Commonwealth of Massachusetts Interoperable Radio System (CoMIRS)

6 CoMIRS Digital Modernization Roadmap

Version 1.0 (May 2017)

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6 COMIRS DIGITAL MODERNIZATION ROADMAP

The CoMIRS Digital Modernization Roadmap is an action plan of the key activities the Commonwealth can follow to replace its aging analog radio system with a robust, modern digital radio network. This Roadmap is consistent with action plans that multiple vendors in the land mobile radio (LMR) industry have successfully implemented.

There are issues with the existing Massachusetts analog radio network that can only be addressed by fully replacing the existing analog network with a digital equivalent. Action on the Roadmap should begin immediately.

Major components of the Roadmap include:

1 First, the Commonwealth needs to **address identified issues with the existing analog radio network** to maintain critical voice communications for public safety across the Commonwealth. Remedial action is needed now and for the next several years until a replace radio network is completed. EOPSS, MSP, and its network maintenance vendor have a strong track record in maintaining the availability of the analog network. This has become harder and costlier as analog components are no longer manufacturer supported and readily available.

2 Second, the Commonwealth of Massachusetts should **invest in a P25 TDMA land mobile radio network** to replace its aging and unsupported analog network. Moving to P25 TDMA will bring Commonwealth public safety communications up to par with industry standards and will significantly improve the capacity and reliability of the radio network. This move will entail infrastructure improvements on radio sites throughout the Commonwealth and will require the replacement of thousands of portable and mobile subscriber units within MSP and other users of the network.

3 Third and optionally, the Commonwealth should **plan how best to leverage the added capacity that a well-designed TDMA LMR network provides.** The move to TDMA opens the avenue for truly shared infrastructure and capital investments for Commonwealth agencies, regional organizations, and approved municipal organizations. Statewide organizations with mission critical voice communications needs, like the Department of State Police and the Massachusetts Department of Transportation, can utilize shared LMR resources that meet their operational needs, while avoiding duplicate investment in digital radio infrastructure throughout the Commonwealth.

The move to digital radio is not cheap. The conceptual plan for the CoMIRS includes more than a hundred radio sites and thousands of upgraded portable and mobile radios. However, as interviews with key stakeholders highlight: *the investment is needed and it is needed now.*

The diagram below summarizes this Roadmap across its three main threads:

6.1. Address Immediate Needs with Current Radio Network

6.2. Replace Analog Network with Digital P25 TDMA Network

6.3. Leverage Expanded Capacity for Other Users and Agencies

Activities are grouped by thread and fiscal year. Additional detail about each activity in the Roadmap is included on the following pages.

CoMIRS Digital Modernization Project Roadmap

Address Immediate Needs with Current Radio Network	Replace Analog Network with Digital P25 TDMA Network	Leverage Expanded Capacity for Other Users and Agencies

FY2017 and FY2018

Address Immediate Needs with Current Radio Network:
- 6.1.1 Replace end of life MSP dispatch consoles
- 6.1.2 Address failing backhaul links
- 6.1.3 Replace aging simulcast reference clocks
- 6.1.4 Test Existing Radio Site Infrastructure
- 6.1.5 Begin upgrading antiquated MSP radios

Replace Analog Network with Digital P25 TDMA Network:
- 6.2.1 Develop detailed TDMA engineering design
- 6.2.2 Develop MOUs for Use of Digital Infrastructure
- 6.2.3 Obtain additional spectrum
- 6.2.4 Obtain FCC frequency approval
- 6.2.5 Obtain long-term capital and operational funding
- 6.2.6 Solicit proposals to transition to digital radio

Leverage Expanded Capacity for Other Users and Agencies:
- 6.3.1 Determine potential expanded use of CoMIRS
  - Berkshire Public Safety
  - Franklin Public Safety
  - MassDOT
  - Department of Correction
  - T-Band Alternative
  - Others
- 6.3.2 Clarify CoMIRS decision making and governance

FY2019

Address Immediate Needs with Current Radio Network:
- 6.1.6 Replace circuit-switched backhaul links
- 6.1.7 Prioritize and address immediate needs repairs

Replace Analog Network with Digital P25 TDMA Network:
- 6.2.7 Acquire TDMA digital radios for current users
- 6.2.8 Prepare for TDMA radio network implementation
- 6.2.8 Upgrade radio network Core
- 6.2.10 Build, lease, or upgrade radio sites
  - Barnstable County
  - Bristol County
  - Essex County
  - Middlesex County
  - Plymouth County
  - Worcester County
- 6.2.11 Enhance and expand backhaul network
- 6.2.12 Coordinate transition to digital radio network
- 6.2.13 Train on digital radio operation & maintenance
- 6.2.14 Decommission analog infrastructure

Leverage Expanded Capacity for Other Users and Agencies:
- 6.3.3 Update and publish CoMIRS standards
- 6.3.4 Formalize new user training
- 6.3.5 Upgrade FDMA radio sites to TDMA sites
  - Berkshire County
  - Franklin County
  - Hampden County
  - Hampshire County

FY2020

FY2021

FY2022

Figure 6-1: CoMIRS Digital Modernization Project Roadmap

6.1 Address Immediate Needs with Current Radio Network

Regardless of the Commonwealth's commitment to move to digital land mobile radio or its timeline for such a transition, significant remedial investments are needed to assure the mission-critical nature of the existing analog radio system. There are several known deficits in the existing infrastructure, largely caused by the age and lack of manufacturer support for critical components. The existing radio network must be maintained a high level of availability until an alternative, mission-critical voice system is available. With proper planning, most investments made to address aging components now can be reused in the future digital LMR infrastructure.

Below are the seven critical major activities need to address the immediate needs of the current Commonwealth radio network:

6.1.1 Replace End of Life MSP Dispatch Consoles

6.1.2 Address Failing Backhaul Links

6.1.3 Replace Aging Simulcast Reference Clocks

6.1.4 Test Existing Radio Site Infrastructure

6.1.5 Begin Upgrading Antiquated MSP Radios

6.1.6 Replace Circuit-Switched Backhaul Links

6.1.7 Prioritize and Address Immediate Needs Repairs

Figure 6-2: Steps to Address Immediate Needs with Current Radio Network

6.1.1 Replace End of Life MSP Dispatch Consoles

There are approximately 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 Motorola Gold Elite family of console systems are no longer supported by the manufacturer, Motorola. The Department of State Police is the only CoMIRS user still operating on this antiquated console platform.

6.1.1 Replace End of Life MSP Dispatch Consoles

MSP Gold Elite consoles are incompatible with the new system release and must be replaced prior to the release upgrade. Failure to address these consoles put dispatch capabilities at risk at eight MSP locations, including Shelburne Falls E-911 PSAP, the New Braintree E-911 PSAP, and the Northampton E-911 Wireless PSAP. These three MSP locations serve as the Regional Emergency Communications Centers for 52 communities, 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. The Gold Elite console systems at MSP General Headquarters, Holden, Middleboro, South Boston, and Danvers also need to be replaced.

Funding is the primary limiting factor in the replacement of these console systems. There are several industry leading console replacements with proven track records. Once funding is obtained, an open procurement should be undertaken to select a console system replacement that interoperates effectively on CoMIRS. Replacement should be scheduled on a site basis for each of the eight MSP locations still operating the Gold Elite console systems. Console operators need to be properly trained on the operation of the new console system and a cutover should be scheduled for each MSP location. Below are the activities need to replace these end-of-life MSP dispatch consoles:
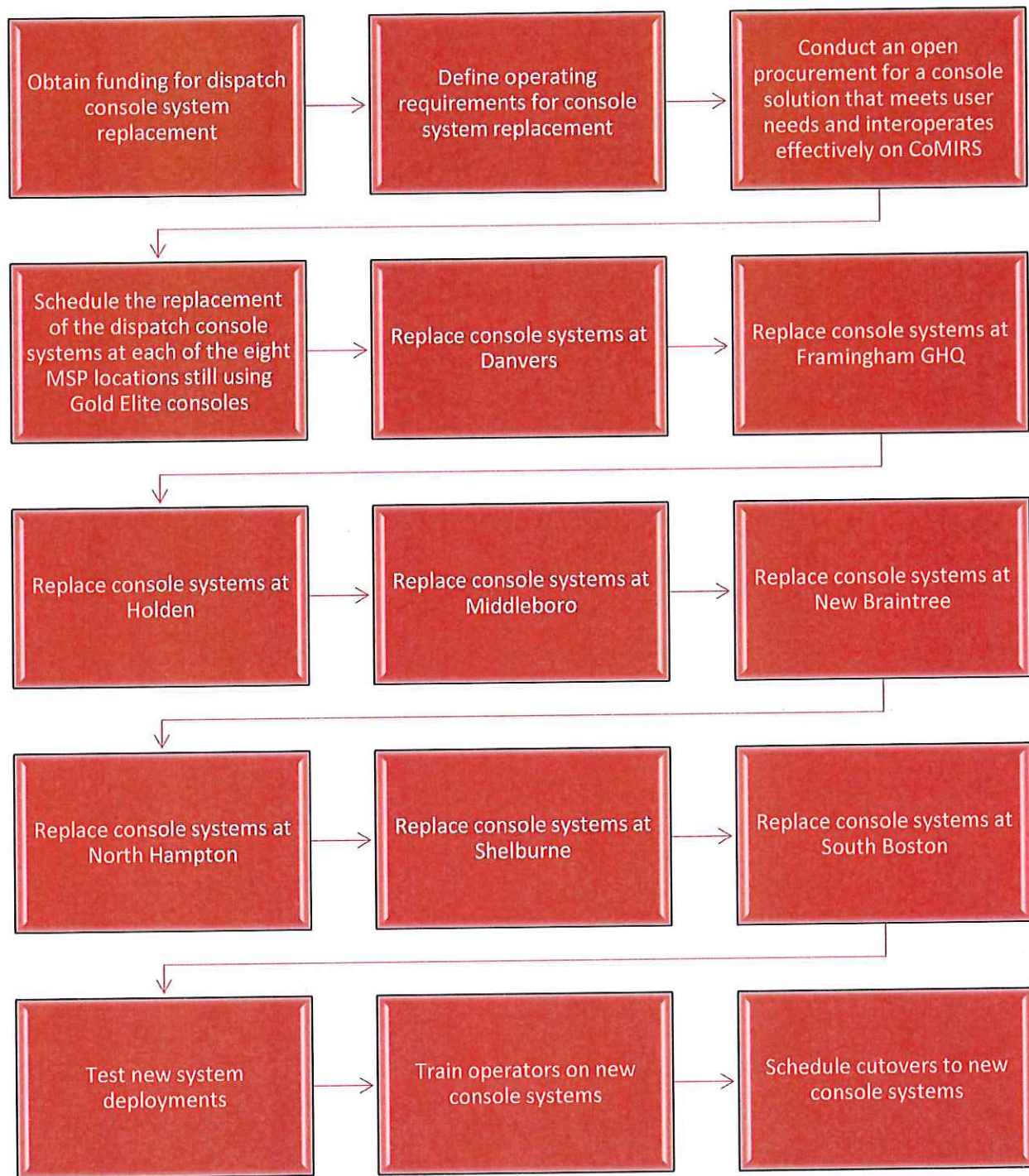
Figure 6-3: Steps to Replace End of Life MSP Dispatch Consoles

6.1.2 Address Failing Backhaul Links

Microwave links are a form of backhaul from radio sites. Backhaul is the means of getting voice and data from a site tower or radio location to a point from which it can be distributed over a network. Without backhaul, there would be no communications with the radio site tower and all users of that tower would be disconnected from communications with others on the radio network.

6.1.2 Address Failing
Backhaul Links

Address Failing Central Massachusetts Microwave Links

Three of the microwave systems (from Microwave Networks Inc.) in central Massachusetts are experiencing regular outages due to path obstructions caused by tree growth. This microwave hardware is also old and in need of upgrade. The fire tower in Oxford used to support the microwave and radio antennae is only 65' high, which is not high enough to overcome tree growth. Oxford is a microwave hub for radio sites at Charlton, Mendon, and Worcester. To overcome these path issues, MSP is planning on relocating its microwave links to a commercial site in Webster. Failure to address this backhaul issue can affect CoMIRS users throughout central Massachusetts and Fire District 7 and risks the loss of wide area communications.

Address Failing Southeast Massachusetts Microwave Links

Similarly, there are existing backhaul communications issues involving three microwave links in use in southeastern Massachusetts. These old microwave links support the analog system through the radio towers at Pine Hill (Plymouth), 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 digital upgrade design. Loss of any of these microwave links would impact wide area communications across the entire southeast 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 southeast Massachusetts and risks the loss of wide area communications.

Address Failing 960 MHz Microwave Links

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, which resulted in a loss of communications for radios using that radio 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 microwave radios, and there are limited functioning replacement parts available to MSP for servicing these microwave links. Failure to address these failing microwave links could risk the loss of radio communications for all users in these areas.

To address these immediate needs, the Commonwealth should give highest priority to replacing backhaul links that are already experiencing failure or sub-optimal performance. Secondary priority should be given 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.

For each link prioritized for replacement, a determination is needed about the nature and location of its replacement. Path studies should be conducted to confirm the suitability of new microwave link paths. Microwave dish sizing and frequencies need to be optimized for the anticipated traffic and distance between transmitting and receiving antennas. Structural analysis of tower locations should be conducted with remediation taken to assure compliance with commercial standards in voice communication. Once properly planned, new microwave links can be procured and installed that address the underlying backhaul issues. Where appropriate, old equipment should be inventoried to serve as replacement parts for other aging microwave links that have yet to be addressed by the digital radio enhancement project.

Below are the steps that should be undertaken to address failing backhaul links on the CoMIRS network:
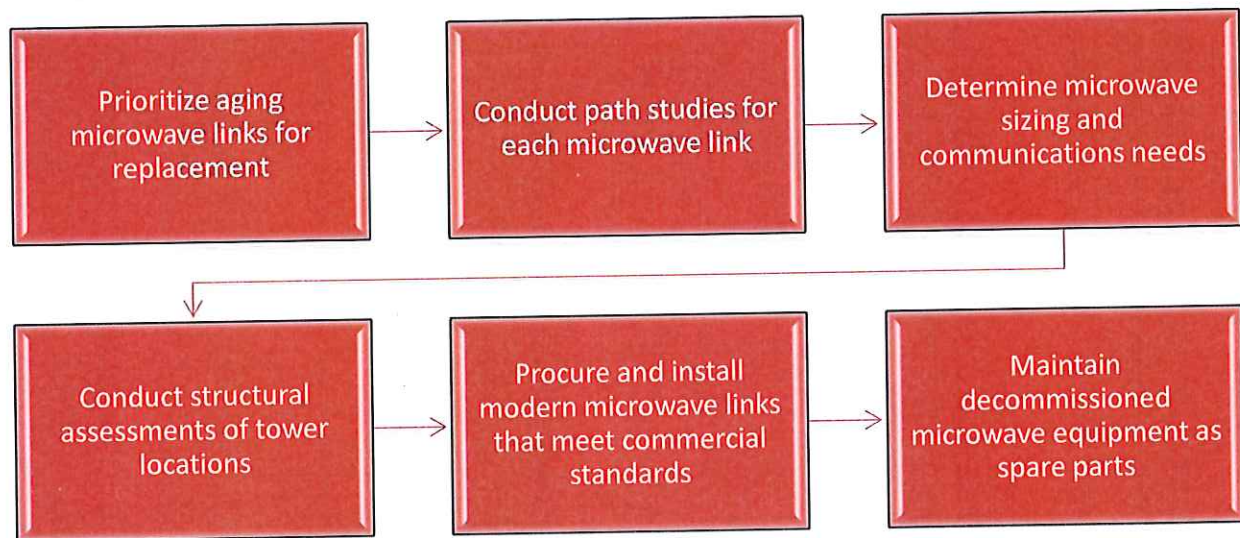
Figure 6-4: Steps to Address Failing Backhaul Links

6.1.3 Replace Aging Simulcast Reference Clocks

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. To prevent interference where signals from different sites overlap, simulcast depends on extremely accurate timing of broadcasts 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.

6.1.3 Replace Aging Simulcast Reference Clocks

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. 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.

To address this immediate need, the Commonwealth should:
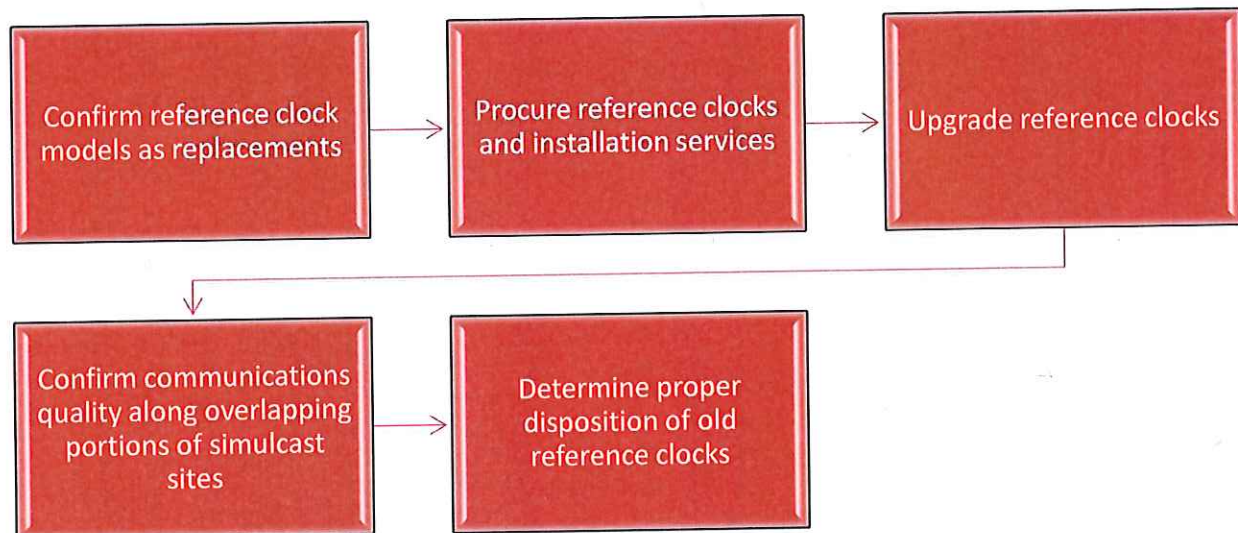
Figure 6-5: Steps to Replace Aging Simulcast Reference Clocks

6.1.4 Test Existing Radio Site Infrastructure

A recommendation of this Strategy Report is to conduct an on-site comprehensive evaluation of the status of key components of the existing radio site infrastructure in the short term. Some of this evaluation may already be conducted on a routine basis by the radio technicians of the Department of State Police or its network maintenance vendor.

6.1.4 Test Existing Radio Site Infrastructure

An antenna and feedline sweep is needed to test and visually inspect if the radio system antenna network is operating within design specifications. This is typically conducted semi-annually.

Combiner and multi-coupler alignment is needed to realign radio transmitter combiners and radio receiver multi-couplers at a fixed radio site to design specifications. The combiner and multi-coupler are part of the radio systems antenna network and allow for multiple radio repeaters to share antennas and feedlines. This is typically performed annually.

Intermodulation testing is needed to evaluate all radio frequencies operating at a given radio site to determine whether there is an improper "mixing" or intermodulation of combinations of radio frequencies active at the radio site. Intermodulation can interfere with proper operation of the impacted radio systems, causing loss of reliable communications throughout the site.

UPS testing and repair is needed to assure that the power supplies at each radio site are sufficient and in working order. Should replacement be needed, UPS at radio sites should be replaced with 48 VDC systems that can be expanded to be used by the digital equipment expected to be installed at that location.

Backup generator testing and repair is needed to evaluate, test, repair, and if necessary replace existing site generators or provide new generators where none currently exists. Existing generators are typically tested on-site semi-annually.

In addition, while on site inventories of site equipment should be updated, the documentation of the placement of antennas and other equipment on the radio tower should be confirmed, and any additional site repair considerations should be noted. These items will serve as inputs into the engineering study to be conducted as part of the activities described in Section 6.2.1, as well as serve as the basis for making prioritized repair decisions as described in Section 6.1.7.

Following are the steps that should be followed to test existing radio site infrastructure:

```
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│                     │      │                     │      │                     │
│ Conduct antenna and │ ───> │ Perform combiner and│ ───> │Conduct intermodula- │
│   feedline sweep    │      │multi-coupler align- │      │   tion testing      │
│                     │      │       ment          │      │                     │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                     │
        ┌────────────────────────────────────────────────────────────┘
        ▼
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│                     │      │    Conduct backup   │      │                     │
│ Conduct UPS testing │ ───> │  generator testing  │ ───> │Update site equipment│
│     and repair      │      │     and repair      │      │     inventories     │
│                     │      │                     │      │                     │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                     │
        ┌────────────────────────────────────────────────────────────┘
        ▼
┌─────────────────────┐      ┌─────────────────────┐
│                     │      │                     │
│Confirm tower loading│ ───> │Identify any additio-│
│   documentation     │      │nal site repair con- │
│                     │      │    siderations      │
└─────────────────────┘      └─────────────────────┘
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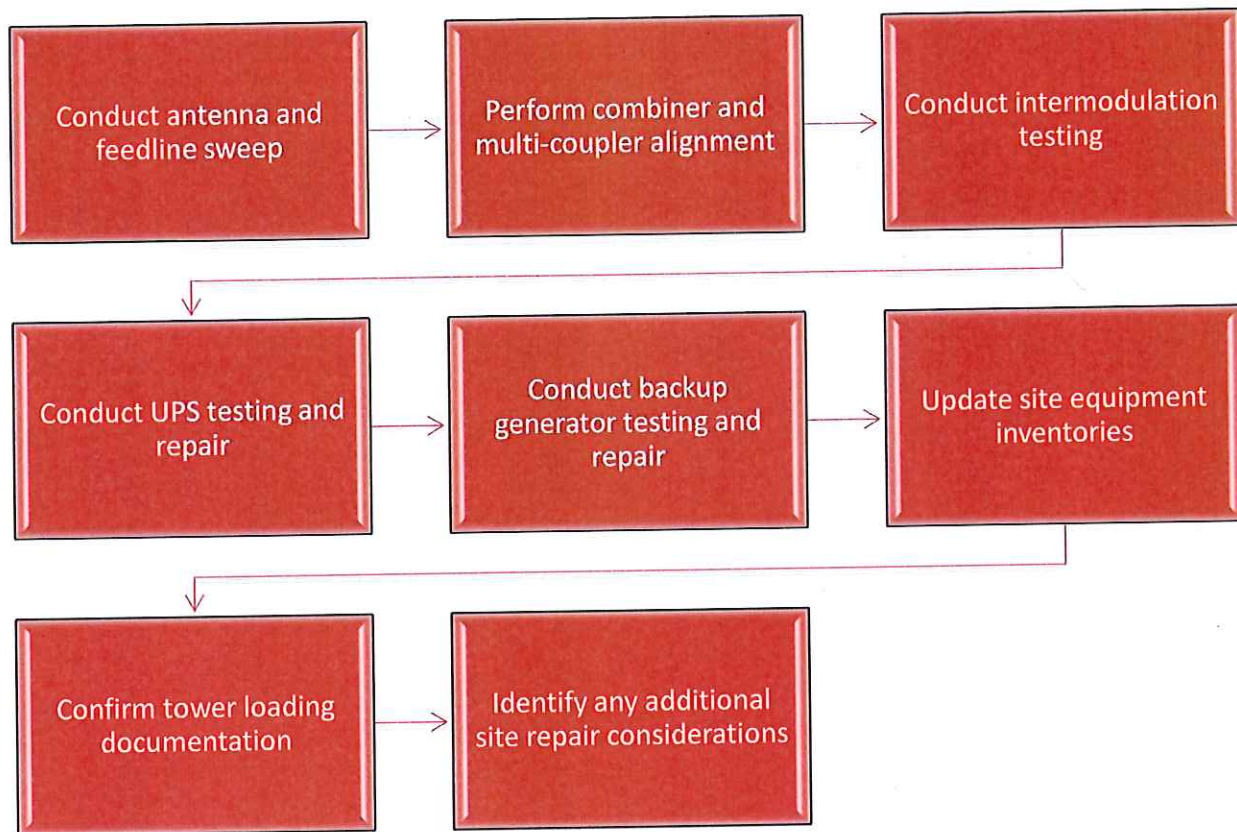
6.1.5 Begin Upgrading Antiquated MSP Radios

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. All analog-only radios need to be upgraded to be TDMA-capable prior to replacing the aging analog radio sites in the corresponding operational areas.

6.1.5 Begin Upgrading Antiquated MSP Radios

Priority should be given to updating the MSP analog-only radios for troops that work in contiguous jurisdictions with disparate analog and digital systems. These include Troop A (operating in Middlesex and Essex Counties), Troop C (operating in Worcester County), and Troop H (operating in Norfolk and Suffolk Counties). In total, approximately 2,700 analog-only MSP mobile and portable radios will need to be replaced over the next few years. Given the number of analog-only radios in current operation and the significant per device cost of each replacement, radio replacement should begin soon, so as to not delay other critical path activities involving the upgrade of the CoMIRS analog radio sites.

Similar to the console system upgrades, funding is the primary limiting factor with radio system replacement. The MSP and other users should confirm their priorities for analog radio replacement and an open procurement should be conducted to seek bids from multiple vendors that provide replacement radios that operate effectively on the current and planned CoMIRS network. Once replacement units are bid and selected, the MSP (and other current users of CoMIRS) should purchase, receive, and inventory the new units. Each radio will need to be properly programmed and encryption keys set, as needed. The replaced analog radios can be used elsewhere, until the cutover to digital radio occurs with the rollout of the TDMA network in Phase 2.

To address this immediate need, the Commonwealth should:

```
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│ Confirm priorities  │     │ Establish schedule  │     │ Determine approach  │
│ for analog radio    │ ──► │ for replacing all   │ ──► │ and schedule for    │
│ replacement         │     │ MSP analog-only     │     │ the replacement of  │
│                     │     │ radio devices       │     │ non-MSP analog-only │
│                     │     │                     │     │ radio devices       │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘

┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│ Define requirements │     │ Solicit competitive │     │ Receive and         │
│ for analog-only     │ ──► │ pricing from        │ ──► │ inventory radios    │
│ radio replacement   │     │ vendors             │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘

┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│ Program radios      │ ──► │ Set encryption keys │ ──► │ Replace all         │
│                     │     │                     │     │ analog-only devices │
│                     │     │                     │     │ in MSP Troop C      │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘

┌─────────────────────┐
│ Replace all         │
│ analog-only devices │
│ in MSP Troops       │
│ A and H             │
└─────────────────────┘
```

Figure 6-6: Steps to Begin Upgrading Antiquated MSP Radios

6.1.6 Replace Circuit-Switched Backhaul Links

Backhaul allows a radio site to communicate with the rest of the radio network. Without it, all the users in that area are disconnected from communications on the radio network.

6.1.6 Replace Circuit-Switched Backhaul Links

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). As a result, backhaul from radio sites using this old technology will not work when the software release is applied.

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.

Currently, there are 34 microwave links and 61 wireline links on CoMIRS that do not support Ethernet natively and need to be replaced. 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.

Upgrades of each circuit-switched link should be addressed on a link by link basis, until all links are upgraded to Ethernet protocols. EOPSS and MSP should work with CoMIRS partners to confirm an inventory of all links that need to be addressed and determine a prioritized schedule for their replacement. When other immediate needs are being addressed at a radio site or when upgrades are being installed, the corresponding backhaul links can be upgraded to Ethernet. All links, though, should be upgraded by 2019.

To address this immediate need, the Commonwealth should:
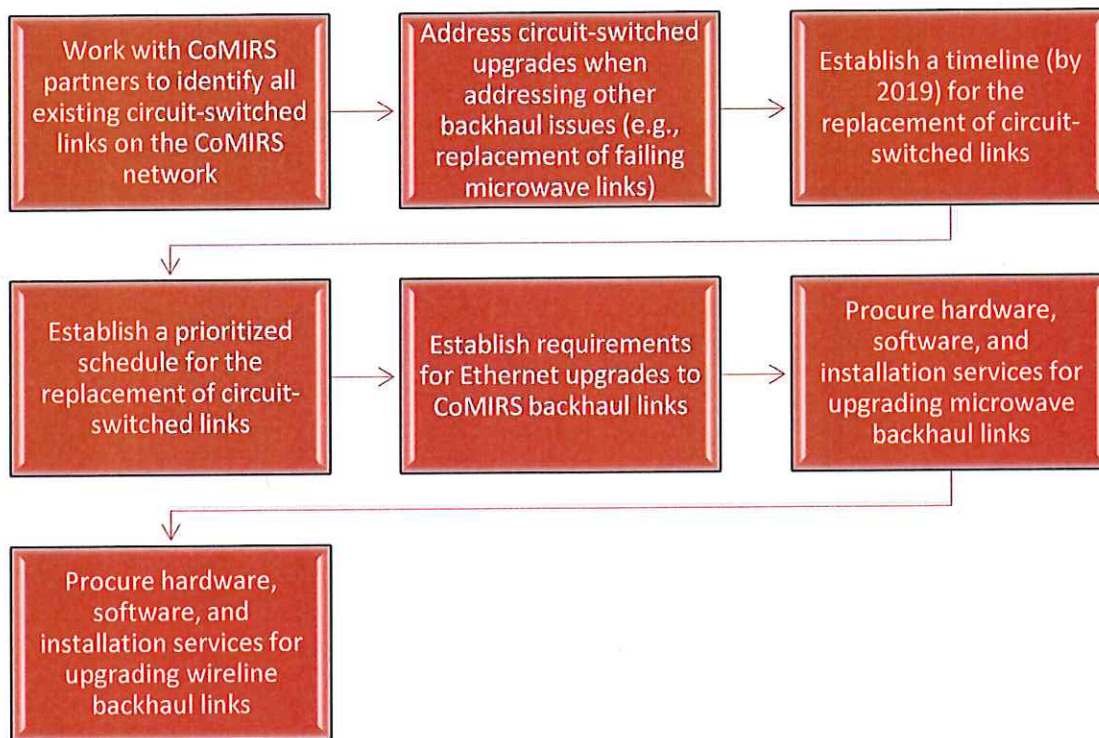
Figure 6-7: Steps to Replace Circuit-Switched Backhaul Links

6.1.7 Prioritize and Address Immediate Needs Repairs

Most of the components of the existing analog trunked radio system are old and at higher risk of failure. Many of the analog portions of CoMIRS are still reliant on system components that date back to the origins of the MSP network in 1993. The Commonwealth should plan for increasing repair needs on the analog portion of the radio network for as long as it is still in operation. Repair needs on the out-of-support analog portion will likely accelerate with any delays in transitioning to a replacement radio network.

6.1.7 Prioritize and Address Immediate Needs Repairs

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. Additionally, analog radio site transmitting equipment will go out of manufacturer support in 2020, and other critical system components are at or beyond the end of manufacturer support.

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. Important to addressing this immediate need is the continuation of a properly funded maintenance contract, the stockpiling of critical analog replacement parts, and proper preventative inspection, testing, and replacement of exiting components.

To address this and other related immediate needs, the Commonwealth should:
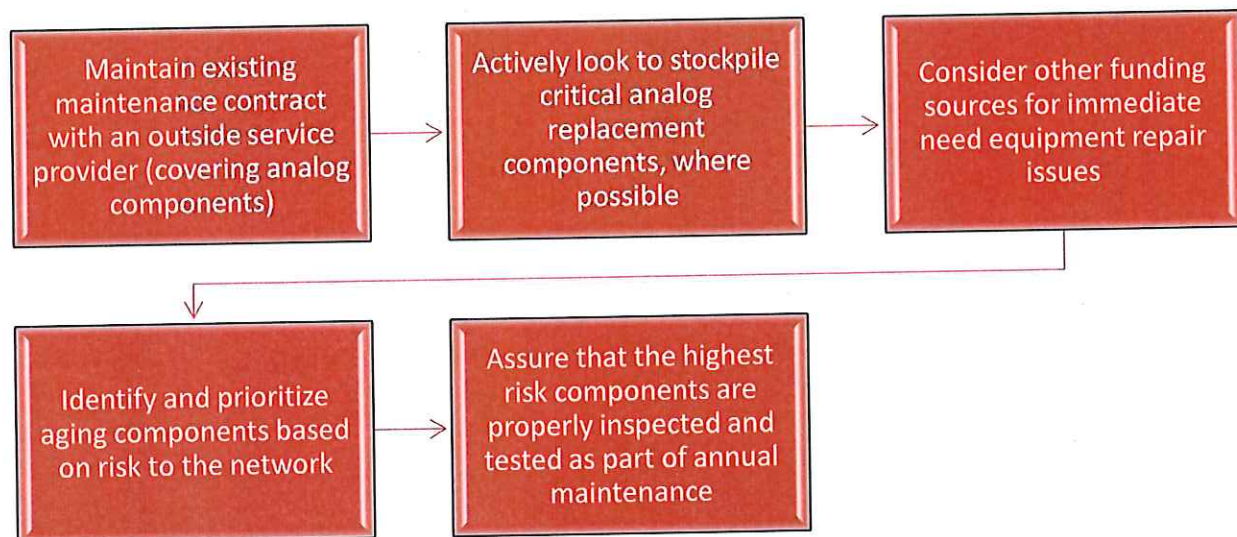
Figure 6-8: *Steps to Prioritize and Address Immediate Needs Repairs*

6.2 Replace Analog Network with Digital P25 TDMA Network

The final resolution of CoMIRS' growing immediate needs issues is the replacement of the decades old analog radio network with a modern P25 digital network. Leveraging the prevailing standards available in land mobile radio technology, the Commonwealth should invest in an upgrade to P25 time-division multiple access (TDMA) digital technology to obtain the reliability and capacity it needs in the years to come.

Below are the critical major activities need to retire the aging analog CoMIRS radio network and replace it with a modern, reliable, digital radio system:

6.2.1 Develop Detailed TDMA Engineering Design

6.2.2 Develop MOUs for Use of Digital Infrastructure
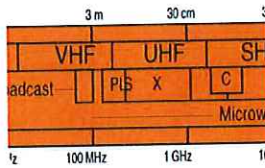
6.2.3 Obtain Additional Spectrum

6.2.4 Obtain FCC Frequency Approval

6.2.5 Obtain Long-Term Capital and Operational Funding

6.2.6 Solicit Proposals to Transition to Digital Radio

6.2.7 Acquire TDMA Digital Radios for Current Users

6.2.8 Prepare for TDMA Radio Network Implementation

6.2.9 Upgrade radio network Core

6.2.10 Build, Lease, or Upgrade Radio Sites

6.2.11 Enhance and Expand Backhaul Network

6.2.12 Coordinate Transition to Digital Radio Network

6.2.13 Train on Digital Radio Operation and Maintenance

6.2.14 Decommission Analog Infrastructure

Additional details for each of these activities are included on the following pages.

6.2.1 Develop Detailed TDMA Engineering Design

Detailed planning and engineering design are critical to the proper implement a modern digital radio network. As the Commonwealth looks to replaces is end-of-life analog radio network, experienced radio engineering consulting services are needed to define the future channel plan for the digital network, determine gaps in existing coverage, assess the adequacy of existing radio tower sites, identify and secure radio sites for the digital network, work with the FCC on obtaining frequencies permissions, and plan the activities needed to transition fully from the existing analog network to the new digital network. These services are anticipated to be multi-year in duration.

6.2.1 Develop Detailed TDMA Engineering Design

The initial activities for this step in the roadmap will focus on selecting a qualified engineering company to aid the Commonwealth in its detailed planning for a TDMA digital radio network to replace its existing analog trunked radio network.

Define engineering needs → Procure engineering services → Execute contract(s)
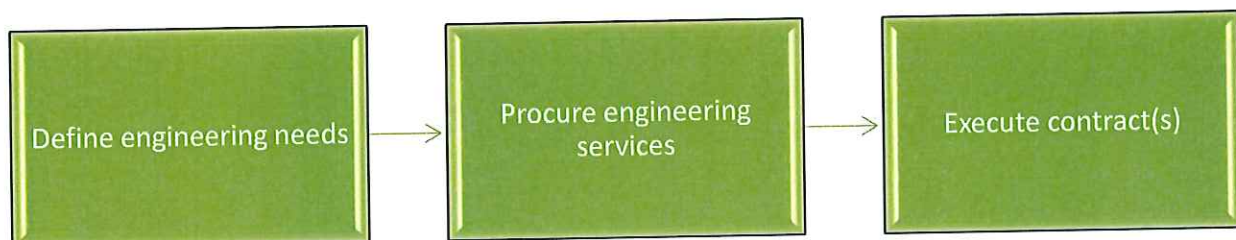
Once an engineering firm is selected, there are numerous tasks needed to clearly define the transition from analog to TDMA digital. Engineering services will include evaluations of coverage needs, planning for optimal simulcast regions, determinations of needed capacity, evaluations of radio sites, and detailed planning of the transition of each site to support TDMA radio usage. These activities include:

```
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│ Identify areas of   │      │ Identify additional │      │ Define population of│
│ insufficient radio  │─────▶│ spectrum needs      │─────▶│ users on the "to be"│
│ coverage            │      │                     │      │ CoMIRS radio network│
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                      │
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│ Determine best      │      │ Determine talkgroup │      │ Develop a channel   │
│ layout for simulcast│─────▶│ and capacity needs  │─────▶│ plan for a P25 TDMA │
│ sites based on areas│      │                     │      │ digital network     │
│ of operation        │      │                     │      │                     │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                      │
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│ Develop conceptual  │      │ Review existing     │      │ Identify new radio  │
│ design of "to be"   │      │ radio sites for use │      │ sites needed for the│
│ CoMIRS radio network│─────▶│ in the future       │─────▶│ future network      │
│ including backhaul  │      │ network (structural │      │                     │
│                     │      │ analysis, shelter   │      │                     │
│                     │      │ space, backhaul     │      │                     │
│                     │      │ availability,       │      │                     │
│                     │      │ antenna positioning,│      │                     │
│                     │      │ power supplies,     │      │                     │
│                     │      │ access, and other   │      │                     │
│                     │      │ site considerations)│      │                     │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                      │
┌─────────────────────┐      ┌─────────────────────┐
│ Determine           │      │ Develop detailed    │
│ gap/transition plan │      │ design of "to be"   │
│ for each radio site │─────▶│ CoMIRS radio network│
│ to upgrade to TDMA  │      │                     │
│ with planned        │      │                     │
│ capacity            │      │                     │
└─────────────────────┘      └─────────────────────┘
```

In addition, broader planning and facilitation will be needed. A consolidated want list of services, hardware, and software will be compiled and a plan for the transition will be developed. These lists and plans will serve as key artifacts for the solicitation of implementation services and hardware from qualified radio service providers.
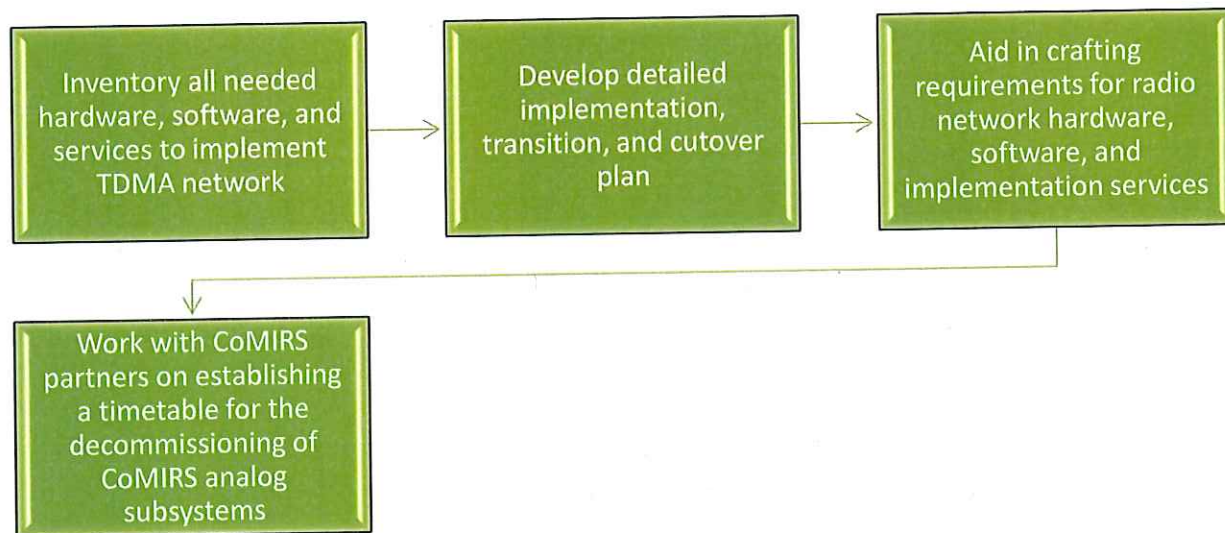
```
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│ Inventory all needed│      │  Develop detailed   │      │   Aid in crafting   │
│ hardware, software, │ ───► │  implementation,    │ ───► │ requirements for    │
│ and services to     │      │  transition, and    │      │ radio network       │
│ implement TDMA      │      │  cutover plan       │      │ hardware, software, │
│ network             │      │                     │      │ and implementation  │
│                     │      │                     │      │ services            │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                     │
┌─────────────────────┐                                             │
│  Work with CoMIRS   │ ◄───────────────────────────────────────────┘
│ partners on         │
│ establishing a      │
│ timetable for the   │
│ decommissioning of  │
│ CoMIRS analog       │
│ subsystems          │
└─────────────────────┘
```

6.2.2 Develop Memorandums of Understanding for Use and Maintenance of Digital Infrastructure

A critical assumption upon which this Roadmap and its associated cost estimates are based is the use of existing municipally owned P25 digital resources in important metropolitan areas of Massachusetts. These include existing digital coverage areas in the Boston metropolitan area and the City of Worcester. There are informal agreements on the use of resources, but formalized agreements are needed for the long-term planning of the CoMIRS network.

6.2.2 Develop MOUs for Use of Digital Infrastructure

Below is a map of the existing and planned P25 digital sites for the CoMIRS network. The green areas represent existing digital coverage areas in the state and the green dots represent existing P25 radio sites. The plans presented in this Strategy Report assume the use of the resources in the future digital network. The P25 sites in western Massachusetts are planned to be upgraded from P25 Phase 1 to Phase 2. The coverage in the Boston and Worcester areas plan to leverage resources owned and operated by their respective municipal agencies. Without agreement on the use of these resources, additional simulcast regions, radio sites, and significant additional cost will be needed to complete the needed P25 digital coverage for the mainland counties of Massachusetts.

City of Boston/ UASI Digital Overlay

City of Worcester P25 Coverage

- ■ Proposed P25 Digital Network
- ● Proposed P25 Digital Sites
- ■ Existing P25 Digital Network
- ● Existing P25 Digital Sites
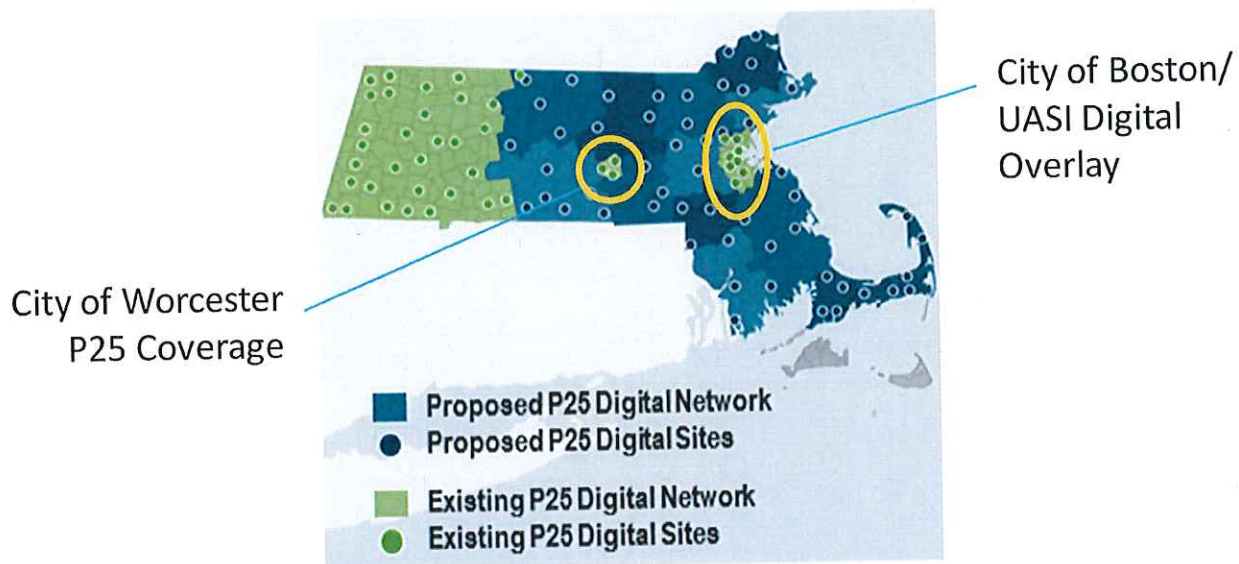
Figure 6-9: Digital Coverage Areas Requiring MOUs

Below are the tasks that should be performed to complete this important activity:

```
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│  Identify municipally│      │ Determine governance│      │Negotiate stipulations│
│  owned radio sites   │ ───► │ of municipally owned│ ───► │for use of these      │
│  planned for inclusion│     │ radio sites         │      │municipally owned     │
│  in the CoMIRS P25   │      │                     │      │radio sites           │
│  channel plan        │      │                     │      │                      │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                     │
        ┌────────────────────────────────────────────────────────────┘
        ▼
┌─────────────────────┐      ┌─────────────────────┐
│  Draft Memorandum of│      │ Obtain appropriate  │
│  Understandings     │ ───► │ sign-offs on MOUs by│
│                     │      │ all appropriate     │
│                     │      │ parties             │
└─────────────────────┘      └─────────────────────┘
```
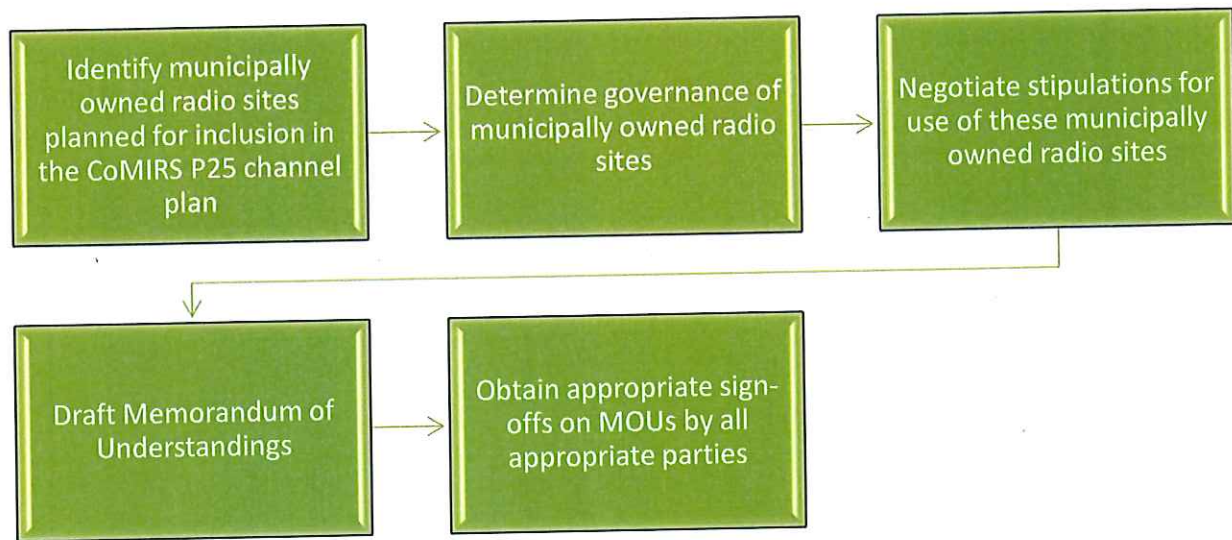
6.2.3 Obtain Additional Spectrum

CoMIRS may need additional frequencies to provide adequate bandwidth as agencies move from analog to digital radio, at least during the transition from analog to digital over the next several years. The need for additional frequencies will be further heightened if additional large agencies request operational use of the CoMIRS network (see 6.3.1 "Determine Potential Expanded Use of CoMIRS").
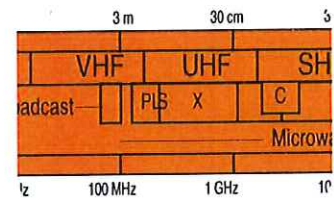
6.2.3 Obtain Additional Spectrum

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.

The following steps should be undertaken to complete this activity.
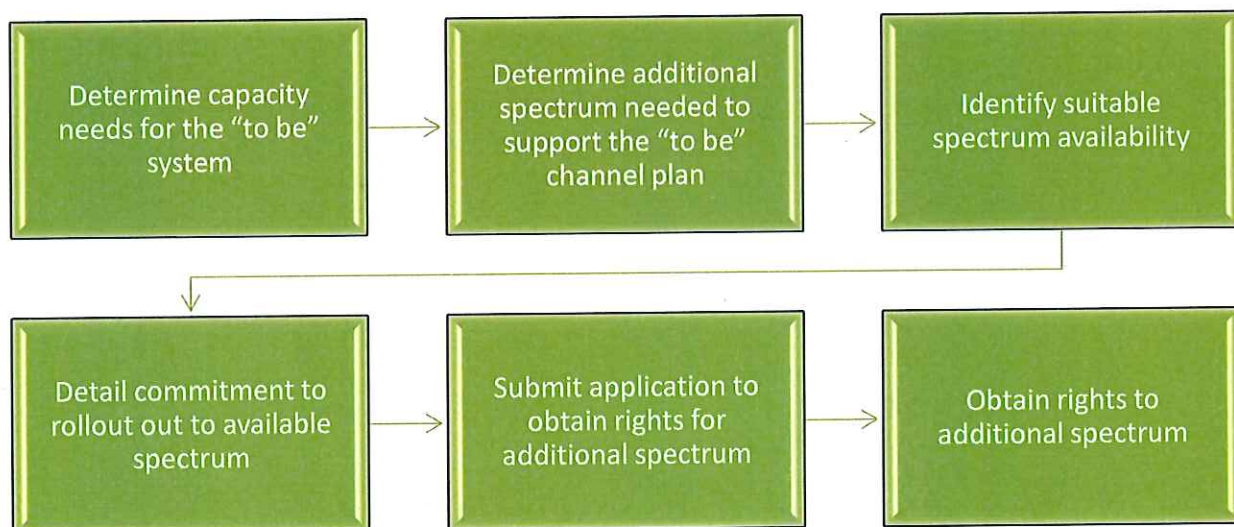
6.2.4 Obtain FCC Frequency Approval

Once a channel plan has been defined and additional spectrum identified, approval is needed from the FCC to implement the channel plan and the supporting microwave links. It is important that all foreseeable future expansion and usage of CoMIRS is taken into consideration. New sites and simulcast broadcast areas need to be defined. Frequency usage needs to be reviewed and professionally coordinated. When ready, applications need to be drafted and submitted to the Federal Communications Commission (FCC) for both the usage of the LMR frequencies as well as the use of microwave frequency planned as CoMIRS backhaul links. These applications need to cover a range of information, including:

6.2.4 Obtain FCC
Frequency Approval

- Frequency Band

- Planned mobile radio count

- Output power/effective radiated power (ERP)

- Emission designators

- Antenna information (including structure type, height, coordinates, site elevation, and FAA registration, among other information)

Once an application is submitted to the FCC, coordination is needed to obtain final approval. Once approved, additional follow-up is required to notify the FCC of construction plans and license renewal. Key tasks for this major activity include:

```
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│                     │     │                     │     │  Finalize antenna   │
│  Obtain frequency   │────▶│ Finalize radio sites│────▶│ placements, broadcast│
│ coordinator services│     │  and broadcast areas│     │    strengths, and   │
│                     │     │                     │     │ transmitter emissions│
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
                                                                    │
        ┌───────────────────────────────────────────────────────────┘
        ▼
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│  Finalize number of │     │                     │     │                     │
│ talkpaths for each  │────▶│ Finalize channel    │────▶│ Finalize backhaul   │
│ radio site or       │     │      plan           │     │       plan          │
│ simulcast region    │     │                     │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
        │                                                          │
        └──────────────────────────────────────────────────────────┘
        ▼
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│                     │     │  Prepare microwave  │     │                     │
│ Prepare LMR frequency│────▶│ frequency application│────▶│ Manage FCC review  │
│ application for FCC │     │     for FCC         │     │  and approval process│
│                     │     │                     │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
        │                                                          │
        └──────────────────────────────────────────────────────────┘
        ▼
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│                     │     │                     │     │                     │
│ Plan implementation │────▶│ Notify FCC of all   │────▶│ Track and manage    │
│ of the channel plan │     │ related construction│     │   license renewal   │
│                     │     │    activities       │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
        │
        ▼
┌─────────────────────┐
│                     │
│ Work with the FCC on│
│ repurposing analog  │
│ spectrum, as needed │
│                     │
└─────────────────────┘
```

6.2.5 Obtain Long-Term Capital and Operational Funding

The most limiting factor in creating a modern, reliable land mobile radio network is funding. Radio networks are expensive to build and radio subscriber units can be expensive to purchase. Incomplete funding can result in a substandard network, with significant areas of unavailable coverage. In the public safety world, this can jeopardize the lives and property of the citizens of the Commonwealth and the safety of the first responders that serve them.

6.2.5 Obtain Long-Term Capital and Operational Funding

For financing purposes, there are three types of funding that should be identified and secured:

1. **Capital Funding for the Build Out**: An immediate funding need is for the modernization of the CoMIRS radio infrastructure. This includes upgrades to nearly 100 radio sites throughout the Commonwealth. These expenditures are centered around purchasing and installing a variety of digital LMR radio components and professionally installing them.

   For financing, this is largely a straightforward capital investment in statewide infrastructure. While used by agencies at the municipal and regional levels of government, most states finance the buildout of their systems with statewide capital funding of some sort. This accounts for nearly half the planned expenditures for the modernization.

2. **Funding for Subscriber Unit Replacement**: Subscriber units (or radios) are a more complicated matter when considering financing. For state agencies, capital funding can be a clear-cut alternative. For the other regional and municipal users already on CoMIRS operationally, the financing decision can be a bit more uncertain. Additionally, other agencies at all three levels of state government (municipal, regional, and state) may seek to join CoMIRS operationally going forward. Rules around responsibilities for radio system replacement need to be established and funding mechanisms identified.

3. **On-going Operational Costs**: The new network will need to be supported. Operational costs will likely increase with the new network, at least during the several years when both the analog and digital networks are in operation. Even after the decommissioning of the analog trunked system, the network services group will be responsible for more users and more sites than today. Reliable funding for a maintenance vendor and statewide support resources is needed.

In some instances, statutory changes or interpretations may be necessary. Some states have financed their system in full or in part by using 911 surcharges or other 911 funding. A legal determination would need to be made if the existing 911 statutes support this funding. If not, a statutory revision may be needed.

Also important in the planning process is how much money is available to finance the network on an annual basis. The Roadmap for this project assumes a five and a half year timeline. If funding is not available to support that timeframe, then the Roadmap will need to be reexamined.

Plans for financing all three funding needs should be addressed in the earliest stages of the project. Additional discussion about finance options is included in Section 8.2 CoMIRS Financing.

Key steps include:

```
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│ Examine capital     │     │ Examine funding     │     │ Determine long-term │
│ funding options for │ ──> │ options for         │ ──> │ operational support │
│ modernizing the     │     │ replacing           │     │ structure and costs │
│ radio network       │     │ subscriber units    │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘

┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│ Examine operational │     │ Seek statutory      │     │ Establish annual    │
│ funding options for │ ──> │ changes or          │ ──> │ funding             │
│ supporting the      │     │ interpretations for │     │ availability        │
│ CoMIRS network      │     │ the use of 911      │     │                     │
│                     │     │ funding (if needed) │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘

┌─────────────────────┐
│ Revise project      │
│ roadmap and         │
│ timetable to        │
│ reflect funding     │
│ availability        │
└─────────────────────┘
```

6.2.6 Solicit Proposals to Transition to Digital Radio

The radio network modernization will be achieved with the support of land mobile radio vendors. In most if not all instances, hardware, software, and related services for the modernization can be procured using requests for quotes (RFQs) off the Commonwealth's existing ITT57 2-Way Radio Equipment and Supplies statewide contract.

6.2.6 Solicit Proposal to Transition to Digital Radio

Based on the majority of activities identified in this Roadmap, the following major categories of procurements should be expected:

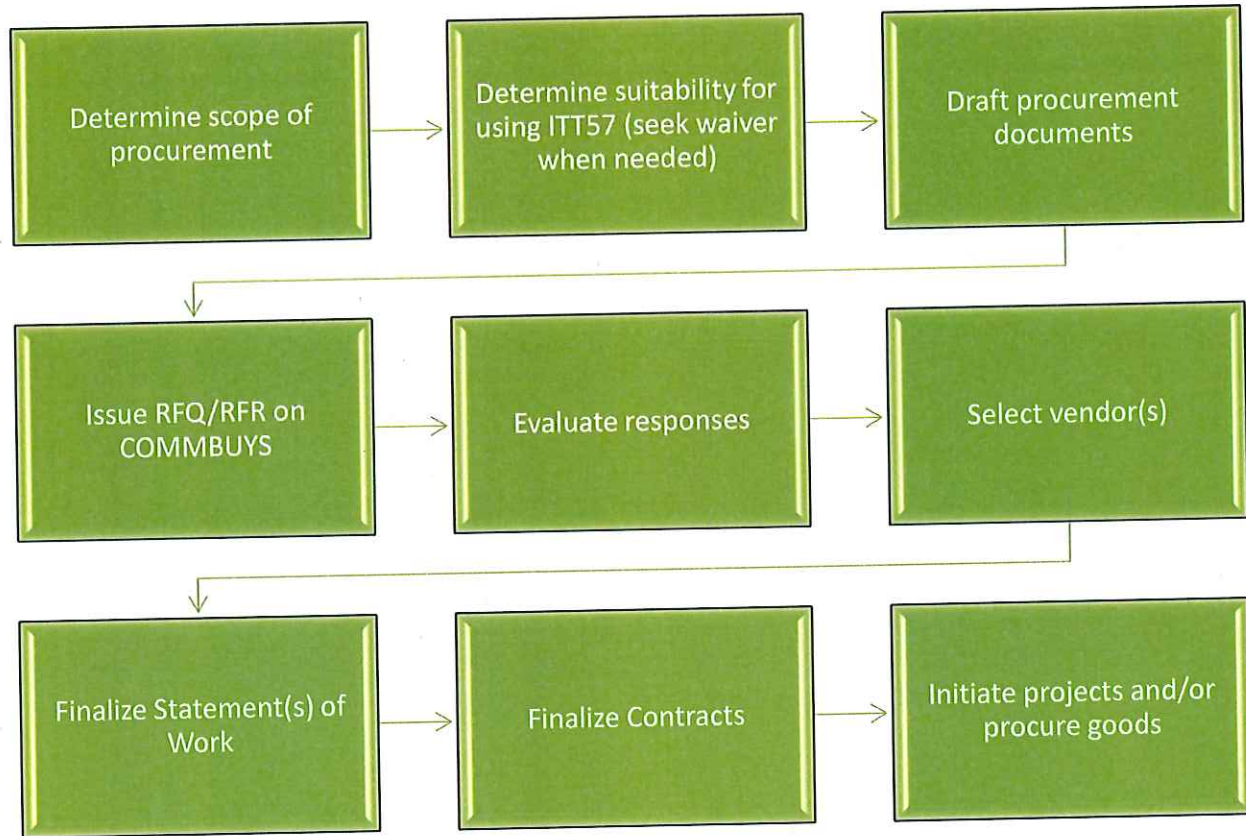1. **Immediate Needs Proposals** – There are a series of immediate needs that should be addressed as soon as possible. These include operator console replacement, network backhaul improvements, subscriber unit replacement, and radio infrastructure repairs. These procurements should be discrete in scope and should be posted to COMMBUYS as soon as funding is available. These procurements are urgent and should not wait until financing is obtained for the entire system modernization.

2. **Engineering Services** – The first major step in the modernization of the CoMIRS network is the procurement of professional engineering services as described in Section 6.2.1 above. These services will create the engineering plans for the modernization of each site and will confirm the overall approach to channel planning and simulcast region layout. These are critical initial steps in the modernization of the network. A determination should be made as to whether or not the existing ITT57 contract includes the companies that best provide these services. If not, a waiver should be sought to issue a request for responses (RFR) on COMMBUYS.

3. **Radio Infrastructure Financing** (as appropriate): If debt financing is determined as an option for financing the network modernization, a procurement for financing can be considered.

4. **Radio Infrastructure Modernization**: A determination needs to be made on whether or not an omnibus approach will be taken to procuring the hardware and services for the radio system modernization. A larger procurement may result in greater overall discounts from the selected vendor, but lock the Commonwealth into the hardware and services of a single vendor. This procurement(s) will focus on upgrades to the Core network and a series of rollouts of the new digital simulcast regions.

5. **Radio Subscriber Unit Replacement**: The approach to procuring replacements for existing subscriber units will be determined largely by the approach the Commonwealth takes to financing subscriber unit replacement. At a minimum, there will need to be a procurement to replace the subscriber units for operable state agencies (the largest of which in terms of radio needs is the Department of State Police). This procurement can be structure to establish pricing from which agencies at all levels of government can purchase radio replacements. The goal here is to obtain a bulk rate discount that would result in greater cost-savings than simply procuring replacements off the existing ITT57 contract.

6. **Radio Network Maintenance and Support**: The long-term support needs for the digital network need to be examined and the role of outside vendors determined. There will likely be

need for a procurement of services for a network maintenance vendor(s) to help support the new digital network.

The typical major activities for these procurements include:

```
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│                     │     │ Determine suitability│     │                     │
│ Determine scope of  │ ──▶ │ for using ITT57 (seek│ ──▶ │  Draft procurement  │
│    procurement      │     │   waiver when needed)│     │     documents       │
│                     │     │                     │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
            ┌───────────────────────────────────────────────────────┘
            ▼
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│                     │     │                     │     │                     │
│  Issue RFQ/RFR on   │ ──▶ │ Evaluate responses  │ ──▶ │  Select vendor(s)   │
│     COMMBUYS        │     │                     │     │                     │
│                     │     │                     │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
            ┌───────────────────────────────────────────────────────┘
            ▼
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│                     │     │                     │     │Initiate projects     │
│Finalize Statement(s)│ ──▶ │  Finalize Contracts │ ──▶ │  and/or procure      │
│     of Work         │     │                     │     │     goods            │
│                     │     │                     │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
```

6.2.7 Acquire TDMA Digital Radios for Current Users

Replacing aging analog radios cannot wait until the digital network is built. Rather, the sheer number of radios that are incompatible with modern digital communications requires a dedicated and long-term approach to subscriber unit replacement. In many instances, users report issues with the reliability of these older units on the existing network. They will not work at all on the new digital network.
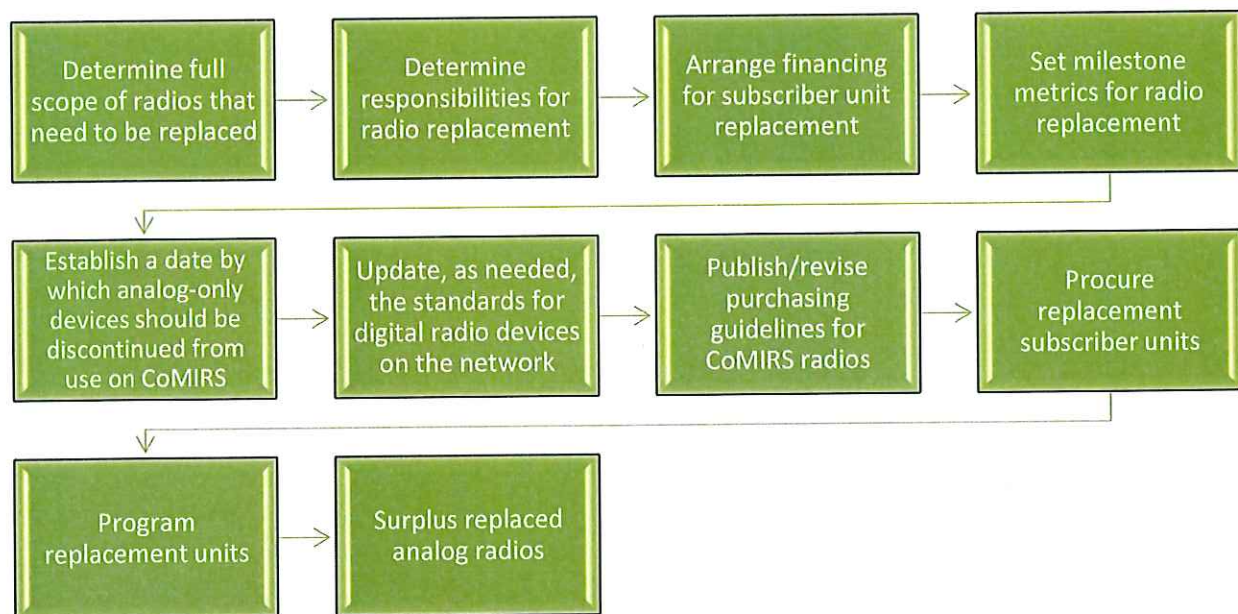
First, responsibility for radio replacement must be clarified, particularly for existing municipal and regional operational users on CoMIRS. Communications and purchasing guidelines should also be communicated to agencies who use CoMIRS for interoperable communications, so that by the time the digital network is ready, they are as well.

6.2.7 Acquire TDMA Digital Radios for Current Users

Milestones should be set for annual or semi-annual replacement of these subscriber units. Progress toward the complete replacement of these incompatible units should be tracked as an integral part of the overall program management of the CoMIRS modernization effort. All critical, operable radios should be replaced prior to the completion of the CoMIRS digital network. Additionally, depending upon the implementation approach selected, certain simulcast digital regions may become operational before others. If that is the project approach, then oversight is needed to assure that the subscriber units operating within that region are prioritized for replacement.

Following are the tasks that should be completed to acquire TDMA digital radios for current users:

```
Determine full          Determine              Arrange financing      Set milestone
scope of radios that -> responsibilities for -> for subscriber unit -> metrics for radio
need to be replaced     radio replacement      replacement            replacement
                                                                            |
                                                                            v
Establish a date by     Update, as needed,     Publish/revise         Procure
which analog-only       the standards for      purchasing             replacement
devices should be    -> digital radio devices -> guidelines for    -> subscriber units
discontinued from       on the network         CoMIRS radios
use on CoMIRS
    |
    v
Program                 Surplus replaced
replacement units    -> analog radios
```

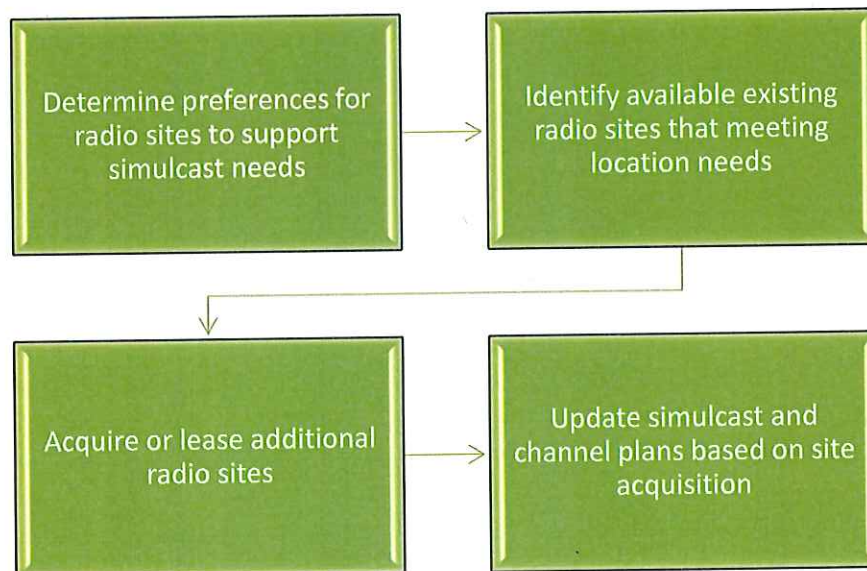## 6.2.8 Prepare for TDMA Radio Network Implementation

The build-out of a statewide radio network is logistically challenging. This is particularly the case for a digital land mobile radio network with as many planned radio sites as the CoMIRS network. Preparation, therefore, is critical to the timely implementation of each site. Luckily, most of the logistical operations needed are the same across sites and efficient processes can be implemented to assure the timely and cost-efficient modernization of each radio site.

6.2.8 Prepare for TDMA Radio Network Implementation

Among the first activities in the upgrade of the statewide network is site identification and acquisition. This is a critical first step, since the plan for each simulcast region is based on where radio sites can be located. This step can often take time and there are often unforeseen issues in acquiring leases or in working out agreements with other governmental entities.

The steps that should be taken to support this activity include:

Determine preferences for radio sites to support simulcast needs → Identify available existing radio sites that meeting location needs

Acquire or lease additional radio sites → Update simulcast and channel plans based on site acquisition

Once sites are identified and leases acquired, preparations can be initiated for the transformation of those sites into fully functioning P25 digital radio sites. These include the following tasks:

```
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│                     │      │ Confirm and update  │      │                     │
│  Inventory each     │ ───▶ │ the site transition │ ───▶ │  Perform needed     │
│  site's radio       │      │ plan for each       │      │  modifications to   │
│  assets             │      │ radio site          │      │  each radio site    │
│                     │      │                     │      │                     │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                     │
        ┌────────────────────────────────────────────────────────────┘
        ▼
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│                     │      │                     │      │  Plan delivery of   │
│  Place equipment    │ ───▶ │  Assemble and       │ ───▶ │  equipment to       │
│  orders             │      │  stage P25          │      │  radio site         │
│                     │      │  infrastructure     │      │  locations          │
│                     │      │                     │      │                     │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
                                                                     │
        ┌────────────────────────────────────────────────────────────┘
        ▼
┌─────────────────────┐      ┌─────────────────────┐
│                     │      │  Work with CoMIRS   │
│  Oversee logistics  │ ───▶ │  partners on        │
│  for delivering     │      │  establishing a     │
│  needed equipment   │      │  timetable for the  │
│                     │      │  decommissioning of │
│                     │      │  CoMIRS analog      │
│                     │      │  subsystems         │
└─────────────────────┘      └─────────────────────┘
```
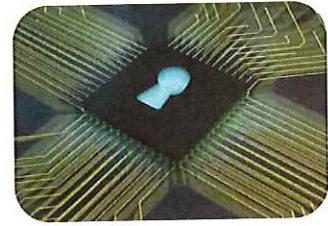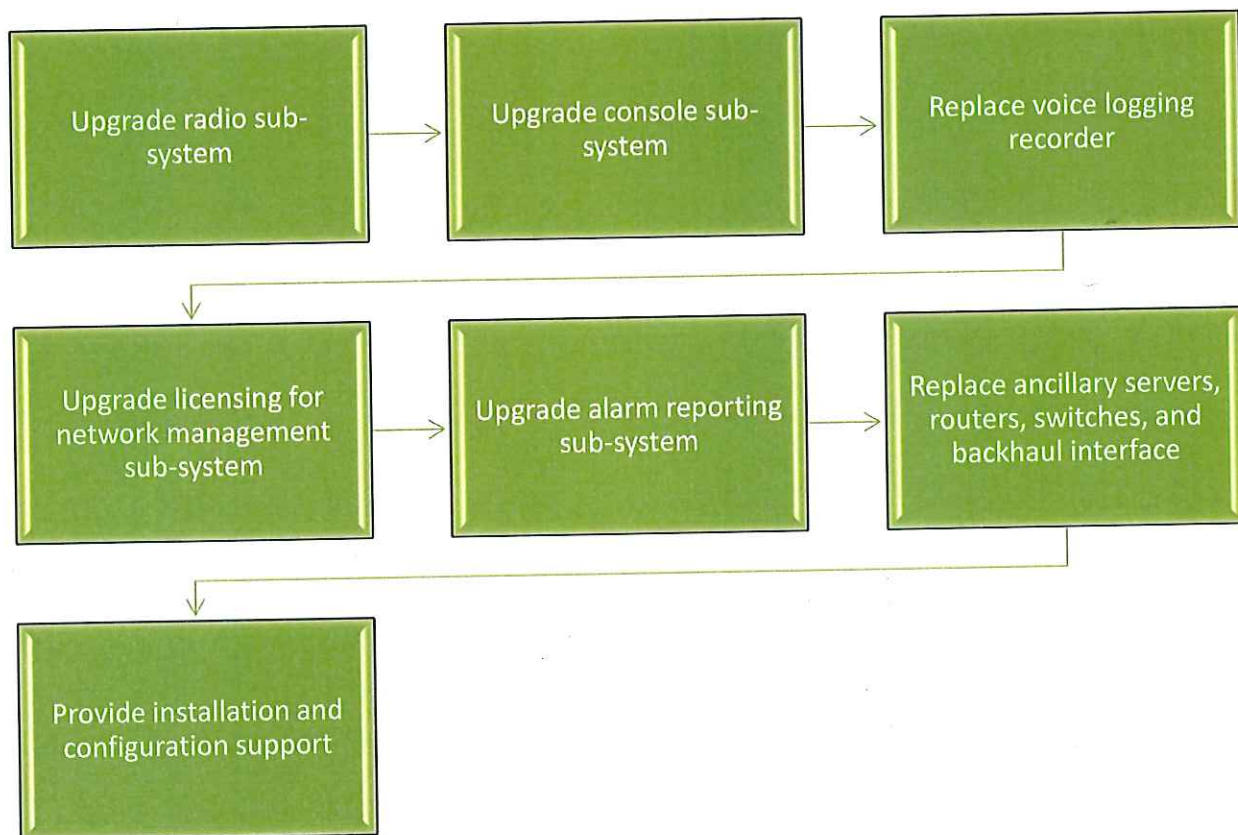
6.2.9 Upgrade Radio Network Core

Before any of the digital simulcast regions can become operational, there are several needed upgrades to the Core or central switching of the CoMIRS network. Most of the central components are organized around an analog radio network and circuit-switched communications. Significant upgrade to the central processing infrastructure is needed to support the envisioned TDMA digital radio network and its internet protocol (IP) based communications.

6.2.9 Upgrade radio network Core

Most of these changes will be performed at the central communications components in Framingham, but some may involve updates to the Zone Controller located in Boston. To upgrade the central switching equipment, the following tasks are needed:

```
┌────────────────────┐     ┌────────────────────┐     ┌────────────────────┐
│ Upgrade radio sub- │ ──▶ │ Upgrade console    │ ──▶ │ Replace voice      │
│ system             │     │ sub-system         │     │ logging recorder   │
└────────────────────┘     └────────────────────┘     └────────────────────┘
            ┌──────────────────────────────────────────────────────┘
            ▼
┌────────────────────┐     ┌────────────────────┐     ┌────────────────────┐
│ Upgrade licensing  │ ──▶ │ Upgrade alarm      │ ──▶ │ Replace ancillary  │
│ for network        │     │ reporting sub-     │     │ servers, routers,  │
│ management sub-    │     │ system             │     │ switches, and      │
│ system             │     │                    │     │ backhaul interface │
└────────────────────┘     └────────────────────┘     └────────────────────┘
      ┌──────────────────────────────────────────────────────────┘
      ▼
┌────────────────────┐
│ Provide            │
│ installation and   │
│ configuration      │
│ support            │
└────────────────────┘
```

6.2.10 Build, Lease, or Upgrade Radio Sites

The building or upgrading of radio sites to P25 digital involves the repetition of scores of activities across the nearly 100 radio sites involved in the digital network.

6.2.10 Build, Lease, or Upgrade Radio Sites

After the core network is upgraded, radio sites need to be modernized. These upgrades should be addressed on a simulcast region basis. In other words, all radio sites within a single simulcast region should be scheduled for upgrade at the same time so that, when completed, the entire simulcast region is available for use by users with the proper digital subscriber units.

There are fourteen simulcast regions planned for the CoMIRS network. Each of these is depicted below.
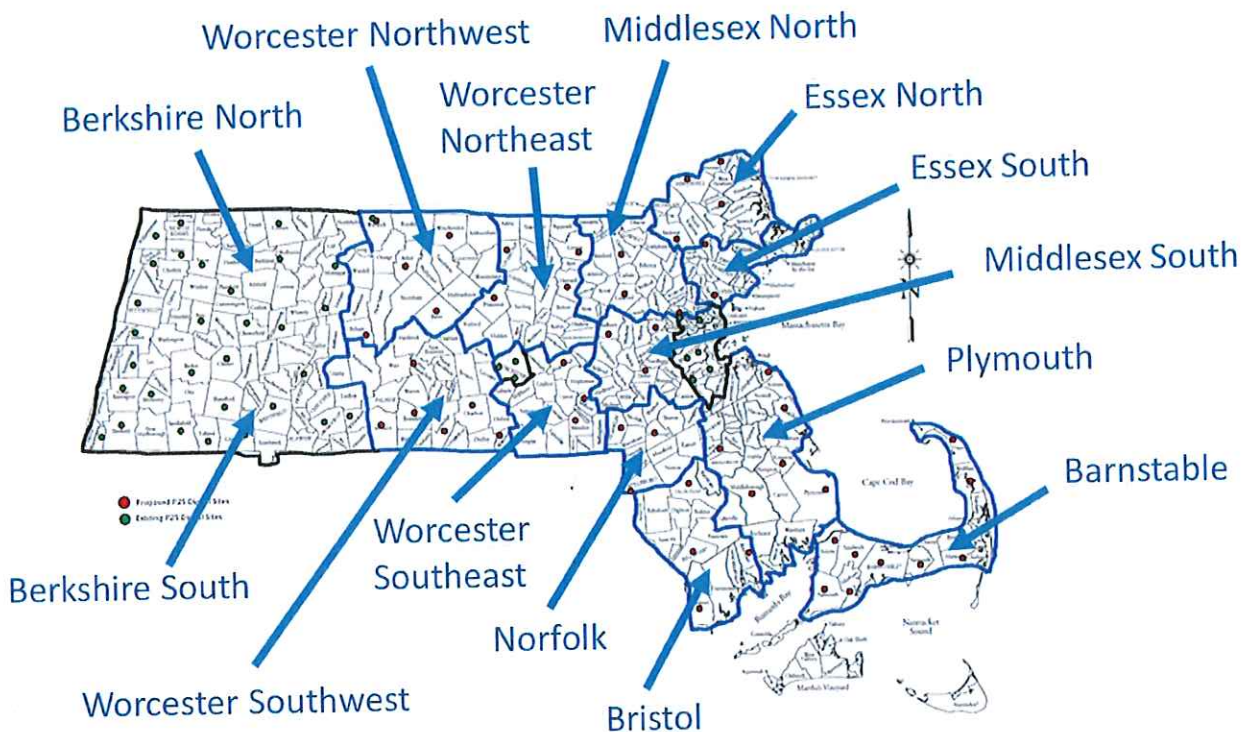

Figure 6-10: Planned Digital Simulcast Regions

The tasks required for each site will vary depending on the specifics of that site. The table below lists the major tasks that can be expected for brand new radio sites that need to be built, for new radio sites on leased commercial towers, and upgrades to existing radio sites. The engineering services described in Section 6.2.1 will provide a detailed site plan for each radio site in the digital CoMIRS network.

Task	Build New Radio Site	Lease New Space on Commercial Radio Site	Upgrade Existing Radio Site
Acquire land	X		
Negotiate lease or other shared use agreement (for tower, shelter, and/or rooftop)		X	
Arrange access to radio site	X	X	X
Determine tower height required for radio coverage and microwave backhaul	X	X	X
Identify number, type, and location of proposed antenna systems on the tower	X	X	X
Perform tower mapping to record existing antenna systems			X
Determine a reasonable growth factor for tower usage	X		
Perform core boring to determine underlying soil conditions	X		
Conduct FAA study to determine potential hazards to aircraft	X		X
Determine tower and foundation design based on loading and soil conditions	X		X
Create shelter and tower design	X		
Perform intermodulation analysis	X	X	X
Obtain local zoning and building permits including compliance with ANSI/TIA 222	X	X	X
Prepare, submit, and obtain electrical permits	X	X	X
Coordinate with local authorities on locations of generators	X		

Task	Build New Radio Site	Lease New Space on Commercial Radio Site	Upgrade Existing Radio Site
Perform site grounding analysis	X	X	X
Upgrade access roads	X		X
Construct shelter foundation	X		
Construct shelter ground ring	X		
Verify readiness of shelter foundation	X		
Build communications tower	X		
Perform structural analysis to determine if tower is in compliance with ANSI/TIA 222			X
Perform structural improvements as required to meet ANSI/TIA 222			X
Install/upgrade mounting supports and housings	X	X	X
Receive and set shelter foundation	X		
Perform tower, shelter, generator, and site prep work		X	X
Install/upgrade cabinets and cable trays	X	X	X
Install/upgrade cable bridge and cable ladder	X	X	X
Install/upgrade antennas, amplifiers, waveguides, combiners, and cabling	X	X	X
Install/upgrade RF transmitters and receivers	X	X	X
Install/upgrade generator	X	X	X
Install/upgrade DC plant racks and battery supplies	X	X	X
Install/upgrade HVACs	X		X

Task	Build New Radio Site	Lease New Space on Commercial Radio Site	Upgrade Existing Radio Site
Install/upgrade dehydrators	X	X	X
Install/upgrade IP phones	X	X	X
Install/upgrade lightning protection devices	X	X	X
Connect power and building ground	X	X	X
Install/upgrade backhaul	X	X	X
Configure simulcasts and RF equipment	X	X	X
Connect RF equipment to backhaul network	X	X	X
Perform line sweeps and functional testing	X	X	X
Install/upgrade security perimeter or fencing	X		X
Connect all alarm points to master alarm system	X	X	X
Cleanup site and inspect for completion	X	X	X
Update radio site/tower documentation and log book	X	X	X
Provide written certification that system has been fully and properly installed and optimized	X	X	X
Decommission, inventory, and/or dispose of legacy system components			X

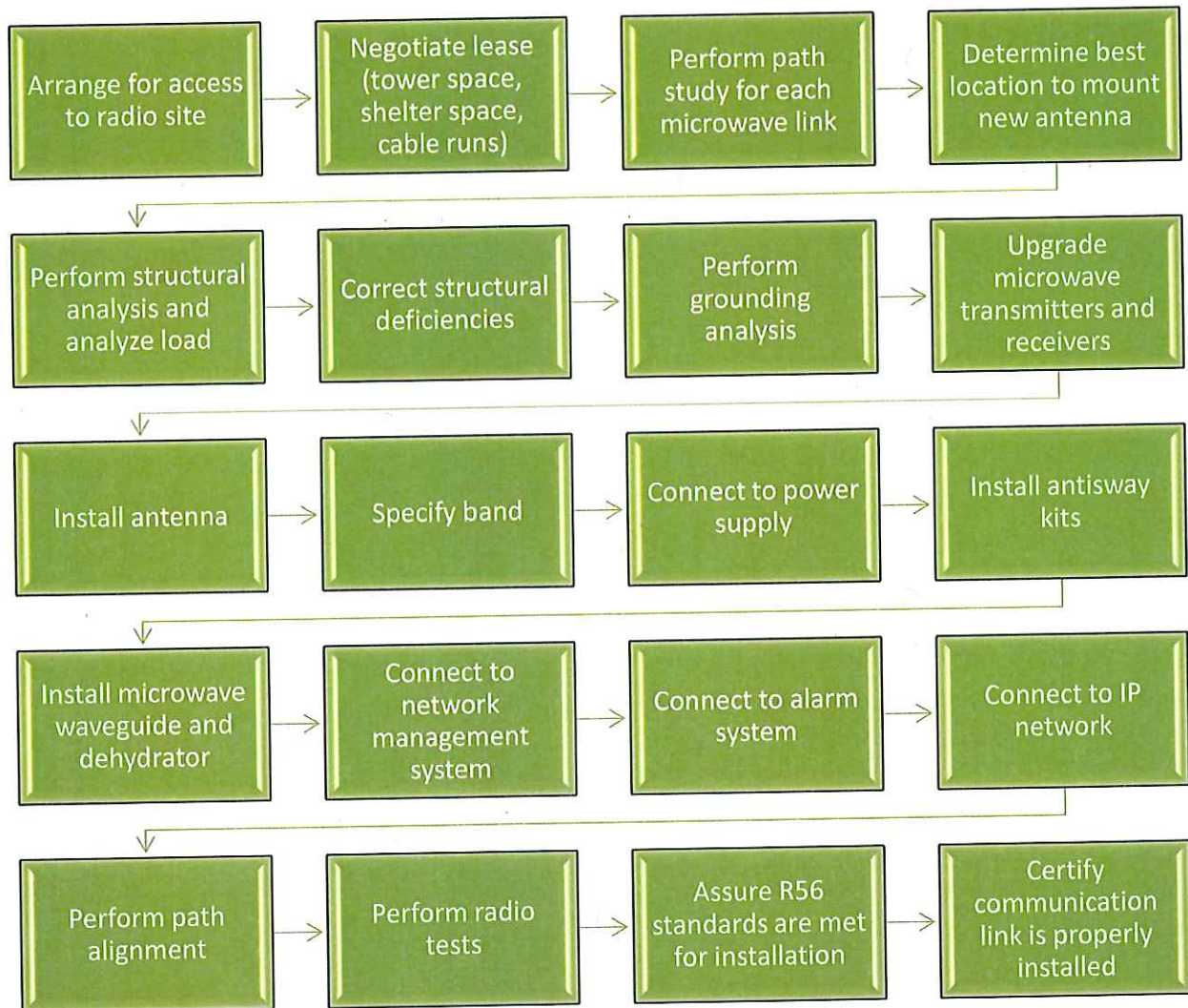*Table 6-1: Tasks Required for Radio Site Modernization*

6.2.11   Enhance and Expand Backhaul Network

In coordination with and as part of the upgrades to each radio site is the upgrade of the overall backhaul communications network. As identified as an immediate need, the nature of the CoMIRS backhaul network needs to modernize as well. Currently, backhaul is circuit-switched. To support upcoming network upgrades, the CoMIRS backhaul needs to be replaced with Ethernet packet-switched based backhaul. See Section 6.1.6 for more detail on this immediate need.

6.2.11 Enhance and Expand Backhaul Network

When planning this Strategy Report, assumptions were made that microwave backhaul would be the predominate mechanism for connecting remote sites. The decision on which backhaul is best is site specific, and sites may utilize other forms of backhaul. In general, the following tasks should be performed to enhance the backhaul network.

Arrange for access to radio site	→ Negotiate lease (tower space, shelter space, cable runs)	→ Perform path study for each microwave link	→ Determine best location to mount new antenna
Perform structural analysis and analyze load	→ Correct structural deficiencies	→ Perform grounding analysis	→ Upgrade microwave transmitters and receivers
Install antenna	→ Specify band	→ Connect to power supply	→ Install antisway kits
Install microwave waveguide and dehydrator	→ Connect to network management system	→ Connect to alarm system	→ Connect to IP network
Perform path alignment	→ Perform radio tests	→ Assure R56 standards are met for installation	→ Certify communication link is properly installed

6.2.12   Coordinate Transition to Digital Radio Network

Setting up of the replacement digital radio network is largely a series of technical implementation items. Use of the network, though, requires extensive interagency coordination and planning.

6.2.12 Coordinate Transition to Digital Radio Network

Whether as part of formal governance proceedings or not, timetables for the cut-over to the digital network need to be discussed and agreed upon. Agencies may be responsible for user equipment replacement, radio programming, and training. The dates set for cut-overs to the digital network need to be established and well-communicated across all key stakeholders. Additionally, progress toward key milestones (e.g., radio replacements, radio site upgrades, etc.) need to be broadly communicated, as failure to achieve key milestones may preclude a proper and timely transition from the analog to the digital radio network.

The key tasks for this activity include:
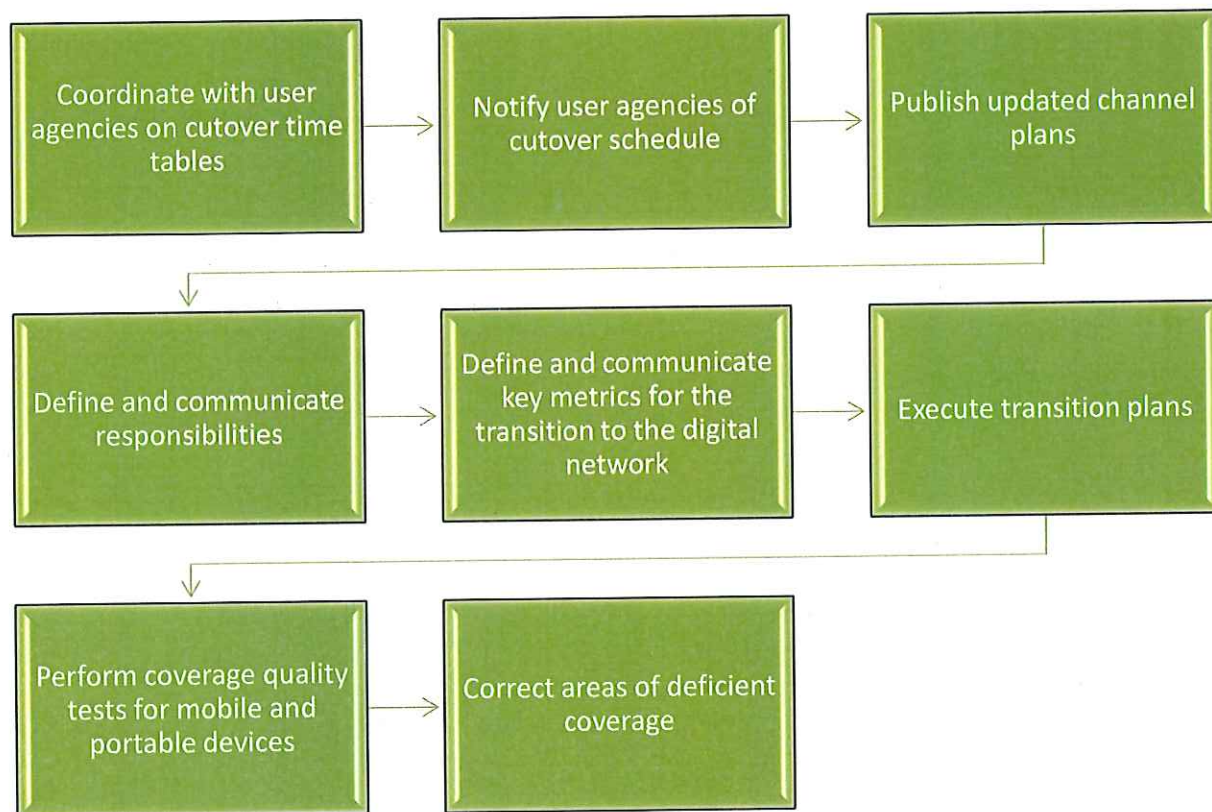
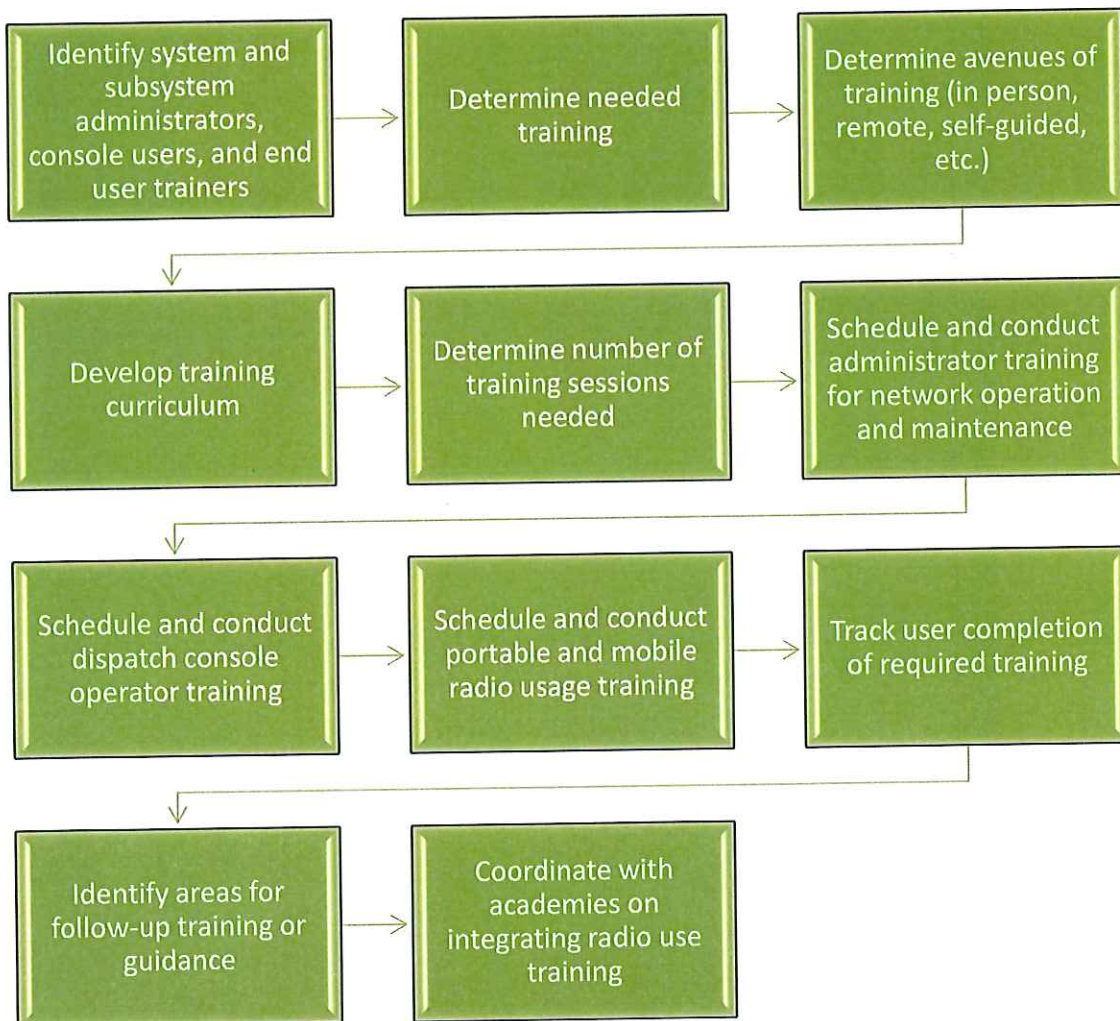## 6.2.13   Train on Digital Radio Operation and Maintenance

As with most mission-critical technology projects, properly targeted training will be needed to assure the best use of the new digital tools.

Digital radio will allow user agencies to do more than is supported on today's networks. Digital networks better support data use, encryption, and remote configurations among other features. The proper use of these new tools will require targeted training for those responsible for administrating these features. In addition, users will need to be trained (or retrained) on the new channel plan and how to use their new digital equipment.

6.2.13 Train on Digital Radio Operation and Maintenance

Below are the tasks that should be considered to properly train CoMIRS users and administrators:

```
Identify system and          Determine needed          Determine avenues of
subsystem                    training          →       training (in person,
administrators,                                         remote, self-guided,
console users, and end                                  etc.)
user trainers
        ↓
Develop training             Determine number of        Schedule and conduct
curriculum          →        training sessions    →     administrator training
                             needed                      for network operation
                                                         and maintenance
        ↓
Schedule and conduct         Schedule and conduct        Track user completion
dispatch console     →       portable and mobile   →     of required training
operator training            radio usage training
        ↓
Identify areas for           Coordinate with
follow-up training or  →     academies on
guidance                     integrating radio use
                             training
```
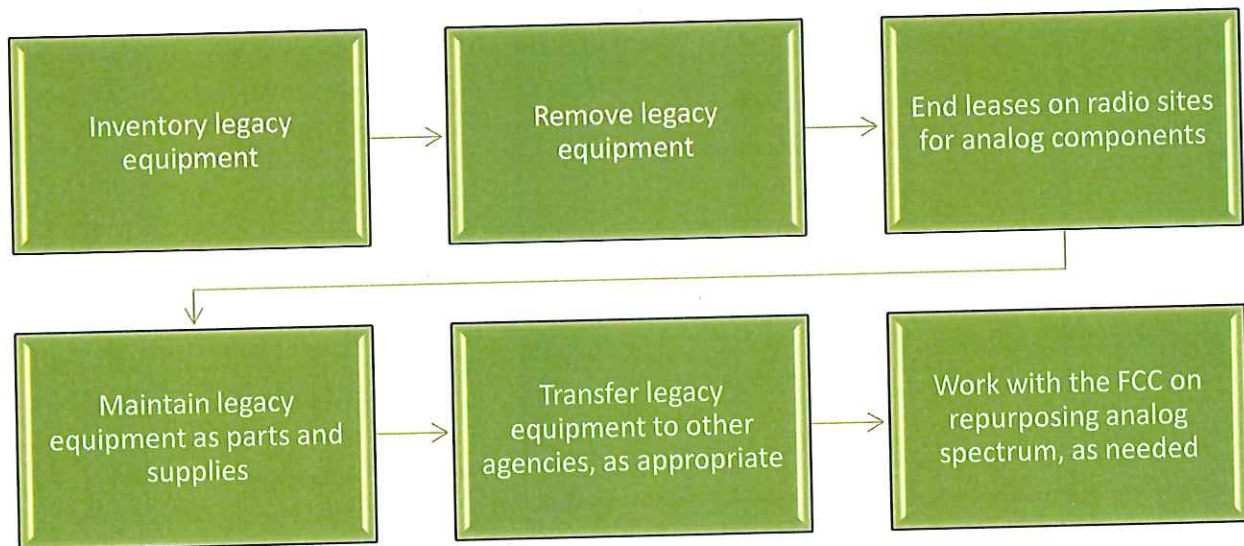
6.2.14 Decommission Analog Infrastructure

As analog sites are no longer needed, analog-only radio sites can be dismantled and analog components can be removed from radio sites operating on the digital network. After analog components are removed, site leases can be terminated or amended to save on-going operating expenses.

6.2.14 Decommission Analog Infrastructure

Analog components that are still in working quality can be inventoried and used for backups for other sites or can be transferred to other radio networks that are still operating analog radios.

Additionally, a complete transition of CoMIRS to digital will free up the frequencies currently in use by the CoMIRS analog trunked system. 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.

The following tasks are involved with the decommissioning of analog components:

Inventory legacy equipment	→	Remove legacy equipment	→	End leases on radio sites for analog components

| Maintain legacy equipment as parts and supplies	→	Transfer legacy equipment to other agencies, as appropriate	→	Work with the FCC on repurposing analog spectrum, as needed

6.3 Leverage Expanded Capacity for Other Users and Agencies

With the implementation of a statewide P25 TDMA radio network, the Commonwealth will have significantly more capacity than is currently available on the analog trunked system. This added capacity provides the opportunity for considerable overall cost savings to the Commonwealth. Agencies currently operating aging analog systems can request to join CoMIRS as operational users, instead of seeking the costly and duplicative replacement of their agency radio systems.

In considering adding more operational users to CoMIRS and in managing its already broad usership, the following five major activities should be undertaken:

6.3.1 Determine Potential Expanded Use of CoMIRS
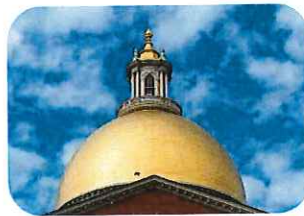
6.3.2 Clarify CoMIRS Decision Making and Governance

6.3.3 Update and Publish CoMIRS Standards

6.3.4 Formalize New User Training

6.3.5 Upgrade FDMA Radio Sites to TDMA Sites

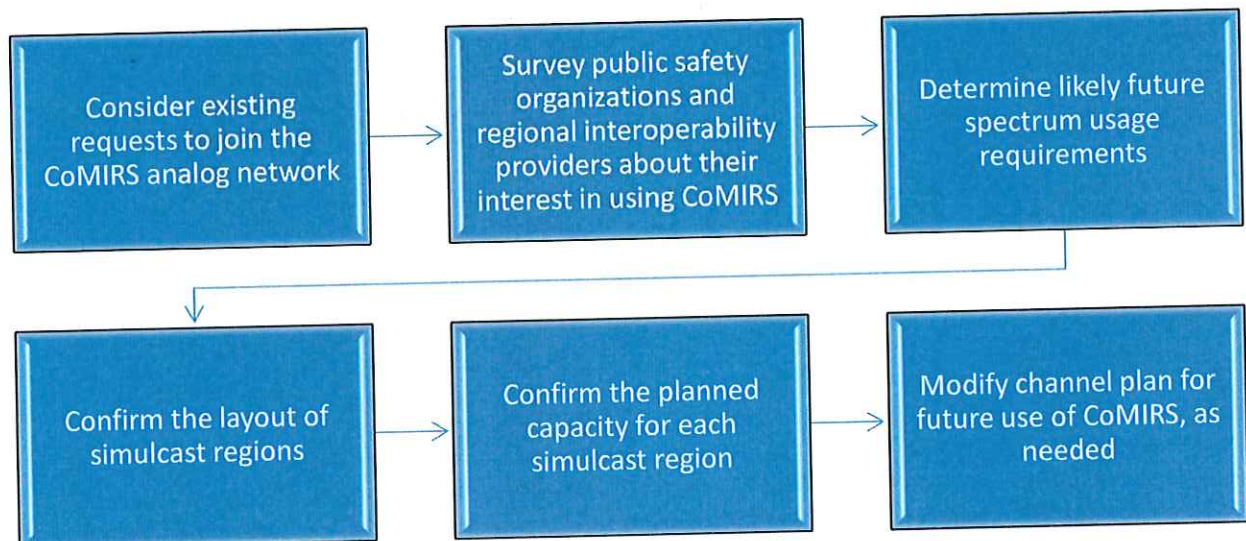## 6.3.1 Determine Potential Expanded Use of CoMIRS

As has been discussed in this Strategy Report, an enormous untapped benefit of moving to a statewide 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.

massDOT
Massachusetts Department of Transportation

6.3.1 Determine
Potential Expanded
Use of CoMIRS

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. It is important to gauge the future interest in using the network now, so that proper spectrum planning and radio site engineering can be accomplished.

To gauge interest and properly plan for the potential expanded use of CoMIRS by other state, regional, or municipal agencies, the following tasks should be undertaken:
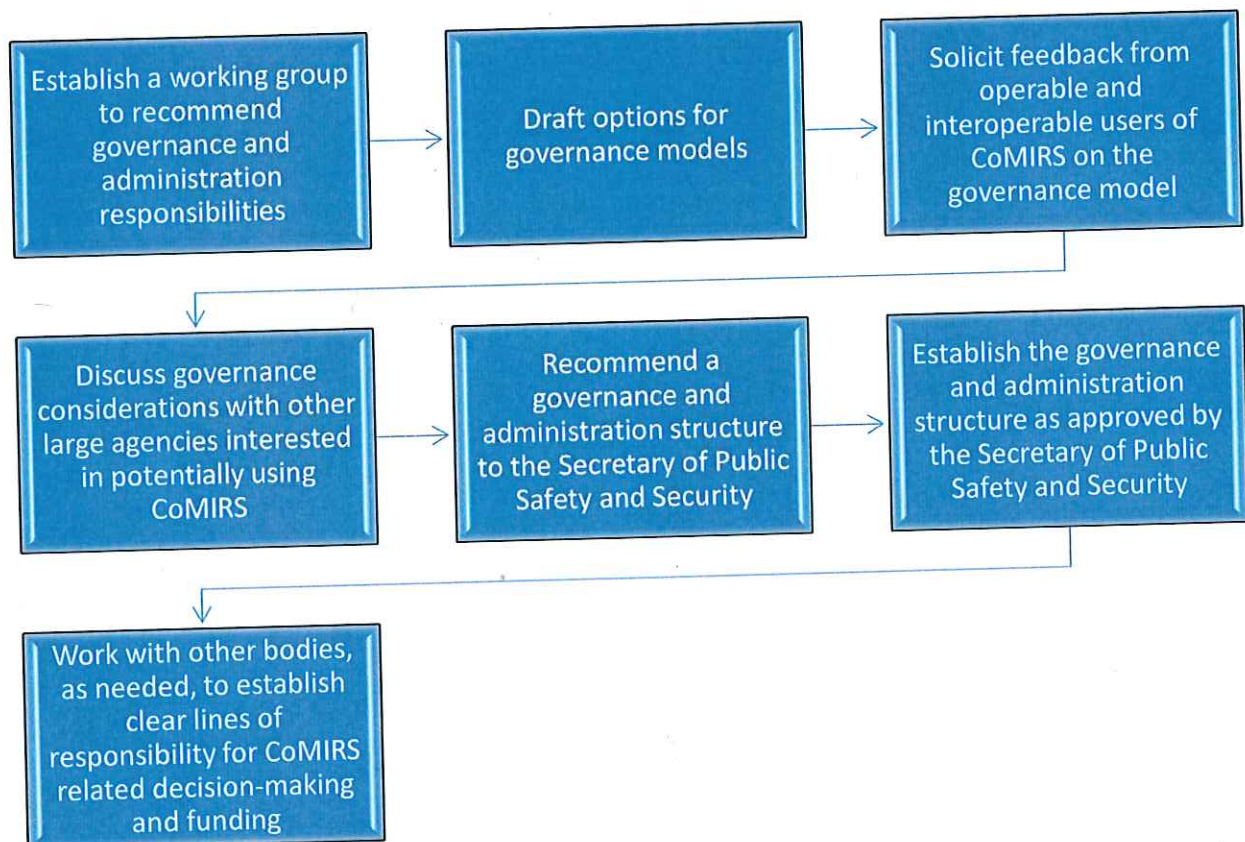
```
┌─────────────────┐     ┌─────────────────┐     ┌─────────────────┐
│ Consider        │     │ Survey public   │     │ Determine       │
│ existing        │ ──> │ safety          │ ──> │ likely future   │
│ requests to     │     │ organizations   │     │ spectrum usage  │
│ join the        │     │ and regional    │     │ requirements    │
│ CoMIRS analog   │     │ interoperability│     │                 │
│ network         │     │ providers about │     │                 │
│                 │     │ their interest  │     │                 │
│                 │     │ in using CoMIRS │     │                 │
└─────────────────┘     └─────────────────┘     └─────────────────┘
                                                          │
        ┌─────────────────────────────────────────────────┘
        v
┌─────────────────┐     ┌─────────────────┐     ┌─────────────────┐
│ Confirm the     │     │ Confirm the     │     │ Modify channel  │
│ layout of       │ ──> │ planned         │ ──> │ plan for future │
│ simulcast       │     │ capacity for    │     │ use of CoMIRS,  │
│ regions         │     │ each simulcast  │     │ as needed       │
│                 │     │ region          │     │                 │
└─────────────────┘     └─────────────────┘     └─────────────────┘
```

6.3.2 Clarify CoMIRS Decision Making and Governance

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).
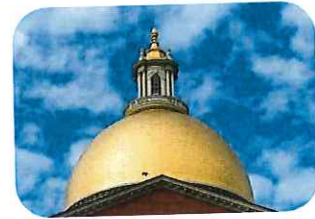
6.3.2 Clarify CoMIRS Decision Making and Governance

To move forward with governance planning, the following tasks should be considered:

Establish a working group to recommend governance and administration responsibilities	→	Draft options for governance models	→	Solicit feedback from operable and interoperable users of CoMIRS on the governance model
Discuss governance considerations with other large agencies interested in potentially using CoMIRS	→	Recommend a governance and administration structure to the Secretary of Public Safety and Security	→	Establish the governance and administration structure as approved by the Secretary of Public Safety and Security
Work with other bodies, as needed, to establish clear lines of responsibility for CoMIRS related decision-making and funding				

6.3.3 Update and Publish CoMIRS Standards

There is an uneven level of documented standard operating procedures and system standards across the agencies that use CoMIRS. Not all agencies operating on CoMIRS have formally documented standard operating procedures nor do they all have consistent radio training for new users. In addition, written agreements defining the support requirements of Core-connected trunked systems and consoles often do not exist.
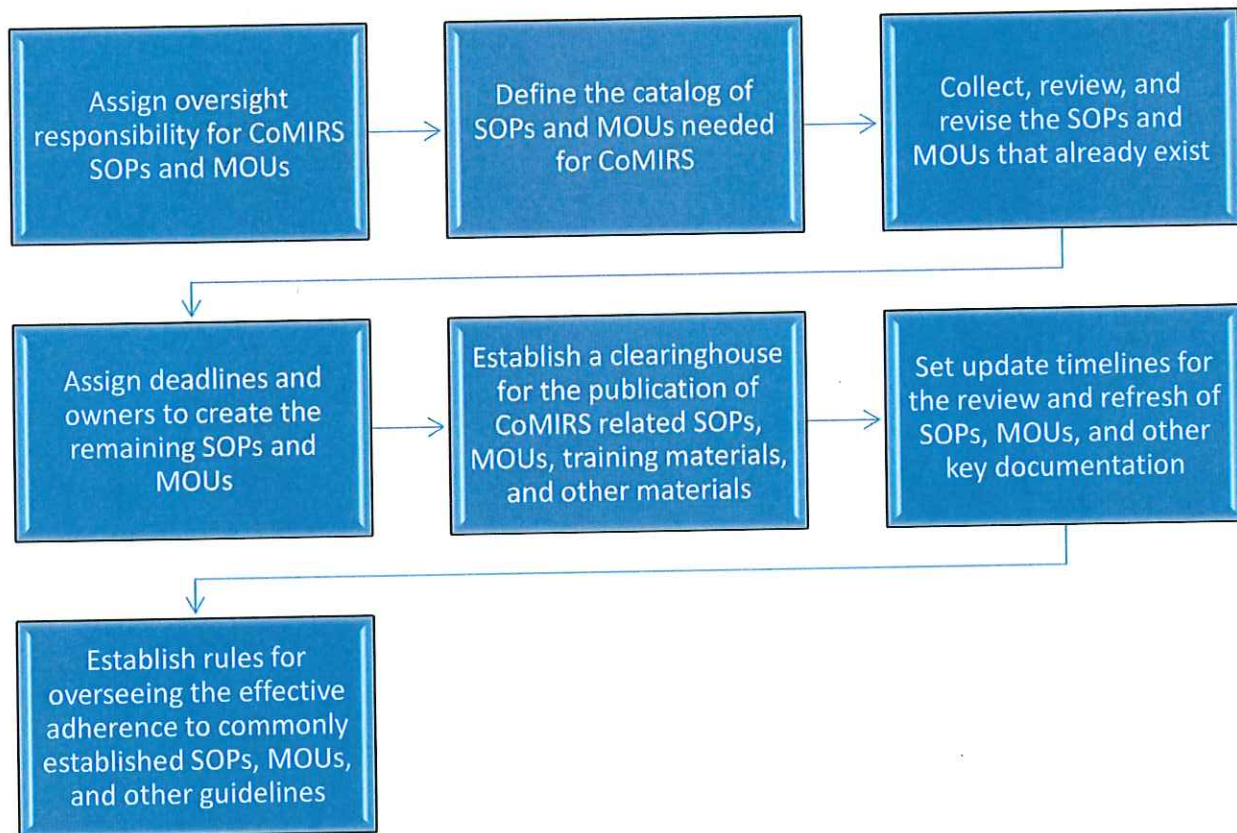

6.3.3 Update and Publish CoMIRS Standards

When planning for the future digital network, new features and functions will be available to users. The proper understanding of these features by all users is needed to assure their proper use on the network. The following are suggested topics for a standards body to consider:

- Establish buying guidelines that support the envisioned TDMA network

- Establish support requirements for Core-connected trunked systems and radio control consoles

- Establish CoMIRS standards for the use of text communications

- Establish CoMIRS standards for the use of location services

- Establish CoMIRS standards for the use of encryption

- Develop procedures, as needed, for the remote programming of radios

- Update, as needed, the standards for digital radio devices on the network

- Establish a date by which analog-only devices should be discontinued from the CoMIRS network

To begin the process of standards improvements, the following tasks should be performed:

```
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│  Assign oversight   │      │ Define the catalog of│      │ Collect, review, and│
│ responsibility for  │─────▶│ SOPs and MOUs needed │─────▶│  revise the SOPs and │
│    CoMIRS SOPs      │      │     for CoMIRS       │      │ MOUs that already    │
│     and MOUs        │      │                      │      │      exist            │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
          │
          ▼
┌─────────────────────┐      ┌─────────────────────┐      ┌─────────────────────┐
│ Assign deadlines and│      │Establish a clearinghouse│   │ Set update timelines │
│ owners to create the│      │ for the publication of│     │ for the review and   │
│ remaining SOPs and  │─────▶│ CoMIRS related SOPs, │─────▶│ refresh of SOPs,     │
│       MOUs          │      │ MOUs, training       │      │ MOUs, and other      │
│                     │      │ materials, and other │      │ key documentation    │
│                     │      │ materials            │      │                      │
└─────────────────────┘      └─────────────────────┘      └─────────────────────┘
          │
          ▼
┌─────────────────────┐
│ Establish rules for │
│ overseeing the      │
│ effective adherence │
│ to commonly         │
│ established SOPs,   │
│ MOUs, and other     │
│ guidelines          │
└─────────────────────┘
```

6.3.4 Formalize New User Training

The current state of training on CoMIRS is described as "ad hoc." Radio training is largely an agency responsibility. 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. This leads to varying degrees of understanding of how the network should operate and how to respond to different situations.

6.3.4 Formalize New User Training

As the network grows and additional digital features are introduced for use on the network, a baseline competency for all CoMIRS users is important. Additionally, CoMIRS managers should consider formalizing a centralized role in developing, providing, and tracking training across CoMIRS agencies. Coordination with professional training academies (like the Massachusetts Firefighting Academy) is recommend. These organization have extensive training expertise and often already use modern learning management systems to track student progress. They are also an existing source of standardized training across municipal, regional, and state organizations.

Below are the tasks that should be considered in improving and standardizing training for all CoMIRS users and agencies:
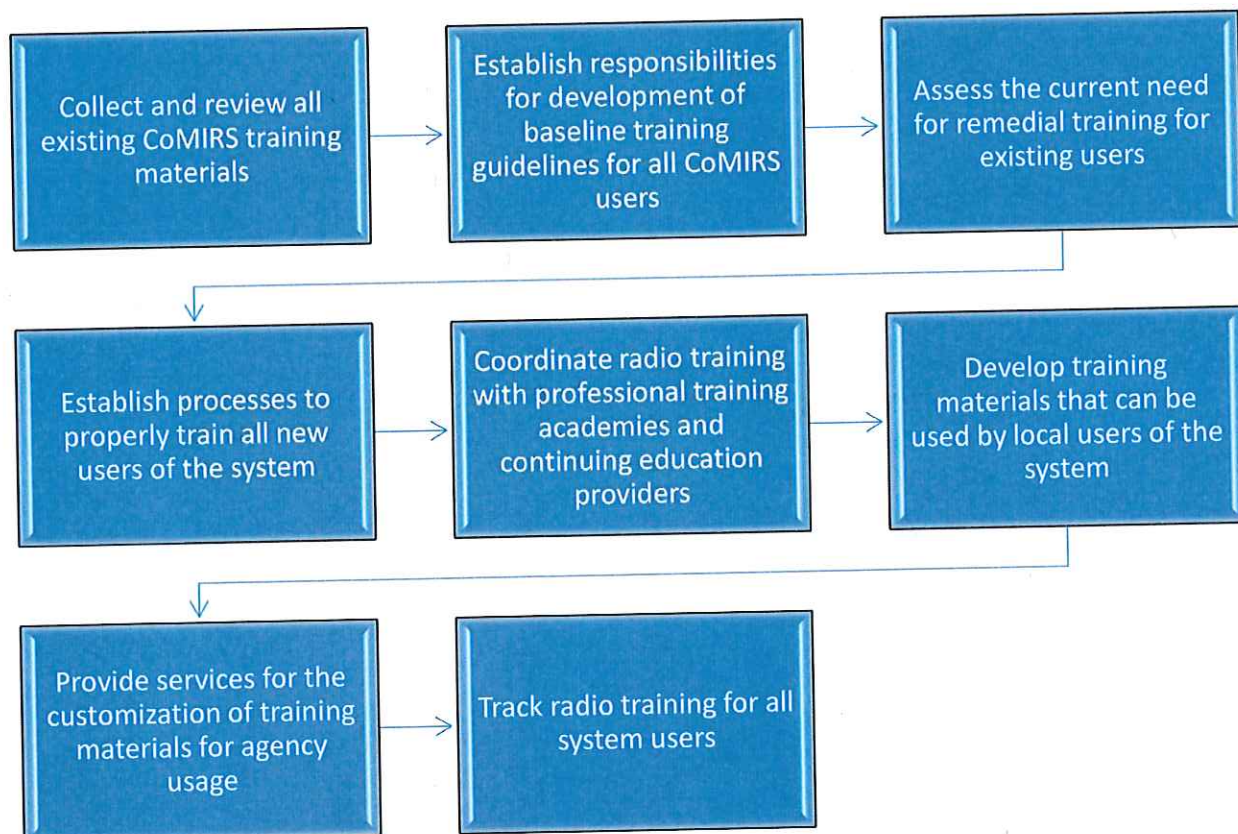
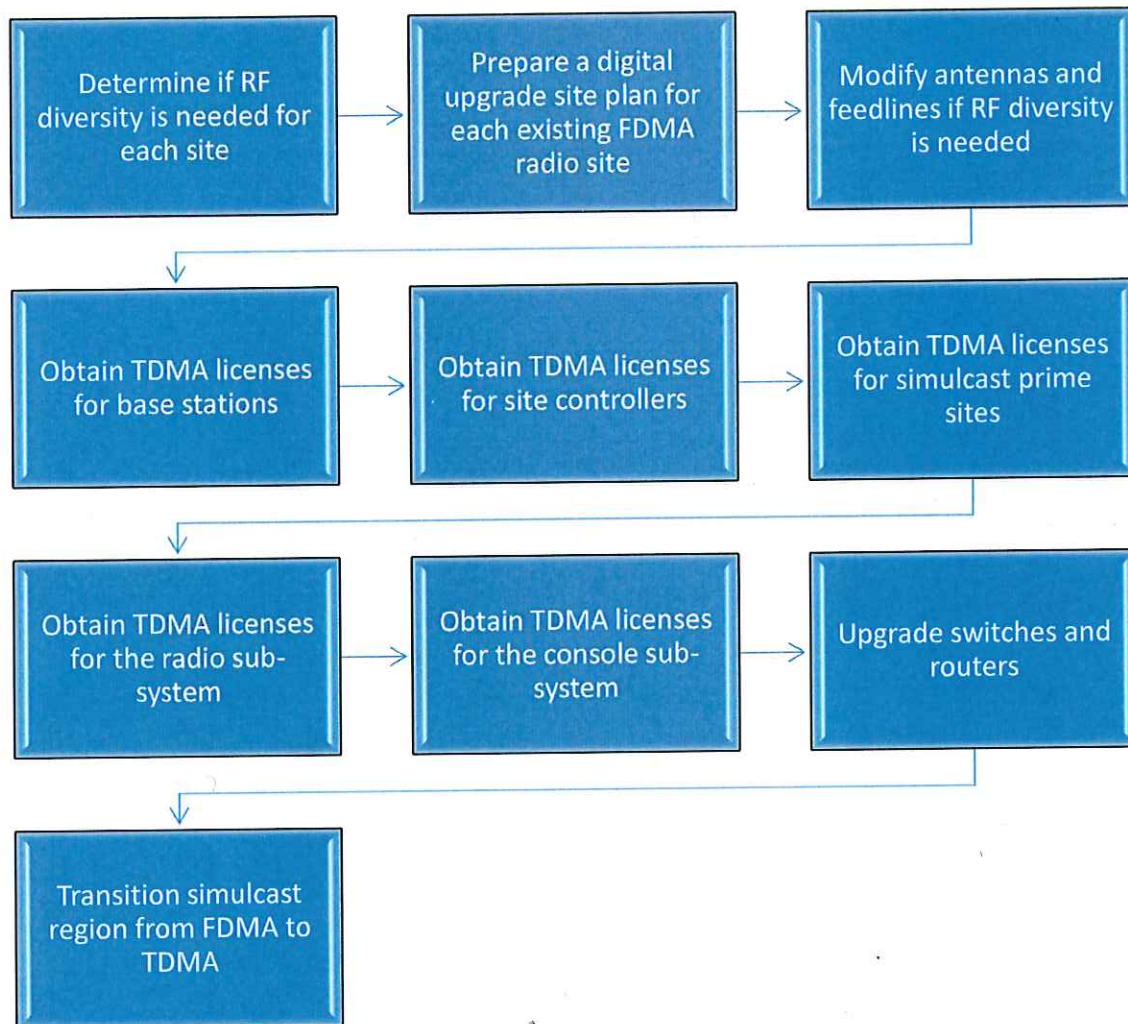## 6.3.5 Upgrade FDMA Radio Sites to TDMA Sites

FDMA and TDMA radio sites can co-exist on the same digital radio network. As users with FDMA-only radios join a TDMA talkgroup, the radio broadcasts for that communication is switched dynamically to FDMA to support all users. The issue with this technical approach to accommodating both FDMA and TDMA on the same digital network is that it significantly reduces some of the spectrum efficiencies inherent to TDMA. If CoMIRS is to expand to include additional users and agencies, it should plan to upgrade its FDMA sites and replace FDMA-only radios.

6.3.5 Upgrade
FDMA Radio Sites
to TDMA Sites

The costing for this Strategy Report assumes that the Commonwealth will upgrade its existing FDMA radios and radio sites to TDMA. The radios and radio sites that need to be upgraded are almost exclusively in western Massachusetts. This area of the state already has requests from other agencies to join CoMIRS operationally, so the additional efficiency of TDMA would be required. Since these radio sites are already digital, the upgrade costs are significantly less than the new radio sites planned for central and eastern Massachusetts.

The following tasks are required to upgrade FDMA sites to TDMA:

```
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│  Determine if RF    │     │  Prepare a digital  │     │ Modify antennas and │
│ diversity is needed │ ──> │ upgrade site plan   │ ──> │ feedlines if RF     │
│    for each site    │     │  for each existing  │     │ diversity is needed │
│                     │     │  FDMA radio site    │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
          │                                                        │
          └────────────────────────────────────────────────┐      │
                                                            │      │
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│ Obtain TDMA licenses│     │ Obtain TDMA licenses│     │ Obtain TDMA licenses│
│  for base stations  │ ──> │  for site           │ ──> │  for simulcast      │
│                     │     │  controllers        │     │  prime sites        │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
          │                                                        │
┌─────────────────────┐     ┌─────────────────────┐     ┌─────────────────────┐
│ Obtain TDMA licenses│     │ Obtain TDMA licenses│     │ Upgrade switches    │
│  for the radio sub- │ ──> │  for the console    │ ──> │  and routers        │
│  system             │     │  sub-system         │     │                     │
└─────────────────────┘     └─────────────────────┘     └─────────────────────┘
          │
┌─────────────────────┐
│ Transition simulcast│
│ region from FDMA to │
│        TDMA         │
└─────────────────────┘
```

6.4 Timeline for Implementation

Looking at similar statewide land mobile radio projects, this Strategy Report has proposed an implementation timeframe of five and a half years to complete the modernization of the CoMIRS network. This timeline covers the activities of the three project threads introduced earlier in this section:

    a. Address Immediate Needs with Current Radio Network

    b. Replace Analog Network with Digital P25 TDMA Network

    c. Leverage Expanded Capacity for Other User and Agencies

The total duration of the actual project will be influenced by the following:

- Ability of the Commonwealth to obtain sufficient capital funding year to year to support this timeframe (see Section 6.2.5)

- Ability of user agencies to replace their incompatible user radios in coordination with simulcast region transitions (see Section 6.2.7)

- Success in the timely completion of the site acquisition activities (see Section 6.2.8)

6.4.1 Fiscal Year 2017 Activities

The activities in fiscal year 2017 focus on the completion of this Strategy Report and addressing immediate needs repairs of the existing CoMIRS network. In addition, key activities include identifying and obtaining additional spectrum and funding and working with other agencies that are interested in using CoMIRS operationally.

The following activities will be initiated (highlighted in green and marked as "new" below) in this fiscal year:

6.1   Address Immediate Needs with Current Radio Network
6.1.2   *Address Failing Backhaul Links (new)*
6.1.3   *Replace Aging Simulcast Reference Clocks (new)*
6.1.7   *Prioritize and Address Immediate Needs Repairs (new)*

6.2   Replace Analog Network with Digital P25 TDMA Network
6.2.3   *Obtain Additional Spectrum (new)*
6.2.5   *Obtain Long-Term Capital and Operational Funding (new)*

6.3   Leverage Expanded Capacity for Other User and Agencies
6.3.1   *Determine Potential Expanded Use of CoMIRS (new)*

6.4.2 Fiscal Year 2018 Activities

The major activities of the CoMIRS Radio Modernization Project are planned to begin in Fiscal Year 2018. During this fiscal year, important remediation of immediate needs will be undertaken, including replacing aging and incompatible dispatch consoles, addressing backhaul issues, replacing old reference clocks, testing existing infrastructure, and addressing other identified critical repair issues. In addition, the replacement of incompatible radios will begin with those units most in need of replacement.

Additionally during this fiscal year, a detailed engineering design for the TDMA system will be developed, key memorandums of understanding will be developed, FCC spectrum approval will be sought, funding will be obtained, and a proposal for implementation services issued. Also during this year, future governance structures should be examined and defined.

The following activities will be initiated (highlighted in green and marked as "new" below) or continued (marked as "ongoing" below) in this fiscal year:

6.1   Address Immediate Needs with Current Radio Network
    6.1.1   Replace End of Life MSP Dispatch Consoles (new)
    6.1.2   Address Failing Backhaul Links (ongoing)
    6.1.3   Replace Aging Simulcast Reference Clocks (ongoing)
    6.1.4   Test Existing Radio Site Infrastructure (new)
    6.1.5   Begin Upgrading Antiquated MSP Radios (new)
    6.1.7   Prioritize and Address Immediate Needs Repairs (ongoing)

6.2   Replace Analog Network with Digital P25 TDMA Network
    6.2.1   Develop Detailed TDMA Engineering Design (new)
    6.2.2   Develop Memorandums of Understanding for Use and Maintenance of Digital Infrastructure (new)
    6.2.3   Obtain Additional Spectrum (ongoing)
    6.2.4   Obtain FCC Frequency Approval (new)
    6.2.5   Obtain Long-Term Capital and Operational Funding (ongoing)
    6.2.6   Solicit Proposals to Transition to Digital Radio (new)

6.3   Leverage Expanded Capacity for Other Users and Agencies
    6.3.1   Determine Potential Expanded Use of CoMIRS (ongoing)
    6.3.2   Clarify CoMIRS Decision Making and Governance (new)

6.4.3 Fiscal Year 2019 Activities

Fiscal Year 2019 will see the project transition from planning to full scale implementation. During this year, circuit-switched backhaul links will begin to be addressed, bulk purchases of replacement radios will be conducted, and the initial radio site enhancement activities will be conducted. Implementation of new digital radio sites is planned to be conducted in four phases, addressing radio sites and simulcast regions in central MA, northeast MA, southeast MA, and Barnstable County. The first of these regions will start to be addressed during this fiscal year. Additionally, it is expected that CoMIRS managers will address the standards for use of the new digital network during this fiscal year.

The following activities will be initiated (highlighted in green and marked as "new" below) or continued (marked as "ongoing" below) in this fiscal year:

6.1 Address Immediate Needs with Current Radio Network
6.1.6 Replace Circuit-Switched Backhaul Links *(new)*
6.1.7 Prioritize and Address Immediate Needs Repairs (ongoing)

6.2 Replace Analog Network with Digital P25 TDMA Network
6.2.7 *Acquire TDMA Digital Radios for Current Users (new)*
6.2.8 *Prepare for TDMA Radio Network Implementation (new)*
6.2.9 *Upgrade Radio Network Core (new)*
6.2.10 *Build, Lease, or Upgrade Radio Sites (new)*

6.3 Leverage Expanded Capacity for Other Users and Agencies
6.3.3 *Update and Publish CoMIRS Standards (new)*

6.4.4 Fiscal Year 2020 Activities

This fiscal year will focus on radio replacement and radio site modernization. This fiscal year will likely require the greatest capital funding as it will address radio sites in three of the five regions of the Commonwealth planned for modernization. In coordination with these radio site enhancements, the supporting backhaul network will also be addressed and the initial user transition and training for the network conducted.

The following activities will be initiated (highlighted in green and marked as "new" below) or continued (marked as "ongoing" below) in this fiscal year:

6.1   Address Immediate Needs with Current Radio Network
6.1.6   Replace Circuit-Switched Backhaul Links (ongoing)
6.1.7   Prioritize and Address Immediate Needs Repairs (ongoing)

6.2   Replace Analog Network with Digital P25 TDMA Network
6.2.7   Acquire TDMA Digital Radios for Current Users (ongoing)
6.2.10 Build, Lease, or Upgrade Radio Sites (ongoing)
6.2.11 *Enhance and Expand Backhaul Network (new)*
6.2.12 *Coordinate Transition to Digital Radio Network (new)*
6.2.13 *Train on Digital Radio Operation and Maintenance (new)*

6.3   Leverage Expanded Capacity for Other Users and Agencies
6.3.4   *Formalize New User Training (new)*

6.4.5 Fiscal Year 2021 Activities

This fiscal year will focus on completing the majority of the new digital sites and upgrading the existing FDMA radio sites to TDMA. At this point, modernization activities will be completed or underway in each of the five regions planned for upgrades. Additional users will receive replacement radios and will be trained on the use of the new digital technology.

The following activities will be initiated (highlighted in green and marked as "new" below) or continued (marked as "ongoing" below) in this fiscal year:

6.1 Address Immediate Needs with Current Radio Network

6.1.6   Replace Circuit-Switched Backhaul Links (ongoing)

6.2 Replace Analog Network with Digital P25 TDMA Network

6.2.7   Acquire TDMA Digital Radios for Current Users (ongoing)

6.2.10 Build, Lease, or Upgrade Radio Sites (ongoing)

6.2.11 Enhance and Expand Backhaul Network (ongoing)

6.2.12 Coordinate Transition to Digital Radio Network (ongoing)

6.2.13 Train on Digital Radio Operation and Maintenance (ongoing)

6.2.14 Decommission Analog Infrastructure (new)

6.3 Leverage Expanded Capacity for Other Users and Agencies

6.3.3   Update and Publish CoMIRS Standards (ongoing)

6.3.4   Formalize New User Training (ongoing)

6.3.5   Upgrade FDMA Radio Sites to TDMA Sites (new)

6.4.6 Fiscal Year 2022 Activities

Fiscal year 2022 is the final year planned for major activities in the modernization of the CoMIRS network. At the end of this fiscal year, all five regions will be modernized and TDMA digital communications will be available throughout the mainland counties of Massachusetts. Additional users will have their old, incompatible radios replaced and will receive training on how to use the new technology. Analog radio site components that are no longer needed will be properly decommissioned.

The following activities will be continued (marked as "ongoing" below) in this fiscal year:

6.1 Address Immediate Needs with Current Radio Network
None.

6.2 Replace Analog Network with Digital P25 TDMA Network
6.2.10 Build, Lease, or Upgrade Radio Sites (ongoing)
6.2.11 Enhance and Expand Backhaul Network (ongoing)
6.2.12 Coordinate Transition to Digital Radio Network (ongoing)
6.2.13 Train on Digital Radio Operation and Maintenance (ongoing)
6.2.14 Decommission Analog Infrastructure (ongoing)

6.3 Leverage Expanded Capacity for Other Users and Agencies
6.3.3 Update and Publish CoMIRS Standards (ongoing)
6.3.4 Formalize New User Training (ongoing)
6.3.5 Upgrade FDMA Radio Sites to TDMA Sites (ongoing)

6.4.7 CoMIRS Radio Modernization High-Level Gantt

Below is a high-level Gantt chart depicting the major activities along the CoMIRS Radio Modernization Roadmap.

6 CoMIRS Digital Modernization Roadmap (Version 1.0)