Public Safety Communications
Close the Digital Gap

APCO P25, TETRA, and DMR are natural next steps to upgrade legacy analog systems

Major flaws in emergency communications systems reveal themselves when catastrophic events, such as terrorist attacks and natural disasters, occur. The lack of interoperability of communications systems between various agencies is one of the most problematic issues. For example, sharing of critical knowledge is impossible if the fire department cannot communicate with the police department.

The dire consequences and lessons learned from isolated communications during catastrophic events prompted police, fire, and other agencies to update their public safety communications. The result is a slow but steady migration from analog land mobile radio (LMR) to digital public safety systems using standards such as the Association of Public Safety Communications Officials (APCO) Project 25 (P25), Terrestrial Trunked Radio (TETRA), and Digital Mobile Radio (DMR).

Despite the existence of these standards and readily available technology, no mandate is in place to enforce the upgrade of legacy analog systems by a specific deadline. In the U.S., the Federal Communications Commission (FCC) has taken steps in the right direction. For example, the FCC mandated Enhanced 911 (E911), which gives emergency dispatchers more information on wireless 911 calls. In 2012, the FCC also allocated 700 MHz of broadband for the Nationwide Public Safety
Broadband Network (NPSBN) to implement the First Responder Network Authority (FirstNet). This move involved a trade-off. It required public safety and other agencies to remove their LMR systems from the T-Band (470 to 412 MHz) by 2023 to auction for alternate use.

Beyond these spectrum dealings, the FCC and governments abroad have generally allowed cities and municipalities to determine their own road maps for public safety communications and equipment. The main issue is budget. Cities and municipalities grapple with road, water, public transit, and other infrastructure issues in addition to economic development. Such a technology migration is a significant strain on time and resources, as it demands planning, funding, management, and procurement.

The advantages of digital public safety communications are compelling in comparison to analog. They include improvements in both voice and range performance, particularly at coverage edges. With the lack of a mandate, cities and government agencies must prioritize and plan their own migration path from analog to digital communications systems using technologies based on the APCO P25, TETRA, or DMR standards.

**APCO P25 Public Safety Communications Standard**

In the U.S., agencies predominantly selected APCO P25 to move LMR systems from analog to digital. LMR systems support voice and low-speed/low-data-rate communications for national, state, and local emergency services units; tribal and regional/territorial units; and ancillary businesses such as public utilities. Generally, LMR systems comprise the following:

- Handheld portable radios
- Higher-power in-vehicle mobile radios boasting longer-range transmission
- Base stations with powerful transmitters, typically located on the highest building or tower
- The connecting network

For longer-range operation, systems often include repeaters for handheld, in-vehicle, and base station radios.

APCO P25 is not one standard but a combination of open standards. Those standards cover the design and manufacturing of two-way public safety communications equipment that is compatible, spectrally efficient, and interoperable between both agencies and vendors. Although APCO P25 offers several air-interface options, the P25 Common Air Interface is most broadly deployed. It provides manufacturer-agnostic interoperability between P25 infrastructure and radios.
APCO P25 offers voice and data services via conventional direct mode operation (DMO) as well as trunked mode operation (TMO) and secure communications. With conventional operation, user-to-user communications occur directly as needed because of a lack of repeaters or demand for communication off the network. It satisfies the needs of smaller agencies or groups with a low density of users. Communication is immediate once users choose the correct radio channel. In contrast, trunked operation is the choice for agencies with a higher density of users or larger groups. While conventional operation dedicates one radio channel to a group, trunking gives users access to a shared variety of radio channels. This option works well for different agencies in a given region — for example, to enable them to communicate seamlessly together.

The APCO P25 standard features two phases of implementation that are not compatible with each other, but a provision is in place for Phase 2 to revert to Phase 1 if needed. Both phases use a 12.5 kHz channel bandwidth but employ different channel access methods. Phase 1 leverages frequency division multiple access, while Phase 2 relies on two-slot time division multiple access (TDMA). As a result, Phase 2 provides increased capacity because each base station provides two voice channels, enabling two simultaneous conversations on a single channel. Phase 2 also offers battery-life benefits, as TDMA requires the transmitter to operate only during part of the transmission time.

**TETRA Public Safety Communications Standard**

Outside of North America, TETRA is the standard for public mobile radio (PMR) across much of the globe. The European Telecommunications Standards Institute (ETSI) developed TETRA in 1995. This open standard provides high data throughput and scalability. With local area and wide area coverage, TETRA serves small through large networks, both private and public.

TETRA offers rapid call setup for group calls over a wide area. It provides high-level voice encryption via digitally encoded algorithms. With DMO, TETRA permits back-to-back radio communications independent of the network. TMO is also available using the TETRA network infrastructure. TETRA occupies different frequencies depending on the country, but generally in pairs allocated to civilian/private versus emergency services. TETRA uses the TDMA channel access method to provide four user channels on a single radio carrier, with 25 kHz spacing between those carriers.

TETRA already supports some forms of data communications. It continues to evolve with the development of new standards, including TETRA Release 2, which features TETRA Enhanced Data Service (TEDS). TEDS enables wideband, high-speed data communications services by utilizing different RF channel bandwidths and data rates for flexible use of PMR frequency bands. Those RF channel bandwidths are 25, 50,
100, and 150 kHz. Because TEDS is compatible with TETRA Release 1, it simplifies the migration process.

TETRA Release 2 includes some additional notable features. In the TMO network, the range is 83 km versus 58 km in Release 1, permitting efficient air-ground-air communications during operation. Release 2 also includes an adaptive multiple rate voice codec, slated for operation in the 4.75 kilobits per second (Kbps) mode. To show the feasibility of interoperability with military communications (MilCom) applications, Release 2 features the mixed excitation linear predictive enhanced (MELPe) voice codec. NATO standardized its digital radio communications on the MELPe codec because of its low bit rate of 2,400 bps, background noise suppression, and voice quality.

**DMR Public Safety Communications Standard**

The preferred choice for business-critical versus mission-critical applications, DMR is also an ETSI open standard. Ratified 10 years after TETRA, it provides voice, data, and related services. DMR has three tiers: unlicensed conventional, licensed conventional, and licensed trunking. DMR applications range from consumer and commercial uses to industries such as construction and, of course, public safety. For public safety in particular, it is a budget-friendly option for smaller U.S. agencies and municipalities that want to upgrade to digital radio communications but do not want to invest heavily in APCO P25.

DMR enables two calls on the same channel independently, providing twice the system channel capacity as a standard two-way analog radio system using two-slot TDMA technology. It achieves reverse-channel signaling via the second TDMA time slot, which provides the system operator features such as priority call control.

DMR operates within the 12.5 kHz channel spacing allocated for land mobile frequency bands worldwide. These systems promise audio benefits through the conversion of voice data to digital data using signal processing algorithms to help minimize distortion. Intelligent audio adjusts the volume in response to the noise level in the environment.

Beyond voice capabilities, DMR supports data applications such as GPS location, text messaging, telemetry, and radio programming. Users can also configure system requirements, such as priorities, features, and operation, to tailor the system to a specific environment. Radios must exchange keys to provide security before operation. DMR offers improved battery life compared to analog, given the partial use of the transmitter due to TDMA.
Conclusion

Many municipalities and cities that have not already done so plan to move to digital communications systems. Because of the lack of a mandate to migrate by a specific date, global agencies will have their own migration plans based on the various standards available: APCO P25, TETRA, and DMR. APCO P25 has seen some deployment outside of North America. Similarly, the U.S. counts a small number of TETRA deployments. While TETRA is generally a more affordable option than APCO P25, DMR has emerged as a cost-effective alternative.

Despite the choice of standard, public safety and other agencies agree that the move to digital communications is important so that in a crisis, everyone on the scene can communicate — regardless of jurisdictions or departments. In addition to standard features such as network coverage, reliability, and security, these agencies need interoperable solutions across networks, devices, and applications. The performance of digital radio systems must be thoroughly tested to the selected standard to ensure correct and accurate operation. A flexible test solution is needed to measure both analog and digital signal formats to validate key parameters, such as transmit and receive performance. As agencies around the world put migration plans in place, the performance of these systems might be quite literally a matter of life and death.

For information on how Keysight’s solutions can help you unlock the future of digital radio test, visit the following web pages:

- For an overview of the trends impacting public safety and military communications, read the white paper “3 Key Trends Driving the Tactical Communications Evolution.”
- To learn more about public safety and military communications systems, check out Military Communications solutions.
- To learn more about additional solutions to solve tomorrow’s defense challenges, check out Aerospace and Defense solutions.

Learn more at: www.keysight.com

For more information on Keysight Technologies’ products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus