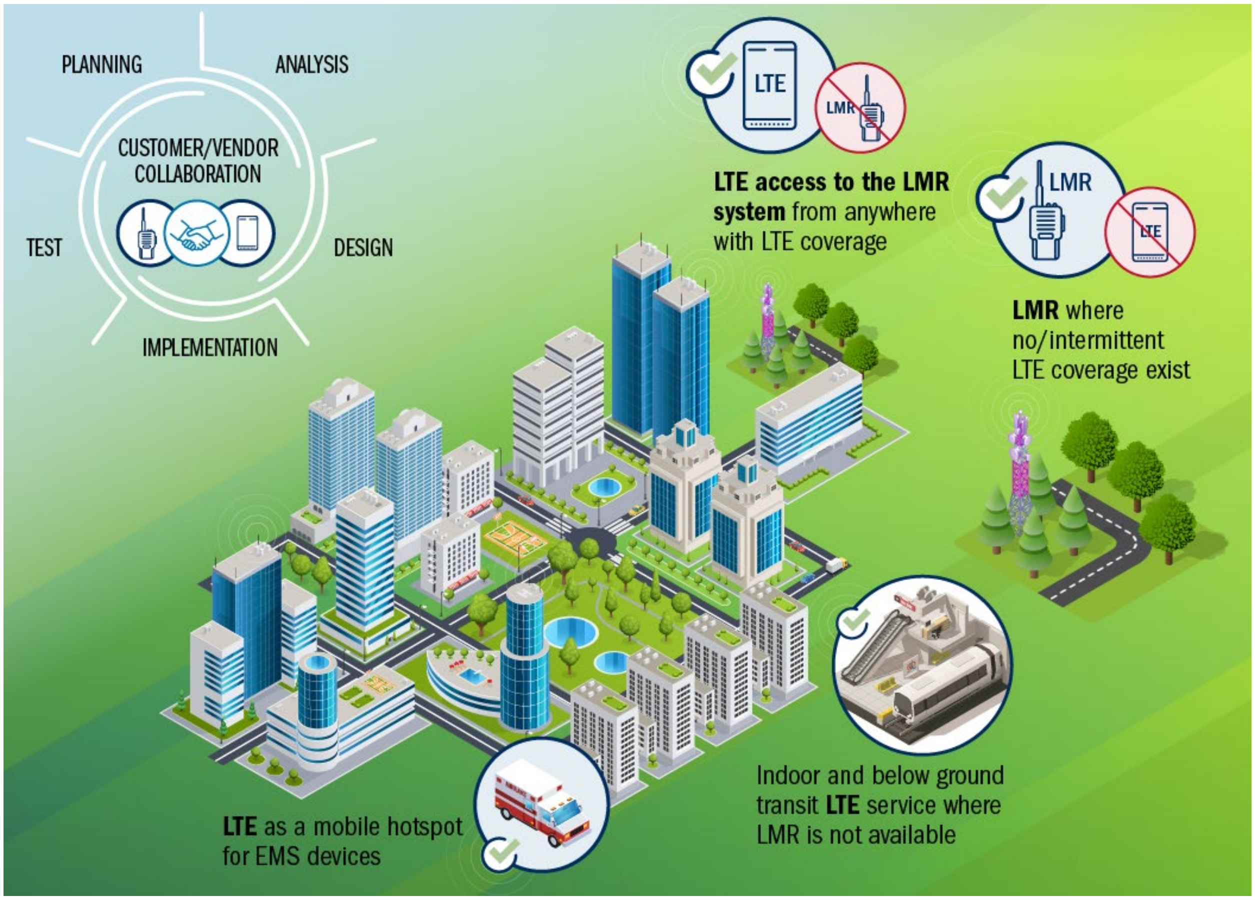
Land Mobile Radio/Long Term Evolution (LMR/LTE) Integration: Best Practices

Overview



For almost a century, radios have been the primary means of communication within the public safety community, linking personnel to their dispatchers and each other. Since the advent of Project 25 (P25)[1] more than 30 years ago, land mobile radio (LMR) systems have become interoperable and acquired a long list of enhanced features and capabilities. While designed primarily for group and individual voice services, LMR systems today offer end-to-end encryption and low-speed, non-broadband data applications for location services, over-the-air rekeying (OTAR), and limited data exchange.

[1] The Project 25 (P25) suite of technical standards enables LMR components and systems from different manufacturers to interoperate, enabling agencies and jurisdictions to communicate regardless of the manufacturer of their equipment.

Over the past decade, mobile broadband services based on Long-Term Evolution (LTE) technology have entered the public safety environment. LTE offers agencies high-speed wireless voice and data communications over the broadband network—capabilities mobile phone owners enjoy. In addition, cellular service providers have begun to offer a variety of "public safety LTE" services, such as broadband push-to-talk (PTT), making the technology increasingly useful to the public safety community.

Each technology has advantages and disadvantages. While its data services are limited, LMR systems can provide one-to-many voice communications on a single frequency/channel, which is vital in large-scale response operations where bandwidth can quickly become congested. LMR subscriber units (radios) broadcast using external antennas at higher power than mobile phones and tablets—features that reduce interference and increase coverage area—and can continue to communicate radio-to-radio even if the LMR infrastructure fails. LTE's strength lies in its high-speed data capabilities and nationwide network coverage. While LTE is vulnerable when natural disasters destroy cell towers or the network is overwhelmed by traffic volume, developers are working toward solutions, and LTE holds the potential for revolutionizing information exchange within and among agencies.

LTE is unlikely to displace LMR in the foreseeable future for various reasons. It is much more likely that the two technologies will merge. Service providers and vendors are already offering gateways and software that can integrate the two, and public safety agencies across the United States are implementing these solutions to enhance their operational efficiency.

This document is a snapshot of early LMR/LTE integration efforts at the state and local levels. Gathered through interviews with public safety practitioners who are pioneering LMR/LTE integration, the information here aims at demonstrating the potential of these efforts and presents some of the lessons these pioneers have learned along the way.

LMR will likely remain the main technology for public safety communications due to its reliability during emergency situations. However, the **future will see LMR and LTE technologies coexisting without compromising the benefits of either.**

Our thanks to the agencies who contributed to this report:

1. Montgomery County, Texas, Hospital District
2. Indiana Integrated Public Safety Commission, State of Indiana
3. Department of Information Technology, Fairfax County, Virginia
4. Michigan Public Safety Communications System
5. Statewide Interoperability Office, State of Missouri
6. New York Metropolitan Regional Radio System; Metropolitan Transportation Authority Police Department

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Applications and Benefits Of LMR/LTE Integration

Many agencies and regions have found significant benefits to integrating public safety LMR and LTE systems and have experimented with different ways to utilize LMR/LTE technologies. In this section you'll find examples drawn from interviews with practitioners in various states across the country.

MICHIGAN

Michigan's Office of Public Communication System began testing several vendor proprietary LMR/LTE integration tools for non-public safety use and discrete operations around 2015. Integrating LMR and LTE solutions at that time proved to be cost prohibitive due to licensing and monthly recurring costs. Recently, the state worked with an LMR manufacturer to implement a statewide integrated system, and the manufacturer's commercially available solution now connects LTE and LMR systems within Michigan as well as with systems in the State of Indiana. Existing Memorandum of Understanding (MOU) structures used for LMR governance between jurisdictions provided a format for establishing LTE governance agreements.

Michigan's plain clothes and uniformed officers use smartphones to connect to the LMR system during covert operations where the use of LMR radios could expose their identity. For large events that usually require distribution of caches of LMR subscriber units, mutual aid partners download an app on their smartphones and are then patched into the LMR communications network. One group of volunteer firefighters uses LTE push to talk (PTT) to receive paging messages on their subscriber units. Although this requires a monthly fee, it is less expensive than purchasing pagers.

Communications challenges at large events may be alleviated by using LTE services. Mutual aid partners can download an app on their mobile phone to be patched into the LMR communications network, eliminating the need to distribute caches of LMR subscriber units.

During a major flood, mutual aid partners were able to share vital high-speed data across the LTE network to aid in disaster response. One LTE provider enabled data streaming from public safety unmanned aerial vehicles (UAV)—drones—to be patched into the LMR system.

TEXAS

Montgomery County's Hospital District uses a P25 Simulcast system utilizing the P25 Inter-RF Subsystem Interface (ISSI).[2] The system is used by emergency medical services (EMS), fire services, and law enforcement.

EMS uses LTE-equipped multiband LMR subscriber units interfaced with LTE modems, primarily in the back of ambulances. Subscriber units can communicate over the LMR system and become a mobile hotspot to communicate with ambulance equipment, such as heart monitors, tablets, and remote telemedicine systems. The LTE system was easy to set up and deploy with a telemedicine capability that proved valuable during COVID-19 testing and vaccination efforts. Because LTE is interfaced with the LMR network's core, LMR/LTE integration is seamless and the geo-redundant

[2] P25 ISSI is a non-proprietary interface that enables RF subsystems built by different manufacturers to be connected into wide area networks, enabling users on different networks to talk with each other.

cores (cores in different locations, each programmed with primary and secondary IP addresses) provide excellent coverage and resiliency.

Statistics indicate that LMR communications are used 95 percent of the time while LTE voice communications are used the remaining 5% in the Montgomery County Hospital District. LTE communications are used when ambulances are out of LMR coverage areas or in underground locations simply by switching to a prescribed channel on the LMR subscriber units.

In the law enforcement environment, personnel prefer to use LMR communications. They find it easier to switch to different zones/channels on the radio than on an LTE device. Some officers have LTE-capable subscriber units; others have an application on their mobile phones that enables them to monitor LMR traffic through earpieces. The LTE app on their phones utilizes the LMR system P25 vcoder.[3] This enables end-to-end encryption and distribution of encryption keys via cellular over-the-air rekeying (OTAR).

LTE is used to augment the LMR network, providing connectivity for ambulances out of LMR coverage areas, in underground locations, or as data hotspots from medical equipment.

During normal operations, communication is mainly on the radio manufacturer's core, where any talkgroup can talk to any other talkgroup if the radios are from the same manufacturer. ISSI enables communication with other manufacturers' cores; however, to ensure interoperability the talkgroups must be mapped or coordinated ahead of time. The ISSI ties together 17+ counties and more than 100,000 users.

MISSOURI

Missouri's objective in integrating LMR with LTE was to extend their trunked P25 LMR capabilities. The state has established its own carrier-agnostic configuration using an on-site server to manage the system with a vendor's subscription-based group communications service. The LTE network provides backhaul and backup services for 130+ RF sites. LTE-capable portable radios enable roaming between LMR and LTE networks, but the LTE capabilities are used primarily by administrators working on tablets. At the same time, LTE users have discovered they do not have to be in the state for their LTE PTT functions to work. They can monitor LMR activity from virtually anywhere they can connect to a cellular network.

[3] A vocoder is a device/method for transforming voice signals into digital signals.

Interfacing with other metropolitan area LMR systems from the same manufacturer is relatively seamless using ISSI connections. Non-P25 systems are integrated through console patching and the P25 Console Subsystem Interface (CSSI).[4]

Law enforcement prefers LTE integrated devices in covert and surveillance operations, when appearing to use a mobile phone is an advantage. Executive leadership also prefers to use LTE devices as they don't have a true need for expensive LMR.

Temporary users can be authorized to use the integrated network for predetermined periods, such as a planned event, on any smartphone. Access can be revoked after the event or at a pre-programmed date to ensure only those who have a need to access the system have access.

In major events or covert operations, **LTE devices allow integrated communications with LMR systems** for temporary user groups or blending in with smartphone users as necessary.

VIRGINIA

The Fairfax County Department of Information Technology (DIT) Radio Services Center (RSC) manages a dual trunked 800 MHz system. The system consists of an analog communications system for public services (schools, transit system, special needs bus service) and a digital P25 communications system for public safety (police, fire, EMS, regional emergency communications). The analog system also serves as the backup for the public safety system.

The RSC decided to decommission the analog system and switch its users to a proprietary LTE PTT system. This enabled some public service system users to switch from pricier LMR devices to LTE devices because they aligned better with their needs and involved lower recurring costs. Launching the LTE public service system resulted in the loss of the LMR backup but increased indoor communications service, which the public service sector needs. Additionally, the LTE service is less expensive than replacing it with a backup digital P25 LMR system.

Through MOUs, Fairfax County's P25 LMR and LTE systems support county agencies and outside jurisdictions, including city governments, colleges and universities, the Virginia State Police, and first responders throughout the National Capital Region (NCR), which includes the District of Columbia and surrounding counties in Maryland and Virginia. Fairfax County also patches the Police Mutual Aid Radio System (PMARS) and Statewide Interagency Radio System (SIRS), both conventional systems, into its LMR system. Any agency that has an MOU with Fairfax County can utilize the county's system to establish backup talk groups.

By using cost effective LMR/LTE integration, Fairfax County **can allow partner and government agencies to utilize its LMR/LTE network talkgroups.**

Law enforcement agencies use LTE-capable LMR subscriber units for certain applications, such as transporting prisoners from the county to other areas within the NCR and when LMR service is inadequate indoors. However, they are not using the cellular PTT applications by choice because they prefer the ergonomics of LMR-type subscriber units. Fire/EMS are in the testing phase of adopting

[4] CSSI is a wireline interface included in the P25 suite of standards, which provides a standardized IP connection between radio frequency subsystems and console equipment.

an integrated LTE solution. Fire talkgroups are available on LTE smartphones via ISSI connections and some fire chiefs use LTE applications on their smartphones to monitor fire communications traffic. The county health department issued ruggedized smartphones to COVID-19 volunteers; such smartphones were also used by the IT group that supported the polls during recent elections, in large part because smartphones are less expensive that LMR subscriber units.

NEW YORK

The New York Metropolitan Regional Radio System (MRRS) covers approximately 5,000 square miles, including 14 counties in New York State and jurisdictions in southern Connecticut. The system provides communications services for commuter and metropolitan railroad lines. The Metropolitan Transportation Authority (MTA) recognized a need to create an underground communications system, based on its five-channel 700 MHz system that provides wide area mobile coverage with a range of 500 yards along rail right of ways through 65 RF sites and seven in-building systems. The system is accessible to any authorized county or state organization that wants to use it.

Like other agencies, the MTA is a strong proponent of LMR largely because MTA can fully manage the system. However, it recognizes LTE as an effective adjunct to LMR and a practical alternative for those jurisdictions that cannot afford LMR as LTE services have a relatively low monthly cost. LTE-capable portable radios were adopted to provide an extension of the LMR system in areas lacking LMR coverage and communications when the LMR system is down for maintenance.

In addition to the LTE capability in LMR radios, MTA enabled software in personnel smartphones to provide LTE-to-LMR functionality. The MTA also contracted to have its radio system's technical staff assist the LMR/LTE vendor with LTE product development tailored to their needs. This partnership tested the system for in-building coverage using 24 radios at several locations in New York City and Westchester County, resulting in the vendor making a host of changes to the LMR system that made LTE integration more successful.

The MTA created agreements with agencies in surrounding counties that enable jurisdictions to share LMR infrastructure and frequencies for law enforcement, fire services, EMS, emergency management, and public service operations. LTE was not added specifically for interoperability, but it does provide partnering organizations coming onto the system with provisional talkgroups with LTE capability in addition to LMR service. Interoperability agreements are established among counties through MOUs that stipulate joint talkgroups can be developed and shared at any time.

LTE as an extension to the LMR system to enhance underground communications **can also provide the same voice quality as LMR** when the customer and vendor work together during system design and integration.

The initial objective of instituting LMR/LTE systems was to increase underground coverage. This has largely been achieved. All areas of the underground system have LTE coverage, and users see no difference in audio quality between LMR and LTE communications. When LMR sites go down, users can switch to an LTE channel simply by turning the toggle switch under the channel selection knob. Unit IDs and aliases are the same for LMR and LTE devices; to dispatchers it looks like any other trunked talk group traffic.

Advanced Encryption Standard (AES) 256 encryption is used exclusively on the system, and each talkgroup has a cleared and encrypted trunking talkgroup. Each agency talkgroup is provisioned a comparable LTE equivalent in clear, encrypted, or off console tactical talkgroups.

To manage issues and suggest improvements during the system integration, the MRRS technical team sent detailed reports to the LMR/LTE system vendors who provided the recommended changes for their software revision updates. When ongoing revisions are completed and tested, the vendor pushes them out to the user community using WiFi mass radio reprogramming. The MRRS technical team has also developed a system manual used in training and shared with partnering agencies.

INDIANA

The Indiana Integrated Public Safety Commission (IPSC) supports emergency response operations and personnel, and it maintains a trunked P25 radio system and an LTE data system covering all 92 counties in the state. The LMR radio system uses two applications to enable LMR-to-broadband functionality. These applications are also used by state police, fire, and health agencies. The state system is both LMR and LTE carrier-agnostic.

While IPSC does not see LTE as a viable standalone technology for mission critical communications, it does consider it a suitable extension of the LMR network in low coverage areas and within structures. The health department used the data capability of the LTE system to transmit COVID test data in support of recent missions.

IPSC conducted cross-border testing with Michigan to evaluate if a vendor's cloud-based P25 ISSI offering could provide interoperability between the two states. Emergency alerts were transferred successfully in both directions while LMR radios roamed outside their home systems. Patching the two systems enabled sharing of encryption keys if the keys were previously loaded on both systems. LTE communications were also successfully passed across both state systems, using a mixture of smartphones from different vendors. The successful testing has attracted other states to the LMR/LTE effort and Wisconsin and Kentucky both are looking to participate in future tests with IPSC.

LMR/LTE integration allowed the Indiana Department of Transportation (INDOT) to resolve a significant communications issue. By switching to an LMR/LTE channel, managers and work crews were **able to communicate clearly throughout a large geographical area.**

After experiencing issues with their LMR radios during a critical mission, IPSC provided a task force with a drop kit that included 10 smartphones for emergency use. An LTE-LTE talkgroup was established solely for smartphone communications during missions. The Indiana Department of Transportation (INDOT) tested an LTE drop kit in its highway work zones, which covers a large geographical area and has several crews working simultaneously. When managers could not hear LMR communications, they switched to an LMR/LTE channel and could communicate clearly among the different work crews and management.

LMR radios are costly compared to LTE devices, and the Indiana Department of Corrections realized that not everyone requires the full capabilities of an LMR subscriber unit. After performing a cost analysis comparing LMR and LTE ownership, the department provided LTE devices with the ability to communicate on the LMR system to 200 staff members who were not in direct law enforcement positions but needed reliable communications. The change resulted in nearly $500,000 in cost savings.

For covert law enforcement operations, IPSC issues LTE remote PTT buttons (about the size of a quarter) that connect to LMR radios via a Bluetooth interface. These devices have been tested successfully and are preferred because they are lower profile and easier to conceal than shoulder microphones and earpieces.

IPSC programs LMR and LTE devices so that LMR radios maintain priority on the LMR system and smartphones have priority on the LTE network. LMR radios automatically switch over to LTE if LMR coverage is poor; similarly, smartphones switch to LMR in areas of poor cellular coverage.

LTE devices can be denied access or shut down through the corporate administrative tool (CAT). CAT can add external users to the system using just a phone number if the phone has the LTE application installed, and then erase all access and history when the mission is completed. In addition, all devices can be geofenced—whenever users enter an area, their LMR radios or LTE devices automatically switch to a designated talkgroup.

Obstacles to Integration

Despite the many benefits, LMR/LTE integration faces obstacles that may prevent organizations from adopting the technology at this time, such as:

1. Limited cellular coverage. Cellular coverage can be unsatisfactory and unreliable, particularly in rural areas. Cellular providers' slow rate of expansion in rural areas often does not provide the expanded coverage desired for LMR integration.
2. Connection obstacles. Emergency managers and dispatchers can find it difficult and cumbersome to establish LMR and LTE talkgroups that are not pre-programmed, especially during emergency situations. Until a standardized procedure for merging the users on the fly is established, many public service agencies may wait to integrate.
3. Training. Currently there are few established procedures for training communicators to set up integrated LMR/LTE talkgroups and patches. Many agencies find that LTE vendors' instructions do not address their public safety needs and must develop their own manuals and training regimens.
4. Long lead times. Many agencies find that LTE vendors require 30-45 days to set up LMR/LTE interoperability for a planned event. This reduces the possibility of using LMR/LTE interoperability communications when unexpected emergencies occur.
5. Priority and preemption features. Priority and preemption features on the cellular networks may not provide enough capacity to be useful to public safety. Cellular carriers may not readily provide this service or cannot guarantee priority will be provided to first responders.
6. Device and user IDs. Dispatchers want to know who a call is coming from, whether it's an LMR or LTE call, and where the caller is located—even if just to assist in writing incident reports. When the system provides different IDs for LTE and LMR devices, user identification is easy. Where the same IDs are used for LMR and LTE devices, dispatchers are unable to differentiate. The system server provides user IDs from the LMR devices to LTE devices. The LTE server facilitates the LMR user alias being displayed on the LTE devices; however, the LTE Unit ID may not be shown on the LMR system.
7. GPS and location information. GPS data can be received from LTE devices through a software app, but some agencies find it difficult to implement and merge with the LMR system.
8. Legacy LMR systems. Many legacy LMR systems cannot accommodate integration with LTE technology due to the system's age, and the cost of upgrading those systems may be prohibitive for some organizations.
9. System management. Cellular vendors manage the LTE services they provide. For many agencies, such loss of control is problematic as they are used to managing the LMR system and devices internally.
10. LTE device characteristics. LTE devices that mimic radios still have characteristics of smartphones that make them less convenient to operate (e.g., incoming cellular calls interrupting LMR conversations). Changing channels and operating other controls on an LMR is straightforward, whereas operating LTE devices is more complicated due to the need to look at the device and perform additional steps. LTE device usage also requires additional training, especially for use during emergencies.
11. Emergency functions. Many agencies find the emergency alarm button function does not work with LTE devices. LTE users can hear emergency alerts from LMR radios but cannot

activate their own emergency alarms. This point is strongly emphasized in training for the LMR/LTE system and some users have been instructed not to use the emergency feature on the LTE devices.

12. Encryption**.** End-to-end encryption may be problematic for some organizations to implement with disparate systems. In some instances, the LTE devices will not accept the encryption from the LMR system.
13. Acceptance. Long-time users of LMR systems find it is adequate for their needs and resist switching to LTE, in part, due to the many steps required to execute a function on an LTE device. Some command staff who have LMR capability integrated into their LTE devices do not use it.
14. Availability. LMR systems are designed to meet the specific public safety communications needs during high demand situations such as natural disasters, planned and unplanned events, and criminal activities. While LMR systems are designed to maintain 99.999% (five nines) availability, LTE systems typically have not been designed with the same level of robustness. For this reason, public safety organizations may be reluctant to solely rely on LTE communications services during high demand situations.

Best Practices for Integration

The practitioners interviewed for this document offered several general recommendations for those considering implementing LMR and LTE systems, namely:

1.	**Partner or consult with agencies** that have experience with LMR/LTE integration and are willing to share their knowledge gained during planning and implementation. Listen to what they have to say about their experiences. Once your agency begins the integration process, share your experiences and lessons learned with others.
2.	**Start out slow.** Begin with a dozen or two LMR/LTE devices to give your agency the opportunity to experiment and identify situations and environments where either LMR or LTE is more effective. A slow start also helps identify items to focus on in training or modify before full system implementation.
3.	**Work with the system vendor** to modify devices, software, and procedures to suit your agency's needs. Do not assume your vendor understands public safety requirements. Establish a formal requirement in the contract with the vendor to work together and involve your technical staff during the implementation process. The best results come when both the vendor and the client have a contractual obligation.
4.	**Coordinate** system nomenclature, parameters, governance, and operating procedures with partner agencies who will share the system to ensure interoperability. Make sure everyone remains updated and communicate all equipment and procedural modifications to all partners in a timely manner.
5.	**Map out talkgroups in advance** when using ISSI to tie systems together to ensure that LTE communications between different manufacturers' systems interoperate smoothly. Connect non-P25 systems through console patching and the P25 CSSI.
6.	**Establish governance policies and procedures** for personal LTE devices used on the integrated network. Especially important are policies regarding lost or stolen devices. Ensure that the network can disable network LTE devices from the core.
7.	**Use existing MOU structures** for LMR governance between jurisdictions as a format for establishing LTE governance agreements.
8.	**Test all devices and functions both within your agency and among your partners.** Keep records of test results and communicate those results to vendors so changes can be made to prevent failures during emergencies. Create a system for collecting feedback from personnel regarding system functionality and features. Regularly meet with partners and vendors to review test results and feedback.
9.	**Establish standard formats and procedures for device IDs.** To assist dispatchers in differentiating calls from LMR and LTE devices, assign different IDs to each type of device.

10.	**Program LMR and LTE devices so that radios maintain priority on the LMR system and smartphones have priority on the LTE system.** LMR radios should automatically switch over to LTE if LMR coverage is poor; similarly, smartphones should switch to LMR in areas of poor cellular coverage.
11.	**Review vendor instructions** to ensure they are accurate and address your agency's priority requirements. Coordinate with partner organizations to develop a system manual that contains clear, straightforward information. Modify the manual any time system changes are made and make sure all parties receive all manual updates.
12.	**Train all personnel in the use of the devices.** Be certain personnel know how to quickly locate and effectively use functions on their devices, especially in emergency situations. Retrain when system modifications are made to eliminate errors in the field.

For more guidance on implementing LMR/LTE, visit CISA.gov/SAFECOM.

Summary

Integrating LMR and LTE communications platforms offers public safety agencies unprecedented flexibility and a host of new options. As with any technology, however, careful thought, research, planning, and training are requisite for success. Start by identifying your agency's needs and learning which aspects of LMR/LTE integration could meet them. Focus your integration plan on the features that will satisfy your highest priority needs first. Involve your agency's communications experts early and build a working relationship with the LTE vendor. Be realistic in your expectations. Roll out the implementation slowly, making sure all personnel affected—system managers and technicians as well as end users—know what to expect and are thoroughly trained.

Monitor progress and track problems that arise. Welcome feedback and act quickly to resolve issues so personnel do not get frustrated and back away from using integrated features.

Throughout the process, keep in mind that scores of other agencies are involved in the same process and are willing to provide advice and guidance based on their experience. Do the same for others who approach you for help.

We are all pioneers in this new world of LMR/LTE integration and resolving challenges as a community is our best guarantee of success.