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State of Missouri / Ameren
Missouri Statewide Mobile Radio
B&V Project 144063/146220

23 March 2007

Subject: Statewide Mobile Radio Concept Study

Dear State of Missouri / Ameren:

Black & Veatch is pleased to submit this Statewide Mobile Radio Concept Study to State of Missouri / Ameren for the Missouri Statewide Mobile Radio Project.

It has been our sincere pleasure to work with representatives from both Ameren and the Missouri State Highway Patrol in support of this concept study. This Final Issue of our report incorporates comments and input received throughout the study process in regularly scheduled meetings and teleconferences.

A statewide mobile radio network represents a substantial investment in building and operating a large amount of infrastructure distributed across the state geography to serve network users. This study provides a defined technical solution based on Missouri's requirements in a statewide network along with a recommended approach for moving forward.

It is our continued objective and commitment to assist the State to continue development of a statewide mobile radio network capability to serve the needs of the Missouri stakeholders and enhance public safety throughout the state. We trust that this submittal meets your expecations and needs. Should you have any comments, please feel free to contact me at (913) 458-8988.

Very truly yours,

BLACK & VEATCH

Charles D. Hill
Project Manager

CDH
Enclosure[s]

cc: Ameren and Missouri State Highway Patrol

State of Missouri / Ameren

Missouri Statewide Mobile Radio

STATEWIDE MOBILE RADIO CONCEPT STUDY

March 2007

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1.0 Executive Summary

Ameren and the Missouri State Highway Patrol have together initiated this study with Black & Veatch to develop a statewide mobile radio network concept for Ameren and state government and present recommendations concerning a statewide mobile radio network to serve public safety and critical infrastructure users throughout Missouri.

Why is a Statewide Mobile Radio Network Needed Now?

The State of Missouri is at a critical crossroads in the area of public safety radio communications infrastructure. Although the citizens of Missouri depend on public safety agencies to assist in the full range of emergency situations, these agencies are dependent upon aging and outdated communications infrastructure inadequate for the task. Radio communications systems in use by various state agencies are fragmented and provide very limited capacity. Disparate, standalone systems exist with separate, dedicated radio channels across a number of different frequency bands. Electric utilities and other critical infrastructure entities in Missouri also have disparate radio systems on separate channels, together duplicating additional systems across the state geography. Other government users at the federal and local level have requirements for radio communications around the state with their own towers and systems. Local government users across Missouri also have outdated systems, many with an FCC mandated requirement for replacement by 2013. A unique combination of factors exists creating a window of opportunity for developing a single, combined statewide radio system that could be expanded over the next few years to efficiently serve all these users. Unless the state moves ahead quickly however, there is significant risk that potential stakeholders will move ahead independently, continuing to build separated new facilities without coordination or integration, at the same time compounding the current obstacles toward interoperability and intercommunication among public safety and other emergency responders in Missouri.

The lack of interoperable communications continues to be a serious public safety problem with regional and nationwide focus. The events of September 11, 2001, as well as the recent hurricanes and other disasters reinforce the real and pressing need for public safety departments and other agencies, including police, firefighters, public health officials, and critical infrastructure workers to communicate reliably and effectively in a larger emergency scenario. While Missouri has undertaken a number of efforts to help with understanding and responding to this need, the development of a shared, mobile

communications infrastructure provides the greatest opportunity for achieving the maximum level of interoperability possible, today and in the future.

As a prime example of a system in need of replacement, the Missouri State Highway Patrol radio communications system technology has not undergone significant change since the 1950's, with only minor cosmetic enhancements through the years for additional geographic dispatch areas, and a change to personal computer based consoles for dispatchers in 1995. The current system provides only a single talk channel for any given geographic area of the state, totally inadequate for broader emergency situations. Other state agency systems also have limited capacity. Ameren, the largest electric utility in Missouri, has similar radio communications needs over a large portion of the state. Ameren's existing radio system, built in the early 1990's, will need to be updated or replaced within the next few years. Ameren is exploring a potential partnership to develop a single, shared system with the state in this current study. The supporting infrastructure in the existing Ameren system such as radio towers, microwave and fiber facilities, and licensed frequencies brings valuable assets to the table for a statewide system. There are other local government participants who have also expressed potential interest in a shared system. Many of these entities also have outdated, separate systems overdue for replacement due to age.

Creating a shared, statewide mobile radio system supports and aligns with several other current initiatives in the state. In 2001, the State Interoperability Executive Committee (SIEC) was formed to address interoperability issues in Missouri. The SIEC has been instrumental in setting standards for interoperable communications equipment and recommending distribution of Homeland Security funding. A shared, statewide radio system would provide the ultimate vehicle for interoperability in Missouri. The Missouri Department of Transportation has developed Intelligent Transportation System (ITS) facilities around the state that can also provide synergy with a shared mobile radio system. New trunked mobile radio systems in the urban centers of Springfield, Independence, St. Joseph, Joplin, and one planned for St. Louis, also provide unique opportunities for integration with a state system. The State of Missouri Office of Administration is exploring a next generation state data network that could also provide unique synergies for sharing backbone facilities such as fiber optics or microwave. The refurbishment of decommissioned microwave networks by the Missouri State Highway Patrol could potentially offer capacity where available to a next generation data network. A statewide mobile radio network infrastructure dovetails very well with all these

initiatives and can be expected to open doors for other future opportunities across the state.

The radio frequency spectrum available upon which to develop networks is extremely limited as regulated by the Federal Communications Commission (FCC). Because there are not enough radio channels available for eligible users, the FCC has instituted "refarming", a requirement for users below 512 Megahertz that will require a large number of local government users in Missouri to replace their existing radio systems before 2013. This FCC mandate creates additional opportunity for local participation on a state system, with cost efficiencies for all. Because of the overdue need for additional spectrum for the accelerating needs of public safety, the FCC has recently allocated an additional band of frequencies in the 700 Megahertz frequency range for public safety use. These frequencies are now available in the State of Missouri to utilize in a statewide system if they are used before they are licensed to others.

Ameren's interest in participating in a state system provides an opportunity for a unique public private partnership with valuable benefits for both Ameren and state government. Cost efficiencies in a statewide system will ultimately benefit both taxpayers and ratepayers in Missouri.

Together, all of these factors present an unprecedented window of opportunity to capitalize on the benefits of a shared, statewide radio system. Unless the state moves quickly however, leading the development of a statewide system, other potential participants will be forced to go their separate ways, using the available frequencies and other assets independently, moving forward to meet their own needs. Instead of improving the state of radio communications for all of the public safety and critical infrastructure professionals across the State of Missouri, the situation would instead become worse. The opportunity would be lost for the foreseeable future, and many of the available, required assets would be depleted.

What are the Requirements for a Statewide Mobile Radio Network?

The requirements of the public safety and commercial infrastructure users in Missouri are important not only for the effective performance of their day to day job duties, but are vital to the safety of life and property for Missouri's citizens. For these users, radio communications are absolutely mission-critical. Mission-critical radio systems are much more robust, more reliable, and tailored more closely to the unique communications needs of public safety than what commercial systems offer today.

While many public safety users may use cellular phones and other commercial wireless devices as a non-critical communications tool, these devices are currently not sufficiently suited for public safety mission-critical communications during critical incidents. As evidenced by incidents such as the Columbine high school tragedy, public safety officials cannot depend on commercial systems that can be overloaded and unavailable even in local emergencies. Examples of the unique and demanding communications needs of public safety and critical infrastructure users include:

- Dedicated channels with immediate priority access available at all times to handle unexpected emergencies.
- Reliable one-to-many broadcast capability, with the flexibility to dynamically assemble talk groups and patch user groups as needed in emergency situations, capabilities not generally available in cellular and other commercial systems.
- Highly reliable and redundant networks that are engineered and maintained to withstand natural disasters, extended power outages, and other emergencies.
- Highly reliable coverage across the entire geographic area, without loss of service in remote locations.
- Unique equipment designed for quick response in emergency situations—dialing, waiting for call connection, dropped calls and busy signals are unthinkable during critical events when seconds can mean the difference between life and death.

A complete matrix of requirements was developed in this study with participation of Missouri stakeholders. This “Requirements Matrix”, along with a detailed description of each of the requirements is included in Section 4.0. In addition to the voice mobile radio requirements, a fundamental mobile data capability is also needed as identified in the requirements. While in the beginning a shared, mobile radio network will not be expected to meet all the future needs across the state with regard to high speed mobile data communications, a statewide radio system will provide a fundamental infrastructure upon which a future, higher capacity mobile data communications capability can be developed.

What Would a Successful Statewide Mobile Radio Network Look Like?

Based on the defined requirements, alternative technologies were evaluated to develop a recommended technology solution for Missouri. Commercial carrier wireless technologies currently available in Missouri do not meet the system or user requirements. The private radio technology most suited to the needs of public safety and critical infrastructure users, and most often used for statewide networks for these types of users is commonly termed "wide area trunking". Wide area refers to signal coverage over a large geographic footprint. Trunking is a term for the technology for sharing a number of available channels among a larger number of users and talk groups on an as needed basis, without interference. Trunking systems also provide features specifically designed to address public safety needs, such as priority access and field-initiated emergency alerts.

The recommended solution includes Project 25 interoperability. Within the public safety community, industry and individual members of local, state, and federal public safety agencies have engaged in a long-term standards development process known as Project 25. Most states and regional consortiums developing shared systems are installing equipment that complies with the Project 25 suite of standards. In addition to being a recognized common standard for public safety networks, Project 25 is also the equipment standard for federal government users.

With regard to radio spectrum, the only frequency band that can support a statewide system based on what's currently available for licensing is the 700 Megahertz band recently allocated by the FCC for public safety. Manufacturers are providing equipment that will work both in this 700 Megahertz band and the 800 Megahertz band currently in use in the urban systems around Missouri as well as Ameren's current system. This availability of dual-band equipment provides another driving factor for selecting this as the primary band for use in a statewide system. Because the higher frequency bands (700 MHz and 800 MHz) will not provide a sufficient range for coverage in the challenging terrain in the southern parts of Missouri, the proposed solution utilizes High Band VHF channels in the Ozarks. In addition, a statewide VHF Mutual Aid capability is included for interoperability with maximum opportunity for all equipped VHF local government users across the state.

The recommended technical solution provides the best approach for meeting Missouri's requirements, offering the opportunity for additional participating entities, and enabling the maximum opportunity for future growth at greatly reduced, incremental

cost. The technical solution presented in this study develops a foundational system to meet the immediate needs of Ameren and the State, with expansion potential for others to join in the days ahead. It is based on maximizing and leveraging the significant value in the existing assets available for a statewide radio system, including potential sites, existing towers, radios, microwave and fiber facilities, etc.

What are the Expected Benefits, Costs, and Risks?

A statewide radio system requires a substantial cost commitment no matter who builds it. In 2003, a national study reported that replacing basic radio systems for a single state public safety agency would cost between $100 million and $300 million. Statewide systems serving multiple agencies are generally estimated in the hundreds of millions. Estimates in other states have projected the costs of building separate systems for individual agencies to be as much as four times the cost of a single, shared solution. The concept design for a statewide network in Missouri estimates a capital cost of $251,664,000 for the fixed infrastructure, with an additional $14,215,000 in user equipment for the Missouri State Highway Patrol. The estimated annual operational cost is $13,802,000 based on budgetary estimates from equipment vendors.

The initial capital cost of a statewide network is significant. This high cost is confirmed by the experience of other states, but there are substantial benefits in a shared system. The most obvious is the efficiency of this shared system cost. Outside of participating in a shared system, agencies with similar needs across Missouri will almost certainly be duplicating each other's purchases at some level. The potential economy of scale offered by sharing a combined, statewide system almost guarantees both capital and operational cost savings by definition. Right now the State of Missouri and Ameren are both actively looking for a shared solution. Other local government and utility entities have also expressed interest in a potential statewide system. All of these parties bring many valuable assets to the table beneficial to the whole. The result of a statewide effort is a synergy that can produce a higher quality system than any one party could achieve on their own at less cost.

It is vital to recognize that the cost of not building a statewide radio system is not zero. In fact, it is not a given that the overall long-term costs of not building a statewide system are less than the costs for building a shared, statewide system. Eventually both the State of Missouri and Ameren will be forced to implement some kind of mobile radio system to meet their own communication needs. If these two systems are built separately, there will be a significant cost spent in overlapping technologies, duplicated

infrastructure, and perhaps a sacrifice in individual system performance, coverage or quality in order to make the costs attainable.

The same joint, shared system concept can be expanded upon with other parties as well. Other utilities, for example, also will need mobile radio coverage in the same geography, multiplying overlapping systems with similar equipment in the future. The ability to share one single radio system amongst several users allows for significant savings among all parties. The more users that come to the table with funding or existing infrastructure, the greater the savings will be for everyone. However, all parties' needs are time sensitive, in that something will need to be done to meet the needs for each in their required timetable. If a shared system cannot be built, individual entities will be forced to act independently in their own interests. Instead of saving money and solving problems, future costs will rise and interoperability problems will be compounded.

As with any large, public infrastructure project, there are a variety of risks that must be controlled and managed to achieve the best results. Identified risks, along with recommended mitigating strategies are included in the study in Section 6.0. In the big picture however, it is obvious that the greatest risk is presented by the guaranteed loss of opportunity in the event the State is unable to move forward within the currently available window of opportunity. The combined value of factors such as the currently available frequency spectrum in the 700 MHz band, as well as Ameren's potential public/ private partnership in a shared system cannot be understated.

What Alternatives are Available for Ownership and Operation (Governance)?

Missouri is not alone in facing these issues. In many states around the U.S., radio systems are long overdue for replacement due to age alone. An increasing number of local, state and federal agencies have come to realize they cannot solve the problem alone. State and local agencies across the U.S. are exploring partnerships to develop shared systems. As a part of this study, other states were researched and interviewed. The summarized results are presented in Section 7.0. A comparison of the approaches and initiatives revealed three general categories of statewide systems: state-owned systems, vendor partnerships, and evolved partnerships. In state-owned systems, the state government provides leadership and funding for a statewide network. In a vendor partnership, an equipment manufacturer builds a system and either provides a "fee-for-service" arrangement for the state, or a "Lease-Purchase" vehicle for the state to own the network without a complete, up-front capital requirement. In the evolved partnerships,

various entities agree to inter-connect their systems, or build on their existing systems as they can over time, creating a "best-effort" capability.

In Missouri, a state-owned system would be the optimal solution. In the view of the general public, it is most often considered the responsibility of state government to provide for the public safety as a fundamental responsibility of government. In consideration of all the factors involved, it appears that the most effective strategy with regard to a statewide mobile radio network for public safety would be a state-owned system. If a statewide network is developed to meet the needs of public safety users, the needs of additional users can also be easily included and accommodated. A state led initiative to build a state-owned network offers the most certain opportunity for meeting the requirements within the next few years.

What are the Recommendations for Missouri?

State ownership and leadership in a statewide mobile radio network offers the best certainty for fulfilling the comprehensive requirements of the state agencies, Ameren, and other future participants. While local agencies are sometimes hesitant to commit to state initiatives when they're still on the drawing board, the experience of other states universally indicates that once a statewide network is in place, local agencies usually become eager to join in because of the benefits. A clear commitment by the state to fund and build a statewide mobile radio capability can be expected to maximize the earliest participation of all the other potential participants and realize the benefits for all users at the lowest cost.

A statewide mobile radio network represents a substantial investment in building and operating a large amount of infrastructure distributed across the state geography to serve network users. In building such a system, we believe that state funding and ownership is the best alternative for meeting the needs and requirements of the stakeholders. A state-owned system also will likely provide the best opportunity for supplemental funding like federal or Homeland Security grants, with the competition for these dollars becoming increasingly focused on the number of entities they benefit and the interoperability achievements.

Due to the high level of capital investment required for such a dedicated state-owned system, however, we also believe it is prudent to "test the market" to see what might be offered by a vendor or commercial wireless carrier before finally committing to building a dedicated infrastructure. We recommend the State of Missouri first explore

the market to determine if there is a viable solution offered by private industry to meet the requirements. While current commercial wireless systems in Missouri do not meet the real requirements of Missouri's public safety and critical infrastructure users, it is not beyond the realm of possibility that a current commercial service provider or equipment vendor might potentially choose to build a dedicated facility on top of other existing commercial infrastructure, leveraging other assets to provide a lower cost alternative. From the responses received, the state can then determine if there is a viable commercial or vendor offering worth pursuing further.

If no offering is made for a viable, attractive solution from private industry, it is our recommendation that the State quickly move to develop a private, shared system with state ownership to meet the needs and provide for the public safety and critical infrastructure users in Missouri.

Public safety is a vitally important issue that affects us all. Missouri's public safety personnel must have reliable mobile communications capabilities throughout the state, regardless of the type of emergency. Their ability to provide for the public safety now and in the future is limited by the available resources at hand. No matter the level of available resources however, a reliable statewide mobile radio network is required to request, coordinate, and implement these resources in the field. Implementing a statewide mobile radio network is one of the most critical elements in public safety. Providing it statewide is logically a state responsibility. Doing so will almost certainly save lives and property, and improve the safety and quality of life of the citizens of Missouri.

2.0 Introduction

2.1 Background and Objective

Within the State of Missouri, there are a large number of private radio networks in use by public and private entities. In the past, different radio frequencies were allocated by the FCC into separate services for use by individual user groups. As a result, multiple radio systems were created to provide communications for individual state agencies and other entities often with overlapping coverage over the same geography. The age of many of these existing individual systems and associated equipment, along with the changes in FCC regulatory requirements, will require replacement of a majority of the existing systems over the next several years.

Modern radio technologies offer the opportunity for new systems that can offer not only a shared infrastructure, but also sharing of radio channels to provide enhanced interoperability for emergency events and disaster response, while also allowing participating agencies to operate autonomously and support their own agency's needs when required, on a common system. For some time, stakeholder representatives within the State of Missouri have sought to promote the concept of a shared mobile radio system among the potential public and private entities that would benefit from or participate in such a system.

Ameren and the Missouri State Highway Patrol have together initiated a study and hired an engineering consultant (Black & Veatch) to develop a statewide mobile radio network concept and present recommendations and findings in this report with a recommended approach concerning a statewide network.

2.2 Approach

The development of this report included review and analysis of several fundamental areas in the recommended network concept. To begin, research and analysis was performed to identify stakeholder needs and requirements for mobile radio. The organizational needs and requirements were analyzed together to create a matrix of specific requirements to serve as the grade card for evaluating and comparing alternative solutions.

Additional information was assembled and researched to identify existing assets that could potentially be leveraged in a statewide network. These assets include existing

radio towers and other antenna support structures, microwave networks, fiber optic networks, dispatch centers, land and right-of-way, etc. Many of these existing assets offer the opportunity for reducing the costs of a new system.

Based on the identified stakeholder requirements and the existing assets, technical alternatives were compared to determine the range of viable solutions. Various frequency bands were considered to define what alternatives are available upon which to develop solutions. Major equipment vendors were interviewed, providing valuable input regarding their latest technologies and plans for development.

As a result of this process, a recommended technical solution was developed specifically for the State of Missouri's needs. A concept design was created, based on this solution, to provide a basis for a budgetary cost estimate.

To draw a clear picture of the financial expectations in a statewide network, budgetary cost estimates are included, with estimated costs for both building and operating a statewide network. Along with these costs, a detailed review and discussion of the anticipated risks and benefits are also presented.

Finally, realizing that a shared, statewide radio network would present several unique challenges, which are neither technical nor operational, alternatives were compared for governance, ownership and operation. As Missouri is not alone in the need for a statewide network, other states' with similar initiatives were researched and interviewed. In some cases, states have built state-owned networks shared with other users. In other cases, statewide networks were provided in vendor/private partnerships with technology providers as owners, with the state government agencies and other entities operating as users or subscribers. In a third category, some states have evolving partnerships with various existing systems and regional efforts. After consideration of these alternatives, recommendations are made for the best path forward to meet Missouri's needs.

The main body of the report is designed to be non-technical, presenting a clear vision for a statewide network easily understandable by a broad range of readers and decision-makers. Chapter headings are targeted to answer the fundamental, key questions around this initiative. Technical details and other supporting documentation are assembled separately in supporting appendices.

2.3 Contributors

This study was developed by professionals in the Black & Veatch Telecommunications Division. The project was led by Charles Hill, Project Manager, with Carl Bushue serving as Project Engineer. Additional Black & Veatch engineering and construction cost estimate support contributed at key points in the process based on our experience with development of wireless tower sites for commercial wireless carriers in Missouri. Private radio equipment manufacturers also contributed budgetary equipment cost figures.

Black & Veatch would like to thank the representative stakeholders from both Ameren and the Missouri State Highway Patrol who provided information, review and significant feedback throughout the development of this study. These representatives from Ameren included Tom Vavra, Stanley Stach, and Mike Vietor. Representatives from the Missouri State Highway Patrol included James Biggerstaff, Roger Strope, Steve Devine, and Shannon McGowan.

3.0 Why is a Statewide Mobile Radio Network Needed Now?

The State of Missouri is at a critical crossroads in the area of public safety communications infrastructure. Although the citizens of Missouri depend on and value the assistance of public safety agencies, these agencies are dependent upon aging and outdated infrastructure inadequate for the task. In a post-911 world there has been a nationwide focus on "interoperability", particularly wide area and regional interoperability to enable and facilitate a coordinated response to routine, emergency, and even disaster situations. While Missouri has undertaken a number of efforts to help with understanding and responding to this need, the development of a shared, mobile communications infrastructure provides the greatest opportunity to achieving the maximum level of interoperability possible, today and in the future. Interoperability, however, is only one of the reasons why the State must move quickly to develop a shared, mobile radio infrastructure in the State of Missouri.

A statewide mobile radio network is needed and it is urgently overdue for development. There are a number of factors that combine together to create a unique window of opportunity to develop a shared system with significant economic benefit and unparalleled efficiency for the state government agencies, as well as other public safety and critical infrastructure entities in the state who might share in the system. These additional potential stakeholders can provide not only economies of scale, but also potentially bring to the table significant stakeholder assets for use by a state system including radio sites and towers, radio frequency FCC licensed channels, or microwave facilities. Due to the new FCC requirements for efficient frequency use, these potential stakeholders will need to update or replace equipment within the next several years.

Unless the state moves quickly, sharing resources with these potential participants, many of these opportunities and efficiencies will be lost, but the overarching need for a statewide mobile radio network will remain. The current situation and potential in the state of Missouri is both unique and temporary. Time is of the essence.

3.1 Background of Existing Networks

Both the Missouri State Highway Patrol and Ameren are viewed as primary anchor tenants in development of a shared, statewide network. Other public safety and critical infrastructure entities may participate in a statewide network as it develops going forward, enhancing the efficiency of the network as a whole, and also potentially spreading the operational costs over a larger number of users in future years.

State Agencies Existing Networks

The current mobile radio system of the Missouri State Highway Patrol began in the late 1940's; with FM transmitters installed at each troop headquarters. This system configuration has a very limited operational flexibility, with each troop essentially its own standalone system without any networking capability across the system. This system operated then (and now) in frequencies known as low-band VHF around 42 MHz. These low-band frequencies provide a wide area capability to cover the increased geography necessary for statewide networks, but they also have significant drawbacks which have resulted in their diminished use in today's environment. With the allocation of these frequencies saturated decades ago, there are no remaining groups of frequencies available in this band upon which to develop new, statewide systems. The Low band VHF frequencies are also subject to "skip", a phenomenon that varies with sunspot cycles, resulting in interference from signals hundreds of miles away as they bounce off of the atmosphere and return to the earth. For these reasons, manufacturers produce a very limited range of equipment in the low band.

As a prime example of a system in need of replacement, the Missouri State Highway Patrol radio communications system technology has not undergone significant change since the 1950's, with only minor cosmetic enhancements through the years for additional geographic dispatch areas, and a change to personal computer based consoles for dispatchers in 1995. The current system provides only a single talk channel for any given geographic area of the state, totally inadequate for broader emergency situations.

This picture is an example of outdated radio equipment still in service today in Missouri.

Each state agency has its own separate system without connectivity to other state agencies. These disparate systems operate on separately licensed frequencies. An "Emergency Communications Interoperability Study" conducted for the State in July 2004 by the Titan Corporation revealed that many of the radios used by other agencies are more than 20 years old and have passed their life expectancy. The limited availability of parts severely limits the capability for repair to ensure reliable ongoing operation. There is a potential opportunity at this time for the various state agencies to share a newly developed statewide system going forward, before each agency moves ahead to replace outdated systems individually and separately.

Ameren Existing Network

The current radio system at Ameren was developed in the early 1990's to replace multiple outdated radio systems with a single, unified system to provide coverage for all the operational business groups throughout the utility service territory. Because of the frequency spectrum available, and the emerging "trunked system" technology available, an 800 MHz trunked system was developed. This new system also utilized the utility's existing microwave network where possible to provide connection between tower facilities.

The trunked radio network provided several significant advantages for Ameren in a single, combined radio system. The system brought the capability and flexibility for any radio user to easily communicate with any other radio user within the organization. The system also provides multiplied capacity and coverage throughout the service territory.

While the current radio system has met the needs of the electric utility, due to the age of fixed equipment, Ameren is exploring alternatives for migrating to a future radio network. There is substantial interest in developing a shared network capability with the state, partly due to the high capital cost of building a replacement network solely for the utility's own needs. The radio system needs of critical infrastructure entities like electric utilities are very similar to those of public safety and other state agencies. Utilities develop radio networks with very similar design and performance characteristics for reliability and survivability under the harshest of conditions, with field workers depending on them for communication during restoration of electrical outages in ice storms, tornado damage, etc.

Other Potential Participants

Within the State of Missouri, there are many other local government entities as well as other utilities who have expressed potential interest in participating in a shared mobile radio network facility. Many of these entities also have outdated, separate systems overdue for replacement due to age. If these entities move forward with separate initiatives to develop their own replacement mobile radio facilities there will be a widespread duplication of efforts at taxpayer expense, without the significant operational benefits of a shared, statewide system.

3.2 Nationwide Focus on Wide Area and Regional Interoperability

The lack of interoperable communications continues to be a serious public safety problem with regional and nationwide focus. The events of September 11, 2001, as well as the recent hurricanes and other disasters reinforce the real and pressing need for public safety departments and other agencies, including police, firefighters, public health officials, and critical infrastructure workers to communicate reliably and effectively in a larger emergency scenario.

Recent disasters and greater emergency scenarios have highlighted a need for a broader interoperability even beyond the traditional definitions of public safety. Critical infrastructure users are increasingly recognized as essential to the overall response and restoration of vital services in emergency events. In Missouri's case, such a capability could be built-in if a shared system is developed with participation of critical infrastructure users.

This crisis of interoperability is driven by a number of factors that may apply in varying degrees within Missouri, but also nationwide, including:

- Incompatible and aging communications equipment
- Limited and fragmented funding
- Limited planning coordination
- Lack of coordination and cooperation among entities
- Limited availability of radio frequency spectrum

Because the need for interoperability solutions exists in all states, there is a nationwide focus on addressing this need. This focus results in federal programs and supplementary funding to assist with the development and implementation of initiatives

to enhance interoperability. Increasingly, states compete for federal dollars. A stated objective in awarding grants and other federal dollars in these areas is to maximize the enhancement of interoperability to a wider range and group of entities. Initiatives that demonstrate participation and plan for a wider involvement and participation at the local level will likely be more likely to leverage this type of funding assistance. While there is no current expectation that the federal government will be funding entire statewide networks, there may be potential for leveraging federal dollars to enhance the ability of local governments to participate in a statewide radio system.

Within the State of Missouri, several million dollars of Homeland Security funds have been used to purchase radio equipment for local government that might also be used to inter-communicate with a shared, statewide radio system. A state-owned, statewide mobile radio system would likely provide the best advantage toward securing similar funding to support and enhance local participation in the future.

3.3 Related Missouri Initiatives

Creating a shared, statewide mobile radio system supports and aligns with several other current initiatives in the state. In 2001, the State Interoperability Executive Committee (SIEC) was formed to address interoperability issues in Missouri. The SIEC has been instrumental in setting standards for interoperable communications equipment and recommending distribution of Homeland Security funding. A shared, statewide radio system would provide the ultimate vehicle for interoperability in Missouri. The Missouri Department of Transportation has developed Intelligent Transportation System (ITS) facilities around the state that can also provide synergy with a shared mobile radio system. New trunked mobile radio systems in the urban centers of Springfield, Independence, St. Joseph, Joplin, and planned for St. Louis, also provide unique opportunities for integration with a state system. The State of Missouri Office of Administration is exploring a next generation state data network that could also provide unique synergies for sharing backbone facilities such as fiber optics or microwave. The refurbishment of decommissioned microwave networks by the Missouri State Highway Patrol could potentially offer capacity where available to a next generation data network. A statewide mobile radio network infrastructure dovetails very well with all these initiatives and can be expected to open doors for other future opportunities across the state.

3.4 Future Growth Requirements Anticipated

The needs of public safety and critical infrastructure users in a mobile radio system today are substantial. These same needs will almost certainly increase and accelerate in the future, particularly with regard to data communications. The network concept in this report provides for an inherent data capability in the system. This capability is in line with current private radio technologies in public safety systems. While the system concept does not provide a high speed or broadband data capability in the initial implementation, virtually all the infrastructure envisioned with the exception of the voice radio equipment itself can be leveraged to support a high speed data capability in the future. The initial concept design provides a complete foundation and opportunity for efficient expansion to provide for future capacity and bandwidth requirements where needed.

3.5 Regulatory Requirements

The FCC oversees radio frequency spectrum management in the U.S., and has allocated specific frequency channels in various frequency bands for specific user categories. These radio channels, as they are commonly called, have historically been allocated to various radio services according to specific groups, Police, Fire, etc.

Narrowbanding Requirements on VHF

Because there were a limited number of channels available in each frequency band, all available channels were allocated. As additional needs arose with multiplied public safety entities, the number of available remaining channels was not sufficient to meet the needs of all the eligible users. So, the FCC began to look for alternatives to address this "frequency congestion". In the VHF high band, which is utilized by large numbers of local government and public safety entities, the FCC instituted an initiative called "refarming" or "narrowbanding" where 25 kHz channels would be divided into two separate 12.5 kHz channels. In this way, the number of channels would be essentially doubled. To utilize these narrowband channels, however, requires existing users to vacate their 25 kHz channels. In order to ensure the success of narrowbanding, the FCC instituted a deadline of 2013, when all existing licensees must abandon their 25 kHz channels and be "narrowband" operation.

Within the State of Missouri, there are a large number of local government and public safety users in the VHF high band. These users will have to replace their radio system equipment with new equipment capable of operation on the smaller, 12.5 kHz radio channels before 2013. Estimates project as much as $40 million or more will have

to be spent to replace these local radio systems and equipment. This replacement is a significant capital expense for local governments already faced with scarce funding. However, this shortage of funding at the local level also presents a unique opportunity and local incentive to participate in a statewide mobile radio network. If local government entities faced with narrowbanding were given an opportunity to share in a statewide network capability, their radio needs could be built into a statewide network. They would have all the benefits, efficiencies, and advantages of a statewide network along with the interoperability capabilities of operating on a shared system. The opportunity for local participation represented by the VHF narrowbanding requirements is also timely. If local entities move forward building separate replacement radio systems on their licensed VHF narrowband frequencies, a large portion of the potential savings for local government in a statewide system could be lost. In addition, continued development of separate, local systems also represents a significant duplication of effort.

3.6 Technology and Spectrum Opportunity (700 MHz)

Realizing the need for additional frequency spectrum for use by public safety, the FCC has allocated a band of frequencies around 700 MHz for their use. This block of frequencies will become available as television broadcasters move toward digital television.

This block of frequencies is significant because it represents new spectrum for public safety. In fact the space allocated in this frequency band will represent about one half of the total frequency space available in all frequency bands. These frequencies are now available in the State of Missouri as prescribed in the approved FCC regional plan. These frequencies can be leveraged by the State and other eligible licensees in development of a statewide mobile radio network.

The State of Missouri has already licensed the channels designated as state channels in this band, but in order to retain these licenses must build out a system in a required timeframe or these frequencies will be automatically taken back by the FCC and redistributed to other General users. The FCC's "build out requirements" (FCC Rules, Part 90.529) are specifically defined as providing "substantial service" to at least one-third of the population or territory by January 1, 2012, expanding to two-thirds by January 1, 2017.

If a statewide network is not developed to utilize the newly authorized 700 MHz frequency band, the frequencies could be licensed by others to support their needs in

separate, individual systems, leaving fewer frequencies available to support a statewide network. The availability of the radio spectrum in 700 MHz, like many of the other factors, represents a temporary window of opportunity for using these frequencies to develop a statewide mobile radio network before they are allocated to others.

3.7 Public Private Stakeholder/Partner Opportunity

Ameren's current willingness to share in a statewide radio network initiative with state government also represents a window of opportunity for a limited time. As a potential partner in developing a statewide mobile radio system, Ameren is one-of-a-kind. Ameren's service territory covers a large portion of the state of Missouri. Ameren has significant supporting assets in their microwave and fiber facilities, in addition to the radio towers, other equipment and supporting facilities in the current Ameren network. As a large, electric utility with radio needs similar to public safety, Ameren's supporting infrastructure has been designed to provide reliability in difficult circumstances, such as extended power outages. Ameren's FCC licensed radio channels also represent an extremely valuable resource for a statewide network.

If the state does not move to develop a shared, statewide network in the near term, Ameren will still need to find an acceptable alternative for their own needs, or start expending significant capital to upgrade or replace their existing system. If Ameren starts developing an independent, future network, the efficiencies in a shared, statewide network would be lost.

3.8 Unique Window of Opportunity

As has been noted throughout this section of the report, many of the contributing factors for success in a statewide mobile radio network are only available in Missouri's current situation. These factors are only temporary. To ensure the best solution with the maximum benefit to all stakeholders, including the citizens of Missouri, the State must move ahead quickly to develop a statewide, shared mobile radio network.

Development of similar networks in other states clearly illustrates that several years are required to implement a statewide network. Unless the State moves ahead quickly, potential stakeholders will move ahead independently, continuing to build separate facilities without coordination or integration, at the same time compounding the current obstacles toward interoperability and intercommunication among public safety and other emergency responders in Missouri. Instead of improving the situation, it will get worse.

4.0 What are Missouri's Requirements for a Statewide Mobile Radio Network?

What are the real requirements of public safety users in the State of Missouri? What about critical infrastructure users? What is needed in a statewide system to support their needs in what circumstances? To answer these questions, a set of requirements was developed to identify and describe them. These "solution criteria" have been assembled in a matrix format on the following pages in this section with a detailed description following.

To be considered as a viable alternative, any system or network alternative must satisfy all of these defined needs as a bare minimum requirement.

4.1 Description of Stakeholders

The stakeholders or users in a statewide network can be envisioned in three primary groups; public safety users, critical infrastructure users, and other local, state, and federal government users.

Public safety generally includes police, fire, law enforcement, and other emergency services normally termed 'first responders', personnel that are called upon when an individual or community is responding to emergencies. While these services are also provided at the local level, state and federal agencies also assist.

Critical infrastructure users can refer to a variety of entities. What Is a Critical Infrastructure? As homeland security has been assigned the highest national priority, the term "critical infrastructure" has become a major concern. Documents dealing with critical infrastructure protection have provided broad definitions of what makes an infrastructure critical. In 1996, the President's Commission on Critical Infrastructure Protection alluded to what makes an infrastructure critical:

> "Certain national infrastructures are so vital that their incapacity or destruction would have a debilitating impact on the defense or economic security of the United States."

According to this Executive Order (EO) these infrastructures included:

- telecommunications;
- electrical power systems;
- gas and oil storage and transportation;
- banking and finance;
- transportation;
- water supply systems;
- emergency services (including medical, police, fire, and rescue);
- continuity of government.

In using the term critical infrastructure in this report, there is no intent to limit its definition, but in this report it is more generally used to refer to the mobile workforce of public and private entities directly responsible for utilities, roadways, etc., such as electric, water, and gas utilities.

The third group is somewhat self-explanatory being other local, state and federal government users. Perhaps the most significant consideration with regard to the third group is that in developing a statewide mobile radio network to serve the stringent needs and requirements of public safety and critical infrastructure users, an installed capability is automatically available for expansion to include users in this third area at a very low, incremental cost. While there must be some additional capacity considerations when adding significant numbers of additional users, the overall performance, features, functionality and reliability of the entire system is available to all the users. Local and other users, who might have difficulty justifying the expense or finding the dollars to build even a replacement local system, can participate in the statewide system without the significant capital expense.

Because the requirements of all groups of users can be understood as included in those of public safety, a single matrix of requirements was developed for the system. This matrix is presented on the following page with detailed description following:

Statewide Mobile Radio Requirements Matrix

System Criteria	Description	Required	Desirable High Priority
Reliable Mobile Coverage	Reliable two-way communications (95% area coverage) to and from vehicles throughout the entire state geography including navigable waterways with focus on all state highways and C/I transmission infrastructure	X	
High Availability	Public Safety and Critical Infrastructure traffic NOT subject to congestion or any other impact from public network wireless, telephone, or data traffic	X	
Dispatch Flexibility	Ability to dispatch any site or region from multiple alternative dispatch locations	X	
Incident Monitoring - Dispatch	Ability to continuously monitor internal department communications throughout system as authorized	X	
Field Initiated Emergency Alert Capability	Ability to declare emergency situation from any field radio with one-button	X	
Local Field Communications	Capability to activate portable field operations to add capacity for emergency or disaster response	X	
Discrete Talk Groups	Ability for stakeholders to operate independently with security from eavesdropping from other system users or agencies	X	
Minimum Capacity	Minimum of 3 talking channels throughout service territory	X	
Site Redundancy	System must provide continued operation without loss of coverage or availability in event of extended power outages, severe storms (minimum 5 days without refueling generators)	X	
Interconnect Backbone	Diverse route connectivity across regions to selected major facilities (HP Troop HQ's, Ameren NOC)	X	
All Call - Dispatch	Ability to Broadcast Single Message to all users		X
Vehicle Location Information	Integrated ability to know where vehicle is located without using separate service provider (Cingular modems)		X
Interoperability Criteria			
Overall	Project 25 Standards Compliance	X	
Disaster Communications	Maximize Mutual Aid capabilities	X	
Disparate Systems	Gateway Capability for Intercommunication	X	
Regional Operation	Regional networks must continue to independently provide trunked communications within regions even if statewide connections are lost	X	

Statewide Mobile Radio Requirements Matrix (continued)

System Criteria	Description	Required	Desirable High Priority
Mobile Data Criteria			
Low Speed Data Signaling	Ability to potentially support low-speed data signaling needs (signalling, telemetry, etc.)		X
Data Speeds	Minimum capability to support text-based messages, paperless reporting, etc.	X	
Data Coverage	Low Speed Data availability over same coverage area as voice	X	
Data Encryption	Encryption for Public Safety Data to meet federal and state requirements (NCIC, MULES, etc.)	X	
Future Data Capability	Capability for Future Expansion to Mobile Broadband Speeds to Accommodate Multi-media (recorded audio, photos, video, etc.)	X	
Operational Requirements			
System Support Monitoring	System monitoring from a 24/7 facility	X	
Low Ongoing Site Costs	Maximize usage of stakeholder owned sites and facilities	X	
Equipment Procurement	Flexible capability for purchase among stakeholders	X	
Equipment Procurement	Multiple sources for subscriber equipment purchase		X

4.2 Detailed Explanation of Requirements Matrix

The requirements in the matrix are described following. Where possible, these requirements are detailed on the basis of function and performance instead of using technical or engineering terms. It is important to note that these requirements are not intended to be exhaustive, but rather to provide the creditable minimum basis for evaluating technical alternatives, and developing a concept design and cost estimate. Further development of specific, detailed technical requirements would be necessary as part of a detailed design activity before constructing a statewide system.

System Criteria

The system criteria include general and technical requirements that apply to the network as a whole, everywhere in the state.

Reliable Mobile Coverage

Mobile coverage refers to the radio signal coverage throughout the geography of the service territory. An acceptable solution system must be useable everywhere in the state. The 'mobile' refers to a radio mounted in a vehicle. For public safety in particular, reliable two-way communications for vehicles anywhere throughout the entire state is an absolute requirement for the statewide radio system. Radio signal coverage is generally expressed as a % of the territory with a radio signal at a level that is reliable based on normal operation of available equipment. In this situation, the requirement for coverage needs to exceed 95% throughout the entire state. This area includes navigable waterways and rural areas, but the primary focus in phasing construction would be on all state highways and critical electrical transmission infrastructure. A 95% requirement for coverage is almost universally used in referring to coverage for public safety, and has been used by a number of other states in developing their statewide networks.

Some local systems are built for portable coverage with walkie-talkie style equipment, but this is considered generally cost-prohibitive in a statewide system. Many statewide systems supplement their mobile coverage through the use of in-vehicle repeater equipment, where a handheld radio communicates back to the vehicle, where the signal is retransmitted over the mobile radio in the vehicle, to extend the range of portable use. In the system concept as presented in this report, the statewide minimum coverage requirement is based on mobile radio use throughout the state, with the

anticipation that agencies might use or not use vehicular repeater equipment as they see fit.

High Availability

In addition to being available everywhere in the state, a satisfactory solution must be available in the most difficult of circumstances. If there is no other lesson learned from the disasters of the recent past, perhaps one of most universal is that public safety and critical infrastructure communications should never be subject to congestion or impact due to public wireless, telephone or data traffic on the public telephone network. Even in local circumstances like the Columbine High School tragedy, cellular phones and other commercial wireless networks were absolutely useless, as they were very quickly overwhelmed by public users. Even 9-1-1 systems become virtually unusable temporarily. An effective statewide system must be ready for use at any time, especially in the disaster or emergency scenario when it is needed most.

This need for availability is also critical in a prolonged outage of electrical power. Base stations and other critical communications components in an acceptable system must have battery-backup and/or backup electric power generation on-site to ensure that it continues to operate during an extended power outage. Since this statewide radio system is envisioned to be used by the very people that will be repairing or restoring the power grid in the event of small or large area outage, it must allow them to communicate continuously in order to accomplish those repairs quickly and safely.

Dispatch Flexibility

With the current outdated systems in place throughout the state, there is little opportunity for operational flexibility. One of the operational benefits of a single, statewide radio network is the capability of having dispatch locations anywhere in the system. This can provide two different types of benefits to the users. First, any dispatch center could serve as a back-up to another dispatch center at a different location on the system. If a dispatch center is temporarily out of service, another dispatch center could take over their responsibilities with little impact to the user. A second benefit to dispatch flexibility is that multiple dispatch centers can be combined to promote efficiency of manpower resources for normal or night shifts.

In today's environment, the highway patrol must staff dispatch at all troop headquarters for all shifts. In order to provide operational flexibility for the future, the

requirements in a new system include the ability to dispatch any site or region from multiple alternative dispatch locations. This will provide the potential for operational savings both within agencies and among other statewide or local stakeholders who might in the future consider consolidating some of their dispatch operations.

Incident Monitoring – Dispatch

An obvious requirement for a replacement system is that users with the appropriate authorization must be able to monitor their internal department communications through the system. This is especially important for statewide users on a routine basis, but also enables an important capability for a larger emergency event. This would enable a direct communications and incident monitoring capability in Jefferson City or multiple other locations for an event anywhere in the state. Management, voice logging, and other oversight functions can be accomplished remotely in the system.

Field-Initiated Emergency Alert Capability

Another vital consideration for first responder communications is the safety of the first responders themselves. In an emergency, radio communications is their lifeline. In an acceptable system, there must be an immediate capability to call for help. Any authorized user must have the ability to declare an emergency situation from any field radio with the push of one button. This vital function was identified as a critical public safety communications requirement in the early 1980's by the Associated Public Safety Communications Officers (APCO) in Project 16. Allowing a field user this ability to immediately declare an emergency could be life-saving. An emergency alert can provide immediate notification and response from both dispatch and field emergency responders. Most of the existing public safety radio users in Missouri do not have this capability for call for help via a simple emergency alert feature.

Local Field Communications

During an emergency or disaster response the system must have the capability of temporarily adding capacity or coverage. This capability could be simply utilizing one or more portable base stations to increase the capacity in the system if a larger number of responders are necessary to respond to an event in a remote area. This same capability is important for disaster response to temporarily substitute for damaged tower sites, for instance. The requirement is the flexibility to increase the capacity when and where it is needed without the significant costs of overbuilding the system on a permanent basis.

Some non-emergency events may even require additional capacity for specified periods of time, such as large fairs, VIP visits, and disaster training exercises.

Discrete Talk Groups

In a statewide system, various user entities and groups must be able to operate independently while at the same time sharing the available radio channels. Users from one group must be able to operate on the system independently without the concern of eavesdropping from users from other systems or agencies. This provides the various users with security equal to or higher than that of operating on their own system.

In a shared radio system, this capability is most often accomplished through the use of trunking technology. In a trunked radio system, different groups of users each have one or more discrete talk groups. The system keeps track of users and talk groups, assigning the available radio channels as needed routinely on a first-come, first-serve basis. In the event all channels are busy, a priority capability is provided to allow authorized first responders more immediate access to the channels in a busy scenario.

Minimum Capacity

In a shared, statewide system, a minimum capacity level is required statewide to provide for users who operate statewide. Based on the initial assessment of state agencies, a reasonable requirement statewide is a minimum of three available talking channels. In specific regions of the state with larger numbers of users such as the Ameren service territory, for instance, a larger number of channels will be required. Additional channels will also need to be added as additional users are added to the system requiring added capacity and radio traffic.

In a trunked radio system environment, additional channels normally require the addition of an additional repeater station at each of the sites in the area where capacity is being expanded.

Site Redundancy

As discussed above in the requirement for availability, the fixed locations in the system must have the standalone resources to continuously operate in the event of an extended power outage or during severe storms or disaster scenarios. The proposed requirement is for battery backup with standby power systems at all fixed locations. Battery backup will provide power for sustained operation until the emergency generator

starts up and takes over. To provide for extended outages, emergency generators and onsite fuel tanks must have the capacity to run at least five days without refueling.

In addition to the site redundancy for power, equipment redundancy in key areas is also required. Redundant equipment is required for key components to ensure that failure of a single component or location does not disable or cause the overall system to fail. Switching elements and region-to-region interconnections must be configured with redundant elements and pathways to insure that single failures do not destroy statewide system capabilities.

Because of the local and regional nature of most emergency and disaster incidents, a maximum level of regional independence is required. If a disaster of broader geographic scope should occur, the system in regions of the state should continue to function at the regional level with remaining available resources. As detailed later on, this critical need has influenced our concept design as a network of networks, recommending a statewide network of regional networks.

Interconnect Backbone

The backbone interconnect refers to the interconnection of switch facilities among the regional networks. A diverse routing for connectivity at this level is required so that if a link between locations is lost, the system will continue to operate through the remaining connectivity. The recommended concept design provides these connections in a loop configuration including selected major facilities such as the switching elements, Highway Patrol Troop Headquarters and Ameren's Network Operations Center. This backbone interconnect is anticipated as a combination of fiber optic or high capacity microwave transmission as an expansion to existing facilities when beneficial.

All Call – Dispatch

The ability to broadcast a single message to all users on the system is a desirable function; however it is not judged in this case as an absolute requirement. This feature allows the dispatcher to broadcast a message to every user group in the entire system.

Vehicle Location Information

The ability to determine the location of a mobile user in the system is also a desirable feature; however it should also not be considered a minimum requirement for the statewide radio system. Vehicle location information allows the dispatcher to find the

exact location of a user's mobile radio at any given time without the need to ask the user to report their location. Dispatch functions are assisted by knowing the nearest assets to a situation. Location information following an Emergency Alert initiated by a mobile user is an obvious application of this feature.

Interoperability Criteria

This area defines and details the minimum requirements for interoperability with the statewide system.

Overall Interoperability

The overall requirement for interoperability is compliance with Project 25 (P25) Standards. Within the public safety community, industry and individual members of local, state, and federal public safety agencies have engaged in a long-term standards development process known as Project 25. Working together, participants have established unambiguous sets of procedures and specifications that have been adopted and published by TIA and EIA. The results are commonly called TIA/EIA-102 or Project 25 standards suite. Most states and regional consortiums developing shared systems are installing equipment that complies with the Project 25 suite of standards.

In addition to being a recognized common standard for public safety networks, Project 25 is also the equipment standard for federal government users. With regard to the P25 standards, a recent publication of the First Response Coalition states:

> *The first responder community and many of the state interoperability programs today include the use of Project 25 (P25) standards…..The FRC supports these standards and believes they will be critical as states pursue unique strategies to achieve interoperability. As disasters and emergency incidents can be regional or even national in scope, it will be essential for first responders, regardless of jurisdiction, to be able to communicate using equipment based on the same standards.*
>
> From "Interoperability Innovation: State Best Practices & Models for First Responder Communications." First Response Coalition, March 2007

Disaster Communications

The statewide system in Missouri must be capable of maximizing mutual aid capabilities to other systems in the event of a disaster. Disasters may involve portions of

the radio system itself. It should be designed to continue to function, perhaps with some reduced capability in some instances, in as many different scenarios as possible. The system should operate with the most emphasis on allowing coordinating groups to communicate to aid in their missions.

In a broader emergency, groups within a statewide system must be able to be patched together flexibly on the fly to facilitate cross-functional capabilities for users responding the same emergency event.

To provide for a statewide mutual aid capability, the concept design includes at least one VHF channel active on at least one site in each county. This will provide MTAC (Missouri Tactical Channel) interface capability throughout the system everywhere in the state. "MTAC is a product of the partnership including The Missouri State Interoperability Executive Committee, The Missouri Department of Public Safety, The Missouri Office of Homeland Security, and The Missouri State Highway Patrol." This system provides interoperability with multiple legacy public safety systems throughout the state. In fact, a large number of local users have purchased equipment with Homeland Security grant funding over the last few years with this mutual aid channel programmed in the equipment. This system requirement will provide interoperability not only for those within the statewide radio network, but also to all other users from other systems with this mutual aid channel available in their equipment.

Disparate Systems

A new statewide network must provide a capability to inter-connect with legacy systems of other users who may not be able to join the statewide network immediately. The new system must be capable of using gateways to intercommunicate or patch existing legacy systems into the statewide system. This capability would allow existing user equipment to become interoperable with the new existing statewide system on a limited, case-by-case basis. Some reduced functionality is expected through these gateways, but there is still the basis benefit of intercommunication where it was not possible in the past.

Regional Operation

Each base station should be capable of operating in an isolated mode if it loses communication with the regional switch and/or other base stations. An individual user

must still be able to communicate with other users in the area, and only lose communications to users on other base-stations.

A similar operational approach should work within each region. If a region loses communication with another region, for instance, communications among users within the region should still be able to function normally within that region if at all possible. Even if statewide user-to-user communications should be interrupted, communications within each region should be preserved as much as is possible.

Mobile Data Option Criteria

An installed statewide network can provide a significant foundation for future development of wireless data communications in the field, but the current primary need is for reliable voice radio communications. Consideration of field mobile data communications in the voice system requirements is limited to the following:

Low Speed Data Signaling

It is desirable, but not required that in addition to voice communications capability, the statewide radio Network has the ability to support low-speed data transmission. This capability will potentially support additional applications for field devices around the state.

Data Speeds

The system should be capable of supporting text based messages and paperless reporting. This will allow a basic text messaging capability for field users. Such capability will provide an immediate Amber Alert capability to all users on the system statewide at the same time.

Data Coverage

Data transmissions should be available throughout the system, wherever there is voice coverage.

Data Encryption

All public safety data that is sent over the system should be encrypted, and the system should be capable of meeting state and Federal requirements for data encryption.

Future Data Capability

The voice system should be capable of expanding to provide mobile broadband data speeds in the future. This future capability will allow wireless transmission of photos, recorded audio, and video, etc…

Operational Requirements

The following are minimum operational requirements in the statewide system.

System Support Monitoring

The statewide radio system must provide operational support to monitor and administrate activity on the system 24 hours per day/7 days a week. This monitoring must include the monitoring of equipment status and alarms throughout the system to indicate system and equipment problems.

Low Ongoing Site Costs

The design for the system should seek to leverage as much existing infrastructure as possible to reduce and minimize ongoing site or lease costs.

Equipment Procurement

Stakeholders should have a flexible capability for purchases of equipment for the statewide radio system. Having multiple vendor sources for purchasing subscriber equipment is desirable.

5.0 What Would a Successful Statewide Mobile Radio Network Look Like?

As detailed in the previous section of the report, the requirements of public safety and critical infrastructure users in a mobile radio network are unique and substantial. In today's environment, these users make up the largest portion of the marketplace for private mobile radio systems technology. Because the overall marketplace for private mobile radio equipment is significantly smaller than the market for commercial wireless technology such as cellular phones, only a handful of manufacturers develop and build systems around these types of requirements. This section of the report details the pivotal alternatives and considerations leading to the recommended technical solution for Missouri's public safety and critical infrastructure users.

5.1 Discussion of Technology Alternatives

With the advancement and proliferation of commercially available wireless technologies like cellular phones, personal digital assistants, etc. many people might ask "Why not just use an existing commercial system for statewide communications?" While this is a logical question, there are several very important factors that reveal why today's commercial wireless networks are not a viable solution for public safety and critical infrastructure users.

In an emergency situation, the current commercial wireless systems simply are not capable of providing the reliable geographic coverage required over the service territory. In cellular systems, virtually every user is familiar with terms like "dropped calls", "no service available" and "network busy" from their own personal user experience. These commercial networks are designed around the traffic requirements of all users, and due to the technologies, the coverage is continually being altered or modified as the network evolves dynamically. In rural areas, coverage on many commercial systems is non-existent.

Commercial wireless systems do not provide a dedicated availability and capacity for emergency use. As evidenced by incidents such as the Columbine high school tragedy, public safety officials cannot depend on commercial systems that become immediately overloaded and unavailable even in local emergencies. In commercial systems, available capacity is shared by all users, generally on a first-come, first-served basis. Even if a dedicated capacity could be reserved in a commercial system for

emergency responders, this would mean this same capacity would be taken away from the general public, perhaps even a commercial user who might themselves be trying to call for immediate emergency assistance.

Commercial wireless systems also do not provide the reliability for prolonged emergency situations. Disasters and emergency incidents over the last few years have demonstrated that private public safety and critical infrastructure radio systems survive in a fully operational state significantly better than commercial systems. In an FCC study following an "Independent Panel Reviewing the Impact of Hurricane Katrina on Communications" it was found that electric utility networks appeared to have a high rate of survivability following Katrina. In this document, the FCC stated "These communications systems did not have a significant rate of failure because: (1) the systems were designed to remain intact to aid restoration of electric service following a significant storm event; (2) they were built with significant onsite back-up power supplies (batteries and generators); (3) last mile connections to tower sites and the backbone transport are typically owned by the utility and have redundant paths (both T1 and fixed microwave); and (4) the staff responsible for the communications network have a focus on continuing maintenance of network elements (for example, exercising standby generators on a routine basis." Cellular and other commercial wireless systems do not provide this level of reliability. Even in the short time duration of the Northeast power blackout of 2003, cellular carriers experienced widespread failure of their services. Services were quickly overloaded as call volume increased to three to four times the normal volume. A few hours later, services failed as equipment shut down as backup battery systems ran out of power. Industry spokesmen at the time stated that "no carrier could afford to engineer its networks and backup power for a power outage of such massive proportions." An ice storm or other major storm damage in Missouri, however, can be expected to result in a power outage lasting not just a few hours, but several days. A disaster event like the catastrophic earthquake that is anticipated in the unknown future in southeast Missouri will almost certainly result in an extended disruption of a wide range of infrastructure. A mission-critical radio system must be designed to provide the best survivability for continued operation in these types of circumstances. This is an important fundamental difference between today's "best effort" commercial wireless systems and the mission-critical communications systems designed to assist with protection of life and property.

Commercial wireless technologies are primarily designed and operated as a "one-to-one" system, providing communications between individuals, not groups. They do not

generally support "one-to-many" communications, where a dispatcher or user communicates with a group of people distributed across a system. Public safety users need the ability to utilize defined talk groups on a routine basis, and a flexible capability to dynamically create, assign, and patch groups together within the system, as well as achieve immediate interoperability with other users' on other systems.

Public safety and critical infrastructure users have unique requirements. They need a mission-critical mobile communications system that is more robust, more reliable, and tailored to meet their operational communications needs for the widest range of routine and broader emergency scenarios.

Private Mobile Radio Technologies

Because of the unique requirements of public safety and critical infrastructure users, private systems still prevail among mission-critical users. When viewed as an industry, public safety agencies, utilities and other similar users are not giving up private radio systems. A mission-critical radio system must deliver its best performance in the worst of circumstances. Private mobile radio technologies will continue to be the preferred platform for mission-critical users.

Over the years, private radio technologies were developed with enhanced features and functions specifically tailored to meet the needs of these users. In fact, users in the marketplace have had significant impact in the development of these products. For example, the Associated Public Safety Communications Officers organization known as APCO has sponsored the development of standards for these types of systems. The APCO Project 16 standards developed in the 1980's were used as the basis for development of the trunking radio systems used in the 800 MHz frequency bands. The APCO Project 25 (P25) standards are also widespread in use among statewide systems and the federal government.

The currently available private mobile radio technology is specifically suited for statewide radio networks. A digital, trunked radio network with Project 25 interoperability is the preferred platform. Digital technology has several advantages over older analog radio systems. Digital radio systems are more efficient in using the available frequencies. Digital signals can have a better voice quality within the designed coverage area. Digital transmissions allow for easy encryption and increased security.

And finally, digital systems are based on data communications, resulting in an integration of voice and data capabilities in a single system.

Private radio systems utilize frequencies either through conventional channels or trunking. A conventional system, still the most popular system type in the United States, utilizes a dedicated frequency channels. If an agency has three frequencies in its radio system, it might use one channel for all car-to-dispatcher calls, one channel for dispatcher-to-car calls, and the third channel for car-to-car transmissions. Alternatively, separate channels are assigned to separate user groups. In a conventional system, whenever a user keys the microphone and transmits on a frequency, everyone else using that channel must wait until he or she is finished before using the channel. When no one is talking on a channel, the channel is idle and not being used by anyone. In a conventional system, it is not unusual for some channels to be temporarily overcrowded and congested, while at the same time others are sitting idle based on the situation and minute by minute changing needs of the users.

Trunking is a technology primarily designed to allow for the efficient use of channels by a larger number of user groups. Trunked radio systems provide a relatively efficient system for multiple agencies in a geographic area that can share a radio system. Trunking is a computer-controlled system that assigns available frequencies in a pool, assigning an available channel whenever someone keys the microphone. Trunked systems use talk groups to determine the group of users who need to communicate with each other. These talk groups can be organized however the users see fit, perhaps by service territory or job function. Patrol officers, for instance can be one talk group, detectives in a second, and tactical teams in a third. All users share the same pool of frequencies. When a user keys the microphone, the system selects an open frequency and puts the user on it. When the user stops transmitting, that frequency immediately becomes available to assign for others. Even within a relatively small urban area, it is not unusual for thousands of individual users to share a pool of twenty channels in a trunked system without interference. A wide-area trunking system over a state can provide similar efficiencies for a large number of user entities.

A digital, trunked radio network with Project 25 interoperability is the preferred platform for meeting the needs of Missouri. This network can fully satisfy all the requirements as defined, and provide opportunity for expansion to accommodate the needs of additional users in the future, and provides the ideal capability for

interoperability both among users within the statewide system, as well as with other users' who may continue to operate with their own separate legacy systems.

5.2 Impact of Frequency Spectrum Availability

The FCC oversees the assignment of radio frequencies for all users, and has allocated certain frequencies for certain groups of users like public safety and utilities. Spectrum refers to the amount of capacity or bandwidth available, and it is a finite resource.

Spectrum Eligibility

Eligible entities are assigned frequencies according to the category that best describes their activities. For example, a utility is licensed from a pool of frequencies for "Industrial/Land Transportation"; a public safety agency would receive frequencies from a "Public Safety" pool, with others in other categories. With minor exceptions, such as a utility owned by a local government, utilities and public safety eligibles could NOT be licensed on or even share frequencies together under current FCC rules. How is it possible, then for a statewide system to be developed in Missouri to include public safety and an electric utility such as Ameren? This can be accomplished through a waiver of the FCC rules. FCC waivers have been granted in similar situations. As long ago as 1995, the FCC granted a waiver in Nevada to allow sharing among the U.S. Department of Energy, Nevada Bell, the Sierra Pacific Power Co., and the State of Nevada. In a similar waiver, the East River Electric Power Cooperative petitioned the FCC to share its system with public safety and business category eligibles. The FCC granted the waiver for public safety, but denied the service to business eligibles. The FCC granted a similar waiver request by Texas Utilities Service to share its system with public safety agencies. The granted waivers in these situations have specified the sharing must be "in no way…for the commercial provision of communications service." This is, in principle, to ensure that a licensed entity is not using their assigned radio frequency resources to make a profit.

A favorable disposition for an FCC waiver for sharing frequencies in a statewide system for Missouri should be expected as long as it is demonstrated that the sharing is non-profit in nature. It is significant however, to note in a shared system scenario in Missouri, any sharing of fees or costs should be carefully planned, accounted for, and executed to clearly demonstrate that the sharing is limited to sharing of actual costs.

Public Safety Frequency Availability

An extremely limited amount of radio spectrum is reserved for public safety. In a February 2003 guide for public officials entitled "Why Can't We Talk?" created by the National Task Force on Interoperability, the following explanation and accompanying chart of the current spectrum situation was presented.

Spectrum "101"

• Radio spectrum is a finite resource. It is the electromagnetic real estate in the sky. What exists today is all there will ever be. It cannot be created or increased. What exists must be re-allocated and better managed.

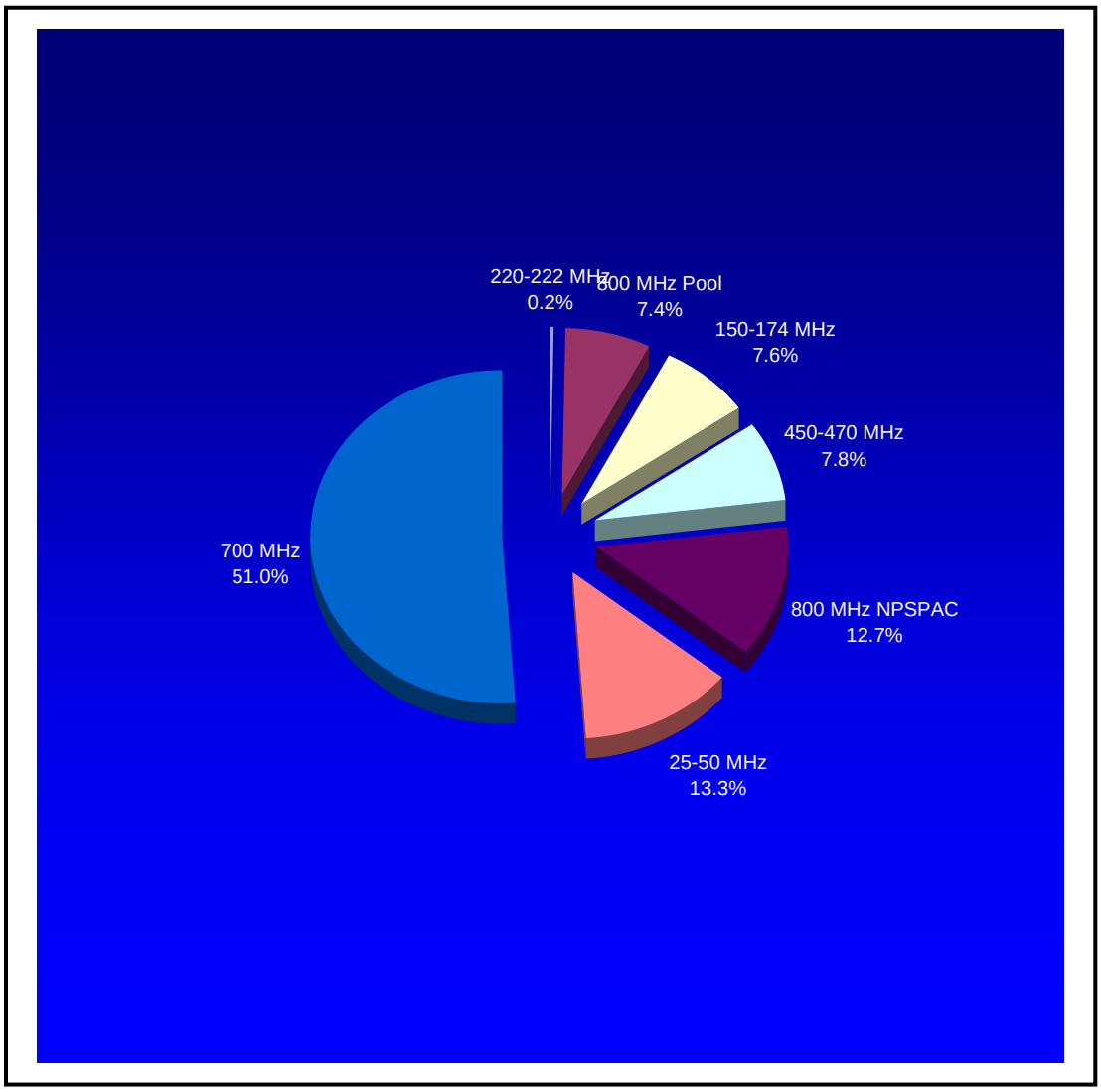
• There is an inadequate amount of radio spectrum dedicated to public safety.

• The limited amount of radio spectrum allocated to public safety is subject to interference from commercial wireless services, radio and TV broadcasters, and from our Mexican and Canadian neighbors.

• The radio spectrum allocated to public safety is not contiguous. Narrow frequency bands for public safety are scattered throughout a wide spectrum range which severely limits the ability of public safety to communicate across agencies and jurisdictions.

• The ability to harness radio spectrum is limited by technology. In most cases, industry, not public safety set the standards for equipment and software. Their needs, not those of public safety, drive research and development.

Public Safety Radio Spectrum



As can be seen in the chart above, the frequencies allocated for public safety use over time have become widely scattered across many different bands. Initially, almost all public safety communications were confined to the low end of the frequency range. As an example, when the FCC authorized the low band VHF frequencies in the 40 MHz range, the Missouri State Highway Patrol developed their statewide system in the 1940's and 50's. As technology advanced and improved, equipment operating on higher frequencies was developed and the FCC assigned additional frequencies in higher frequency bands. Authorizing new bands only provided a temporary fix for congestion,

however, as each time the eligible users quickly licensed and built systems using up the available channels in a relatively short time frame. The current situation—public safety eligibles today operate primarily in 10 separate bands as illustrated in the above chart. When the situation is considered in this manner, it is easy to understand why the various systems in use by various entities are fragmented and interoperability is difficult.

What is not clear by simply looking at the chart above is the scarceness of available frequencies upon which to develop a new system. With the exception of the newly assigned 700 MHz band noted by the asterisk in the chart, the available frequencies are almost all already licensed by others for use in their existing systems. And, while you might expect the situation might be improved in the area below 512 MHz due to the "refarming", the reality is that the newer, narrowband channels will not be fully available until the existing users have replaced equipment by the 2013 deadline. So, both in terms of available channels to use in a new system now, and potential for future growth, the 700 MHz band is the logical choice. In fact, in terms of the available channels upon which to develop a statewide system, the number of available channels in the 700 MHz band would be significantly more than the number of available channels in all the other bands combined.

As identified by the National Task Force on Interoperability, the 700 MHz band allocation provides the best opportunity for available frequencies upon which to develop statewide systems. The equipment operating in the 700 MHz band will also be interoperable with the existing 800 MHz band frequencies. Because of the availability, and the fact that a portion of the band has been allocated for direct licensing to the States, the Task Force concludes that "The 700 MHz band is particularly well suited for wide area (county, large city, State) systems that can accommodate all public safety users and are inherently interoperable.

The 700 MHz band is also anticipated to be a focus for development of technology advancement for public safety. A report from the First Response Coalition in May 2005, titled "A Quantum Leap in Public Safety: Spectrum Solutions for First Responder Communications Needs", states:

> *The 700 MHz frequencies, combined with cutting edge technologies, can revolutionize first responder communications by providing new applications. Public safety capabilities will see a quantum leap forward with the use of tools such as remote video monitoring, secure and encrypted communications, satellite*

and GPS devices, and wireless broadband connections that can keep all first responders, regardless of which department they are part of, in constant contact. Examples of these amazing capabilities are already in place, and they must be made available to first responders in all communities.

In March 2007, the same First Response Coalition in a paper titled "Interoperability Innovation: State Best Practices and Models for First Responder Communications" noted:

As technology has evolved, the 800 MHz band has become the preferred spectrum space for statewide interoperable networks. The additional 24 MHz of spectrum in the 700 MHz promised to first responders as part of the digital television (DTV) transition, scheduled to be completely available by February 2009, will provide state and local governments with more opportunities to upgrade their communications networks.

It is clear that on the basis of frequency availability and compatibility with existing 800 MHz systems, a 700/800 MHz system is the logical conclusion. Unfortunately, the 700/800 MHz frequency bands do not provide good coverage in all areas and types of terrain in comparison with other frequency bands. In general, lower frequency bands provide better range or distance. The table below illustrates the comparison of the typical effective range among several frequency bands, along with a comparison of the interference potential and noise environment.

Band	100 Ft. Tower Typical Range	Interference Potential		Noise
		Close By	Distant	
25 – 50 MHz (Low Band VHF)	> 35 Mi.	Lo	High	High
150 – 174 MHz (High Band VHF)	20 Mi.	Lo	Mid	Lo
450 – 470 MHz (UHF)	15 Mi.	Lo	Lo	Lo
700/800 MHz	8 Mi.	Lo	Lo	Lo

As clearly seen from the table, the higher frequencies have less range. This translates in a larger number of towers required to cover a given area. As illustrated in the table, the VHF low band (25-50 MHz) provides greater coverage and range for a wide

area network. As stated earlier, however, there are very few available channels in this band, and it is susceptible to long range interference from "skip" conditions and a higher level of environmental noise.

In the 700/800 MHz frequencies, while an effective range of 8 miles or more would be considered typical for average terrain, in mountainous terrain this reliable range is reduced to less than 2 miles. In particular, in southern parts of Missouri with Ozark terrain, building a reliable system at 700/800 MHz would require constructing a large number of towers in an area where the communications capacity requirements would be expected to be minimal. To achieve reliable, efficient coverage for this challenging terrain area, High Band VHF frequencies are recommended. Another factor in selecting the VHF High Band for this area is the fact that the VHF High Band is also the primary band in use by other local entities in their existing Missouri systems. These local entities could choose to participate in a statewide system, and could bring their licensed frequencies with them for shared use.

Based on the superior range characteristics of VHF High Band, the question could be asked, "Why not develop the entire statewide system on VHF frequencies instead of 700/800 MHz?" This would potentially be a viable solution if only there were enough available VHF frequencies? A minimal capacity statewide system with a small number of channels would likely require well over 100 VHF channels to start. The reality is that there are not enough available channels to develop a statewide system. Using available 700 MHz and 800 MHz frequencies, channels are available for both an initial system and future growth. While there are not a sufficient number of High Band VHF channels available to allow development of a statewide system on VHF, the State should be able to obtain use of enough High Band VHF frequencies to provide coverage in the tough terrain portion of the state geography.

A Hybrid Statewide Solution

In conclusion, the availability of frequencies and technology indicates the 700/800 MHz spectrum as the best choice for a statewide system. Because these frequencies do not provide reliable coverage over challenging terrain, High Band VHF frequencies should be utilized in the Ozark area.

5.3 Impact of Available Existing Assets

In developing a statewide mobile radio system, the State is not starting from scratch. There is a wide range of existing assets that would likely be available for a statewide system around the state. Examples of these types of assets include existing radio tower locations, sites, microwave and fiber optic facilities, etc. Some of these facilities are operated by agencies of the state government, some by Ameren and other utilities, and others by local governments throughout the state.

In preliminary discussions with various entities around the state prior to this study, many of these entities indicated a potential willingness to share these facilities with the state. A database of potential shared tower sites was compiled from these types of entities. The value of such shared facilities cannot be understated, both with regard to schedule and cost.

Many local entities throughout the state have purchased radio equipment with Homeland Security grant funds that can intercommunicate with the recommended concept design on the designated VHF MTAC channel. Providing this additional channel as part of the statewide network would provide a minimum level of interoperability with equipped local agencies regardless of their participation in a statewide system as a user.

In addition, the cities of Independence and St. Louis have switching facilities in their urban systems that can also potentially be utilized in their regions of the state, tying them in to a statewide network.

The technology and spectrum choices for a statewide system in Missouri are driven by available frequency spectrum and the specific requirements of Missouri users. In addition to the rest of the technology and spectrum considerations in Missouri's case, the technical solution presented in this study was developed to maximize the use of existing, available assets for sharing.

5.4 Description of Recommended Technical Solution

A statewide mobile radio network for the State of Missouri is best envisioned as a "network of networks", in this case a statewide network of regional networks. As such, this statewide concept network can be illustrated and understood in three primary layers; an interconnect core backbone layer, a regional network infrastructure layer, and a radio frequency layer.

Interconnect Backbone Layer
Regional Network Infrastructure
Radio Frequency Layer

The **interconnect core backbone layer** provides for the overall operation and administration of the network, provides the wide area connectivity between regions throughout the state, and includes the Network Operation and Control (NOC) facilities and wide area switching facilities.

The **regional network infrastructure layer** includes the radio towers and other network facilities located within a region of the state. Individual dispatch and stakeholder operational facilities are included in this layer. A regional network development approach is recommended for several reasons.

1. Planning efforts for interoperability among public and private entities with radio systems is ongoing on a regional basis. These regional stakeholders have assets of value to both a regional network operation as well as a statewide facility. Coordinating the planning and development of a statewide mobile radio network along the same regional lines will provide synergy with these initiatives and help prevent confusion. This strategy also targets the best inclusion and leverage of the potential participation of stakeholders in each region.

2. The need for and use of interoperability in both routine and emergency situations would be primarily local and regional in geographic scope.

3. A regional network approach provides added flexibility for a coordinated implementation in multiple phases.

Because of the synergy with the existing regional initiatives, the technical solution and concept design is built upon the existing state government regional divisions as used by the State Highway Patrol and others.

The **radio frequency layer** is comprised of the radio towers, antennas, and subscriber radio equipment used in the field by the mobile workforce. The radio frequency layer is the most significant element in network implementation, both for overall cost and schedule. While this layer is also considered as a part of a regional network, it is treated separately because of this significance, and also to provide the

highest priority and consideration of geographic signal coverage, reliability, and performance.

Unlike commercial wireless systems, where dropped calls and lost connections can be a nuisance, a public safety grade radio system must provide continuous, highly reliable performance for the protection of life, safety, and property in all circumstances and conditions. In emergency or disaster scenarios when other infrastructure might be expected to be unavailable or experience extended outages, a statewide mobile radio system must be planned to provide a foundation of communications capability for emergency response and disaster recovery.

Interconnect Core Backbone Infrastructure

The interconnect core infrastructure will tie the network together at the highest level, providing the connectivity between the regional networks and facilities. This will provide for statewide wide area communications, operations, network management and administration.

The interconnect core backbone will provide wide area communications between regional networks and may also provide connectivity to some sites if collocated.

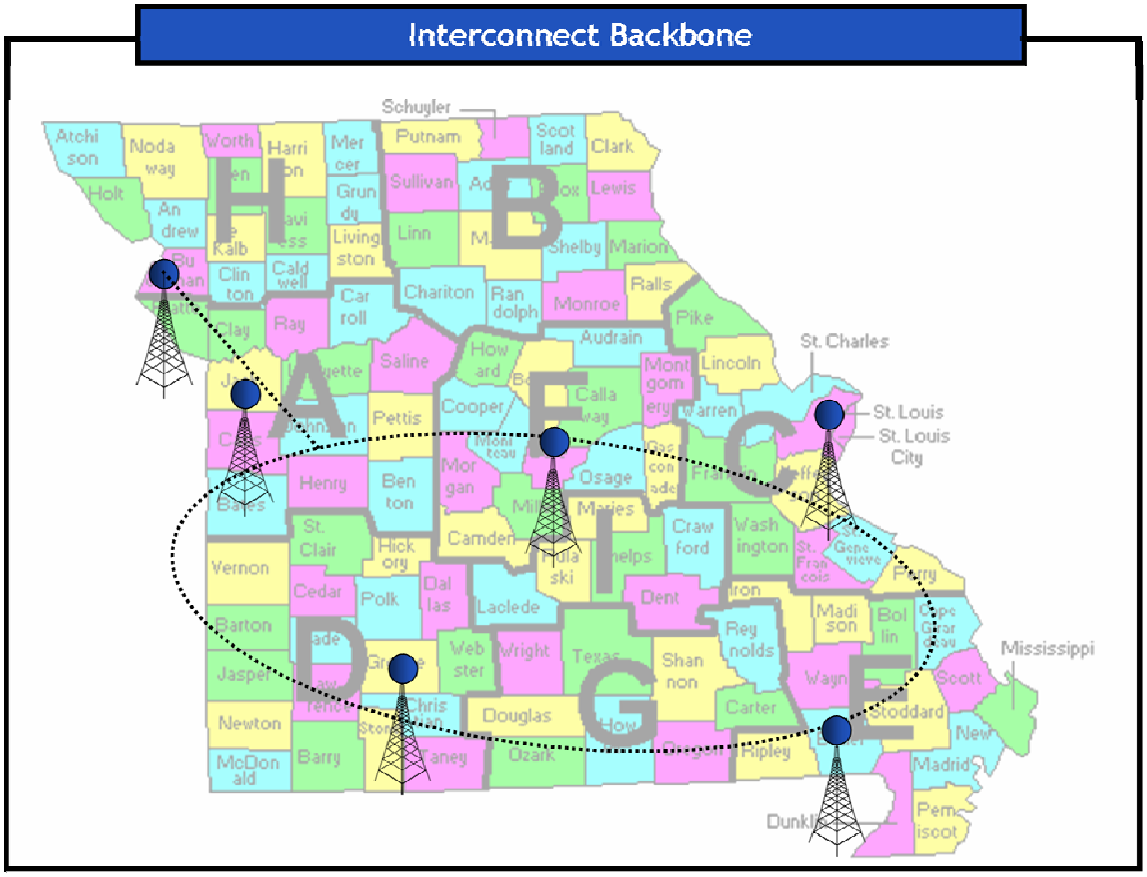
The interconnect core backbone is anticipated to include a NOC facility to provide 24/7 network monitoring and control. A secondary or backup NOC facility capability should also be planned for to provide NOC operations in an emergency scenario.

Switching Facilities

Multiple switching facilities are required to provide control and switching of communications across the network from the tower sites. While a separate switch capability may not be required to be located in every region based on capacity requirements, switching capability at multiple locations across the state is necessary to enable several significant benefits and provide the best reliability for in-region communications under all conditions.

Switching capability at multiple regional locations provides a superior solution for redundancy as individual switches can be sized smaller and in concept paired with other switches for redundancy. Switching in several regions also makes regions less dependent

on long distance connections for backhaul (the link between individual tower locations and switches), and provides best failure operational scenarios. Finally, switching capability in multiple regions offers the maximum opportunity and flexibility for regional interoperability with existing and legacy systems in use by other entities who are potential stakeholders to share or connect with the statewide network.



Interconnect Core Network Connectivity

Interconnect connectivity among the regional locations is envisioned to be configured in loops (similar to the loop in the above illustration) to provide redundant connections to each switch facility resulting in maximum protection against loss of any single connection path or link. With this built-in redundancy, wide area (statewide) communications will not depend on a single path or connection. The connectivity between regional hubs can be provided by a combination of technologies.

Fiber optic networks are the gold standard in today's telecommunications industry. Fiber optic networks provide almost unlimited capacity, extremely high

reliability, and low-cost future growth of capacity between connected locations. While fiber optic networks have a high cost of construction, expanding the use of existing fiber optic networks often represents a low-cost opportunity. There are existing fiber optic networks that could provide dedicated connections in support of the core infrastructure for a statewide mobile radio network. Ameren owns and operates a fiber optic network supporting their current 800 MHz radio system and electric infrastructure operations that could provide interconnection to some of the network. The State of Missouri also has dark fiber rights from a previous fiber construction project in public right-of-way originally negotiated with Department of Transportation. Several commercial carriers as well as other utilities in the State of Missouri also have extensive fiber optic networks in substantial parts of the State of Missouri.

Microwave technology continues to be a popular communications solution. Even with the proliferation of fiber optic networks, microwave technologies continue to advance and thrive. One of the more common applications for microwave technology includes extending private network coverage for voice and data networks. Even in the commercial wireless industry, there is an increased interest and use of microwave to provide connections from individual tower sites on their networks due to enhanced reliability and lower long-term cost.

The State of Missouri has existing licenses for microwave that can also be used to support this network. To provide relatively high bandwidth connections over long distances, microwave remains a cost-effective choice for reliable, dedicated communications. In reaching new network locations, microwave is often much less costly than fiber construction, especially where existing tower or other antenna structures can be re-used or expanded. Adding microwave onto existing towers many times will require significant modification or replacement of existing tower structures to provide support for the dish type antennas with their substantial ice and wind loading requirements. In such cases, microwave costs increase, but they remain generally much lower than construction of new fiber.

Commercial telecommunications carriers in the state might potentially provide leased circuits on their existing commercial networks to provide connections to tower sites on a statewide network. Leased services represent a long-term operational cost as opposed to the up-front capital cost of dedicated fiber or microwave. Leased services also introduce further dependence on outside third-party network facilities and operations which can complicate troubleshooting and emergency outage response. The experience

of existing stakeholders in the state also indicates that leased circuits are somewhat unreliable in many parts of the state on a routine basis. For all of these reasons, leased circuits are not considered an attractive alternative for interconnection of a statewide mobile radio network, especially where the interconnect core network is concerned.

In comparing the technologies in this case, our recommended technical solution is based on the use of the existing, dedicated fiber optic networks (MODOT and Ameren) as the first choice for connectivity for all regional hub locations near to them, and the use of newly constructed microwave connections for the rest of the locations. This strategy is the basis for the concept design and cost estimates in this report.

Network Operations Center (NOC) Facilities

A network operations center capability is required for the network. A single, primary NOC facility can provide 24 hour/7 day network monitoring and control. Ameren currently monitors and controls their network through a NOC located in their General Headquarters in the St. Louis area. Our concept design assumes use of this existing capability for the statewide network. A secondary or backup NOC facility capability is envisioned to be planned for at an unspecified location to provide NOC operations for the radio system in an emergency scenario. Due to the redundancy in the interconnect core network, this secondary facility could be co-located at any regional hub location as it would require minimal physical space and equipment. Both the primary and secondary NOC facilities would provide for monitoring and control of the statewide network.

Regional Network Infrastructure

The **regional network infrastructure layer** includes the radio towers and other network facilities located within a region of the state. Individual dispatch and stakeholder operational facilities are included in this layer. As detailed previously, a regional approach is recommended for this statewide network for a number of significant reasons. In order to coordinate and leverage related statewide initiatives, the concept design is based on combining the nine (9) existing geographic regions of the State Highway Patrol.

The available mobile radio technology in today's marketplace for wide area radio networks provides development through individual building blocks generally in either

zones or local systems. Each of the regional radio networks must provide and support the stakeholder requirements, including:

Reliable Signal Coverage throughout the Service Territory

Shared Channel Capacity (Trunking Operation, minimum three talk paths)

Seamless Roaming for Mobile Users

Interoperability for VHF Narrowband Mutual Aid Frequencies

Integration for Roaming with Existing and Planned Urban Radio Systems

Capability for Connection with Existing Legacy Systems

Expansion Capability to Add Local and Regional Users as Stakeholders

The regional approach serves to maximize the opportunity for reuse of existing infrastructure (existing towers and antenna structures, etc.) and participation of local stakeholders who will need to replace their existing radio systems due to age or FCC deadlines for refarming. The regional approach also provides maximum leverage of investments in equipment over the last few years through grants and other interoperability funding. The regional approach will also provide maximum opportunity for interoperability at the local and regional level where it is most likely to be needed. Regional users can have opportunity to interconnect with the state system at the regional switch locations.

Within each region, the regional network infrastructure includes the radio towers, connected dispatch centers, and the backhaul links from each of these to the nearest regional switch capability.

Radio Towers

There are a large number of existing towers and other antenna structures currently owned by the state, county and local government entities, as well as public and private critical infrastructure utilities that would likely be available to support a statewide mobile radio network. Most of these same entities also represent potential stakeholders who

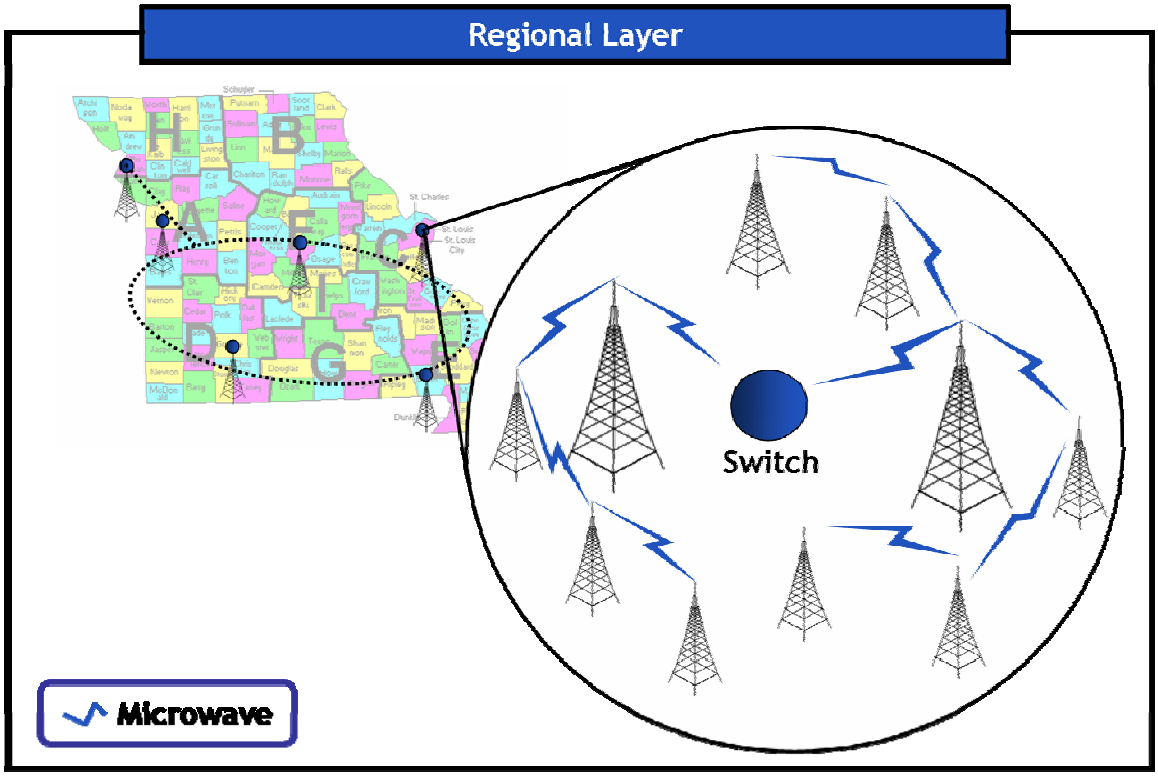
could share the statewide network in the future instead of maintaining separate radio networks.

In support of this technical solution, a database of existing sites from these types of entities was already gathered by representatives within the state government. This database was used to determine the basis for the conceptual design. Through analysis of the preliminary data gathered on these sites, the following assumptions were developed to form the basis for the concept design.

- All sites in the database were considered candidates for a statewide concept.
- An antenna height of greater than or equal to about 175 feet above ground level should be generally available.
- A significant number of site alternatives exist in each region reducing the probability of needing to look for Greenfield site locations.

Dispatch Facilities

The concept design assumes location of dispatch facilities of statewide, regional, and future individual agencies remains the same. State agency dispatch facilities are assumed to be connected to this network in the cost estimates. The concept design provides for the ability to connect to others in the region, but the cost of these additional connections is not included in the cost estimate. Connecting with dispatch facilities provides additional flexibility for joint, shared, or remote operations either within a region or from other state locations (in the case of wide area network users).



Regional Backhaul

The technology alternatives available to connect sites together at the regional level are the same as those for the interconnect core network. The backhaul technology strategy recommended in this case is parallel to that for the core network with a couple of regional considerations. First, the existing, dedicated fiber optic networks do not exist in several regions, and so there is no opportunity to use them everywhere. Secondly, the cost of microwave facilities will increase depending on the anticipated link distance. Maintaining reliability over a longer distance link requires an increase in the size of the dish antenna, or will many times require an additional antenna. In these instances, there is a high likelihood that existing tower structures would not support such additional loading, as they were not designed and constructed to support them.

As a result of these factors, our concept design assumes that where longer distance links are required, a new tower structure is assumed to be required, but the existing tower site remains available for the new tower. In such a situation, the existing facilities would either be moved on to the new tower, or the old tower could be dismantled if the user entities moved their radio users onto the statewide system.

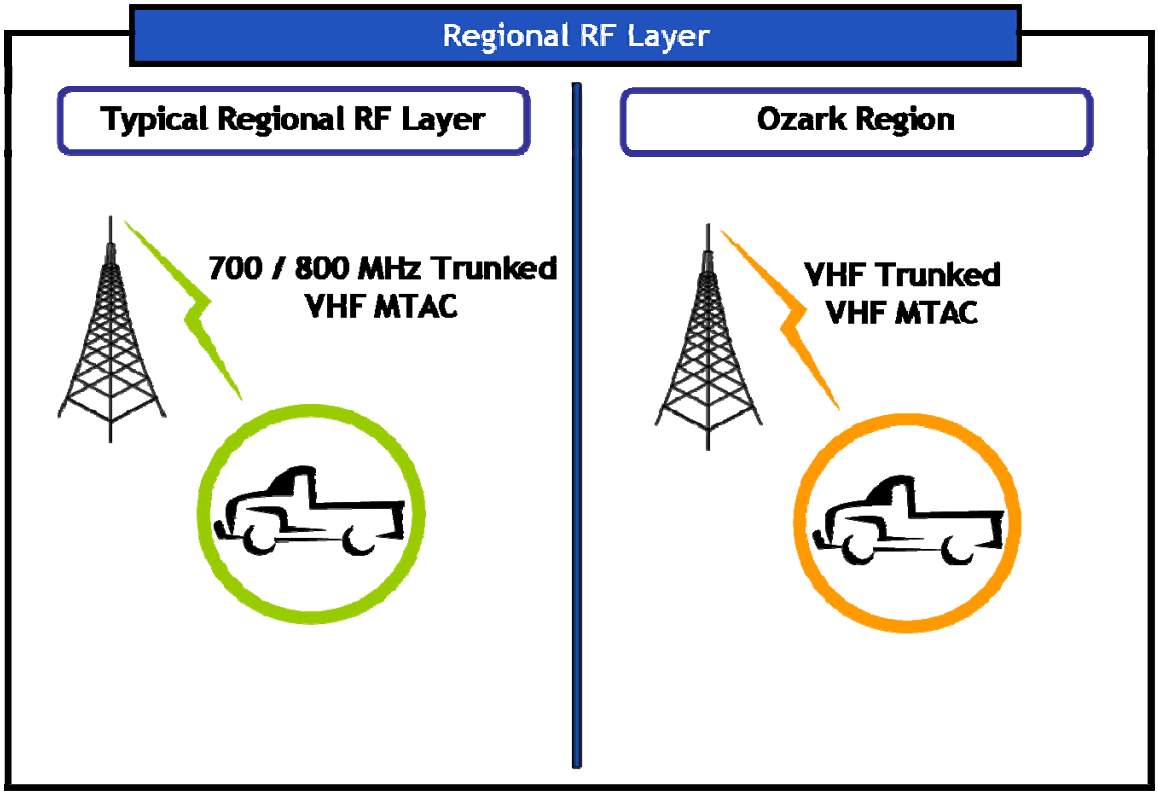
Regional Interoperability

As an added capability to provide statewide interoperability for each region, VHF MTAC channels are planned to be installed for public safety users throughout the state. This requires an additional repeater at selected sites throughout the state. A growing number of local agencies already have these channels programmed into their field radio equipment. The technical solution and concept design includes provision of a single VHF MTAC channel on a statewide basis throughout each region.

Radio Frequency Layer

The recommended technical solution for radio frequency layer of the statewide mobile radio network is a combination of frequency bands, VHF and 700/800 MHz. The 700/800 MHz band offers the maximum spectrum available for both current and future growth capability. As discussed earlier in this report, the 700 MHz frequency spectrum allocation itself is larger than the sum of all the other frequency bands available to public safety. Due to the propagation characteristics at these higher frequencies, however, they are not practical in areas with challenging terrain like the Ozarks. The VHF frequency band provides superior coverage and range in comparison, but VHF frequencies are almost all already licensed to others, with a limited number of VHF channels currently licensed to state agencies.

For these reasons, the recommended technical solution utilizes the 700 MHz public safety frequency allocation as the primary resource for the statewide system to provide current needs, and accommodate maximum future growth and capacity for numbers of subscribers and future data bandwidth potential. In areas of the state where signal coverage is obstructed by terrain and radio traffic capacity requirements are anticipated to be minimal, VHF is substituted. One disadvantage of this hybrid solution is that two radios in a vehicle will be necessary for some statewide mobile radio users. Some equipment manufacturers are developing dual band radios for such applications, integrating with one control head in the vehicle. As the current Ameren radio system on 800 MHz already covers a large portion of the state, the technical solution also applies the 700/800 MHz coverage throughout Ameren Service territory.



In applying this strategy at the regional level, where VHF is needed the concept design also seeks to apply VHF consistently throughout a region to maximum interoperability with VHF users within the region and minimize any requirement for future regional users to need dual band equipment. Regional users in these areas have full capabilities with only VHF subscriber equipment. These same users will have some statewide interoperability by virtue of the VHF MTAC channels planned to be installed for public safety users throughout the state. The technical solution and concept design includes provision of a single VHF MTAC channel on a statewide basis throughout each region.

6.0 What are the Expected Benefits, Risks, and Costs?

The need for a statewide mobile radio system in Missouri has been widely recognized for some time. This same need exists in most of the states across the U.S. As early as 1993, the National Performance Review (NPR) recognized the need for the public safety community to develop multi-agency, multi-jurisdictional radio systems. State and local agencies must work together to meet their responsibilities and ensure that their radio systems will support their responsibility to the public.

Efforts to coordinate statewide and regional planning for shared systems can help state and local governments and other stakeholders realize significant cost and spectrum efficiencies as well as resolve technical, operational, and organizational issues that impede interoperability.

The cost of building statewide systems are substantial as documented by the National Task Force on Interoperability in their February 2003 guide for public officials, titled *Why Can't We Talk?*

> *At the state level, replacing basic radio systems for a single public safety agency can cost between $100 million and $300 million. When considering statewide systems serving multiple agencies, costs are generally estimated in the hundreds of millions…*

The high costs of a statewide system are also evidenced by various estimates and cost figures projected in various stages from other state systems:

- Colorado -$120 Million
- Michigan - $235 Million
- Ohio - $272 Million
- Alaska - $151 Million
- Virginia - $329 Million
- Florida - $40 Million Up-Front, $15 Million/yr for 20 yr
- Arizona - $380 Million
- California - $500 Million Budgeted

Building a single statewide radio network that can be structured to meet the present and future needs ensures that money is spent in an efficient manner. The

redundancy of building multiple, overlapping systems for each user entity is prevented, and that money can instead be redirected to other resources.

6.1 Efficiencies and Synergies in a Statewide Network

A primary benefit of a single, shared system is cost efficiency. Building a shared system at the state level makes sense. Shared statewide systems are a definite trend, the wave of the future. Because of the high cost of radio systems, their infrastructure, and the lack of available frequency spectrum, shared systems are the inevitable result.

Estimates in other states have projected the costs of building separate systems for individual entities at about four times the cost of a single statewide solution.

Outside of participating in a shared system, agencies with similar needs will almost certainly be duplicating each other's purchases at some level. The potential economies of scale offered by sharing a combined system almost guarantee both capital and operational cost savings by definition.

6.2 Benefits by Stakeholder

Developing a statewide system under state government leadership will ensure the maximum benefits in a shared system for the user entities in the system. In addition, it is important to recognize the greater benefit for the citizens across the state as well.

Citizens of Missouri

The overall justification and benefit to be realized in a statewide mobile radio system is the increased public safety for all the citizens of Missouri in the lower risk of loss of life and property. Ultimately, public safety is a core function of governments. Adequate public safety radio communications are essential to performing public safety functions. The public looks to the elected and appointed officials to be prepared for, and provide basic public safety, guidance and management during a crisis.

A statewide mobile radio system will provide an increased ability for public safety and critical infrastructure professionals to more quickly and effectively respond to both routine and emergency incidents throughout the state. Without a statewide system, the State of Missouri is in a vulnerable, unacceptable position given the threats to

Homeland Security, and other large scope emergency scenarios such as severe storms and earthquake.

A shared, statewide system provides the most efficient use of all the available, existing assets for all the potential stakeholders in a statewide system. Existing radio towers, microwave and fiber facilities, etc. may be able to be leveraged in a statewide system providing cost savings when compared with building from scratch. The cost of locating and constructing a new tower site with site improvements and equipment can be up to $1,000,000 per site. In a very real sense, these cost savings would accrue back to the citizens of Missouri.

A list of other overall benefits would include:

- Lower Risk of Loss of Life and Property
- Improved and Enhanced Operational Capability
- Increased Flexibility for Inter-Agency Partnerships and Collaboration
- Increased Interoperability for Emergencies
- Faster Response
- Enhanced Safety for First Responder Professionals
- Enhanced Efficiency and Coordination of Overall Emergency Response Resources

Public Safety Stakeholders

In addition to the overall benefits to all users, there are several significant benefits for public safety in a shared system. For example, the highest level of interoperability is achieved when public safety agencies agree to migrate to a single, shared communications system. Trunked systems are most often the technical choice of technology. Trunked systems bring with them significant operational flexibility for separating or combining talk groups as needed, based on evolving requirements in the field. Trunked systems provide the capability of wide area broadcast messages to all involved if needed.

Developing a shared system provides the best utilization of the scarce radio spectrum resources available to public safety. Because of the shortage of available radio frequencies in various frequency bands, public safety agencies are extremely limited in what can be developed separately. With a statewide system, however, once a system is in

place, others can be added with minimum cost and without duplicating facilities and systems.

With regard to the Missouri State Highway Patrol, the current radio system provides only a single talk channel in each region of the state. This results in congestion on the radio channel when multiple or broader emergencies occur at the same time. In such an event, the existing system is not always available to other users. A statewide system will provide the additional shared capacity to allow for the seamless operation of multiple incidents in the field.

Smaller public safety agencies also have the capability in a statewide system to access state-of-the-art technology that might otherwise be cost-prohibitive for them on a standalone basis.

Critical Infrastructure Stakeholders

Critical infrastructure, such as electric utility companies, can logically be considered as major stakeholders in the statewide radio system. Because of the similarity of requirements, other statewide systems sometimes include large utilities as users. In South Carolina, for instance, a statewide radio initiative was developed by the utility SCANA and the State Highway Patrol. The ownership and management of the system, known as the "Palmetto 800 Shared Trunked Network" was purchased in 2001 by Motorola under a contract with the State of South Carolina Chief Information Office. In Nevada, the Nevada Shared Radio System includes state government and both of the state's large utilities, Sierra Pacific Electric Power and Nevada Power Company. In Illinois, Ameren is migrating their mobile radio users onto a shared system with the Illinois state government known as "StarCom21".

Within Missouri, the electric utility Ameren is currently at a stage where their existing radio system is outdated and will need to be upgraded or replaced in the near future. They have significant additional supporting infrastructure assets already in place such as towers, microwave links, etc. that might be reusable in a statewide system.

In emergency scenarios, it would be very beneficial for critical infrastructure users in the field to be able to contact and communicate with public safety as needed. This might be on a routine basis upon observing something during workday travel, or to seek public safety assistance during an emergency needing a public safety response such as a storm or severe weather event, fire, gas leak, etc.

Other Federal, State and Local Government Stakeholders

As discussed earlier in this report, the FCC mandate for narrowbanding in the VHF spectrum presents an imminent challenge to a large number of local government users in Missouri. Many local public safety entities in Missouri have older systems that will need to be replaced due to age, and moving to a statewide system instead of continuing to build separate capabilities would be beneficial for many of those entities.

Local public safety entities in Missouri also have systems that will need to be replaced to meet narrowbanding requirements before the year 2013. Local entities are each typically very small in their number of users, and therefore are not typically capable of investing large amounts of money into a radio system. As local users are added to a statewide system, the cost per user ratio is reduced.

With a separate system, the other entities would not have a statewide capability. In separate, individual systems, each is responsible for not only their own purchasing and construction costs, but also the ongoing maintenance and operation of the fixed infrastructure. In a shared system, while each entity still owns and maintains their own user radio equipment, the smaller agencies are no longer saddled with the capital, maintenance, and operational costs at the "system level".

Statewide shared systems provide volume purchasing opportunities which also benefit smaller users. Because a statewide system involves larger volumes of equipment, pricing is advantageous in comparison with bidding a smaller, separate system with a smaller quantity of user equipment. Not only are the actual equipment costs lower, but the local entity no longer finds it necessary to procure the equipment, saving the costs of procurement (bidding, RFP development, evaluation, contract negotiations, etc.) for both the fixed infrastructure and user equipment.

A shared, statewide system often can provide greater reliability than a smaller, local system. Local systems often cannot afford to build in additional redundancy and reliability in a smaller system.

Finally, a shared system greatly enhances the opportunity for compatibility and consistency across all users for the future. This principle applies not only to the equipment in the system, but also the administration and operation in general. In working together at all levels of government, sharing a statewide system greatly facilities the joint

ability to respond and work together to solve operational problems. In an emergency, familiarity with a system and its operation are critical to effective response. On a shared system, users become familiar with working together routinely, better prepared to respond to an "out of the box" emergency when it occurs.

Commercial Wireless Carriers

A statewide mobile radio initiative could even potentially provide benefit to commercial wireless service providers in Missouri. As towers are modified or replaced, there may be opportunity on a case-by-case basis for either sharing the cost of new tower construction, or leasing space to wireless carriers looking to expand their network coverage. Sharing towers with others in the wireless industry is termed "co-location" and is the preferred method for network expansion among wireless carriers. The co-location opportunities inherent in developing a statewide mobile radio network will benefit both Missouri's wireless carriers and the statewide network in reduced costs.

6.3 Risks and Mitigation Strategies

The risks of going forward with a statewide radio system should not be overlooked. There are multiple areas of risk that need to be recognized and addressed in building and implementing a statewide system, as well as ongoing and future risks in operating a statewide system. Listed below are some common areas of risk anticipated in a statewide mobile radio network, along with a recommended strategy for mitigating the risk.

Risk Category	Description	Mitigation Strategies
Technical	Available Frequency Spectrum is very limited.	• Use the 700 MHz band unless restricted by terrain because of its available capacity for future growth. • Use the VHF frequency band in low capacity areas challenged by difficult terrain. • Leverage the frequency assets of others who join to participate in the system when beneficial.
Technical	New system may become outdated before it can be replaced.	• Build system based on public safety industry standards. • Establish ongoing funding to keep system up-to-date.

Technical	System not adequate to meet requirements of future added users.	• Engage other potential participants up front to ensure they participate in the initial planning process. • Develop a plan and process for funding and implementing system expansion.
Budget	System costs must be kept within budget.	• Develop a detailed design sufficient to drive out cost variables early on. • Develop a phase 1 project to verify cost assumptions.
Funding	Funding reduced before system completion.	• Consider long range capital cost funding to ensure sufficient dollars are available to complete the system over several years. • Make a strategic priority commitment for a statewide radio system.
Funding	Insufficient funding for ongoing operations.	• Consider a long term strategy for sharing operational costs among other stakeholder participants in the system.
Operational	Insufficient technical resources	• Consider outsourcing contract for disaster response or severe outage events.

6.4 Risk of Inaction

It is vital to recognize that the costs of not building a statewide radio system are not zero. In fact, it is likely that the overall long-term costs of not building a shared system would be significantly greater than the costs of building a shared system now.

The costs that should be focused in on at this stage are the costs associated with doing nothing, or more accurately putting off making a decision. Right now the State of Missouri and Ameren are both actively looking for a shared solution for a Missouri radio network. Other local government and utility entities have also expressed interest in the potential system. All of these parties bring many valuable assets to the table beneficial to the whole. The result of a joint effort is a compilation or synergy that can produce a higher quality system for less capital costs than it is likely that any one party could do on their own separately for themselves.

If nothing is decided, eventually both the State of Missouri and Ameren will be forced to implement some kind of system to meet their own communication needs. If

these two systems are built separately, then there will be a significant cost spent in overlapping technologies, duplicated infrastructure, and perhaps a sacrifice in individual system performance, coverage, or quality in order to make the costs attainable.

The same joint system concept can be expanded upon with other parties as well. If there is a third party that needs a radio network in the same geography, there could now be three overlapping systems with similar equipment. The ability to share one single radio system amongst several users allows for significant savings among all parties. The more users that come to the table with funding or existing infrastructure, the greater the savings will be for everyone. However, all parties' needs are time sensitive, in that something will need to be done soon to meet their needs in their required timetable. If a shared system cannot be built, individual entities will be forced to act independently in their own interests. Instead of solving problems with interoperability, this would only compound them.

It is likely that the overall long-term costs of <u>not</u> building a shared system would be significantly greater than the costs of building a shared system now.

Public safety is a vitally important issue that affects us all. Our public safety personnel must have reliable mobile communications capabilities throughout the state, regardless of the type of emergency they are required to respond and address. Their ability to provide for the public safety now and in the future will be limited by the available resources at hand. No matter the level of available resources, however, a reliable, statewide mobile radio network is required to request, coordinate, and implement these resources in the field. Implementing a statewide mobile radio network is one of the most critical elements in public safety. Providing it statewide is a state responsibility. Not doing so will almost certainly cost lives and property and degrade the safety and quality of life of the citizens of Missouri.

6.5 Capital Cost Estimate

CAPITAL EXPENDITURES

1 Preliminary Work

		Each / Percent	Quantity / Total
a.	Prelim Planning and Engineering Costs	$ 850,000	$ 850,000

2 Network Equipment - *Network Operation*

a.	Network Operations Control Center	$ 225,000	2
b.	Regional Switch (additional)	$ 2,500,000	4
c.	Regional Network Switch	$ 225,000	6
d.	Router / Network Switch	$ 12,000	229
e.	Total Trunked Tower Sites		228
f.	% of Trunked Tower Sites that are 'Medium Size'	30%	
g.	% of Trunked Tower Sites that are 'Large Size'	10%	
h.	Trunked Tower Sites (Small, 3 chan)	$ 525,000	131
i.	Trunked Tower Sites (Small, VHF only, 3 chan)	$ 560,000	9
j.	Trunked Tower Sites (Medium, 7 chan)	$ 696,000	65
k.	Trunked Tower Sites (Large, 10 chan)	$ 771,000	23
l.	Tower Structural Analysis (each tower)	$ 18,000	44
m.	New Towers on New Sites (200' Self Support)	$ 192,000	13
n.	Tower Replacement (Incremental cost)	$ 140,000	201
o.	Microwave Link (per hop)	$ 135,000	208
p.	Microwave Link, Regional Backbone (per hop)	$ 155,000	37
q.	Legacy Gateway (ex: MACom/Motorola)	$ 30,000	2
r.	Permitting	$ 5,000	245
s.	Spare equipment	2%	
t.	Engineering	8%	
u.	Contingency	5%	
		Sub-Total	$250,543,600

3 Spectrum - *Network Operation*

a.	Allowance for Purchase of VHF channels	$ 10,000	27
		Sub-Total	$ 270,000

	Total
Capital Network Total	$251,663,600

4 User Equipment (MSHP only) - *Capital - Sales*

a.	Handheld Radio	$ 3,000	800
b.	Mobile Radio - 700/800MHz	$ 4,500	1200
c.	Mobile Radio - VHF	$ 4,500	1200
d.	Dispatch Console (conversion)	$ 35,000	54

	Total
Capital User Radio Total	$ 15,090,000

1. Preliminary Work

   This is the preliminary planning and engineering costs that are required before detailed design begins. This would include defining the RFP for a Vendor or Carrier Partnership. It should also define the availability of the sites that have been presented. Available frequencies that can be used for the system should also be investigated. Solidifying partnerships with all potential parties for the statewide system should be organized and completed. It may be beneficial to develop a small-scale proof-of-concept highlighting the benefits resulting from the development of a robust communications system utilized by multiple agencies and multiple jurisdictions.

2. Network Equipment

   The network equipment is the equipment and installation of the entire fixed infrastructure for the statewide trunking radio system. It encompasses everything that is needed to make up a statewide system with the exception of user radio equipment and dispatch consoles.

3. Spectrum – Network Operation

   This is an allowance for costs associated with licensing or acquiring frequencies to use on the system. This is primarily a concern with the VHF area of the spectrum because the resource is fairly limited.

4. User Radios

   These expenses include radios that are installed in public safety vehicles as well as the portable units contribute to capital costs. Dispatch consoles will also need to be converted to operate on the statewide trunked system.

Black & Veatch has developed the assumptions and cost estimates used for this study based on a wide range of industry experience developing wireless communications networks for both public and private entities. As in any concept design, assumptions are made to support estimated costs. The current cost estimates in this study are based on defined assumptions such as the availability of sites for use in a statewide system, the number of the existing towers that can be re-used, the number of tower structures that will need to be replaced, and the expectation that microwave links will have an adequate line-of-sight to communicate with an adjacent tower. The detailed assumptions are provided in Appendices. Radio equipment manufacturers also provided budgetary cost figures for equipment. The individual assumptions cannot be confirmed without a

detailed design based on specific locations. Local conditions are indeed local, and until actual site conditions are verified in a due diligence process to support an actual detailed design, assumptions remain just assumptions.

6.6 Operational Cost Estimate

OPERATIONS AND MAINTENANCE

5	**Maintenance - *O&M***			
a.	General Cost Per Trunked Site (per year)	$ 35,000	$ 7,980,000
b.	Software Upgrades (per site per year)	$ 9,000	$ 2,052,000
c.	Software/License Upgrades (per Region)	$ 57,000	$ 342,000
d.	MW Maintenance (% of MW Capital Cost)	5%	$ 1,690,750
		Maint Total	$ 12,064,750
6	**Tower Site Lease Charges - *O&M***		
a.	Cost per site/year unimproved or shared	$ 2,200	45
		Lease Total	$ 99,000
7	**Energy Cost - *O&M***		
a.	Power cost per KWh	$ 0.065	
b.	Regional/Central Operations Center - KW per hour	12.0	$ 41,025
c.	Basestation site - KW per hour	6.9	$ 896,394
d.	Propane cost per site per year	$ 500	$ 122,500
		Energy Total	$ 1,059,919
8	**Test equipment - *O&M***		
a.	Site Equipment Allowance	$ 100,000	$ 100,000
b.	Switch Test Equipment Allowance	$ 100,000	$ 100,000
9	**Staffing - *Operation & Administration***		
a.	Technical System Manager	$ 90,000	$ 90,000
b.	Assistant Managers (2 x $70k)	$ 140,000	$ 140,000
c.	Regional Coordinators (4 x 60k)	$ 240,000	$ 240,000
d.	NOC Staffing (5 x 50k)	$ 250,000	$ 250,000
		O&M Total	$ 13,801,669

5. Maintenance

   For the purposes of this cost estimate, it is assumed that the general maintenance on the trunked radio system is contracted out to a vendor or manufacturer. It should be noted that it is possible that the State could maintain their own system for less money, provided they have the expertise to do so. This maintenance expense also includes the

cost to upgrade and maintain the software at the regional level as well as at the individual trunking towers. It does not include updating any components on the system with updated hardware. Maintaining the microwave communication links is also included in the expenses to maintain the system.

6. Site Leases
   In areas that do not already have trunking tower locations, some additional sites will be required. This category includes this cost to lease new tower sites, or share existing towers that are owned by other entities.

7. Energy Cost
   The cost to power the equipment should also be considered. The electricity consumption is measured in kilowatt-hours, and the cost to supply propane for backup power generation is also included.

8. Test Equipment
   This is an allowance to purchase user and network test equipment. This amount is not sufficient to do full testing and repair, but it should allow for on/off diagnostics and be able to classify equipment as working/not-working.

9. Staffing
   All staffing numbers listed are for administration and operation of the system. For the purposes of this estimate only, it is assumed that maintenance and operation of the facilities is outsourced.

Black & Veatch has developed the assumptions and cost estimates used for the operational cost estimate in this study based on a wide range of industry experience developing wireless communications networks for both public and private entities. Maintenance cost projections assume outsourcing all fixed infrastructure maintenance based on budgetary figures from equipment suppliers. Existing self-maintenance strategies in place today may offer potential efficiencies and cost savings. This should be evaluated further as the system becomes better defined. Staffing and operational cost inquiries were made in interviews with the statewide radio programs of other states, and additional operational cost inputs were provided by equipment manufacturers.

7.0 What Alternatives are Available for Ownership and Operation (Governance)?

Missouri is not alone in facing the issues associated with mobile radio infrastructure. In many jurisdictions all around the U.S., radio communications systems and infrastructure (towers, base and dispatch stations, and mobile and portable radio equipment) are long overdue for replacement due to age alone, sometimes 20 to 40 years old. An increasing number of local, state and federal agencies have come to realize they cannot solve the problem alone. Officials at all levels of government are taking action to improve coordination and create partnerships to facilitate interoperability and develop new paradigms. Specifically, state and local agencies are exploring partnerships to develop shared systems.

Shared systems begin with a number of goals and objectives, including lower costs, widespread interoperability, community interaction, and shared management and control. One common approach is to work toward the development of regional and statewide mobile radio systems that provide multi-jurisdictional coverage for local, state and federal users on the public safety side. These shared systems sometimes also include critical infrastructure entities (electric and other utilities, for example) as major participants in a shared system. States can establish agreements with local public safety agencies to include them in critical planning and operational processes to ensure their needs are recognized and included. At the local level, shared radio systems are becoming increasingly prevalent and fiscally necessary, especially in rural areas, due to the difficulty of obtaining the funding required to build or upgrade on their own.

Many other states around the country have moved forward to develop these shared mobile radio systems. Interviews were conducted with representatives from some of these systems to review and analyze the various alternatives and approaches they pursued, and also to solicit their input and advice in an effort to formulate a recommendation for Missouri. This section of the study report provides a brief background and overview of the various systems surveyed, followed by a comparison of these systems in a number of critical areas. Finally, a specific recommendation is formulated for Missouri's situation.

7.1 Shared Mobile Radio Systems in Other States

The following provides a brief description of other states' initiatives from information gained in the interview process along with supplemental information on these systems.

Arizona - http://www.azdps.gov/pscc/

Arizona is currently still in the early stages of a statewide network initiative. An oversight commission has been formed with participation from multiple stakeholders. At this time, they plan to develop an 800 MHz trunking radio system owned by the state. The initiative is currently in the conceptual design stage with costs estimated to exceed $380M. Aside from any available general funds, Arizona has not yet determined where the overall funding for the project will come from. Backbone connections for the Arizona network are anticipated to utilize a microwave system also to be constructed.

Colorado - http://www.colorado.gov/dpa/doit/comm/dtrs/index.htm

The Colorado Digital Trunked Radio (DTR) system began in 1998. The project is governed by a group of committees created by the state of Colorado for this sole purpose. The DTR project was developed and built through partnerships between the State and local governments and was funded with local, State, and Federal funding. The system is mixed ownership by the State and local governments.

The Colorado system is a Motorola Project 25 800MHz system with some 700MHz equipment incorporated into the system in urban areas. The communication backbone is primarily created by microwave links. There are currently over 400 agencies and approximately 23,300 users on the DTR. The completion of the system is planned for 2008.

Florida - http://www.macom-wireless.com/slers/default.asp

Florida began its current Statewide Law Enforcement Radio System (SLERS) more than 17 years ago when Florida created the SLERS trust fund. A fee was placed on vehicle registrations throughout the state to support funding a statewide radio system. The system was developed over several years, with Phase 3 deployed in 2003. Florida is one of a handful of states that has implemented a vendor/public partnership for their statewide radio system. The system is privately owned and maintained by M/A-COM while the state of Florida is considered the primary client of the system. Florida invested an initial $40 million start-up payment and pays an annual surcharge of approximately

$13 to 17 million via a $1 motor vehicle registration fee. The original contract duration was 20 years.

The Florida system is a M/A-COM 800 MHz EDACS system with more than 14,000 users. The SLERS project was completed in 2005.

Illinois - http://www.motorola.com/starcom21

The State of Illinois radio network is called STARCOM21, and it began in 2006. Since Motorola is headquartered in the state of Illinois, it was beneficial to leverage a vendor/private partnership with Motorola to provide a statewide interoperable radio system. Being the home state of Motorola, this system also provided a unique, competitive motivation among bidding vendors. The Statewide Interoperability Executive Committee governs the system, and the state of Illinois pays Motorola as the primary user or anchor tenant. Each user also pays $53 each per month for use of the system. Ameren is migrating their mobile radio users in Illinois onto this system, also planning to become a user on the STARCOM21 system.

The system is an 800MHz Trunked Radio system with Project 25 compatibility. The number of users on the system is not certain at this time, but the contract between Motorola and the State of Illinois guarantees at least 6000 users. Users are responsible for their own maintenance. The project is projected to be completed in 2007.

Kansas

Kansas is currently in the process of upgrading their statewide 800 MHz conventional system to a Digital P25, trunked system with four channel capacity statewide. They began this conversion work in 2006 and it is managed and operated by the Kansas Department of Transportation. Funding for their original system from general state funds built the system over a 10 year period. The P25 trunking upgrade has been partially funded with federal funds as well as monies from the general state fund and will also take several years to accomplish. The state retains ownership of and maintains the system.

The upgraded system will be a Motorola P25 trunked radio system operating in the 800MHz spectrum. The communication backbone is a mix of owned and leased fiber as well as microwave. There are currently less than 5,000 users on the radio network,

and completion of the upgrade to the network will be done as quickly as the funding is acquired.

Montana

Montana is in the process of developing a statewide Public Safety Radio Communications Program through a series of regional initiatives. The program began in 2003 and is led by a Statewide Interoperability Executive Committee (SIEC), appointed by the Governor. The first regional initiative was for Lewis and Clark County and was partly funded by a FEMA ICE grant. A second regional initiative is being built this year along the Canadian border including 12 counties and 4 tribal reservations.

Montana utilizes a Motorola trunked VHF system that is P-25 compliant. The Montana system includes federal users (Department of Interior, Border Patrol) and also shares federal VHF frequencies. The communication backbone is primarily shared Microwave links with some fiber in urban areas. No leased fiber was available for their use. The state is currently operating on a single switch location with plans to add a second switch in 2009. State agencies have been mandated by the Governor to use the statewide radio system, and eventual users are estimated at 10,000 users. The anticipated date for completion of the statewide system will be 2009 or later.

Nevada - http://nitoc.nv.gov/IT_NCSC.htm

The Nevada Shared Radio System began around 1996. The project was funded as a joint venture between the state government and two private utilities: Nevada Power and Sierra Pacific. The FCC granted a waiver to allow these entities to share their individually assigned frequencies together. Initially, no contractual agreement was made, but each party shared the infrastructure that was already built. There is no specific governing body. Each new site that was implemented was funded by the entity that needed coverage in that area, as funding is available. Ownership of each site is retained by the builder of the site, and ongoing maintenance is provided by that owner.

The system is a trunked 800MHz EDACS system with 3 regional switches by M/A-COM. The communication backbone is comprised of a variety of leased, shared and private microwave and fiber links. Major users consist of the Department of Transportation, Highway Patrol, Nevada Power and Sierra Pacific. No user fees are assessed, however new users that enter the system must pay for any new infrastructure upgrades required to meet their needs. The system was considered completed in 2006,

although new sites are continually added to the system to enhance coverage on an ongoing basis.

Ohio - http://www.oit.ohio.gov/sdd/networkservices/index.aspx

The state of Ohio began their Multi Agency Radio Communications System (MARCS) in 1994 with establishment of the MARCS Steering Committee. Funding to create the statewide network was paid for with state government bonds (>$270M) that are now paid back by the general state budget.

MARCS is a Motorola ASTRO (non P-25) digital 800MHz trunking system. The communications backbone is made up of leased fiber from AT&T. There are approximately 20,000 users on the system, and each user pays a $19 per month user-fee for each radio. The system was originally designed for state agencies, but the number of local users has now surpassed the number of state users. The MARCS system was completed in the end of 2004.

Oklahoma

Oklahoma's statewide radio system might be described as "best effort". The system was initially built in 1982 to serve areas along the interstate corridors and provided coverage to approximately 70% of the population in the state. The system has continued to expand with available funding and is expected to have 98% coverage of the state at its completion.

The system adopted the Motorola Project 25 standard in 1995 and utilizes the 800MHz frequency spectrum. The backbone consists of both owned microwave and leased T-1s. Public Safety users are responsible for purchasing and maintaining their own equipment, however no user fees are required to access the radio network.

South Carolina - http://www.cio.sc.gov/cioContent.asp?pageID=756&menuID=411

The Palmetto 800 Radio System was developed by an electric and gas utility SCANA and the South Carolina Highway Patrol. Palmetto 800 is a vendor/private partnership. The system was originally operated by the utility and later purchased by Motorola in 2001, with State and local governments as well as power utilities being the main users for the system. This frequency sharing arrangement with public safety and utility users together required a waiver with the FCC.

Palmetto 800 is a Motorola SmartZone trunked system at 800MHz with 69 transmitter sites. The communications backbone is primarily leased T-1 lines. There are approximately 22,000 users on the system. Each user is responsible for purchasing and maintaining their own mobile and portable radio equipment and user fees are assessed based on the number of base stations needed to communicate. Statewide coverage costs $63 per user per month. The system was completed in 2004.

South Dakota

South Dakota's statewide radio communication system began construction in 2002. The system is owned by the state, and controlled by the SD Bureau of Information and Telecommunications.

The South Dakota system is a Motorola Project 25 trunked VHF system, with a communication backbone made up primarily of leased T-1 lines. 14,000 users are on the system, consisting mainly of local government. State agencies and tribal agencies are also minor users for the system. There are no user fees assessed to the user; however they are responsible for purchasing and maintaining their own equipment. The system was turned on in 2003.

Virginia - http://www.vsp.state.va.us/stars.shtm

The Commonwealth of Virginia began constructing their Statewide Agencies Radio System (STARS) in 2005. The system is funded and governed by the state.

STARS is a Motorola Astro 25 (Project 25 compliant) system that uses the VHF spectrum. About one-half of the state geography is made up of the Smoky Mountains, so 700/800 was not considered an option due to coverage. Assembling enough VHF channels to develop the system required about $8 Million dollars over a two year period just to negotiate and purchase VHF license rights from other licensed users. The system currently serves only the 21 state agencies, with about 4,000 users and is managed and operated by the State Police. There is little expectation for expansion to include additional user entities as there are no additional VHF frequencies available for future growth or expansion. Local entities could participate, but must bring their own VHF frequencies and fund their own expansion. The communications backbone is planned to be a dedicated microwave network, owned by the state. Anticipated completion is in 2009. Virginia has passed a statewide mandate that all agencies and localities must comply with the Statewide Interoperability Strategic Plan by 2015.

Wyoming - http://wyolink.state.wy.us/

Wyoming adopted the plan for their state network in 2003 and began construction on their WyoLink radio system in 2005. The initial project was partially funded by a Homeland Security Grant, and the remainder is anticipated to be funded by the state's general budget over several years. They have 5 sites currently on the air, with 43 additional sites planned for this year. System completion is anticipated in 2007, with further expansion anticipated in 2007-2010.

WyoLink is a Motorola VHF system based primarily on mountain-top sites using Project 25 trunking technology. A perceived benefit to using this equipment is that it is backward compatible with existing radios. The WyoLink communication backbone is a dedicated microwave network, owned by the state. The system has 12,000 users and no fees are assessed to the user.

7.2 Comparison of Shared State Radio Systems

States	P25	Trunking	Frequency Band	State Owns Infrastructure	Vendor Partnership	User Fees	Funded by State Budget	Year Start Operation	Planned Year Complete
Arizona	TBD	Yes	800MHz	Planned	No	TBD	TBD	TBD	TBD
Colorado	Yes	Yes	800Mhz	Mixed	No	No	Partially	1998	2008
Florida	No	Yes	800Mhz	No	Yes	No	Yes	2000	2006
Illinois	Yes	Migration	800Mhz	No	Yes	Yes	Startup only	2006	2007
Kansas	Yes	Yes	800MHz	Yes	No	No	Yes	2005	unknown
Montana	Yes	Yes	VHF	Minimal	No	No	Partially	2003	2009
Nevada	No	Yes	800MHz	Mixed	No	No	Partially	1996	2006
Ohio	No	Yes	800MHz	Yes	No	Yes	No	2001	2004
Oklahoma	Yes	Yes	800MHz	Yes	No	No	Mostly	1994 (P-25)	unknown
South Carolina	Yes	Yes	800MHz	No	Evolved	Yes	Partially	2001	2004
South Dakota	Yes	Yes	VHF	Almost All	No	No	Mostly	2002	2003
Virginia	Astro25	Yes	VHF	Yes	No	No	Yes	2005	2009
Wyoming	Yes	Yes	VHF	Yes	No	No	Yes	2003	2009

Several common factors are obvious from the above comparison table of other states' network initiatives. With very few exceptions, almost all the statewide systems' initiatives either have implemented Project 25 standards on their system, or anticipate integrating P25 into their systems in the next few years. Virtually all of the systems plan to utilize trunked radio technology. A lot of the states have planned or are currently planning their systems based on the 700/800 MHz bands. A few states are developing systems on VHF High Band frequencies, some with significant federal users such as Department of Interior who brought a significant number of licensed channels to the table, and others trying to assemble, purchase, or negotiate enough VHF channels for a state system based on mountain-top sites.

Funding and Ownership

In considering the challenges of developing a shared, statewide mobile radio system, the most difficult challenge stated was almost universally funding. Identifying funding for both the capital and ongoing operational costs for a modern mobile communications infrastructure is essentially a new cost for many states who in the past operated legacy systems built decades ago. As is seen in other states, some have identified and committed funding for a statewide mobile radio network designed to meet the requirements of public safety in coverage and reliability, while others are evolving as best they can over time, tying together various regional efforts as they form.

In fact, upon reviewing the situations in each of the state network initiatives, funding is the apparent driving factor for most of the other organizational and structural decisions around a statewide system.

The answer to the question of who owns what assets in a statewide system varies based on a number of factors. In the case of existing assets that support a new network, such as existing sites, towers, microwave systems, etc., when reused these assets generally remain assets of the original owner entity. To recognize the value of these assets to the new system, an ongoing credit is sometimes allocated to the owner to support ongoing maintenance costs. When new assets are purchased or constructed, the new assets are owned by the funding purchaser, whether the state government or another entity. With regard to the individual user agency radios (mobiles, portables, dispatch center consoles, etc.), these are always owned by the individual user agencies who are also responsible to make their own choices for maintenance of this equipment.

So how do states fund these high cost systems? Several financing methods and examples are provided from the February 2003 Guide for Public Officials entitled "Why Can't We Talk?" published by the National Task Force on Interoperability.

Financing methods

Financing methods most often used include lease purchase agreements, capital appropriations, and bond proceeds. A government entity can use more than one financing method to achieve full funding. It is important to remember that financing methods used to fund assets like radio communication systems generally must match the life of the asset. For instance, individual radios usually cannot be financed using bonds, but radio communication systems can.

Lease purchase agreements or fee for service

With most jurisdictions facing shrinking budgets, the search for alternative financing methods that do not require large capital investments has led to fee for service or lease purchase agreements. A private company or source can build and own the communications system and lease it back to a government entity for a charge, which usually includes a maintenance agreement.

Capital appropriation

As opposed to long-term financing, capital appropriation is in the pay as you go category. The funding comes from revenues that are collected from current year taxes and fees. The government entity sets aside the funds to be used for capital projects that usually take less than 10 years to pay back. Capital appropriations are also used to reduce dependency on long-term financing.

Bond proceeds

This is a long-term financing method that can be used for purchases that average 20 years to pay back. For instance, a government entity needing $5 million for towers and other infrastructure could prepare a public bond issue. The government entity obtains the money right away and makes payments through their debt service budget. A stream of revenue will still need to be identified to satisfy bondholders.

Revenue enhancement

Some local and State governments have adopted specific fees, increased existing fees, or diverted some of the revenues from existing fees to fund new communication systems. The Report Card on Funding Mechanisms for Public Safety Radio Communications, a detailed report by the Public Safety Wireless Network (PSWN) Program, a program of the U.S. Department of Treasury and the Federal Bureau of Investigation, provides an in-depth review of existing funding options and new funding mechanisms.

- ***E-9-1-1 fees**—Funding for interoperability can come from fees collected from special fees, such as the enhanced 9-1-1 fee for both landline and wireless communications. These funds are normally used to fund call taking and dispatch equipment in the dispatch center and equipment to determine the location of a wireless caller. Expect opposition from telephone companies who currently receive a great deal of the monies*

from these fees for lease or sale of the equipment, as well as from some dispatch operators who fear that they will receive less funding.

*• **User fees**—Many interoperable communication systems charge user fees to other agencies based on the number of radios used by the agency. This is particularly effective in funding long-term costs; however, charging user fees can present fiscal and psychological barriers for agencies deciding to come on to the system.*

*• **Motor vehicle fees**—Some States have used either existing fees or increased fees on motor vehicle and boat transactions. Due to the large number of transactions, these fees can generate significant funds.*

*• **Gaming fees**—Several States having gaming operations that generate significant sums of revenue. Diversion of the existing revenue collected or increasing the amount of revenue collected can provide a significant source of funds, both in the short and long term.*

Transportation funds

Some transportation funds can be used for public safety communications. Federal Intelligent Transportation Systems (ITS) and Congestion Mitigation and Air Quality (CMAQ) funds have been used for this purpose.

Public/private partnerships

Revenue can be generated by using a governmental entity's assets (towers or land) to develop leasing revenue from a commercial communications company. Of course, this can present significant public issues.

Other funding sources

Are you aware of the existing funding available through State and Federal sources that can supplement your local resources? Funding sources should be reviewed and prioritized based on whether they are currently available, they will last more than a year or two, and whether you can reasonably predict that this source will be around in the future.

Funding In Other States Interviewed

In funding among the state-owned systems interviewed for this study, a variety of funding mechanisms have been used to fund part or all of the costs. In the case of Florida, a special $1 tax was placed on each vehicle license registration to support a

statewide system. Other states used long term capital bond funding for the fixed radio infrastructure.

Sometimes user fees are instituted to offset the substantial ongoing system costs of operating and maintaining the network. User fees are generally instituted as a monthly or annual fee for each radio or user on the system. In some cases, the fee is the same for all users. In other cases, the fee is set based on what portion of the system the user normally operates in. Sometimes a credit against user fees is allocated based on the assets (tower sites, frequencies, etc.) contributed for use in the shared, state system.

Some states view this as a necessary support to guarantee sufficient funding each year to keep the system up-to-date. In the mobile radio technology market, it is common for equipment software enhancements or upgrades to be routinely released, with a required incremental cost to upgrade dispatch consoles, switching controllers, mobile radios, portables, or other specific parts of the system. User fees, in addition to paying for the internal staffing and operational costs, are generally expected to provide for overall system maintenance and keep the overall system current. Among those interviewed, the recommendation was to set the user fees to include a budget for keeping equipment "up to date" as enhancements or software revisions become available.

User fees are not used in all state systems. Some states have avoided them, seeing them as an obstacle to recruiting local agency participation in a statewide system. Where user fees exist, they are limited to paying forward operational costs, maintenance, and system update budget. User fees were never envisioned to pay back the high costs of capital infrastructure construction.

So what funding mechanism should Missouri utilize for a statewide radio infrastructure? That is a question for the State government to address in the days ahead. To assist in this consideration, excerpts below are offered as best practices input.

FUNDING BEST PRACTICES

… the best practices that any state or region can use to assist in obtaining funding for their wireless communications system. These actionable best practices are derived from the common strategies identified across the states of Alaska, Arizona, and Wyoming. Specific state examples further illustrate the effectiveness of these best practices.

Examine all possible funding mechanisms. *While bonds, loans, and state appropriations are the most common methods for a state to use in funding a public safety wireless communications system, these funding mechanisms are not the only viable strategies. Additional funding mechanisms (e.g., federal appropriations, grants, surcharges, taxes, trust funds, public–private partnerships) must be identified, researched, and implemented in order to increase the likelihood of receiving funding.*

• The State of Alaska considered numerous mechanisms to fund their public safety communications system. These mechanisms included—

— Federal Homeland Security and U.S. Department of Transportation's Transportation Equity Act for the 21st Century (TEA-21) funds

— Federal DoD Partnership

— Denali Commission trust fund…

— Public–private partnership with the Alyeska Pipeline.

• Additionally, Alaska obtained approximately $4,000,000 from the state legislature and in federal grants to fund the pilot radio system in the Anchorage area.

• In Arizona, the state debated using portions of funds generated from a surcharge on all telephone lines in the state to help supplement the monies needed to support the statewide communications system being planned by the Arizona PSCC.

• Additionally, Arizona obtained approximately $500,000 in federal funds to pay for the costs of an in-depth needs assessment.

• The State of Wyoming received the governor's approval for state agencies to fund up to $300,000 for an in-depth needs assessment.

• ***Foster cooperative efforts to ensure maximum cost savings.*** *Cost savings can be realized through coordination and partnership efforts. State interoperability executive committee (SIEC)-type organizations (e.g., ALMR-ESC, Arizona PSCC, Wyoming PSMC Initiative), involving entities across all levels of government, foster efforts to coordinate planning and resources. Potential cost saving and/or avoidance opportunities include sharing infrastructure, cooperatively purchasing equipment, and developing joint grant applications.*

• Alaska's proposed application for a TEA-21 grant is unique, because these grants have rarely been used for public safety interoperability, and extensive cooperation and sharing of infrastructure among the participating agencies is required.

• The ALMR-ESC approached local and tribal governments to coordinate and expand opportunities for grant funding.
• The State of Wyoming considered providing funding incentives for counties and localities to instill a sense of ownership in the new system.

• ***Identify and educate stakeholders to build consensus and support.*** *By establishing consensus on goals and objectives for a statewide system, system planners can give potential funders a clear picture of the most appropriate uses of their investments. By sending a uniform message to all key stakeholders and initiating open communications, a state establishes a firm foundation to build cooperative efforts. The proper format (e.g., summaries, briefs, graphical representations, detailed business cases), targeted to the specific audience, is critical to the successful delivery of the funding message.*
• The State of Arizona developed an outreach and education strategy to determine key stakeholders and participants. Tailored, concise materials were then designed to educate these audiences and build consensus on the need for a statewide public safety communication system. The types of materials that the PSWN Program developed included the following—
- *Consensus statements*
- *Fact sheets*
- *Executive briefings and talking points*
- *Web site content*
- *Video script.*

• In the State of Wyoming, the PSWN Program assisted in the development of a business case strategy to guide the state's funding efforts. A business case can be developed for many purposes—to assess system needs, compare possible variations in system buildout, or develop a plan for implementation. In its most basic sense, a business case serves to influence audiences to fund the system and show where and how the money would be used. Key components of this business case strategy included—
- *Identification of business case drivers*
- *Determination of the preferred operating environment*
- *Determination of the recommended technical alternative*
- *Development of the implementation plan*
- *Marketing of the business case.*

• In Alaska, Arizona, and Wyoming, officials focused on gaining maximum involvement from state agencies. States worked to build consensus through

stakeholder meetings and strategy sessions. Arizona and Wyoming also co-sponsored 1-day symposiums with the PSWN Program to present their statewide communications plans to potential users, legislators, and other key stakeholders.

• ***Determine a recognized and accepted authority for procuring, implementing, and operating the new communications system.*** *Managing various funding mechanisms and investigating new mechanisms, in addition to balancing budget dollars from the revenue streams, are key tasks for system success. In many cases, assigning this responsibility to an existing committee or agency that leads the system effort is beneficial.*
• In Alaska, the ALMR-ESC is responsible to assess, assemble, and consolidate communications requirements that support daily operations, disaster relief, and crisis management.
• The State of Arizona PSCC, sponsored by the DPS, is an entity similar to an SIEC, which manages the lifecycle of the proposed interoperable, statewide public safety communications system.
• WYDOT, as the largest public safety mobile communications network provider in Wyoming, leads the PSMC efforts to update, improve, and expand the state's public safety communications capabilities.

• ***Examine the successful funding processes of similar states or regions.*** *This report focuses on three states; however, it is important to recognize the successes in states or regions that have reached full system implementation. Through investigating other states or regions that are similar in geography or political landscape, additional best practices can be identified.*
• State officials in Alaska examined the radio system-sharing plan between the counties of Imperial and San Diego, California. Alaska public safety officials were invited to tour the San Diego facilities and meet with the public safety officials to discuss their best practices.
• Arizona officials participate in several committees and conferences, such as PSWN Program symposiums, to network with colleagues and gain understanding of successful system implementation models.
• Officials in Wyoming reviewed the system planning efforts of the states of Florida, Colorado, Montana, and Arizona.

• ***Develop a firm understanding of the governmental structure and control of budgets.***

State and regional governments vary in makeup and administration. Having a clear understanding of these "chains of command," the associated budgetary control, and any legal constraints is critical in the pursuit of funding. This knowledge will point to the key stakeholders that can successfully promote the clear need for funding.

• In Alaska, the ALMR-ESC had to consider the legal constraints that prohibit the DoD from transferring equipment and funds to the state.

• In Wyoming, WYDOT, as leader of the PSMC planning efforts, is a commission with control of its own budget. However, another key stakeholder, Administration and Information (A&I) is an executive branch department with a budget delineated by the legislature.

• ***Use anecdotal stories to emphasize the funding need.*** *Anecdotal stories highlighting specific events or incidents can illustrate the inadequacies of the existing public safety wireless communications capabilities. Specifically, these stories may detail issues such as insufficient interoperable communications, delays in communications, coverage issues, or channel congestion. These stories are useful for documenting needs and requirements and can effectively demonstrate the benefits of funding a new system.*

• The ALMR Project Overview detailed Alaska's recent natural disasters, such as wild fires and avalanches, that were not easily addressed due in large part to the lack of interoperable radio communications between local, state, and federal public safety providers.

• Wyoming officials documented interagency mobile communications shortfalls on a high-speed chase on Interstate 25 near the Wyoming–Colorado border.

From Funding Best Practices from "Federal Interoperability Assistance Support – Funding Strategy Best Practices Report", November 2002, PSWN Program.

Operations and Maintenance

In the area of operations and maintenance of the radio system equipment, decisions in this area generally also follow funding. In examples where regional or large, shared systems are tied together, the large system owners generally maintain their own systems in their own geography. In examples of state-owned systems, the state generally maintains the entirety. This is not to say that these systems always staff their own maintenance organization. Maintenance is often outsourced for some or all of the equipment. In some cases, the manufacturer, for instance, monitors the switching network 24 hours a day, 7 days a week via a remote connection. In some cases, the

manufacturer is responsible for an overall maintenance agreement for the statewide system, with user equipment maintenance offered at the option of participating agencies.

The choices made in these areas appear to be primarily driven by the existing in-house skills and capabilities. States with existing technical skills and maintenance organizations most often keep, retrain, and continue to use the same staff and other capabilities in a replacement system. Because public safety departments most often have the most stringent operational and performance requirements, most states have historically developed their radio technical resources within public safety.

Three Broad Categories of Shared Systems

In analyzing the initiatives in other states, these systems could be considered in three general broad categories; state owned, vendor public/private systems, and evolved partnerships.

State Owned Systems

Examples of state owned systems would include South Dakota, Virginia, and Wyoming. The state owned systems are usually funded and built by state government primarily in the interest of public safety with no expectation of capital cost recovery from other users. In these cases, the state accepts responsibility for provision of a statewide mobile radio network capability as part of their overall responsibility for public safety.

Some states have even gone so far as to purchase or contribute to subscriber equipment for local users to motivate local participation in the shared system. Even though the user equipment was purchased with funding through the state, however, the local agencies took ownership and responsibility for the maintenance of their own user equipment going forward.

With regard to participation of local government entities, most systems report better than anticipated local participation once the network is in place. Sometimes local incentives are needed, but once a system is in place, local users almost always want to join in because of the many benefits the statewide system offers in comparison with the legacy local systems.

Vendor / Private Systems

There are a few states that have systems provided by a vendor in a vendor/private partnership. Examples of this type of arrangement are the StarCom21 system in Illinois and the SLERS system in Florida. In these systems, the vendor partner builds a statewide network and the state agencies and other users participate as customers.

In the states with these systems, the competitive environment among vendors is generally reported as a key to success. Both Florida and Illinois, for instance, had unique market-competition characteristics based on timing, where they were located, and the vendor's existing market-share and layout of other systems in that part of the country.

It is important to note that a vendor/private partnership in this area does not provide something for nothing. In particular, there is still roughly the same substantial capital cost of building a statewide system regardless of who builds it. For a vendor, building a state system represents an individual business case that must pay for itself. The substantial capital costs as well as financing costs must be recovered. In fact, because an equipment vendor's core business is in manufacturing and selling equipment, and not in building and operating networks, vendors should not be expected to build on speculation, but rather expected to demand a guarantee of sufficient cash flow to support the business case, either through a minimum number of users at a specified monthly cost, or a specified annual cost.

In the vendor/ private partnerships, user agencies still purchase and own their user specific equipment (mobiles, portables, dispatch equipment) and sometimes provide their own maintenance to some extent.

Because a statewide system is usually built leveraging some existing assets of the state (existing sites, towers, and microwave) these vendor/private systems result in a complicated asset mix and responsibilities. In Florida, for instance, the state actually conveyed existing radio towers and some of the other assets to vendor ownership, with a credit against a substantial upfront capital commitment by the state to support the cost of construction.

One of the perceived advantages of a vendor/private partnership is the expectation that the state network would automatically be continually updated by the vendor to offer the latest in technology. In the interviews with the existing systems, this has only been successful up to a point, generally within the product line originally purchased. This

highlights a significant difference between private mobile radio technology in comparison with commercial wireless technologies such as cellular or PCS. While commercial wireless systems have a large base of subscribers over which to spread the cost of technology enhancement, and the enhanced revenue expectation of selling new and additional services over the commercial network, this is not generally true in the private mobile radio world in statewide systems.

A statewide private mobile radio network is a relatively closed system, with a finite number of users, and relatively finite number of potential future users that could be added over which to spread the costs. For this reason, it might be expected that in the case of Missouri, a vendor private partnership could represent a questionable and difficult business proposition for a vendor unless a large number of users are committed up front. The Illinois system reportedly guaranteed 6,000 minimum users. It should not be assumed that potential vendor/partners will assume a "build it and they will come" philosophy, hoping to gain enough users in the future to pay off their investment in infrastructure. It should also be recognized that if the number of guaranteed users is limited to state agencies and Ameren, a positive business case would very likely require extremely high per user fees, with some sort of funding to support up-front capital costs for construction.

Commercial wireless carriers have no experience providing a statewide public safety network to date. Commercial wireless systems in place today do not begin to provide the substantial coverage, availability, operational flexibility, and reliability requirements of public safety and critical infrastructure users. In fact, the widespread emergency scenarios of the past few years (power outages, hurricanes) have highlighted the failures and weaknesses in existing commercial wireless systems to provide for the needs of the public users in disaster and emergency conditions. Nevertheless, commercial wireless carriers do have substantial supporting assets (towers, backhaul connections, etc.) that could potentially provide a foundation upon which to build a dedicated capability for a statewide system. And, for commercial wireless carriers, their core business is in building and operating wide area wireless networks. While a commercial carrier private partnership with a wireless carrier is a theoretical possibility, it is highly questionable that an offering would be made to meet the stringent requirements of public safety based on what's been done to date elsewhere.

Evolved Partnerships

A third category among the existing systems can arguably be classified as "best effort" systems. In these cases, because funding a statewide system was either denied or viewed as an insurmountable obstacle, large users or regional stakeholders move forward to develop wider area capabilities over time based on the available funding of the individual user entities. The South Carolina system started out in this manner, and Nevada and Montana are also on a similar path.

While they function as "state systems" initiatives, they are also in a certain sense still separate systems tied together. Ownership usually remains with multiple large users, and expansion depends on the requirements of funding users.

While these systems do bring modern radio technology and features far beyond the legacy systems of the past, it is important to understand that these evolved systems are generally not guaranteed to meet statewide requirements for signal coverage, capacity and reliability over the entire state in a defined time period. While these generally are long term goals, the advancement of the system toward statewide coverage and performance year by year is more or less an agreed "best effort".

The governance of these evolved systems is generally driven by politics, in that they tend to be organized around other regional initiatives, seeking to leverage regional funding opportunities, grants, etc.

7.3 Recommended Alternative for Missouri

In consideration of the three general categories of systems above, an evolved partnership is not a recommended alternative for Missouri. Replacing the outdated systems in place and providing for the overdue needs of Missouri's public safety and critical infrastructure users requires a defined plan for a statewide system built to meet specific performance requirements in a specific time frame. Meeting this need will also require a committed funding source to guarantee completion to meet the requirements in a defined period.

In consideration of all the factors involved, a state-owned system is the optimal solution. In the view of the general public, it is most often considered the responsibility of state government to provide for the public safety as a fundamental responsibility of government. A state led initiative to build a state-owned network offers the opportunity for meeting the overall needs. Other entities' requirements are generally a subset of the

whole. The multiple state agencies' with radio requirements all generally have the broader geographic coverage requirements of the whole state geography. If a statewide system is built to meet those requirements, particularly for public safety, the requirements of other stakeholders can also be accommodated. The caveat in the area of requirements is capacity. Additional radio channels will need to be added to the system for additional user entities based on the number of their subscribers and the service territory in which they operate. With regard to Ameren, for instance, additional capacity would be needed in the Ameren service territory to serve state agencies plus Ameren's field mobile radio users. A state-owed mobile radio network would also most likely be preferred as making the best case for supplementary funding such as federal grants, etc. A state owned system would easily demonstrate the interoperability benefits to multiple entities and the clear and direct benefit to public safety, both important priorities in such funding awards.

It is unlikely that a vendor or carrier private partnership will offer a substantial cost savings over the long term in comparison with a state owned system. For the most part, the same system would be required to be built whether built by the state or a vendor or carrier private partner. It is, however, not possible to rule out a vendor/private alternative, or even speculate on what terms or schedule might be offered to the state based on the unique characteristics and timing of Missouri's requirements. The only way to finally determine if there is an acceptable alternative in a vendor partnership for a statewide mobile radio system is to test the marketplace based on the actual requirements in the State of Missouri.

Overall Recommendation

A statewide mobile radio network represents a substantial investment in building and operating a large amount of infrastructure distributed across the state geography to serve network users. In building such a system, we believe that state funding and ownership is the best alternative for meeting the needs and requirements of the stakeholders. There are substantial existing assets (tower sites, etc.) within the State and among other potential stakeholders (utilities, local governments, etc.) that present a unique opportunity for development of a state-owned system.

Due to the high level of capital investment required for such a dedicated state-owned system, however, we also believe it is prudent to "test the market" to see what might be offered by a vendor or commercial wireless carrier before finally committing to building a dedicated infrastructure. We recommend the State first initiate a request for

information (RFI) or request for proposal (RFP) to determine if there is a viable solution offered by private industry to meet the state's requirements. While current commercial wireless systems in Missouri do not even begin to meet the real requirements of Missouri's public safety and critical infrastructure users, it is not beyond the realm of possibility that a current commercial service provider or even an equipment manufacturer might potentially choose to build a dedicated facility on top of other existing commercial infrastructure, leveraging other assets to provide a lower cost alternative. From the responses received, the State can then determine if there is a viable vendor or carrier/private offering worth pursuing further.

If no offering is made for a viable, attractive solution from private industry, it is our recommendation that the State quickly move to develop a shared system with state ownership to meet the needs and provide for the public safety and critical infrastructure users in Missouri.

8.0 Recommendations

This final section of the report assembles various recommendations developed throughout the course of this study.

8.1 General Network Recommendations

The following recommendations apply in general to the statewide radio network.

1. Connect to other Missouri systems whenever and wherever it is feasible. In general principle, the value of any network multiplies with an increased number of network connections. A similar principle would be anticipated in this network in considering the number of participants. In moving forward, connecting with existing, local systems and other systems around the State of Missouri will only add to the adaptability, flexibility, and capability of the network as a whole.

2. Retain ownership of backbone facilities among mission-critical locations. Regardless of whether the system is ultimately constructed in a vendor or carrier partnership, the connectivity between mission-critical locations in the network provides synergy and future opportunity beyond the voice radio network. To preserve future opportunity, we recommend State ownership of this part of the network in all cases.

3. Explore increased application of VHF on a regional basis going forward. Because VHF frequencies provide better range and require fewer towers to cover the same geography, expanding the use of VHF in additional regions could result in significant cost savings. For this to be possible, however, will require significant local participation in a region with local entities bringing enough VHF channels to the table to create a VHF trunked capability sufficient to meet the capacity needs of all the region's participants. Because there is no certainty of this situation, we could not project a lower cost estimate because of it. Nevertheless, it may be an opportunity in some regions that should not be overlooked going forward.

4. Consider including the needs of all state agencies in a detailed design. Because the cost efficiency of a statewide network improves significantly with additional users, it would be beneficial for all state agencies to join in a single, network. If it is necessary to build a pilot network in a region of the state to prove the performance and gain support from other agencies, this should be considered.

8.2 Next Step Implementation Recommendations

In order to implement a statewide mobile radio system, either through a vendor or carrier partnership or through direct construction, the situation requires a more complete definition of the available resources. In a simple construction-set view, building a system requires available tower sites, radio frequency channels, user entities as participants, and sufficient funding. In order to develop a statewide network, these four fundamental areas need to be fleshed out reliably in more detail.

1. Further define the available sites. What sites are truly available for a statewide system? Further development of a site database is needed. Information on each candidate site is needed to be able to determine the availability and suitability of particular sites. The available space on an existing site, existing equipment, tower height, age, etc., all could make a specific site either usable or unusable. A more complete information package should be developed from owners of potential sites with some field survey probably required. The catalog of readily available sites will be a significant cost driver valuable to either a vendor RFP or an owner-build strategy. In a vendor partnership, a vendor has to be able to accurately estimate the cost of construction in order to make a proposal, and the location and condition of available sites is the fundamental cost driver.

2. Further define the available frequencies. Some investigation into which VHF frequencies currently licensed by others that could be available in a shared system would be useful. What conditions would be needed in a statewide system for federal users, local users, or other VHF licensees to join in and offer to share their VHF frequencies? This issue should be presented and discussed with local entities. Additional VHF channels could represent significant cost savings in significant portions of the state geography if a greater area could be developed on VHF in less populated areas of the state. In a vendor or carrier partnership, adequate frequency channels are still required to operate the system.

3. Solidify potential partnership participation. Ameren is currently interested in participating in a shared system. Others may also be willing to commit to a partnership. The State should lead an effort to determine what are the required parameters of others to make a commitment to participation. In a vendor or carrier partnership, the number of potentials users fundamentally drives the business case for a vendor or carrier. In a state-built system, the number of

partners can also have significant impact due to the other existing assets of partners such as microwave, etc.

4. Further define the funding alternatives. The availability and commitment of a long-term funding mechanism to support the capital and on-going cost of a network is critical. Even in a vendor or carrier system, the capital cost must be paid back over time.

5. Keep current on regulatory issues. It is important for the State to stay up-to-date with regulatory changes at the FCC. FCC decisions with regard to frequency spectrum may offer additional opportunity or otherwise impact the direction of a statewide network initiative.

6. Wait as long as possible to make technology commitments. Because technology advances quickly, it will likely be advantageous to make technology commitments only when you are actually ready to design and construct a system. This will allow for the latest enhancements to be considered and included in a system implementation.

8.3 Governance Recommendations

A governance structure is the group that is authorized to make decisions about and oversee the planning an implementation of an initiative. The governance structure can be an existing board, committee, council, or commission authorized specifically for the task, or could be the shared responsibility of two or more entities or individuals.

1. Pursue Sate ownership and leadership. State ownership and leadership in a statewide mobile radio network offers the best certainty for fulfilling the comprehensive requirements of the state agencies, Ameren, and other future participants. While local agencies are sometimes hesitant to commit to state initiatives when they're still on the drawing board, the experience of other states universally has been that once a statewide network is in place, local agencies usually become eager to join in because of the benefits.

2. Establish a governance committee and solicit input in process from all potential participants. Among the advice offered from other existing state network initiatives and systems, early involvement of local stakeholders is advertised as a "best practice" for a statewide network initiative, even if local funding is not

sought in the initial construction. If nothing else, this keeps local government informed of the status and plans of the state, so they can integrate their plans, hopefully preventing the need for them to make an independent choice to build their own replacement system separately. Aside from this, the governance approach usually provides a representative from each of the participating entities. With regard to this, it is recommended that Ameren, as a major user/stakeholder in a state system, should be included at the highest level in any governance structure. Voting representation in a governance strategy must recognize asset contributions by the participating entities.

As additional input in the area of Governance, the following guiding principles are offered from the February 2003 Guide for Public Officials entitled "Why Can't We Talk?" published by the National Task Force on Interoperability

Guiding principles for a governance structure

There is no right or wrong way to build a governance structure. Governance structures can be formal or informal but tend to begin with agreements, such as MOUs, by the people who will be most affected by the structures. Governance structures can be created in a number of other ways as well, through State law, joint powers agreements signed by agencies in separate jurisdictions or by several jurisdictions in a region, or signed charters or other agreements. Whatever the agreement, the document should be a statement of general goals that identifies the members and the decision-making process. As you establish a governance structure, consider the following guiding principles.

• Ensure involvement and participation from all agencies and jurisdictions involved. Turf battles can significantly be reduced or eliminated if all relevant agencies and jurisdictions, regardless of size, are brought to the table and allowed fair involvement and participation. If a statewide or regional system is being developed, the governance structure should be representative of all the disciplines and levels of government.

• Set realistic goals and objectives with a reasonable timeframe for the plan to work.

• Identify immediate short-term successes that can be achieved early on in the planning process. Such achievements will motivate participants to strive for long-term accomplishments.

• Explore and secure funding for both the governance structure to be able to do its job and to fund the interoperability effort. Funding problems and concerns are major obstacles to interoperability and can mean success or failure of the effort. Maintain ongoing, open lines of communication with all agencies and jurisdictions involved. A governance structure helps to facilitate ongoing dialogue and other communication between the stakeholders. With all parties, or representatives of the parties at the table, needs and concerns will be addressed to the extent possible. Structures can be destroyed when decisions are made by cliques within the structure, when essential parties are excluded from the communication links, and when parties involved are not open and honest.

• Obtain the support of county boards, mayors and city councils, governors and State legislators, and other elected and appointed leaders. Many efforts fail because they do not have the support of elected and appointed officials, such leaders do not understand public safety radio communication needs, or they do not include elected and appointed officials in the planning process. The key to a successful effort resides within the strengths of committed leadership and the governance structure. Well-defined and structured governance will empower the effort because it requires the cooperation of both the public safety agencies and elected and appointed officials.

3. Identify State funding. The funding requirements of a statewide system are substantial. Even with a vendor/private partnership, there is generally still a substantial up-front capital requirement to support the purchase of user equipment, and sometimes additional up-front payments required to support the up-front capital costs of the private partner. It is important for the state government to move quickly to identify specific funding mechanisms for a statewide system in Missouri, both in the area of capital costs, as well as ongoing operation and maintenance costs. Unless a funding mechanism is identified early on, funding can delay substantial infrastructure projects by several years.

4. Maintain flexibility with regard to existing supporting assets. The State should take a flexible approach to existing assets. Ameren has significant existing assets valuable to a statewide system. Ameren has licensed radio channels, towers, microwave and fiber systems that can be used to help support a statewide system in a large portion of the state geography. There are other critical infrastructure

entities within the state that may also offer similar assets and could participate as users on a statewide system. Ameren should retain ownership of their towers, microwave, etc., as they support their core electric business. Locals and other stakeholders may also want to retain ownership of towers, etc., or may want the state to purchase or maintain them. These decisions will have to be considered on a case-by-case basis.

5. Assign public safety with primary responsibility for day-to-day operations and administration. State led systems, with the exception of the evolved partnerships, are most often administered and operated on a day-to-day basis by public safety departments such as state police. Because the most stringent requirements are presented by public safety, and public safety must provide leadership in the greater emergency and disaster scenarios, public safety is the logical choice for routine operation and administration of a statewide system.

6. Be flexible with regard to maintenance. Maintenance in a statewide system in other states is generally driven by the past maintenance strategies in existing systems. Maintenance of system infrastructure is usually controlled and managed by a single entity, most often public safety. Maintenance of user agency equipment is many times outsourced at the option of the user agency. It is not unusual for state agencies to have their own staff for installation and maintenance of mobile radios, etc., or for a single agency to provide services to other state agencies. The optimal solution in Missouri should be determined based on geography and technical skills currently available. It is also important to recognize that perceived maintenance costs for user equipment can sometimes overlook significant logistical factors such as personnel lost time, travel time, etc. that can sometimes make a more local strategy more economical overall.

8.4 Conclusion

It is likely that the overall long-term costs of not building a shared system would be significantly greater than the costs of building a shared system now. Today there is an unprecedented window of opportunity to capitalize on the benefits of a shared, statewide radio system. Unless the state moves quickly however, other potential participants will be forced to go their separate ways, using the available frequencies and other assets independently, moving forward to meet their own needs. Instead of improving the state

of radio communications for all of the public safety and critical infrastructure professionals across the State of Missouri, the situation would instead become worse. The opportunity would be lost for the foreseeable future, and many of the available, required assets would be depleted.

Public safety is a vitally important issue that affects us all. Missouri's public safety personnel must have reliable mobile communications capabilities throughout the state, regardless of the type of emergency. Implementing a statewide mobile radio network is one of the most critical elements in public safety. Providing it statewide is logically a state responsibility. Doing so will almost certainly save lives and property, and improve the safety and quality of life of the citizens of Missouri.

Appendix A.

Bound Separately