North Dakota Statewide Radio Systems Assessment and Evolution Study

Sponsored by

Statewide Interoperability Executive Committee (SIEC)

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Project Sponsors and Leaders

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1 Executive Summary

1.1 Program Overview and Objectives

The State of North Dakota is undergoing tremendous social and economic changes in response to the rapid growth in the State's energy resource sector. While the State and its citizens receive undeniably important benefits from the energy boom, the resulting growth is stressing critical infrastructure and services vital to the life and safety of the citizens of the State. This report focuses on the mission critical radio communications systems that serve as the lifeline of public safety responders and public service entities throughout the State. Land Mobile Radio (LMR) networks are an essential lifeline communications tool used to distribute and relay mission critical information within the overall emergency alert and response structure. State and Local communities have diligently labored to maintain and evolve these networks under limited budgets to deliver reliable communications to end users. However, most of the existing legacy radio systems are operating at well beyond their expected lifecycle and/or are anchored on an outdated generation of radio technology dating back to the 1970s.

Over the past decade, there has been general recognition by the radio network users that the current radio networks are not delivering the required level of reliability, performance and interoperability. The Statewide Interoperability Executive Committee (SIEC)[1]—the governing oversight committee responsible for advancing voice and data interoperability for North Dakota—assembled a coalition of public safety entities to fund this study, and engaged Televate, LLC, a nationally-recognized public safety communications and information technology company, to assess the current status of mission critical LMR networks statewide, and to develop a strategic plan to enhance and evolve these networks into a an architecture that enhances public safety response statewide.

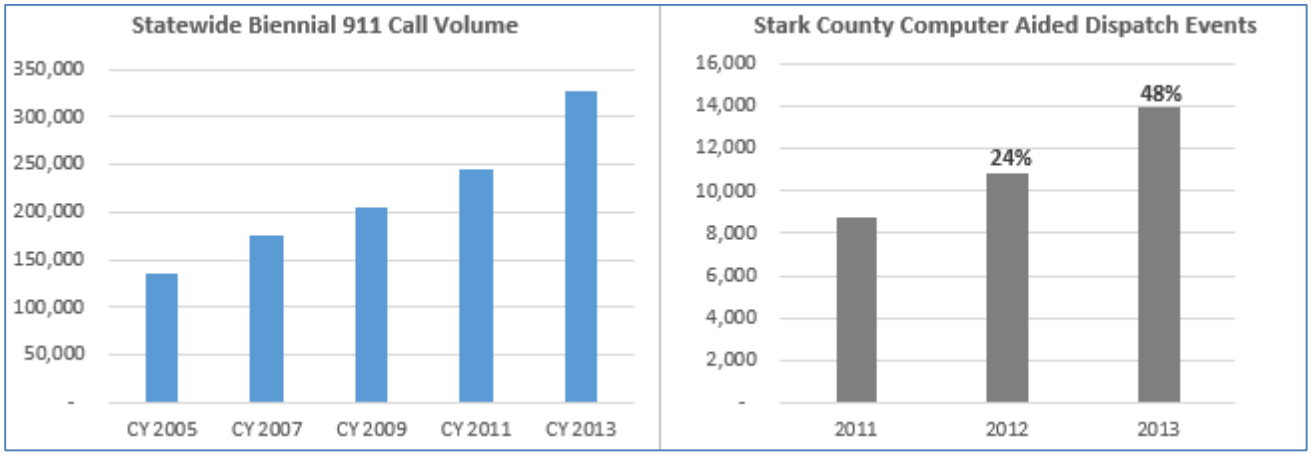


Figure 1: Biennial Statewide 911 Calls (Left); Stark County Emergency and Service Dispatch Trends (Right)

Public calls for 9-1-1 service provide an important perspective into the level of public safety response activities through the State and further illustrate the demands being placed on voice and paging radio communications systems. As reported by the North Dakota Emergency Services Coordinating Committee

[1] The SIEC was established by the Governor and is composed of local and state executive representatives from law enforcement, fire, EMS, emergency services, 9-1-1, transportation, and other first responder disciplines.

and illustrated in Figure 1,[2,3] between 2005 and 2013, the number of 9-1-1 calls statewide have nearly tripled. Figure 1 further demonstrates that this increase in 911 call volume has led to a rapid increase in the public safety personnel dispatched in response to citizens' call for service. In western counties such as Stark County, the number of incidents to which public safety agencies have responded have increased by 50% over a three year time frame. These data represent the increasing impact of the rapidly expanding State population on services delivered by public safety personnel and the corresponding demand on the tools they employ to fulfill their duties. These trends can be expected to expand at a similar pace with projected growth in the future permanent and service populations, underscoring the need to outline a mission critical radio network solution that is reliable and feature-rich, provides high quality voice communications, supports interoperable communications between responders of all agencies and jurisdictions, and evolves with the ever-increasing demands on the public safety community.

1.2 Project Approach and Methodology

In order to fully assess the capabilities and reliability of the State and Local radio networks operating within the State of North Dakota, a comprehensive program was designed to ensure that appropriate information on the legacy networks was assembled, and that broad participation by the stakeholder community was obtained. Figure 2 illustrates the programmatic approach undertaken to achieve the underlying objectives and goals of the study. Over a period of two months, a comprehensive requirements and data collection effort was undertaken to determine and assess the radio communications needs of the State of North Dakota's public safety practitioners, agency managers, radio network and 911 Call Center operators, emergency coordinators, public works stakeholders, and all radio network user populations.

Figure 2: ND Statewide Radio Network Assessment Approach

Broad participation by stakeholders, as depicted in Table 1, is a testament to the importance of mission critical systems and interest in the program. This project created a forum for the public safety community to convey its requirements and to engage in a collective dialogue on prospective solutions. The requirements definition activities were focused on the evaluation of current State and Local radio systems, and an assessment of current and future mobile communications requirements relevant to evolving statewide radio communications. In conjunction with stakeholder meetings, an extensive data collection effort was conducted to gather technical information on the dozens of State and Local radio networks and devices throughout the State. These efforts are integral to establishing a performance baseline for current

[2] North Dakota Emergency Services Communications Coordinating Committee. (2014). *Emergency Services Communication in North Dakota: A Biennial Status Report 2014.*

[3] Fargo/Cass CAD data has been normalized to represent changes in service call accounting procedures.

networks, and to support the investigation and development of future solutions. The report evaluations and recommendations are anchored on the survey findings and corresponding technical analyses.

Methodology	Participating Jurisdictions	Total Number of Participants
Online Surveys	43 Counties 5 State Agencies 3 Others[4]	320 Responses
Physical Meetings/ Conference Calls	32 Counties 2 State Agencies 1 Tribal Entity	155 (35 Meetings)

Table 1: Requirements Gathering Web surveys and Interviews Scope

1.3 Key Findings and Areas for Improvement

End user survey findings and independent technical analyses of the radio systems are integral to the proper evolution of mission critical radio systems. Information documented throughout the program is used to define future requirements, to identify cost-effective solutions that address end users' needs, and to consider optimal operational and governance structures. To that effect, in-person interviews, online surveys, and radio system documentation efforts covered a comprehensive range of topics including:

- Existing radio systems, portable/mobile radio terminals and their respective lifecycle status
- System attributes including coverage, capacity and network features
- Local and cross-jurisdictional interoperability (city, county, tribal, state)
- Dispatch capabilities and requirements
- Current and projected interoperable voice and data communications needs
- Prospective statewide solutions and governance models
- Guidance on training, exercises and other state-led initiatives

Overall network satisfaction is gauged by the composite performance of technical attributes including adequate coverage and capacity, high reliability, seamless interoperability across user groups, and corresponding operational elements such as training, governance, and standard operational procedures and policies. The degree to which existing mission critical communications tools fulfill statewide end user requirements vary by county, agency function, and the architecture of the underlying radio systems and corresponding historical investment. Populous or oil-impacted counties have made the requisite investments to evolve their individual networks while smaller, rural counties face a variety of technical and financial limitations. Despite these differences, participants articulated several common and salient themes regarding current operational gaps and future requirements of public safety radio systems.

- **Evolve Fragmented Legacy Radio Technologies**: Dozens of medium to small fragmented radio systems, with some anchored on legacy technologies from the 1970s, are operated by public safety and public service entities across the State. Despite a collection of over 300 state and local radio towers and facilities, lack of open and regular dialogue across independent entities, and use

[4] "Other" designation includes businesses that public safety services such as private ambulance and EMS companies.

of outdated technologies severely limit the beneficial use of this radio ecosystem by all users. Radio service and infrastructure is often times duplicated by Local and State networks,[5] and field users have to be constantly aware of their location in relationship to a radio tower to initiate successful communications. As systems evolve, it is critical to streamline communications and improve the current coverage delivered at the State and Local levels.

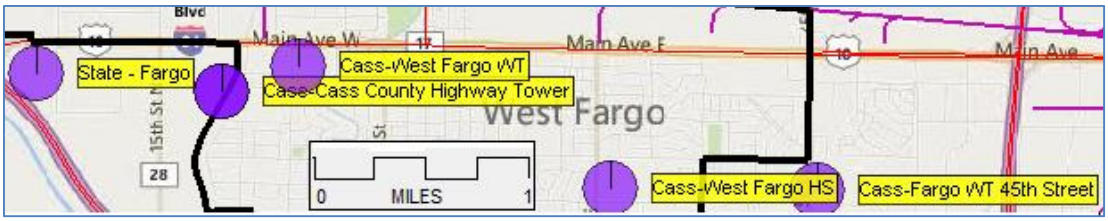


Figure 3: Metro Fargo Radio Sites

- **Improve Radio System Coverage and Capacity:** Various areas within the State experience significant coverage limitations particularly when using handheld radios (or portables). Use of legacy technology and outdated network configuration causes systems to interfere with themselves, thus limiting system performance, reliability and coverage. Oversubscribed and simultaneous use of a limited number of State Radio[6] channels employed for a host of State and Local functional network use can result in "bleed over" (having to listen to an interfering conversation) from distant communications, nuisance transmissions, or missed communications. Radio systems must therefore be improved to support reliable mobile and portable (including indoor) coverage statewide, and to provide agencies independent and group calls with sufficient capacity.

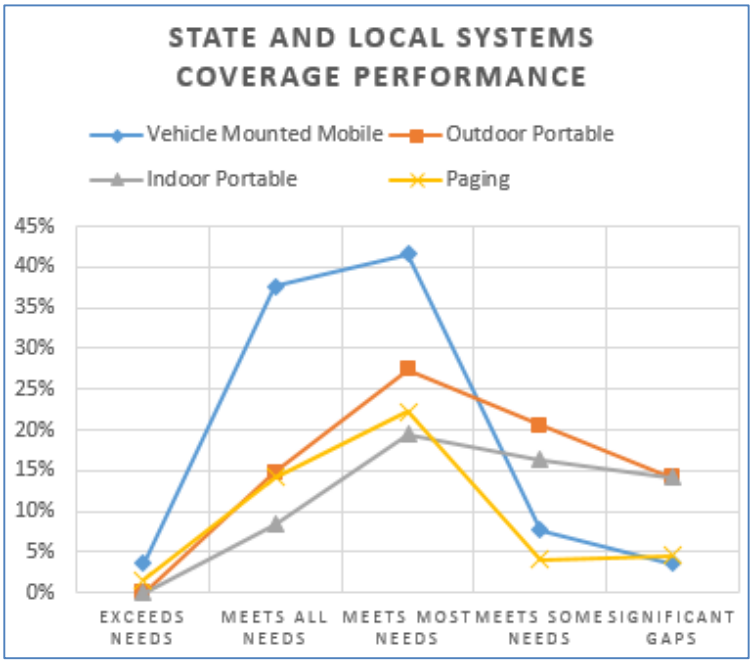


Figure 4: State and Local Coverage Performance Rating

[5] As an example, see Figure **3**: the City of Fargo, the City of West Fargo, Cass County and the State of North Dakota each operate independent towers within relatively short distances of the other facilities.

[6] State Radio is an independent radio network providing service to a variety of state and local end users. The term State Radio may be used to refer to the radio network as well as the entity – Division of State Radio – that operates the network, dispatch center and ancillary services.

- **Enhance State and Local Interoperability**: Various intra- and inter-jurisdiction interoperability gaps exist due to poor cross-agency planning, cumbersome legacy network provisioning, and limited centralized standards. Notable gaps exist with neighboring state, federal and Canadian counterparts. To overcome these barriers, agencies typically resort to their cellular phones to relay messages. As a fundamental objective of federal funding in the wake of 9/11 and Hurricane Katrina, seamless interoperability is a critical operational requirement for mission critical systems, and under current operational capabilities, has to be enhanced throughout the State to achieve desired baseline performance.

- **Conduct Effective Training and Exercises**: Even when network resources are adequate, insufficient training impedes effective use of state and local systems, particularly, by volunteer agencies that use the systems sporadically. By and large, surveyed users identified the need for effective and recurring training to be conducted at the state, county and agency levels.

- **Improve Funding Allocation**: Capital to evolve radio systems has been a major challenge, particularly, for large rural counties with small tax bases. Grant funding has been important; however, it does not provide the sustainable means required to implement a well-conceived, long term strategy for public safety communications. Funding limitations have also impacted public safety's ability to train and retain qualified dispatch and other first responder personnel amidst rising private sector wages.

- **Engage Local Stakeholders in the Development of State Initiatives**: Program participants underscored the importance of soliciting local input in cultivating and advancing state-led initiatives. The State has established various bodies to solicit input from the public safety community; however, historically this involvement was limited. Survey users emphasized advancing these programs to actively foster dialogue to refine technology initiatives in a bilateral manner.

- **Centralize State Systems while providing Local Autonomy**: Surveyed users almost unanimously supported a centralized, trunked radio[7] solution, and were willing to contribute or share their assets (towers, radio frequencies and transport facilities) provided suitable governance, sufficient local autonomy, and importantly, the solution – network and radios – is State-funded. A unified statewide trunked radio network would also provide sufficient local leverage and influence over system contractors and the large number of two-way radio service vendors that currently have varying degrees of capabilities and capacity.

1.4 System Evolution Recommendations

[7] Trunked radio networks facilitate wide area radio communications capabilities and eliminate the challenging need for end users to know what tower they are communicating on. Radio trunking, which is similar in concept to cell phone communications, also support simultaneous radio communications between first responders across large geographic areas (citywide, countywide, and statewide). Most State and Local legacy networks do not support seamless wide area communications.

1.4.1 Proposed Solution Overview

Developing a comprehensive strategy that addresses the unique requirements of a multi-faceted, geographically diverse user base, while ensuring the operational, technical and lifecycle sustainment benefits of future investments, is a complex endeavor. The following fundamental program objectives were established, in collaboration with the State Project team. These program objectives serve to guide the future of mission critical communications, and are based on the extensive stakeholder survey and systems assessment conducted over the course of the study:

- **Maximize mobile radio coverage throughout the State to provide a baseline means of communications for first and second responders**
- **Improve portable radio coverage in populated areas, roadways and high-incident areas[8]**
- **Minimize system interference and establish a coordinated frequency plan**
- **Enhance network capacity to support private group communications paths for different disciplines and functions**
- **Leverage existing State and Local assets to benefit all network users**
- **Automate various network functions to simplify dispatcher and field user operations**
- **Establish policies, procedures, technical standards and funding requirements to ensure sustainable networks anchored on long-term technology goals and objectives**
- **Support enhanced features such as end-to-end encryption and GPS location services**
- **Achieve seamless interoperability across all State, Local and Tribal users and neighboring states**
- **Maintain independent Public Safety Answer Point (PSAP) service area autonomy over locally based assets and resources**

In advancing a solution that addresses these underlying objectives, a variety of consolidated and independent land mobile radio technologies were considered. A statewide trunking radio system architecture (Figure 5) composed of the following radio access layers was nominated as the most viable option to fulfill the communications goals set forth above:

- A 114-site VHF trunked network[9] providing statewide mobile radio coverage and maximizing portable radio (with enhancements supported by vehicular repeaters as required)
- 700/800 MHz radio layers in metropolitan areas of the State to better support reliable in-building coverage and vacate VHF frequency resources

[8] Prospective systems should also not degrade the coverage footprint delivered by local radio systems.

[9] The actual number of VHF radio sites will be refined over the course of a detailed network design effort. The budgetary 110 site design represents a realistic estimate, but additional efficiencies may be achievable.

- Statewide VHF paging and fire alerting layer
- Statewide analog VHF interoperability and transition layer

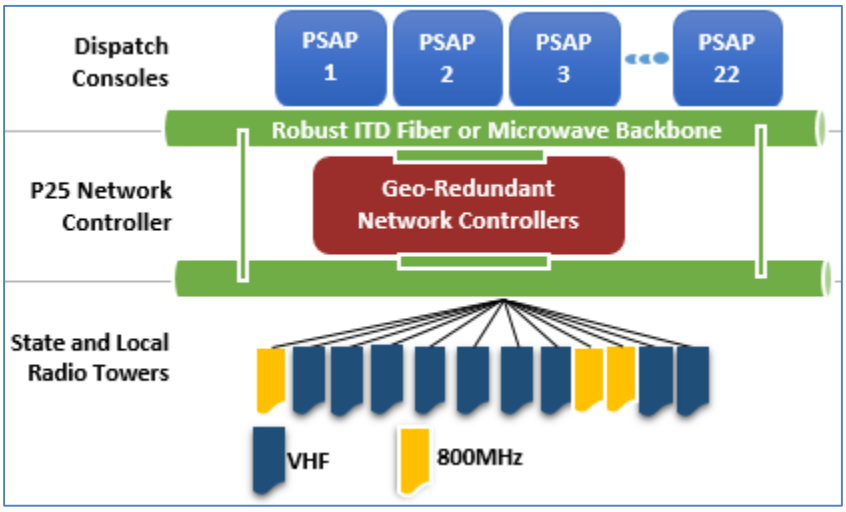


Figure 5: Proposed Architecture High Level Elements

Figure 6 depicts the predicted radio system coverage delivered by the proposed VHF trunked radio network[10]. Trunked mode of operation over this consolidated network configuration would enable approved users to roam throughout the network and experience enhanced interoperability. The proposed system is anchored on existing assets including radio towers and Ethernet capable backhaul connectivity, centralizing all network elements and dispatch consoles. In addition, 16,300 mobile and portable radio devices are proposed to be replaced or upgraded to support digital trunking operation. Other related technical recommendations such as in-building systems and repeaters to meet unique needs in radio coverage challenging areas and key state and local facilities are described within the report. Similarly, a variety of operational enhancements including first responder training and exercises, policies and procedures guiding interoperability, service vendor certification and others are detailed in Section 6.

[10] 800 MHz radio access layers are currently proposed for metropolitan areas including Fargo, Bismarck-Mandan, Minot and Grand Forks. However, these layers may be expanded pending further investigation to other dense locales such as Williston, Dickinson and/or Jamestown with minimal impact to the estimated budget.

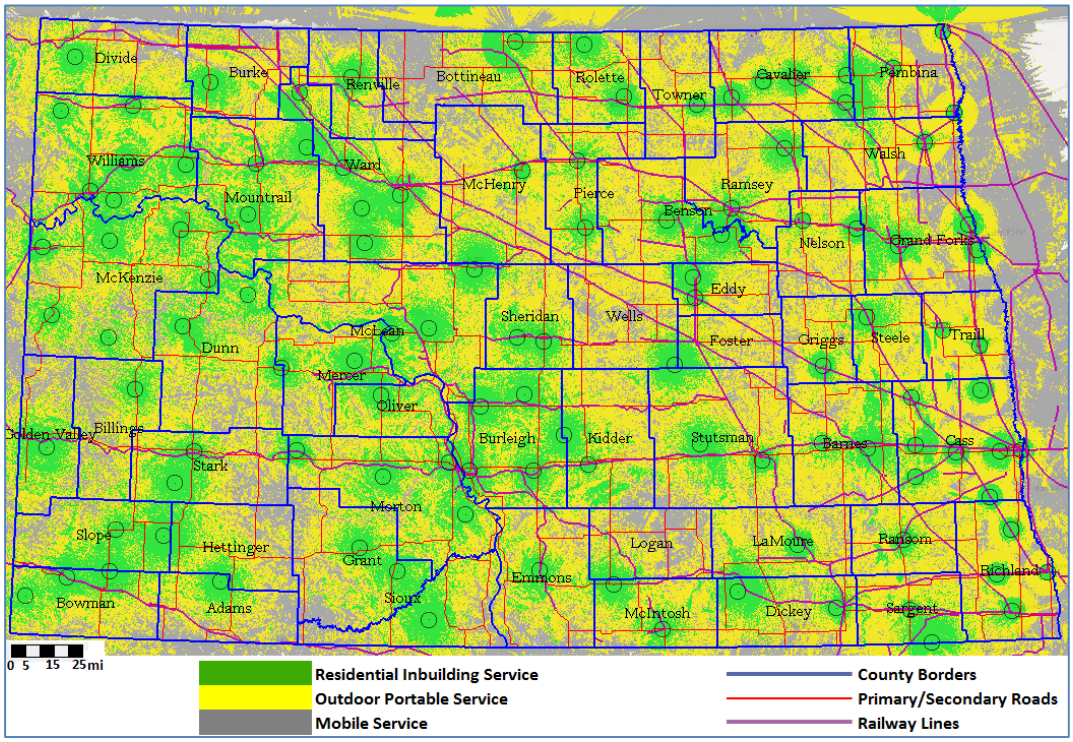


Figure 6: Prospective 114-Site Statewide VHF Coverage Solution

The coverage map in Figure 7 reflects the overall improvement in statewide coverage delivered by the proposed radio network over the current coverage delivered by the State Radio network (Figure 6).

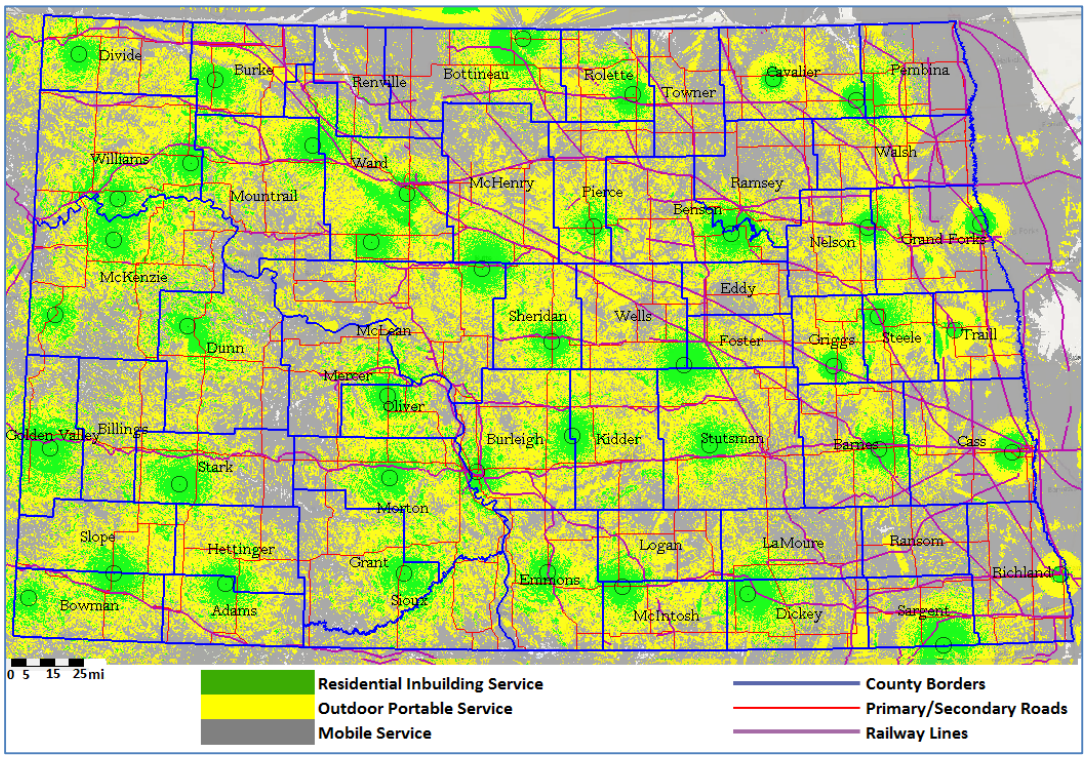


Figure 7: Current State Radio Coverage

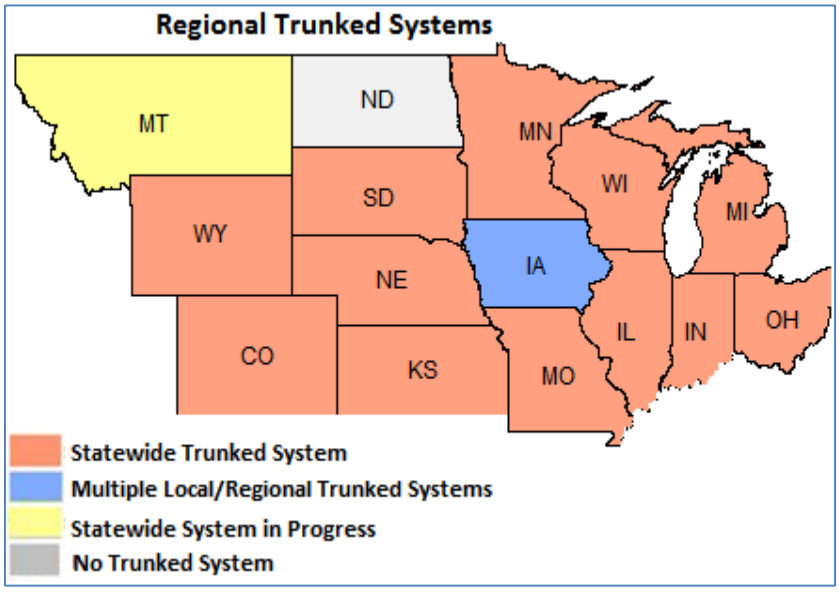


Figure 8: Mid-West and North Central Region State and Local Trunked Systems

Trunked radio technology, primarily based on the public safety Project 25 (P25) standards, has become the dominant radio architecture for public safety nationwide. As illustrated in Figure 8, all states in the region operate or are in the process of deploying statewide trunked radio networks. In fact, nationwide, only Vermont and North Dakota have no statewide or local trunking systems. The performance and operational benefits of these networks underlie their preference as the optimal radio architecture for public safety and commercial entities alike.

1.4.2 Estimated Capital and Operational Costs

Although a dual layer VHF and 800 MHz trunked radio architecture is recommended as the most suitable solution to meet stakeholder requirements and radio communications objectives, there are a variety of underlying factors and assumptions that influence the ultimate network architecture and associated capital and operational cost. These factors include the level of local adoption and participation, system implementation time, retention of existing network assets and devices, and the acquisition strategy. Table 2 presents the capital expenditure (CapEx) estimates; these costs are based on extensive market research and past experiences on the land mobile radio (LMR) vendor equipment and services required to implement a system of this scope and size. Major CapEx components of the proposed solution comprise geo-redundant central network controllers, radio site base station infrastructure, site development, interfaces to the 22 regional and local PSAPs and corresponding dispatch operator consoles, and professional services including engineering, project management, network testing, optimization and provisioning.[11] These costs constitute standard discounts over list price that radio vendors typically offer in state and local schedules. However, competitive and modular acquisition of various elements and vendor negotiations are expected to yield a reduction of 15% – 20%.

[11] In deploying a wireless network of this scope and size, it is important to budget for a wide range of potential issues including tower strengthening, radio programming, and other costly items that may arise. A contingency fund in the amount of 10% is incorporated into the estimated cost; it is recommended that these funds be retained until the completion of the project to minimize delays in acquiring funds for required changes.

Network Cost Component	Estimated Costs
Land Mobile Radio Network and Systems	$ 45,304,711.96
PSAP Centers Equipment and Interfaces	$ 7,068,750.00
Services - Engineering, Installation, Management and Training	$ 14,691,500.00
Services - Site Development and Preparation	$ 11,909,000.00
State & Third Party Costs[12]	$ 4,950,000.00
In-building Systems	$ 2,512,500.00
10% System Contingency	$ 8,148,646.20
Total	**$ 94,585,108.15**

Table 2: North Dakota Radio Network Estimated Capital Costs

Additionally, the replacement or upgrade[13] of end user subscriber devices, deployment of vehicular repeaters, and key system features such as encryption are included in the overall statewide mission critical communications costs (Table 3). Estimated cost of subscriber devices are inclusive of the associated services such as installation and programming. These costs are sourced from list price costs of land mobile radio vendors; it is expected that bulk purchases and competitive acquisition could reduce the total costs.

Subscriber Device Category	Estimated Costs
Radio Replacement and Features	$ 44,543,953.00
Radio Upgrades	$ 5,601,840.00
Vehicular Repeaters	$ 12,100,000.00
Pagers	$ 2,310,750.00
Total Estimated Costs	**$ 64,556,543.00**

Table 3: North Dakota End User Devices Estimated Capital Costs

At an estimated total capital investment of $160,000,000 spread over a five year network implementation timeframe, Table 4 provides a logical list of project implementation activities completed each year and the projected funding requirement per year over this five year timeframe.

[12] A list of "soft costs" including, but not limited to, specifications development, preliminary design, a project management office, regional project coordinators and others are accounted for and detailed in Section 5.2.4

[13] A review of the documentation collected indicates that upwards of 40% of existing subscribers, notably of the Motorola XTS and XTL make, have the capability to support trunked operation with firmware upgrades. These devices as well as others from manufacturers such as iCOM, Harris, Tait and Bendix King are expected to function well beyond the manufacturer's published end-of-support dates. However, as vendors implemented their planned obsolescence of products, software upgrades for out-of-support radios will not be available beyond 2019. Therefore, the successful reuse of these devices is predicated on an expedited transition to the proposed radio network.

Phase	High Level Activities	Y1	Y2	Y3	Y4	Y5
I - Pre-Acquisition	▪ *Site selection, analysis and preparation* ▪ *800MHz/VHF Frequency search/licensing* ▪ *Radio equipment inventory development*					
II - System Acquisition	▪ *Specifications development and vendor negotiations* ▪ *System Selection and contract execution*					
III – Metro Area 800 MHz	▪ *Migrate Metro Areas to 800 MHz to vacate frequencies and prepare portables and mobiles for reallocation*					
IV – Regional VHF layer Implementation	▪ *Regional VHF deployment - four to six regions approach -PSAPs*					
Radio Procurement Redistribution and Programming	▪ *On-going efforts to gather, provision and distribute radios*					
Estimated Annual Costs (in Millions)		**$ 10.20**	**$ 47.34**	**$ 38.96**	**$ 37.49**	**$25.16**
Total Cost of Goods and Services (in Millions)		**$159,140,000**				

Table 4: Projected Five Year Funding Requirements

Network sustainment, operation, maintenance and administration of a statewide mission critical grade communications system is a significant components of the total lifecycle ownership costs. LMR network operational structures vary widely nationwide, ranging from government agencies that employ the requisite internal staff and tools supporting comprehensive system maintenance, to agencies that outsource all operational and maintenance activities to third-party contractors. Long term commitment of operational funding is critical to fulfilling the annual software support, maintenance, technology upgrades, engineering and administrative personnel, and a wide variety of recurring network costs, regardless of the operational structure the state pursues. Well-established network sustainment plans and budgets safeguard the longevity of the network and better manage the financial burden of operating a statewide system. Table 5 summarizes the projected annual costs for the first five years after implementation based on current operational expenditures (OpEx) by State Radio and other regional system operators, typical network equipment lifecycle costs, the estimated human capital, and anticipated inflation.

Operational Cost Category	Year 1	Year 2	Year 3	Year 4	Year 5
Vendor Network Maintenance & Technology Refresh	$3,420,000	$3,520,000	$3,630,000	$3,730,000	$3,850,000
Infrastructure Maintenance & Support: Utilities, Lease, Upkeep	$1,220,000	$1,250,000	$1,290,000	$1,330,000	$1,370,000
Network Facilities and Data Center Connectivity/Leased Lines	$ 860,000	$ 890,000	$ 920,000	$ 940,000	$ 970,000

Operations and Maintenance Personnel	$2,210,000	$2,270,000	$2,340,000	$2,410,000	$2,480,000
Estimated Annual Costs	**$7,710,000**	**$7,930,000**	**$8,180,000**	**$8,410,000**	**$8,670,000**

Table 5: Annual Operational Costs Estimates

1.5 Proposed Solution Considerations and Next Steps

On behalf of the State of North Dakota, the SIEC and the project sponsors, have taken an important initial step in the evolution of mission critical voice and paging systems by commissioning this Radio Assessment project. Several key initiatives and related activities are germane to realizing the proposed solution that will require concerted efforts by State and Local authorities. Under the oversight of the SIEC, the State should assemble a dedicated project team that is tasked with advancing the program to a successful conclusion. The project team would assume responsibility for conducting the required project planning, and for performing various preliminary technical tasks such as project planning, site selection and advanced network design. This team would additionally support the State project office team and the SIEC's programmatic efforts to foster buy-in at the local levels through effective public relations and outreach. In addition, the project team would devise and lead the acquisition and deployment strategy[14] to guide a complex multi-year specifications development, procurement, and implementation process that fulfills the vision of the public safety stakeholder community.

Central to the success of a statewide network is the development of a symbiotic governance framework that defines the shared ownership, operation and sustainment at all levels of government. A consolidated radio network would require even greater collaboration and present significant opportunities for State, Local and Tribal agencies to enhance interoperability and cross agency/jurisdiction response and mutual aid. A well-conceived and structured governance organization would address membership, fee structures, operational process and procedures, asset contributions (towers, frequencies, backhaul, and other shared facilities), interoperable communication requirements (communications plans, standard operational procedures, mutual aid channels, etc.), and other salient requirements.

Finally, several near-term operational enhancements and recommendations are outlined in the report to supplement the technology transition as well as to better optimize existing legacy radio networks in the interim. These include training and exercise programs tailored to ensure effective use of current and future systems, and in forming regional Emergency Communications Working Groups to facilitate dialogue on public safety initiatives and to gather additional requirements. Guidance on these issues should aim to evaluate effective means of providing other data and information technology services that are increasingly becoming invaluable tools to the public safety community.

[14] See Acquisition Strategies

2 Introduction/Project Overview

The State of North Dakota is undergoing tremendous social and economic changes in response to the rapid growth in the State's energy resource sector. While the State and its citizens receive undeniably important benefits from the energy boom, the resulting growth is stressing critical infrastructure and services vital to the life and safety of the citizens of the State. This report focuses on the mission critical radio communications systems that serve as the lifeline of public safety responders and public service entities throughout the State. At this time, most of the existing legacy radio systems are operating at well beyond their expected lifecycle and/or are anchored on an outdated generation of radio technology that communities across the State have diligently labored to maintain and evolve under limited budgets to deliver reliable communications to end users.

These public safety radio systems operate within an overall emergency alert and response structure that begins with a 9-1-1 call for emergency assistance made by a member of the public via landline or cellular telephone to the local Public Safety Answering Point (PSAP), also referred to as the 9-1-1 Center. Once the service request has been made, the PSAP dispatcher will initiate a radio page and dispatch a call over the Local or State radio network to the appropriate agency: law enforcement, fire, emergency medical service (EMS), emergency management, public works or other required responder. The radio and paging networks support the call for response, and then serve as the primary means of communications between the responding personnel, and between the responders and the dispatchers.

The radio network is an essential lifeline communications tool and as such must be reliable, provide high quality voice communications, be feature-rich, and support interoperable communications between responders of all agencies and jurisdictions. The networks must support interoperability between police, fire, EMS, and other responders of State, Local, Tribal and Federal agencies during multi-agency, multi-jurisdiction emergency incidents. Large-scale emergency incidents are certainly not uncommon where flooding in the Red River Valley and along the Missouri and Souris Rivers occurs regularly, where blizzards and tornados strike the State, and more recently, where oil tanker train derailments occur. All of these incidents place the lives and property of citizens, and the public safety personnel responding to these events, at great risk. The first responders depend on the reliability of the land mobile radio (LMR) networks to facilitate incident response communications. It is therefore essential that these private government networks be designed to "public safety grade", and that they perform more reliably than commercial communications networks.

In order to fully assess the capabilities and reliability of the multiple State and Local radio networks operating within the State, the Statewide Interoperability Executive Committee (SIEC)[15]—the governing oversight committee responsible for advancing voice and data interoperability for North Dakota—funded a study to assess the current status of mission critical LMR networks statewide, and to develop a strategic plan to enhance and evolve these networks into a next-generation architecture. Many of the existing statewide radio networks operate under a conventional architecture similar to those implemented during

[15] The SIEC was established by the Governor and is composed of local and state executive representatives from law enforcement, fire, EMS, emergency services, 9-1-1, transportation, and other first responder disciplines.

the 1970s. These systems do not facilitate seamless interoperability, or support communications between responders who are not directly located at the scene of the incident. In other words, responders en route to the incident are unable to communicate with one another over the radio networks until they are on the scene, and once on the scene, can experience challenges in communicating with other on site responders over the network.[16] Essentially, the statewide radio network is at least one generation behind where most nationwide public safety LMR network are today, including the state networks of all of North Dakota neighboring states.[17]

2.1 Radio Network Assessment Project Overview

The land mobile radio (LMR) network assessment project as designed by the SIEC was formulated with the objective to understand the LMR "ecosystem" within the State of North Dakota, to determine statewide stakeholder requirements for radio communications, and to identify existing gaps in the delivery of interoperable radio communications. Due to the urgency and value of the radio study to the first responder community in the State, there was broad-based support to quantify the current needs and develop a strategic plan to evolve the radio networks into a future standards based architecture. There has been general recognition by the radio network users that the state's radio networks are not delivering the required level of reliability, performance and interoperability. In response to these challenges, this report was funded by a variety of agencies and associations (named below) in conjunction with the SIEC commission, and developed by Televate, LLC, a nationally-recognized public safety communications and information technology company responsible for performing the study and making recommendations based on stakeholder requirements for how to best evolve statewide radio communications.

The study has broad support across the State, as evidenced by the breadth of public safety agencies and associations funding it. The following agencies and associations provided support for this report:

- North Dakota 911 Association
- North Dakota Association of Public Safety Communications Officials
- North Dakota Fire Chiefs Association
- North Dakota Peace Officers Association
- North Dakota Emergency Management Association
- North Dakota Department of Transportation
- North Dakota Department of Emergency Services
- North Dakota Highway Patrol
- North Dakota Information Technology Department
- North Dakota Sheriff's and Deputies Association

[16] The State has addressed radio interoperability requirements through the implementation of "Bank Five", which is a creative radio-to-radio, or walkie-talkie, mode of operations. However, this thoughtful effort has not been evenly adopted throughout the State due to training challenges and technical limitations such as repeated operation and lack of dispatch monitoring capabilities, which further places the responder community at risk during large multi-agency incident response.

[17] See Figure 8: Mid-West and North Central Region State and Local Trunked Systems

These funding entities represent the critical first responder communities in State and Local government statewide and are the primary users of radio communications. The representatives of these organizations have the greatest familiarity with the current radio networks and best understand the gaps and requirements for the future of public safety communications.

In addition to the funding agencies, the number of participants from State and Local governments who provided their time and information to advance the study is a testament to its importance to the public safety community. Section 3 of this report provides further details of the broad participation and documents radio communications requirements as stated by the statewide stakeholder community. It is important to note that while the focus on this study was on interoperable radio voice communications, the study was extended to determine the status and communications gaps for mobile data, PSAP capabilities, training and exercises, and other content of interest to the State's public safety community.

2.1.1 Radio Assessment Report Approach and Methodology

A comprehensive program was designed to ensure that appropriate information on the legacy networks was assembled, and that broad participation by the stakeholder community was obtained. Figure 9**Error! Reference source not found.** illustrates the programmatic approach undertaken to achieve the underlying objectives and goals of the study. Once the radio system data and end users requirements were defined, various optional solutions for advancing statewide radio communications were assessed against the requirements. Finally, a strategic plan, as detailed within this report, was prepared.

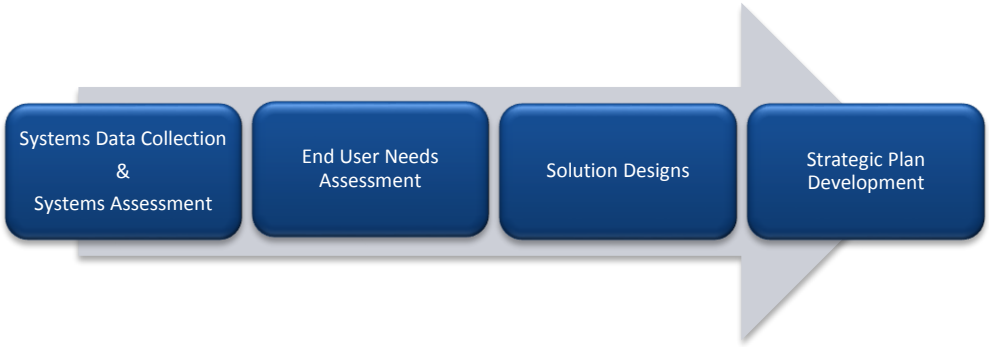


Figure 9: ND Statewide Radio Network Assessment Approach

The radio network assessment project plan was organized into a logical set of tasks that were refined in collaboration with the SIEC leadership, and with the respective project managers of the SIEC and Televate. Collectively, these activities allowed the project team to execute a comprehensive program resulting in the findings and recommendations detailed in this report. The high level tasks are listed below:

- State and Local Radio Information Data Collection Methodology
  - Various data files and formats gathered
  - Face-to-face meetings
  - Online surveys
- Evaluate Statewide Radio Systems
  - Coverage studies – existing and prospective sites

        - Consider independent County towers, privately-owned towers, and others as identified by the state
    - Vehicular Repeater Service (VRS) performance and operations
    - Capacity studies
    - Interoperability capabilities, requirements and gaps
    - System performance and features
    - High-level lifecycle evaluation
- End-User and Operator Assessment
    - Current system's strengths and gaps
    - Communications requirements (local, regional, statewide)
        - Coverage, capacity, interoperability, features
    - Gaps with current radio communications
    - Dispatch/PSAP operations
    - Near-term vs. long-term solutions
    - Training and exercises
    - Prospect of system/service consolidation
    - Current expenditures on radio
    - Impact on governance
- Methodology
    - Web surveys
    - Face to face interviews

The following sections within this chapter discuss how the impact of population growth and the associated rise in criminal offenses, fire and EMS incidents, and 9-1-1 calls for emergency response are placing greater demands on the legacy radio networks, and on the overall community of emergency responders within the State. Now, more than ever, the radio networks in the State need to perform at a greater level of reliability and at the highest possible quality. This is also an important opportunity for the State to consider migrating to a single radio network platform, thereby integrating all independent radio networks into a common LMR network. This approach will deliver enhanced interoperability and, as further detailed, is supported by the statewide community and can deliver a variety of long-term operational benefits and cost consolidation

2.2 Population Growth

The State of North Dakota is experiencing dynamic population growth that is directly related to the State's oil and gas economic prosperity. As illustrated in Figure 10, the permanent population of the State has increase by more than 13% over the past 12 years, making North Dakota the fasting growing State in the nation.

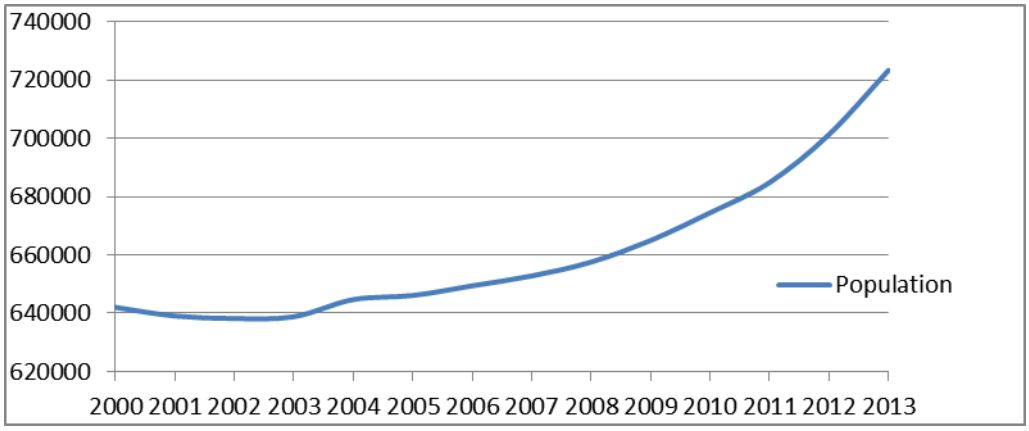


Figure 10: State of North Dakota Population Growth (U.S. Census)

This population expansion has been more prominent within the fossil fuel rich counties, and within the major cities of Bismarck-Mandan, Fargo, Minot, and Grand Forks and their respective counties. However, as shown in Figure 11, over 70% of the State's counties and jurisdictions are undergoing a swell in permanent population. Even more compelling to the growth of the State's permanent population, the growth of the temporary "service population" within the oil and gas rich counties and adjoining counties and cities has generated even more significant overall population growth. A recent study published by the North Dakota State University[18] estimated that the dramatic rise in the service population has resulted in a doubling of the population of some central and western counties even beyond the population increase reported by the United States Census Bureau.

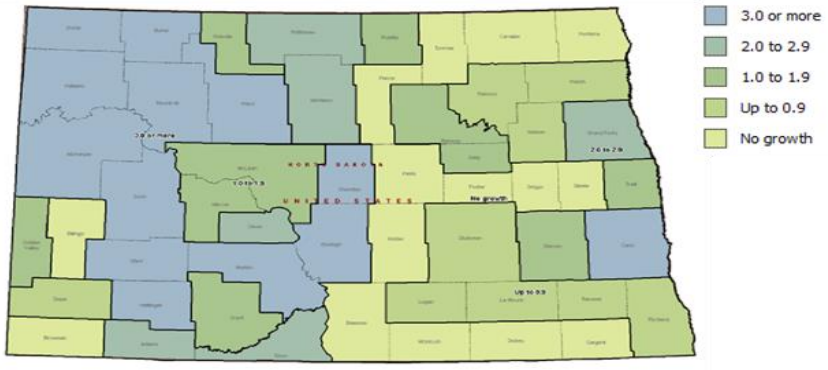


Figure 11: County-by-County Population Growth[19]

2.3 Criminal Offenses as Related to Population Expansion

As the State's population has expanded, the percent of criminal offenses statewide has risen even faster than the permanent population. Between 2004 and 2013, as illustrated in Figure 12 and Figure 13, crime

[18] *Population Estimates for the City of Williston*, Nancy M. Hodur and Dean A. Bangsund, Agribusiness and Applied Economics Report No. 707-S, January 2013

[19] U.S. Census Bureau; Story Map, County Population Growth Between 2012 and 2013 and the Primary Source of Population Change; <http://storymaps.esri.com/stories/2014/census-county-population-change/>; (9 November 2014).

within the State has increased by over 21%. This increase has placed tremendous demands on all levels of public safety response and mitigation, and as the permanent and service population throughout the State continues to increase, greater challenges for the law enforcement community and the radio networks supporting their communications can be expected.

Crime Index Offense Summary

Year	Population	Crime Index Offense Total	% Change in Number from Previous Year	Crime Rate per 100,000 Population	% Change in Rate from Previous Year	Percent Cleared
2004	634,500	12,412	-4.6%	1956.2	-4.7%	20.7%
2005	637,000	12,979	4.6	2037.5	4.2	20.2
2006	636,000	13,099	0.9	2059.6	1.1	21.0
2007	640,000	12,532	-4.3	1958.1	-4.9	22.2
2008	641,500	12,850	2.5	2003.1	2.3	26.1
2009	647,000	12,822	-0.2	1981.8	-1.1	27.5
2010	672,591	12,427	-3.1	1847.6	-6.8	28.9
2011	683,932	13,778	10.9	2014.5	9.0	27.3
2012	699,628	14,866	7.9	2124.8	5.5	25.6
2013	723,393	15,685	5.5	2168.3	2.0	24.5

Figure 12: North Dakota Crime Index[20]

Crime Index Offenses, 2004-2013

Crime Index Offense	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Murder/Non-Neg. Mansl.	10	14	9	17	4	15	11	15	20	14
Forcible Rape	181	179	195	202	222	206	222	207	243	237
Robbery	49	53	72	68	71	102	85	91	117	151
Aggravated Assault	343	444	532	599	738	795	847	1040	1071	1156
Burglary	1953	1966	2302	2096	2035	2180	1826	2227	2200	2656
Larceny/Theft	8984	9293	9012	8672	8926	8699	8673	9344	10184	10243
Motor Vehicle Theft	892	1030	977	878	854	825	763	854	1031	1228
Crime Index Offense Total	**12412**	**12979**	**13099**	**12532**	**12850**	**12822**	**12427**	**13778**	**14866**	**15685**

Figure 13: North Dakota Crime Index Offense Summary[21]

2.4 9-1-1 Call Volumes to Public Safety Answering Points (PSAPs)

There are 22 Public Safety Answering Points (PSAPs) operational throughout the State of North Dakota. Twenty-one of the PSAPS are operated at the County/Regional level, and the Division of State Radio— a division of the Department of Emergency Services (DES)—provides dispatch for the North Dakota Highway Patrol (NDHP), other State and Federal law enforcement and public safety responders, and for 24 rural Counties that do not operate a local PSAP[22]. The PSAP, commonly referred to as the 9-1-1 Center or the dispatch center, is responsible for fielding emergency response request calls from the public, and for alerting responders via a radio page[23] and for dispatching public safety responders over the radio network.

[20] State of North Dakota, Office of the Attorney General, Bureau of Criminal Investigations, *Crime in North Dakota, 2013: A Summary of Uniform Crime Report Data.*

[21] Ibid.

[22] State Radio also provides radio communications over the State radio network to NDHP, other State and Federal law enforcement agencies, and public safety responders, and the 24 rural counties being served by the State radio PSAP.

[23] Typically fire fighters and emergency medical service (EMS) responders are alerted over a radio pager about the incident and once en route will begin communications with dispatch and one another over the radio network.

The State Radio dispatch also incorporated a Computer Aided Dispatch (CAD) as did a few additional PSAPs. The CAD dispatch is made in addition to the radio dispatch.

Public calls for 9-1-1 service provide an important perspective into the level of public safety response activities through the State and further illustrate the demands being place on radio paging and radio communications. As illustrated in Figure 14, the number of 9-1-1 calls statewide has steadily increased between 2005 and 2013. Over this timeframe, requests for emergency services have nearly tripled, which represents the impact of the rapidly expanding population base throughout the State. The 9-1-1 calls can be expected to expand at a similar pace with future permanent and service population.

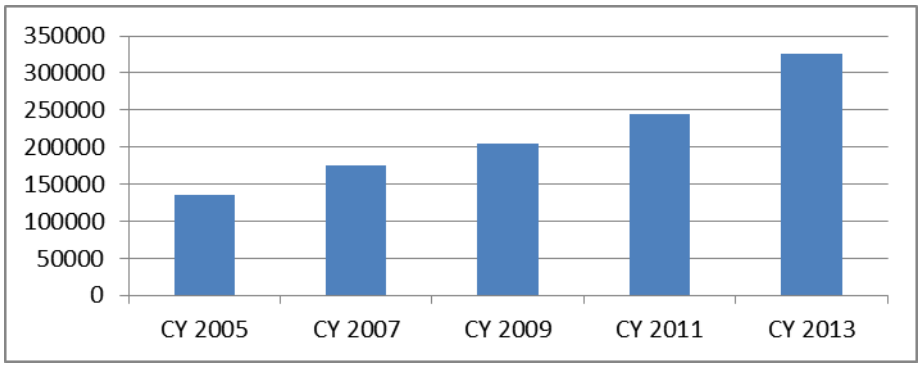


Figure 14: Annual Statewide 911 Call Volume[24]

It is important to note that the call volume at the PSAPs directly translates into greater demands and requirements on the paging and radio networks supporting emergency alerts, notifications, dispatch, and incident response and management. Citizen calls for help initiate the emergency response process, which is dependent on the quality, availability and interoperability of private radio paging and land mobile radio networks. As demonstrated within this report, the 9-1-1 facilities and personnel are at the center of the overall emergency response process, and they regularly encounter challenges in providing the required level of service due to radio network issues and other operational limitations.[25]

[24] North Dakota Emergency Services Communications Coordinating Committee. (2014). *Emergency Services Communication in North Dakota: A Biennial Status Report 2014.*

[25] While not directly included in the Radio Network Assessment project, PSAP personnel indicated challenges with Computer Aided Dispatch (CAD) systems, or the lack of a CAD; challenges in maintaining qualified personnel due to salary competition and other factors; the absence of mobile data solutions; and in the need for additional tools, training and exercises. It is also important to note that the Next Generation 911 (NG911) enhancements now being implemented that will allow citizens to send text 911 requests and forward photos and videos, as well as provide additional capabilities, are likely to increase the need for additional training and staffing.

3 Stakeholder Requirements Gathering Survey

3.1 Requirements Gathering Methodology and Participation

The active engagement of the end user stakeholders is integral to the development of any technology initiative. A program of the magnitude and impact of a statewide mission critical communications must certainly be anchored on clear and comprehensive stakeholder requirements. Investments in, and the adoption of technology is best driven by the user community to ensure that the next generation radio network satisfies their unique communications needs, and likewise considers fundamental financial and governance objectives. A comprehensive requirements and data collection effort was undertaken to determine and evaluate the radio communications needs of the State of North Dakota's public safety practitioners, agency managers, radio network and PSAP operators, emergency coordinators, public works stakeholders, and all radio network user populations. The requirements definition activities were additionally focused on the assessment of current and future mobile communications requirements and documented legacy network performance strengths and weaknesses, with the objective of investigating various information relevant to defining an optimal approach to evolve statewide radio communications. The evaluations and recommendations presented in this report appropriately incorporate the findings of these surveys.

Methodology	Participating Jurisdictions	Total Number of Participants
Online Surveys	43 Counties 5 State Agencies 3 Others[26]	320 Responses
Physical Meetings/ Conference Calls	32 Counties 2 State Agencies 1 Tribal Entity	155 (35 Meetings)

Table 6: Requirements Gathering Web surveys and Interviews Scope

To ensure broad participation among all systems' managers and users, information collection was conducted using various approaches and covered a wide range of tactical operational and radio communications technology topics (See Table 6). Over the course of the program, an extensive outreach effort was undertaken targeting a wide cross-section of State, Local and Tribal public safety stakeholders throughout the State (See Figure 15). Televate conducted dozens of regional meetings and teleconferences, administered a comprehensive web-survey, and collected documentation on the communications systems currently in use throughout the State. Survey questions and data collection templates were developed in conjunction with the North Dakota SIEC and targeted the following elements:

- Existing radio systems, portable/mobile radio terminals and their respective lifecycle status
- System attributes including coverage, capacity and network features
- Local and cross-jurisdictional interoperability
- Dispatch capabilities and requirements

[26] "Other" designation includes businesses that public safety services such as private ambulance and EMS companies.

- Current and projected interoperable voice and data communications needs
- Prospective statewide solutions and governance models
- Guidance on training and other state-led initiatives

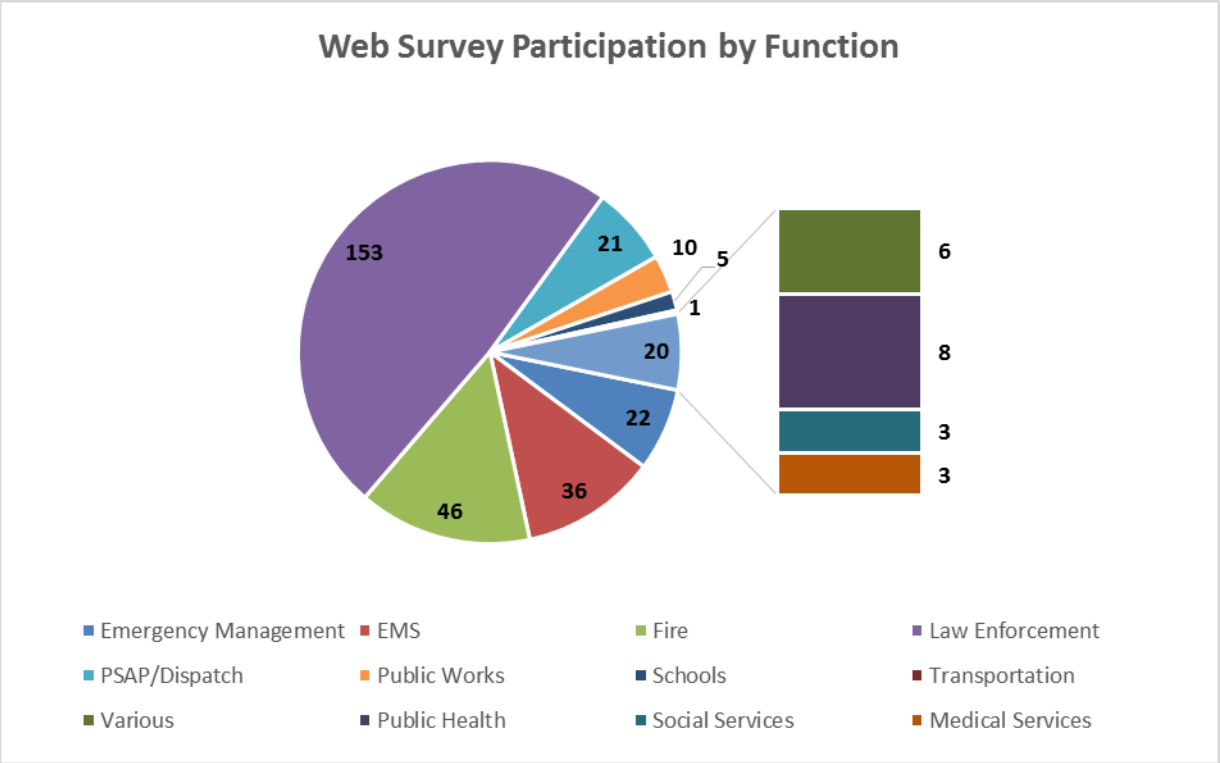


Figure 15: Web Survey Participation by Function (Combine more)

Communications Systems Information Collection

Data collection forms were distributed to all 53 counties and multiple state agencies to document specific information on their respective radio communications tools, and to conduct independent evaluations of the existing system capabilities. Establishing a comprehensive baseline of the current infrastructure and components is an essential early step in defining how future solutions can best leverage state and local capital investments to evolve the public safety communications systems. A thorough understanding of existing assets facilitated technical analyses of the strengths and weaknesses of the current networks to determine optimal and cost-efficient approaches for their evolution. Statewide documentation collected and analyzed over the course of this program include:

- Existing assets including network architecture and connectivity, radio towers and related infrastructure (equipment buildings, back-up power, HVAC, etc.)
- Base station equipment and radio frequency licenses
- PSAP facility tools such as radio consoles, telephony systems, and dispatch applications
- End user devices including portable and mobile radios, local repeaters

Relevant findings and technical functionality evaluations on the technologies and networks gathered and assessed are presented throughout the document to substantiate technical shortcomings and prospective

solutions; this section summarizes critical themes documented from the online surveys and meetings that directly highlight the need for and impact the evolution of radio systems in the State of North Dakota.

3.2 Stakeholder Assessments and Requirements Highlights

Reliable access to and the exchange of information among citizens, PSAP facilities, and first responders is fundamental to the effective preservation of life and property. Mission critical voice and paging communications systems provide a vital resource for public safety practitioners in fulfilling their daily duties and emergency response operations. Survey participants stressed reliance on their respective radio systems, and acknowledged that their State and Local governments have historically been committed to sustaining communications networks within their financial means to support functional operations. However, as the State's population and public safety response increase, a host of key issues including, the lack of centralized planning, and the requisite capital to advance communications systems, have made mission communications less reliable and more susceptible to operational issues.

"Rather than a lifeline, our radio system causes us more stress."

"It has gotten to the point where you just go to your cell phone instead of using the radio"

"We no longer consider the radio network as a mission critical communications system"

3.2.1 Current Gaps and Future Requirements

Overall network satisfaction is gauged by the composite performance of technical attributes including adequate coverage and capacity, high reliability, seamless interoperability across user groups, and corresponding operational elements such as training, standard operational planning and procedures. Both in-person interviews and online surveys sought input on a these wide range of topics to evaluate key technical and operational attributes in support of defining future network and administrative solutions. The degree to which existing mission critical communications tools fulfill statewide end user requirements vary by County, agency function, and the architecture of the underlying radio systems and corresponding historical investment; however, several common themes regarding current operational gaps and future requirements of public safety radio were articulated by the participants.

Despite recent significant investments in costly radio systems, several personnel resort to a variety of tools, including cellular phones, and mobile data terminals to fulfill their mission critical communications need. In certain cases, public safety personnel are unable to communicate among each other, or with their dispatch center at all. To develop a proper understanding of the end user requirements for advancing a suitable next generation radio solution, an in-depth assessment of the survey responses and the in-person discussion is imperative.

Table 7 provides central themes as stated on the gaps and the limitations of State and Local radio system along with desired stakeholder requirements. The remainder of this section describes key documented features that drive the evolution of radio systems statewide.

Table 7: Central Themes on Gaps in Radio Service

Topic	Relevant Findings Summary
System Coverage	▪ Significant outdoor and indoor portable radio coverage gaps in existing State and Local systems ▪ Typically, absent interference, sufficient vehicle mobile coverage of State and local systems ▫ However, vehicular repeaters used to extend radio network coverage to portables have experienced operational issues and restrict the flexibility and features (scanning, changing channels, etc.) of the network infrastructure ▪ Rugged terrain in the West, low lying riverbed or valley/gorge communities, and remote rural areas experience adequate coverage challenges ▪ Decreasing reliability of systems (due to age and increased usage) have resulted in some entities using their cellphones as the first resource where carrier coverage is available
System Capacity	▪ Oversubscribed and simultaneous use of State Radio channels for a host of State and Local functional network use causes bleed over from distant communications, nuisance transmissions, or missed communications
Conventional Radio Technology	▪ All radio systems require users to be constantly aware of their location in relationship to a radio tower to initiate successful communications. Some exceptions are more populous areas such as Bismarck, Mandan, Fargo, Grand Forks, Williams and Ward which use simulcast systems. ▪ Inability to exploit all available radio sites due to restricted access or radio programming limitations impedes communications ▪ Reuse of the same channels at all radio sites by the State Radio system causes significant interference impacts
Interoperability	▪ Lack of coordinated regional and local frequency sharing and decentralized independent systems impede the ability to communicate with mutual aid partners ▪ Limited direct means of radio communications with neighboring jurisdictions; use cellular phones or other means to initiate communication ▪ Interoperability gaps with federal partners and Canadian counterparts (other than the national interoperable channel VLAW 31)
Funding	▪ Major funding challenges for rural counties with small tax bases to evolve radio systems and fulfill federal and state mandates ▪ State grants are being directed to areas experiencing oil impact although those regions also have more direct access to oil revenue

Topic	Relevant Findings Summary
	▪ Lack of sustainable funding and access to technical guidance hamper ability to implement a well-conceived, long term strategy for public safety communications ▪ Critical paging systems and pagers – the initial tier of alerting Fire and EMS volunteer – not eligible for grant funding ▪ Grant funding is perceived to typically deploy State led initiatives, not locally cultivated programs (grant program initiatives are recommended by the DESAC[27] a State and local advisory board) ▪ State and Local dispatch agencies typically experience challenges in retaining qualified dispatch personnel due to competitive compensation and other factors
State Led Initiatives	▪ State and federal directives and programs are well-intentioned but are perceived to be unilaterally imposed and require Local input, training and funding ▫ Costly mandates with no noticeable performance enhancements ▪ Direct mode only capability[28] of Bank 5 and inconsistent operational training limits practical use during incidents ▪ Increased participation by local public safety entities in the development of technology and interoperability initiatives ▪ Limited long term technology planning and guidance has led to frequent short term changes in radio technology and programming with limited functional benefit to the end users ▪ Regular State and Local level training is required to efficiently leverage the available tools
Operations and Maintenance	▪ Distant two way radio vendors – long response/issue resolution time ▪ Fragmented vendors some with less training than others ▪ No dedicated Operational Expenditure (OpEx) budget
On Centralized Solutions	▪ Virtually all participants were amenable to a centralized solution that afforded a framework for local autonomy and to contribute their assets but emphasized the need for the solution to be State funded

[27] Department of Emergency Services Advisory Committee

[28] Bank 5 is a set of frequencies all public safety agencies are required to support on their radios geared at enhancing interoperability across all functions statewide.

State and Local Radio Systems Coverage Assessment

To closely investigate coverage limitations across a large State with a wide array of functional users, different approaches were used during the requirements gathering efforts. Discussion and online surveys focused on the existing coverage gaps of the available Local and State radio network sources, and likewise explored potential solutions to these gaps. Figure 16 demonstrates that field users who strictly employ high powered mobile radios responded that the existing networks typically meets all, or most of their needs. When other form factors, such as low powered portable devices are used, the degree to which state and local network fulfill their needs significantly decreases. Survey participants indicated the prevalence of poor or sporadic audio, the complications stemming from distant audio bleed over or radio interference, and the ability to hear dispatch communications but an inability to respond, as the key issues affecting their experience. As described in Section 4, these issues are largely caused due to the legacy technologies employed and/or the lack of proper usage or fragmentation of the networks. Approximately 340 radio sites are now currently in use by State and Local entities within North Dakota, however, a given user group is typically provisioned for access to only a limited subset of these facilities. Additionally, the coordination of Local, Regional, State and Federal user access to existing channels, while being advanced under the right intentions and objectives, is also not sufficiently managed or structured to facilitate statewide requirements.

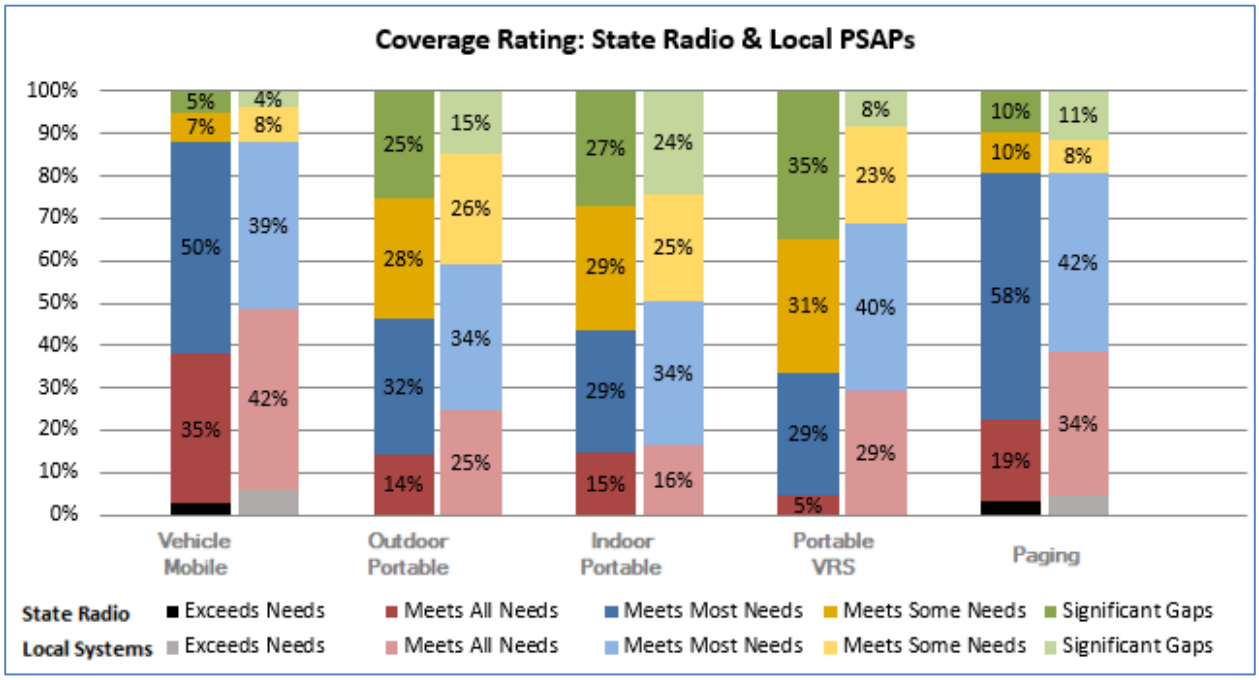


Figure 16: Coverage Needs Fulfillment – State Radio & Local Systems

Figure 16 additionally indicates the notable difference in satisfaction between users of State Radio – primarily State Highway Patrol and rural counties – and the assortment local radio systems at the County and local levels. While all first responders consider the ability to communicate a critical need, larger counties with more populated municipalities have higher requirements. Given this need and their larger tax base, these counties have deployed infrastructure to better satisfy their requirements. In some cases,

a populous county may employ several sites while the State Radio network consists of 43 statewide averaging less than one site per County. In fact, some Highway Patrol participants indicated their inclination to using local networks due to the enhanced coverage; however, this heightens risk as their dispatcher are not able to monitor their communications. A fundamental recommendation of this report is therefore the transition to a centralized network that leverages the collective benefit of all existing infrastructure in the state for all users.

Such an architecture would not only greatly enhance radio coverage for all participating state and local users but will also advance seamless interoperability across all State and local users. Figure 17 demonstrates the differences in the respondents' ability to communicate among their own county or agencies and first responders from other jurisdictions. Enhancing seamless interoperability has been the central focus of the first responder community and legislators in the wake of glaring public safety communications gaps during identified emergencies such as 9/11 and Hurricane Katrina. Locally, recent oil spills and train derailments highlight the need for interoperability across functional and jurisdictional lines.

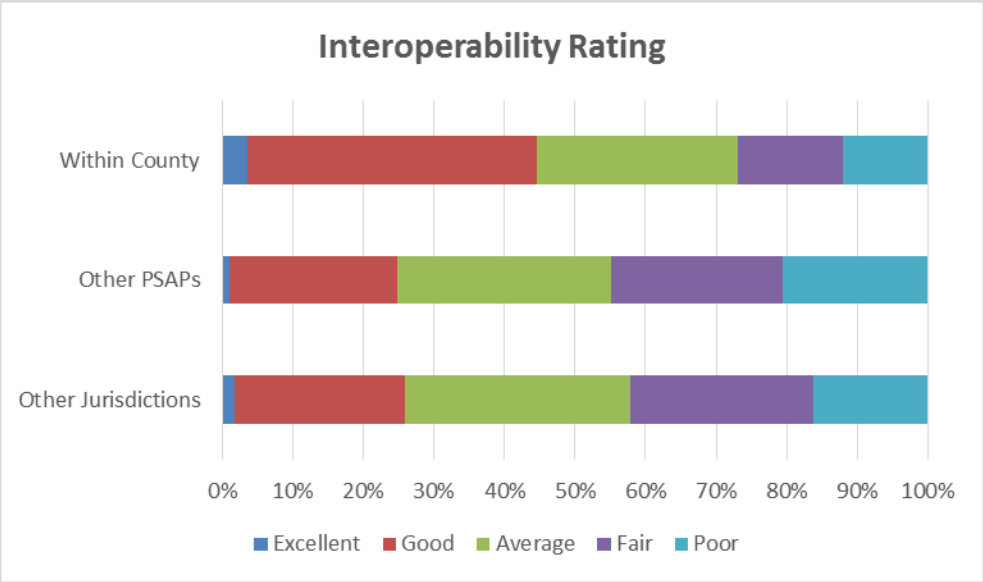


Figure 17: End User Interoperable Radio Communications Ratings

Implications of findings on future solutions evolution

The requirements gathering effort generated several key attributes that will drive the technical and operational evolution of mission critical voice communications within the State. These key attributes include:

- Maximize mobile radio coverage throughout the state to provide a baseline means of communications for first and second responders
- Improve portable radio coverage in populated areas, roadways and high incident areas
- Enhance network capacity by providing a mechanism to support private group communications links for different disciplines and functions
- Deliver enhanced features such as end-to-end encryption and GPS location services

- Achieve seamless interoperability across all State, Local and Tribal users and neighboring states
- Maintain local PSAP service area autonomy over locally based assets and resources
- Provide centralized guidance outlining long term technology goals and objectives for State and Local entities
- Engage actively county and local end-user communities during the development of future technology initiatives
- Provide a framework for underserved counties to leverage funded mission critical communications tools such as computer aided dispatch, GIS mapping and records management

4 North Dakota State and Local Radio Systems

4.1 Public Safety Communications Systems Overview

Public safety entities in rural communities throughout the United States have historically operated a myriad of small, localized networks and solutions to support the mission critical communications needs of decentralized career and volunteer first and second responder agencies. In particular, large rural counties with sparsely distributed population centers have traditionally implemented independent systems under limited collaboration with their regional counterparts. This practice has been perpetuated due to a variety of reasons such as varied funding streams, the absence of communications standards and best practices, and the inability of centralized interoperable communications governance to drive the definition and coordination of appropriate policies and procedures[29]. With over 130 law enforcement agencies, 175 public and private EMS departments, and 385 volunteer fire departments, operational across 54 counties, Tribal nations, and the State, North Dakota is no exception.

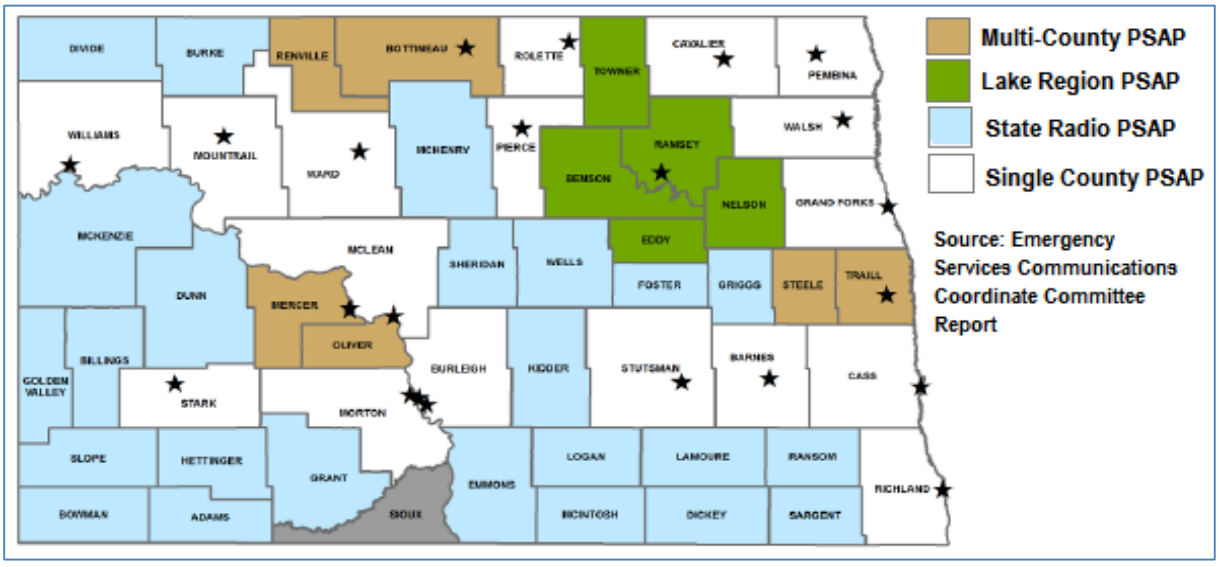


Figure 18: North Dakota Public Safety Answering Point (PSAP) Service Areas

[29] Through the Statewide Radio Assessment Program, the North Dakota Statewide Interoperable Executive Committee (SIEC) is defining radio communications needs and identifying opportunities for the SIEC to advance initiatives to address current shortcomings. Statewide stakeholder are eager to support the SIEC on this imitative.

Land mobile radio systems in the State of North Dakota are comprised of disparate statewide, regional and local two-way voice and paging systems with varying levels of performance and sophistication. Figure 18 depicts the PSAP service areas classifications in the state illustrating the network affiliations by County. Typically, most counties in the State operate an independent, or local dispatch facility and communications system, or have partnered with one or more neighboring counties to form consolidated systems. Populous counties or jurisdictions such as Burleigh, Grand Forks and the City of Fargo each maintain independent simulcast radio systems utilizing several sites to provide the requisite hand held or portable coverage to their end users. A number of the less populous rural counties employ the State Radio network, further detailed below, for all their primary mission critical communication needs including 911 call taking and processing, first responder dispatching and radio communications. Most counties additionally operate various small, local areas communications networks to provide two-way voice services to secondary agencies such as highway departments, public works and schools. (Figure 18 illustrates the alliances or consortiums currently in place by PSAP service areas). Therefore, while dispatch services statewide are being delivered by 22 PSAPs, the communications needs of first and second responder agencies in the State are delivered by dozens of county and regional radio networks and the State Radio system.

While the use of disparate systems may at times impede interoperable communications, virtually all systems operate on the Very High Frequency (VHF) radio spectrum and therefore provide baseline interoperability capabilities among the first and second responder agencies. Agencies typically share their frequencies with their regional and State Patrol mutual aid partners, and across jurisdictional lines providing them the ability to communicate with each other if properly provisioned[30]. However, as regional disasters underscore the importance of seamless interoperable voice communications among first responders and other secondary partners such as schools, hospital, transportation agencies and others, a centralized, yet autonomous, land mobile radio network may be better suited to cost-effectively evolve current legacy systems and enhance interoperability. Based upon the extensive requirements gathering efforts performed, and an independent evaluation of the LMR systems in the State, a consolidated and sustainable radio system with independent control of local elements is advanced in this report as an optimal solution.

4.2 State and Local Radio Spectrum and Licensing

The Federal Communication Commission (FCC) allocates a portion of the radio spectrum – an increasingly scarce resource – for State and Local governments engaged in public safety activities (Figure 19). In the State of North Dakota, public safety radio systems primarily employ frequencies in the VHF spectrum due to its superior propagation characteristics (greater mobile radio coverage), and its prevalence and availability in the early days of land mobile radio. Legacy public safety systems have been operating over the VHF spectrum for decades and public safety entities have historically licensed this spectrum with limited coordination between each other. Therefore, despite its regulation by the FCC, as use of the VHF spectrum increased, the spectrum became interference prone and optimal structured use became increasingly difficult to achieve.

[30] A number of stakeholders interviewed detailed issues they had encountered in having their radio properly programmed and/or in not being provided access to frequencies that would support their desired communications.

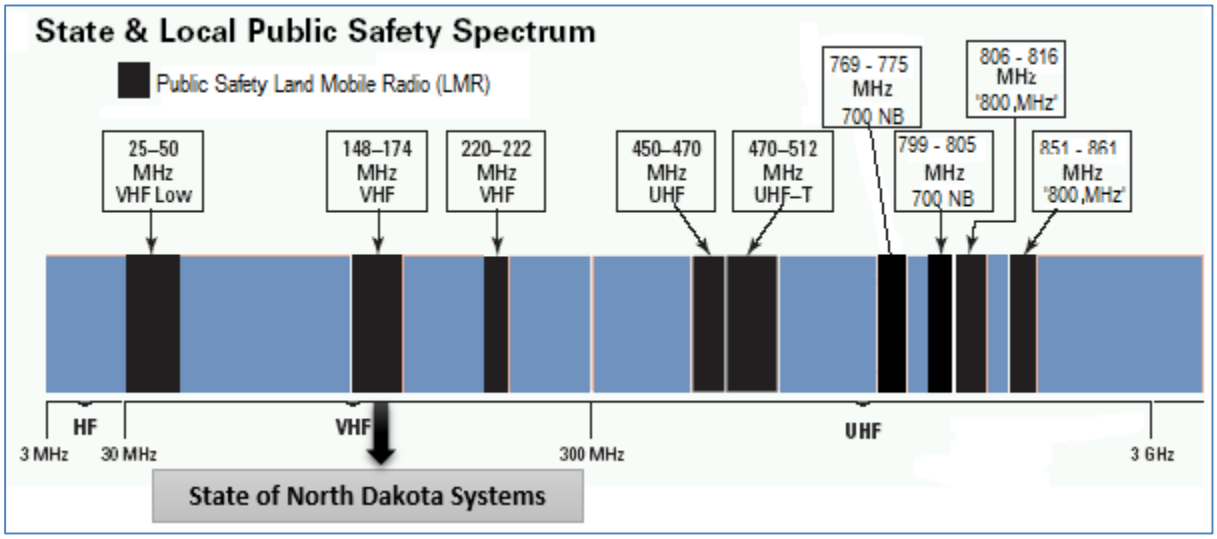


Figure 19: United States Public Safety Spectrum Bands[31]

As discussed in later sections of this report, the evaluation of the radio spectrum and the availability of frequencies is germane to the feasibility of retaining a centralized system that operates over the VHF spectrum. Conventional radio systems require a dedicated channel for a given user group; therefore, the abundance of independent local systems in the State require a significant number of channels to support end user needs. Extensive research[32] of all statewide public safety and public service licensed VHF frequencies yield a total of 354 distinct frequencies currently licensed by agencies for a wide range of functions (Table 8). Many of these frequencies are reused (in compliance to FCC regulations) multiple times across the State; some counties lack any unique frequencies. Within a given county each public safety and public service function typically licenses individual frequencies. Because of these limitations and the historically low capacity needs, the State Radio system reuses the same set of three frequencies at all 43 sites (the performance implications of such frequent reuse in discussed in the next Section).

County	Total Channels	Unique	County	Total	Unique	County	Total	Unique
ADAMS	11		GRIGGS	19		RICHLAND	42	1
BARNES	25	7	HETTINGER	7		ROLETTE	16	1
BENSON	11		KIDDER	3		SARGENT	12	
BILLINGS	15	2	LAMOURE	8		SHERIDAN	13	
BOTTINEAU	17	1	LOGAN	9		SIOUX	11	
BOWMAN	19		MCHENRY	10	3	SLOPE	8	
BURKE	14		MCIN TOSH	14	1	SPIRIT LAKE SIOUX	2	1
BURLEIGH	85	27	MCKENZIE	23	3	STARK	37	11
CASS	94	29	MCLEAN	23	1	STATE	46	10
CAVALIER	41	7	MERCER	19	1	STEELE	18	

[31] Source: http://www.nij.gov

[32] State Frequency Coordinator Databases, Independent Online Research/Tools, Direct collection from surveys

County	Total Channels	Unique	County	Total	Unique	County	Total	Unique
DICKEY	16		MORTON	36	8	STUTSMAN	30	
DIVIDE	7	1	MOUNTRAIL	22	6	TOWNER	8	1
DUNN	13	3	NELSON	18		TRAILL	24	3
EDDY	18		OLIVER	6		TURTLE MT.	3	2
EMMONS	13		PEMBINA	16		WALSH	27	4
FOSTER	11		PIERCE	14		WARD	63	9
GOLDEN VALLEY	12		RAMSEY	26	6	WELLS	25	
GRAND FORKS	40	2	RANSOM	16	2	WILLIAMS	40	4
GRANT	10		RENVILLE	8				

Table 8: State and Local VHF Frequencies

As the radio network user base increases, so does the need for additional radio channels to support day-to-day and emergency response communications. Acquiring channels in the VHF band in a State with international borders is increasingly difficult. In order to fulfill the projected needs of the user community, efficient use of the existing channels and broad participation of all first and second responder licensees (including schools, public works and others) will be essential.

4.3 State Radio System Overview

The Department of Emergency Services (DES), in collaboration with Department of Transportation (NDDOT), operates a 43-site land mobile radio system, commonly referred to as State Radio. The State Radio network, and the associated dispatch services offered by State Radio, serves as the primary mission critical voice and paging communications system for all State agencies, and twenty-four (24) North Dakota counties. Originally implemented in the mid-1970s as an analog conventional system comprised of 35 sites, the State Radio network has gradually evolved into a hybrid digital and analog conventional radio network to comply with Federal mandates and to provide enhanced end user features such as Caller ID and encryption.

All State Radio remote tower sites are interconnected with the dispatch subsystem located at the Fraine Barracks Public Safety Answering Point (PSAP) in Bismarck. The network is interconnected (base station towers to the central dispatch facility) over a highly available Internet Protocol (IP) network that is provisioned by the State Information Technology Department (ITD), which is anchored on the Dakota Carrier Network fiber optic circuits. Each remote radio site consists of the same three radio channels – a vestige of its legacy architectural origin[33]. These channels provide the communications link between the dispatch facility and State and Local first responder agencies within the 24 State Radio counties and are additionally used for interoperability throughout the state for a variety of functions and incident response needs.

[33] NDDOT operates additional channels over the same constellation of towers.

4.3.1 State Radio PSAP/Dispatch Center

Public safety answering points (PSAP) serve as the critical hub of the public safety communications ecosystem facilitating the exchange of information between citizens' call for service and the first responders that provide emergency response services. Telecommunicators, or dispatchers, at the State Operations Center located within the Fraine Barracks employ a wide range of telephony, GIS, database, and communications tools to orchestrate the right front line call taking and response dispatch. During typical operational work shift, eight individuals handle and dispatch all 911 calls for service for the State Highway Patrol, other State and Federal law enforcement and other public safety, and the 24 counties that rely on State Radio for this service. In addition to the extensive multi-tasking required by these telecommunicators to deliver critical services over simplistic but challenging to manage State Radio network architecture, telecommunicators have to be:

- Constantly aware of the State and Local first responder location with respect to a State Radio site
- Endure several non-responses to their dispatch instruction, which are heard by field users who cannot respond due to device and network limitations
- Monitor and manage simultaneous communications across multiple functions due to the shared use of the three state channels

While the benefits and the services provided by the State Radio network, and the respective network manager, telecommunicators, and support staff are essential to the user community they serve, the State Radio network requires labor intensive efforts from both the end user community and the telecommunicators to foster desired communications. It is a testament to the capabilities and hard work of these individuals to support mission critical communications, but even under the best network performance, many end users of the State Radio expressed concern and dissatisfaction with the network, some of which stated that the network was not supporting their mission critical communications requirements.

4.3.2 State Radio Coverage

Reliable radio coverage is the most important attribute of a mission critical communications system. Unlike commercial carriers which focus their service in populated areas and major roadways, public safety networks are typically designed to achieve greater than 95% coverage with 95% reliability throughout the defined service area. Given the large rural nature of North Dakota, the State Radio network has been designed to maximize mobile radio coverage utilizing the VHF radio spectrum, which has superior propagation characteristics and delivers greater coverage ranges than radio systems in the UHF and 700-800 MHz spectrum. However, various factors such as terrain, use of identical frequencies, and distance of towers from populated communities limit the State Radio network's ability to fully exploit the existing site constellation and serve municipal public safety agencies. The VHF spectrum does also not generally provide high quality and reliable in building coverage, which is best achieved with alternative UHF and 700-800 MHz spectrum.

The utility of a two-way radio system is measured by its ability to successfully deliver information in two directions – from the base station tower to an end user radio (talk-out), and from an end-user radio to the system (talk-in). Base station repeaters typically transmit at 50 – 200 watts, while end user devices such as vehicle mounted mobile and handheld portables transmit at 50 – 100 watts and 5 watts respectively. Therefore, when portable coverage is required, two-way radio systems are designed to accommodate the power limitations of the significantly weaker end users devices that additionally experience signal attenuation, or loss of signal, from shielding by the user's body and other barriers in close proximity to the radio. To overcome this limiting factor, and to ensure successful talk-in (to the system), the performance from a portable or handheld device requires significantly more sites than a system that provides baseline mobile radio service.

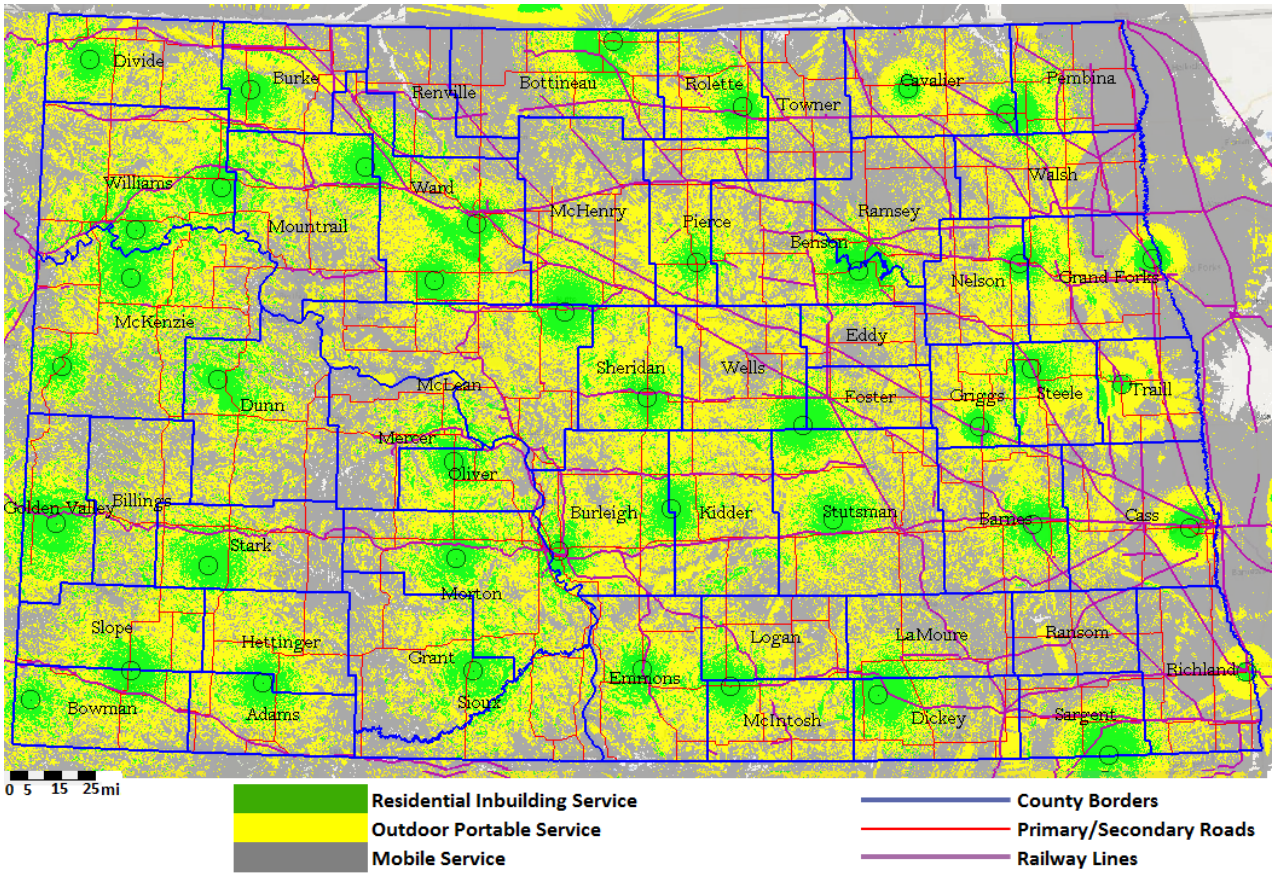


Figure 20: State Radio Network Mobile and Portable Talk-In Coverage Prediction

State Radio was primarily designed to provide mobile radio service to the North Dakota Highway Patrol (NDHP), and the State's Department of Transportation (NDDOT), and has made very efficient use of 43 radio sites to deliver satisfactory mobile coverage throughout the State. Figure 20 depicts the mobile and outdoor portable radio propagation studies of the State Radio system which demonstrates that, while mobile coverage is relatively adequate, large portions of the State do not have reliable portable level service. The survey findings support these predictive studies with almost 90% of respondents indicating that the State Radio system serves most or all of their radio communications needs when using a high powered mobile radio (Figure 21).

In sharp contrast, 55% of the surveyed users indicated that the system either meets some of their needs or has significant gaps when communicating using a handheld device. To bridge this gap, all NDHP field users employ vehicular repeater systems (VRS) to extend the State Radio service when using low power portable radios. In this configuration, a hand held device relays the message to the vehicle mounted repeaters, which in turn transmits the message to the State Radio PSAP. Depending on the amount of vehicles in service and the type of network access or features required, equipping vehicles with VRS systems may be more cost-effective than deploying additional radio towers. However, the feature and operational limitations of employing VRS on a wide scale should be measured against specific use cases. As Figure 21 illustrates, surveyed users indicated an even lower satisfaction with their ability to access the network using portables through a VRS (Portable via VRS) than directly over the portables themselves (Outdoor Portable).

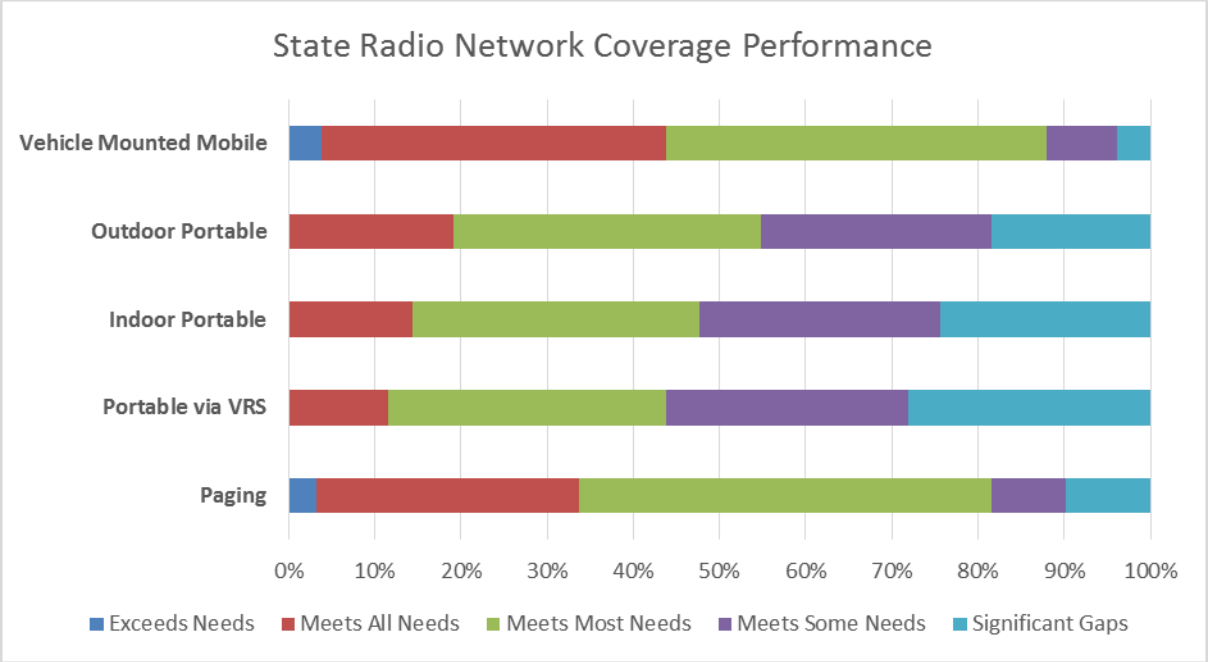
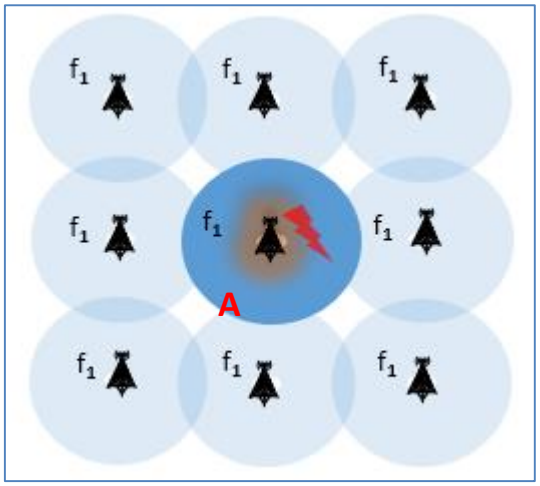


Figure 21: State Radio Network Coverage Performance

Lack of Frequency Plan and Interference Impact on Coverage

The primary attributes of a public safety grade radio system are reliable coverage over the required service area, and access to highly available radio frequency resources that are free of interference. Wide area radio networks generally employ an automated system controller or central switch to allocate radio channel resources, to manage device mobility and interference, and to connect users distributed across multiple radio towers. Land mobile radio (LMR) systems employ a well-conceived frequency plan that assigns *unique* frequencies to radio sites that are within a given distance of each other. This configuration enables the simultaneous use of available towers while limiting interference.



Due to the common reuse of the same three frequencies at all 43 towers, the State Radio system can only provide service from a small subset of these towers concurrently. In the figure to the left, only Site A can be used transmit at any given time. Since the system architecture does not have an automated controller, dispatch personnel are assigned a set of sites over which to dispatch and are trained to refrain from simultaneously transmitting on adjacent radio sites. Dispatchers often have to verbally communicate with each other to ensure proximate sites are not being used simultaneously to better manage interference, and hence function as the de facto radio network manager.[34] For example, during a call within, say the central site, call requests from adjacent sites may be overlooked or experience significant voice quality degradation. Therefore, even in cases when a user is within what would typically be considered the reliable coverage range of the State Radio system, communications may not be possible due to inherent interference in the current network architecture.

The FCC restricts the reuse of frequencies at adjacent sites by independent entities; however, within a single operating entity, such as State Radio, the management of this phenomenon is left to that entity. Figure 22 demonstrates contours within which radio sites are not allowed to reuse the same frequency; several State Radio tower sites fall within any given contour and are therefore prone to interference when used simultaneously. Of course, the State Radio dispatchers work to manage such interference, however end user communications requirements at times place demands on the network that can result in harmful interference and performance.

[34] A concern regarding dispatcher background chatter, which is required to manage adjacent channel assignments, was expressed by a number of stakeholders interviewed.

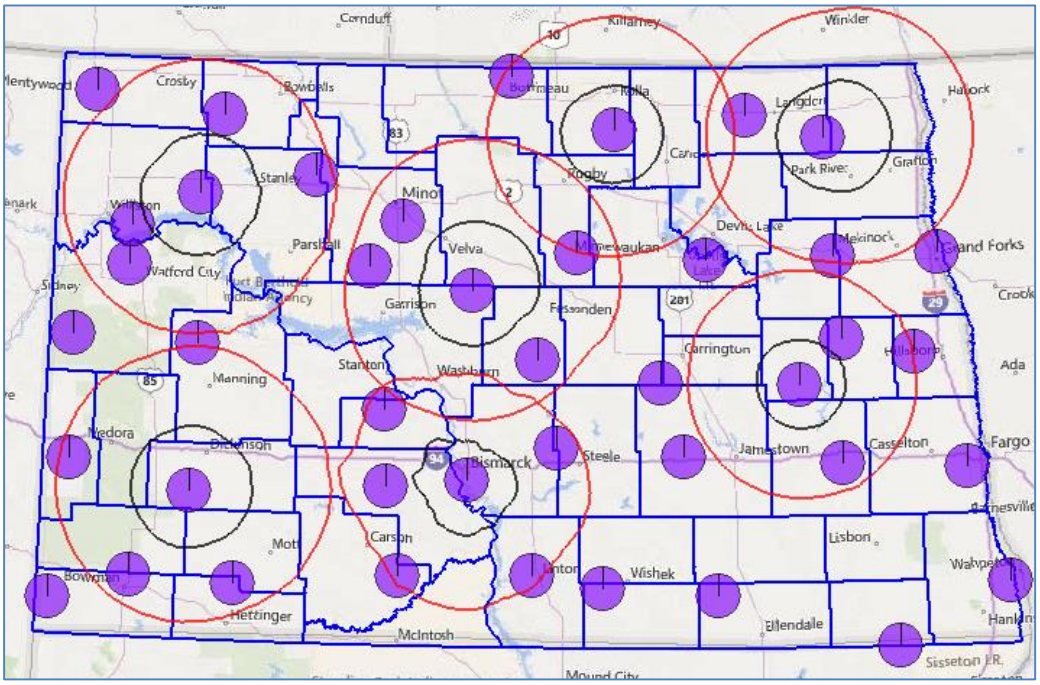


Figure 22: Frequency Pattern Reuse Guidelines

The State Radio system has effectively maintained this network architecture which provides efficient use of scarce VHF channel resources since the 1970s when capacity requirements on the system were significantly less than required today. Due to the rural and sparsely populated nature of North Dakota, the likelihood of multiple users making concurrent requests for a radio channel request within a given area was historically limited. However, as the first responder population increases and new base station sites are added to enhance coverage, this legacy architecture has increasingly become challenging and difficult to use.

This sentiment was highlighted broadly by State Radio (State and local) users during the needs assessment efforts. End users indicated that issues such as audio bleed over (a consequence of sites interfering with each other), and oversubscription of State Radio channels, to name but a few, have significantly impacted their ability to confidently rely on State Radio network as their mission critical communications system. Therefore, the solutions put forth by this report will emphasize the transition from reusing the same set of frequencies, expanding system capacity where required and implementing more recent and automated technologies to manage resource allocation.

Local Augmentation of State Radio Service

Although, the State Radio system is the primary communications network for the 24 counties that are served by the DES State Operations Center, virtually all of these counties maintain additional radio infrastructure assets to fulfill their local voice and paging needs. The 43-site State Radio network was implemented to maximize mobile radio coverage throughout the State and along State roadways – the jurisdiction of Highway Patrol and the State's Department of Transportation. At the local level, various incorporated municipalities require enhanced portable voice and paging services; these needs are

typically met with locally maintained sites near populated cities and towns. If the State transitions to a centralized statewide system, it is imperative that this locally developed radio coverage is sustained.

State Radio Capacity Limitations

State and Local agencies maintain several hundred frequencies using conventional technology to support their agencies communications needs. These frequency resources are used to communicate with dispatch personnel over radio networks or in direct-mode among users on the field. Many frequencies in the State are simultaneously used by multiple agencies and hence experience limitations in capacity. At these levels of channel oversubscription, network resources are not available for use when required. Additionally, sharing conventional channels across multiple agencies with independent functions, in some cases, causes irrelevant distractions. Future solutions should aim to make efficient use of available resources and provide disparate agencies with the ability to conduct private function specific group calls as well capabilities for interoperability.

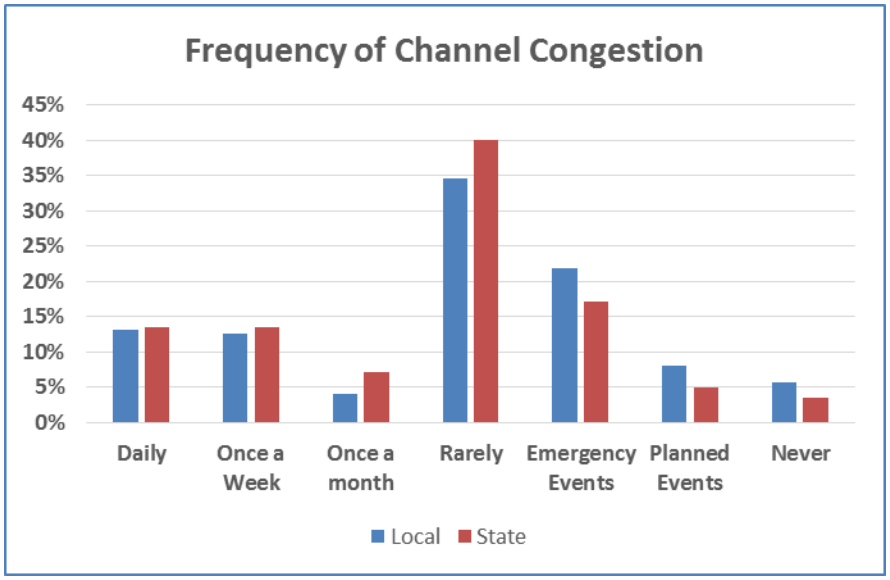


Figure 23: Channel Capacity Performance

4.4 Independent PSAPs and Radio Systems

4.4.1 Independent PSAP Systems Overview

The majority of public safety services in the State are provided by local PSAPs and radio systems implemented at the county, regional or tribal level. In addition to the 24 counties that use State Radio as their primary communications solution, 29 of the 53 counties maintain PSAPs and radio systems that are independently operated, managed and administered. Nearly 90% of the State's population are served by these independent PSAPs;[35] additionally, 1,250 of the 1,500 sworn officers in the State maintain their mission critical communications over these independent systems. While these counties and jurisdictions receive general guidance and direction on communications standards and technologies, they have invested in and deployed communications systems that are designed to meet their unique local communications needs, whereas the State Radio network was designed to support mobile radio

[35] The State Highway Patrol supports law enforcement (LE) duties throughout the State and does serve all the State's population. However, beyond NDHP's jurisdiction (primarily roadways), local LE's, fire and medical departments and others are the primary emergency service providers to citizens.

requirements of various State and Local users. Unlike the Highway Patrol, whose primary jurisdiction consists of roadways, much of which can be supported by a system that provides mobile and outdoor portable service, local systems aim to provide their first responder agencies adequate indoor radio service in populated areas to the extent their funding allows.

Larger counties with densely populated hubs or cities such as Cass, Burleigh, Ward and Grand Forks, maintain complex, robust multi-site radio systems to provide the requisite service to their career and volunteer public safety practitioners. Medium sized counties either operate small localized systems using legacy equipment or have formed partnerships with neighboring counties to implement multi-county systems. Within each of those counties, various first and second responder agencies may operate multiple fragmented base station towers that fulfill unique coverage requirements. Additionally, as previously noted, most State Radio counties also maintain additional base stations to augment the radio service provided at the State level.

Within some counties, an incorporated city, county sheriff, fire departments, schools and public works agencies may all operate small localized independent networks comprised of a single or several base station towers. This proliferation of small networks with unique conventional frequencies causes duplication of services and adds a layer of operational complexity (agencies have to continually program and add frequencies to their radios to maintain interoperability as their neighbors make changes). Overall, there are dozens of localized radio systems with varying levels of architectural complexity, age of operations currently operating within the State. Most areas within North Dakota have sufficient coverage footprint from the summation of all the sites operated independently by agencies within that area. However, a given agency may only have access to a unique subset of sites and may experience limitations in coverage since they do not have access to sites operated by other agencies. For instance, a law enforcement agency may have two radio sites, the fire departments another site, and the highway department another set of sites, each of which meet the coverage requirements of the agency, but that collectively provide reasonable coverage throughout the county. In considering an integrated statewide solution, it is important that the enhanced local radio and paging service provided by these independent systems be maintained.

Table 9 provides a few examples of county level systems that further illustrates the breadth and scale of communications assets in operation in the State.

PSAP Service Area	Counties	Brief System Description
Lake Region 911	Towner, Ramsey, Eddy, Benson, Nelson	Hybrid analog and digital system with one or two sites per County. Analog systems maintained for volunteer fire departments and paging. Employs technologies to limit interference. Dispatch equipment upgraded in 2005. Most systems implemented between 1995 and 2005. Employs computer aided dispatch; no mobile access to databases.
Burleigh	Burleigh County	Multi-site (total of 11 towers) digital simulcast and multicast system implemented in 2011; provides in-building coverage in populated areas (including Bismarck/Mandan). Sites

		connected by IP backhaul. The Dispatch Center utilizes wide range of tools including computer aided dispatch, IP based dispatch consoles and 911 call taking systems; centralized paging system, mobile data terminals for field users, location based dispatch capabilities
Mercer/Oliver 911	Mercer and Oliver Counties	A total of 4 sites – Mercer (3), Oliver (1). Legacy Telco lines connect sites and PSAP.
Traill County Dispatch	Trail and Steele Counties	Hybrid digital and analog system with five sites serving a total 1,500 sq. miles. Typical age of network equipment is 15 years. No computer aided dispatch capabilities. Additional civil service systems for highway departments, public works and other supporting agencies.
McLean 911	McLean	Four towers with repeaters implemented in 1998. Legacy equipment software upgraded to digital/P25 in 2012. Backhaul connectivity is attained via a mixture of T-1 and fiber links. Most equipment beyond vendor recommended lifecycle.
William 911	Williams County	Sheriff's Office operates 4 site single channel P25 simulcast systems (2014 implementation) Williston PD – two site voted system Additional analog repeaters serving volunteer fire fighters and other rural agencies

Table 9: Examples of County and Municipality Radio Systems

Local Systems Funding

Public safety system operators utilize a variety of funding sources to sustain their local radio networks including capital project funding, dedicated annual budgets, taxes and other fees, debt service and federal and state grants. For rural counties with small tax bases in North Dakota, grants are the primary, and sometimes the sole, funding source for deploying and maintaining emergency communications systems. Federal and state mandates aimed at standardizing technology, improving interoperability and making efficient use of the radio spectrum have required that most entities replace or upgrade their systems. The North Dakota Department of Emergency Services (NDDES) administers and issues federal grants to support jurisdictional compliance with various operational object and regulatory mandates. However, these grants are typically dedicated for compliance with mandates and may not directly enhance system performance or fund locally cultivated initiatives to advance public safety communications. Additionally, as Homeland Security grants targeting public safety communications diminish nationwide, rural communities have struggled to maintain their mission critical systems.

Within the State, the variation in implemented technologies is marked and is directly correlated with the funding capabilities of the county or region. Wealthier, populous counties as well as State Radio, for instance, employ state of the art fiber infrastructure to interconnect their sites, while rural counties with limited access to funds utilize technologies such as analog telephone lines that are over 30 years old, and radio links. Additionally, large counties, and more recently, counties with increasing oil extraction related

revenue, have sourced local funds in supplement grant funds to deploy systems that better suit their needs. Ironically, various counties indicated that grant funds are increasingly directed at "oil-impacted" areas that further limit their ability to qualify for much needed grants. While grants comprise an important source of network funding, short performance periods and unpredictable grant amounts result in incremental system patches. Many rural counties in the state, therefore, operate legacy systems dating back to over 15 years; these systems are beyond their serviceable lifespans and are at greater risk of failure.

4.4.2 Local Radio Tower Assets

In addition to the 43-site State Radio system, almost 300 two way radio and paging infrastructure facilities are owned or leased by County and municipal governments in the State of North Dakota to sustain mission critical voice and paging services (Figure 24). The size and scope of these tower assets varies from robust infrastructure supporting multiple antennas to small structures mounted atop fire stations or schools. This variety depends on the communications needs and, as discussed above, the financial capabilities of the operator.

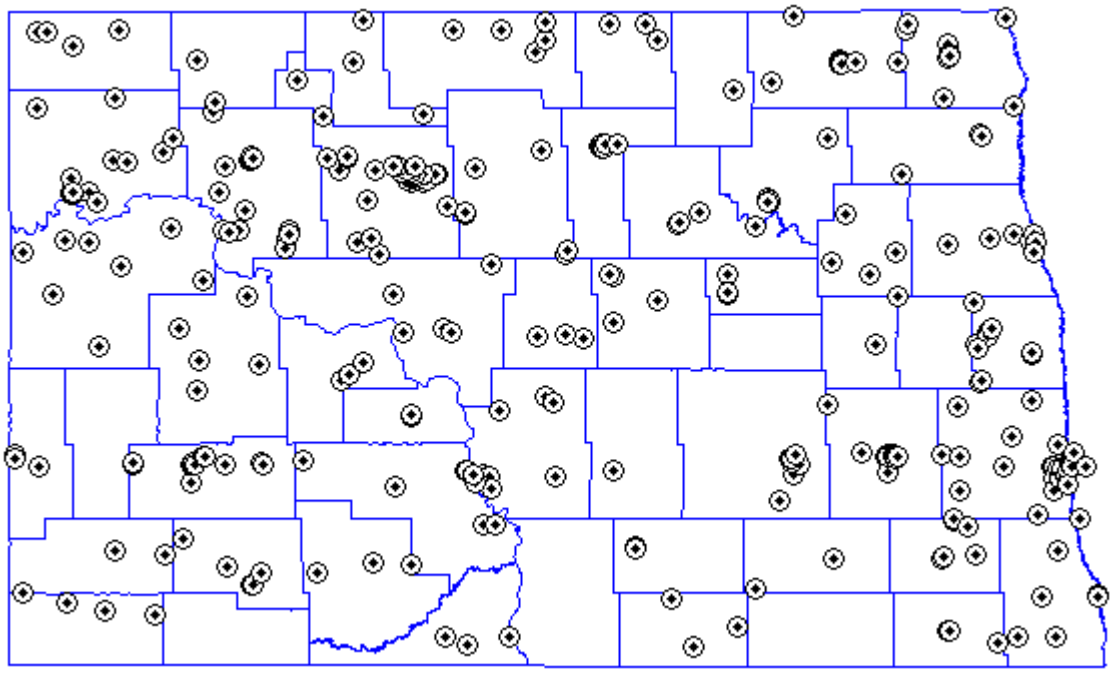


Figure 24: State and Local Radio Site Facilities in North Dakota

Due to limited historical collaboration across jurisdictional lines in implementing regionally based radio systems, the duplication of assets that cover common geographic areas is prevalent. In some cases, State Radio, a local law enforcement agency, neighboring fire departments, and transportation agencies might maintain tower sites within a few miles of each other. As an example, in Figure 25, the City of Fargo, the City of West Fargo, Cass County and the State of North Dakota each operate independent towers within relatively short distances of the other facilities. Leveraging radio technologies anchored on a centralized architecture could enable optimal and shared use of these assets by all state and local entities, significantly reducing this duplication of effort and capital.

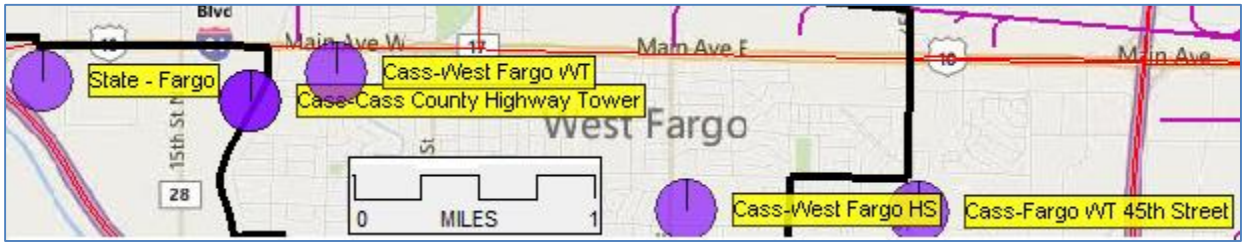


Figure 25: Metro Fargo Radio Sites

4.5 Paging and Notification Systems

Paging systems are a vital and cost-effective solution to alert permanent and volunteer based fire, ambulance and EMS personnel departments. Fire Services in the State are primarily provided by volunteer fire fighters; 94%[36] of the North Dakota's fire fighters are dedicated volunteers that sacrifice their time in protecting their communities at no direct compensation. Because volunteer agencies are comprised of citizens that generally have full time jobs, they tend to be organizations that are generally much larger per capita than career based departments. Equipping such a large base of volunteer personnel with two-way radios is cost prohibitive; therefore, volunteers carry less expensive tone and voice pagers to receive incident notification. Upon arriving on scene or at fire stations, responding personnel, that do not have personally assigned or apparatus installed radios, are provided with two way radios to fulfill their communications needs. The paging systems are also utilized to transmit two tone fire station alerting to selectively notify a single or group of fire stations, and to trigger other electronic relays such as sirens at fire stations.

To fulfill the paging needs of the over hundreds of fire, ambulance and EMS agencies, dozens of paging systems and local relays are utilized in the State. Because pager devices are typically being worn indoors when the alert notifications is transmitted, where pager coverage is limited, many counties maintain additional paging infrastructure beyond their two way radio towers to ensure successful reception of alerts. State Radio counties, for instance, receive the initial page from the State PSAP; however, due to the limitations of the system in delivering pager coverage indoors, counties use local relays mounted on smaller infrastructure or fire stations to retransmit the alert. In addition to private radio based paging systems, many entities also employ commercial carrier based paging applications that deliver alerts directly to cellular phones. Several survey participants noted that paging systems are not eligible for grant funding, which have led them to explore alternative commercial based text messaging solutions. While these systems require less initial capital investment, and leverage the volunteer's personal cellphones, unreliable rural carrier coverage and the technical limitations of local IT infrastructure have confined these solutions to a secondary tool. Therefore, in the near to mid-term, private paging/test messaging systems have to be retained and sufficiently funded to fulfill this critical emergency alert notification for first responders.

[36] U.S. Fire Administration: www.usfa.fema.gov

4.6 Radio Network Operations and Maintenance

Network operations and maintenance (O&M) of a mission critical network requires significant human and financial resource investment to achieve the desired public safety grade of performance quality and reliability. O&M consists of a variety of key tasks including, but not limited to, preventive maintenance, network repair and restoration, network monitoring, and software updates, all of which are key in preserving the integrity of service. State and Local North Dakota LMR operators use various approaches to deliver O&M services, including retaining equipment vendors, third-party contractors, local radio shops and internal staff (See Table 10).

	Vendor	Third-Party	Internal
Recurring Costs			
Technology Refresh			
Periodic Upgrades & Minor Enhancements	√		
Services	√	√	√
Support			
Software & Hardware	√	√	√
End-User	√	√	√
Maintenance			
Warranty	√		
Software & Hardware	√	√	√
Physical Infrastructure	√	√	√

Table 10: Radio Network Potential O&M Approaches

The Department of Transportation has a highly trained team of central and regional network maintenance system technologists and technicians that tend to the operational requirements of the State Radio network and end user State agencies. DOT outsources specific portions of the radio network maintenance, but primarily maintains the system with internal staff. Conversely, independent Counties predominantly rely on the myriad small business two way radio vendors and service shops for network design and deployment, system and subscriber provisioning, maintenance and upkeep.

The prevalence of small service shops in a large rural state is vital to the timely provision of service, and ultimately fosters healthy competition yielding financial benefit to local governments. Nonetheless, according to surveyed stakeholders, this independent and fragmented ecosystem of vendors occasionally affects proper implementation of interoperable parameters set forth by the State. Technical information such as radio programming requirements established locally and at the State level are not always circulated methodically to radio service vendors. They may gather information on requirements directly from a field user, a county technical manager, other sources including FCC licenses and online literature. To ensure that local first and second responder agencies with limited in-house technical capabilities receive equitable and high quality service from vendors, a centralized vendor certification and validation program is recommended.

5 System Evolution Recommendations

5.1 Overview of Gaps and Challenges | General System Evolution Considerations

Developing a comprehensive strategy addressing the needs and challenges of a multi-faceted user base distributed across a vast geography, while ensuring the operational, technical and lifecycle sustainment benefits of future investments, is a complex endeavor. The future of public safety voice communications has to account for a variety of salient factors fundamental to its evolution. Below are the key considerations that influence the development of the future radio systems within the State.

- **Coverage Retention and Enhancement**: Virtually all local counties and other entities operate radio infrastructure (in addition to the 43 State Radio sites) to meet unique local requirements including enhanced service in populated regions and other key areas where State Radio service is lacking. Despite this added infrastructure, several entities within the State continue to experience coverage difficulties. Therefore, future solutions have to, at minimum, sustain the service delivered by local systems while enhancing radio service where there is documented need. In order to support the overall coverage needs of the public safety community in the most cost effective manner, leveraging existing assets to the greatest extent possible is paramount. It is expected that a statewide radio network that does not match or exceed the performance and coverage that is currently available or required at the local level will affect network adoption by local users. Those jurisdictions who may opt to retain independent networks would prolong the worst aspects of the status quo – duplicative and less interoperable two-way radio service.

- **Frequency Planning and Elimination of Interference:** Frequent and uncoordinated reuse of State and Local channels severely affects the optimal operations of the networks. While using a common set of channels at all sites may have served the needs of users in previous decades, the ever increasing demand and user base cannot be sustained by such an architecture. It is imperative that future solutions use methodical assignment of channel resources and implement an automated central management system to effectively allocate frequencies and to make optimal use of existing infrastructure.

- **PSAP and Local Autonomy:** While the majority of the surveyed counties and PSAP operators supported the concept of a centralized solution, they emphasized the need to maintain local autonomy over their dispatch functions and systems. The system should provide local control and priority management of radio resources to effectively govern the use of a centralized system by local first responders, state level agencies and public service agencies. Standardized interfaces in the APCO TIA-25 suite of standards enable independent entities to deploy and maintain dispatch consoles that are interfaced to centralized radio systems.

- **Interoperability Improvement:** Interoperable communications among agencies in North Dakota is maintained through the use of a common VHF spectrum, which provides the ability to provision radios for accessing disparate entities' radio systems. However, the technical limitations of conventional systems and the complexity of provisioning radios with multiple frequencies, as well

as the lack of standard operating procedures, coordination and training, limit true interoperability. Therefore, achieving seamless interoperability across all layers – intra-county, inter-county, statewide – should be a major underlying consideration in advancing mission critical communications.

- **Effective Use of State/Local Assets by Consolidation and Sharing**: Essential to a cost-effective, interoperable, mission-critical solution is the shared use of assets, namely radio towers and frequencies. Cooperative and coordinated use of State and Local assets mutually benefit all participating State and Local members, ensures effective use of the available assets, eliminates duplication of effort and investment, and enhances key considerations such as coverage and interoperability.

- **Simplify Dispatcher and Field User Operations**: The existing conventional radio systems require field users and dispatchers to be constantly aware of their location with respect to a radio tower that can compromise the effective use of the system. Employing more current radio technologies would eliminate the requirement to affiliate with the local radio site by leveraging automated resource management systems, thereby reducing the incidence of interference and missed calls, and simplifying not only dispatcher operations, but also field user communications.

- **Sustainability through Centralized Guidance**: Investments in public safety systems have historically been reactive to events or incidents as opposed to directed through well-conceived long term planning. In particular, smaller rural communities rely almost entirely on two-way radio vendors to conceive and implement their respective communications systems. These reactive advancements have resulted in significant investment on solutions with limited sustainability or long term functionality, as well as duplicated services. Centralization of the radio backbone at the direction of a dedicated implementation project team ensures that the evolution of, and the investment in systems at the State and Local level considers and addresses the collective needs of all public safety users in a sustainable and cost-effective manner.

5.2 Radio System Evolution Recommendations

5.2.1 Review of Proposed and Evaluated Technologies

In developing a sustainable, cost effective and interoperable network to meet the unique technical and operational needs of hundreds of statewide public safety and public service agencies, a variety of standards based radio network solutions were considered and discussed directly with the stakeholder community. The stakeholders were asked to consider their perspective on enhancing the legacy "conventional" networks they were currently operating, or if a consolidated statewide "trunked" network was more suitable in meeting their operational requirements. There was near unanimous support for a statewide trunked radio network, assuming that the state could cover the network capital investment, and that a viable network governance model could be established. Two primary technologies within the standards suite – conventional operation (the status quo) and trunked radio systems – each with minor variations are available with which to implement such a framework were measured against the objectives set forth above.

Conventional Radio Systems

Conventional radio systems are better-suited for small agencies with limited need for seamless interoperability with other agencies within their jurisdiction, or across a large geographic area where mutual aid response could comprise several agencies. In a conventional system, each user agency is typically assigned a specific radio frequency or channel to limit communications over other agencies' communications channels. Therefore, within a given jurisdiction, law enforcement, fire, EMS, schools, highway departments, public works and other agencies could be assigned unique radio channels to support independent agency communications and/or other interoperability radio channels for communications between agencies.

Frequency licensing limitations in the VHF spectrum have led many counties to share a few channels, or deploy the same co-channels at adjacent tower sites, which prevent simultaneous use of these facilities. The State Radio system uses the same set of three frequencies across all 43 sites, which can place operational limitations on end users and also creates issues. Local agencies can hear one another when not appropriate or unwanted radio communications from two or three counties away. In some counties, all primary emergency and public service agencies employ a single channel, or frequency for radio communications causing undesired congestion.

To mitigate this phenomenon within the conventional radio network architecture, each radio tower would have to employ a dedicated set of frequencies to facilitate wide area coverage and manage interference. As detailed in the following section, to support the coverage needs of all State and Local users, approximately 114 radio sites will be required. Therefore, addressing the documented needs and objectives would require a significantly higher number of frequencies.[37] Employing conventional technology for a centralized system of this scope and size would additionally become increasingly challenging to effectively maintain and manage. In order to manage the technical constraints, to best manage the cost, and to meet stated radio communications requirements, a single statewide network anchored on trunked radio technology is proposed as the optimal evolution of public safety communications within the State of North Dakota.[38]

Independent Internetworked Radio Systems

The prospect of implementing independent yet inter-networked (trunked or conventional) State and Local systems was considered as an option for the evolution of LMR systems in the State. Current two-way radio P25 standards support the ability for independent conventional or trunked systems to be interfaced to create a "network of networks" approach to address the fundamental objectives outlined in this report. These standardized interfaces would permit local system owners to be fully autonomous and evolve their

[37] Conventional system would require two to five[37] times more radio channels to maintain the same level of service; Assessment of Alternative Future Federal Land Mobile Radio Systems, NTIA Report 08-451 December 2007

[38] It is appropriate to note that given sufficient frequencies to support the number of radio towers needed to meet statewide coverage requirements, conventional radio systems could be designed to support expanded operational objectives, however this architecture would not achieve the advanced capabilities and operational flexibilities supported by trunked radio networks.

systems relatively independently with a vendor of their choice if desired. However, such an approach was eliminated due to the following reasons:

- Does not achieve the requisite seamless interoperability requirements of the public safety community
- Does not support a number of additional operational requirements including wide area incident response communications (responders in different locations of the county, jurisdiction or state can talk simultaneously with one another) and others deemed appropriate
- Is a perpetuation of the status quo fragmentation and duplication of state and local systems, and would likely require higher cumulative costs
- Would require complicated manual provisioning and management of local and roaming users on a large number of systems resulting in the perpetuation of operational challenges of the current network architecture

Centralized Trunked Radio Systems and Benefits

Trunking technology was developed in the 1980s to ensure efficient usage of the radio spectrum – a scare resource, and to deliverable enhanced first responder communications capabilities not supported by conventional radio networks. Trunked systems do not require dedicated channels for a specific use, rather, any available resource is allocated based upon the end user agencies' needs. From an operational perspective, digital trunked systems have several key additional capabilities including caller ID display, automated radio mobility management, user prioritization, wide area roaming, enhanced interoperability, dispatching features. These elements enhance the user experience, increase network reliability, improve radio communications quality, and ultimately create a safer emergency communications and response environment. Trunked systems provide the following benefits to the State's public safety community:

- Supports multi-agency, multi-jurisdiction interoperable communications anywhere within the state for all mutual aid network end users
- Enables efficient shared use of the VHF spectrum while providing dedicated links to user agencies
- Facilitates, through centralized system switching, effective federated operation and local control of channel resources, while eliminating the need for human intervention and potential human error
- Enables the shared use of radio towers across jurisdictional lines based upon mutually established priority access schemes, thereby, significantly reducing the requirement, and associated costs of operating dozens of disparate radio networks
- Supports the ability for any approved user to access any PSAP statewide enabling redundant dispatching capabilities
- Supports automated mobility management of field users and dispatchers alike enabling them to roam over a wide area without the need to change frequencies
- Simplifies management of radio users profiles, device provisioning and network operations

- Supports preset or spontaneous multi-function or group calls to address the mutual aid response at hand
- Automatically registers and monitors end user devices providing network operators, dispatchers and managers information on who is utilizing the network
- Increases system reliability by assigning any available channel to any approved user in the event of partial equipment failure
- Supports the ability to centralize or create redundant systems for other PSAP functions such as CAD, logging recorders, call taking systems
- A statewide network would better manage the requirement, and associated costs, to operate dozens of disparate radio networks

5.2.2 Architecture of Statewide Radio Network Solutions

Figure 26 illustrates the primary layers of the proposed statewide land mobile radio network with the following functional radio access network elements anchored on a geographically redundant central network core:

- A 114 site VHF trunked network[39] providing statewide mobile radio coverage and maximizing portable radio (with enhancements supported by vehicular repeaters as required)
- 700/800 MHz radio layers in metropolitan areas of the State where the need for reliable in-building coverage is best supported by the 700/800 MHz spectrum
- Statewide VHF paging and fire alerting layer to support career and volunteer fire and emergency medical services
- Statewide analog VHF interoperability and transition layer to facilitate interoperability with mutual aid responders from out of State

[39] The actual number of VHF radio sites will be refined over the course of a detailed network design effort. The budgetary 110 site design represents a realistic estimate, but additional efficiencies may be achievable.

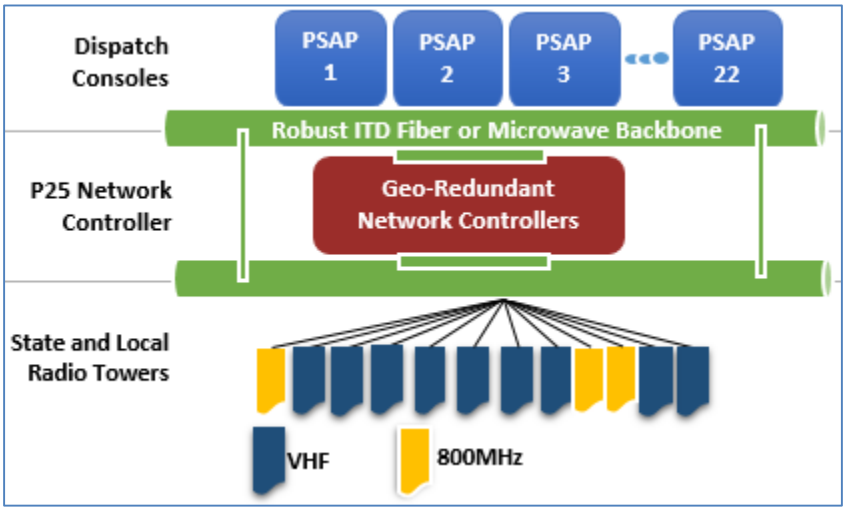


Figure 26: Proposed Architecture High Level Elements

The consolidated network configuration would be anchored on existing assets including radio towers and Ethernet capable backhaul connectivity centralizing all network elements and dispatch consoles. The centralized redundant network controller can manage the operation of all local and remote subsystems utilizing existing fiber and/or future IP-based microwave networks. Depending on the final implementation plan, this framework can be augmented to extend a full suite of PSAP services including computer aided dispatch and logging recorders to independent PSAPs.

Statewide Radio System Coverage Solutions

In designing a statewide radio network to consolidate all State and Local agency users onto a common radio network, comprehensive operational requirements must be gathered and assessed. It is additionally important to document the potential assets that can be integrated into the network or that need to be enhanced or replaced to support wide scale adoption and operations. These activities were undertaken in conjunction with the statewide radio assessment program and key objectives facilitating the design of the network were defined. The following key objectives were established to drive the conceptual coverage design development and to evaluate the technical and financial implications:

- Provide baseline statewide VHF mobile service statewide
- Maximize portable service in key areas including populated geographies, roadways and rail lines, and other areas with documented need
- Ensure the unique radio service that County and local governments have implemented is retained
- Anchor the network on assets owned or leased by public safety and public safety entities

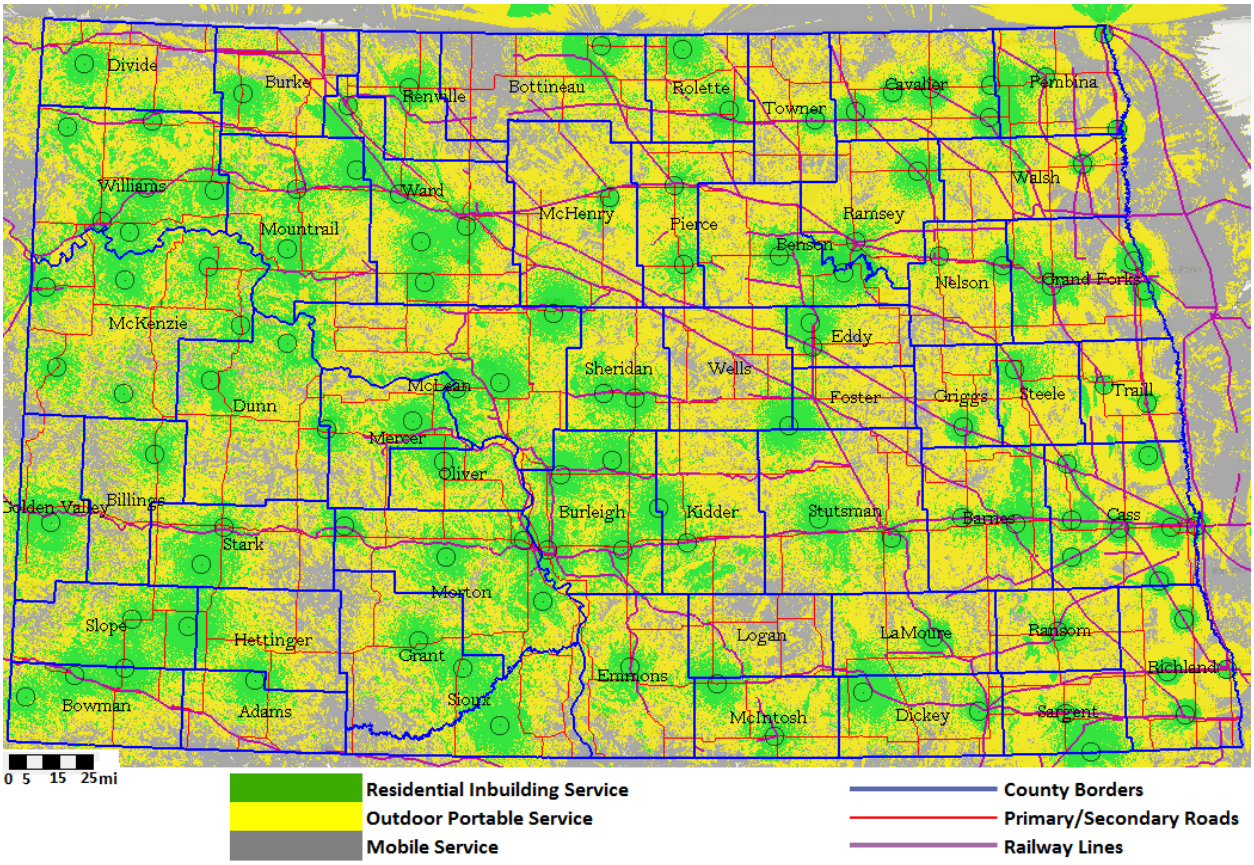


Figure 27: Prospective Site Statewide VHF Coverage Solution

Figure 27 illustrates a prospective 114[40] site VHF radio access network design that addresses these primary objectives with the largest nine counties accounting for 40% of the sites (See Table 11 for sites by County).[41] The conceptual prediction design employs the industry standard Anderson 2D propagation model with a variety of morphological layers to simulate losses from terrain, vegetation and man-made infrastructure that obstruct radio signals. Additionally, the model was optimized with empirical data collected by the DHS Office of Emergency Communications Technical Assistance Program (ICTAP) in 2010 and furnished to Televate by the State.

County	Sites	County	Sites	County	Sites
Adams	1	Grant	2	Renville	1
Barnes	2	Griggs	1	Richland	4
Benson	2	Kidder	2	Rolette	2
Billings	1	LaMoure	1	Sargent	2
Bottineau	1	McHenry	1	Sheridan	2
Bowman	3	McIntosh	2	Sioux	1
Burke	1	McKenzie	6	Slope	2

[40] Five privately owned sites were used where no current public safety assets were available.

[41] Site count does not account for metro area 800 MHz layers discussed later in this report

Burleigh	4	McLean	3	Stark	2
Cass	8	Mercer	1	Steele	1
Cavalier	5	Morton	4	Stutsman	2
Dickey	2	Mountrail	4	Towner	1
Divide	1	Nelson	2	Traill	2
Dunn	3	Oliver	1	Walsh	1
Eddy	2	Pembina	3	Ward	5
Emmons	1	Pierce	2	Wells	1
Golden Valley	1	Ramsey	2	Williams	6
Grand Forks	3	Ransom	1		

Table 11: Site Quantities By County

There are a variety of additional efforts the State could undertake to further refine and optimize the prospective design that may yield opportunities for reducing the total site count including:

- Conducting focused meetings with key stakeholders to further refine the coverage requirements and design
  - In some counties, potential radio sites operated by the local entity and state radio exist but have unique coverage footprints; depending on the collective coverage needs, a single site may serve all parties adequately
- Exploring private entity radio tower structures – hundreds of privately owned sites exist in the State some of which are more optimally located, and in a few cases potentially could support the coverage provided by two sites

Service Delivery Alternatives

The service provided by the proposed site constellation is considered essential to fulfilling the documented needs of first and second responders thereby ensuring participation by all local stakeholders.[42] There are, however, service delivery alternatives with which to sustain this level of coverage, each of which has unique technical, operational and financial implications.

- **Vehicular Repeater Systems Alternative:** Vehicular Repeater Systems (VRS) extend network service to a portable device by leveraging the high powered mobile radio. The portable communicates directly to a vehicular repeater which in turn relays the message to the network. VRS units are employed extensively by NDHP as the 43-site State Radio system provides limited direct portable service. Most sheriff deputies also employ VRS equipment to facilitate out of patrol car portable radio communications. VRS units can indeed provide connectivity in remote areas of the State, but should not be employed as the sole method of reliably accessing the network statewide. However, the overall operational needs of the stakeholders cannot be fully met by the feature limited vehicular repeaters.

[42] Televate conducted various designs and corresponding cost analyses including a solution with fewer sites than proposed. The loss in service and potential reduction in buy-in from local counties did not justify the limited cost savings.

The capital cost estimates provided in this report account for 1,100 cross-band VRS units operating on the 800MHz for law enforcement and key emergency vehicles and corresponding dual band end-user radios in the event that additional system coverage is required. This approach exploits the more readily available 800 MHz spectrum for network extension and in-building coverage, while equipping users with handheld devices that can operate on both the network and vehicular repeaters. It should be noted that if additional VHF frequencies are available upon final network design, implementing an in-band VHF VR system may also be considered.

- **Receive Only Radio Sites:** The required coverage footprint may be supplied by replacing a subset of the proposed site constellation with receive-only sites. In such an architecture, the talk-out link (network to end user device) for a given area is delivered by a portion of strategically selected transmitter sites, whereas the talk-in link (end user device to network) are supplied by receiver sites at the remaining locations to ensure low-powered handhelds can reliably connect with the network. All radio tower sites have fixed costs; however, equipment associated with a receive-only site is approximately one-third that of a full blown base station rendering it a viable and cost-effective solution. The optimal architecture will be refined over the course of the Request for Proposal (RFP) process.

- **Critical Infrastructure In-Building Systems**: Wireless systems will invariably have limitations delivering service within all man-made infrastructure facilities. In addition to recent events that highlight the need for enhanced coverage within schools and other key facilities, these facilities are designed to serve as public shelters during tornadoes and other natural disasters. Therefore, the budget reserves an additional $2.5 M to supply in-building radio distribution equipment for 75 such structures.

Metro areas 800 MHz Migrations Considerations

The proposed statewide VHF solution addresses the coverage needs of North Dakota users with the exception of the State's metropolitan areas, where first responders have greater in-building portable service requirements that cannot be supported by the VHF spectrum. The VHF radio signal is not conducive to delivering reliable coverage within buildings. While most densely populated areas such as Fargo, Bismarck, Minot and other major cities operate multiple VHF sites to enhance in-building coverage, they continue to experience coverage constraints while communicating within large structures. A

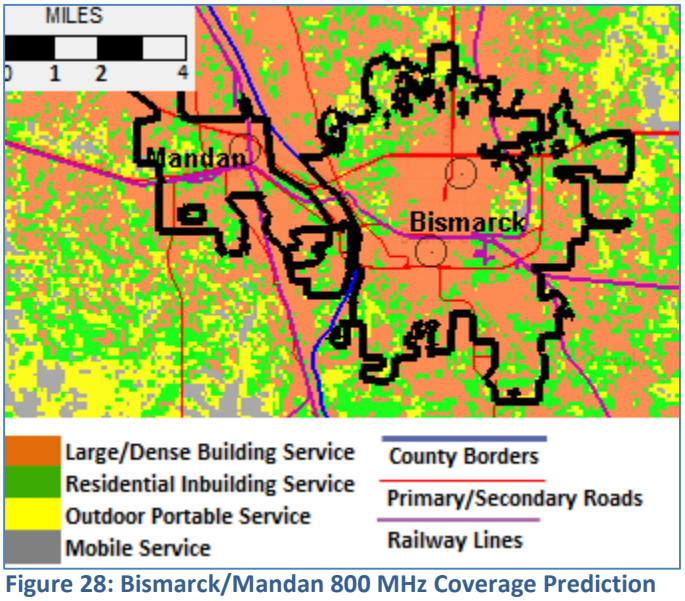


Figure 28: Bismarck/Mandan 800 MHz Coverage Prediction

viable solution to alleviating these coverage issues is the implementation of a 800 MHz network layer in all major areas including – Metro Fargo, Bismarck/Mandan, Grand Forks and Minot. Depending on pending requirements to be obtained, the proposed 800 MHz layer may also be extended to other larger towns such as Williston, Dickinson and Jamestown with limited variations in network cost. The 800 MHz radio layer being deployed in denser populated areas has the following key benefits:

- Enhanced in-building coverage typically with fewer radio base station sites than currently deployed[43]
- Vacate VHF channels for use in other parts of the State
- Enhanced interoperability for Grand Forks and Fargo with their Minnesota counterparts
- Provide seamless interoperability with VHF statewide end users

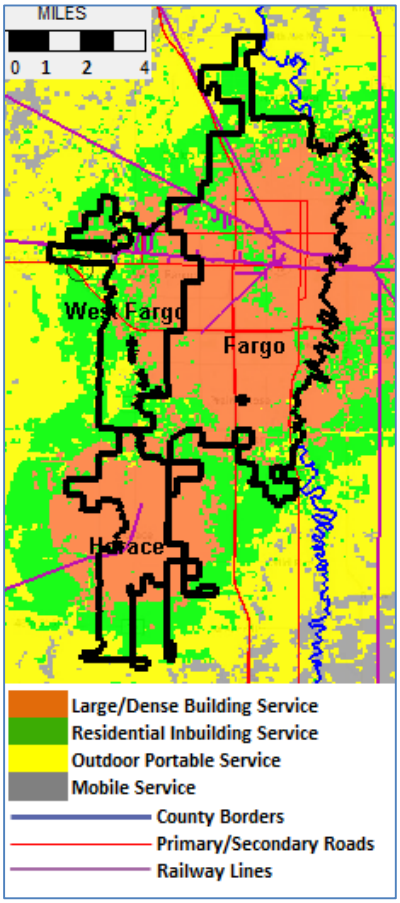


Figure 29: Metro Fargo 800 MHz Coverage Prediction

Figure 28 and **Error! Reference source not found.** demonstrates that an 800 MHz layer can be designed to fulfill the coverage need of these areas leveraging only existing public safety assets.

Hybrid Spectrum Interoperability

By employing a central switch, trunking technology is frequency agnostic and hence supports interoperability between users of both the VHF and 800 MHz spectrum in areas where the services intersect. The proposed statewide VHF solution would still maintain baseline service levels within each of the 800 MHz cities to support in-bound mutual aid responders, and primarily to support State agency VHF subscribers. Select units within each of these cities would be equipped with dual band (VHF/800 MHz) radios to maintain interoperability when responding outside of their jurisdiction[44].

Network Capacity and Frequency Considerations

Eliminating the use of the same set of frequencies at all sites by the State Radio and wherever deployed throughout the State and implementing a structured use of the VHF spectrum statewide is a primary consideration of this report. This network design strategy will enhance radio network performance and quality, simplify operations, be more reliable, and best manage the radio interference currently experienced. The FCC has well-established rules anchored on engineering principles to govern frequency

[43] The City of Fargo has deployed 11 sites and is still experiencing coverage issues. It is expected that the 800 MHz network would use only a subset of these sites and would be anchored on the most optimal tower sites.

[44] It should be noted that migration to the 800 MHz spectrum statewide is not viable and cost effective. The propagation characteristics of the radio signal at this band in flat rural counties are significantly inferior and would require two or three times more sites to provide equivalent coverage.

reuse by proximate entities; radio trunking technology will require unique sets of frequencies at proximate sites to comply with these rules and to manage intra-network interference. Unlike radio spectrum in other bands, the VHF spectrum, which has been available for use by two-way systems for decades, lacks a structured "band plan" which may pose challenges in using this spectrum band statewide. Therefore, the viability of a statewide solution is contingent upon the availability of sufficient VHF frequencies that can be uniquely allocated to each site within the allotted distance.

No of Voice Channels Pairs [45]	No of Channels
2	20
3	50
4	12
5*	21
6*	4
7*	8

***Generally, counties with more than 5 channels include metro areas for which migration to 800 MHz is recommended for the largest cities. Since the bulk of the population will therefore use 800 MHz, there is a potential to reduce the projected number of VHF channels at these sites.**

Table 12: Frequency Requirements by County

While a comprehensive frequency planning effort is beyond the scope of the project, analysis of this potential obstacle is critical in evaluating the feasibility of deploying a centralized VHF network statewide. The capacity needs of all State, Local and Tribal users was estimated using a variety of variables including population density and growth, existing and projected future radio user populations, heightened use during emergencies, and redundancy during equipment failure among others. The projected radio channel needs by County (Table 12) was compared with the current total and unique number of frequencies currently in use by all public safety and public service agencies as summarized in Table 8 (Section 4.2). This assessment demonstrates that a well-conceived reuse plan of existing frequencies could be sufficient to implement the proposed statewide VHF network. Figure 30 depicts conservative (western portion) and average (eastern) frequency reuse patterns; each contour depicts an area within which a given channel can only be used once. However, it is important to note that this model and recommendation is reliant on broad participation of state and local agencies such that the entire pool of existing frequencies can be optimally leveraged.

[45] One additional channel is required for trunking control.

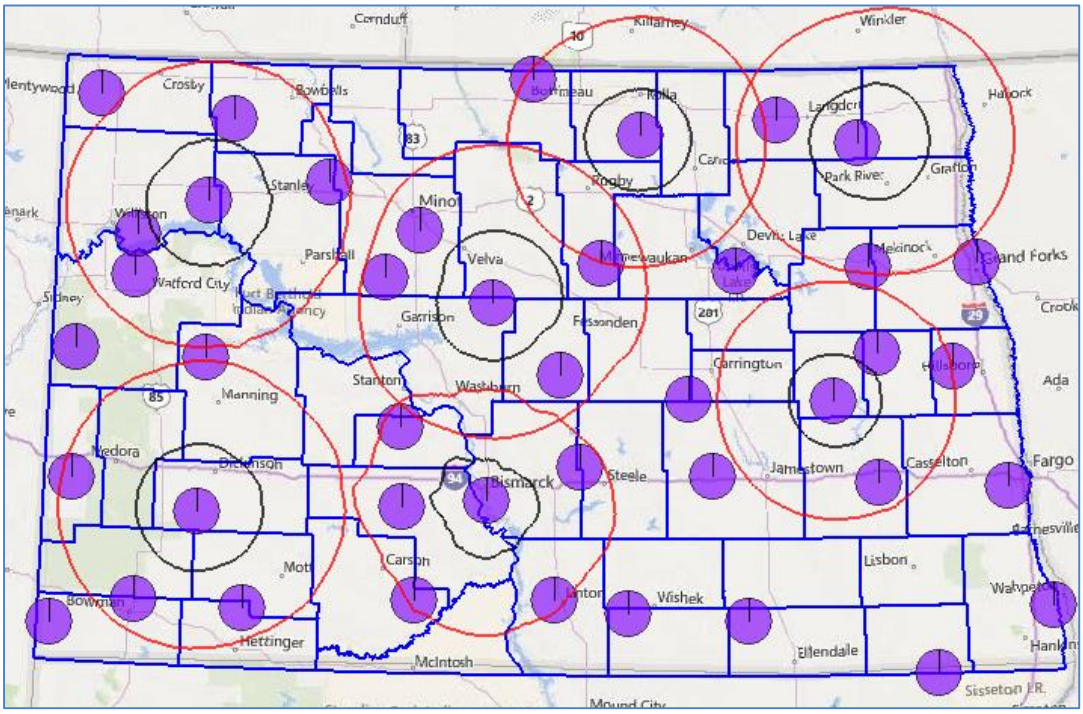


Figure 30: Typical Frequency Reuse Patterns in the VHF Spectrum

Additional analysis is required to determine the number of unique VHF frequencies required to implement the statewide network. Based on a preliminary assessment of the total number of VHF frequencies currently licensed within the state, and an inquiry into the availability of additional VHF frequencies that could potentially be licensed from the FCC, sufficient VHF resources should be available. Additional engineering analysis will also be required on a site by site basis[46] along with an investigation of frequency use in neighboring states to finalize the VHF frequency reuse plan. However, there are available approaches to managing effective frequency reuse and/or reducing overall need:

- More frequent reuse of low priority or oft unused channels
- Use of receive only sites – receive only sites do not require a unique set of transmit channels
- Encourage participation by other entities holding VHF licenses including federal agencies and the private sector

Infrastructure Facilities Connectivity

A centralized network requires that all network components, including radio sites and dispatch consoles (at PSAPs), be interconnected with the central controllers and switches over a robust, reliable network backbone, often called the backhaul or interconnection subsystem. Division of State Radio already supports fiber connectivity provided by the Information Technology Department (NDITD) to all 43 sites, and most large cities maintain high available fiber or IP microwave links. The capacity of these links will

[46] Specific parameters such as transmitter frequency separation, transmitter and receiver isolation and intra-site intermodulation have to be evaluated in a structured and iterative process to validate feasibility.

depend on the function of the facility – that is, a PSAP with a large number of dispatch positions will require higher throughput than a site with fewer frequencies. Existing infrastructure can be leveraged where available, but it is expected that several rural county sites will require new equipment to be integrated into the statewide system.

Microwave links require a higher initial capital investment than the fiber connectivity currently contracted to the State delivered at a cost of $1,200 per month. At $1,200 per month, the microwave capital investment would be amortized within four to six years and could be considered to be a more prudent investment over the long term than the fiber connectivity. There are pros and cons for both options that will impact the Capital Expenditure (CapEx) and the Operational Expenditures (OpEx) investment and budgets.

5.2.3 Underlying Implications of Recommended Solutions

Transitioning to a centralized trunked system has a variety of technical, operational and financial implications that require proper consideration. These considerations include but are not limited to the following:

- **Impact on the competitive market place**: Presently, the independence of local radio systems has enabled a large number of two-way radio vendors, technologies and products to thrive within the State. While centralized trunked systems enable a certain degree of autonomy and vendor flexibility with respect to dispatch and subscriber equipment, centralization precludes the intermingling of central controller and radio site equipment across different vendors. The subsystems and components that comprise a significant portion of the network and corresponding capital have to be procured from a single land mobile radio manufacturer and require unanimous commitment to the selected vendor from all participating members.

  Radio Template and System Access Standardization: To fully exploit the benefits of the proposed radio system, a centralized body has to establish guidelines and regulations on the provisioning of users for system access and interoperability. Specific radio communications user groups would be defined for local and interoperable use by State and Local government agencies and functions. It is expected that system-wide, hundreds of such users groups would be created to sustain the unique and common needs of Local, State and Federal agencies. Radio fleetmaps outline when, where, and with whom they can communicate, what system features they have access to, and which dispatch center supports their operations. A trunked system does have the ability to dynamically create user groups for specific use cases; however, it is vital that a pre-established framework is in place for most operations. Development of a well-conceived governance and operational framework that outlines these complex variables requires dedicated resources to further refine user needs (See Section 5.4 for additional discussion)

- **Operational Usage Considerations**: Transitioning to a fundamentally different technology will likely result in operational changes and undoubtedly require the users' base to be adequately trained. The fundamental changes resulting in the transition to a new radio technology include:

- Division of user groups that have vast jurisdictional geographies yet localized operations into smaller sub groups for system efficiency. For example, Highway Patrol may be divided into HP North East, South West and so forth to ensure that all radio communications are not unnecessarily heard statewide if not required.
- Separation of functional user groups: Since some counties currently have radio channel or system limitations, many agencies share a single conventional channel and all radio subscriber can hear all communications. End users have grown accustomed to listening to all communications, which in some cases are not relevant to their operation, but may have a latent benefit. This functionality can be retained, but trunking would enable private communications while sharing the same channel

- **End User Device Considerations**: Standards enable system users to acquire portable and mobile radios from a large pool of vendors. However, it is recommended that a certified and approved list of vendors and radio models/types be established centrally to ensure that the radio access and feature provisioning complexities do not result in errors compromising effective use and interoperability. The system operator could leverage the Compliance Assessment Program (CAP) – a standardized test facilitated by APCO – to develop such a list and refine with local needs.

5.2.4 Statewide Network Capital and Operational Costs Estimates

Public safety LMR networks require substantial investments to deliver mission critical wireless service to the first responder community. Therefore, a thorough evaluation of the capital and operational impact of the available deployment scenarios is a prudent undertaking. Although a dual layer VHF and 800 MHz trunked radio architecture appears to be the best option to meet stakeholder requirements and radio communications objectives, there are a variety of underlying factors and assumptions that influence the ultimate network architecture and associate capital and operational cost. These factors include the level of local adoption and participation, system implementation time, retention of existing network assets and devices, and the acquisition strategy. This section provides comprehensive capital costs for the evolution of all State, Local and Tribal two-way radio and ancillary systems, subsystems and devices statewide to the proposed primary solution[47]. Where applicable, the impact of these assumptions and corresponding financial and technical implications are presented. It is, nonetheless, important that the State consider and plan for this holistic budget; savings that come to bear due to variations in assumptions may likely have to be diverted to address other elements.

Statewide Radio System Capital Budget Estimates

The capital expenditure estimates presented in the section are based upon extensive market research and past experiences on the cost of LMR vendor equipment and services required to implement a system of

[47] It is important to note that some jurisdictions and Tribal entities may not initially adopt the concept of a statewide network. Only a very small percentage of the total number of stakeholders interviewed expressed concern with the consolidated network and it was not possible to interview all agencies statewide. There was only limited Tribal involvement as well. However, a public relations component of the program would likely flush out and address stakeholder concerns and ideally gain support throughout the State for a consolidated trunked network.

this scope and size. Additionally, the following key assumption and considerations were used to develop the estimated budget:

- **Radio Site Infrastructure**: A total of 114 VHF base station sites anchored on existing infrastructure (radio towers, water towers, building, grain elevators, etc.) are assumed.[48] However, a portion of the radio sites may be implemented as receive-only sites, which would require less capital investment and are expected to provide the same level of service. The financial impact to this network architecture is discussed within this section. 800 MHz Metro area systems will consist of an estimated total of 16 radio site facilities.

- **Site Development** Most sites will require typical Architectural and Engineering (A&E) services and site development activities; however, approximately 40% of the proposed sites are estimated to require additional site development activities to strengthen infrastructure, to construct radio equipment shelters and other civil work required to support the proposed radio equipment.

- **Retention of Existing Infrastructure Equipment**: The ability to reuse certain network components is a primary consideration in the recommendations to remain on the VHF spectrum. Several underlying assumptions to reuse or upgrade equipment including transmission lines and antennas, power and environmental systems (UPS, HVAC and generators), base station repeater and microwave equipment, etc. have been made.

- **PSAP Equipment and Interfaces:** The proposed solution requires all 22 PSAP centers to be interfaced with the centralized network control to monitor and manage their user base. Various PSAPs currently operate legacy dispatch consoles and networking equipment that need to be upgraded to complement the proposed solution. Therefore, replacement of dispatch center equipment, interfaces and corresponding applications is included.

- **Professional Services:** Implementing a network of this scope and scale requires significant engineering, project management, administrative and coordination efforts to ensure a smooth deployment. Numerous assumptions based on similar past deployments and the projected implementation schedule have been made to estimate the expected contracted services and costs.

- **Contingency:** In deploying of a wireless network with over 100 base station sites with differing statuses and 17,000 users, it is important to budget for a wide range of potential issues including tower strengthening, additional rounds of radio programming, and others costly items that may arise. A contingency fund in the amount of 10% is incorporated into the estimated cost; it is recommended that these funds be retained until the completion of the project to minimize delays in acquiring funds for required changes.

Table 13 outlines a Rough Order Magnitude (ROM) costs for a complete mission critical radio network solution based upon the enhancements and recommendations discussed within this report. These costs

[48] Five privately owned sites currently not is use (or leased) by public safety are included.

constitute standard discounts over list price that radio vendors typically offer in state and local schedules. However, competitive and modular acquisition of various elements and vendor negotiations are expected to yield a reduction of 15% – 20%. Radio network vendors typically subcontract most services such as site development and preparation, equipment installation, civil engineering, frequency licensing and permitting to local firms with significant markups to the purchaser; by acquiring these services in a modular fashion (separate RFPs) cost escalation can be controlled.

Category	Estimated Costs
Land Mobile Radio Network and Systems	
Analog Overlay	$ 1,221,740.00
Backhaul Subsystem Equipment	$ 4,322,086.96
Central Network Switch	$ 4,300,000.00
Equipment Spares + Test Gear	$ 1,800,000.00
Paging Systems Overlay	$ 1,974,850.00
Power Systems	$ 6,223,000.00
Site Radio Equipment	$ 25,463,035.00
PSAP Centers Equipment and Interfaces	
Network Interfaces	$ 1,250,000.00
Paging Systems Overlay	$ 990,000.00
PSAP Equipment - Consoles	$ 2,868,750.00
PSAP Equipment - Logging Recorder	$ 1,960,000.00
Services - Engineering, Installation, Management and Training	
Install - Site Radio Equipment	$ 4,606,500.00
Professional/Engineering Services	$ 9,560,000.00
Training	$ 525,000.00
Services - Site Development and Preparation	
Power Systems	$ 952,500.00
Prof Services - Site Radio Equipment	$ 3,936,000.00
Professional/Engineering Services	$ 1,750,000.00
Site Development	$ 5,270,500.00
State & Third Party Costs[49]	
State & Third Party Costs	$ 4,950,000.00
In-building Systems	
In-building Systems	$ 2,512,500.00
Contingency	
System Contingency	$ 8,148,646.20
Total	**$ 94,585,108.15**

Table 13: Estimated Radio Network Capital Costs

[49] A list of "soft costs" including, but not limited to, specifications development, preliminary design, a project management office, regional project coordinators and others are accounted for and detailed in Section 5.4.2

Estimated End User Subscriber Device Costs

Subscriber devices including mobiles, portables and control stations account for a significant portion of the overall land mobile radio migration costs. Unit costs for a device vary widely depending on a large range of functionality, features and the respective manufacturer's cost structure. The evolution of the P25 standard has garnered an increasing number of device manufacturers for the public safety and public sector industry; however, due to the small public safety/service user market (in comparison to the at large population), device costs remain much higher than typical consumer devices. Therefore, funding of these devices by the State was a central theme conveyed by survey participants to ensure high rate of adoption by local jurisdictions and volunteer agencies.

In estimating the cost of radios, a variety of assumptions were made regarding the user population, the ability to upgrade existing equipment and others as detailed below. Importantly, in recent years, State and Local governments have invested significantly in subscriber devices that can be upgraded to operate on the proposed statewide trunked network. A review of the documentation collected indicates that upwards of 40% of existing subscribers, notably of the Motorola XTS and XTL make, have the capability to support trunked operation with firmware upgrades. These devices as well as others from manufacturers such as iCOM, Harris, Tait and Bendix King are expected to function well beyond the manufacturer's published end-of-support dates. However, as vendors implement their planned obsolescence of products, software upgrades for out of support radios will not be available. Upgrade firmware for the Motorola products, for instance are available until only until 2019. Therefore, the successful reuse of these devices with a projected $ 20 M in savings is predicated on an expedited transition to the proposed radio network.

A complete list of assumptions on the development of radio device costs are outlined below:

- Total public safety and public sector radios in operation in North Dakota is 16,700[50]
- Various device and feature tiers targeting different users – career metropolitan area front line first responders would be furnished with higher-tier radios than rural highway departments
- Approximately 5,300[51] radios can be upgraded and repurposed for use by volunteer agencies, public services entities and others, existing higher-tier radios within agencies migrating to 800 MHz can be utilized by law enforcement and other first responders[52]
- All sworn law enforcement devices will be encrypted with multi-key capabilities

[50] A total of 13,200 radios were documented during the project directly from 42 counties and 3 state agencies. However, most documentation was reported to exclude various user groups such as public works, schools, transportation departments and other secondary users. Therefore, estimates were made to account for the remaining 11 counties, missing state agencies and many secondary user agencies based upon trends in existing data, populations served and projections documented through interview and web surveys.

[51] Further investigation of the capability of existing services is recommended to verify whether additional subscribers can be upgraded without replacement.

[52] Metropolitan area agencies (e.g., Grand Forks PD) maintain the bulk of devices that could support migration to trunking technology; therefore, migration of these entities to 800 MHz as the initial phase in the implementation will enable radios to be prepared for distribution to other agencies.

- 1,000 dual band radios are distributed to key city and rural stakeholder to support cross band interoperability
- 1,100 cross-band vehicular systems to be installed in law enforcement and other key emergency vehicles
    - 1,100 dual band radios to pair with cross-band 800 MHz VRS network extenders
- 50% of legacy pagers will be replaced[53]

Table 14 summarizes the estimated cost of subscriber devices inclusive of the associated services such as installation and programming. These costs represent typical list price costs; it is expected that bulk purchases and competitive acquisition could reduce the total costs.

Radio Type	Control Station	Mobile	Portable	Cost
High-Tier	105	1214	1285	$ 14,601,662
Mid-Tier	148	1702	1884	$ 15,552,613
Low-Tier	203	2412	2144	$ 11,599,677
Upgrade Only	222	2553	2826	$ 5,601,840
Vehicular Repeaters			1100	$ 12,100,000
Encryption			1500	$ 900,000
Dual Band			2100	$ 1,890,000
Pagers			5135	$ 2,310,750
Estimated Total Cost				**$ 64,556,543**

Table 14: End User Subscriber Devices Estimated Cost

At an estimated total capital investment of $160,000,000 spread over a five year network implementation timeframe, Table 15 provides a logical list of project implementation activities completed each year and the projected funding requirement per year over this five year timeframe. These activities and corresponding schedule are presented in Section 5.2.6. The spend analysis additionally includes an annual Cost Escalation of 3/5/10 percent to represent how potential changes in the economy of the State could further affect the overall project costs.

[53] Over the lifespan of the proposed network, it is expected that all pagers will require replacement. However, with the advancement of cellular based paging solutions, counties are encouraged to explore alternative solutions in the long term. Additionally, recently purchased pagers can be re-provisioned for continued use over the future solution.

Network Solution Elements	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Land Mobile Radio Network and Systems	$ 0	$15,890,000	$11,160,000	$ 8,880,000	$ 9,380,000	$ 45,300,000
PSAP Centers Equipment and Interfaces	$ 0	$4,390,000	$1,210,000	$1,210,000	$250,000	$ 7,070,000
Services - Engineering, Installation, Management and Training	$3,900,000	$3,810,000	$2,250,000	$2,510,000	$2,230,000	$ 14,690,000
Services - Site Development and Preparation	$ 3,190,000	$4,480,000	$2,350,000	$1,650,000	$240,000	$11,910,000
State & Third Party Costs*	$1,490,000	$990,000	$990,000	$990,000	$500,000	$4,950,000
Vehicular Repeater Systems	$ 0	$3,030,000	$3,630,000	$3,630,000	$1,820,000	$12,100,000
Pagers	$ 0	$580,000	$690,000	$690,000	$350,000	$2,310,000
Mobile & Portable Radios	$ 0	$12.540,000	$15,040,000	$15,040,000	$7,520,000	$50,150,000
In-building Systems	$ 0	$ 0	$ 0	$1,260,000	$1,260,000	$2,510,000
Contingency	$1,630.000	$1,630,000	$1,630,000	$1,630,000	$1,630,000	$8.150,000
Total	**$10,200,000**	**$47,340,000**	**$38,960,000**	**$37,490.000**	**$25,160,000**	**$159,140,000**
No Cost Escalation	$10,200,000	$47,340,000	$38,960,000	$37,490,000	$25,160,000	$159,140.000
3% Annual Cost Escalation	$10,200,000	$48,760,000	$41,330,000	$40,970,000	$28,320,000	$169,570,000
5% Annual Cost Escalation	$10,200,000	$49,700,000	$42,950,000	$43,400,000	$30,580,000	$176,830,000
10% Annual Cost Escalation	$10,200,000	$52,070,000	$47,140,000	$49,900,000	$36,830,000	$196,140,000

Table 15: Project Annual Funding Plan per Project Activity

Other "Soft" Costs or Resource Allocation Items

The SIEC has made a significant step towards evolving mission critical communications in the State by initiating the statewide radio assessment and feasibility study. In advancing the evolution of public safety radio communications statewide, there are several important programmatic and preliminary engineering activities the State has to pursue to formally initiate a statewide radio network implementation, and to promote the concept of an integrated statewide solution. Additional activities and funding to establish a project management office (PMO) and to support a variety of administrative and community outreach

and governance are required. The budget to support these activities have been incorporated into the CapEx estimates in this section; recommended activities include the following:

- Formalize project charter and assemble a project committee and project management office (PMO) team to advance the study and program
- Investigate optimal governance models and conduct statewide outreach to gather ideas, support and adoption
- Conduct concerted outreach, training and public relations programs to establish a solid and legitimate brand, and ensure broad participation (activities include speaking engagements, website development, system branding)
- Advance existing asset collection to obtain additional details and to refine the feasibility of reuse and integration of these assets into the program
- Comprehensive VHF channel search, documentation and planning studies
- Refine radio network solution architecture and develop technical specifications and vendor(s) scope of work
- Develop the strategic plan and secure funding required to procure the network

Statewide System Sustainment and Lifecycle Costs

Network sustainment, operations, maintenance and administration of a statewide mission critical grade communications system is a significant component of the total lifecycle ownership costs. LMR network operational structures vary widely nationwide ranging from government agencies that employ the requisite internal staff and tools supporting comprehensive system maintenance, to agencies that outsource all operational and maintenance needs to third-party contractors. Some operators even opt for a fully vendor owned and operated network and pay subscription fees to use the system. Regardless of the operational structure the state pursues, long term commitment of operational funding is critical to fulfilling the annual software support, maintenance, technology upgrades, engineering and administrative personnel, and a wide variety of recurring network costs,. Well-established network sustainment plans and budget safeguard the longevity of the network and better manage the financial burden of operating a statewide system.

Table 16 summarizes the projected annual costs for the first five years after implementation based upon current expenditures by State Radio and other regional system operators, typical network equipment lifecycle costs, the estimated human capital and anticipated inflation. As radio system manufacturers increasingly anchor their solutions on third party networking equipment and software, comprehensive software and hardware sustainment plans are becoming a common place operational expenditure for recently deployed LMR networks. The estimated operational expenditure presented is based on costs of comparable systems; due to these recently changing paradigm however, the costs for these plans remains dynamic and could vary greatly depending on the ultimate O &M structure. In addition to typical radio network sustainment cost, support personnel resources at the state, regional and local levels to support the technical, administrative and functional needs of the users are included.

Operational Cost Category	Year 1	Year 2	Year 3	Year 4	Year 5
Vendor Network Maintenance & Technology Refresh	$3,420,000	$3,520,000	$3,630,000	$3,730,000	$3,850,000
Infrastructure Maintenance & Support: Utilities, Lease, Upkeep	$1,220,000	$1,250,000	$1,290,000	$1,330,000	$1,370,000
Network Facilities and Data Center Connectivity/Leased Lines	$ 860,000	$ 890,000	$ 920,000	$ 940,000	$ 970,000
Operations and Maintenance Personnel	$2,210,000	$2,270,000	$2,340,000	$2,410,000	$2,480,000
Estimated Annual Costs	**$7,710,000**	**$7,930,000**	**$8,180,000**	**$8,410,000**	**$8,670,000**

Table 16: Annual Operational Costs Estimates

5.2.5 Funding Strategies

The funding of the consolidated statewide radio network implementation will require a significant capital commitment that would ideally be expended over a 3-5 year timeframe. A project of this magnitude can be completed within this schedule, particularly in consideration that the State has significant existing assets, and is unlikely have to build new radio towers. The construction of new towers is one of the longer lead items in radio network deployment programs and typically result in project delays.

The schedule of the capital allocation depends on the pace in which the State proceeds with the implementation program as described. At a projected capital investment of $165,000,000 spread over a five year timeframe, a funding allocation strategy of $33,000,000 committed annually over that period of time represents a conservative funding approach. Completing the program within a five year timeframe would also allow the State to upgrade a substantial percentage of existing radios, after which time these radios would need to be replaced. Therefore, the speed of the implementation will affect the final projected cost.

Regarding the source of the capital funding, the State of North Dakota would need to assure the funding availability to proceed with the program. While there is broad support for a consolidated trunked radio network, based on the results of the stakeholder survey, there are limited sources of funding available at the local level to support the program. The State legislature would need to commit to the program and associated funding via a direct capital allocation or via a bond initiative. The funding commitment must cover the radio network infrastructure, the portable and mobile radios, the project management team and all other associated program costs. It is also recommended that an ongoing State funding allocation be considered to maintain and operate the network, or at a minimum, while a radio governance structure is solidified to include the ongoing contribution of end users entities to sustain the network, that the State fund the network operations over an appropriate timeframe.

In summary of the funding strategy, the following considerations are offered:

- The baseline radio system and radio subscribers funding is provided by the State

- State funding for radio subscribers and radio paging devices for State and Local public safety agencies, Volunteers Fire and Medical Service personnel, and public service agencies including public works, schools and others

- The conversion of private ambulance operators and personnel onto the network could either be subsidized via a grant, a no/low interest loan, or an alternative funding mechanism where appropriate
- Opportunity to provide access to the network to private commercial entities including utility, transportation and oil and gas and other entities and to secure capital funding from these businesses[54]

Acquisition Strategies

The approach for procuring the proposed radio network should be based on an open competitive process. While there are only a few companies that would provide the trunked radio infrastructure, there are many other system integrator companies that might be interested in the program, and there are a variety of radio subscriber companies that can provide portable and mobile radio that can properly operate on the network. It is likewise important that State of North Dakota radio shops that currently support State and Local radio communications requirement be integrated into the ultimate solution.
In summary of the solution acquisition process, the following considerations are recommended:

- Competitive radio infrastructure equipment, construction and installation process
- Radio network and subscriber equipment based on the public safety Project 25 standard, which will further stimulate the competitive vendor environment
- Select equipment including radio subscribers, vehicular repeater systems (VRS), radio consoles, computer aided dispatch (CAD) and others to be incorporated into an Indefinite Delivery Indefinite Quantity (IDIQ) supply schedule for approved vendors and equipment to facilitate long term individual entity procurement requirements
- Modular acquisition with direct contractor firms for site development, civil and electrical work
- Program management office contract staff to support the State in the system procurement and implementation process, to prepare and deliver training, develop standard operating procedures (SOP), field operations guides (FOG) and communications plans; and to support the program and act as the agency that manages the network implementation, adoption and cutover

5.2.6 Phased Implementation Approaches

Implementing a seamless technology migration of this scope is a complex and challenging undertaking requiring a well-conceived approach that minimizes network downtime and aligns with the appropriated funding. A series of logical steps as outlined below may be used to guide statewide implementation of the proposed solution over a period of three to five years. This timeframe is a critical aspect of retaining the ability to reuse subscriber equipment with an estimated saving of $20 M that cannot be upgraded beyond

[54] Alternatively to seeking capital funding from commercial users, securing their commitment to use the network under a monthly fee based relationship should be considered.

2019. Importantly, as described in Section 6 Next Steps, a variety of key internal activities that precede acquisition of a statewide solution and the commencement of network implementation will have significant impact on the overall deployment schedule. Of foremost importance is the development of a program that fosters broad participation in the prospective solution by State and Local entities under a structured governance framework. The State should immediately begin the requisite outreach and branding efforts, and establish a project team and charter to ensure timely network implementation. These efforts would be conducted in parallel with technical and engineering activities including site selection, frequency engineering and requirements refinement in support of comprehensive specifications and scope of work development.

A high-level phased implementation plan approach is presented below.

Phase	High Level Activities	Y1	Y2	Y3	Y4	Y5
I - Pre-Acquisition	▪ *Site selection, analysis and preparation* ▪ *800MHz/VHF Frequency search/licensing* ▪ *Radio equipment inventory development*					
II - System Acquisition	▪ *Specifications development and vendor negotiations* ▪ *System Selection and contract execution*					
III – Metro Area 800 MHz	▪ *Migrate Metro Areas to 800 MHz to vacate frequencies and prepare portables and mobiles for reallocation*					
IV – Regional VHF layer Implementation	▪ *Regional VHF deployment - four to six regions approach -PSAPs*					
Radio Procurement Redistribution and Programming	▪ *On-going efforts to gather, provision and distribute radios*					
Estimated Annual Costs (in Millions)		**$ 10.20**	**$ 47.34**	**$ 38.96**	**$ 37.49**	**$25.16**
Total Cost of Goods and Services (in Millions)		**$159,140,000**				

Table 17: High Level Network Implementation Timeline

5.3 Near Term Enhancements and Other Initiatives

The North Dakota Department of Emergency Services (DES) has expended considerable effort to advance public safety radio communications throughout the State. Their achievements are commendable, particularly considering budgetary and staffing limitations within the department. While DES actions are favorably recognized by the statewide community they support, there are a variety of communications needs of the statewide public safety community and new initiatives that should be considered. A next generation mission critical radio network will certainly mitigate current communications gaps and provide end users with desired features and performance reliability; however, there are a variety of near-term enhancements that will provide end users with improvements and capabilities that will deliver important

operational benefits immediately. Table 18 describes recommended near term activities and other opportunities that can be undertaken to enhance public safety communications capabilities, personnel safety and interoperability.

Activity Name	Activity Description
Radio and Communications Training	End users, particularly volunteer fire fighter and emergency response personnel, need additional training on radio capabilities and operations. Training considerations include: ▪ Develop online training modules ▪ Develop a web-based collaboration site and information exchange board for radio users and others to ask questions and share knowledge ▪ Retain fulltime and/or as-needed trainers in all public safety divisions (police, fire, EMS, EMA, etc.) and provide ongoing/periodic training onsite ▪ Develop and foster a train-the-trainer program ▪ Conduct periodic radio certification to ensure and demonstrate capabilities ▪ Develop a requirement or incentive to ensure volunteers attendance.
Exercises	▪ Facilitate regular exercises to regularly demonstrate capabilities and to identify gaps that need to be addressed ▪ Exercises should be coordinated and facilitated by the State, ideally through the State DES ▪ Develop and make available scripted exercise to ensure that these events achieve the desired outcome and that gaps identified are reported and addressed
Regional Emergency Communications Working Groups	▪ Implement a program to foster the development of Regional Emergency Communications Working Groups that regularly discuss capabilities, gather and refine requirements and define initiatives to enhance voice and data interoperable communications ▪ These Working Groups would be composed of key public safety agency representatives, facilitated by the appropriate State agency (possibly the State DES) that can present the mission critical communications requirements of their respective regions ▪ Retain Regional Interoperability Coordinators (RICs) who maintain a dialogue with the regional committees, gather information and function as a liaison among the regional committees, SIEC and lead State agency
Utility and Railroad Partnership	▪ Develop and maintain an ongoing relationship and partner with energy and transportation authorities and utilities, and the oil and gas industry to expand the network subscribership to these entities
Vendor Certification	▪ Implement a certification program for all radio shops to ensure they possess the required skills, capabilities and knowledge regarding State and Local public safety communications requirements and associated processes

	▪ Conduct semi-annual meetings with the radio shops to discuss requirements, issues, new technologies, performance gaps, and other topics of mutual interest ▪ Enter into a dialogue with the major manufacturers represented by statewide communications shops and develop a process by which local service shops and vendors are certified and trained on the vendor products
Additional Data Interoperability Initiatives	▪ Develop a framework for the State to support a hub-and-spoke model for extending complex and costly data systems to underserved rural leveraging the economies of scale ▪ Approach can be used common CAD systems, 911 call-taking systems, mobile data systems, and database sharing including law enforcement records and Geographical Information System (GIS) data sets ▪ Work with the stakeholder community to define and advance data sharing initiatives to provide access to a robust family of law enforcement, fire, emergency medical, emergency management and others
Enhanced Paging Services	▪ Supplement the current radio page with an email blast and text message to first responders not currently receiving mobile data dispatches ▪ While eDispatch and IamResponding commercial text messaging applications are being utilized by volunteer fire and ambulance services that can afford these applications, not all volunteers have access to these solutions, and such services could be offered centrally ▪ Alternatively, the State could enter into a master agreement with the providers of eDispatch and/or IamResponding and offer volume discounts to end users

Table 18: Near Term Activities to Enhance Public Safety Communications

5.4 Emergency Communications System Governance and Operations

The Statewide Interoperability Executive Committee (SIEC) and various public safety and Local government associations (Sheriffs and Deputies, Fire Chiefs, 9-1-1 Coordinators, Emergency Management, APCO and others) represent their respective constituents regarding matters of emergency communications, operations and practices, among other challenges. The SIEC plays a more central role in the assessment of mission critical communication requirements and gaps, and in the advancement of initiatives to address major challenges. Structurally, the SIEC organization includes committee members from these key public safety associations, along with other large public safety radio system end user entities (ND Highway Patrol, ND Department of Transportation, Emergency Medical), and therefore collectively the SIEC represents the statewide radio stakeholders.

The SIEC will continue to assess and guide public safety and emergency system communications and information sharing requirements and initiatives. Individual agencies and associations will continue to focus on the unique requirements within their respective disciplines. A consolidated radio network would

require even greater collaboration and present significant opportunities for State, Local and Tribal agencies to enhance interoperability and cross-agency/jurisdiction response and mutual aid. The statewide network will require a functional governance structure and associated organizational composition to define requirements and guide the eventual network operator to properly operate and maintain the network to the defined public safety grade. A statewide network supporting all or most State, Local and Tribal end users will encounter operational challenges, but when properly governed will deliver tremendous performance, interoperability and cost management benefits.

In architecting the governance model, the State begins with a fresh start and should assess and vet the model with members a variety of options before creating a final structure. The primary objective of the radio network governance – or perhaps best referenced as the emergency communications systems governance organization – is to integrate the broadest possible statewide participation from rural, metropolitan, state, tribal and commercial entities into the organization. Collectively, operating under a formal Charter and well-structured Bylaws, the governance organization would define network operational requirements, determine and manage membership, define and assess fees, address operational issues and network evolution, and ultimately manage network operations from a tactical perspective. The governance organization should also advise the SIEC on matters of voice and data interoperability and make recommendations regarding future initiatives to advance interoperable communications.

An inclusive organization does not necessarily require that all voting members attend every statewide committee meeting in concern that their respective requirements and local jurisdiction's voice is not represented. The regional-based model, as illustrated in Figure 31, would be structured such that regions within the state are organized and tasked with the governance of their respective regions. The regions would be created based on the most rational mutual aid relationship and could adopt existing regional composition as derived from Emergency Management, State Radio or other current structures. Delegated members of the region would additionally represent their region in a statewide executive committee where requirements of the statewide emergency systems are advanced.

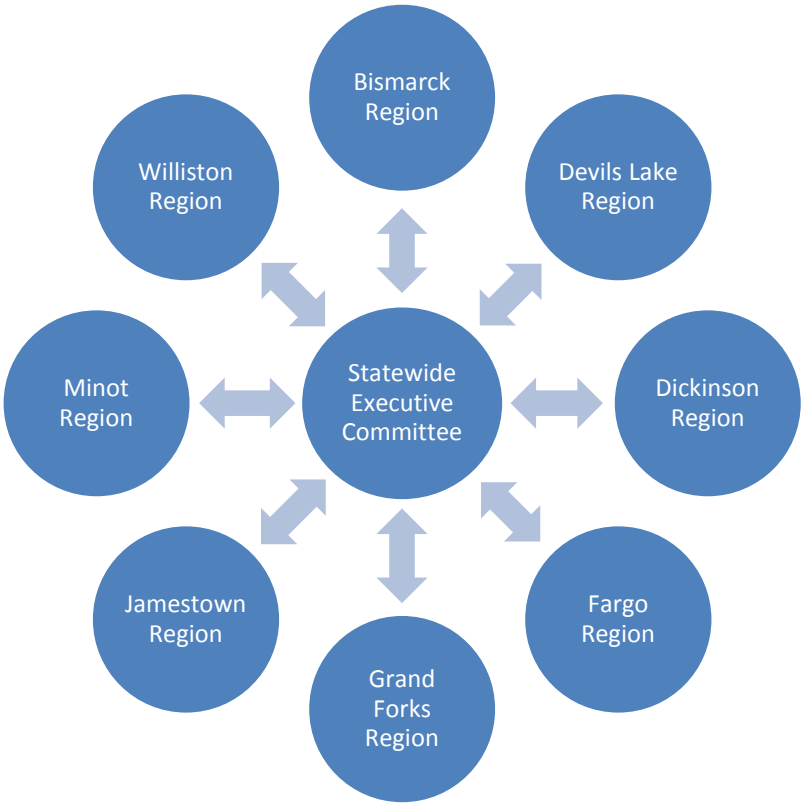


Figure 31: Region Based Governance Structure

Figure 32 illustrates an alternative Functional Areas based governance structure where the representation of areas is based on the unique geographic or functional focus of emergency communication system end users. A combination of both the regional and functional areas might also be investigated.

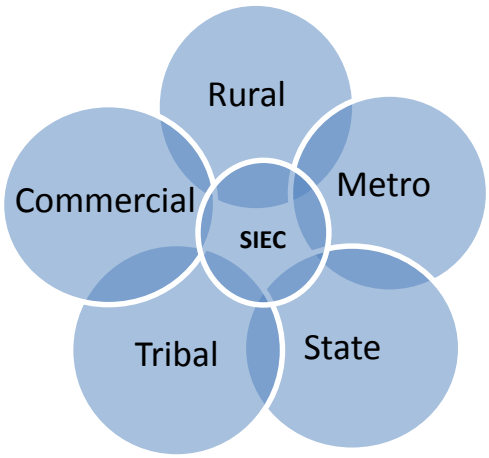


Figure 32: Functional Area Based Statewide Governance Structure

A well-conceived and structured governance organization will best ensure the proper design, operations and sustainability of the proposed consolidated radio network and other emergency communications

systems that may be considered by the regional and state committees. The governance organization should be vetted with stakeholders during the outreach and public relationships efforts, and options and ideas should be solicited during those meetings. The best model will be a reflection of the stakeholder community's goals and objectives.

6 Next Steps

The SIEC endorsed the statewide Radio Assessment to determine needs and options to enhance and advance public safety communications throughout the State. The public safety agencies and their employees identified their respective requirements and identified radio communications gaps. Table 19 details fundamental next steps and decisions that need to be undertaken to define and implement a successful program to achieve the desired goals and objectives.

Table 19: Next Steps and Actions

Next Step Tasks/Decisions	Task Description
Consolidated Radio Network	▪ The consolidate trunked radio network is designed to support all State, and Local requirements, however a decision to pursue this architecture must be determined ▪ In the event that the State does not advance a statewide trunked radio network, the individual State and Local network enhancements strategy and associated costs need to be investigated
Outreach and Public Relations	▪ Once an executive decision is made regarding the radio network funding and strategy, outreach to the statewide community must be undertaken ▪ While there was widespread support for a consolidated statewide network expressed at the public safety level, outreach to the local government leadership will be required to gain their support ▪ Additional outreach and Public Relations (PR) at the public safety level for all State, County, Cities, Tribal Nations and others must also be undertaken
Governance Structure and Organization	▪ The governance organization and associated charter and bylaws governing the decision-making process and operations of the consolidated radio network must be created ▪ Governance would address membership, fee structures, operational process and procedures, asset contributions (towers, frequencies, backhaul, and other shared facilities), interoperable communication requirements (communications plans, standard operational procedures, mutual aid channels, etc.), and other salient requirements
Procurement Plan and Approach	▪ Once the necessary funding is appropriated, the radio network procurement strategy and support team would be defined and assigned

	▪ While relevant information (radios, tower assets, frequencies, number of users, etc.) and requirements were gathered over the course of the Radio Assessment program, more comprehensive efforts to gather, assess, and catalogue this information must be undertaken statewide ▪ The proposal development team would prepare the competitive Request for Proposal and the evaluation team would be assembled
Preliminary Radio Network Design and Specifications	▪ In conjunction with the network procurement process, a preliminary radio network design, elaborating on the work advanced through the Radio Assessment project, would be developed ▪ Develop a design to further assess radio tower and equipment facility availability and to assess radio spectrum licenses and assignment to the design ▪ The preliminary design facilitates the procurement effort by assembling essential content for the RFP, validates the radio network design, and best positions the State for a successful program
Project Management Office - Implementation Plan and Schedule	▪ A project of this magnitude and scope will require a dedicated Project Management Office (PMO) to facilitate all activities associated with the Project and Fiscal Budget Management, Outreach, Governance, Procurement, Network Construction and Implementation, Training, and Cutover ▪ An implementation project plan and associated schedule is required to guide the overall program and would be the responsibility of the PMO to develop and oversee ▪ The lead agency responsible for providing executive oversight must be selected – recommendations include the Information Technology Department (ITD), the Department of Emergency Services (DES) and the Department of Transportation (DOT)
Radio Network Operator	▪ The North Dakota Department of Transportation (DOT) currently operates the State Radio network and a decision to continue that operator relationship must be made ▪ An alternative radio network operator strategy could be determined by the executive governance committee
Network Operational Committee	▪ A working committee would be established to determine the critical considerations, procedures and processes that must be achieved to advance the radio network implementation and cutover plan for all end users. Activities to include but not be limited to: ▫ Individual agency radio communications requirements and associated radio fleetmaps ▫ Multi-agency/multi-jurisdiction interoperability requirements and associated fleetmaps ▫ Training, exercise, communications plans and standard operating procedures ▫ Trouble reporting and resolution approach

	▫ Process to suggest network enhancements and expansion ▪ The working group members would include broad representation of all radio user stakeholder agencies and entities to ensure that a comprehensive network adoption and operational plan is prepared and implemented

7 Concluding Remarks

North Dakota public safety agencies have a great and growing need for upgrades to their radio communications systems. Through a process that involved interviewing and surveying agencies throughout the State, it became clear that many agencies lacked access to modern radio technology; that maximally effective use of the network and devices can be challenging to ensure; and that there are critical requirements to improve coverage, capacity, and interoperability. Rectifying these shortcomings relies on investing in network and operational solutions that enhance user experience and network sustainment, operations, maintenance, and administration. However, none of this can be achieved optimally without including those user agencies in the decision-making process. The State has taken an important step in this matter by commissioning this Radio Assessment project. It is to the benefit of the entire State and its citizens that we meet the needs of State and Local public safety agencies and provide them access to a mission critical radio network that supports the many communications demands placed on them. Affording them these resources is how we assume the responsibility to protect those who protect us.