean's Commercial Two-Way to launch service on the TETRA network in 2014.

At the end of 2013, eight sites of the 13-site system were in test mode. The ninth site went online in January, with sites 10 through 13 beginning service in the first half of the year. The network began as eight sites but after Diverse Power purchased Pataula Electric Membership Cooperation (EMC), based in Cuthbert, Georgia, the network expanded.

Dean's Commercial Two-Way had test radios on the network and performed optimization, said Dean Ginn, the owner of the dealer business. About 175 Diverse Power subscribers will be added in the first phase, increasing to 250 Diverse Power customers total.

**"We put gateways into our system so we have interoperability with any of our constituents."
— Dean Ginn, Dean's Commercial Two-Way**

The network is using 450 – 470 MHz spectrum, with a combination of channels the cooperative previously owned and additional paging channels the utility acquired. The utility transitioned from a 220 MHz MPT 1327 two-site network. "They needed more feature sets and a greater coverage area," said Ginn. "The MPT network didn't give them what they needed."

The Harris County Sheriff's Department, EMS and volunteer fire departments will add 425 subscribers to the network. The law enforcement and EMS officials are switching to the TETRA network from an 800 MHz analog trunked system. The fire departments are on an analog VHF network. Interoperability with other public-safety agencies won't be a problem for Harris County officials, Ginn said. "We put gateways into our system so we have interoperability with any of our constituents," he said.

There is a gateway in place for an existing 800 MHz system that services a four-county area. All hospitals in the operating area will be given TETRA radios dedicated to the network. The outlying areas with existing VHF equipment have an interoperability channel they can use and be patched onto the TETRA network.

Project 25 (P25) currently isn't deployed by any public-safety agencies in the mostly rural Diverse Power operating area, about 60 miles south of Atlanta, Ginn said. "Should it be deployed in this area, we can work with them and add a P25 gateway," he said.

The utility had data needs for supervisory control and data acquisition (SCADA), which TETRA fulfilled, along with other robust features and redundancy. The utility contracted Hytera Communications for the network infrastructure and radios.

"The price point for what we're getting is much cheaper than the other technologies we looked at, and the scalability for future growth is the key to it," Ginn said. "The network goes from one to many. It led us back to TETRA all the way around."

Dean's Commercial Two-Way has been in business 18 years, running community repeaters and trunking systems. The business also operates a multisite Digital Mobile Radio (DMR) network, also supplied by Hytera, for non-public-safety users including a school district. The Harris County public-safety agencies originally planned to use the DMR network.

“Our priority was good coverage for portables, and one thing we’ve been pleasantly surprised with is that the voice quality is amazing.”
— Jay Kenyon, Cobb EMC

“When the Diverse system came up and they reached out to us for a public-safety-grade systems, it was a good opportunity for Harris County and Diverse to share resources,” Ginn said. “We showed them the resources, feature sets and range.”

Several other EMCs in the state with about 300 to 400 subscribers each are looking to join the Diverse Power network. The network has capacity for 4,000 subscribers and is scalable. “Our goal is to build out as much of this area as we have licensed,” Ginn said. “We’ll be expanding during 2014 and 2015.”

“The goal is to get a regional, interoperable system in play,” said Ginn. “We are licensed to expand through middle Georgia.”

Private Utility Network

In 2013, Cobb EMC, located north of Diverse Power and based in Marietta, Georgia, signed a contract for a four-site UHF TETRA system and 315 subscriber units. The utility will deploy a fifth site as a mobile site that the utility can deploy during critical events to ensure coverage, said Gary Lorenz, Hytera vice president of sales.

The four-site system went live in 2014. “Our priority was good coverage for portables, and one thing we’ve been pleasantly surprised with is that the voice quality is amazing,” said Jay Kenyon, Cobb EMC associate vice president of communications systems. The utility is transitioning from a 900 MHz EDACS network. Because there are P25 public-safety users in Cobb’s operation area in Cobb, Bartow, Cherokee, Fulton and Paulding counties, the EMC plans to add a P25 gateway so dispatchers can communicate console to console. Steve Macke, principal with consulting firm Advent, provided consulting services on the upgrade.

The project is 25 percent under budget, even after building a tower the utility wasn’t planning to build, Kenyon said. Cobb EMC owns one tower, shares a tower with Cobb County, and leases space on the other two towers, one with an adjoining county and one through American Tower.

The company also added a 3.65 GHz microwave backhaul network with equipment from Fluidmesh. The backhaul network has the benefits of using

licensed spectrum and a small antenna footprint, Kenyon said.

Cobb EMC’s distribution system consists of 9,101 miles of line across 1,414 square miles. With more than 195,000 meters served, Cobb EMC is one of the largest of Georgia’s 41 EMCs. The utility is planning to add data capabilities once the voice network is operational.

“We’re very interested in data,” he said. “For our SCADA and automation, TETRA seems to have a quick latency time between setup and disconnect. It’s good for quick bursts of data.”

Both Ginn and Kenyon have hopes of expanding their respective networks to regional or statewide systems, making TETRA in Georgia a topic to watch.

Sandra Wendelken is editor of MissionCritical Communications *magazine.*

Section 4: Public Safety

A Quarter Century of Project 25 Milestones

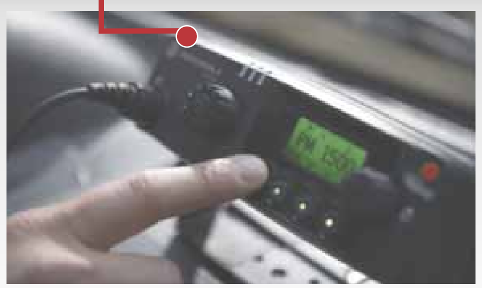
25 Years of Project 25

By James Downes and George Crouch

On a warm day in October 1989, the top technology experts from federal, state and local government agencies and organizations met in a conference room in the Herbert Hoover Building at the U.S. Department of Commerce for the "Advanced Technology Seminar" to address the future of public-safety communications technology. Little did they know how much of an impact they would have on public-safety communications during the past 25 years and for the foreseeable future.

At that time, mobile radio technology was just beginning to advance into the digital world. Cellular phones were still analog and LMR technology for business and government had been thrust into the digital world without much thought about standards. The Association of Public-Safety Communications Officials (APCO) International was determined to enhance its APCO Project 16A trunking recommendations that only described functional requirements to include cross-manufacturer interoperability through the development of a detailed technical standards suite. Another organization, the National Association of State Telecommunications Directors (NASTD) was also interested in developing the capability to provide additional procurement sources for radio systems and provide interoperability, especially for statewide public-safety and public-service systems. In a parallel effort, a federal government committee had been working to standardize digital radio technology for federal agencies.

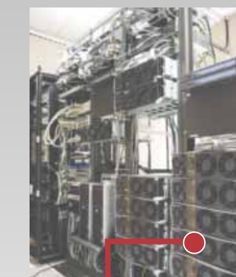
1989 First meeting about a common digital standard



1992 Committees and subcommittees established

1995 Phase 1 Common Air Interface (CAI) standard completed

2008 P25 Compliance Assessment Program (CAP) charter executed



2010 First commercial ISSI tests in Dallas

2012 Phase 2 TDMA trunking standards published

2014 P25 radio programming spreadsheet published

A major concern was that digital trunked technology be standardized to allow for interoperability among systems provided by different vendors. This concern was exemplified in the 1980s when two major vendors provided incompatible digital technologies, although both solutions were compliant with the published encryption standards.

The common goal of all participants in the initial 1989 meeting was to provide an organized means for public-safety communications to migrate from analog technology to a digital conventional and trunked environment. Some manufacturers were already producing digital radio systems that were not interoperable. If that trend were to continue, many of the goals of this first meeting could not be realized. The results were promising as the participants agreed to continue to meet, developing a partnership that has lasted 25 years. What began in 1989 is now known as Project 25 (P25), a successful suite of standards for interoperable digital voice communications. The initial goals seemed intuitive, and the technology leaders believed it would be a process that would last four or five years, but the process quickly turned out to be quite complex. The five initial principles of P25 were:

1. Interoperability
2. Spectral efficiency
3. Competition in system life-cycle procurements
4. Graceful migration (backward and forward)
5. User-friendly equipment

The framework for the standardization of digital public-safety communications was developed at this initial meeting. As a user-driven effort, standards would be based on user requirements, rather than what current technology could provide. As the effort progressed, the manufacturing industry, through the Telecommunications Industry Association (TIA), became a key partner, providing necessary technical knowledge.

The Early Years

Organizing partnerships was a key element in the early years of P25. After all, this was the first public safety user-driven LMR communications standards effort. The original partnership was formally organized into a Steering Committee. The Project 25 Steering Committee was composed of three representatives from APCO, three representatives from NASTD, and three representatives from the federal government: one each from the National Communications System (NCS), the National Security Agency (NSA) and the National Telecommunications and Information Administration (NTIA). APCO and NASTD each provided an additional

The common goal of all participants in the initial 1989 meeting was to provide an organized means for public-safety communications to migrate from analog technology to a digital conventional and trunked environment. Some manufacturers were already producing digital radio systems that were not interoperable.

representative to serve as co-chairs of the Steering Committee. A number of meetings were held during the next several months to further define the project. As in the first meeting, the manufacturing community was interested in assisting the Steering Committee with technical standards development.

The P25 Steering Committee worked closely with public-safety users and the manufacturing community for the next several years to develop a process and a validation method for creation of the required standards. Although the Steering Committee and its subcommittees were staffed by well-qualified and competent leaders and technologists, it quickly became evident that a formal partnership with the communications industry would be beneficial to ensure the success of the effort. In these early days, the partnership was formalized in a memorandum of understanding (MoU) called APCO Project 25 or APCO/NASTD/FED Project 25. About 10 years into the project, the name was shortened to Project 25, in recognition that the project had increased in magnitude significantly beyond just APCO.

The MoU

By 1992, the P25 Steering Committee participants, in coordination with other user and manufacturing representatives, had detailed how the public-safety user community could work with the communications industry to develop the suite of P25 standards. The effort was organized into the following committees and subcommittees to manage and staff the effort:

- The P25 Steering Committee: Responsible for managing the process, providing leadership and guidance.
- The User Needs Subcommittee (UNS): Responsible for developing user requirements.
- The APCO Project 25 Interface Committee (APIC): Tasked with developing collaborative recommended standards by working with users and manufacturers.

- TIA 2 TR-8 Private Radio Engineering Committee: Tasked with publishing the collaborative standards documents as P25 and American National Standards Institute (ANSI) standards.

These committees were made up of a number of subcommittees, task and work groups, that addressed specific subjects, as required.

In April 1992, an MoU was signed between the co-chairs of the P25 Steering Committee, the respective presidents of APCO and NASTD, and TIA. The MoU formalized the process and procedures for the development and publication of a series of TIA-102 standards. The P25 Steering Committee reviews and approves the standards as P25 endorsed documents.

The MoU defined the P25 standard as a cooperative effort between the users (APCO/NASTD/FED) and industry (TIA). It specified how the standards were developed from user-defined requirements, as well as the relationship between the user community and industry. It also addressed the important aspects of intellectual property (IP) rights essential to the development and adoption of an effective standard. A supplemental MoU was executed in 1993 to further clarify processes and procedures. After the MoU was signed, the P25 Steering Committee realized the project should be broken down into multiple parts to best address the user requirements. The committee created a multi-phased approach focused on baseline standards first, followed by advanced features later.

Phase 1

The initial phase focused on the Common Air Interface (CAI) and voice encoder-decoder (vocoder) as its baseline, to be followed by advanced features and wireline interfaces later. Phase 1 of the P25 standard defined the first step toward providing a standardized digital LMR technology. Phase 1 included the specifications for 12.5-kilohertz FDMA equipment and systems that could interoperate with multiple vendors' radios in conventional or trunked mode, as well as legacy analog FM radio systems. Although the core of the Phase 1 standard is the CAI that defines how the basic radio operates over the air and provides the basis of interoperability, the initial task was the selection of the vocoder. Following the approval and publishing of the vocoder specifications, the CAI standard was completed in 1995. Since then, additional Phase 1 standards have been developed to address trunking; security services, including encryption and over-the-air-rekeying (OTAR); network management and telephone interfaces; and the data network interface. Additionally, there have been ongoing maintenance

The CAP program provides the user community assurance that the communications equipment they are implementing meets the standards for performance, conformance and interoperability.

revisions and updates to the existing standards.

The P25 Steering Committee announced the completion of the P25 Phase 1 standards in August 1995. P25 Phase 1 systems are now commonplace, enabling interoperability, competition among manufacturers, backward compatibility and spectrum efficiency to fulfill the original goals of the P25 effort.

Phase 2

Phase 2 was designed to satisfy public safety's need to transition to a 6.25-kilohertz or equivalent occupied channel bandwidth and maintain backward compatibility to Phase 1 technology, allowing for graceful migration toward greater spectrum efficiency. Although the need was identified for standards to address additional interfaces and testing procedures, the primary focus for the Phase 2 suite of standards was defined by a two-slot TDMA approach to spectrum efficiency as opposed to a 6.25-kilohertz FDMA technology.

The Phase 2 suite of standards addressing TDMA trunking technology was completed and published in 2012, but the standards allowing initial product development were published in 2010. Work continues on P25 to address revisions and updates to the existing standards, based on technology upgrades and to develop the necessary test procedures to confirm standards compliance.

A significant number of standards documents addressing the P25 Inter-RF Subsystem Interface (ISSI) have been developed and published. There are a number of public-safety agencies implementing or planning to implement the P25 ISSI to interconnect P25 systems. The standards for the Conventional Fixed Station Interface (CFSI) and Console Subsystem Interface (CSSI) have also been completed and successfully deployed. Additionally, standards have been developed and published to address a number of interfaces relevant to security services, to include the Inter-Key Management Facility Interface (IKI).

More than 94 documents are included in the P25 suite of standards that have been approved by the P25 Steering Committee. These documents include specifications and standards for the applicable features and interfaces, as well as almost 30 documents addressing specific test procedures.

P25 Compliance Assessment Program

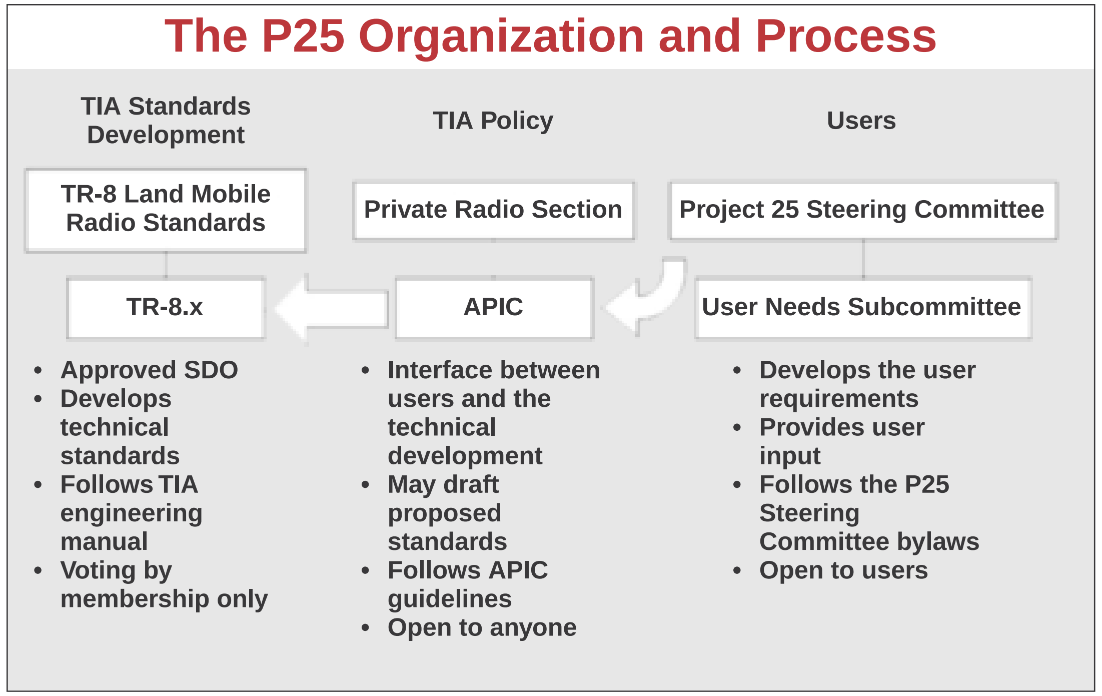
Both the user and manufacturing communities identified a need to establish procedures to confirm that P25 equipment and systems were compliant with the published standards. This led to the development of the P25 Compliance Assessment Program (CAP), a voluntary program that allows suppliers of P25 equipment to demonstrate that their respective products are compliant with P25 baseline requirements reflected in the suite of standards. The program, developed by the Department of Homeland Security (DHS) and the National Institute of Standards and Technology (NIST), provides the user community assurance that the communications equipment they are implementing meets the standards for performance, conformance and interoperability. The charter for the P25 CAP was executed in April 2008, and eight laboratories were accredited to conduct performance and interoperability tests relevant to the P25 Phase 1 CAI.

The user community has repeatedly emphasized the need for expanded P25 CAP testing. DHS is working with industry and users to identify the required procedures to validate compliance with Phase 2 equipment and systems, particularly for TDMA operation and the ISSI. In the meantime, users are encouraged to seriously consider the existing tests that are included in the P25 suite of standards for interim compliance testing and validation.

The Future

There is no doubt that P25 is a success. P25 has met or exceeded its original goals of spectrum efficiency, backward compatibility, competition, and perhaps most importantly, interoperability. Furthermore, P25 is the predominant public-safety technology in the U.S. and is accepted as a primary public-safety standard in 83 countries worldwide. According to the Project 25 Technology Interest Group (PTIG), 38 vendors provide P25 systems and services available in all public-safety frequency bands with the exception of VHF low band. P25 has been selected by most U.S. federal agencies as their choice for interoperability, reliability and security. End users have realized that implementing P25 standards-based products results in cost effective and spectrum-efficient systems and radios that are necessary to support our nation's public-safety communications requirements.

As Phase 2 systems are developed and deployed, the P25 Steering



The P25 Organization and Process

Committee continues to work closely with the user community and industry to address the future of LMR. Without a doubt, LMR will be prominent in public-safety voice communications for years to come.

When Will P25 Be Completed?

Some officials have asked when P25 standards development will be finished. P25 is a "living" standards effort, which has continued to evolve alongside technology and user requirements. Therefore, the standards will continue to evolve. An example of this evolution is the recent realization by the vendors and users that a standard for Link Layer Encryption and Authentication supports a more robust security capability.

Most standards development bodies, including ANSI and TIA, stress that "a completed standard is a dead standard," emphasizing the need to continually add technology enhancements to maintain the relevancy of existing standards.

P25 continues to evolve to meet public-safety communications requirements, to include interfaces and interconnections to broadband technology. Broadband may be the wave of the future, but P25 is the rock public safety depends on for solid, reliable and secure public-safety digital communications. Let's celebrate the success of P25 as we look forward to the future.

James Downes is a telecommunications manager with the Department of Homeland Security (DHS) Office of Emergency Communications (OEC). Prior to moving to DHS in 2003, he was the deputy director of the Wireless Management Office in the Department of the Treasury. He has worked for more than 40 years in wireless communications, primarily in the public safety and federal law enforcement environments. In 2011, he was elected chair of the P25 Steering Committee.

George Crouch is vice chair of the P25 Steering Committee and serves as one of the National Association of State Technology Directors (NASTD) representatives on the committee. Crouch is the administrator for South Carolina's statewide radio system, Palmetto 800.

MissionCritical Communications I www.MCCmag.com I Digital Radio in the Americas: A Guide for New Deployments and System Upgrades

Options for Funding Your Digital Network

By Dominic Tusa

For the past several years, the lingering effects of the Great Recession have plagued the public-safety radio industry. Cities and counties have historically paid for radio technology solutions through general funds or 9-1-1 district monies. Yet, declined real estate values coupled with lessened personal spending trends have lowered tax collections. Combined with downward trending landline telephony fees, fewer funds have made it difficult to pay for changes to aged radio technologies. Many system owners are reluctant to shut down Project 16 warhorse trunked radio systems as they have provided great service, value and excellent audio quality for many years.

Unfortunately, the sunset has arrived for those using legacy trunked radio configurations as vendors have moved on to Project 25 (P25) digital technology. Familiar product names such as EDACS, SmartNet and SmartZone have already or will soon lose factory parts support, making it risky for owners to maintain the degree of reliability and readiness expected for mission-critical/life-safety communications.

As system owners begin their investigations of new system alternatives, many are shocked to see that a radio configuration purchased in 1990 for $10 million may cost two to three times that amount to replace today. Because of the competitive nature of P25 and the many suppliers, radio equipment costs have decreased yet the cost for replacement systems has dramatically increased because of changes in coverage, reliability and safety expectations, as well as the increased dependence on digital signal processors/computer code vs. traditional hardware elements.

A public-safety radio user expects reliable, high-quality in-building portable radio coverage throughout rural and urban areas. Increasing requirements are for ubiquitous voice encryption, multiband radios, text messaging and GPS location services, with the eventual goal of location services extended to within building structures. Enhanced coverage and audio quality require more tower sites, which are a large initial and ongoing maintenance expense. Enhanced reliability means having multiple standby electric power sources and hardened backhaul site connectivity. Increased capacity requires larger numbers of licensed radio channels (not always possible) or the use of channel-splitting techniques such as P25's Phase 2 TDMA technology, all of which translates into higher procurement costs to the system owner. These expectations and new services come at a monetary cost that impacts how adequately an owner can balance needs with fiscal reality.

Cost accelerants have forced radio system owners to seek new ways to fund next-generation communications systems. Several purchase methodologies outside the traditional use of general funds, federal grant initiatives or lease-purchase programs have gained acceptance.

Project-Specific Tax Initiatives

It is becoming more common for cities and counties to ask voters to pay for specific services including the construction of public-safety radio systems. The state of Georgia, for example, allows counties to enact a special temporary sales tax for projects as determined by voter referendum. The term for such a temporary tax is five years, and the added tax rate collected can be as high as 2 percent. The advantage to this sort of funding is that the public is directly involved, and the new funds are dedicated solely to specific projects. The funds cannot be used for any other purpose and, most importantly, the tax will cease at a known point in time.

Service/User Fee Assessment

Shared radio systems, becoming more common for large counties, regional groups of counties and states, often charge radio users unit fees for access on expansive trunked radio systems. The most common form of cost sharing is to spread the system's cost universally across the total number of user radios employed on the system. In other cases, user fees

As new P25 radio systems are entering the planning stages, many cities and counties are taking a step back, working more closely with neighbors and considering public-public partnerships as a way to lower net purchase and maintenance costs.

might be assessed depending on operational circumstance. For example, radio users requiring statewide roaming coverage might pay a higher fee per radio than those users whose radio coverage needs are more localized, i.e. tower sites within a single city or county. Because the majority of public-safety radio users provide police and highway patrol services, some states have placed the operational costs for radio systems onto motor vehicle owners through fees. Typically, these fees are associated with vehicle license plate registrations and moving violations, and the money collected is used to support the purchase, enhancement and maintenance of radio communications systems.

Public-Public Partnerships

When 800 MHz trunking was in its infancy in the 1980s, it was common for one city or county in an area to step up and take advantage of the new features and efficiencies of this frontier thing called radio trunking while the others in the region sat back in relative safety and watched what happened next. As each trailblazer's system had its initial kinks worked out — a process common for any new technology shift — neighboring systems sprang up. In many cases, system designers had to go to elaborate lengths to make each separate system's coverage conform to FCC regulations related to spill over into adjacent areas. Had all in a geographic area embraced the concept of regional overlapping coverage, the net result would have been meeting the same coverage needs with fewer tower sites. Of course that wasn't possible then as trunking technology was new, immature and unproven with each system operating as a stovepipe among like neighbors. Now, faced with costly forklift changes from analog to digital radio, it's a far different story, and the money needed to construct and maintain these new systems is tight.

As new P25 radio systems are entering the planning stages, many cities and counties are taking a step back, working more closely with neighbors and considering public-public partnerships as a way to lower net purchase and maintenance costs. Through partnerships, sites, system management

In public-private partnerships, the cost of the tower's construction and maintenance as paid by the host public-safety entity is either zero or some portioned amount as determined in negotiations.

and maintenance resources are shared in a way that addresses the partnership's joint coverage, capacity and user-agency autonomy needs.

This model is one that involves fewer physical parts but yields an interwoven, more resilient and seamlessly interoperable radio solution. In a public-public partnership, fees are generally assessed annually based on the total numbers of users, however, agencies that contribute resources essential for the total system's construction and operation often see a reduced fee structure compared with others who simply consume air-time resources. And because the effect of a public-public partnership is to lower net costs compared with a go-it-alone approach, many agencies find this to be a good way to fit new system purchases within the limits of existing revenue sources.

Public-Private Partnerships

The proliferation of commercial cellular radio services and new allied technologies has ushered in a seemingly insatiable thirst for coverage and capacity. These needs are being solved by making cell-site footprints smaller, and by doing so, allowing the reuse of limited radio spectrum among new tower sites, use of multiband personal devices and the deployment of new technologies such as 4G Long Term Evolution (LTE). This means towers — and lots of them — are in demand. Locating commercial cellular tower sites is difficult for a number of reasons involving cost of property, zoning, environmental regulations and public outcry. All of this makes tower sites and land owned by local government and public-safety agencies a valuable commodity in the eyes of cellular companies and third-party, commercial tower site development firms.

There is a win-win possibility through public-private partnerships with cellular providers and tower site development firms. The public-safety system owner allows the cellular/site development firm to construct, at cost, a tower on the owner's property in exchange for antenna space. Or both the parties could share the cost of construction and split the revenues produced by the tower. In any case, the cost of the tower's construction and maintenance as paid by the host public-safety entity is

either zero or some portioned amount as determined in negotiations. Partnerships such as this have value to the commercial entity because the sites can be built relatively quickly and often in highly desirable settings to encourage collocation by other carriers. The public benefits through lowered radio system construction costs and a visually more appealing environment because fewer towers are constructed.

Outsourced Radio Solution

The complexity of statewide radio systems, coupled with the rapid changes in the radio communications field itself, have driven some toward a fully outsourced radio solution. Conceptually, the user agencies buy radios, pay a fee and operate on radio system infrastructure constructed, managed and maintained by a vendor, usually a radio system manufacturer. Relatively few radio systems are procured and operated in this manner, yet as the cost of buying systems and keeping the technology current increases this procurement option could become more attractive. Of course, the details of such a solution and the unknowns for maintaining a proper grade of service are areas for concern.

In developing a successful outsourced radio solution, the key is in fully defining requirements, expectations and performance-measuring metrics, as well as clearly defined penalties to ensure these are each met by the vendor. Coverage and audio quality requirements must be clearly defined by agreement and supported by coverage maps and industry-accepted coverage verification practice. Radio site, system and backhaul infrastructure reliability metrics must be determined, integrated within the contract, and continuously monitored and managed. Initial capacity and the means to add capacity in step with user growth must be considered. And, most importantly, service restoration objectives and technology refreshment during the life of the radio system must be a component of the negotiated services agreement.

An outsourced services solution must confront and mitigate risk. The risk to the user is the vendor can't provide the levels of service and reliability required by the agreement. A divorce from an outsourced services agreement is painful, costly and protracted, particularly because constructing a replacement system would take years of planning and construction while still living under the service provider's "radio roof." Yet, the advantages of this approach can be significant. The cost of the system is predictably spread over the agreement's term (typically 15 operational, post-construction years) and across the full user base. Technology

As the cost of buying systems and keeping the technology current increases, vendor outsourcing could become more attractive. Of course, the details of such a solution and the unknowns for maintaining a proper grade of service are areas of concern.

upgrades, maintenance and network management become a vendor responsibility, thereby lessening personnel and facility costs borne by the state.

The vendor, aside from the project itself, stands to earn added revenue through radio equipment and accessory sales to users, but shoulders a staggering set of risks as well. The vendor essentially fronts the cost to construct the radio system, must maintain the highest levels of system availability and hardening, and must gracefully refresh the system's technology, transparently, while safely supporting live radio traffic. These risks and the profit margin necessary for the vendor to view the deal as beneficial translates into higher annual fees borne by radio users compared with other methods.

Possibly the biggest driver for consideration of an outsourced solution lies in the fact that radio technology is at the threshold of a major change involving the integration of traditional push-to-talk (PTT) radio and broadband LTE data that will eventually reside on the same IP core/backhaul network. During early periods of transition, past history suggests some technologies and processes will thrive while others will gradually wilt away. This might be the best time to trade dollars for someone else to absorb that risk.

Numerous methods for funding modernized communications systems exist, and most agencies are willing to discuss their experiences, pro and con, with peers embarking along this unsteady path. Reach out and learn from their experiences. Likewise, perform an outreach program within your user community to make certain the vision for a new communications network is fully in sync with their vision. The worst possible outcome is to develop a costly radio system configuration that no one wants or that is managed without input or direction from its user community.

Dominic (Nick) Tusa is a principal radio communications consultant and founder of Tusa Consulting Services. Tusa has more than 35 years' experience providing technical services involving the design, implementation and maintenance of radio and microwave communications systems for both public safety and private industry. Tusa Consulting Services was founded in 1991 and is headquartered in Covington, Louisiana. The firm has key personnel in Kansas City, Missouri; Atlanta; Tallahassee, Florida; Lancaster, Pennsylvania; and New Orleans. In 2013, Tusa founded EZ-Spectrum to assist operators of radio communications systems to identify and secure viable spectrum in all land mobile frequency bands.

Local Officials Offer Advice on Open P25 Procurements

By Sandra Wendelken

Two local officials offered advice for multivendor public-safety procurements, with both saying there must be one point of contact who can bring parties together and address issues as they arise.

The officials made the remarks at a symposium focused on the benefits of multivendor networks.

Steve Graves, chief information officer (CIO) for the city of Richardson, Texas, oversaw a $7.5 million Project 25 (P25) procurement in his city in 2012. Airbus DS Communications, formerly Cassidian Communications, was the system integrator for the project and the point of contact to ensure the system worked as part of its contract.

"For any problems with radios or consoles, that was the throat we were going to choke," Graves said.

The system comprises infrastructure from Airbus DS Communications and radios from Motorola Solutions. The system also includes console systems from Avtec, tower and shelter equipment from Sabre Industries, Voiceprint recording equipment and a fire alerting solution from Zetron. Under the city's maintenance agreement, there is a five-year refresh program for servers and other equipment. The city used existing fiber infrastructure.

Graves estimated the city saved more than $4 million through the open-source competitive tender. He said partnerships between the IT and radio departments were necessary for the project.

"You must have really good partners and partnerships with people you might never have partnered with before," he said. "Open standards equals responsible government and saving taxpayers' money."

When Frank Kiernan, director of emergency communications in Meriden, Connecticut, launched his request for proposals (RFP), he received only two

One proposal was $3.1 million, and the second proposal was from a consultant offering numerous alternatives, one of which eventually saved the city $1 million.

bids. One proposal was $3.1 million, and the second proposal was from a consultant offering numerous alternatives, one of which eventually saved the city $1 million.

"We relied heavily on a consultant, and it was a good learning process," Kiernan said.

Kiernan, who heads the Association of Public-Safety Communications Officials (APCO) International standards development committee, said the 800 MHz system required users to be educated and reassured about the multivendor environment. The city's fire department still operates on VHF spectrum.

During the symposium, executives from P25 vendors also offered competitive procurement advice.

Kevin Sumrell, vice president of utility and public-safety sales for Avtec, warned of bundled packaging. He said initial bundled pricing often reflects enticing discounts but when a user starts to upgrade, later pricing is not consistent with the initial sale.

"Changes to the original proposal always have a cost impact," he said.

Sumrell said open standards offer freedom of choice. Users have the option to change if desired through a competitive environment, and forced upgrades decline.

Steve Begeda, director of system sales for Zetron, said avoiding proprietary pitfalls begins with the bid specification. He said a consultant can dictate how the procurement flows and ensure it allows for flexible bidding. Avoiding the inclusion of proprietary requirements is key, and users should ask for itemized costs, especially with respect to licensing.

Begeda said any P25 supplier should be available for factory and customer acceptance testing, and an infrastructure provider should have previously tested with a radio manufacturer and have test reports. "Providers should participate in integration testing of any third-party pieces that are part of the overall solution," he said.

Independent console providers can dovetail into a complete radio system deployment through the P25 Console Subsystem Interface (CSSI). "No one company can be the best at everything," he said. "Look for a provider that

partners for each piece of the system."

Helmut Koch, president of Exacom, and Mat Schwartz, vice president of engineering for the communications division of Eventide, touted the benefits of system redundancy and storage. Although there is not yet a recording database or storage standard within P25, both executives said they would contribute to the process.

Koch said service and support are part of standards sustainability. "Consultants could work together on that and add value," he said.

Sandra Wendelken is editor of MissionCritical Communications *magazine.*

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Tusa Consulting Services is a public safety communications consultancy founded in 1991. Servicing mostly municipalities, counties or regional groups that are already using some form of radio communications, TCS has helped clients with their transition to P25. The company has been instrumental in achieving interoperability among first responders in multiple jurisdictions and streamlining communications for rural communities with limited tower capabilities. TCS handles all stages of system design and implementation including needs assessments, conceptual design and specification development, proposal evaluation services (RFPs), narrowbanding, FCC compliance and maintenance planning. Tusa also offers customized video production for training and public information purposes. www.tusaconsulting.com

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