Copicut Hill (Fall River), Middleboro, and Mendal Hill (Acushnet). Pine Hill, Copicut Hill, and Middleboro are all microwave hub sites in both the analog system and the current CoMIRS upgrade design. Loss of any of these microwave links would impact wide area communications across the entire southeastern Massachusetts area. At Mendal Hill, the microwave link to Copicut Hill is presently operating without any redundancy due to no availability of spare parts. The microwave radio systems in southeast Massachusetts are the oldest in the entire network and have been out of support since 2001. Failure to address this backhaul issue can impact CoMIRS users throughout southeastern Massachusetts and risks the loss of wide area communications.

960 MHz Microwave Radios: Beginning in May 2016, the MSP trunked radio system began experiencing problems with the microwave backhaul link for the Quabbin tower site. The link became unstable and began dropping its connection. This resulted in a loss of communications for radios using that tower site. The alarm indicating this condition has occurred 250+ times since May 2016 and continues today.

The microwave link for the Quabbin tower utilizes 960 MHz radios manufactured by GE MDS. There are currently two additional links (from Charlton to Brimfield and West Brookfield to Monson in south central Massachusetts) using these same radios. They were installed in the late 1990s and early 2000s. MDS no longer supports or repairs these radios. There are limited functioning replacement parts available to MSP for servicing these microwave radios. MSP is currently planning to replace these three legacy, circuit-switched 960 MHz radio links with three 960 MHz radio links manufactured by Moseley. The Moseley product is a hybrid link that supports legacy, circuit-switched connections as currently used by CoMIRS, as well as newer, packet-switched IP connections. The Moseley replacement links, which were designed as a direct replacement for MDS customers, could utilize the same antenna systems and frequencies as the ones currently in use.

2.2.2.3 Network Management

Network management includes the software and hardware that coordinate and manage the land mobile radio network. This section introduces the CoMIRS network Core, its Zone Controllers, and the software used to manage the network. The components of the CoMIRS Network Management are depicted in Figure 2-35 below.

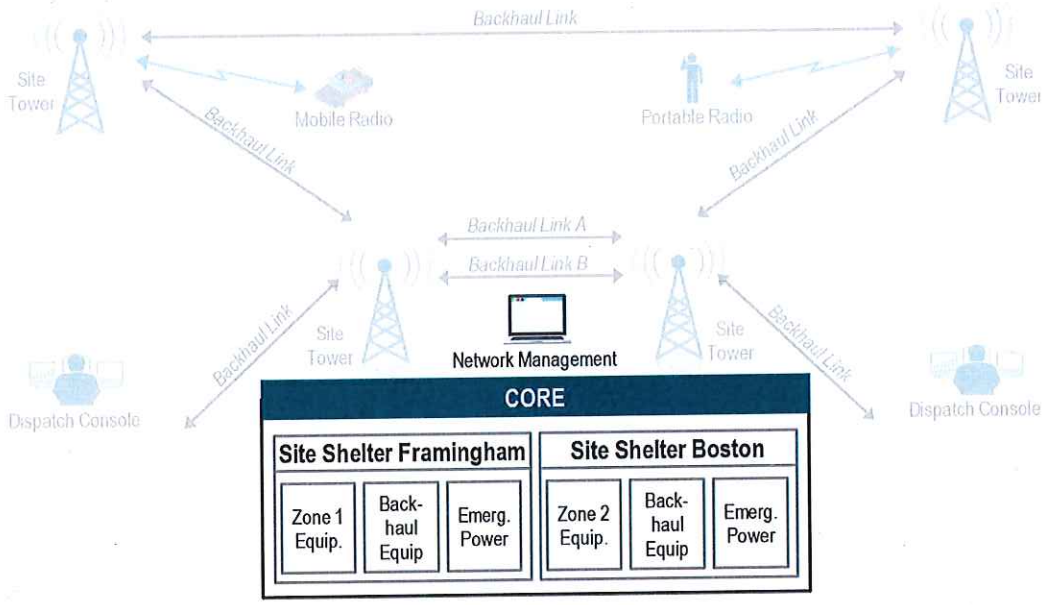


Figure 2-35: Network Management and Core

Network Core and Zone Controllers

At the heart of the CoMIRS network is the network Core. The network Core serves as the configuration manager, fault manager, and performance reporter for CoMIRS. The Core serves as a single point for configuring and managing the entire radio system, including consoles. The CoMIRS Core is located at MSP General Headquarters in Framingham.

The CoMIRS Core is linked to two Zone Controllers, located at MSP General Headquarters (Zone 1) and Boston Police Department (Zone 2). Zone Controllers are the hub for all radio activity on CoMIRS. All network links from radio sites and subsystems terminate at one of the two Zone Controllers. Each Zone Controller uses the assets managed by the Core to complete its activities.

Zone Controllers consist of multiple servers, IP switches, and routers configured to manage:	
• Call Processing	• Network Management
• System Authentication	• Data Communications
• Security Management	• Interoperability Management
• Back-up and Restore Functions	• MCC7500/7100 and Gold Elite Dispatch Consoles

In addition to providing day-to-day operational support to the primary users of the network, the network Core and its Zone Controllers serve as an intersystem interface for other critical first responder networks across the Commonwealth. Figure 2-36 shows the assets in the CoMIRS network that connect through one of the two Zone Controllers.

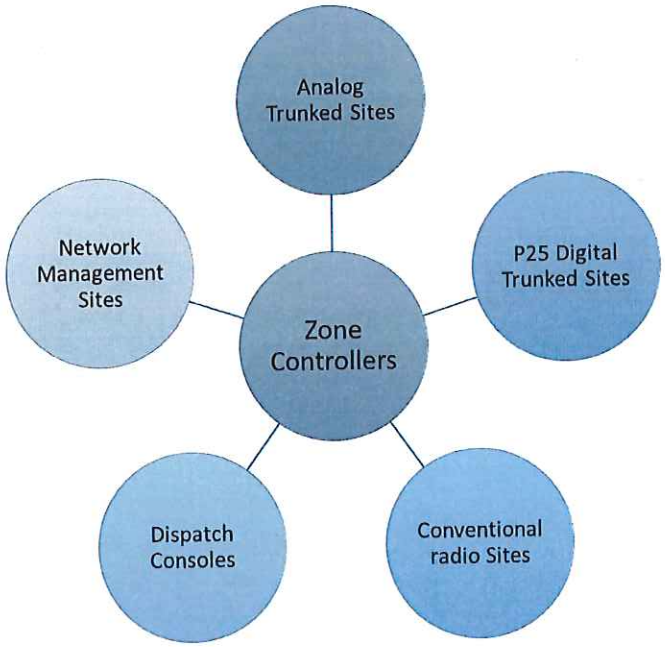


Figure 2-36: Assets Connected to CoMIRS Zone Controllers

The CoMIRS Zone Controllers are designed to support P25 digital communications and features. To support the Massachusetts migration from analog to P25 digital trunked systems, gateways are used to convert signaling schemes from legacy radio and console systems to P25 signaling. CoMIRS currently employs two gateway types:

- **Analog trunked radio sites to P25 Core** – Eighteen Motorola Smart-X gateways are located in the MSP General Headquarters equipment shelter, one for each analog simulcast prime site and each analog standalone trunked site. These gateways enable direct communications between radios using the analog systems and radios using the digital systems. System release 7.17 is the last release to support Smart-X operation and the analog system interface to the Core. *No future system releases can be applied until all analog systems are decommissioned.*

- **Gold Elite Consoles to P25 Core** – The Motorola Gold Elite Gateway (MGEG) enables the circuit switched architecture of the Gold Elite Consoles to access and control a packet switched P25 FDMA radio network. This gateway is not compatible with P25 TDMA operation. MSP Gold Elite consoles can intercommunicate and share resources with other MSP Gold Elite consoles, but they cannot intercommunicate or share resources with MCC7500 consoles in the network. System release 7.15 is the last release to support Gold Elite Console operation on the network. State Police consoles will not function when the system is upgraded to SR 7.17. *The Commonwealth must replace the MSP Gold Elite console systems before another software upgrade can be applied to CoMIRS.*



observation

No future system releases can be applied to CoMIRS (or its subnetworks like the City of Boston) until all analog systems are decommissioned and all Gold Elite Console Systems are replaced.

The CoMIRS two Zone Core system is capable of expansion for additional individual radio IDs, radio sites, and dispatch console sites as illustrated in Figure 2-37.

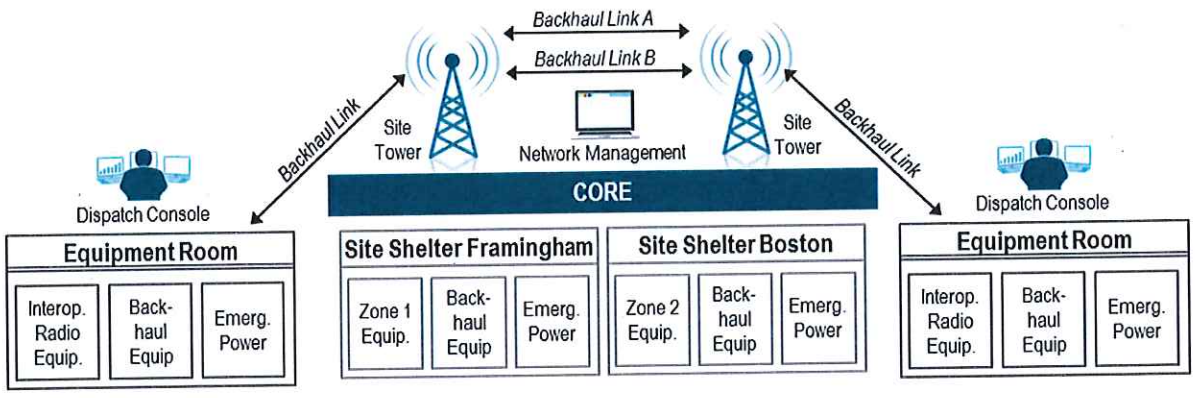


Figure 2-37: Core System Diagram

The two Zone Controllers are interconnected forming a multi-zone system through redundant interzone back haul links. Link A is a Framingham to Boston microwave wireless connection, and Link B is a state owned fiber connection. In the current installed System Release (7.15), the two zone core system is capable of expansion for additional individual radio ID's, radio sites, and dispatch console sites as illustrated in Figure 2-38.

System Components	2 Zone Capacity	Present Count
Individual Radio ID	128,000	37,000
Radio Sites	150	39
Dispatch Console Sites	110	36

Figure 2-38: Two Zone System Capacity

CoMIRS and its subsystem networks are due for a system software upgrade during 2017. The move to system release 7.17 will further increase the capacity of the CoMIRS network to allow:

- 150,000 individual radio IDs per Zone
- 250,000 individual radio IDs per system
- 100 dispatch console sites per Zone
- 500 dispatch console operator positions per Zone



observation

The CoMIRS Core has sufficient capacity for current and envisioned future users of the network.

Network Management Systems

Network management systems provide for the central management, alarming, and control of remote network components. MSP administers the network management system with limited administrative rights granted to private system owners and large fleet administrators, such as Barnstable County and the Department of Correction.

Motorola, the contracted maintenance vendor, remotely monitors the network management system 24 x 7 for system faults and alarms. In the event of a system alarm, the contractor coordinates required action with local service personnel, MSP, and other appropriate system operators. MSP administers a second alarm system (MOSCAD), which monitors radio site alarms for intrusion, fire, generator faults, battery faults, antenna system faults, and other environmental conditions. Alarms received by MOSCAD generate text messages to MSP and maintenance contract personnel directly. The primary terminals for both alarm systems are located at MSP Headquarters in Framingham. Both analog and digital radio sites utilize the same network management and alarm systems.

MSP is the overall manager of CoMIRS. As such, MSP sets operational guidelines and rules for system use. MSP retains the highest level of administrative rights. Some system administrative rights are granted to administrators representing Boston, Cambridge, Massport, Worcester, and Hampden County. Levels of administrative rights are protected by password, and mandatory training is required for a system owner to receive administrative rights.

2.2.2.4 Mobile, Portable, and Desktop Radios

The most visible, and often the most costly, components of a land mobile radio system are the individual subscriber units that allow users to communicate on the network. The common types of subscriber equipment used on the CoMIRS network are portable, mobile, and desktop radios. Portable radios (i.e., walkie-talkies) are typically belt worn radios carried by public safety personnel. Portable radios tend to have a limited transmission range. Mobile radios (mobiles) are typically permanently mounted in first responder vehicles and use the vehicle's power supply and a larger antenna, providing a greater transmission range than handheld portable radios. Desktop radios are mounted in fixed locations for office or small dispatch area use. Each of these radios provides a single user the ability to communicate on the radio network.

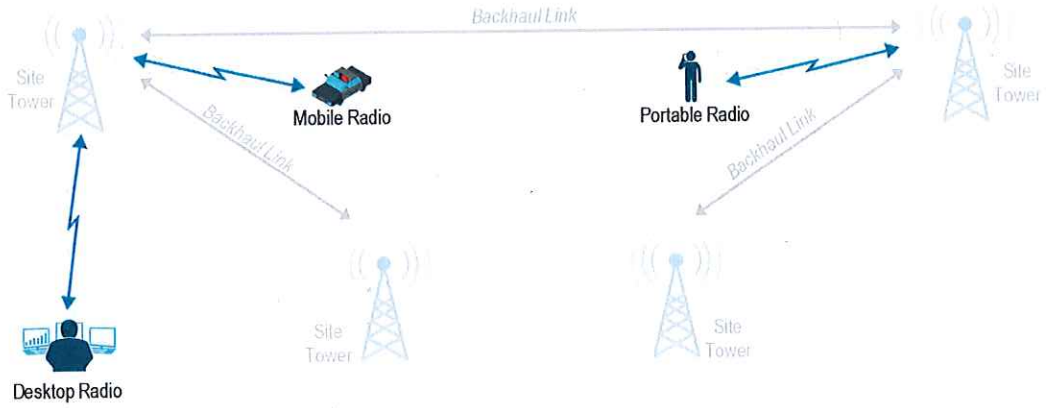


Figure 2-39: Mobile, Portable, and Desktop Radios

CoMIRS Radio Standards

In all cases, CoMIRS radio users are responsible to purchase and maintain their own mobile, portable, and desktop radios for use on the network. To ensure the proper operation on the network, the MSP, as the manager of the trunked network, maintains recommendations for certain basic radio requirements for all user agencies, including:

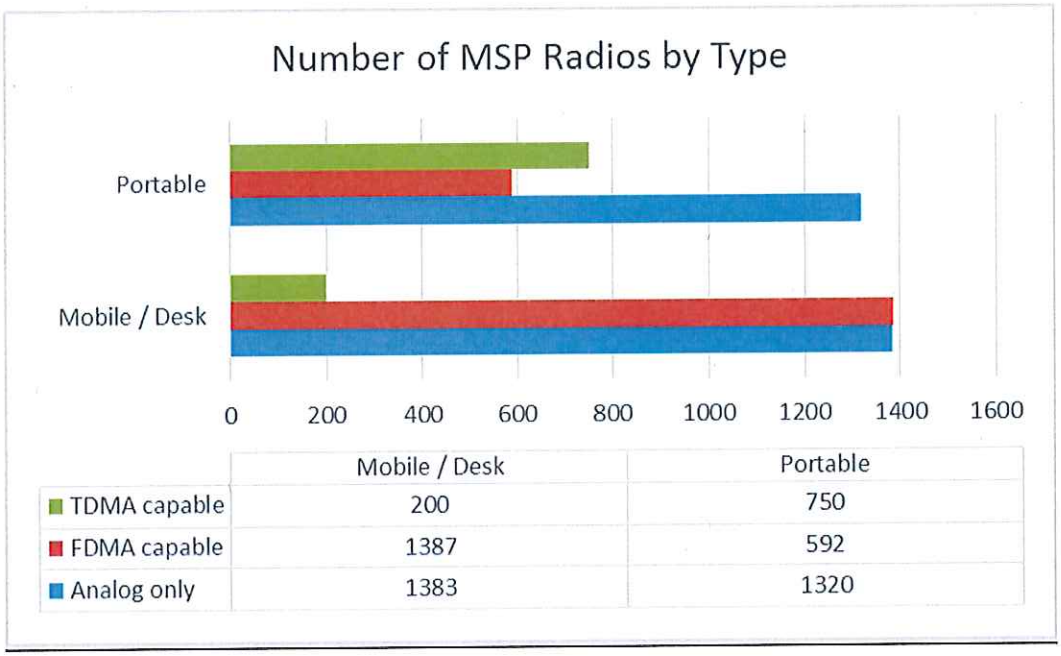
- **Analog and P25 Digital Trunked Operation** – Radios must be equipped to operate on legacy analog systems, as well as more modern digital P25 FDMA and TDMA systems.
- **Automatic Roaming** – Radios must automatically switch radio sites as required to maintain coverage.
- **Push to Talk ID** – Unique individual IDs must be assigned to each radio and must be broadcasted on each transmission.
- **Emergency Alarm** – Radios must be equipped with an emergency button which, when pressed, sends a "Help" signal to dispatch consoles.

- **Trunked and Conventional Operation** – Radios must operate on both trunked systems and non-trunked conventional channels, which are used for short-range communications and interoperability channels.
- **Channel Plan Programmability** – Radios must have sufficient channel capacity to program both agency operability and common interoperability talkgroups and channels.

It is up to the individual user agency to adhere to these standards when purchasing new subscriber units for use on CoMIRS.

Types of Radios on CoMIRS

Through stakeholder interviews, it was found that mobile, portable, and desktop radios operating on the system range broadly in age and capabilities. Most agencies follow guidance offered by MSP system administrators when purchasing radios for operation on the network. MSP system administrators currently recommend analog, P25 FDMA, and TDMA compatibility to agencies purchasing new equipment. Mobile and portable radios currently operating on the network are broken into three basic categories: Analog Only, P25 FDMA capable and P25 TDMA capable. Figure 2-40 shows the count of radios by type currently in use by MSP.



	Mobile / Desk	Portable
TDMA capable	200	750
FDMA capable	1387	592
Analog only	1383	1320

Figure 2-40: Types of Radios in use by MSP on CoMIRS

Analog Only Radios – The majority of the radios purchased prior to 2008 are analog only radios. These radios were purchased before the implementation of the P25 digital subnetwork in western Massachusetts. These analog only radios cannot operate on the P25 digital systems. The MSP is the largest user of analog only radios with approximately 2,600 analog only mobile and portable radios still in operation. Other CoMIRS users, including many users in Barnstable County, also still rely on analog only radios for day-to-day operations.

All analog only radios are well beyond the period of manufacturers' technical support. Radios in this category include Motorola MCS-2000 mobile or Motorola MTS-2000 portable radios. Manufacturer support of these models ended in 2010. Troopers with these analog radios are restricted in their ability to communicate effectively in areas where the digital network is predominately used. This creates a public safety concern when troopers must respond to incidents in areas with predominate digital coverage or when troops operate outside of their typical operating areas. These radios are the highest priority for replacement.

P25 Digital FDMA Radios – Radios purchased between 2008 and 2012 are generally capable of operation on analog systems and P25 Digital Phase 1 (FDMA) systems. These radios were purchased prior to the general adoption of the P25 Phase 2 standards, but they can operate throughout the existing analog or P25 Phase 1 digital areas. Most radios in this category are Motorola ASTRO or XTL mobiles or Motorola ASTRO and XTS portables. Manufacturer support for ASTRO radios ended in 2010; manufacturer support of XTL/XTS will end in 2019. Priority should be given to replacing the approximately 100 ASTRO mobile radios in the MSP fleet.

observation

To modernize to a TDMA network, the MSP will need to replace over 4,500 radio units (nearly 80% of its 5,632 current units). Thousands more are used by other CoMIRS users and will need to be replaced.

P25 Digital TDMA Radios – Radios purchased since 2012 are generally capable of operation on analog systems, P25 Phase 1 (FDMA), and P25 Phase 2 (TDMA) systems. Most radios in this category are Motorola APX mobiles or portables. Users in Barnstable County recently purchased radios from E.F. Johnson. These radios operate on the analog system today and are capable of operating on P25 Phase 1 and Phase 2 in the future. Some local agencies in western Massachusetts have purchased P25 digital radios from other manufacturers and these radios are not capable of operating on the proprietary analog trunked systems. However, the agencies' jurisdictions are within the western Massachusetts P25 system coverage area so their needs are largely satisfied.

observation



There are over 2,600 analog only radios used by MSP that are no longer supported and must be replaced. Thousands more are used by other users of CoMIRS.

Based on a MSP provided inventory of active radios, 48% of all current MSP radios are analog only. Another 35% are FDMA capable, only 17% are analog, FDMA, and TDMA capable. Figure 2-41 shows the percentage of radios in use by MSP by category.

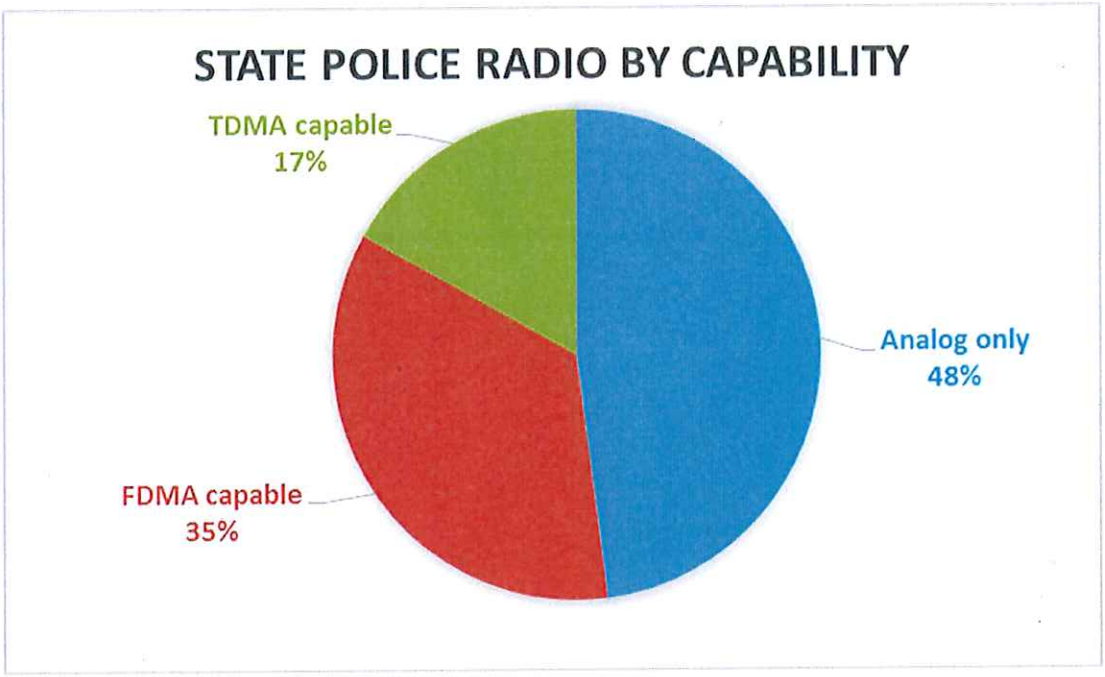


Figure 2-41: MSP Radio by Capability

When both analog and digital radios are used at a common incident, there are often significant voice quality and intelligibility issues. Voice quality on calls that transit both analog and digital systems is degraded due to the multiple transitions from analog to digital that are required to process these calls. This degraded voice quality can jeopardize mission critical communications amongst first responders on different types of voice networks. The quality of voice communications will significantly improve as more users transition to digital radio communications.

observation

Voice communications are degraded when users are operating on both analog and digital networks simultaneously. This degraded voice quality can jeopardize mission critical communications.

Advanced Digital Features

Encryption of radio traffic is used within the P25 digital segments of CoMIRS by various agencies; however, there is no universally adopted encryption scheme within the system. Each user agency determines if encryption is required, and, if so, what type encryption to use.

Encryption is crucial to sensitive radio traffic such as body descriptions, names, discreet locations, and personally identifiable information. Motorola's proprietary Advanced Digital Privacy (ADP) encryption is currently used over the digital portions of the network by MSP and other users. ADP is included in the cost of the Motorola APX radios. ADP is relatively weak and can be easily compromised in comparison to the Advanced Encryption Standard (AES) encryption that is recommended for high-risk operations. AES is included in the P25 standards for digital radio.

Currently, each individual radio must be physically touched to provide an encryption key or to re-key a fleet of radios should the key become compromised. During manual keying, radios without the current encryption key cannot communicate with other radios in the encrypted mode. Encryption, by its very nature, does not lend itself well to interoperability without proper planning to coordinate encryption codes.



observation

Some important advanced features, like AES encryption and remote programming, are not available to users on the analog portions of the CoMIRS network.

The use of proprietary Motorola ADP encryption will limit opportunities for full interoperability. To ensure adequate voice security when required and to promote full interoperability, AES encryption is preferred as a system wide standard. All P25 equipment vendors offer AES encryption.

Other advanced features are available in P25 digital radios operating on a P25 digital network, including radio location, text messaging, Over the Air Rekeying (OTAR) of encryption codes, and data terminal communications. None of these features is in widespread use within CoMIRS, but many user agencies have expressed an interest in utilizing these features when they are available on the updated network.

2.2.2.5 Dispatch Consoles

As introduced before, dispatch consoles are computer software and hardware that are typically used for dispatch, command, and control activities. Consoles are typically wired equipment located in a public safety answering point (PSAP) or in an agency's communications or emergency operations center. Consoles allow an authorized user to monitor communications over multiple radio channels, patch separate channels together for shared communications, and broadcast important information to users of the radio network.

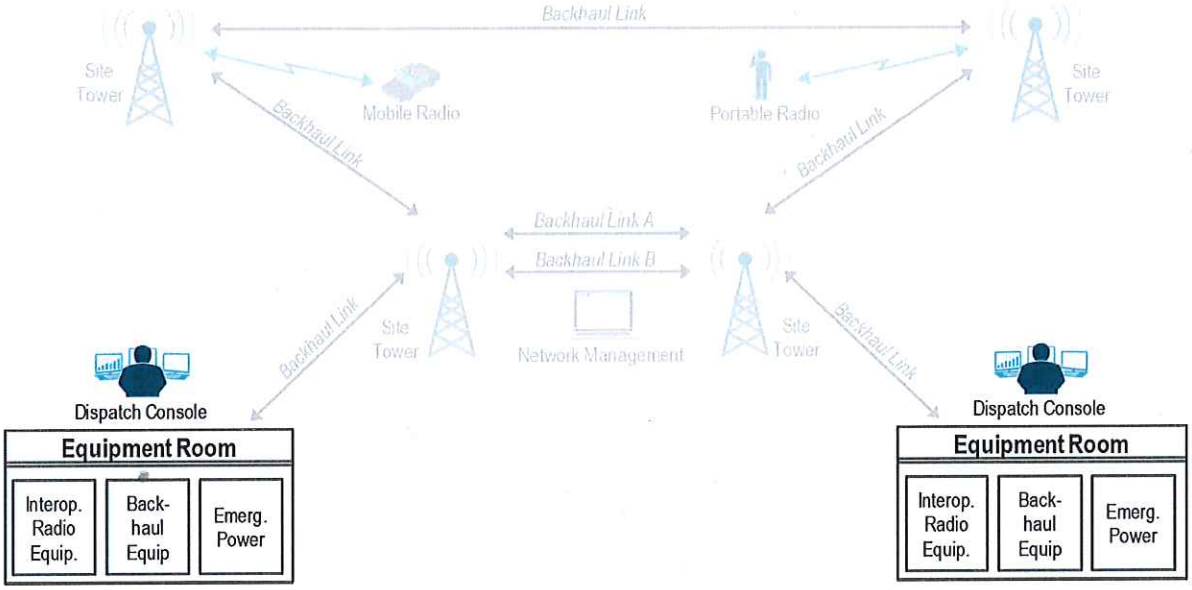


Figure 2-42: Dispatch Consoles

As with mobile and portable radios, each user agency is responsible to purchase and maintain the dispatch consoles they operate on CoMIRS. All CoMIRS dispatch consoles are connected to the network via the network Core. The Core connections are made at the Zone level (Zone 1 in MSP GHQ in Framingham or Zone 2 at BPD HQ in Boston). These connections to the Core are made by microwave radio link, leased fiber connection, or other hard wire method. Currently, the MSP uses out-of-date Gold Elite consoles. All other network console operators use new MCC7500 consoles on CoMIRS.

This common connection provides for permission-based resource sharing across the entire network. Various dispatch consoles can communicate with each other through the Core connection and can share radio resources through the same connection. This interconnection provides some level of redundancy between centers.

The entire CoMIRS network was upgraded to the Motorola Astro 25 7.15 system release in late 2015. Gold Elite Consoles have not been supported by the manufacturer since the upgrade to the 7.15 system. However, MSP users have found no major issues that affect service with operation of the outdated Gold Elite Consoles since the upgrade.

System releases are typically renewed every two years under a contact between the MSP and Motorola. To maintain functionality within the network, all Gold Elite Consoles presently connected to the CoMIRS Core will require replacement with a modern console platform prior to the next system release (SR 7.17) upgrade scheduled for 2017. The manufacturer (Motorola) canceled the Gold Elite Console platform in 2011. Technical support will end in 2018.

MSP Dispatch Responsibilities

MSP operates Core connected Gold Elite dispatch console systems at eight locations. Figure 2-43 shows the list of sites where these outdated console systems are used for state and local dispatch operations.

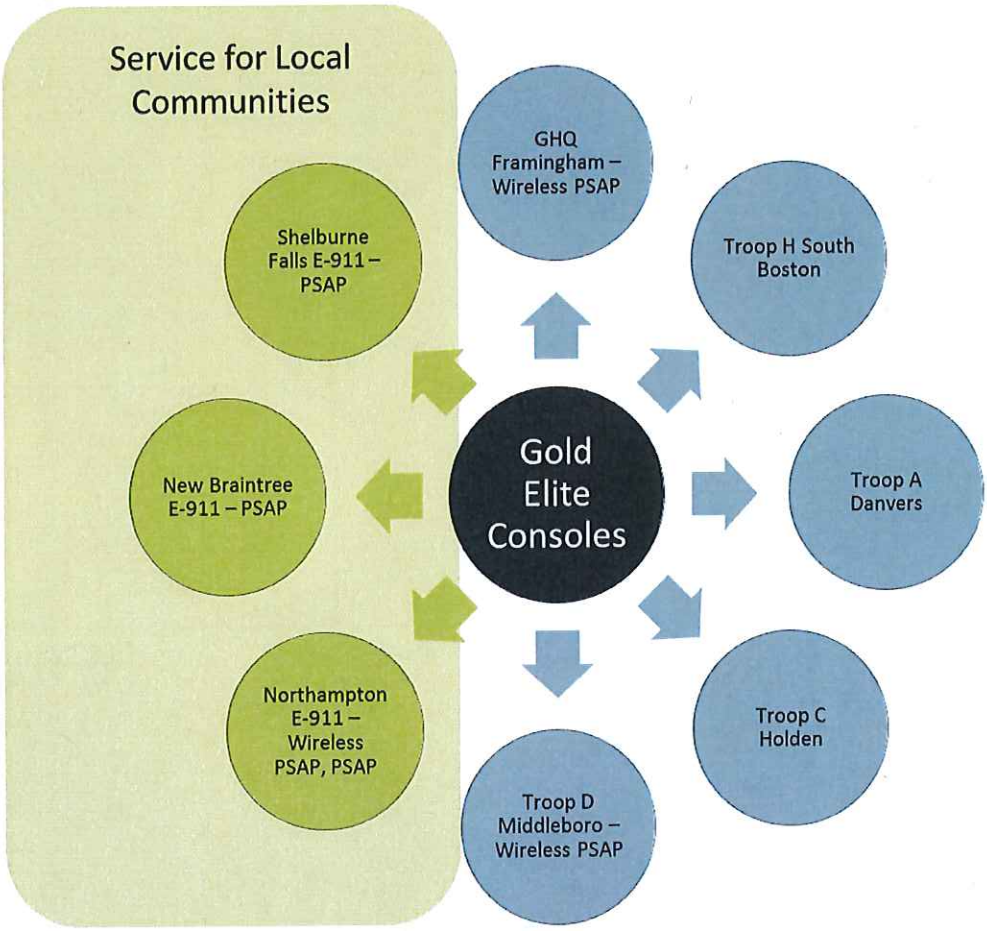


Figure 2-43: MSP Gold Elite Dispatch Locations

Wireless Public Safety Answering Points (PSAPs) located at MSP facilities in Framingham, Middleboro, and Northampton respond to wireless calls for service from cellular telephones statewide and relay those calls to appropriate local PSAPs for dispatching of first responders. These three centers handle approximately 1.8 million wireless 911 calls per year.



observation

There are currently 29 Gold Elite console operator stations at 8 MSP dispatch locations. Each of these console systems must be replaced prior to next CoMIRS release upgrade. Manufacturer support ends in 2018.

Additionally, the MSP provides E-911 call taking and dispatching services to 52 communities from the Northampton, New Braintree, and Shelburne Falls E-911 centers. These three MSP locations serve as the Regional Emergency Communications Centers for these 52 communities. They receive emergency calls through the Massachusetts E-911 system and dispatch first responders via the various radio networks interfaced to the dispatch consoles at those locations. All activities involving radio communications are handled via the radio dispatch console.

Figure 2-44 shows the flow of a call coming into a PSAP and the reliance on the CoMIRS network to dispatch first responders to an incident. Full funding from the State 911 Department is available to cover the costs of receiving and processing a 911 call. Less reliable funding is available for the dispatch part of the 911 call process.

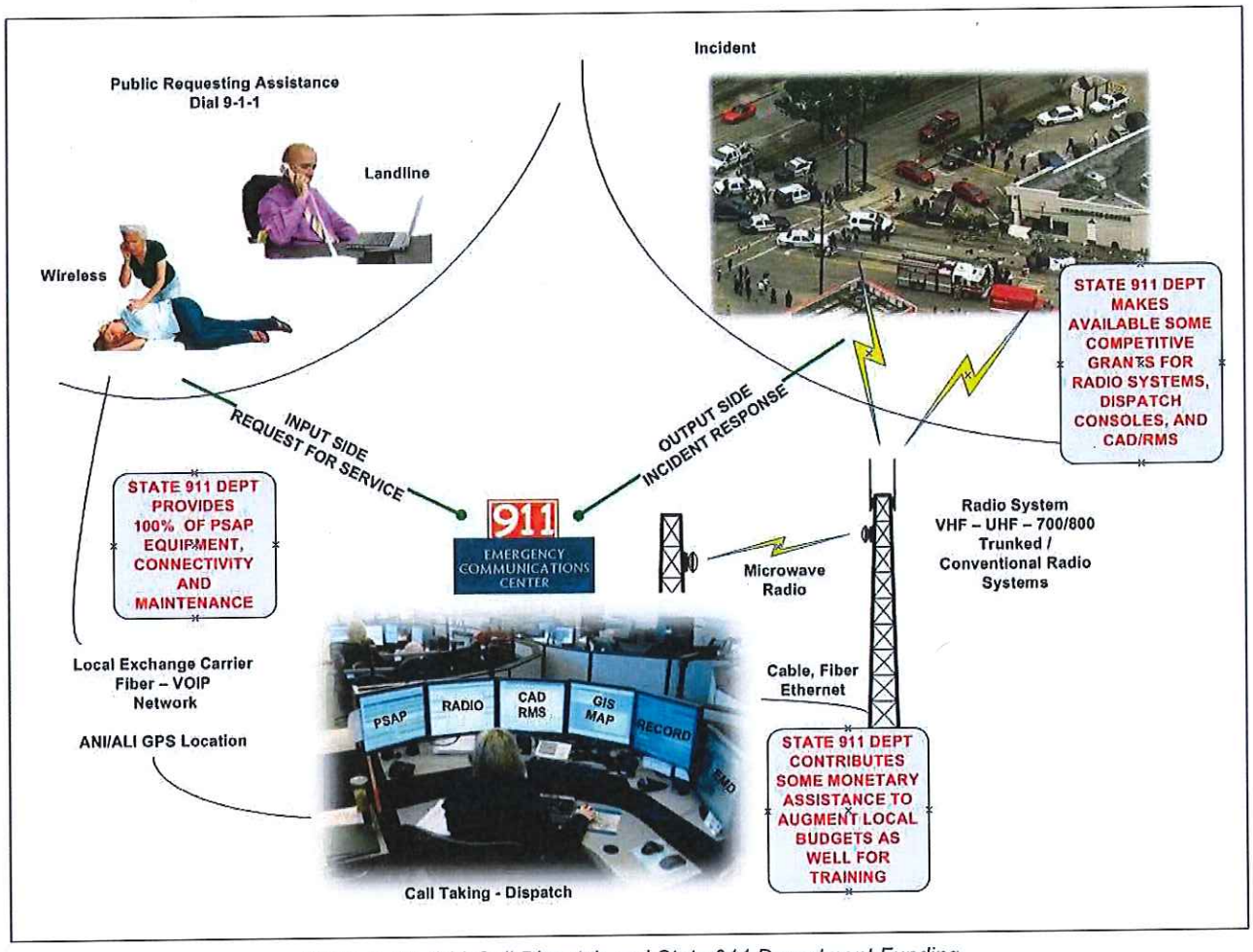


Figure 2-44: 911 Call Dispatch and State 911 Department Funding

Currently, the Commonwealth of Massachusetts has 241 PSAPs statewide. These PSAPs handle over 1.5 million wireline 911 calls per year.

Basic Console Functions

While dispatch consoles vary by type and configuration, the following are the basic features that are common to dispatch consoles operating on CoMIRS:

- **Push to Talk**: The dispatch consoles provide a Push-to-Talk (PTT) functionality that allows the dispatcher to communicate directly to field radio users. This PTT function can be accessed with a foot pedal, mouse click, or a touchscreen interface, depending upon the type and configuration of the dispatch console.
- **"Patch" Communications**: A dispatch console operator can "patch" multiple groups of users, who typically do not communicate on the same channel or talkgroup, together for joint communications. The patch creates a logical, temporary talkgroup that combines users from multiple channels or talkgroups together. This technique is used in interjurisdictional situations, like a car chase, that may begin in one jurisdiction and passes through several others. Employing a patch provides situational awareness for all responding agencies involved in the incident. In other instances, a permanent patch is programmed between two channels that should share communications on a regular basis. For example, a permanent patch exists to share communications between BAPERN users operating on analog channels and those operating on digital channels.
- **Simultaneous Broadcast**: The radio console also offers an option for simultaneous broadcast of traffic from the dispatcher. The simultaneous broadcast can be pre-programmed into the radio console the same way a patch can and allows the dispatcher to make one way broadcast radio transmissions to alert radio users of certain information. A routine use of a simultaneous broadcast is a 'Be On (the) Look Out' (BOLO) alert. With this type of radio console transmission, the dispatcher's voice is heard by all talkgroups involved in the broadcast. However, as the individual radio units respond back to dispatch, only the dispatcher hears the user.
- **Cross Mute**: The radio dispatch consoles also have the capability of cross mute. This allows one console that is in the same room with another console to mute the adjacent dispatchers transmitted audio. This prevents feedback from being transmitted to the radios in the field. The consoles also have the capability to communicate directly with one another without the assistance of a telephone line, as this is a function of the Core.
- **Analog and Digital**: The CoMIRS network handles both analog and digital P25 radio traffic. Many of the radios operating on the radio system are mid-90's models and do not support P25 transmissions. Therefore, the dispatch consoles handle both analog and digital radio traffic.
- **Full-duplex**: The radio consoles are a full-duplex (FDX) system, which means that they can transmit and receive simultaneously. The dispatch console is the only component in the radio system that has the capability to transmit and receive simultaneously. FDX capability allows the dispatcher to receive multiple calls from different talkgroups while transmitting. This minimizes the risk of the dispatcher missing a call.

- **Select and Unselect**: There are two types of audio sources derived from the dispatch console: "Select" and "Unselect". Typically, the Select audio is routed to one speaker and, if the dispatcher's headset is plugged into the console, audio is routed to their earpiece. Additionally, the microphone that is used for the radio traffic transmissions is also on the headset. Frequently, the primary dispatch talkgroup is chosen for Select audio. Unselect audio is routed through a separate speaker, which allows multiple talkgroups to be monitored via a single speaker by a method of summed audio. This method will adjust the volume control on each talkgroup to distinguish which group is active. However, many agencies use multiple speakers to minimize the risk of missing radio traffic.

Emergency Functions

Most radio units (subscribers) operating on the network have a red emergency button to expedite an emergency call to the dispatch center. The radio console processes and transfers the emergency call to the dispatcher. The dispatch console alerts the dispatcher to which talkgroup the emergency was declared upon and identifies the subscriber unit that placed the emergency call. Additionally, some radio systems are configured to force the emergency declaring user's radio microphone to go live for a predetermined period. During an emergency, dispatch is alerted both audibly and visually that an emergency has been declared.

The dispatcher has the capability to silence the alarm and then to clear it once the emergency has been addressed. Silencing the alarm does not clear the alarm from the system or other consoles. It merely eliminates the audible alarm so that the call can be addressed. When the alarm is cleared from the radio console, the alarm is cleared from the radio system, other consoles, and all subscriber units in the field. In most cases, the initiating subscriber can also clear an emergency call where the radio is programmed to allow.

Programming

Stakeholder interviews revealed that the MSP radio programming is consistent. However, other users statewide have other standards for radio programming, which can result in radios that operate differently between agencies. For example, there are differences in the emergency button programming between agencies. Some agencies use the emergency button on their subscribers and others do not. While some agencies do not allow the microphone to go live during an emergency declaration, other agencies do allow the microphone to go live. Another difference in programming between agencies is the ability of a dispatcher to clear emergency calls.

Compatibility and Redundancy

All MSP Gold Elite consoles are configured to be redundant for one another. In the event of a failure at one Gold Elite dispatch center, any other MSP Gold Elite dispatch center can provide backup radio

control. For example, if the Shelburne Falls 911 center required evacuation, the New Braintree 911 center could take over radio dispatch on behalf of Shelburne Falls.

This is also the case for all 193 IP-based dispatch consoles. Any CoMIRS dispatch location operating a MCC7500/7100 console can control the resources at any other MCC7500/7100 equipped center. These IP-based dispatch centers, though, cannot serve as backup for the eight MSP Gold Elite Console System locations, since the Gold Elite cannot effectively interact with the MCC7500/7100 console systems. Additionally, the Gold Elite consoles cannot share CoMIRS conventional channel resources with locations operating the more modern MCC7500/7100 consoles. These incompatibilities between the old Gold Elite platform and the modern IP-based platforms limits the redundancy in the network.

2.2.2.6 CoMIRS Aging Analog Technology

As mentioned before, the CoMIRS network includes analog components that are at, or near, the end of their lifecycle. The continued use of these components may threaten the mission-critical nature of the CoMIRS network. Table 2-8 below shows the critical analog components currently in use on CoMIRS with their corresponding age, maintenance status, and last planned supported Motorola software release. Issues of significant concern are highlighted in red.

Critical Analog System Components Status	Qty	Age-Years	End of Maintenance Support	Last System Release Supported
Circuit Switched M/W Backhaul Systems	34	11 - 21	2009	7.18
Circuit Switched wired backhaul	61			
6809 Trunked Site Controllers	33	20-26	2010	7.17
MTC 3600 Trunked Site Controllers	6		2017	7.17
Analog Trunked Radio Sites	48	16-22	2020	7.17
Analog site to P25 CORE interface (Smart-X)	17	5	2023	7.17
Antenna Systems	48	16-22	N/A	N/A
Emergency Power Systems	48	16-22	N/A	N/A
Analog Mobile/Portable Radios	2,703	14-21	2010	N/A
P25 FDMA/Analog Mobile and Portable Radios	1,979	4-14	2019	N/A
State Police Gold Elite Consoles	27	10-21	2018	7.15

Table 2-8: CoMIRS Critical Analog Components

While age alone is not always a determining factor for replacement, the age of equipment does correspond to the wear and tear to which certain components are exposed. For example, the antenna systems that have been exposed to over fifteen years of weather elements are much more likely to fail than newer equipment or equipment residing in a shelter. This exposure to wind, rain, and temperature extremes wears on the equipment over the years.



observation

Many analog portable radios have become fatigued and defective due to over a decade of continuous use.

As shown above, the State Police have over 2,700 radios that have been in almost daily use for over a decade, some as old as twenty years old. Much of the equipment shown is either near the end or out of maintenance support by the manufacturer. As this older equipment fails, finding replacement parts and getting it repaired becomes expensive and time consuming.

Much of the analog network equipment is also running up against issues with the need to stay up-to-date with Motorola software releases. Massachusetts has a maintenance contract with Motorola,

where Motorola provides support services including system releases. Currently, the system is operating on release 7.15, which was installed in 2015. Keeping up to date with system releases is much like keeping a computer or smartphone up-to-date with the latest software upgrades. The next release scheduled for CoMIRS is 7.17, which will be installed during 2017. As shown above, much of the analog equipment will no longer be supported beyond this release and the twenty-nine Gold Elite Consoles used by the State Police for dispatch are no longer supported beyond release 7.15.

2.2.3 CoMIRS Coverage

This section depicts and analyzes the existing radio coverage areas for CoMIRS based on coverage maps and performance reports provided by the current CoMIRS maintenance vendor, Motorola. Network radio coverage is the aggregate of radio coverage provided by the radio tower sites that comprise the network. In the early stages of the development of the analog network, the Commonwealth utilized state-owned tower sites and other sites that were made available at minimal cost to the project. The MSP then worked to maximize the coverage possible from these low-cost tower sites.

Many of the tower sites in the analog system are DCR Fire Towers that are 60'-75' high. This limited tower height is not optimal for use as radio sites since it puts transmitting antennas at or below the height of surrounding trees. This can impede antenna radiation patterns and block microwave backhaul links. DCR fire towers are typically located where the ground elevation is higher than the surrounding terrain, making these locations desirable for use as radio transmitter sites. Proper use of these locations for radio transmission would entail the building of commercial quality towers on these sites. Traditional radio towers of 120'-180' are preferable to reach optimal antenna heights that clear local obstructions. To improve radio coverage with P25 digital radio deployments in central and eastern portions of the Commonwealth, additional tower sites will be required and existing tower sites will require improvements to increase antenna heights.

The level of radio coverage provided by the existing network of analog and digital radio sites is dependent upon the type of subscriber radio used. Mobile (vehicle mounted) radios are higher power (15-35 watts) than portable radios (3 watts), and they use a more effective antenna system typically consisting of a roof mounted, high gain antenna. Portable radios (walkie-talkies) are typically worn on the belt with a remote speaker microphone worn at shoulder level. The portable radio antenna is mounted on the portable radio so in most cases the portable radio is transmitting from hip level (3 ft.) and is shielded by the operator's body. This results in a much smaller operating area for portable radios than for mobile radios.

The difference between mobile radio coverage areas and portable radio coverage areas are apparent when evaluating the coverage prediction maps included in this section. Two types of radio categorizes are used in determining radio coverage within the network:

- **Mobile Radio**: vehicle mounted 35 watt radio with roof-top mounted antenna
- **Portable Radio:** handheld 3 watt portable radio with flexible whip antenna worn on the belt, operated in outdoor areas



observation

To meet the coverage needs of the MSP and the other users of CoMIRS, coverage improvements should be included in any network enhancement efforts.

Coverage goals for the analog portions of the system were for universal mobile radio coverage and "in street," as opposed to "in building," portable radio coverage. "As-Is" coverage predication maps provided by the equipment vendor for the analog systems show that mobile coverage for the analog

systems is fairly reliable across the service area, while portable "in-street" coverage is poor or non-existent in some areas. Users in these areas of poor and non-existent portable coverage are without communications through the network once they leave their vehicle radio.

2.2.3.1 Network Coverage Maps

Painted areas shown on the coverage maps (Figure 2-46, Figure 2-47, and Figure 2-48) meet 97% reliability with a Delivered Audio Quality of 3.0. Delivered Audio Quality (DAQ) is a measure of audio quality over a transmission medium. This metric quantifies the quality of audio heard over a radio system. The scale shown in Figure 2-45 defines DAQ levels:

DAQ	Definition
1	Unusable. Speech present but not understandable
2	Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion.
3	Speech understandable with slight effort. Requires occasional repetition due to noise or distortion.
3.5	Speech understandable without repetition. Some noise or distortion present.
4	Speech easily understandable. Little noise or distortion.
4.5	Speech easily understandable. Rare noise or distortion.
5	Perfect. No distortion or noise discernible.

Figure 2-45: Delivered Audio Quality Scale

Non-painted areas shown on the coverage prediction maps do not meet the 97% reliability and DAQ 3.0 criteria. This does not mean there is no radio coverage. Rather, it means that communications available fall below the minimum criteria used for the maps. Motorola, the vendor for the existing systems, provided three coverage maps:

1. MSP Network 800 MHz analog coverage – Mobile Radio
2. MSP Network 800 MHz analog coverage – Portable Radio
3. MSP Network 800 MHz P25 digital coverage – Mobile Radio



observation

Despite MSP's statewide jurisdiction, most MSP radios cannot operate on both analog and digital. This reduces the effective radio coverage area, since the current network is a patchwork of digital and analog coverage.

No portable radio coverage map was provided for western Massachusetts. In western Massachusetts (MSP Troop B operating area), mobile radio coverage was the design goal and vehicle repeaters were installed in MSP vehicles to provide communications to/from portable radios in this area.

Analog Mobile Coverage

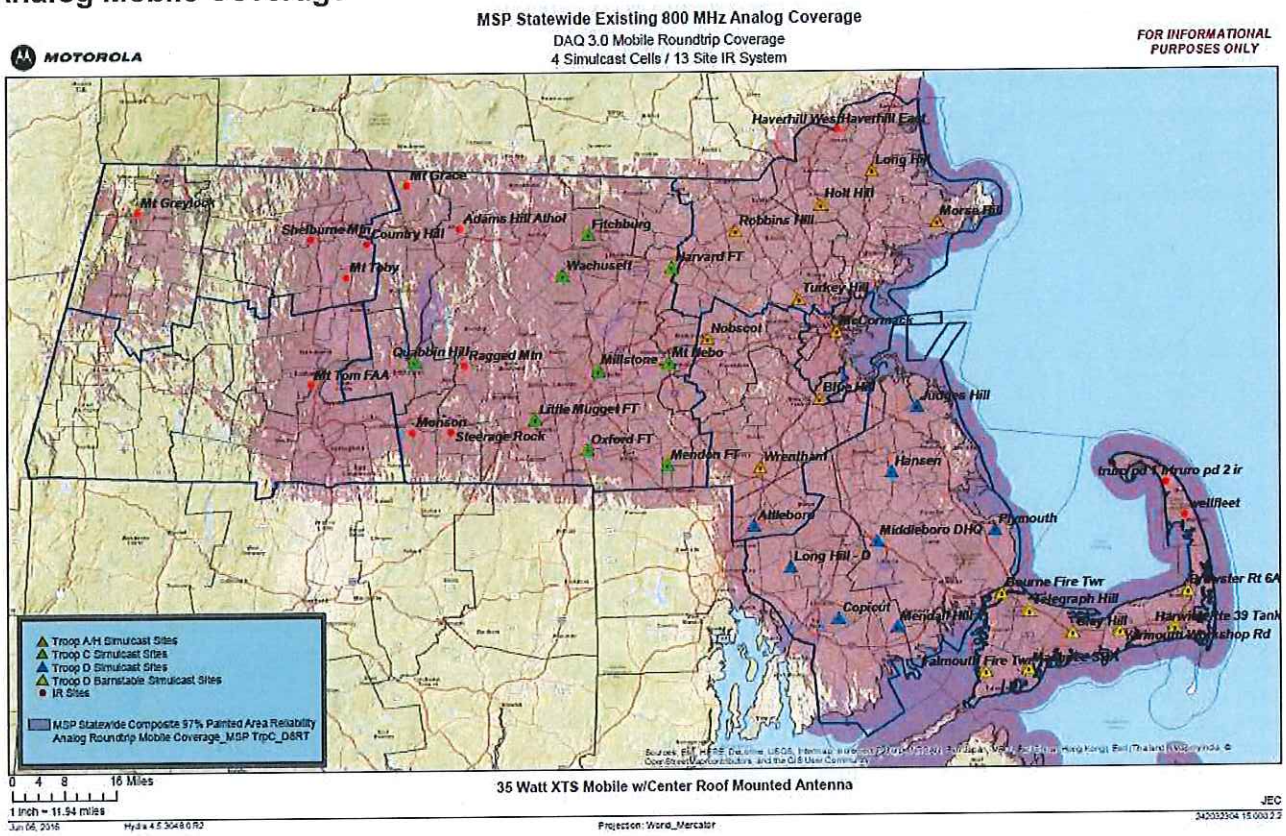


Figure 2-46: Analog Mobile Coverage

The service area for the analog radio system is described as Barnstable, Bristol, Essex, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester Counties. There is little analog coverage in western Massachusetts and analog coverage is being replaced by digital coverage in parts of metropolitan Boston. The mobile radio coverage area within the analog service area is generally considered good, but there are areas of poor coverage represented on the coverage map as unpainted areas.

Analog Portable Coverage

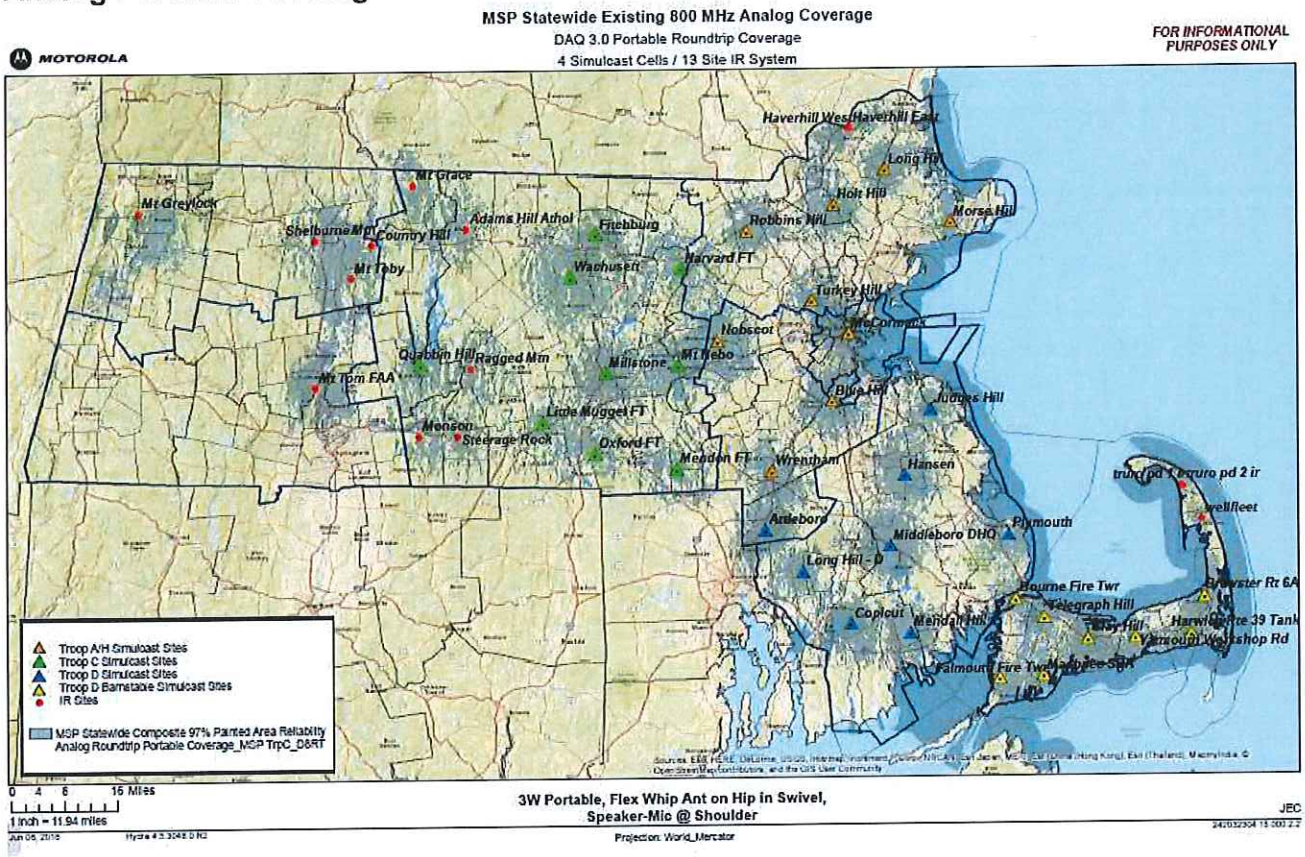


Figure 2-47: Analog Portable Coverage

Since portable radios are lower power, have less effective antenna systems, and are worn at hip level, the portable radio coverage maps show considerably less coverage when compared to the mobile radio coverage maps. While there may be some coverage in non-painted areas of the coverage maps, the quality of radio coverage in those areas falls below the minimum criteria for acceptable coverage and requires improvement. Coverage can be improved by adding radio tower sites.

Since the Commonwealth adopted the strategy of migrating from analog trunked technology to P25 digital technology in 2011, little has been done to improve the coverage of the analog system. A P25 digital design to support existing users should address these areas of poor coverage. Options to expand analog coverage in the short term are limited due to the unavailability of some older, out-of-manufacture analog components.

Digital Mobile Coverage

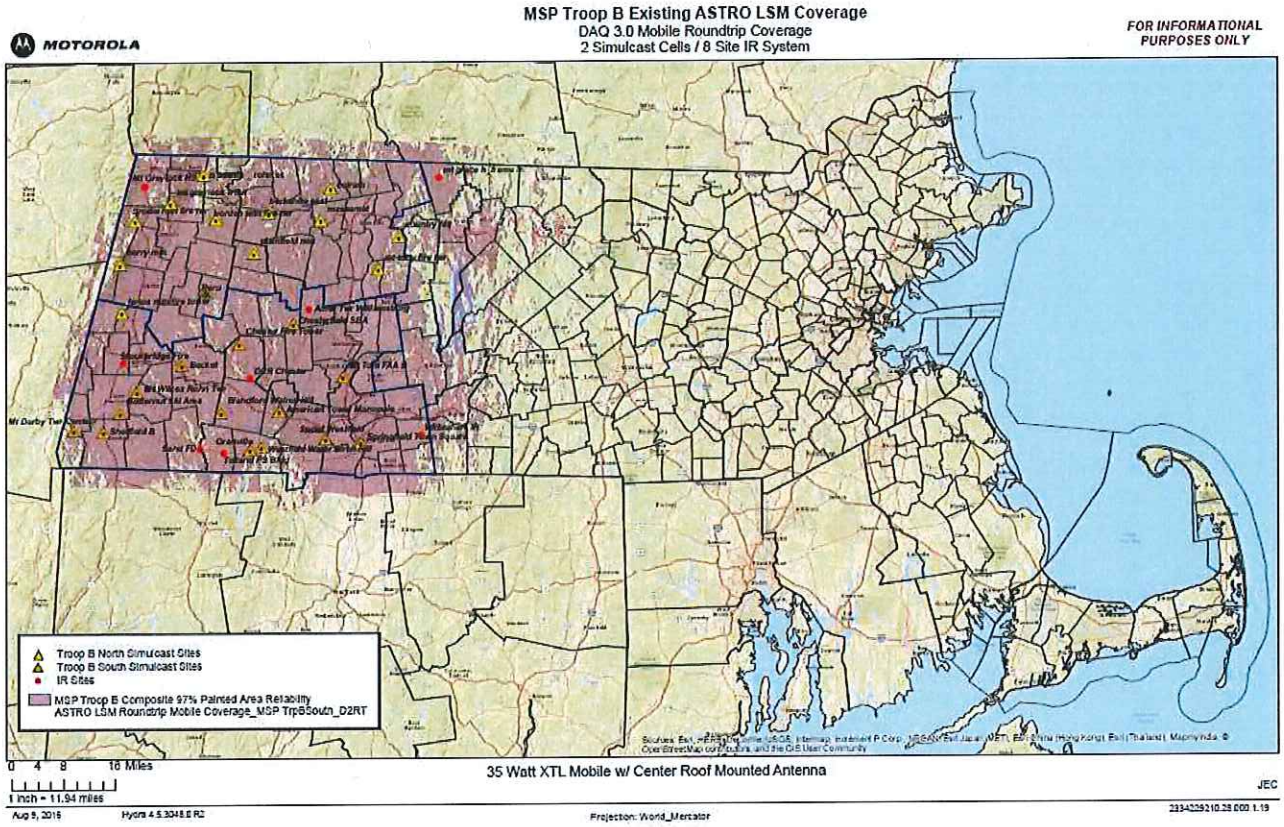


Figure 2-48: Digital Mobile Coverage

The service area for the existing P25 digital systems is described as Berkshire, Hampden, Hampshire, and Franklin Counties. The concentration of radios sites is much higher in western Massachusetts due to the rugged terrain that limits the range of radio service from each radio tower site. Mobile radio service in this area is generally considered good. Portable radio service for MSP users is achieved using vehicle repeaters in each MSP cruiser. The vehicle repeater relays portable radio communications through the mobile radio in the cruiser to the network. The portable radio must be within a quarter mile of the cruiser to operate through the vehicle repeater. Portable radios have the ability to communicate directly to the radio tower and the CoMIRS network without the aid of a vehicle repeater when the radio is operating near a radio tower site.

2.2.3.2 Coverage in Underground Highways and MBTA Tunnels

Radio signals from tower sites constructed above ground do not typically penetrate into underground areas. This loss of signal is overcome by installing Distributed Antenna Systems (DASs) inside the tunnels. DAS distribute radio signals throughout the underground tunnel systems, expanding the coverage of the above ground system into underground areas.

Two such DASs are employed in the greater Boston area. The Massachusetts Bay Transportation Authority (MBTA) and Massachusetts Department of Transportation (MassDOT) own and operate DAS networks to support their operations on the network's 800 MHz analog systems. The MBTA DAS distributes signals throughout the MBTA tunnels. The MassDOT DAS distributes signals throughout the Central Artery Route 93 and the Ted Williams tunnels. Both networks amplify the frequencies used in the northeast Massachusetts (Troop A/H) analog system. Any system user on this system also benefits from this expanded coverage inside the tunnels. Since these DAS solely rebroadcast analog signals, both DAS networks would need to be upgraded to support digital broadcasts when CoMIRS is fully upgraded to digital.



observation

Existing MBTA and MassDOT underground DAS networks require upgrade to operate on new frequencies likely used in any CoMIRS expansion or upgrade.

The MBTA and MassDOT are responsible for the operation and maintenance of their respective agency owned DAS systems.

2.2.3.3 In Building Coverage

To improve radio coverage inside large buildings, Bi-Directional Amplifiers (BDAs) are deployed. BDAs overcome the loss of radio signal by amplifying the signal from tower sites to user radios indoors, and vice versa amplifying indoor radio user signals from portable radios to broadcast to the tower sites. BDAs are available in many configurations and individual BDA design is typically left to the building or fleet operator. Boston, Cambridge, Logan Airport, and others have deployed BDAs to improve radio coverage inside public buildings or hospitals where radio users frequently require service. BDAs installed by system stakeholders are typically professionally designed and maintained by qualified agency personnel and outside contractors.

observation



Inappropriately deployed in-building repeaters can cause interference, degrading otherwise normal radio communications.

Stakeholder interviews indicate that scores if not hundreds of BDAs are deployed throughout the network service area by others with little or no coordination with network administrators. Many have been installed to improve cellular communications and are only discovered when MSP or other system

maintainers search for the source of system interference. Improperly deployed or poorly maintained BDAs are often a cause of interference with CoMIRS user radios.

2.2.3.4 Incomplete Analog and Digital Coverage

The incomplete separate analog and digital coverage areas in CoMIRS provides operating issues for users that work across typical jurisdictions. Radio equipment is typically purchased for and used in areas that maximize the available coverage for the user in that area. For instance, all of MSP Troop B (western Massachusetts) operates with digital radios, since the predominate coverage in western Massachusetts is digital. Troopers in Troop C (central Massachusetts) typically use older analog-only radios. Within the typical operating area of Troop C, these radios provide adequate coverage, though many are aging and failing from years of continuous usage.



observation

Public and officer safety can be at risk when users of the over 2,600 MSP analog-only radios are assigned or respond to an area with predominate digital coverage like western Massachusetts.

The problem arises when troopers from Troop C are called to work or respond within the operating area of Troop B. Here, troopers with analog-only radios will have limited, and in many places no, coverage. A reporting officer from Troop B responding to an emergency in western Massachusetts may be unable to communicate directly with the troopers and incident commander on the scene. Rather, a patch may be needed between analog and digital channels to enable communications and this may take critical time in an emergency. Once patched, the voice communications for officers talking across troops (from digital in Troop B to analog in Troop C) will be degraded as the voice pattern is converted from analog to a digital signal or vice versa. This degraded voice quality is a factor in many current MSP communications between troops and between officers in the same troop with different radio types.

The same can be a problem when troopers from throughout the state are called to work major events in the metropolitan Boston area. Here the City of Boston is moving aggressively toward the usage of digital radio throughout its jurisdiction with the plans of retiring its analog service. Troopers working metropolitan Boston events should have radios that operate on both the analog and digital networks available in that area.

Nearly half of the existing radios in the MSP inventory are analog-only. These old analog-only radios have limited programmable channel capabilities, which can further limit the user's ability to effectively communicate interoperably.

2.2.4 CoMIRS Capacity

The CoMIRS network consists of multiple analog and P25 digital regional subsystems integrated into a single network through the two Zone Controllers of the CoMIRS Core. Regionally constructed subsystems, each with different voice channel capacity, provide radio service within their respective regions. Voice channel capacity varies from a two voice channel multicast site in far western Massachusetts to a 10 voice channel simulcast subsystem in Barnstable County. The channel capacity for each of the radio subsystems making up CoMIRS is shown in Table 2-9 below.

Analog		P25 Digital	
Simulcast Subsystems (# Voice Channels)	**Multi-Cast Sites** (# Voice Channels)	**Simulcast Subsystems** (# Voice Channels)	**Multi-Cast Sites** (# Voice Channels)
A/H Simulcast (9)	Haverhill (4)	P25 B South (5)	P25 Grace (4)
C Simulcast (7)	Wellfleet (4)	P25 B North (5)	P25 Wilbraham (4)
D Simulcast (7)	Truro (5)		P25 Stockbridge FD (4)
Barnstable Simulcast (10)	Mt. Grace (4)		P25 Williamsburg (4)
	Adams Hill Athol (4)		P25 Sandisfield (4)
	Country Hill (4)		P25 DCR Chester (4)
	Ragged Hill (5)		P25 Tolland (4)
	Monson (4)		P25 Greylock HS (4)
	Steerage Rock (4)		
	Mt. Greylock (2)		
	Mt Tom (5)		
	Shelburne Mtn (4)		

Table 2-9: CoMIRS Radio Subsystems, Sites, and Voice Channels

CoMIRS supports users with local or regional operational areas, such as MassDOT, DOC, MBTA Police, and Barnstable County, and users with statewide service areas such as State Police, Environmental Police, and MEMA. Local and regional users are limited to service within their operational boundaries, while system administrators authorize statewide users to roam throughout all analog or digital service areas.

A trunked radio system shares radio frequency (RF) channels among all users on the system. The system is designed to handle every subscriber on the system on an as needed basis. This approach minimizes the time users must wait should no channels be available when one is needed. If a channel

is not available, the system is considered "busy" and users cannot access the radio system until a channel becomes available.

It is the primary objective of network managers to monitor the network for system "busies". Grade of Service (GoS) is a radio industry-wide accepted concept of quantitatively measuring the performance of a radio system with the goal of minimizing the risk of a fully loaded system. GoS is applied to the entire network (or to individual sub-systems within the network) and can pinpoint sites that need attention. Too few RF channels at a site for the given load, an RF channel failure, or too much radio traffic will yield a poor GoS. For example, careful analysis of a poor GoS figure may show that the overall radio system is performing well; however, one site has too few RF channels to handle the load and frequently becomes busy, causing the overall poor GoS.



observation

The CoMIRS Grade of Service goal is that under 2% of all calls during the busiest hours experience busy times over 3 seconds (GoS of 2%). The current system is highly reliable and meets its Grade of Service goal.

Being able to assign communications resources regionally helps network managers balance the use of the available capacity in the network, which results in a low percentage of "busy" signals in the network and a favorable GoS. The network generates busy signals when a user requests a communications path and no channel is immediately available to process the call. When a channel resource becomes available, the network automatically signals the requesting radio that a channel is available to proceed with the call.

The MSP provided monthly system reports detailing the number of busy signals caused by "no channel resource available" recorded on each of the subsystems in the network. These reports included statistics for July 2015, November 2015, January 2016, and April 2016. The months used for the reports were chosen to represent the seasonal differences in the use of the network. The full monthly reports provided by the MSP are included in the appendix to this document.

Table 2-10 summarizes the use statistics for each site comprising the network. The table shows the number of calls, the total number of busies, the number of unacceptable busies (over 3 seconds), site utilization, and calculated actual GoS for the busiest hour of each month for each site. Below is analysis on some of the higher GoS numbers reported in Table 2-10:

- On April 4, 2016, a spring snowstorm hit eastern Massachusetts and may have been the cause of the spike in GoS for the D Simulcast and C Simulcast subsystems.
- The Mt. Greylock site consistently experiences a higher GoS because there are only two voice channels available to process analog calls on that site.

Overall, the current network is highly reliable, experiences minimal busy queues, and has not recorded any instances (in the four month sample) exceeding the established GoS goal. Despite this overall acceptable level of performance, portions of the analog system are beyond life cycle support. This means that spare parts from other machines and direct replacement products are no longer available, when needed. This aging equipment and the difficulty in remediating failed equipment threatens

CoMIRS quality of service going forward. Section 2.2.2 CoMIRS Technology addresses the specifics of this concern for unsupported equipment.

Sub System	Voice Channels	Region	July-15					October-15					January-16					April-16				
			PTT Requests	Busy Count	Unacceptable Busies	Site Utilization	Actual GOS	PTT Requests	Busy Count	Unacceptable Busies	Site Utilization	Actual GOS	PTT Requests	Busy Count	Unacceptable Busies	Site Utilization	Actual GOS	PTT Requests	Busy Count	Unacceptable Busies	Site Utilization	Actual GOS
Cape Simulcast	10	Cape Cod	1174	0	0	27.44%	0.00%	553	0	0	47.05%	0.00%	862	0	0	18.79%	0.0%	930	0	0	21.71%	0.00%
Truro	5	Cape Cod	376	0	0	17.71%	0.00%	171	0	0	10.99%	0.00%	216	0	0	11.93%	0.0%	374	0	0	17.37%	0.00%
Wellfleet	4	Cape Cod	374	0	0	20.60%	0.00%	302	0	0	16.50%	0.00%	232	9	3	15.79%	1.3%	354	0	0	21.22%	0.00%
Athol	5	Central	233	0	0	17.96%	0.00%	44	0	0	40.50%	0.00%	299	0	0	16.97%	0.0%	283	0	0	16.86%	0.00%
C Simulcast	7	Central	832	7	0	27.62%	0.00%	196	0	0	28.10%	0.00%	689	0	0	25.60%	0.0%	918	17	8	34.07%	0.87%
Country Hill	4	Central	138	0	0	9.99%	0.00%	149	0	0	10.20%	0.00%	90	0	0	4.66%	0.0%	180	0	0	9.43%	0.00%
Monson	4	Central	354	0	0	20.59%	0.00%	309	0	0	19.28%	0.00%	207	0	0	13.75%	0.0%	295	0	0	19.74%	0.00%
Mt Grace	4	Central	147	0	0	9.58%	0.00%	32	0	0	39.60%	0.00%	116	0	0	8.18%	0.0%	217	0	0	13.41%	0.00%
Ragged	5	Central	352	0	0	18.20%	0.00%	343	0	0	16.87%	0.00%	368	0	0	18.78%	0.0%	386	0	0	16.86%	0.00%
Steerage	4	Central	274	0	0	17.38%	0.00%	65	0	0	41.69%	0.00%	307	0	0	18.43%	0.0%	318	0	0	21.12%	0.00%
A/H Simulcast	9	Northeast	973	0	0	26.99%	0.00%	939	0	0	27.46%	0.00%	918	0	0	26.09%	0.0%	1154	1	1	33.83%	0.09%
Haverhill	4	Northeast	215	0	0	16.10%	0.00%	78	0	0	14.59%	0.00%	307	0	0	18.93%	0.0%	274	0	0	20.87%	0.00%
Vent 1	4	Northeast	177	0	0	8.81%	0.00%	182	0	0	12.04%	0.00%	180	0	0	9.15%	0.0%	163	0	0	10.64%	0.00%
D Simulcast	7	Southeast	779	0	0	25.17%	0.00%	132	0	0	47.05%	0.00%	829	0	0	27.47%	0.0%	933	15	3	30.39%	0.32%
Mt Greylock	2	West	169	2	2	18.11%	1.18%	234	5	4	24.29%	1.71%	140	0	0	23.48%	0.0%	150	0	0	22.34%	0.00%
Mt Toby	4	West	187	0	0	13.06%	0.00%	200	0	0	14.38%	0.00%	137	0	0	11.50%	0.0%	134	0	0	11.60%	0.00%
Mt Tom	5	West	520	0	0	21.89%	0.00%	102	0	0	35.09%	0.00%	381	0	0	17.60%	0.0%	500	4	1	22.79%	0.20%
Shelburne Mtn	4	West	234	0	0	16.40%	0.00%	275	0	0	18.48%	0.00%	312	0	0	16.05%	0.0%	294	0	0	19.36%	0.00%
P25 B North	5	West	422	0	0	24.10%	0.00%	106	0	0	35.41%	0.00%	307	0	0	18.14%	0.0%	340	0	0	18.59%	0.00%
P25 B South	5	West	491	0	0	26.43%	0.00%	128	0	0	35.83%	0.00%	298	0	0	18.27%	0.0%	525	0	0	24.94%	0.00%
P25 Chester Rte 20	4	West	Not Installed										13	0	0	0.96%	0.0%	102	0	0	5.05%	0.00%
P25 Greylock HS	4	West	73	0	0	7.05%	0.00%	129	0	0	9.23%	0.00%	49	0	0	3.49%	0.0%	102	0	0	5.05%	0.00%
P25 Mt Grace	4	West	180	0	0	12.79%	0.00%	128	0	0	9.20%	0.00%	73	0	0	5.67%	0.0%	161	0	0	8.84%	0.00%
P25 Sandisfield	4	West	Not Installed										Not Installed					82	0	0	6.48%	0.00%
P25 Stockbridge	4	West	49	0	0	4.02%	0.00%	128	0	0	9.20%	0.00%	62	0	0	4.13%	0.0%	111	0	0	13.05%	0.00%
P25 Tolland	4	West	Not Installed										Not Installed					102	0	0	5.05%	0.00%
P25 Wilbraham	4	West	171	0	0	12.61%	0.00%	34	0	0	39.80%	0.00%	156	0	0	12.63%	0.0%	199	0	0	12.61%	0.00%
P25 Willamsburg	4	West	88	0	0	5.80%	0.00%	128	0	0	9.20%	0.00%	121	0	0	6.95%	0.0%	78	0	0	5.43%	0.00%

Table 2-10: GoS Summary – Loading During Busiest Hour by Subsystem

2.2.5 CoMIRS Financing

As part of this Strategy Report, available operational and capital expenditures from 2005 through 2016 related to the CoMIRS network were reviewed. Below is a summary of the operational and capital expenditure during this time period.

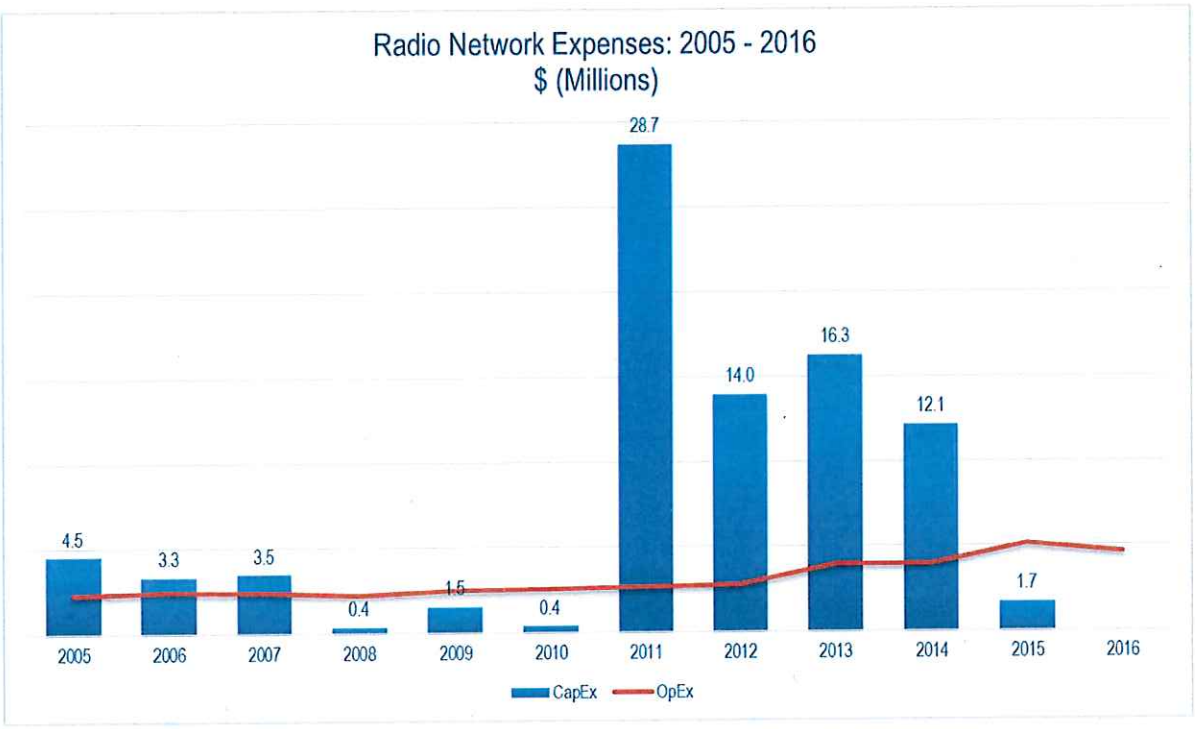


Figure 2-49: Network Expenses 2005 - 2016

2.2.5.1 CoMIRS Operational Funding

As shown by the red trend-line in the graph above, operational funding has been largely constant peaking at nearly $5 million in 2015. There are three main categories of operational expenses – services, leasing, and energy. Services account for around 78% of all operational expenses. This includes network services staff and payments made to the network maintenance vendor for annual support and upgrades. Leasing of radio sites accounts for another 12%. The remainder are energy expenses at the various radio sites.

Operational Funding Category	Amount
Services	$29,038,605
Leasing	$4,340,211
Energy	$3,635,604

Table 2-11: Total Operational Expenses (2005 - 2016)

2.2.5.2 CoMIRS Capital Funding

Capital funding has been more sporadic. In several years, there was little or no capital investment in the radio network. From 2011 through 2014, there was a spike in funding for the digital upgrade in western Massachusetts. Overall, from 2005 through 2016 there was a total of $86 million invested in the radio network. This included $72.5 M (or 88%) on radio site infrastructure and $13,700,263 (or 12%) on subscriber units.

From 2011 through 2014, the Commonwealth also spent over $40 million on the Troop B P25 Digital Network. In addition to this major upgrade, the Commonwealth investments during this period included an Emergency Response Vehicle, the TAC Stack, and the Boston Zone Controller among the major upgrades for the system. The table below shows the identified purchases made during 2011.

Capital Funding Item	Amount
TAC Stack – interoperable infrastructure	$3,451,000
Zone 2 Controller – Boston	$2,400,000
Fiber Backbone METFON	$2,000,000
New Braintree Phase II VHF Simulcast Network	$1,250,000
Troop B Peru	$1,000,000
Emergency Response Vehicle (ERV)	$900,000
Northampton VHF Fire System	$403,554
Troop C Channel Expansion	$250,000
New Braintree Subscribers	$64,000

Table 2-12: Capital Expenditures in 2011

2.2.5.3 CoMIRS Capital Funding Sources

Looking at the funding sources over this time period, the Massachusetts Capital Bond and the federal Public Safety Interoperable Communications (PSIC) grant program were the largest sources of capital financing for the network.

Capital Funding Source	Amount
Capital Bond	$47,745,251
Public Safety Interoperable Communications (PSIC) grant program	$13,328,400
Unspecified (likely from operational accounts)	$8,696,026
IT Bond	$5,000,000
911 Fund	$3,340,000
Community Oriented Policing Services (COPS) grant program	$3,250,000
HSF	$1,854,191
Brewer	$1,116,000
Department of Correction	$1,005,000
Match	$900,000

Table 2-13: Capital Investment Funding Sources (2005 to 2016)

2.2.6 CoMIRS Governance and Administration

Currently, MSP radio staff take the primary lead in administering the network, managing the system, controlling access, and developing processes and procedures for all users. This role of the MSP radio staff in managing key governance and administration processes grew out of the origins of the network as a primarily MSP radio network. Over the past two decades, the network has expanded beyond the exclusive use of the State Police to include additional state agencies and regional communities. Among the multiple groups using the network, there are very few operating agreements to ensure that both financial and equipment contributions are equitable and that service levels are maintained. Other states have introduced a dedicated governance body to help ensure that organizations across the state operate with common technology standards and procedures to provide interoperable statewide communications in times of crisis or multi-jurisdictional response.

2.2.6.1 Governance

A well-defined Governance framework can help establish guidelines and principles, promote proper funding, and reduce jurisdictional conflicts. Governance structures provide the framework in which stakeholders can collaborate and make decisions that represent a common objective. It has become increasingly clear to the emergency response community that communications interoperability cannot be solved by any one entity. Achieving interoperability requires a partnership among emergency response organizations across all levels of government. As such, a governing body should represent all stakeholders, including:

- All levels of applicable government (local, county, regional, tribal, state, federal or non-governmental)
- All involved disciplines (police, fire, EMS, emergency response, transportation, public health, environmental, custodial, and others)
- All primary uses of the network (operable and/or interoperable communications)

Currently, the Executive Office of Public Safety and Security (EOPSS), the Department of State Police, and the State Interoperability Executive Committee (SIEC) perform different aspects of CoMIRS governance and administration. EOPSS is the funding and oversight agency for the Department of State Police and representatives of EOPSS chair the SIEC. Requests for and oversight of funding for the CoMIRS network is ultimately an EOPSS responsibility. The Department of State Police is responsible for the management and operation of the network.

Governor Deval Patrick issued Executive Order No. 493 on November 29, 2007, creating the State Interoperability Executive Committee. The SIEC has a broad membership, as specified in the Executive Order. The committee provides a forum for interoperability planning and serves as a recommendations and governance body for the use of certain Department of Homeland Security interoperability grant funds. The Governor designated EOPSS as the State Administrative Agency (SAA) for interoperability grant funding, and the Secretary of Public Safety and Security has "the final responsibility to render decisions on funding for interoperability planning and implementation."

Section 5. The SIEC will advise the SAA on priorities and approval of all interoperability expenditures and requests for expenditure of federal funds. In carrying out this responsibility, consistent with the goals and objectives of the State Homeland Security Strategy, the SIEC will issue objectives and goals; provide guidance for the development of standard operating procedures and best practices when implementing interoperable communications statewide; and give other advice necessary to achieve statewide interoperability and the objectives of the SCIP.

Section 6. The operations of the SIEC will be in accordance with a charter, approved by the SIEC and updated annually, setting forth the roles and responsibilities of the SIEC members, its governance structure, and its policies and procedures.

Section 7. The SIEC shall be entitled to the cooperation of every department, agency, and office of the Commonwealth in furtherance of its functions.

Figure 2-50: Excerpts from Executive Order No. 493

The SIEC reviews requests for federal grant interoperability funding within the Commonwealth. In this approval process, the SIEC does have the ability to influence grantees towards the purchase of standardized, interoperable equipment. The recommendations and guidelines set by the SIEC, though, are largely non-binding on the municipalities and agencies of the Commonwealth.

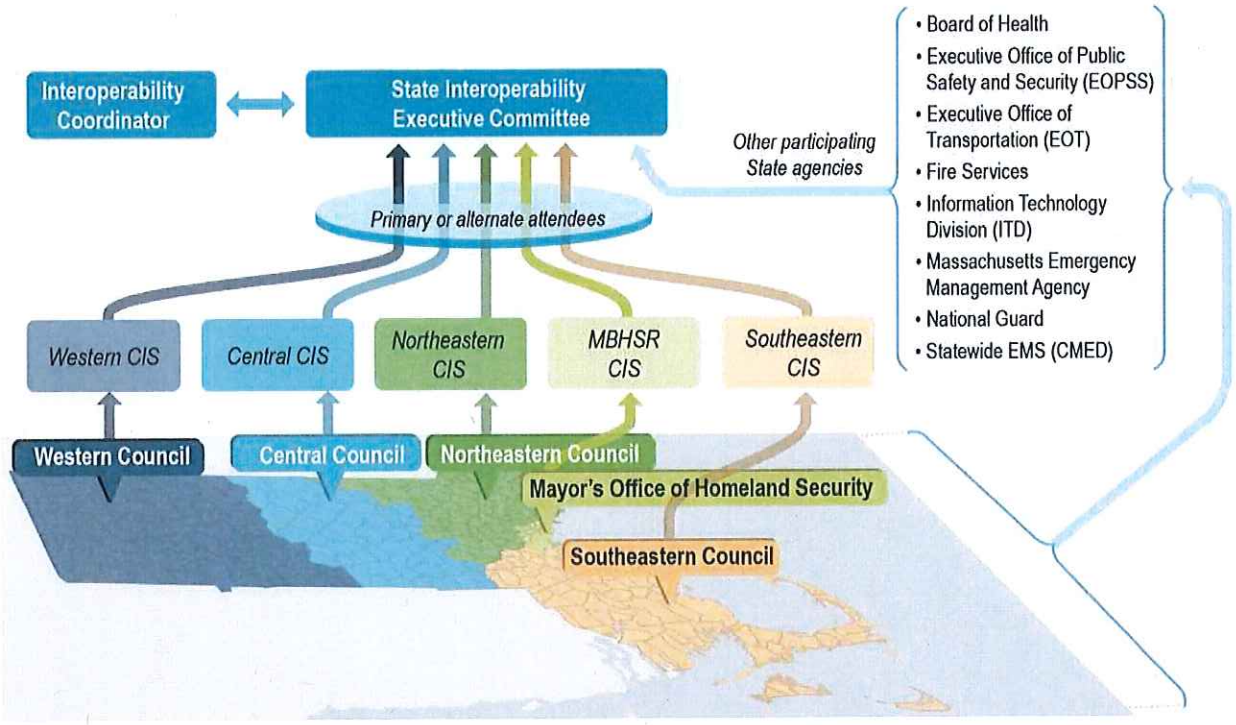


Figure 2-51: Statewide Communications Interoperability Plan (SCIP) Interoperability Governance Model (2007)

In most aspects, the Executive Office of Public Safety and Security serves as the ultimate decision maker in matters related to the CoMIRS network. Most funding decisions concerning the network ultimately must obtain EOPSS approval. Within EOPSS, CoMIRS funding and decision making can be made in coordination with other important public safety communication efforts, including wired broadband, involvement in the National Public Safety Broadband Network (or FirstNet), and other funding efforts. Additionally, the position of the Statewide Interoperability Coordinator (SWIC) has recently been moved to EOPSS to allow broader focus on public safety interoperability communications.



observation

There is currently no process to document and approve on-going support requirements for Core connected trunked systems and consoles. This is an perennial concern of CoMIRS administrators.

2.2.6.2 Standard Operating Procedures

Many Standard Operation Procedures (SOPs) exist for public safety radio operators across the Commonwealth. In some cases, formalized procedures exist, such as radio training, which is conducted as part of the curriculum at the MSP Academy. In other cases, these SOPs are codified through documents distributed to users for use in the field. An example of this field training is the Department of Conservation and Recreation's "Radio for Dummies" guidebook. Overall, though, limited documented SOPs were available from the various agencies using the network.

For the purposes of interoperability, SOPs generally take the form of memoranda of understanding (MOU) between the State Police and other user agencies or verbal guidance provided by the MSP engineers who administer the statewide network. Not all user agencies on the statewide system have a formal MOU in place. Additionally, there is no formal review process to ensure that MOUs are modified over time to reflect changes to the network or the user base. As a result, the level of maturity for SOPs across the Commonwealth is very mature in some agencies and immature in others, leading to an uneven level of documentation and understanding across the entire set of stakeholders.

One area where CoMIRS administrators have expressed a desire for greater coordination is in the support requirements for Core connected trunked systems and consoles. While each subsystem is an integrated component of the overall CoMIRS network, support requirements are managed by the individual owner of the subsystem. There is a desire for more coordination on service levels, maintenance requirements, and other matters.

Several major annual events exercise interoperability of radio systems on a regular basis. Communications support for recurring events – such as the Boston Marathon, Fourth of July celebrations, and parades – are clear indicators that a broad base of users know how to connect to, and use, the statewide network for interoperability and do so on a regular basis.

At the regional level, networks like BAPERN and WMLEC have established operating procedures for their users. These regional procedures are not entirely consistent with the statewide network, but are consistent where necessary to provide connectivity for interoperability. There are opportunities to

enhance the consistency of radio usage across all CoMIRS subsystems, aiding interoperability when needed.

2.2.6.3 Training

The level of radio operation training across Massachusetts is uneven. This is a natural outcome of the current structure of a series of locally provisioned and managed radio networks. While certain agencies have formal training programs for users, others have periodic classes or orientations, and still others simply publish user guidance that can be provided to new hires. Some of this variance is due to differences in mission criticality. In other cases, it is driven by the seasonality of hiring. Similarly, with 241 PSAPs across the state serving a variety of local communities, dispatchers are not trained to a common level because of unique localized needs.

Regardless of the cause, there is currently no statewide common baseline of user radio training. While there are regional standards established for networks like BAPERN and WMLEC, no commonly accepted statewide training standards have yet emerged.

2.2.6.4 Spectrum Management

Radio spectrum is a precious commodity and is critical for the proper functioning of a wireless network. This is especially true of wireless networks, like CoMIRS, where the number of users has been growing steadily over time. Because of the scarcity of useable spectrum, radio networks are required to be spectrally efficient. The CoMIRS network has elements of efficiency due to its use of trunking technology.

The system's capacity is finite and is largely dictated by the number of frequencies or channels deployed within the network. Generally, each channel in the system is capable of supporting a single call. For example, if a site within the system has four voice channels available, it can support four different radio calls simultaneously. The efficiencies of trunking technology allows scores of different agencies to share the same four channels for private communications while minimizing interference and limiting the percentage of calls that are blocked due to lack of available channels. There are additional efficiencies that can be obtained if CoMIRS were to migrate fully to a P25 digital system.

Spectrum Approval

The Federal Communications Commission (FCC) authorizes the use of radio frequencies for systems such as CoMIRS. The Department of State Police and the Commonwealth of Massachusetts hold the licenses for frequencies used in the statewide trunked systems. These frequencies are licensed in the 700 MHz and 800 MHz blocks.

The FCC allocates frequencies in the 851-860 MHz range for Public Safety use[5]. Massachusetts holds over 60 licenses for use of frequencies in this band in support of the network. All analog systems in the network use 800 MHz frequencies, as do the digital systems deployed in western Massachusetts. Analog systems utilize one 20 kHz or 25 kHz wide channel per voice call. The P25 digital system deployed in western Massachusetts utilizes one 12.5 kHz wide channel per voice call, doubling the

[5] https://www.fcc.gov/general/800-mhz-spectrum

efficiency of the spectrum usage. The adoption of TDMA by CoMIRS would further double this spectrum efficiency, allowing two voice calls per one 12.5 kHz channel.

As part of the national digital television transition, a new block of spectrum previously used for television services is available for commercial and public safety use. Within this large block of spectrum, the 799-805 MHz[6] block is reserved for public safety "narrowband" two-way radio communications. Within the 700 MHz public safety narrowband allocation, several categories of use are assigned to maximize the effectiveness and reuse of the channels between geographic and political boundaries. The categories are:

- **Interoperability** – These are common channels shared by all licensees for use when interoperability between agencies is required. Massachusetts utilizes these common channels in both the 700 and 800 MHz bands.
- **General Use** – These are channels available to public safety agencies to license for private systems within their jurisdictional boundaries. This is the largest collection of channels available in 700 MHz block. These channels support operable communications by eligible local, county, and state public safety agencies.
- **Statewide** – These are channels licensed to all states and are intended to be used statewide. As such, each state must coordinate its use of these channels to prevent interference along its borders. Massachusetts was granted a statewide license in 2002. The Federal Communications Commission established a June 2014 deadline for construction on these channels. By this date, the licensee must provide or be prepared to provide substantial service on state channels to an area including one-third of the territory or population of the state and by June 2019 to two-thirds of the territory or population of the state. Failure to meet these deadlines could result in forfeiture of the license with channels reverting to the General Use category.[7] To meet the June 2014 deadline, the Commonwealth and the City of Boston cooperated to use twelve state channels in the deployment of the Boston P25 interoperable trunked system that provides substantial 700 MHz service to one-third of the state's population.
- **Air to Ground** – These channels are reserved for air to ground operations.
- **Low Power** – These channels are assigned for low power use in mobile and portable radios. Massachusetts utilizes low power channels in this band for vehicle repeater operation.

Additionally, FCC rules for the use of the 700 MHz band mandate digital operations, because digital technology allows for a more efficient use of available spectrum. In 2011, Massachusetts adopted P25 standards for the deployment of digital systems within the network. Phase 1 (FDMA) of the P25 standard allows one voice call per 12.5 kHz channel. Phase 2 (TDMA) of the P25 standard allows two simultaneous voice calls per 12.5 kHz channel. The western Massachusetts P25 system is deployed on 800 MHz channels using Phase 1 (FDMA) standards, which was the most efficient standard at the time. The interoperable P25 digital system deployed in the City of Boston operates on 700 MHz channels derived from the state channel allocation. The City of Boston system utilizes a mix of Phase 1

[6] https://www.fcc.gov/general/700-mhz-public-safety-spectrum-0#block-menu-block-4
[7] https://apps.fcc.gov/edocs_public/attachmatch/DA-12-1942A1.pdf

and Phase 2 digital channels. The interoperable P25 digital system in Worcester is deployed on 800 MHz channels and also utilizes a mix of Phase 1 and Phase 2 channels.

Interest in Expanded Use of CoMIRS

During stakeholder interviews, it became clear that thousands of additional users might be interested in using the statewide network in the coming years. There are a couple of critical drivers behind this potential upcoming need. One is the elimination of the 500 MHz T-Band channels, which thousands of Massachusetts subscribers currently use. These T-Band channels are currently set to be vacated by public safety use by 2022 or 2023 as part of the FirstNet Spectrum Act. Another driver for increased usage of the statewide network is aging legacy equipment on local and regional systems that is no longer vendor supported. Owners and users of these systems may look for existing radio networks to use, instead of fully replacing their aging systems.

observation



Should large groups of new users seek to shift operations to CoMIRS, additional spectrum will be required. Some have already expressed interest.

If significantly more users join the CoMIRS network, EOPSS will need to consider adding RF channels to their existing system and/or migrate to P25 Phase 2 TDMA standards in order to meet the demand. Additional channels would allow more simultaneous calls on the network. The adoption of TDMA would significantly enhance spectral efficiency, providing up to four times the efficiency of the current analog network. While simply adding channels will increase capacity, combining that with a migration to Phase 2 will increase the spectral efficiency of those new and old channels. However, most legacy subscribers cannot operate on TDMA networks with their current equipment, and thus an adoption of TDMA for CoMIRS will require a well-planned, staged approach to end-user cutover.

2.3 Key Findings

This "Key Findings" section details the most important issues and observations found during the analysis of the current state of the CoMIRS network. These key findings serve as the basis for the discrete recommendations for how the Commonwealth should move forward with improving the CoMIRS network for all current and potential future users. These findings are aimed at defining the issues that must be addressed by MSP, EOPSS, and others in order to keep the critical public safety radio network operating at a high grade of service, and set the path forward for moving the network to an industry standard digital network in the years to come.

2.3.1 Summary of Findings

Since 1993, the CoMIRS network has been patched together with a series of regional analog and later digital expansions. Today, the CoMIRS network supports nearly 30,000 radio devices operated by 245 state and municipal agencies throughout the Commonwealth. CoMIRS is used for operable (or day-to-day) communications by large state agencies like the Department of State Police and local community police, fire, and EMS users in Barnstable County and central Massachusetts. It is also used for statewide interoperability by thousands of first responders throughout the Commonwealth.

This baseline assessment details the improvements needed for CoMIRS to continue to serve reliably as the primary operational communications network for the MSP and others as well as to serve as the only statewide platform for interoperable public safety communications. Below is a high-level summary of these findings:



First and foremost, the network is antiquated. The CoMIRS network, as it currently exists, was patched together over time with a variety of regional analog and digital expansions. Some of the analog subnetworks still in use on CoMIRS are more than 20 years old and use technology that has been abandoned by the telecommunications industry for nearly a decade. No modern LMR network is being built using analog technology and most owners of analog radio networks have already replaced or are in the process of replacing those networks.



Second and related, the network is reliant on old, unsupported, and often failing system components. Many system components still in use today are original hardware from network implementations dating back to 1993. Original manufacturers have long since ended support for these components, and replacement parts, when available, are often used and of uncertain reliability. This includes many critical pieces of radio infrastructure that, when they fail, will result in the loss of mission critical voice communications to hundreds or thousands of first responders.



Third, the current network does not meet the operational needs of its users. CoMIRS is comprised of a collection of 800 MHz analog, 800 MHz P25 digital, and 700 MHz P25 digital overlapping trunked radio networks across the state. Neither the analog nor the digital radio coverage is truly statewide, and there are important areas without portable radio coverage. As a patchwork network, users operating at the same incident often cannot communicate without the intervention of a system administrator or dispatch operator to properly patch together analog and digital channels. When communications are established across analog and digital channels, voice quality is often degraded, and advanced features like encryption are not available.



Finally, enormous benefits can be obtained by replacing the analog network with a modern digital system. Analog land mobile radio technology has been in use in the United States since the 1930s. The Commonwealth has the opportunity to leap several generations of technology to vastly improve radio communications in Massachusetts. The adoption of a fully P25 TDMA radio network will:

- Significantly improve radio quality and coverage areas
- Enhance interoperability, with more channels available on the same frequencies
- Vastly expand the capacity of the network, allowing more organizations and agencies to use the network
- Assure the long term availability of mission critical, public safety voice communications throughout the Commonwealth

These findings show an outdated network that requires both immediate and long-term investments in order to continue to provide a reliable grade of service for first responders in Massachusetts. The following sections describe the immediate needs, which should be addressed in fiscal year 2018, and the longer-term needs, which should be addressed from FY2019 through FY2022.

2.3.2 Immediate Needs (FY18)

After a review of the current state of the CoMIRS network, four key findings require immediate attention, funding, and resolution. These are:

> ***Key Finding #1**: State Police dispatch console systems are no longer supported by the network software and must be replaced.*
>
> ***Key Finding #2**: Important backhaul components need to be replaced to assure continued radio communications.*
>
> ***Key Finding #3**: The oldest time and frequency reference clocks cannot be repaired and are in need of immediate replacement.*
>
> ***Key Finding #4**: Analog radios do not meet the operational needs of current users and must be replaced to operate on a digital network.*

Each of these four key findings is described below and include recommended funding priorities for the Commonwealth's Fiscal Year 2018.

Key Finding #1: State Police dispatch console systems are no longer supported by the network software and must be replaced.	Urgency	Cost
	Immediate Need	$$

Twenty-nine of the consoles in operation at eight State Police locations are from the Motorola Gold Elite family of console systems. The Motorola Gold Elite family of console systems are no longer supported by the manufacturer. These Gold Elite Console Systems are incompatible with the most recent system software release and must be replaced prior to the release upgrade. Manufacturers support for Gold Elite components ends in 2018.

There are currently 220 dispatch consoles in use on the CoMIRS network. Twenty-nine of these consoles, which are all in operation at eight State Police locations, are from the Motorola Gold Elite family of console systems. The Department of State Police is the only CoMIRS user still operating on the Gold Elite console platform. The other consoles in use on CoMIRS are Motorola MCC7500/7100 consoles operated by state, county, and local agencies.

The Gold Elite Console System is a circuit switch platform. The MCC7500/7100 is a new IP-based platform. This key difference in platforms makes these two types of console systems incompatible with each other. The Gold Elite Console Systems are interfaced to the P25 Core at Zone 1 through a gateway that was designed to provide a temporary interface as the network is upgraded from circuit switched to Ethernet backhaul. This "temporary" gateway has been in place since 2011.

A system release upgrade for CoMIRS is included in the annual Motorola maintenance contract and scheduled for 2017. State Police consoles are incompatible with the new system release and must be replaced prior to the release upgrade. Since all system upgrades must be simultaneously applied by all

subnetworks, no other users of the CoMIRS Network (including the Cities of Boston, Cambridge, and Worcester) can apply the software upgrade until the MSP has retired its use of the Gold Elite Console System.

Manufacturer support for Gold Elite components ends in 2018.



Immediate Action Required: The Department of State Police must immediately replace the Gold Elite Console Systems in operation at General Headquarters (Framingham), Troop H (South Boston), Troop A (Danvers), Troop C (Holden), Troop D/Wireless PSAP (Middleboro), Shelburne Fall E-911 PSAP, New Braintree E-911 PSAP, and the Northampton E-911 Wireless PSAP. These console systems should be replaced with new Ethernet-based dispatch console systems.

Remediation Activities

1. Obtain funding for dispatch console system replacement.
2. Define operating requirements for console system replacement.
3. Conduct an open procurement looking for any manufacturer's console solution that meets the needs of the MSP and interoperates effectively on CoMIRS.
4. Schedule the replacement of the dispatch console systems at each of the eight MSP locations still using Gold Elite consoles.
5. Retire the Gold Elite Console Systems.
6. Schedule the upgrade of the CoMIRS firmware for all subsystems.

Key Finding #2: Important backhaul components need to be replaced to assure continued radio communications.	Urgency	Cost
	Immediate Need	$$

The MSP trunked subsystems of CoMIRS rely heavily on wireless microwave point-to-point links to backhaul communications from radio tower sites. Many of these important links are beyond manufacturer support and some are experiencing performance issues due to path obstructions that cannot be resolved. When point-to-point links fail, radio communications from sites at the end of the path are lost to the network creating large coverage "holes".

The 21 microwave backhaul links using Telesciences (7), Microwave Networks Inc. (13), and California Microwave (1) systems are beyond the manufacturers' support period. Plans should be made to replace these links with manufacturer supported microwave backhaul systems.

Additionally, several links in the MSP trunked backhaul network are already experiencing periodic failure due to line of site obstructions and aging equipment. These include:

- Backhaul communications going through the Oxford Fire Tower in central Massachusetts,
- Backhaul links using GE MDS microwave radios in south central Massachusetts, and
- Communications going through the Pine Hill (Plymouth), Copicut Hill (Fall River), Middleboro, and Mendal Hill (Acushnet) radio sites in southeastern Massachusetts.

These issues should be prioritized for immediate funding and resolution. Failure to address these issues risks loss of wide area communications and would impact CoMIRS radio users throughout central and southeastern Massachusetts.

When addressing existing communications needs, the MSP should seek to modernize the communications equipment and not just address the cause of the current communications failures. For instance, the three links transiting the Oxford Fire Tower are circuit switched backhaul links. The primary pressing issue with the Oxford Fire Tower, though, is line of sight with other radio sites. The MSP should address the circuit switched communications at the same time as it addresses the line of sight issues. The circuit switched backhaul links in these areas should be replaced with Ethernet based backhaul links. Ethernet microwave systems can be configured to support both Ethernet communications paths and circuit switched communications paths.

The remainder of the 35 total Telesciences, Microwave Networks, California Microwave, GE MDS, Harris Constellation, and Harris True Point microwave links should be replaced as part of future P25 digital upgrades in the coming fiscal years.



Immediate Action Required: Failing microwave backhaul links in central and southeastern Massachusetts should be addressed immediately to maintain mission critical radio communications in those areas.

Remediation Activities

1. Prioritize aging microwave links for replacement.
    a. Give highest priority to replacing backhaul links that are already experiencing failure or sub-optimal performance.

b. Give secondary priority based on whether or not the link is likely to be used for future backhaul as the network transitions to digital coverage. Tower sites that are likely to be used for digital coverage are candidates for near-term upgrade. Those unlikely to be part of a future digital site map should be replaced on an as needed basis.

c. Confirm priorities for microwave link upgrades.

2. Conduct path studies for each microwave link.
3. Determine microwave sizing and communications needs.
4. Conduct structural assessments of tower locations.
5. Procure and install modern microwave links that meet current commercial standards.
6. Maintain decommissioned microwave equipment as spare parts to support other remaining microwave links on the MSP trunked subsystem.
7. Plan for the replacement of the remaining aging microwave links as part of the transition to digital radio communications in later stages of the enhancement project.

Key Finding #3: The oldest time and frequency reference clocks cannot be repaired and are in need of immediate replacement.	Urgency	Cost
	Immediate Need	$

The analog portion of the CoMIRS network includes four simulcast sites. Highly accurate and dependable reference clocks are required to maintain the functioning of these simulcast sites. The reference clocks at some of these analog sites are outdated and need immediate replacement. Failure to upgrade these clocks threatens the voice communications in important areas of these simulcast sites.

Simulcast site standards are critical to the operation of the simulcast radio subsystems on the CoMIRS network. To prevent interference where signals from different sites overlap, simulcast depends on extremely accurate timing of broadcast from different sites so the signals received at the target radio all arrive simultaneously. Without this accurate timing, signals received in overlap areas are distorted and unintelligible to the user.

There are four simulcast subsystems in the analog portions of CoMIRS. These subsystems include 34 individual radio sites. Reference clocks have been replaced with current products at many of the analog sites, but 13 reference clocks still require replacement. These include seven radio sites in Bristol and Plymouth Counties and six radio sites in central Massachusetts (MSP Troop C). These clocks are not repairable and must be replaced. Modern reference clocks can support both analog and digital systems, so investments in clock upgrades can be used in future digital simulcast sites.



Immediate Action Required: The 13 oldest reference clocks should be replaced to assure the continued quality of voice communications on the analog portions of the CoMIRS network.

Remediation Activities

1. Confirm reference clock models as replacements.
2. Procure reference clocks and installation services.
3. Upgrade reference clocks.
4. Confirm communications quality along overlapping portions of simulcast sites.
5. Determine proper disposition of old reference clocks.

Key Finding #4: Analog radios do not meet the operational needs of current users and must be replaced to operate on a digital network.	Urgency	Cost
	Immediate Need	$$$

The CoMIRS network is presently a mix of analog and digital subsystems without full statewide coverage in either technology. Agencies with statewide jurisdiction should be equipped with radios that can operate on both analog and digital systems to maximize coverage availability. Additionally, when users on different types of systems (analog and digital) interact, they often cannot communicate with one another until a system administrator patches their channels together. After communications are established, there is often also a significant degradation in the quality of voice communications across the two platforms.

Priority should be given to updating the MSP radio fleet so that all MSP radios can operate across the analog and digital systems comprising CoMIRS.

MSP operates a fleet of approximately 6,600 mobile, portable, and desktop radios. Only about 17% of these radios are fully capable of operating on the entire CoMIRS network, including the analog, P25 FDMA (Phase 1), and P25 TDMA (Phase 2) portions of the network. When troopers operating with different types of radios respond to a common incident, many times these troopers cannot communicate without the intervention of a dispatch operator to patch analog and digital channels together.

The oldest analog radios currently active in the MSP fleet only support 48 total talkgroups/channels. Current talkgroup/channel requirements for MSP radios require nearly 300 talkgroups/channels. As a result, troopers using these analog radios do not have important talkgroups or channels planned in their

radios. The realization of the need for a radio channel patch and the identification of which channels to patch together can often take precious time, during which different groups of responding officers cannot properly communicate.

Once patched, voice communications between the analog and digital users are often significantly degraded as the analog and digital signals must be converted to be audible on other channels. This affects voice communications for all users on the patched channels.

Digital radios will be required to operate on a fully digital network as the analog portions of CoMIRS are decommissioned. The task of replacing radios in a large percentage of the MSP fleet is not a short-term project. Thousands of these digital capable radios will need to be purchased to move fully from the aging and unsupported analog subsystems. This turnover of portable and mobile radios will be costly, but can be done incrementally addressing higher priority upgrades first. The following order of priority should be used in determining the types and the location of devices to be replaced first:

1. **Replace analog-only radios first**. The current MSP radio fleet is comprised of 48% analog-only devices. Most of these devices are over a decade old and they cannot communicate on the channels most typically used in western Massachusetts and many areas of metropolitan Boston.

2. **Replace radios in troops that operate in or border areas of predominately digital coverage**. Troops that operate in areas where CoMIRS partners operate digital networks (e.g., Massport facilities, the City of Boston, the City of Cambridge, etc.) cannot easily communicate with other officers and first responders in those areas. Additionally, groups like MSP Troop C often operate or respond to incidents in areas where the incident commanders will be operating on digital channels, such as the operating areas of MSP Troop B. These replacement should begin immediately.

3. **Replace radios in troops that do not typically operate in or border areas of predominately digital coverage**. Other officers that operate further away from predominately digital coverage areas will also need their analog-only devices replaced as the network is transitioned to fully TDMA digital. These replacements should be made in the next two to three years.

4. **Replace devices that cannot operate on P25 TDMA (Phase 2)**. Around 35% of the current MSP radio fleet are analog and FDMA digital capable units. These subscriber units can operate on all of the current radio channels broadcast as part of CoMIRS. They will not, though, be able to operate on the spectrum-efficient TDMA digital radio channels to which CoMIRS should be moving. These radios can be replaced when TDMA networks are significantly rolled out throughout CoMIRS. These replacements should be made in conjunction with the upgrade of the FDMA radio sites in western Massachusetts to TDMA.

These portable and mobile radio upgrades should be undertaken in a systematic fashion, addressing entire troops to ensure the consistency of communications amongst officers that interact on a regular basis. Using this preference criteria, analog-only devices in Troops C, A, and H should be replaced first. Troop C borders Troop B, where the P25 FDMA system is implemented. The Troop C radio replacement entails approximately 500 radios. Troops A and H often operate in and intercommunicate

with officers operating on the digital radio networks operated by Massport and the Cities of Boston and Cambridge. The upgrade of these troops will allow significantly improved interoperability in these areas.

The MSP is not the only user on the CoMIRS network that operate analog-only devices. Users in Barnstable County and other areas operate thousands of analog-only devices that will also need to be replaced as the CoMIRS network evolves into a TDMA digital network.



Immediate Action Required: Immediate priority should be given to replacing the analog-only radio devices in MSP troops that often operate in areas of primarily digital coverage. These include Troop C in central Massachusetts and Troops A and H in the Boston metropolitan area.

Remediation Activities

1. Confirm priorities for analog radio replacement.
2. Establish schedule for replacing all MSP analog-only radio devices.
3. Determine approach and schedule for the replacement of non-MSP analog-only radio devices.
4. Define requirements for analog-only radio replacement.
5. Solicit competitive pricing from multiple vendors that offer analog, FDMA, and TDMA capable devices that will operate effectively on CoMIRS.
6. Replace all analog-only devices in MSP Troop C.
7. Replace all analog-only devices in MSP Troops A and H.

2.3.3 Longer-Term Needs (FY19 to FY22)

The review of the current state of the CoMIRS network also highlighted a number of longer-term needs that should be addressed in next two to five years. These include:

> ***Key Finding #5**: Many of the backhaul circuits to radio tower sites will not be supported in future releases of the radio network software.*
>
> ***Key Finding #6**: The current CoMIRS network is old, and it relies on unsupported analog radio components.*
>
> ***Key Finding #7**: The current CoMIRS network does not meet stated goals for statewide coverage.*
>
> ***Key Finding #8**: The reliance on analog technology precludes the use of important advanced radio features.*
>
> ***Key Finding #9**: CoMIRS should adopt P25 TDMA as its broadcast standard to significantly improve spectrum efficiency and capacity.*
>
> ***Key Finding #10**: Critical, aging components of the CoMIRS infrastructure require continued attention and support to assure network availability.*
>
> ***Key Finding #11**: Consistent and sufficient annual operational and capital funding is needed to support, maintain, and grow the network.*
>
> ***Key Finding #12**: CoMIRS needs a clearly defined decision-making structure that supports operable and interoperable users.*
>
> ***Key Finding #13**: There needs to be clear standards for all users on the CoMIRS network and clear standards of service for subnetworks.*
>
> ***Key Finding #14**: There is an uneven level of user knowledge on how to properly use CoMIRS interoperability channels.*
>
> ***Key Finding #15**: CoMIRS will likely require additional spectrum, at least during the transition from analog to digital.*

Each of these key findings is important to assure the continued mission critical nature of the CoMIRS network. Proper planning should be started now to assure that each of these is addressed over the next few years.

Key Finding #5: Many of the backhaul circuits to radio tower sites will not be supported in future releases of the radio network software.	Urgency	Cost
	2 to 3 years	$$

Backhaul allows a radio site to communicate with the rest of the network. Without it, all the users in that area are disconnected from communications on the radio network. Much of the existing CoMIRS backhaul network uses old, circuit-switched backhaul technology. The telecommunications industry has moved away from circuit-switched technology to Ethernet packet based transmission protocols as a more bandwidth efficient and flexible method for point-to-point communications.

The circuit-switched backhaul technology that is in use in much of the existing CoMIRS backhaul network will not be supported by the CoMIRS radio software by 2019 (Motorola System Release 7.19). Backhaul from radio sites using this old technology will not work when the software release is applied and therefore radio communications relying on those radio sites will not work.

Circuit-switching is a type of communications in which a dedicated channel (or circuit) is established for the duration of a transmission. The most widely used circuit-switching network is the wireline telephone system, which links together multiple wired segments to create a single unbroken line for each telephone call. In a radio system, a dedicated circuit is assigned to each radio channel in the network. CoMIRS employs both T-1 formatted and Trunk Line Network (TLN) formatted circuits. T-1 is a high capacity link (24 channels @ 64 kbp/s) used to connect high capacity radio sites. TLN is a single channel link used to connect a single radio remote site to a dispatch console location.

Ethernet packet-switched based transmission protocol (Ethernet) is the process of routing and transferring data by means of addressed packets so that a channel is occupied during the transmission of the packet only. Upon completion of the transmission, the channel is made available for the transfer of other traffic. Ethernet protocol is far more efficient than circuit-switched transmissions and can be employed on wireless, fiber optic cable, coaxial cable, copper lines, and other mediums.

The following backhaul methods are utilized in CoMIRS:

- 34 microwave links do not support Ethernet natively
- 61 wireline links do not support Ethernet natively
- 129 site links are currently circuit-switched
- 53 site links are currently Ethernet protocol
- 12 site links are currently supporting both circuit-switched and Ethernet protocols

Massport is currently utilizing circuit-switched T1 links to connect to Zone 1, and they are in the process of moving to Ethernet links utilizing Massport and State fiber optic cables.

Circuit-switched links should be migrated to Ethernet links when possible and prior to the CoMIRS 7.19 software release upgrade planned for 2019. Until all links utilize Ethernet protocol, the CoMIRS

software cannot be upgraded to release 7.19. This affects all users of the CoMIRS network, not just the users of the MSP trunked system.

Remediation Activities

1. Work with CoMIRS partners to identify all existing circuit-switched links on the CoMIRS network.
2. Address circuit-switched upgrades when addressing other backhaul issues (e.g., replacement of failing microwave links).
3. Establish a timeline (by 2019) for the replacement of circuit-switched links.
4. Establish a prioritized schedule for the replacement of circuit-switched links.
5. Establish requirements for Ethernet upgrades to CoMIRS backhaul links.
6. Procure hardware, software, and installation services for upgrading microwave backhaul links.
7. Procure hardware, software, and installation services for upgrading wireline backhaul links.

Key Finding #6: The current CoMIRS network is old, and it relies on unsupported analog radio components.	Urgency	Cost
	2 to 5 years	$$

The current CoMIRS network is reliant on out of date and often unsupported analog equipment that is at the end of its life and must be replaced in order for the network to continue to provide the level of communications service required for first responders across the Commonwealth.

The analog portions of CoMIRS are still reliant on system components that date back to the origins of the MSP network in 1993. Additional regional analog systems were added to CoMIRS through 2000, and many of the components from these original analog radio network deployments are still in use today. Many of these component risk failure, are no longer supported by the manufacturer, and are difficult to obtain replacement components.

Of critical importance are the analog trunked system controllers. The controllers are the heart of the analog radio subnetworks and have been out of manufacturer support since 2012. "Out of manufacturer support" means that there are no replacement parts being manufactured and there is no service available for board repair. The MSP and others must rely on the second-hand market (e.g., eBay and parts from decommissioned networks) to locate many replacement parts. Often, old replacement parts on hand do not properly function and cannot serve as reliable replacements.

Additionally, analog radio site transmitting equipment will go out of manufacturer support in 2020, and other critical system components are at or beyond support periods as described elsewhere in these key

findings. Each year, the risk to the reliability of the CoMIRS analog network increases, threatening mission critical communications for thousands of first responders throughout the Commonwealth.

Remediation Activities

1. Stockpile critical analog components when available.
2. Look to transfer inventories of analog parts from other public safety networks that are upgrading to digital networks.
3. Transition to a fully digital network and retire the analog portions of CoMIRS.

Key Finding #7: The current CoMIRS network does not meet stated goals for statewide coverage.	Urgency	Cost
	2 to 5 years	$$$

CoMIRS consist of a mix of regional analog and P25 digital trunked systems. No complete statewide coverage exists through either the analog systems or the P25 digital systems alone.

Forty-eight analog trunked radio sites installed between 1993 and 2000 provide analog service from Springfield to Provincetown. These 48 sites are organized into regional analog systems in the Northeast and Southeast regions, Barnstable County, central Massachusetts, and Route 91. Thirty-four P25 FDMA radio sites installed since 2013 provide digital coverage in western Massachusetts.

Within the analog coverage area, there are radio "dead spots" where poor radio coverage or no radio coverage is present. These coverage gaps should be corrected to establish reliable coverage throughout the Commonwealth for the first responders utilizing the network.

Migrating the regional analog systems to P25 digital operation will result in a single ubiquitous communications platform across the state allowing a subscriber radio to retain reliable communications from Pittsfield to Provincetown without having to manually adjust radio settings.

Remediation Activities

1. Identify areas of insufficient radio coverage.
2. Review and confirm a channel plan for a P25 TDMA digital network.
3. Identify available additional frequencies for use by the CoMIRS digital network.
4. Seek approval of the CoMIRS channel plan by the Federal Communications Commission.

5. Review existing radio sites for use in a future network. This should include structural analysis, shelter space, backhaul availability, antenna positioning, sufficient power supplies, access, and other site considerations.
6. Identify new radio sites needed for TDMA channel plan.
7. Acquire or lease additional radio sites.
8. Rollout out FCC approved TDMA channel plan.

Key Finding #8: The reliance on analog technology precludes the use of important advanced radio features.	Urgency	Cost
	2 to 5 years	$$$

Advanced radio features used within the P25 segments of CoMIRS have improved user safety and efficiency. These features are not available in the analog networks.

P25 digital systems provide consistent audio quality throughout their coverage area, eliminating "scratchy" unintelligible communications at the edges of the coverage area and providing better options for noise reduction in voice communications. In addition to this primary intelligibility benefit, digital radios also provide the following:

1. **Voice and data services**: Modern digital radios provide both voice and data communications. This includes sending data about the calling subscriber unit when communications are initiated on the network. Data services allow users to send text messages from their radios and allow information about the subscriber unit to be shared with computer aided dispatch (CAD) and other mission critical applications.
2. **Location services**: Digital radios allow organizations to activate location services to track where subscriber units are in the field. This can provide critical situational awareness information to incident commanders, dispatchers, and others.
3. **Voice encryption**: Voice encryption is critical to modern day first responder communications. Analog radio communications do not support voice encryption. There are many different standards available for digital voice encryption. This is important for protected communications over the radio network.
4. **Remote programming**: An important maintenance feature of modern digital radios is the ability for authorized administrators to remotely program radios. This means that when new channels are added or new encryption keys needed, the configurations for those changes can be pushed to the radio device without requiring the user to bring in the radio and surrender it for a time to be reprogrammed.

5. **Greater coverage range**: Both analog and digital coverage diminish as the user moves further from the radio broadcast site. However, modern digital radios have greater range (extending coverage areas) than analog-only devices and are more resistant to interference from other signals.

6. **Improved battery performance**: Communicating on an analog radio is power-intensive. Modern digital radios have significantly improved battery performance, allowing the same devices to be used the field much longer without having to be swapped out to be recharged.

7. **Support analog and digital**: Digital devices can be selected that support both analog and digital communications. This will allow the seamless transition for users as the CoMIRS network moves from primarily analog to fully digital coverage over the next few years.

Standards governing how many of these advanced features are implemented and used on CoMIRS will need to be defined and promulgated to all users of the CoMIRS network.

Remediation Activities

1. Continue the remediation activities identified in Key Finding #4: Analog radios do not meet the operational needs of current users and must be replaced to operate on a digital network." for the replacement of analog-only and non-TDMA radios.
2. Establish CoMIRS standards for the use of text communications.
3. Establish CoMIRS standards for the use of location services.
4. Establish CoMIRS standards for the use of encryption.
5. Develop procedures, as needed, for the remote programming of radios.
6. Update, as needed, the standards for digital radio devices on the network.
7. Establish a date by which analog-only devices should be discontinued from the CoMIRS network.

Key Finding #9: CoMIRS should adopt P25 TDMA as its broadcast standard to significantly improve spectrum efficiency and capacity.	Urgency	Cost
	2 to 5 years	$$$

The telecommunications industry has generally moved from analog to digital based communications. One of the drivers for the move is improving the efficiency of how limited available spectrum is used. CoMIRS P25 TDMA subsystems are 4 times more frequency efficient than CoMIRS analog subsystems.

CoMIRS analog systems require one 25 kHz wide frequency and one base station for each transmission. CoMIRS P25 FDMA systems, like the digital trunked system deployed in western Massachusetts, require one 12.5 kHz wide frequency and one base station for each transmission. This doubles the spectrum efficiency compared to analog systems.

P25 TDMA subsystems, like those in use in the City of Boston, provide further efficiency compared to FDMA systems. P25 TDMA base stations can each support two simultaneous transmissions and are four times as efficient as analog systems. Utilization of P25 TDMA means higher system capacity, lower fixed equipment cost, a smaller equipment footprint, reduced power consumption at radio sites, and lower ongoing maintenance costs.

Once fully moved to a TDMA digital system, CoMIRS will be able to support three to four times more users than the current analog system supports because of the spectrum efficiencies inherent to TDMA digital radio systems. This will allow more users on the network without taxing the quality of services needed by current operable and interoperable users. This added capacity will allow EOPSS to consider expanded usage of the CoMIRS network by groups like:

- Regional interoperability providers
- Municipal systems (in need of transitional communications or system replacement)
- State agencies (that currently operate their own radio systems)

Additionally, a complete transition of CoMIRS to digital frequencies will free up the analog frequencies currently in use by CoMIRS. With FCC approval, these frequencies can be repurposed for other public safety agencies in need of additional spectrum. This may be a valuable asset should current plans for public safety agencies to vacate the T-Band spectrum by 2022 continue without change.

Remediation Activities

1. Continue the remediation activities identified in Key Finding #7: The current CoMIRS network does not meet stated goals for statewide coverage." for the rollout of improved digital coverage throughout the Commonwealth.
2. Survey public safety organizations and regional interoperability providers about their interest in using a statewide TDMA radio network.
3. Review and plan the needed capacity for each region of the Commonwealth.
4. Prepare a site transition plan for each existing analog radio site.
5. Prepare a digital upgrade site plan for each existing FDMA radio site.
6. Work with CoMIRS partners on establishing a timetable for the decommissioning of CoMIRS analog subsystems.
7. Work with the FCC on repurposing analog spectrum, as needed.

Key Finding #10: Critical, aging components of the CoMIRS infrastructure require continued attention and support to assure network availability.	Urgency	Cost
	2 to 5 years	$

MSP and EOPSS administer a maintenance contract with an outside vendor for preventative maintenance and repair of the analog and P25 digital components of the CoMIRS radio network. The contract includes a system release upgrade every two years for the P25 digital components of the network. It is anticipated that issues involving aging analog components will only worsen as CoMIRS continues to rely on its analog subsystems. Sufficient funding should be made available to support emergency repair needs for the aging analog network.

Critical components of the analog network are beyond the manufacturer support period, and replacement parts and board repair are no longer available. While MSP and its maintenance vendor have been careful to retain in-house spare parts for use in emergencies, much of the spare equipment is just as old as the active equipment and cannot be considered a reliable substitute for manufacturer support. Continued maintenance of the existing systems, as new digital equipment is installed, is critical to the uninterrupted communications required by first responders statewide.

EOPSS should continue to fund preventative and remediative maintenance and should expect that the incidence of failing analog equipment will increase with every year the analog system is active.

Remediation Activities

1. Maintain existing maintenance contract with an outside service provider. Assure maintenance provisions cover timely repair for aging analog components.
2. Actively look to stockpile critical analog replacement components, where possible.
3. Consider other funding sources for immediate need equipment repair issues.
4. Identify and prioritize aging components based on risk to the network.
5. Assure that the highest risk components are properly inspected and tested as part of annual maintenance.

Key Finding #11: Consistent and sufficient annual operational and capital funding is needed to support, maintain, and grow the network.	Urgency	Cost
	2 to 5 years	$$$

CoMIRS capital funding has been sporadic, and, in many years, there is little or no capital reinvestment in the radio network. Operational funding has been largely level, but additional operational funding will be needed to properly support the network in the coming years.

Whether originally anticipated or not, CoMIRS has become a Commonwealth enterprise service, providing operational and interoperational radio communications services to 245 agencies throughout the Commonwealth. The network, though, is still funded as a single-agency system and is subject to significant funding swings from year to year and uncertain long-term capital investment.

As the analog network is replaced, additional burdens will be placed on the state's network management team to maintain the aging network while at the same time supporting the build-out of a new network. Additional state resources will likely be needed over this time period. Once the digital network is established, the Commonwealth will be paying its network maintenance vendor extra to support both the analog and digital systems until the analog system can be completely replaced.

Adequate financing needs to be obtained for the capital investment needed to build out the statewide network and operational funding to support both the new (digital) and old (analog) networks.

Remediation Activities

1. Determine appropriate sources of capital funding.
2. Determine long-term responsibilities for supporting and financing the new digital network.
3. Establish milestones for the decommissioning of the analog network (to eliminate additional annual operating costs).

Key Finding #12: CoMIRS needs a clearly defined decision-making structure that supports operable and interoperable users.	Urgency	Cost
	2 to 5 years	$

Governance and administration for the CoMIRS network is performed primarily today by EOPSS and MSP, respectively. Additionally, the SIEC provides advisory guidance on certain interoperability matters involving the network. It is not currently well-understood universally which organization is responsible for the different aspects of governance and administration, including policy decision making, financing, administration, spectrum management, and standards development. CoMIRS needs a clearly defined governance structure that can address governance issues that affect the operable use of CoMIRS (by groups like MSP and Barnstable County) and/or the interoperable use of CoMIRS (by agencies throughout the Commonwealth).

Like the network itself, governance and administration for the CoMIRS network has grown over time and finds its roots in the Department of State Police. The MSP assumes much of the responsibility, formally or informally, for the proper use and continued maintenance of the network. While this has generally been sufficient over the years, the size and complexity of the current and potentially future usage of the CoMIRS network suggests that governance and administration responsibilities should be reconsidered as part of an overall network enhancement project.

Based on the overall picture of public safety communications governance, Massachusetts would be most aptly rated as "*ad hoc*" in level of governance. The SIEC is the closest entity to a governance body, but it has limited membership and decision-making influence across all radio network users. The MSP, by default, serves the primary role today in network administration. EOPSS is ultimately responsible for the success and funding of the network. A future governance model should leverage the strengths of these organizations and establish a well-understood and lasting governance for the network in the years to come.

The ultimate decision on the nature of a CoMIRS governance structure should be made by those most actively involved with the CoMIRS network. In the consideration of an optimal governance structure, the following options should be considered:

Primary Leadership	Advantages	Disadvantages
EOPSS Led	EOPSS has the primary, ultimate responsibility for the CoMIRS network today. Statutorily, many of the agencies operating on CoMIRS report to EOPSS and are reliant on EOPSS for funding. As an organization, EOPSS has a broad responsibility for public safety across public safety disciplines. Additionally, as the State Administrative Agency for the SIEC, EOPSS has final responsibility for interoperable grant approval.	EOPSS may be viewed as too narrow of an organization to be the entire or predominate decision making authority. A focus on EOPSS may limit or complicate any future plans to move other large, non-public safety agencies over to the CoMIRS network.
SIEC Led	The SIEC already exists as an effective, inter-departmental advisory body. It serves an important role in recommending interoperable improvements and standards throughout the Commonwealth.	The SIEC does not address operability issues and the most predominant day-to-day usage of the CoMIRS network is for operable communications. Groups like Barnstable County may not be effectively represented on this body.
New CoMIRS Governance Body Led	A new body would allow the crafting of membership to reflect both the primary operational users as well as a broad cross-section of interoperable users of the network.	The addition of another governance body could further complicate decision making, as some governance responsibilities are already assigned to organizations like EOPSS, the MSP, and the SIEC.

Table 2-14: Options for Primary Leadership in CoMIRS Governance

When evaluating governance approaches, the following principles should be considered:

1. **Recognize the statutory primacy of the EOPSS in public safety decision-making and funding**. Some responsibilities are set by statute and are not likely to be altered. These include many of the funding and oversight responsibilities of the Executive Office of Public Safety and Security. The statutory roles can be taken into account by a variety of means, including assigning EOPSS as the chair of any governance body or separating EOPSS statutory obligations from the charter of any governance body.

2. **Account for representation of operable and interoperable organizations.** CoMIRS has two roles and they are very different to the organizations that rely on them. While CoMIRS is the primary statewide interoperable radio platform, it is also the day-to-day operable radio platform for many agencies. Any governance body must be able to seek representation from both operable and interoperable users and be able to handle both operable and interoperable issues and requests.

3. **Leverage existing resources as best as possible.** Whether the SIEC is the appropriate body for CoMIRS governance or not, it serves an important role in interoperability planning in the Commonwealth. Whatever governance structure is settled on for CoMIRS should clearly define what elements of CoMIRS, if any, should be handled by the SIEC.

4. **Think of CoMIRS as a service.** CoMIRS has grown to be used by 245 agencies throughout the Commonwealth, yet support for the network has never been clearly defined. It is provided, by default, by the radio technicians and administrators of the MSP. This group has clear expertise in the network and should be intimately involved going forward. The role, though, of this group in administration needs to be clearly defined and properly funded as a service provider for the other 244 agencies on the network.

5. **Plan for expansion**. The CoMIRS network, with proper upgrades to TDMA digital service, is well-suited to serve a greater role in public safety communications. There are opportunities for large groups of new users to move to the network and for other aging networks to be retired. Governance planning needs to consider that the user base may significantly shift in the next ten years. Whatever governance model is adopted, it should provide avenues for expanded governance roles to other large stakeholders who may assume a larger funding or management responsibility in the future.

6. **Clearly define responsibilities**. Governance and administration are broad principles. All aspects of governance and administration need not be overseen by a single governance body. Rather, aspects of spectrum management, new user approval, policy development, training, finance, and system service agreements can be assigned to different organizations, but responsibilities must be clearly defined and well-understood by all users of CoMIRS.

Remediation Activities

1. Establish a working group to recommend governance and administration responsibilities for CoMIRS to the Secretary of Public Safety and Security.

2. Draft options for governance models.

3. Solicit feedback from operable and interoperable users of CoMIRS on the governance model.

4. Discuss governance considerations with other large agencies interested in potentially using CoMIRS.

5. Recommend a governance and administration structure to the Secretary of Public Safety and Security.
6. Establish the governance and administration structure as approved by the Secretary of Public Safety and Security.
7. Work with other bodies, as needed, to establish clear lines of responsibility for CoMIRS related decision-making and funding.

Key Finding #13: There needs to be clear standards for all users on the CoMIRS network and clear standards of service for subnetworks.	Urgency	Cost
	2 to 5 years	text

Due largely to the federated nature of the CoMIRS network, where individual agencies or regional groups are responsible for large subnetworks and the provision of their own radio devices, there is inconsistency in the nature and promulgation of system standards and standard operating procedures (SOPs). Not all subnetworks on CoMIRS need to behave the same. There should, however, be an understanding across agencies, and approval when needed, when deviations in SOPs are implemented on the network. Additionally, there needs to be clear expectations for the levels of service and the standards for maintenance of all of the subsystems of CoMIRS.

There is an uneven level of documented standard operating procedures across users of CoMIRS. Broadly speaking there are three levels of assessment concerning CoMIRS' SOPs:

1. At the statewide level on the network administered by the MSP, the nature of SOP creation is "collaborative" between entries. Documentation for SOPs, and particularly upkeep of MOUs, can be improved upon, but the basic operating rules clearly work and are relatively well understood by the major user agencies.
2. At the regional level, regional networks like WMLEC and BAPERN have a strong understanding of operations internally. In terms of coordination with the larger statewide network, these regional organizations clearly understand how to operate effectively, and do so routinely. Documentation, though, of SOPs is scarce. Where SOPs exist, some of these regional procedures are not entirely consistent with the others on the statewide network.
3. For agencies using CoMIRS for interoperability, the creation and maintenance of SOPs is "ad hoc" in nature. These SOPs, if they exist at all, vary significantly from organization to organization.

Not all agencies operating on CoMIRS have formally documented standard operating procedures nor do they all have consistent radio training for new users. The lack of formally documented SOPs and end-user training creates a significant operating risk on a network that supports many users and many agencies. Moreover, without clear documentation that spells out operating procedures and the

relationship of member agencies to the statewide network, there may be a natural hesitancy from agencies and local governments to fully participate in the network.

Lack of formal guidance can also result in buying substandard equipment. As an example, consider the technical requirements for radios to operate fully and properly on the statewide network. Since smaller agencies and local governments control their own budgets, most currently buy their own equipment. Often, the equipment they choose to buy is less expensive than radios that are fully compatible with the infrastructure in place or planned to be in place. Budget constraints and a lack of knowledge of preferred standards may result in these users unknowingly sacrificing functionality and interoperability for a lower cost of acquisition.

Since 2014, owners and operators of public safety P25 digital trunked systems have interfaced their systems to the Commonwealth Core. The benefit to sharing the Commonwealth Core is that all connected subnetworks can share access to network resources and provide a level of resiliency that would not otherwise be possible. There is also the perception that sharing a common Core would result in lower capital acquisition costs and lower on-going maintenance costs overall. All user agencies with trunked radio systems or radio control consoles connected to the Core fall under the common system management network that is part of the Core. Agencies differ widely in their technical capabilities to manage and maintain their systems, but because they are connected to a common Core, all agencies are required to follow the same basic management, maintenance, and software update procedures and processes. There is currently no process in place to formally document the on-going support requirements for Core connected trunked systems or radio control consoles. This has been an on-going concern for MSP system administrators and user agencies and should be formally addressed.

Remediation Activities

1. Assign oversight responsibility for CoMIRS standard operating procedures and memorandums of understanding.
2. Define the catalog of SOPs and MOUs needed for CoMIRS.
3. Collect, review, and revise these SOPs and MOUs that already exist.
4. Assign deadlines and owners to create the remaining SOPs and MOUs.
5. Establish a clearinghouse for the publication of CoMIRS related SOPs, MOUs, training materials, and other materials.
6. Set update timelines for the review and refresh of SOPs, MOUs, and other key documentation.
7. Establish rules for overseeing the effective adherence to commonly established SOPs, MOUs, and other guidelines.

Key Finding #14: There is an uneven level of user knowledge on how to properly use CoMIRS interoperability channels.	Urgency	Cost
	2 to 5 years	$

A radio network is only as effective as the users on the network. There are standards and best practices that, when universally understood, enhance the value of the network as a whole. Currently, decisions on the nature, content, and timing of radio training is left to each individual agency on the network. This can result in confusion and inefficiency when interjurisdictional communications are required.

The current state of training on CoMIRS is rated as "*ad hoc.*" While certain agencies are more mature and have formalized training programs for end users, dispatchers, and radio technicians, other agencies have little or no formalized training.

The primary impact of non-standardized training is an uneven level of user competency across the state. Some of this unevenness is to be expected. For instance, an experienced state trooper will almost certainly be more familiar with his or her radio than a seasonal employee working at DCR. Yet for a true statewide interoperability network to function effectively, there must be a common baseline of user competency across all agencies that will use the network. Currently, that baseline competency does not exist or at least it is unknown whether it exists. Without remediation, this potential issue of radio competency could pose an operational risk to the statewide network.

Similarly, there are uneven levels of training for system administrators and dispatchers staffing the numerous PSAPs across the Commonwealth. Most training for these administrators and dispatches is done locally, based on local standards for operation. This leads to varying degrees of understanding on how the network should operate and how to respond to different situations. This can be an issue when PSAPs are consolidated or serve as failovers for other locations.

Remediation Activities

1. Collect and review all existing CoMIRS training materials.
2. Establish responsibilities for development of baseline training guidelines for all CoMIRS users.
3. Assess the current need for remedial training for existing users.
4. Establish processes to properly train all new users of the system, including formalized training as part of professional training academies and continuing education.
5. Develop training materials that can be used by local users of the system.
6. Provide services for the customization of training materials for agency usage.
7. Track radio training for all system users.

Key Finding #15: CoMIRS will likely require additional spectrum, at least during the transition from analog to digital.	Urgency	Cost
	2 to 5 years	$

The expanded use of radio frequencies cannot be accommodated overnight. Rather, potential future demands for frequencies must be planned for years in advance. CoMIRS will likely need additional frequencies to provide adequate bandwidth as agencies move from analog to digital radio. Additionally, after CoMIRS transitions fully to a digital network, other user may seek to use the network to address their frequency or financial concerns. CoMIRS administrators should gauge future interest in the network now, so that capacity can be properly planned and implemented during the digital transition.

The demand for service with the current CoMIRS user base is quite stable, and the system is generally capable of handling the current load throughout the network with an acceptable Grade of Service. However, as the system migrates from analog to digital technology, it is very likely that additional channel capacity will be required:

- **To support parallel systems during the digital buildout and cutover**. Analog systems must remain in service to support the very large analog user base while new digital systems are constructed. Analog and digital systems cannot share the same channels in the same operating areas, so new channels may be required for digital systems during cutover period. At the end of the cutover period, analog system channels can be returned to the FCC pool, used in the digital system to expand system capacity, or offered to other public safety entities in eastern Massachusetts as a replacement band for T-band.

- **To provide operational communications for additional state agencies.** An enormous untapped benefit of moving to a TDMA digital network is the opportunity for the Commonwealth to consolidate multiple large networks into a single Commonwealth network. This has the potential benefit of averting the enormous investment needed to migrate multiple analog networks to separate digital networks. Further, there are likely significant annual cost savings for avoiding the upkeep costs for parallel statewide networks. For example, MassDOT currently uses CoMIRS in the eastern areas of the Commonwealth, while the balance of MassDOT operations remains on low band systems that are due for upgrade. Limited coverage and capacity on CoMIRS has prevented MassDOT from requesting additional service on the system. A move to TDMA for CoMIRS may be sufficient for MassDOT to decide it is in its best interests to seek use of CoMIRS for its operational communications needs.

- **To serve as an option for T-Band departments**. Upwards of 166 police departments and 83 fire departments[8] in eastern Massachusetts may be impacted by legislative actions to remove 500 MHz (T-Band) spectrum from the public safety pool by 2022 or 2023[9]. As of 2021, the 500 MHz channels currently in use by Boston Area Police Emergency Radio Network (BAPERN) members, Metrofire Network members, and others will revert back to the FCC for public auction

[8] http://www.npstc.org/download.jsp?tableId=37&column=217&id=2852&file=TBand_APCO_Presentation_130821.pdf&page=NPSTC

[9] https://www.dhs.gov/sites/default/files/publications/T-Band Slick...

in 2023 and must be vacated. This action will force a migration from 500 MHz to others bands such as 150 MHz, 450 MHZ, 700 MHz, and 800 MHz. This action will accelerate demand for 700/800MHz channels or drive dislocated users to request service on CoMIRS or both.

Compared to P25 Phase 1, the adoption of P25 Phase 2 technology would effectively double the capacity of the licensed spectrum in the 700 and 800 MHz bands and would be four times as efficient as the current analog network. With the channels currently licensed, the potential for additional channels in the 700 MHz band, and the opportunity to deploy P25 Phase 2 frequency efficient technology, the Commonwealth is in a good position for continued support of the existing user base and is well-positioned to expand its user base to include new CoMIRS users.

The need for proper planning and coordination of spectrum usage is critical. The process to design, coordinate, and license spectrum typically takes years and other potential licensees may be competing for the same spectrum. Plans for spectrum usage need to be determine early on and addressed with the FCC as soon as possible.

Remediation Activities

1. Gauge interest in potential future expanded use of CoMIRS from other state agencies, regional interoperability providers, and jurisdictions subject to T-Band reversion.
2. Determine likely future spectrum usage requirements.
3. Comprise channel plan for future use of CoMIRS.
4. Seek approval of channel plan from FCC.
5. Plan implementation of the channel plan with potential adoption of new users on CoMIRS.