Land Mobile Radio (LMR) for Information Technology (IT) Professionals

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Cybersecurity and Infrastructure Security Agency

LAND MOBILE RADIO (LMR) FOR INFORMATION TECHNOLOGY (IT) PROFESSIONALS

PURPOSE

To present considerations Information Technology (IT) professionals should make when coordinating with Land Mobile Radio (LMR) engineers to plan, integrate, and maintain an LMR system. This document will:

- Introduce what LMR is and how it integrates with traditional IT systems
- Provide a high-level overview of LMR technologies, use, and capabilities
- Highlight how public safety agencies implement LMR technologies
- Discuss possible disconnects between IT professionals and LMR engineers
- Explore best practices for planning, integrating, and implementing LMR and IT network technologies

BACKGROUND

IT professionals are often tasked with planning, provisioning, implementing, and managing LMR networks with the assumption that all computer networks are basically the same and have the same general requirements. However, in some cases this assumption has resulted in LMR networks being inadequately provisioned, resourced, and managed or maintained. While each system is a network, significant differences between the two must be considered to address the infrastructure, planning, and lifecycle needs of typical IT networks versus the unique requirements of LMR networks. Budgets – both capital and operations and maintenance (O&M) – for LMR systems are often inadequately funded due to an incomplete understanding of what is required to develop and maintain an LMR system and its supporting networks. This document explores some of the differences and unique requirements between LMR and IT networks to increase the IT industry's understanding of what is involved in planning, implementing, and managing an LMR network by providing a high-level overview of system components, technologies, and operational needs. This document also explores how public safety organizations implement LMR technologies, provides some LMR system implementation and integration best practices, and addresses some LMR O&M considerations.

WHAT IS LMR?

LMR systems are terrestrially based, wireless, two-way communications systems commonly used by federal, state, local, tribal, and territorial emergency responders, public works, commercial companies, and the military in tactical and non-tactical environments. To support voice and low-speed data communications, LMR systems typically consist of handheld portable radios, mobile

radios, base stations, repeaters, and a network[1] to connect these components together. Mobile and portable radios are often referred to as subscriber units (SUs). **Figure 1** depicts a high-level LMR system diagram.

- **Handheld portable radios** are carried by public safety personnel and tend to have a limited transmission range.
- **Mobile radios** are often located in vehicles and use the vehicle's power supply and a larger antenna, providing a greater transmission range than handheld portable radios.
- **Base station radios** are essentially mobile radios that are configured to operate as fixed infrastructure, supplying a dispatch or control point for the system. They are typically found in public safety answering points (PSAPs), emergency communications centers (ECCs) or dispatch centers and tend to have powerful transmitters.
- **Repeaters** are used to increase the effective communications range of handheld portable radios, mobile radios, and base station radios by retransmitting received radio signals.
- **A network** connects LMR system components, serves as a transport mechanism for voice and data communications, and extends the communications coverage area of the LMR system. LMR networks contain servers, routers, switches, gateways, and point-to-point microwave systems servers, routers, and microwave systems. In some cases, LMR networks interface with private enterprise and/or public internet protocol (IP) networks via fiber optics, ethernet, cellular/ long-term evolution (LTE) and microwave links to support interoperability.

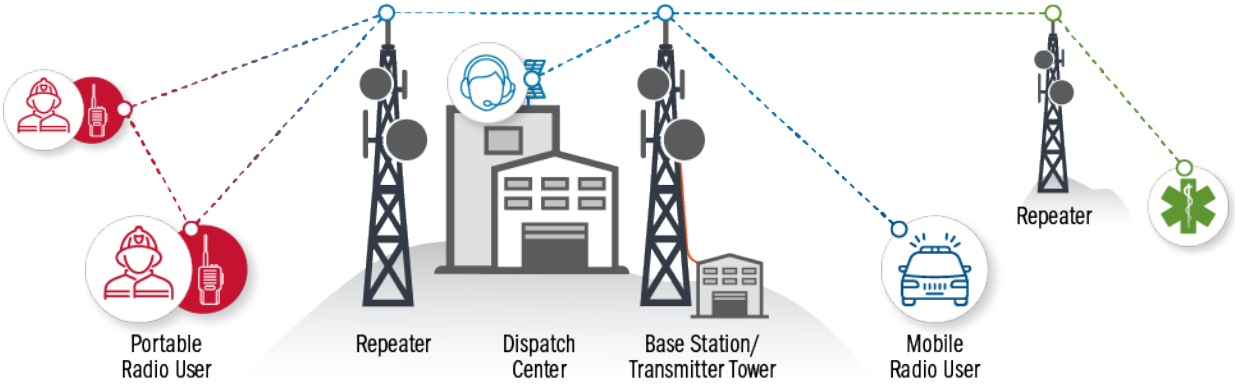

Figure 1: Example of LMR System

Public safety, first responders, public works personnel and commercial entities have used LMR technologies for many years because they provide a reliable means of voice communications. LMR system variants include analog and digital conventional and trunked systems. Conventional LMR systems consist of radio channels with dedicated frequencies. Trunked LMR systems use a control channel to assign SUs within a talkgroup to specific voice frequency channels. LMR system communications often extend between a central dispatch location and the users in the field via radio frequency (RF) links and/or wireline circuits, or network subnets as well as SU-SU via direct RF links.

LMR communication technology continues to evolve to incorporate features such as rapid voice call-setup, group calling, high-quality audio, and secure voice communications. These improvements, along with the Project 25 (P25) technology standards[2], have improved availability, interoperability, spectral efficiency, security, reliability, redundancy and functionality of voice and low-speed data communications. LMR and LTE integration capability is improving to extend coverage, increase interoperability, and utilize improved faster and higher capacity data services.

[1] Cybersecurity and Infrastructure Security Agency, "Land Mobile Radio 101" February 2016
[2] 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.

DIFFERENCES BETWEEN LMR NETWORK AND IT NETWORK SYSTEM INTEGRATION/IMPLEMENTATION

Planning & Implementation: While LMR networks share similarities with traditional IT networks, there are differences that must be considered when planning, provisioning, integrating, and implementing an LMR systems. A key difference between LMR and IT network planning is that the LMR system's physical infrastructure spans far beyond the building in which the system is located and may provide services far beyond the system owner's jurisdictional boundaries to entities outside of the system owner's organization. An LMR network may consist of multiple (sometimes more than 50) RF sites. RF sites contain the LMR system towers, repeaters, antennas, routers, and radio equipment that facilitate the expansion of the communication coverage area. The RF sites are often located in remote locations such as mountaintops (shown in **Figure 2**) and throughout a state or region, and may require real estate purchasing and leasing, zoning, environmental studies, ecological studies, geological studies, historical preservation assessments, and additional utility considerations. Such considerations are not typically required when implementing a traditional IT network as the system is contained within a building or campus environment and will commonly have access to physical connections to the cloud or the Internet.

Figure 2: Remote RF Site Located on Mountaintop

Even though the public recognizes the importance of LMR systems for public safety, some view RF sites and towers as obtrusive to the pristine and natural views they desire to maintain. There may also be significant impacts to historic preservation areas. To mitigate community objections to building RF sites, organizations may have to plan for public town hall meetings to address concerns. Organizations may also be required to make concessions, such as building "stealth" RF towers or paint the communication shelters specific colors that help the RF site blend with its surroundings. In some cases, organizations may be unsuccessful in reaching an agreement with the community or locality and must look for alternative locations or use of existing structures if feasible, technically sufficient, and available. These modifications and alternate site searches may be unforeseen and will add to the LMR system implementation schedule and budget.

Project schedules and budgets must account for additional time and resources to accommodate possible site feasibility studies, lease negotiations, legislature approval, environmental testing, utility company coordination, and site construction. Some locations may have limited construction seasons due to weather or wildlife mating seasons. In some instances, this may result in an additional year or longer to complete these activities. Coordinating these activities for each RF site only adds time to the implementation schedule and further complicates the implementation when RF sites are in

different cities, counties, or states that may have different rules and regulations for obtaining required permitting.

System Integration: With traditional IT network implementation, there may be one company performing the design and installation of the network. Because of the various disciplines involved with implementing a large LMR system, several vendors may be engaged and use of a system integrator is recommended to manage all involved parties. LMR system integration may consist of the network design engineering team that may or may not include the LMR equipment vendor, civil and environmental engineers with licensed professional engineers on staff to validate that LMR system designs meet the codes in each jurisdiction, real estate professionals for land purchasing or leasing, construction companies to build the RF sites, technicians to install the LMR equipment, shelter and tower manufacturing companies, and someone to manage the schedule coordination between these components and affected utility companies.

Network segmentation and priorities should be considered when integrating LMR systems with traditional enterprise IT networks. Public safety operations may involve life or death scenarios where a loss of communications due to network congestion could result in the inability to render timely and life saving services. Just as LMR networks provide priority of voice communications over data communications, priorities must be established for LMR data transmission and adequate server/processing capacity to ensure public safety communications are not negatively impacted by IT systems operating at a lower priority. Ensuring dedicated network resources for LMR systems is recommended for a robust and resilient communications network. LMR and IT technicians should work together to maintain both networks and safeguard against system outages.

Operations and Maintenance (O&M): Another key difference between LMR and IT networks is in the O&M of the systems. System reliability and availability is vital to both system types. However, when issues arise within IT systems, it is rare that the system administrator will have to leave the building in which they work to resolve the issues. When issues develop within LMR networks, it may require the LMR technician to travel to one or more remote RF sites to make repairs. This could require traveling several hours or even a helicopter flight for access, due to the rural nature of some sites. Site access, as shown in **Figure 3**, could be impacted by poor weather conditions (e.g., snow and extreme winds), wildfires, or damaged roadways. Planning for repairs could require access to helicopter transport on standby, four-wheel drive vehicles, or all-terrain vehicles (ATVs) to access some of the more remote locations. Due to the remoteness of many RF sites, LMR technicians are advised to carry additional equipment and tools to the sites in anticipation of the various issues that may have caused the outage. Being overly prepared prior to traveling to the sites will help reduce the system down-time and the number of trips to the sites.

Figure 3: Example of Trail Leading to Mountaintop RF Site

Figure 4: RF Site with Solar Power Plant

From a maintenance perspective, some RF sites are powered by solar panels (see **Figure 4**), generators, and batteries. O&M budgets must include funds to maintain and improve these systems over the network lifecycle. In addition, the generators require fuel that must be replenished, potentially requiring a helicopter to transport refueling tanks to the RF sites. Proper logistics planning must occur to ensure fuel supplies are never depleted. Preventative maintenance should be scheduled to help avoid outages when it is most difficult to reach the RF sites (e.g., during the winter and heavy rain season). Maintenance agreements should be developed to establish agreed upon repair schedules, based on system outage severity and the organization's downtime tolerances. Lower tolerances for outages will require a more significant number of spare parts and more technicians to address the repairs as well as perform preventative maintenance on the system. Agreements should address emergency situations (including all-hazards situations) to ensure vendors and/or repair technicians will always have the appropriate personnel available to respond and make repairs. In addition, the agreements should specify access and availability to the necessary inventory, tools, equipment, and transportation.

LMR PROFESSIONALS' PAIN POINTS

A common misconception that arises when implementing LMR systems is that the existing team of IT technicians can automatically take responsibility and adequately manage the LMR network. LMR networks have unique infrastructures and require specialized training and understanding. Some components of the LMR network are the same (i.e., computers, routers, switches, backup power supplies, cabling). However, beyond these components is where the differences occur, and the technician must be knowledgeable of the various radio components. The LMR technician must have the knowledge to maintain and ensure proper operation of radio transmitters, receivers, multiplexers, duplexers, antenna systems, microwave backhaul equipment, and frequency spectrum management. The LMR technician is also responsible for programming the codeplugs into the SU, establishing talkgroups and channel assignments, maintaining system parameters and infrastructure, and managing proper encryption keys.

LMR network managers also experience challenges similar to IT technicians when it comes to network security and configuration management. One such challenge is establishing resilience and security plans to ensure the network's continuous operation and prevent malicious attacks. LMR network managers must collaborate, develop, implement, and perform security updates (both physical and cyber related) to the system to maintain its designated security posture. In enterprise environments, this would also entail collaboration with the IT department cyber team, chief security officer (CSO) or other security personnel to ensure that LMR networks have the most robust cyber and physical security capabilities that may be extended and provided by the enterprise while not interfering with the functionality and provision of services. It is advisable to ensure any cyber or product performance/enhancement updates to the LMR system are tested on a test platform prior to installing on a live system to prevent adverse impacts that could cause system interruption or compromise.

Network management and security comes at a cost that should be included in the overall O&M budget. LMR technology is evolving and funds for periodic equipment upgrades, and updates have

been given lesser priority as compared to traditional IT networks. These budgetary considerations should not be forgotten during the O&M budgeting for LMR network requirements and equipment.

THE DIFFERENCE BETWEEN LMR AND OTHER IT SYSTEMS LOGISTICS

Availability %	Downtime Per Year
90% (one 9)	36.5 days
99% (two 9's)	3.7 days
99.9% (three 9's)	8.8 hours
99.99% (four 9's)	52.6 minutes
99.999% (five 9's)	**5.3 minutes**

Figure 5: The Nines of Availability

A component of the LMR system planning is establishing the organization's threshold for system outages. A common rule of thumb for public safety LMR systems is for it to be available 99.999% (referred to as "five 9's") of the time. This level of availability equates to a total LMR network outage of less than 6 minutes per year. To achieve this level of resiliency, the LMR network must include robust redundant and resilient communication paths, backup power systems, the ability to predict system outages through proper network management techniques, and knowledgeable technicians to keep the system operable to the highest degree.

Remote RF sites as well as local LMR systems should be equipped with an adequately designed power source and a backup/redundant power system(s) to ensure power is always available to the LMR network and critical components. Primary power may be supplied by a local utility company or a properly engineered solar power plant. Backup power may consist of one or more of the following components: solar power panels, batteries, uninterruptable power supplies, and/or generators with the appropriate amount of fuel (propane, natural gas) with an accompanying logistics contract for resupply in times of an emergency or disaster incident. The appropriately rated power transfer switching system is also required to transfer the LMR system from its main power source to the alternate source without disrupting the operation of the system. There are software applications available that will monitor and predict the health of the battery systems to provide an alert when a particular battery cell is underperforming. The generator fuel levels can be monitored remotely to determine when refills are required. As part of the preventive maintenance schedule, these backup systems should be tested to ensure proper operation.

By the pure nature of LMR systems, RF sites are often located in areas with high elevations like mountain tops to provide a more unobstructed line of site for radio transmissions. As such, accessing these sites during construction and to perform maintenance may require alternate means of transportation such as a helicopter, ATVs, and four-wheel drive trucks. Some prefabricated RF site shelters and towers are too heavy to be transported on a trailer along some unimproved trails and may weigh more than the typical helicopter can safely carry. In this case, a sky crane helicopter may be necessary to carry the heavy shelters to the RF sites. Unfortunately, most sky cranes are located on the West Cost of the United States and are also used to fight forest fires. Use of the sky cranes for RF site construction projects may take a lower priority during the wildfire season, which could have adverse impacts to the site construction schedule.

Figure 6: Sky Crane Lifting Communication Tower

The remoteness of sites could also impact the ability to access the RF sites for maintenance and repairs, as mentioned earlier. LMR system owners should budget for helicopter transport services when normal modes of transportation are unavailable. It is recommended the helicopter be capable of performing long line transport of fuel and LMR site components such as antennas, microwave dishes, and ice shields that may also require replacement on the towers.