Iowa Statewide Interoperable Communications System Master Plan

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Executive Summary

Many state agencies and local governments across the State of Iowa own and operate disparate radio systems that are aging rapidly and in need of modernization. The lack of ability to intercommunicate with other agencies (multi-jurisdictional or cross-discipline), especially in emergency situations, is a matter of great concern to public safety officials. In order to address the issue of interoperability, Governor Chet Culver signed legislation in April 2007 establishing the Iowa Statewide Interoperable Communications System Board (ISICSB). The ISICSB was given the responsibility to develop, implement and oversee the policy, operations, and fiscal components of communications interoperability efforts at the state and local level and is ultimately responsible for developing and overseeing the operation of a statewide integrated public safety communications system.

Through a highly competitive selection process, the ISICSB selected Federal Engineering, Inc. (***FE***) to further analyze the communication needs across the State, and develop an overall strategy to address an interoperable communications system design and implementation plan for public safety agencies in Iowa. The system, referred to as the Iowa Statewide Interoperable Communications System (ISICS), will provide voice, data, video, and enhanced 911 communications capability for local public safety entities across the State, as well as state agencies such as the Department of Public Safety, Department of Transportation, and Department of Public Defense - Homeland Security and Emergency Management Division. Pivotal to this system offering is the underlying capability to provide ease of interoperation between and among the various state and local agencies in Iowa.

This ISICS Master Plan was developed through a collaborative process involving stakeholders form both state and local agencies, and includes the following:

- Analysis and results of user surveys
- Results of coverage modeling
- Radio and transport conceptual designs
- Plans for state and local agency migration to the statewide system including alternatives for joining the system or interfacing to it
- Proposed phased implementation approach
- System costing estimates and funding strategy options

There are a number of key phases in the development of the overall statewide system design that are captured in the ISICS Master Plan. These are:

1. Identification of the current Iowa public safety communication environment
2. Evaluation of Iowa public safety communication needs and issues to be addressed in the ISICS offering
3. Creation of a conceptual design for the ISICS offering
4. Definition of interoperability processes for working with the ISICS network
5. Estimation of system cost and identification of funding strategy options for a phased system implementation

At the monthly ISICSB meetings, ***FE*** provided technical presentations and briefed the Board members on project progress. During these briefings, the Board affirmed ***FE's*** general findings with regards to user need analysis, and overall conceptual system design.

The current communications environment throughout the State of Iowa is described in this document and partitioned into segments that each focus on the state and local levels. As a starting point to understanding the Iowa communication environment, ***FE*** used the previous *Iowa Statewide Interoperable Radio System Feasibility Study* conducted by CTA Communications in 2007. Additionally, baseline system assumptions from the ISICSB including such as the use of 700 MHz narrowband spectrum, APCO P25 trunked system, dedicated microwave backbone, reuse of existing tower sites, and shared system approach were used to guide the ISICS conceptual system design. Essential to the overall design process was a concerted effort to accomplish widespread stakeholder participation of Iowa's public safety agencies at all levels – state and local, rural, and urban alike. ***FE*** conducted an extensive survey process to identify the user's needs as well as document the various current systems and their characteristics. These efforts included:

- Addressing the broadest user audience possible across the public safety agencies of Iowa (local and state agencies, small and large, urban and rural) through electronic survey questionnaires. Approximately 300 agencies responded from multiple disciplines (e.g., fire, law enforcement, emergency management, medical services, and communications).

- Conducting in-person meetings, discussions, and telephone interviews, with individuals and groups to augment the questionnaire responses. Issues needing further clarification were handled via the personal interview process.

The ***FE*** team drew upon its depth of experience with advanced communication system design to analyze the information gathered through the survey process, to identify issues for the current communication offerings and discern elements of common needs across the stakeholders.

Factored into development of the system conceptual design were trends in technology (e.g., Internet Protocol (IP) based technologies, peer to peer architecture approach, “end of production” types of equipment) and the FCC mandate that all communications systems operating in the VHF and UHF frequency bands migrate to narrowband emissions prior to January 1, 2013. These considerations will greatly extend the life of the ISICS solution and allow for upgrades to future technologies currently being proposed. The outcome of this extensive analysis defined the common needs and points of focus for the communication system design. These were categorized into the following main categories:

- Shared state and local agency need (e.g., improved county level coverage, seamless roaming)
- State agency need (e.g., seamless roaming throughout the State of Iowa)
- Local agency need (e.g., portable radio coverage)

The shared state and local agency needs and the state agency needs are primary drivers for the conceptual communication system design. The local agency needs are addressed as considerations in the system design, such that flexibility of the design supports inclusion of these elements, but they are not considered mandatory at this time. Some primary drivers from this analysis for the ISICS system design are:

- Standards-based solutions
- Common frequency band
- Mobile coverage across the State
- Seamless roaming support
- Flexible architecture
- Wireless video service support
- Advanced data service support

The ISICS is a network-of-networks designed to provide unified voice and data services for local and state agency users on a statewide basis. The ISICS consists of the ISICS radio network, the ISICS wireless data network, and the ISICS dispatch network; all interconnected via an IP-based ISICS transport network. The ISICS conceptual design incorporates the following key system tenets:

- *Encourages use of current and proposed standards-based solutions* – a narrowband voice and data system based on APCO Project 25 (P25) trunked standards (current and proposed)
- *Defines a common communication platform* – employs flexible system topology and configurations to meet the demands of geographic constraints, and operational needs
- *Incorporate peer-to-peer architecture* – distributed call control for wireless communications spanning multiple communication areas
- *Employ IP networking technologies* – a common IP-based transport backbone network interconnecting the network elements of the ISICS offering

The ISICS radio network forms a wireless communication framework to support the voice communication needs for local and state agency users throughout the state, employing APCO P25 trunked system technology in the 700 MHz public safety spectrum. The radio network is segmented into three regions across the State of Iowa. Each region has a regional controller that manages communication needs within that region. Each regional controller interacts with the other regional controllers on a peer-to-peer level to provide support for communications that span regions. The radio network is designed to be fault tolerant and avoids any single point of failure that could totally disrupt communications.

The coverage goal for ISICS is to support a minimum of mobile-based coverage across 95% of each county in Iowa, providing a DAQ of 3.4 (public safety grade performance). As a point of comparison, the current VHF statewide LEA communication achieves the mobile-based 95% coverage goal in only 19 of the 99 Iowa counties. The ***FE*** coverage analysis indicates a network of 265 700 MHz sites can meet this coverage performance goal. The conceptual design allows flexibility to address future coverage need enhancement.

The ISICS wireless data network supports the wireless data communication needs for state and local agency users across the State. This is provided as a tiered approach sharing the 700 MHz public safety spectrum with a ubiquitous low bandwidth narrowband data solution, and a high bandwidth broadband overlay data solution. This combines the TIA standards-based P25 narrowband integrated voice and data solution with the 3GPP standards-based Long Term Evolution (LTE) broadband data offerings in the 700 MHz public safety spectrum. The P25 narrowband integrated voice and data solution is available throughout the ISICS coverage area. The LTE solution is to be implemented initially in select areas that have an immediate need for high speed data functionality, such as high density population centers, or public safety control centers, and later expanded to other areas of the ISICS network coverage. ISICS users may also utilize other available high-speed data services (e.g., cellular, WiFi) in the area to address data service throughput needs in excess of the P25 narrowband data solution.

The ISICS dispatch network supports the interface between the E911 centers and the ISICS network to facilitate dispatch operations for state and local public safety agencies. Information captured from the E911 caller provided through the E911 PSTN-based network, and the Next Generation 911 (NG911) IP-based networks may be shared with the dispatch positions that support direct IP-based interfaces to the ISICS, or with radio control centers that interface via the ISICS radio network. The dispatch positions utilize the ISICS radio network and ISICS wireless data network to perform the necessary dispatch communications between the field responder units.

The ISICS transport network provides the cohesive interconnect between each of these networks (radio, wireless data, and dispatch) as well as the intra-network connectivity for all the elements of each of those networks. The ISICS transport network is a fault-tolerant, self-healing IP-based architecture composed of dedicated microwave network that is supplemented by wireline segments to interconnect each of the elements of the ISICS network. In this fashion, information and control can span the entire statewide network. This allows the potential for physical separation of controlling and controlled elements to afford better system resiliency.

The overarching driver for the ISICS development goes beyond simply supporting operable communications, addressing the need for effective interoperability among the multitude of first responders in the State of Iowa. Traditionally, jurisdictions and agencies have built stand-alone systems that meet their individual agency needs. However, these independent non-integrated systems throughout the State hamper inter-jurisdictional, and interdisciplinary (police, fire, EMS, transportation, etc.) communications. The ISICS design fosters ease of interoperability between state and local agencies through the statewide coverage network employing a unified radio system architecture. Implementing ISICS will allow state and local entities to communicate and share information in real time, provide for the consolidation of resources, and maintain a level of independence and autonomy during day-to-day operations.

While directly integrating with the ISICS common platform represents the highest level of interoperability as defined on the SAFECOM Interoperability Continuum (shown in Figure 1 – SAFECOM interoperability continuum), local entities will have the ability to join the ISICS network on a voluntary basis. Each entity will have the flexibility to consider their current infrastructure investment and make one of the following choices:

- Adopt the ISICS common platform (representing a Level 5 on the SAFECOM Interoperability Continuum)
- Directly interface their current P25-compatible system assets into ISICS (approaching a statewide Level 5 on the SAFECOM Interoperability Continuum)
- Keep non-compatible infrastructure equipment and use available technologies to access ISICS with a lower level of interoperability possible and associated limitations with the given approach (Level 2 on the SAFECOM Interoperability Continuum)
- Operate at the lowest level of interoperability using a radio cache when needed (Level 1 on the SAFECOM Interoperability Continuum)

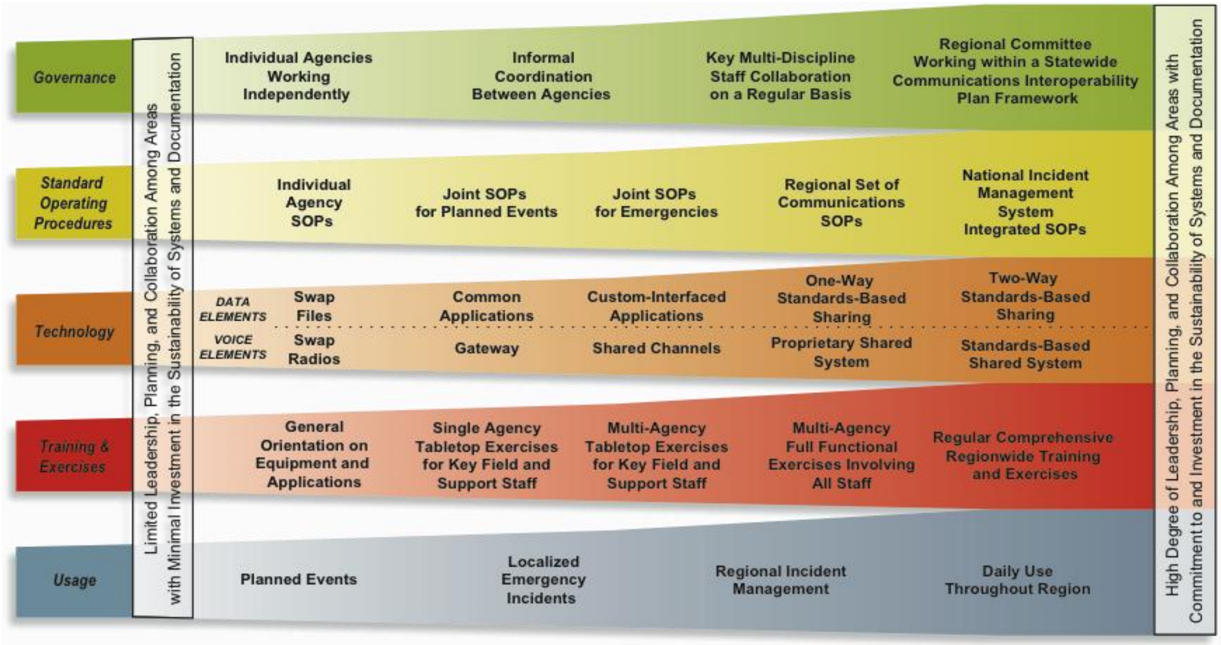

Figure 1 – SAFECOM interoperability continuum

Strategies have been developed to help establish what level of interoperability can be achieved within a given approach.

Although the migration to ISICS encompasses many complex tasks, it can be achieved through an orderly process and partnership of the ISICSB, state and local agencies, project consultants, and the system contractor selected via competitive procurement. This Master Plan recommends that the 265-site ISICS be deployed in six phases that take into account limited financial resources, functional building blocks, the initial proof of concept, and logical expansion of the system. In addition, costs estimates associated with each phase have been included to aide for planning and budgetary purposes. The estimates provided are based on current and historical data derived from similar procurements in comparable jurisdictions The following elements are included in the total cost estimate of ($336M):

- Site equipment
- Digital microwave network
- Physical infrastructure
- Project management, engineering, and implementation
- Contingency and spares

Since the subscriber costs will be driven by individual jurisdictions' implementation plans, the ISICSB chose to focus this analysis on the infrastructure cost elements. Subscriber costs are not included in the estimates, but need to be accounted for in each jurisdiction's ISICS budget.

The ability to obtain necessary funding or financing represents one of the greatest challenges and risks to a statewide project of this scope. The procurement and implementation of ISICS can be funded through several approaches such as capital appropriations, bond issues and vendor lease-purchase agreements and may be supplemented with federal grants or the redirection of existing state revenue resources. Often, combinations of these sources are used over several budgetary cycles. While the approach that Iowa employs to fund the ISICS will be unique to its deployment, ***FE*** has provided examples of how similar procurement and implementation strategies addressed funding for significant statewide technology programs around the country.

In order for ISICS to succeed, more than technology needs to be addressed. As outlined in the SAFECOM Interoperability Continuum, interoperability must be addressed at the statewide level with regards to technology, governance, standard operating procedures (SOP), training, and system usage. As the creation of ISICS moves forward, emphasis on the establishment of regional committees representing stakeholder interests statewide should be prioritized.

Implementing ISICS will provide benefits far beyond its main purpose of achieving statewide interoperability. The ISICS architecture provides a statewide framework to address future communication system directions and enhancements, such as future movement to more stringent narrowband requirements (6.25 kHz equivalency). With the unified communication architecture ISICS will provide for the consolidation of resources while maintaining independence and autonomy during day-to-day operations. This cooperative use of assets will provide interoperability among agencies as well as potential future cost saving opportunities. The ISICS common standards-based platforms can leverage equipment costs across a multitude of state and local agencies in Iowa, and can benefit from utilizing nationwide standard equipment. The unification of the statewide communication offering through ISICS during a time of fragmented and limited funding, can minimize the need for the construction and maintenance of multiple disparate communications networks. In addition, ISICS interconnectivity can be available to non-public safety entities such as schools, hospitals, and other private enterprises fostering an environment of collaboration and unity around the common goal of interoperability.

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1. Introduction

In April 2007 Governor Culver signed House File 353 that established the Iowa Statewide Interoperable Communications System Board (ISICSB), hereinafter referred to as the Board. This Board is under the joint purview of the Department of Public Safety (DPS) and the Department of Transportation (DOT). The ISICSB was given the responsibility to develop, implement and oversee the policy, operations, and fiscal components of communications interoperability efforts at the state and local level. The ISICSB will ultimately develop and oversee the operation of the Iowa Statewide Interoperable Communications System (ISICS).

The ability to intercommunicate with other agencies, whether same-discipline or cross-discipline is a matter of great concern and has been deemed a critical link in maintaining the safety of personnel in the field and the public being served. Therefore, a study was funded to assess the current condition of the statewide emergency communications infrastructure. The study, conducted by CTA Communications in 2007, concluded that Iowa's existing emergency communications radio infrastructure comprises outdated technology with numerous disparate systems implemented across the State. While there are some local and regional initiatives underway addressing the need for interoperability, there remains significant work to be done. As such, many other state agencies and local governments across Iowa own and operate radio systems that are aging rapidly and in need of modernization.

In order to achieve the statewide interoperability goal commissioned to ISICSB, the State of Iowa must replace existing state entity radio system infrastructures with a statewide interoperable communications system, which allows for cost effective use of state resources and enables improved government services at all levels. ISICSB selected Federal Engineering Incorporated (***FE***) to further analyze the user needs across the State and to create a comprehensive strategy for deploying this system, including a functional design and implementation plan.

This ISICS Master Plan describes and documents the results of ***FE's*** efforts. Contained in the Master Plan is the conceptual design of a wireless communications infrastructure for Iowa public safety entities, as well as the creation of a comprehensive statewide wireless communications planning document. The Statewide Interoperable Communications System Master Plan will outline how emergency responders in Iowa can achieve interoperability on a local and statewide basis. In order to ensure that this plan is well grounded and accurate, this milestone includes widespread stakeholder participation across the state and guidance from the ISICSB.

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2. Master Plan Structure

Understanding the concept and goals of interoperability among public safety agencies is crucial to making meaningful improvements to public safety communications systems. Interoperability has increased importance because so many weekly or even daily events—such as criminal pursuits and highway incidents—require cooperative responses. This has not always been the case. Although multiple agencies have historically responded jointly to major emergencies such as fires, train wrecks and industrial accidents, throughout most of the past century local agencies and districts of state agencies operated with much greater autonomy than is possible in today's world.

A statewide communications system that allows for state agencies, local entities, and federal partners to communicate and share information in real time using interoperable technology is a means to improving interoperability. Implementation of this system will allow state and local entities the opportunity, not mandates, to individually join the State network on a voluntary basis. In doing so, each entity would have the flexibility to consider their current infrastructure investment and make one of the following choices:

- Partner with the State and join the newly designed statewide system by adopting the ISICSB proposed technologies
- Partner with the State and directly interface current compatible system assets into the newly designed statewide system
- Keep non-compatible infrastructure equipment and use available technologies to access the newly designed statewide system taking into consideration the level of interoperability possible and associated limitations with the given approach

The ISICS network opens the avenue for partnerships with non-traditional public safety entities or other private/public entities. These partnerships can be in the direction of indirect system support through which the public safety entities can benefit in fulfilling their communications needs (e.g., backhaul support via low/no cost leasing agreements). Additionally there is the opportunity for the non-traditional public safety entity (e.g., university, airport) to become active members of the ISICS network via a set of autonomous ISICS compliant channels dedicated to the use of the non-traditional entity, but which can be accessed by the ISICS public safety agencies to directly interoperate with the non-traditional entity.

Funding and affordability criteria will determine how fast progress can be made in implementing a coordinated solution statewide. The dual goal of achieving functional interoperability without sacrificing local systems or local decision-making became the central challenge in developing the ISICS Master Plan.

In preparation of this Master Plan, ***FE*** worked with the ISICSB to ensure there was wide-spread participation throughout the State. A methodical approach was taken to understand public safety agency needs by focusing on each of the six Homeland Security and Emergency Management (HLS&EM) regions throughout the State. These regions are depicted in Figure 2 – HLS&EM regions and the methodology used during this data gathering effort is documented in Section 3, Needs Analysis Methodology.

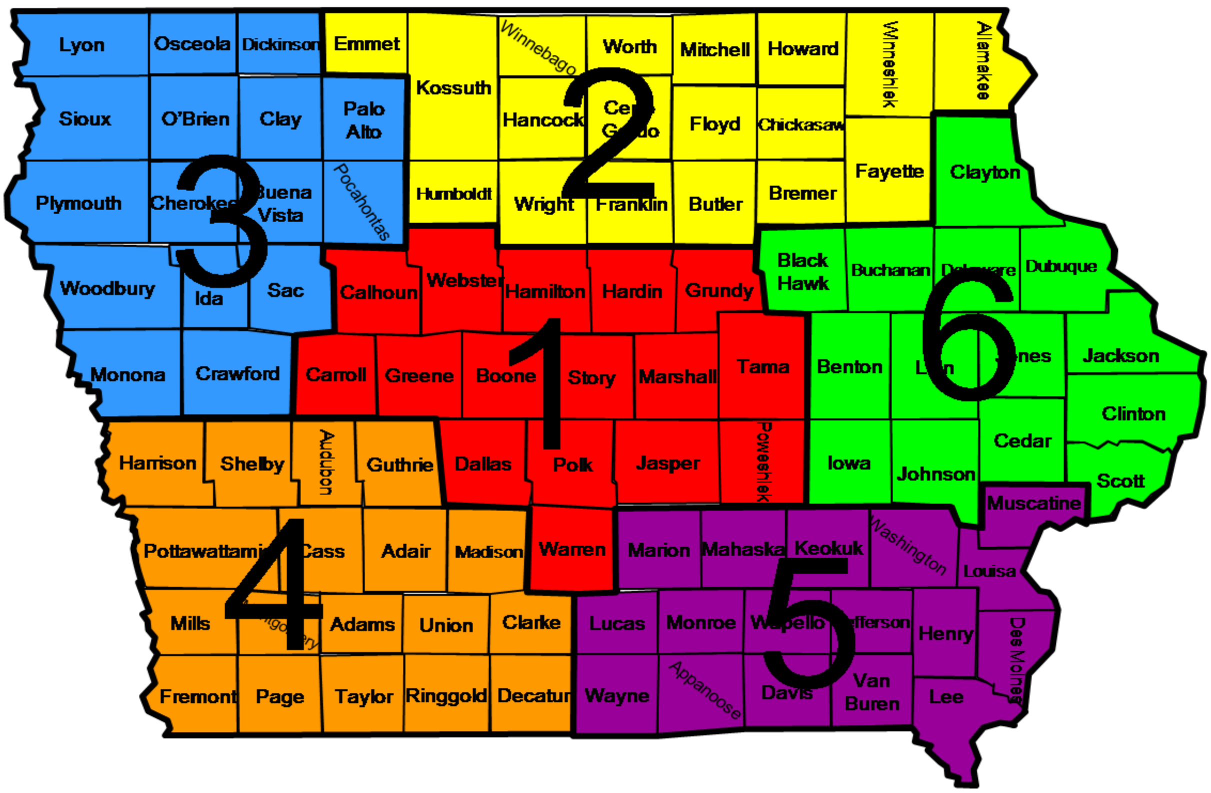

Figure 2 – HLS&EM regions

This Master Plan encompasses all key aspects of the ISICS design process, from user needs, to design structure, and system implementation. While each stage of this effort required different levels of support and coordinated engineering activities, the overall process was managed to maximize the inputs from individual agencies and the ISICSB alike. The output of this endeavor is a comprehensive ISICS Master Plan, which is segmented into the following major components:

- **Needs analysis methodology**

  In order to maximize stakeholder participation, the overall planning process was approached in a logical and systematic manner. This section of the Master Plan describes what methods were used and how each phase in the process supported the next step to produce the final plan.

- **Current communications environment**

  An overview of the current communications environment in the State of Iowa is provided to facilitate the readers' understanding of the overall system design needs. This includes voice and data communications, and public safety answering points (PSAPs) throughout the State. A synopsis of state agencies and local agencies is also provided.

- **Interoperability**

  While supporting operable communications, the need for effective interoperability across the multitude of first responders in the State of Iowa is a significant component of the overall plan. Needs are identified with regard to ease of sharing information, as well as major issues with the current modes of interoperability available to users across agencies and jurisdictions. The focus is on how to make communicating among and between multiple agencies or jurisdictions an easy and efficient mode of operation, especially in emergency situations.

- **System needs analysis**

  Designing the ISICS consists of the systematic application of requirements, trends, and technology, tailored to address the needs of the system users. The system is framed by some trends in technology and a base set of assumptions regarding the communication system characteristics. The information is combined to produce a set of design drivers that define the characteristics and attributes of the communication system. This section describes how design drivers are used to structure the system architecture and the overall system design.

- **Conceptual system design**

  A major component of this document is the ISICS design. This section provides the architecture framework that drives the overall system design and includes radio signal coverage analysis, traffic loading, backbone transport needs, wireless data, and readiness for Next Generation (NG) 911 services.

- **Migration strategies**

  Analysis of agency-supplied data resulted in the categorization of current communications systems throughout the State of Iowa. With this information, migration strategies have been created to provide state and local entities with alternative paths to achieve interoperability.

- **Phased implementation strategy**

  The deployment and operational transition to ISICS throughout the State will require a systematic process led by a partnership of the ISICSB, state and local agencies, project consultants, and the systems contractor(s) selected via competitive procurement. The ISICS will be rolled out according to available funding, operational impact, regional priorities, available infrastructure, and required facility construction. Leadership and consensus within the State's six HLS&EM regions will drive participation and implementation success.

- **Funding strategies**

  A considerable investment of both time and capital will be required to procure, implement and ultimately operate the ISICS system. The challenge of funding such a major capital project is magnified by the current economic picture as well as competition from other states and government agencies competing for the same limited financial resources pool. Examples of system programs and funding approaches from other states are provided.

Additional subsections within the Master Plan provide supplementary information that supports ***FE'***s findings, design approach, and overall system architecture.

3. Needs Analysis Methodology

Understanding agency needs throughout the State of Iowa is an important aspect of the planning process. Surveys were used to gather information representative of Iowa's public safety agency needs from the local, regional, and statewide levels.

To maximize the participation of users and the effectiveness of the survey process, interfacing with all levels of stakeholders was managed in a logical and systematic manner. Partitioning the State of Iowa into smaller, more manageable regions and using the HLS&EM regions as a guide was the most sensible solution, given stakeholder awareness of these regions. The schematic for this approach is shown in Figure 3.

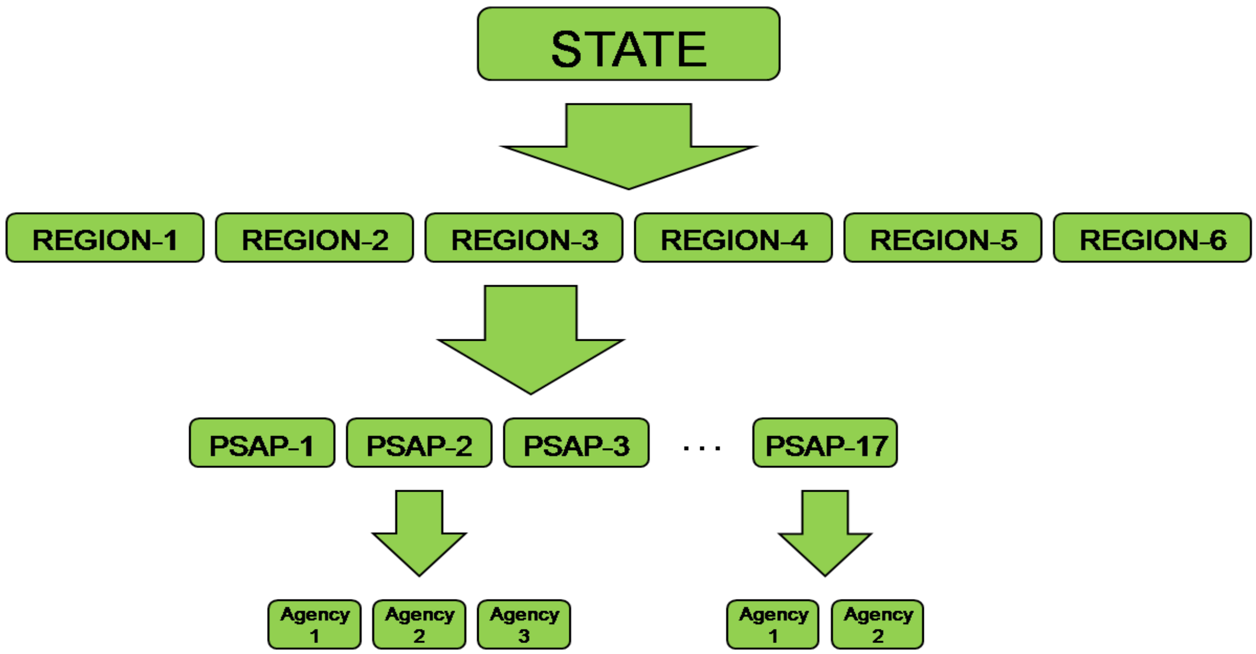

Figure 3 – POC cross-reference matrix

Since there was no central repository for information about existing local public safety agencies, systems, and associated points of contact, ***FE*** first developed a method to collect contact information for agencies throughout the State. With the support of the ISICSB and PSAPs throughout the State, a point of contact (POC) cross-reference matrix was created and managed on a regional basis, using each HLS&EM region. Each PSAP provided contact information for agencies they support and ***FE*** used this to extend invitations to as many agencies as possible to partake in the planning process..

The planning process started with the evaluation of current DPS and DOT systems documentation, previous studies, and associated support information. ***FE*** determined that additional information was necessary to support the overall goal of designing a system that satisfies agency needs from the local level up to regional and state levels. An electronic survey method was selected that efficiently allowed for a wide distribution, resulting in a broad user representation throughout the State. This method avoided biasing results towards the larger metropolitan areas.

To minimize the burden on survey respondents, ***FE*** designed these surveys as user-friendly as possible by focusing them on specific audience categories. As depicted in Figure 4 – Surveys, this resulted in the creation of three specific survey types; two of which focused on current user environment and overall needs, and a third survey that focused on low-level technical details for system owners.

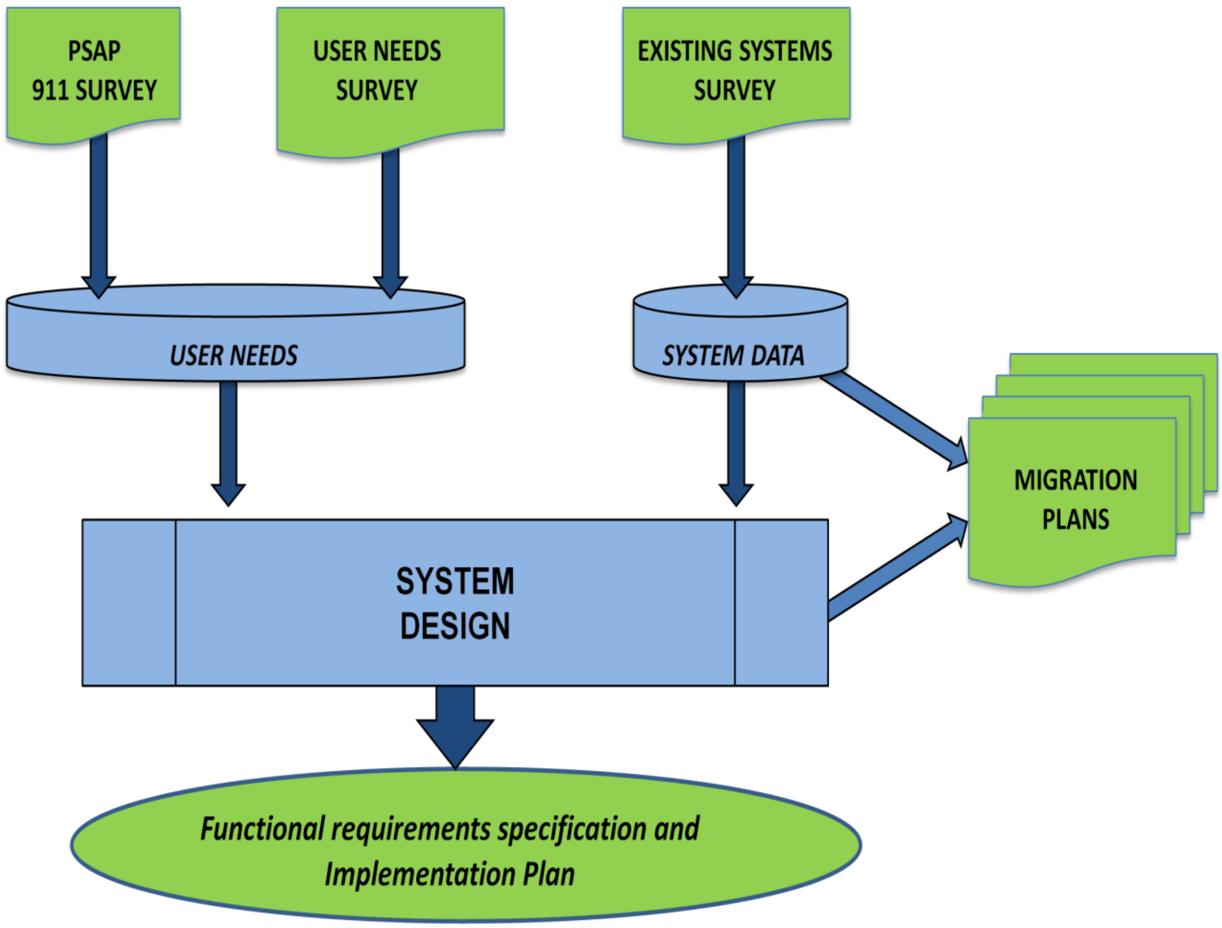

Figure 4 – Surveys

The three surveys are summarized as follows:

- **911 PSAP Survey** – This survey focused on information regarding the operations of each 911 PSAP in the State of Iowa. It was also instrumental in identifying user agencies throughout the State.
- **User Needs Survey** – This survey focuses on user needs and included interoperability, radio coverage, data, and video needs.
- **Existing System Survey** – This survey focused on specific system configuration such as site information, tower coordinates, frequency band, and other system specific information.

While each survey category fulfills a specific need, responses from all three surveys have an influence on the overall interoperable radio communications system design for the State of Iowa. The system design is used in conjunction with the *Existing System Survey* data to produce migration plans for agencies that represent a cross-section of systems throughout the State. The chart in Figure 5 shows the organization and timeline for this effort. Three primary tasks were conducted in overlapping phases.

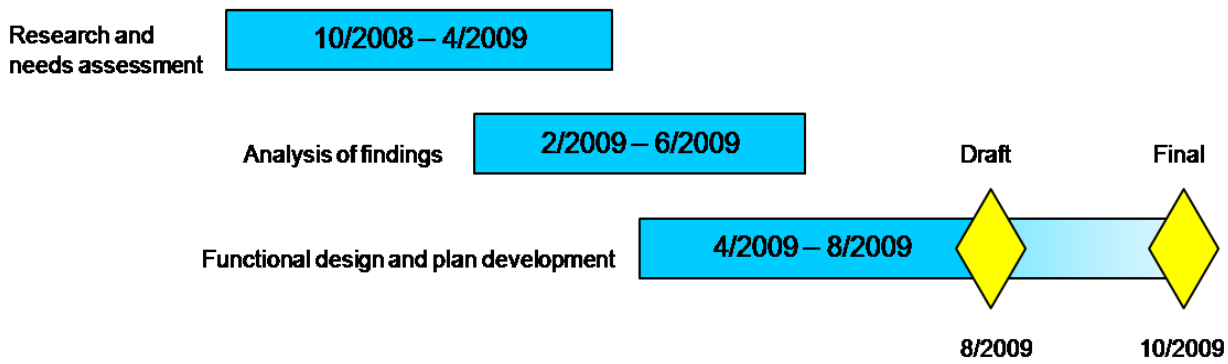

Figure 5 – ISICS design timeline

Activities in the first two phases included an extensive schedule of statewide interviews, outreach support, online surveys, follow up interviews, and secondary research using documentation provided by the State.

3.1 Electronic Surveys

Electronic surveys where deployed to gather user needs, PSAP information, and existing systems details such as frequency band, site locations, channel count, and other relevant data. The initial survey was an electronic form file distributed via e-mail. The other two surveys were Web-based surveys initiated with e-mail invitations. Collecting user input through electronic survey also allowed interview and meeting time to be devoted to planning and requirements discussions rather than filling out questionnaires and surveys.

The survey also allowed members of the public safety community who did not attend meetings or interviews to participate in the process from their home locations. To encourage responses to the surveys, the ISICSB sent out multiple mailings to state and local public safety agencies. In addition, ***FE*** conducted call campaigns to these agencies to alert them to the coming surveys and provided technical support and general encouragement as needed. Figure 6 – Survey participation provides a visual summary of survey participation by county of origin. The counties highlighted in green represent active participants in the survey process.

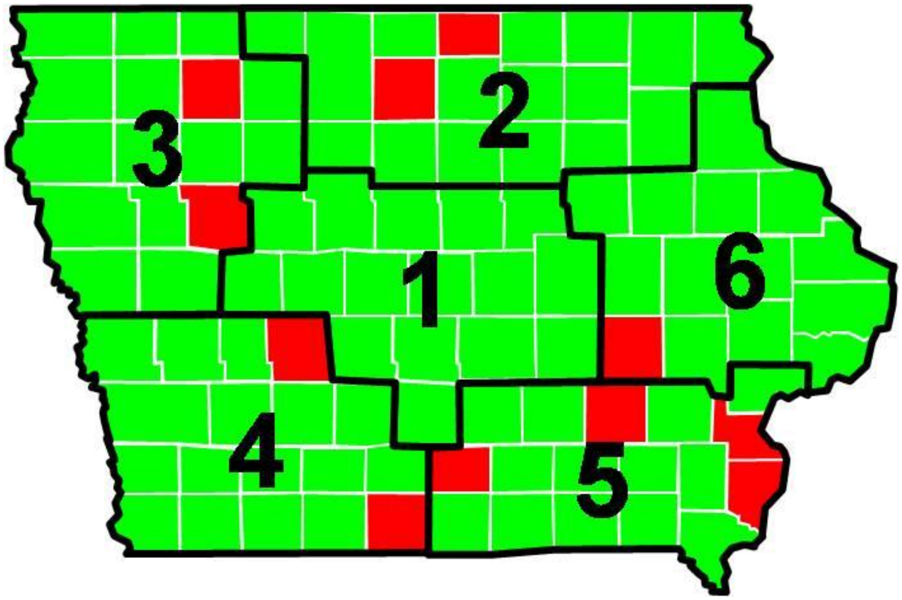

Figure 6 – Survey participation

While not all agencies participated in all three surveys, 85% of PSAPs participated in their targeted survey and over 240 surveys were received from local law enforcement agencies (police departments and sheriff's offices), local fire departments, and emergency management service providers (EMS). From the approximately 300 responses received, ***FE*** and the ISICSB concluded that there was good representation of public safety agencies throughout the State. This represents a good cross-section from which statewide planning and functional design can be achieved.

3.2 Interviews and Other Forums

During the planning and analysis phases of this project, ***FE*** conducted numerous individual and small group interviews with state and local agency representatives. Interviews included each of the major state agencies, and a sample of local agencies. Numerous site visits were also performed to better understand local systems and agency specific operational structures. These site visits also provided a good cross-sectional view of the State, from rural areas to higher density cities.

The following is a sample of agencies interviewed at the local level, which represent a cross-section of local agencies throughout the State:

Large agencies

- Johnson County Sheriff

- Pottawattamie County 911
- Woodbury County Disaster and Emergency Services
- Council Bluffs Police Department
- WESTCOM
- Cedar Rapids Police Department
- Linn County Sheriff

Small agencies

- Tama County Sheriff
- Clarinda Police Department
- Shenandoah Police Department
- Perry Police Department
- Iowa Falls Police Department
- Hardin County Sheriff
- Adair County Sheriff
- Shelby County Emergency Management
- Dallas County Sheriff

Electronic Engineering users

- Story County Sheriff
- Ames Police Department
- Iowa State University Police Department

RACOM users

- Dubuque County Sheriff
- Dubuque Police Department
- Davenport Police Department
- Scott County Sheriff

FE also gathered information from public forums, conferences, and group meetings, from seven to over 50 participants each. In these settings, ***FE*** provided information to increase awareness about the ISICS project and its goals, answer general questions, and encourage agency participation. Some of these forums are listed below:

- Iowa Homeland Security Conference
- Safeguard Iowa Partnership Meeting
- Commissioner and DPS Department Head Meeting

- Iowa Chapter of APCO
- Iowa NENA Spring Conference

FE also provided the ISICSB with outreach support information such as tri-fold brochures and presentations for local meetings. In addition to meeting with public safety agencies, ***FE*** met with land mobile radio (LMR) service providers in Iowa, RACOM and Electronic Engineering to better understand their business organization and system structure. ***FE*** also interviewed large commercial service providers Sprint and Verizon Wireless to understand data service offerings, coverage footprint, data throughput, and other associated technical issues. In addition to service providers, ***FE*** interviewed private entities to better understand current system, operational needs, and how interoperability is envisioned by such organization. This included Quaker Foods, Contemporary Services Corporation, Blue Cross / Blue Shield, Alliant Energy, and Kirkwood Community College.

3.3 ISICSB Briefing Sessions

At the monthly ISICSB meetings, ***FE*** worked with the Board members to systematically determine ISICS functional requirements and resolve issues as they unfolded from the needs assessment findings. ***FE*** also prepared briefings for the Board members on technical matters and project progress. These presentations were significant in educating the ISICSB on the issues to be considered and the technical challenges associated with such a large project.

3.4 Analysis and System Design Activities

FE conducted technical analyses and system design activities both on-site in Iowa and at its offices in Virginia and elsewhere. Activities included frequency research, tower inventory and coverage (propagation) studies, statistical analyses, system conceptual design development, channel loading, point-to-point link analysis, and trade-off analysis. The results of these activities are presented in Section 7, System Needs Analysis, and Section 8, ISICS Conceptual Design.

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4. Study Participants

Essential to the planning and design process was participation of Iowa's public safety agencies at all levels – state, local, rural, and urban areas alike. As such, ***FE*** made every effort to gather input from Iowa's public safety professionals by conducting over 600 phone calls, e-mails, interviews and other meetings coordinated through the ISICSB. The following sections provide a brief synopsis of the participation level achieved in this endeavor.

4.1 Iowa Statewide Interoperable Communications System Board

At the time of this report, there are fifteen voting members that make up the ISICSB. Members are selected to represent the broadest possible spectrum of state and local agencies and public safety disciplines. Three non-voting members are also listed.

- Todd A. Misel, Chairperson, Department of Public Safety
- Dina McKenna, Vice Chair, Story County Sheriff's Office
- John R. Benson, Homeland Security Emergency Management
- Robert A. Younie, Department of Transportation
- Jason Sandholdt, Department of Natural Resources
- Michael Dreke, Department of Corrections
- Tom Boeckmann, Department of Public Health
- Ted Kamatchus, Marshall County Sheriff
- Mark Frese, Davenport Fire Department
- Tom Berger, Dubuque County, Volunteer Fire
- Jeremy Logan, Oelwein Police Department
- Roxane Warnell, Tama County Emergency Management
- Sandy Morris, Des Moines Police Department Communications
- Wendi Hess, Woodbury County Communications
- Ron Miller, At-Large Member
- Senator Tom Hancock, Iowa Senate Majority (non-voting member)
- Senator Shawn Hammerlink, Iowa Senate Minority (non-voting member)
- Representative Kerry Burt, Iowa House Majority (non-voting member)
- Representative David Tjepkes, Iowa House Minority (non-voting member)

The ISICSB, led by the Chairperson, was active in the entire process, from selecting ***FE*** as the study consultants to involvement in each phase of the project providing input, guidance, and support.

4.2 Local Public Safety Agencies

Response to requests for participation from local public safety agencies was excellent. Approximately 300 representative agencies from all public safety sectors provided input to ***FE***. A list of participants can be found in Appendix F.

4.3 State Public Safety Agencies

Radio systems operated by state agencies vary in age, capabilities, and technology. Although some of the agencies listed below may not use public safety radio equipment, each was consulted to ensure their current or future needs for communications capabilities are accounted for.

- Department of Corrections
- Department of Public Safety
    - Division of Administrative Services
    - Division of Criminal Investigation
    - Division of Narcotics Enforcement
    - Division of State Fire Marshal
        - Arson and Explosives Bureau
        - Inspections
    - Division of State Patrol
- Law Enforcement Academy
- Emergency Management Division
- Iowa Environmental Protection
- Iowa Department of Transportation (DOT)
    - IT Division
    - Motor Vehicle Enforcement Division
    - Office of Aviation
    - Office of Public Transit
    - Vehicle Services
    - Office of Rail Transportation
- Department of Human Services
- State Medical Examiner
- Department of Agriculture and Land Stewardship
- Iowa National Guard
    - Air National Guard
    - Army National Guard
- Department of Natural Resources - Law Enforcement
- Department of Public Health

5. Current Wireless Communications Environment

Based on recent incidents over the past decade, it is clear that today's public safety communications environment must include interoperable communications between adjacent public safety jurisdictions based on common goals; and cannot be established or driven by the needs of a single agency.

Since the 1950's agencies have collaborated and attempted to develop an approach that was acceptable to all participants. Originally, the simple practice of swapping radios at the scene of a joint operation was an acceptable means to achieve interoperability. As technology improved, radio channels designated for interoperability were created or patched together via consoles or gateways. Most recently, states and regions have established interoperable approaches that range from interconnecting radio channels over a wide area that agencies can use for interoperability, to complete systems that agencies can share. In the latter approach, a P25 standards-based shared system not only provides for operability, but also becomes the means of achieving enhanced interoperability.

The current communications environment must be understood before any specific functional or technical design requirements can be developed. Within Iowa, key considerations include understanding the missions and priorities of state and local public safety organizations, their many different existing systems, local and state level management practices, demographic and public policy factors, and various laws and regulations. Externally, federal policies and the technology marketplace affect Iowa's options; the experiences of other states can offer useful lessons as well. It is also important to coordinate and ensure compatibility with the six adjacent states, whose wireless systems overlap Iowa's borders and with who coordinated public safety responses are often carried out.

Implementing the ISICS will provide benefits far beyond its main purpose of achieving interoperability at the state and local level; it will also provide opportunities and a means to unite efforts at the regional and federal levels. It will provide for the consolidation of resources while maintaining independence and autonomy during day-to-day operations. This cooperative use of assets provides interoperability among agencies as well as significant cost saving opportunities during a time of fragmented and limited funding, by avoiding the construction and maintenance of multiple disparate communications networks. In addition, the availability of network access to non-traditional partners such as schools, hospitals, and select private enterprises will foster an environment of collaboration and unity around the common goal of interoperability.

5.1 Iowa's Public Safety Wireless Community

The term *public safety* as used in this document includes departments and divisions with the mission of law enforcement, fire response, emergency management, emergency medical service, defense, and special responses (e.g., handling hazardous materials). In addition, public service organizations that use wireless communications, such as the Department of Transportation, Department of Health, and other similar organizations, although not strictly public safety, are an integral part of emergency response efforts and have been included in the statewide planning effort.

The term *wireless communications* is used in this document to signify communications that use radio transmissions to exchange information. The primary type of wireless communications systems used by public safety agencies is land mobile radio (LMR). LMR is the standard term for two-way wireless communications systems that are licensed by the FCC and dedicated to a specific organization or set of users. At the most basic level, LMR provides for inherent *one-to-many* conversations where one user can talk to many other users simultaneously. Alternative technologies used in Iowa include cellular telephones that are typically limited to *one-to-one* conversations. With this approach, one need only acquire suitable cellular subscriber units and appropriate cellular service subscription to provide service with the perception of better confidentiality. While the cellular service approach provides a lower initial entry cost solution basically due to avoiding the expense of a supporting radio infrastructure, the cellular service does not work well for LMR users given the one-to-one nature in cellular telephone environments, lack of system management control, and the possibility of losing service when high network demand is present.

The public safety wireless community is multi-layered and includes government, volunteer, and private entities. The government agencies considered in this study, including federal, state, and local, are those whose missions necessitate using or coordinating wireless communications. As illustrated in Figure 7 – Local, area, regional, and state systems, relevant distinctions can be made among local, area, regional, and statewide public safety radio systems.

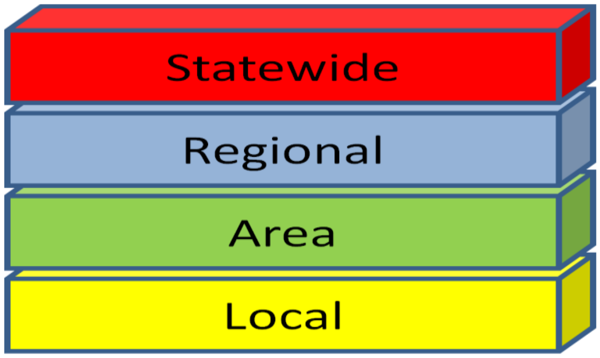

Figure 7 – Local, area, regional, and state systems

Within the context of this document, these levels of radio systems are defined as follows:

<u>Local systems</u>

Local systems include local agency systems such as police departments, sheriff's offices, emergency management agencies, fire departments, and emergency medical or rescue services.

<u>Area systems</u>

Area systems are operated by self-defined cooperating groups of two or more local agencies; they may be any size from sub-county to multiple counties in scope.

<u>Regional systems</u>

These are systems that provide service for large areas within a significant segment of a state. In Iowa, state agency districts can be classified as regional systems.

<u>Statewide systems</u>

Statewide radio systems operate border-to-border—they allow a user to communicate with another user anywhere in Iowa. Agencies in this category include, but are not limited to, the State Patrol, the State Fire Marshal, public safety functions of the Game and Parks Commission, public safety functions of the Department of Transportation, inmate transportation functions across multiple geographic areas, emergency government functions within the Military Department, and emergency medical service coordination functions within the Health and Human Services System. During times of disaster or emergency, the need of full statewide communications can extend to local agencies as well.

Law enforcement, fire and rescue departments, and other emergency services collectively hold the responsibility for guarding the life and safety of every Iowa citizen.

When public safety responders are unable to communicate with each other, life and safety for the citizens and these responders are placed at risk.

5.1.1 Radio Spectrum Frequency Use

Throughout this Master Plan, many references are made to public safety radio *frequency bands*. A brief explanation of the terms used in these discussions follows.

All wireless communications systems operate within specific parts of the electromagnetic spectrum. Each specific segment of this spectrum is called a *frequency band* and is expressed in millions of cycles per second, or megahertz, and is abbreviated MHz. Since the radio spectrum contains a limited number of frequencies, they must be shared among many users and many types of systems—broadcast radio and television, mobile radio and cellular, air navigation, commercial, government and military. The electromagnetic spectrum allocated for public safety is depicted in Figure 8 – Allocated public safety frequency bands.

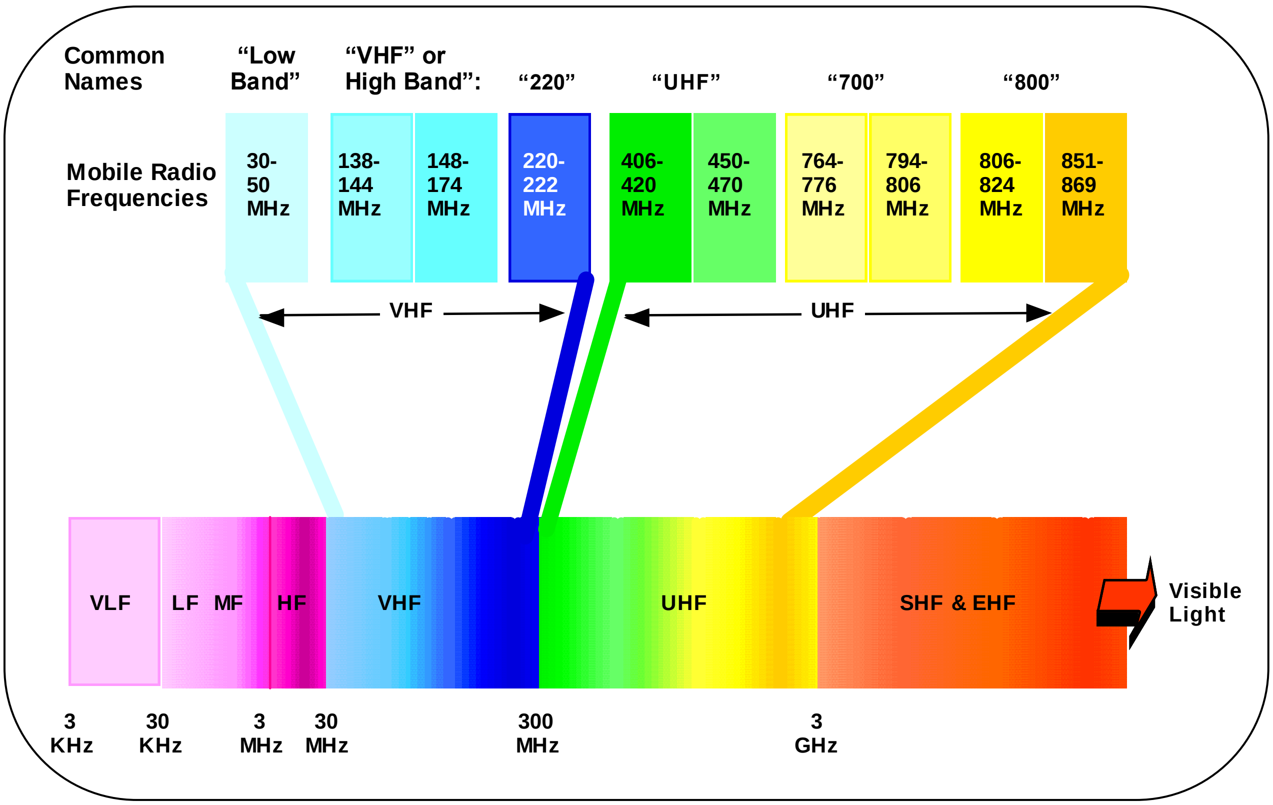

Figure 8 – Allocated public safety frequency band

Given the limited number of frequencies available for public safety entities, they must be shared and reused throughout the United States. This creates the potential for harmful interference between radio signals. Careful coordination of channel usage is required to mitigate potential interference between communications systems. Public safety agency needs for LMR frequencies in specific frequency bands are protected by the Federal Communications Commission (FCC) through the allocation of frequencies for the exclusive use of public safety jurisdictions in specific frequency bands.

Current public safety agencies in Iowa have radio systems in four frequency bands: VHF (low-band), VHF (high-band), UHF, and 800 MHz bands. The 700 MHz band reserved for public safety agencies is currently in the process of being allocated by the Region-15 Regional Planning Committee (RPC). As such, little or no use is being made of this band throughout the State as yet. The four frequency bands generally used in Iowa are as follows:

VHF (low-band)

Commonly called *low-band radio*, this portion of the radio spectrum was popular in the 1950's, 60's and 70's. Virtually all of the radios used in this band have been replaced with VHF high-band equipment. At this time, no state agency local jurisdiction users were identified as operating in this band. Very limited products (new equipment) are available and many manufacturers have discontinued manufacturing radios in this band. This band does not support most of the features and capabilities that public safety has come to rely on and as such is not considered an option for the State.

VHF (high-band)

This is the most common system frequency band currently used by state agencies as well as most local agencies. About 75% of respondents indicated this is their primary system frequency band. This band has a limited number of channels available compared to the 700 or 800 MHz band and is more subject to atmospheric interference than the other bands. Users in this band must supplement their equipment in order to interoperate with agencies on other frequency bands.

- This frequency band carries the statewide mutual aid channels and is known by many local agencies as the sheriff's channel.
- Because small local agencies, especially volunteer fire departments use the VHF fire frequency for their day-to-day operations, many other agencies program this channel into their radios for interoperability at the local level.

- Local agencies that migrated to newer technologies reserve use of this frequency band as a backup mechanism. In addition, it is used to interoperate with State Patrol and other high-band users.

UHF

This band is currently used by law enforcement and EMS service providers such as ambulances and hospitals,.. Approximately 10% of the local public safety agencies that responded to the survey indicated this band as their primary system frequency band. Although UHF is used for some voice communications, most first responders use VHF equipment as a primary means of communications with local public safety users.

700 MHz

After many years of petitioning the FCC for additional spectrum, public safety users were allocated addition spectrum in the 700 MHz band. The 700 MHz channels designated by the FCC are adjacent to those previously allocated in the 800 MHz band. Further, dual-band radio equipment capable of operating in both the 700 and 800 MHz frequency bands are becoming the norm. The number of channels allocated by the FCC at 700 MHz is greater than the combined number of channels available in the VHF, UHF and 800 MHz bands. Since the channel plan for the State of Iowa has yet to be developed, no agency within the State currently operates within this band. ***FE*** evaluated the 700 MHz regional plan developed by the Region 15 RPC and made recommendations for enhancing the plan to address potential shortfalls that could result in the FCCs delayed approval. Refer to the Region 15, 700MHz Regional Plan section for further details.

800 MHz

Approximately 13% of survey respondents indicated the use of this frequency band as supporting their primary communications system. In this band there is a combination of standards-based and proprietary systems either owned by local agencies or leased from commercial service providers, some of which have a large presence in the State.

It should be noted that a critical component of interoperability deals with FCC regulations and requirements. An important regulatory mandate issued by the FCC requires special attention due to its near future impact on communications systems in the State of Iowa and across the country. The FCC mandated that two-way radio systems including those used by public safety agencies must meet new narrowband requirements for specific sections of spectrum by January 1, 2013. Historically, radio signal bandwidths have been progressively narrowed as technology developed and the need for additional radio spectrum increased. Many of the current VHF and UHF radio systems within Iowa use wide bandwidths, and the FCC mandate is to reduce these in half to create two voice talk paths where only one exists today.

Narrowband migration has been occurring throughout the history of radio. The current narrowband mandate began in 1992, with four FCC Reports and Orders between 1995 and 2008 setting the requirements. By January 1, 2011, the FCC will no longer issue new wideband licenses. Further, the FCC will not modify wideband licenses to extend the coverage area of a system. It should be noted that the FCC will no longer allow manufacturers to sell radios capable of wideband operations. By January 1, 2013, all radio systems operating between 150 -512 MHz (VHF and UHF) must be migrated to narrowband operation.

5.1.2 Region 15 700 MHz Regional Plan

In 1998, the FCC established a structure that provided Regional Planning Committees (RPCs) with the flexibility to accommodate new developments in technology and equipment for state and local public safety needs. The FCC designated the geographical area of the State of Iowa as Region 15.

In response to FCC requirements, Region 15 must provide a 700 MHz regional plan for *General Use* channels within the State of Iowa. Since *State Use* channels are to be managed by the State, approval of a plan for the *State Use* channels is not required. The FCC's role in relation to the RPCs is limited to the following:

- Defining the regional boundaries
- Requiring fair and open procedures (e.g. requiring notice, opportunity for comment, and reasonable consideration)
- Specifying the elements that all regional plans must include
- Reviewing and accepting proposed plans or rejecting them with an explanation

The FCC expects each RPC to ensure that they are representative of all public safety entities in their regions by providing reasonable notice of all meetings and deliberations. Regional plans must include an explanation of how all eligible entities within the region were given such notice.

On July 31, 2007, the FCC adopted a Second Report and Order revising the rules governing wireless licenses in the 700 MHz band. The FCC designated the lower half of the 700 MHz public safety band for broadband communications (763-768/793-798 MHz) and consolidated existing narrowband allocations in the upper half of the public safety 700 MHz band (769-775/799-805 MHz). The FCC noted that consolidation of the narrowband channels in the upper part of the band would impact approved and pending 700 MHz RPC plans (i.e., require that the plans be amended). As a result, the Public Safety and Homeland Security Bureau of the FCC provided additional guidance for the development of regional plans.

FE evaluated the Region 15 700 MHz Plan and identified several items that needed to be enhanced, included, or modified to assure that the plan would meet the needs of all public safety users and remain acceptable to the FCC. The following is a summary of ***FE's*** findings and recommendations:

- Increase the participation of public safety users throughout the State in developing and approving the plan
- The notification process for RPC meetings was limited and needed to be expanded in order to meet FCC requirements
- Delegation of dispute resolution by the RPC did not meet FCC requirements
- Reallocate narrowband voice channels to maximize spectrum efficiency requirements.
- Re-coordinate the modified plan with adjacent regions
- RPC operational procedures needed some clarification
- Allow the State of Iowa the flexibility to utilize General Use channels
- Minimize the potential for orphan channels
- Establish a priority matrix for license applications
- Reassess the criteria for traffic loading studies

In addition to the above recommendations, ***FE*** has recommended that *General Use* and *State Use* channels be repacked at 12.5 kHz channel spacing. This will standardize both channel pools across the entire state while preparing for future FCC narrowband requirements. It is important to understand that preliminary site planning for the statewide 700 MHz system is based on 12.5 kHz public safety channel allotments with some consideration for 6.25 kHz equivalent TDMA technology.

The current draft 700 MHz plan identifies a limited number of low-speed mobile data channels using a portion of the existing 25 kHz voice channels. When the plan is revised, these channels will be reallocated to better facilitate implementing a statewide mobile data system.

Lastly, some of the *State Use* and *General Use* 25 kHz channels may be kept in reserve for coordinated use with adjacent states. A significant number of interoperability channels in the 700 MHz band have been identified by the FCC and dedicated for interstate and intrastate use by public safety. The Region 15 700 MHz RPC should work in conjunction with the ISICSB to ensure *General Use* and *State Use* channels are used in a spectrally efficient manner.

5.2 Iowa State and Regional Systems

In order to understand state agency operational and system requirements, ***FE*** consulted with many state agencies. While some of these entities may not use public safety radio equipment, each was consulted to determine if there is a current or future need for communications capabilities.

5.2.1 State Agency Systems

The information that follows summarizes the existing systems in use by some of the major state agencies with public safety missions.

Department of Transportation

The Iowa Department of Transportation (DOT) radio communications needs are centered in two primary areas. These are the Motor Vehicle Division and the Highway Division. These divisions are responsible for enforcement and maintenance as well as other aspects of Iowa DOT's basic mission. The enforcement group can be classified as a public safety group and has the need to communicate with other state agencies as well as local public safety jurisdictions. The maintenance group is responsible for the day-to-day upkeep of the multitude of roads and byways within the state. Although their mission is related more to public service, they must have the ability to communicate with state agencies and local jurisdictions. The following is a list of divisions within Iowa DOT:

- IT Division
- Motor Vehicle Enforcement Division
- Office of Aviation
- Office of Public Transit
- Vehicle Services
- Office of Rail Transportation

Iowa DOT uses 175 tower sites throughout the state and has deployed more than 1,450 mobile radios and about 200 portable radios. The 2013 FCC deadline for transition to narrowband equipment affects a significant portion of their radio assets with exception to the enforcement group that has subscriber radios capable of operating using wideband and narrowband emissions as well as analog and digital VHF APCO P25 modulation modes. Nevertheless, there is very limited capability to communicate with local, regional, state and federal users that operate on other radio bands.

Historically, upgrading subscriber equipment to stay current with technology has been problematic due to prioritization of needs and limited funding. Infrastructure costs have steadily increased in the past; and with a significant number of towers and shelters to maintain, upkeep of these facilities has taken a greater and greater portion of the funding available.

Although the Iowa DOT system and infrastructure provides adequate communications, the current system architecture is one of *communications islands* where each county infrastructure provides service for that particular geographic area. Communications beyond that service area is done with the assistance of the DPS dispatch centers.

The Iowa DOT statewide agencies can join the ISICS network to address current system deficiencies and meet FCC mandates.

Department of Public Safety

The Iowa DPS radio communications system is structured to meet the requirements of the various divisions and bureaus within the agency. The following is a list of divisions/bureaus within DPS:

- Division of Administrative Services
- Division of Criminal Investigation
- Division of Narcotics Enforcement
- Division of State Fire Marshal
- Division of State Patrol

To facilitate communications, DPS is divided into six operational regions. DPS uses 28 tower sites throughout the state and has deployed approximately 1,400 subscriber units estimated to consist of 600 portable and 800 mobile radios.. While the distribution of radio users is not uniform throughout the State, user allocations closely follow population distributions. The DPS system operates in the VHF frequency band with one pair of analog wideband duplex channels per site with a frequency reuse pattern developed by the State that allows for access by local jurisdictions. Additional simplex frequencies are used to support user-to-user *talk-around* communications. These mobiles, portables and tower sites must be converted to narrowband operation by January 1, 2013.

Like the IDOT system, the infrastructure and subscriber equipment of DPS is operating effectively, but the fast approaching 2013 deadlines set by the FCC represent a major challenge. The DPS statewide agencies can join the ISICS network to address current system deficiencies and meet FCC mandates.

Department of Corrections

The Department of Corrections' mission encompasses the operation of all state correctional facilities and related programs, the state's adult parole system, and the transport of inmates to and from state facilities. The bulk of the department's responsibilities center on the district's facilities, each of which uses one or two radio systems for internal custody and maintenance functions. The Department of Corrections (DoC) does not have its own wide area radio system, but uses a combination of mutual-aid frequencies and commercial services. Inmate transports are most commonly performed for two primary reasons: (1) from one state facility to another, and (2) from a state facility to a work site. Vehicles equipped with VHF (high-band) radios operating on the Law Enforcement Agency (LEA) channel support the inmate transport process. Unification of all these diverse systems would be more productive and efficient for the agency as a whole, as well as supporting needed interoperability with others.

It should be noted that at present time, the DoC does not make use of wireless data or automatic vehicle location (AVL) services. In addition, secure communications functionality is not deployed. As with DPS and IDOT, the 2013 deadlines set by the FCC represent a major challenge for the DoC. Like other state agencies, the ISICS statewide project is seen as an avenue to meet current system deficiencies and FCC mandates as well. By incorporating and transitioning radio assets that currently meet the FCC requirements and replacing noncompliant equipment with radios that will work on the ISICS statewide system, DoC can meet its needs and become interoperable with other local, state and federal users.

Department of Natural Resources

The Iowa Department of Natural Resources (DNR) is the primary agency charged with the responsibility of assuring that the natural resources within the State are managed for the public good. Radio communications are structured to meet the operational requirements of the agency. DNR operates out of six regional offices, two in the eastern, two in the central and two in the western parts of the State. DNR uses over 200 radios split about equally between mobiles and portables. This radio equipment operates within these six districts and normally is evenly distributed within these districts. However, these radio users can and do congregate within a specific area for operational reasons on a temporary basis.

DNR uses VHF radio equipment exclusively and operates on the DPS infrastructure for dispatch purposes. Primary communications is accomplished through the LEA and mutual aid channels with local county frequencies preprogrammed in the radios. No special equipment configuration is needed for day-to-day operations. However, tactical operations are conducted on a talk-around basis without infrastructure support. Since this mode of operation is done on a clear channel licensed for statewide use, encrypted communications would greatly improve operational integrity and personnel safety. While the results of the survey indicated DNR's existing radio communication is generally adequate, radio coverage in remote areas is limited. One user group affected by this is game wardens that normally operate in these remote areas. Therefore, DNR's coverage needs differ from the DPS needs that focus more on major highways.

Finally, DNR is currently implementing a limited deployment of mobile data equipment via commercial service providers. While there is a need for data services, the coverage area provided by commercial service providers does not meet the all agency needs.

Department of Agriculture and Land Stewardship

The Iowa Department of Agriculture and Land Stewardship is responsible for a wide range of programs that affect the quality of life of every Iowan. This includes regulating meat processing, commercial feed and fertilizer, pesticide application, and dairy production and processing. The State Climatologist, Entomologist, and Veterinarian are also all part of this department. Other areas of responsibility include Agriculture Statistics, Homeland Security and the Iowa Horse and Dog Breeding program. Normal activities include disease control and managing disease outbreaks for livestock within the state. During large scale emergencies such as flooding or other large disasters, staff must work with local public safety officials to manage animal health situations.

There are limited numbers of radios used by the agency with primary internal communications being provided through RACOM, an LMR commercial service provider operating on the 800 MHz frequency band. The Department of Agriculture and Land Stewardship's area of operations is statewide and a small number of VHF mobiles are used by veterinarians to contact local jurisdictions as well as DPS through the LEA channel on the DPS network. While internal communications is provided through RACOM commercial service, contact with local law enforcement is done through the VHF local or DPS system.

Communications with local officials during large-scale emergency situations where animal health is in jeopardy is critical. This normally occurs when people are displaced and cannot care for livestock. Given the nature of internal discussions and the possibility of making decisions that could affect many people or cause alarm for Iowa citizens, a need for internal encrypted communications was expressed.

Emergency Management Division

The Iowa Homeland Security and Emergency Management Division (HSEMD) is an umbrella agency that operates with less than 100 state employees. While each HLS&EM region has an emergency planner, each county provides a dedicated emergency manager (county employee) whose focus is on their particular county.

HSEMD plays a significant role in emergencies and disasters of all types. The Iowa National Guard is a first responder for hazardous materials risks connected to highway, railroad or aircraft accidents involving federal vehicles. The Iowa Air National Guard also has responsibility for fire safety at the airport where their base is located. In the event of a disaster, HSEMD will become active upon request from local government agencies and its primary mission is to facilitate coordination among all the responding agencies. It should be noted that as HSEMD staff coordinates with emergency managers (EM's) in each county, many of these county EM's have other responsibilities and use whatever radios they have available. Therefore, it is common for a county EM who is also a firefighter to use his or her fire department radio—most often a VHF high-band unit—for emergencies of all types.

HSEMD uses a limited amount of radio equipment since primary communications is handled through DPS and the Iowa National Guard. Internal radio communications is accomplished through subscriber radio lease agreement with RACOM, a commercial LMR communications provider in the State of Iowa. This agreement includes eight portable and three mobile encryption-capable radios operating in the 800 MHz band. Each HLS&EM region has a dedicated talkgroup plus access to a statewide tactical talk group. In addition, HSEMD operates an HF single sideband (SSB) system (5 – 25 MHz) for long distance communications. Its primary use is for interfacing to federal agencies and as a backup to commercial communications as required by federal mandate. The HSEMD currently has no dedicated public safety wireless data capability; commercially provided services are used for this purpose.

Department of Public Health

The Iowa Department of Public Health (IDPH) plays a key coordinating role among the hundreds of EMS services around the State and the hospitals they connect with. The IDPH works with local public health agencies, hospitals, and other healthcare entities to ensure integrated communication systems, capacity, capability, emergency planning, drills, and education are in place to detect, respond to, and recover from bioterrorism, public health emergencies, and other disasters that may affect the health of Iowans and visitors alike.

Public health emergencies – from human threats such as terrorism, to natural disasters like floods and tornadoes, to disease outbreaks like pandemic influenza – can affect all Iowans. EMS serves as an entry point to the Iowa health care system and Iowa ambulance services throughout the state receive 240,000 calls for help each year. Approximately 200,000 patients per year are transported to a healthcare facility, requiring a reliable communications system that provides interoperability between fire, EMS, and other local and state agencies. Interfaces among these first responders and agencies can be accomplished through ISICS.

Within the IDPH there is a mix of radios that provide operational communications. They use approximately 450 radios operating on RACOM, a commercial service provider network in the 800 MHz band. These radios are evenly distributed throughout the State with each of the 99 local county health officials equipped with control stations and approximately 30 portable radios scattered throughout the State. During emergency situations, as many as 200 mobile and portable radios can congregate within a specific area for operations on a temporary basis.

There are IDPH entities that operate in the VHF frequency band as well. Each of the 117 hospitals within the State is equipped with VHF and RACOM radio equipment. In order to interoperate with these and other local EMS services, a set of cache radio units (20 mobile and 50 portable) are used to operate on EMS and statewide LEA channels.

The IDPH does not use wireless data or AVL services. In addition, secure encrypted communications functionality is currently not deployed, but was identified as a future need. Like other state agencies, the fast-approaching narrowband deadline set by the FCC represents a major challenge. As with many state agencies, the ISICS project is seen as an avenue to meet current system deficiencies and FCC mandates.

Iowa National Guard

The Governor activates the Iowa Army National Guard for disaster response and the Iowa Air National Guard may be called when needed. When either group is activated, they typically join HSEMD at the scene of an incident and provide their own radio communications equipment, which will interface with state and local agencies via on-scene gateway devices or other equipment. These Guard units use military HF and VHF high-band radios. These systems are designed to support only internal Guard functions and are not available to other first responders. In disasters, the Air National Guard has radio equipment in their aircraft that can communicate via air-to-ground channels with ground support.

The Iowa National Guard currently operates throughout the State and maintains over 100 armories. The communication equipment they use meets Department of Defense requirements but does not lend itself to direct interoperable communications with other federal, state or local users. Gateway devices and interface radio equipment is necessary to interoperate the Iowa National Guard with state and local agencies.

A primary need identified by the National Guard is the ability for local armories to communicate with each other and with state headquarters. The ISICS is envisioned as a means to facilitate these needs by providing the National Guard access on a local, regional or statewide basis during routine and emergency operations.

5.2.2 Regional Districts and Dispatching

Six DPS communications centers provide support services for several State public safety departments and organizations. Examples include: all Divisions within the Department of Public Safety, Department of Natural Resources, Department of Transportation - Motor Vehicle Enforcement, Department of Corrections, and the Department of Public Health. These six DPS communications centers are dispersed among six dispatch regions illustrated in Figure 9 – DPS dispatch regions.

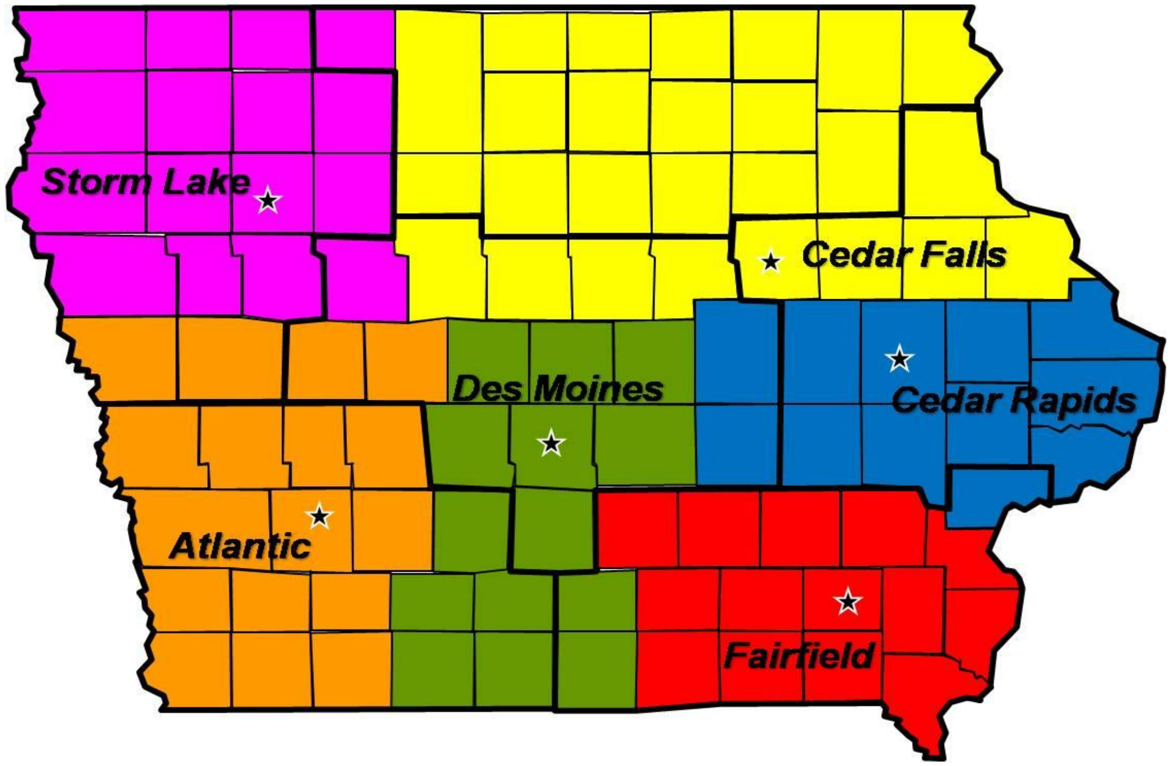

Figure 9 – DPS dispatch regions

The radio system as a whole is accessed, managed, and controlled via a Motorola *Gold Elite* console system. All sites are interconnected by leased T1 circuits to a time division multiplexed (TDM) switch at the Des Moines dispatch center located in the Iowa National Guard Armory. The system structure is depicted in Figure 10 – DPS dispatch system.

Recent upgrades to each communications center allow for the rerouting of 911 calls from disabled PSAPs. In addition, users now have remote access to each other's radio resources through the integrated dispatch system. Finally, each communications center is equipped with control stations, which are to be used in the event of a console system failure.

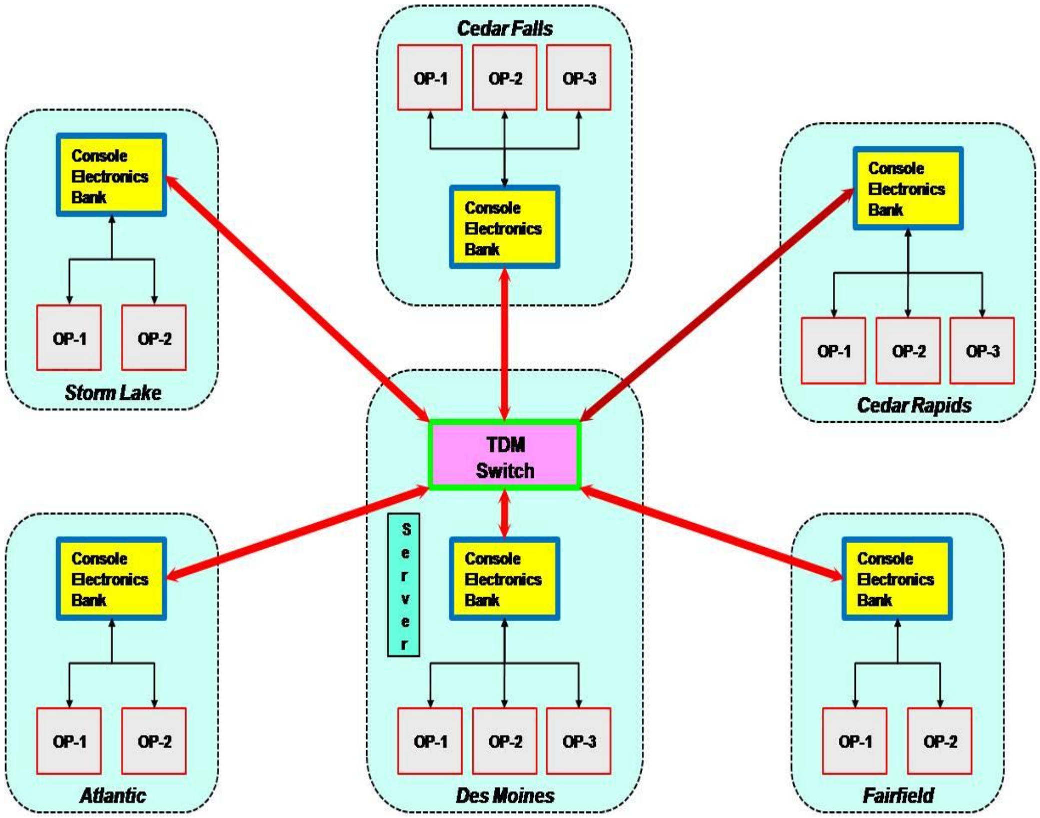

Figure 10 – DPS dispatch system

5.3 Iowa Local Systems

Local agencies that participated in the user survey are highly interested and concerned about the future of public safety radio communications in Iowa. While recognizing the need for a statewide interoperable system, some users expressed concerned about funding issues and others reiterated the need for continued autonomy from the State.

The local public safety agencies currently are spread across multiple bands of the available radio spectrum across the State of Iowa, with radio systems operating in the VHF, UHF, and 800 MHz bands. The radio system technologies employed by these local agency systems are also variegated, from conventional channel based systems, to proprietary trunked systems (e.g., Harris, Motorola), to standards based (P25) trunked and conventional systems.

In general, Iowa's public safety agencies are strongly predisposed toward providing mutual aid when needed. While not uncommon in other states, this approach is a notable finding from this study. Representative users at the community level are quick to point out that most public safety work occurs locally, and that local needs should drive statewide coordination efforts.

To provide a perspective of the interoperability supported by the various types of communications systems used at the local level in the State of Iowa, they are presented in the following functional categories: *conventional shared channels*, *proprietary trunked shared system*, and *standards-based trunked shared system*.

Conventional shared channels

A majority of the agencies that ***FE*** surveyed use VHF high-band (151-162 MHz) conventional channel communications systems. With the majority of users throughout the State operating on the same frequency band, greater opportunities for interoperability between agencies exist. Agencies interviewed identified the existing ability to communicate directly to neighboring agencies in the field using VHF interoperable frequencies listed in Table 1 – Common VHF shared channels. This is an example of agencies using shared channels to obtain interoperability.

This widespread use of the VHF band also brings more interference problems inherent to the congested VHF band and impacts the ability for dispatch centers and users to effective communicate throughout the State. Almost all VHF users ***FE*** interviewed had experienced some interference issues.

Table 1 – Common VHF shared channels

Fire Mutual Aid	154.280 MHz
Law Enforcement Mutual Aid	155.475 MHz
EMS Mutual Aid	155.340 MHz
Point to Point	155.370 MHz

Proprietary trunked shared system

As an example of a proprietary trunked shared system Story County uses a Motorola Type I trunked system owned and operated by Electronic Engineering. Within Story County there are approximately 13 fire departments, three ambulance services, and four law enforcement agencies using the same system.

Other proprietary trunked shared systems are used in various locations around the State. RACOM of Marshalltown and Electronic Engineering of Des Moines are the primary system owners with a significant presence in Iowa. RACOM owns, operates, and maintains a proprietary EDACS (Harris) trunked system while Electronic Engineering uses a Motorola Type 1 proprietary-based trunked system. Both operate in the 800 MHz frequency band.

Standards-based trunked shared system

The use of a standards-based trunked shared system enables agencies to use a wider selection of products. Woodbury County's use of a Motorola P25 800MHz simulcast trunked radio system is an example of a standards-based shared system. This system services 75 agencies within the tri-state area of Iowa, Nebraska and South Dakota. The Siouxland Tri-state Area Communications (STARCOMM) system is governed by a board comprising members from Woodbury County, Iowa, Dakota County, Nebraska, and Union County, South Dakota.

The STARCOMM radio network consists of six channels located at five tower sites. These tower sites are interconnected via a microwave ring network. The STARCOMM network has a coverage area of over 1,350 square miles throughout three counties with a combined population of 136,714 people. Agencies using the system pay a set fee based on the populations of the areas they serve.

5.3.1 Local Law Enforcement Agencies

County sheriff offices and police departments throughout the State rely heavily on VHF systems. Using VHF systems allows local agencies to talk directly with the Iowa State Patrol and other state law enforcement agencies via the LEA frequency. A large portion of law enforcement agencies surveyed used commercial cell phones to augment their current communications equipment. Mobile data terminals used by law enforcement agencies operated on dedicated radio data systems or are equipped with air-cards for operation over cellular networks. A few agencies that currently operate 800 MHz trunked systems indicated the intent to upgrade their existing system to provide data services.

5.3.2 Local Fire and EMS Departments

As with local law enforcement agencies, the majority of local fire departments and EMS agencies rely on VHF communications for daily and emergency operations, including the use of LEA or mutual aid channels for interoperability as incident response requires. In general, fire departments sampled were found to have less advanced communications systems and infrastructure than law enforcement agencies. Local fire departments and EMS agencies surveyed operate fewer repeaters with increased reliance on paging and simplex communications to meet their communications needs.

5.3.3 Local Communications Centers

Communications centers throughout the State generally provide dispatch service for multiple agencies. At a minimum, dispatch centers service local police and fire departments within a jurisdiction. All centers surveyed were physically located at the agency's PSAP 911 center.

The majority (61%) of survey participants indicated that the current dispatch system consists of a computer-based dispatched solution; 25% use control stations or push button consoles; and the remaining 14% did not provide a response. Further analysis of survey data indicates that the great majority of dispatch centers were configured with four or less dispatch consoles.

A few counties are in the process of consolidating PSAP's. As an example, Johnson County is currently working to combine dispatch operators from the Johnson County PSAP and the Iowa City PSAP into one building. The county as a whole plans to transition into a countywide Harris P25, 800 MHz trunked radio system. Another example of PSAP consolidation is that of Scott County, which is in the process of consolidating PSAPs from the Davenport Police Department and the Bettendorf Police Department. However, these three counties all plan to transition to commercial service provider RACOM's proprietary EDACS System.

5.3.4 Tribal Communications

Three tribes occupy land in the State of Iowa - Sac & Fox of the Mississippi, Winnebago Tribe of Nebraska, and the Omaha Tribe of Nebraska. The Winnebago and The Omaha tribes are located primarily in the State of Nebraska. Nevertheless, there are small portions of land that cross the Missouri river into Iowa. These tribal areas are illustrated in Figure 11 – Tribal Areas in Iowa.

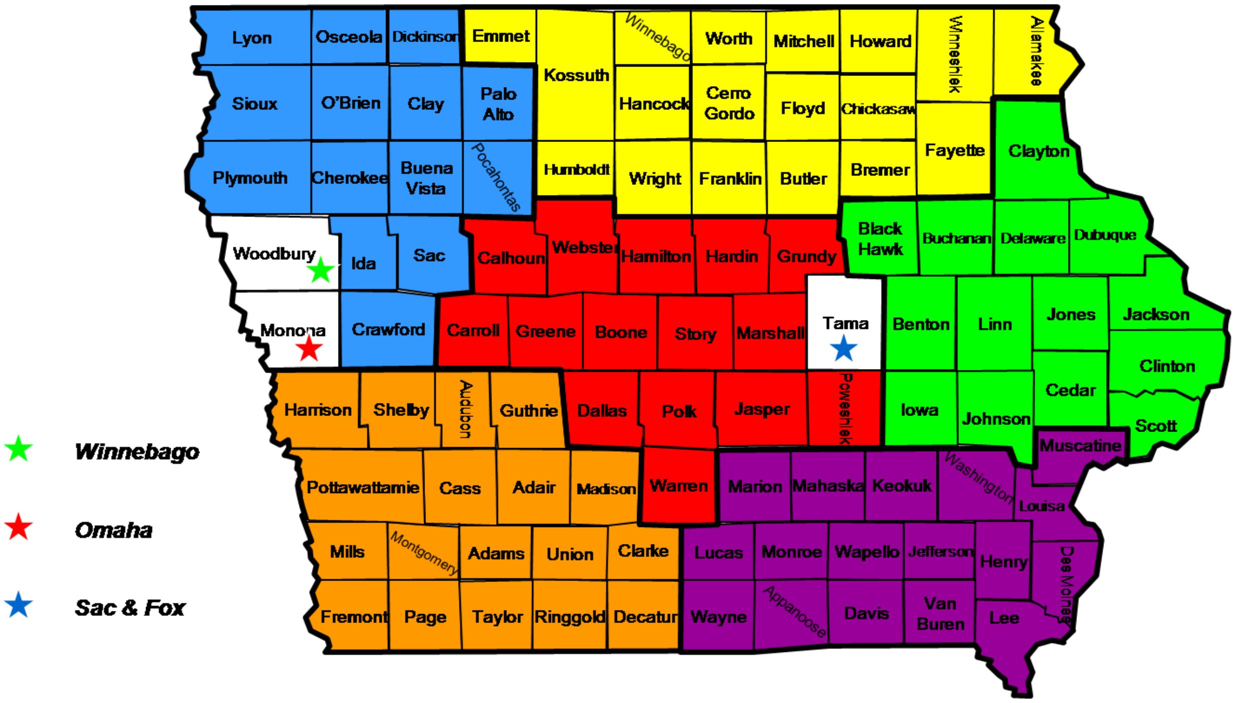

Figure 11 – Tribal Areas in Iowa

Each tribal land uses local Iowa PSAPs for 911 calls, fire, and rescue. Sac & Fox uses Tama County resources while the Winnebago use Woodbury County resources. The Omaha tribe uses Monona County resources for calls on the Iowa side and a local number is used for emergency services terminated at the Nebraska tribe police dispatch point.

Sac & Fox Tribe

The Sac & Fox have a 12 square mile settlement in Tama County, Iowa. Better known as the Meskwaki Indians, they have tribal schools, tribunal courts, and a police force on the settlement of about 800 people. Also on the land is the Meskwaki casino resort that provides gaming activities.

The Sac & Fox settlement uses a VHF radio repeater system licensed to Tama County and all 911 calls are routed to the Tama County sheriff PSAP dispatch center. Coverage issues are mostly characterized as *dead spots* since there are no towers inside the tribal area.

The tribe currently has six officers that are dispatched out of the Tama county PSAP dispatch center. They are equipped with five mobile and six portable radios. The City of Toledo and the Tama fire and rescue units manage tribal emergencies.

Omaha Tribe

The Omaha Tribe resides mainly in the following Nebraska counties: Burt, Cumming, Wayne and Thurston counties. A small strip of the reservation extends across the Missouri River into Iowa's Monona County. This strip consists of 10,000 acres of land and is mostly along the river's edge from three miles north of Macy to the southern border near Decatur, Iowa. When surveyed, only one family was known to live on the Iowa side of the reservation.

The tribe currently has 10 officers in the Omaha tribal police. The Omaha Tribe makes use of the VHF frequency band. Tribal police officers are equipped with 10 mobile and 12 portable radios. It should be noted that the Omaha Tribe has a pending grant for radio communication improvement, which will be used to join the proposed multiple county Northeast Nebraska County 800 MHz trunked system.

All 911 calls on the Nebraska side are routed to the PSAP in Nebraska, while calls in Iowa are routed to the Monona County sheriff's office. The Department of Natural Resources is routinely contacted for game poaching on the Iowa side of the Missouri River due to abundant game and natural habitat. A casino was operated near Owana, Iowa, but was closed this year. An Omaha tribal police department served this casino.

Winnebago Tribe

Most of the Winnebago tribe is located in the northern half of Nebraska's Thurston County. Some reservation lands extend into Iowa near Woodbury County, but are mostly inaccessible from the Nebraska reservations. The closest city in Iowa is Sioux City, which is approximately 20 miles north. While the Winnebago tribe has approximately 120,000 acres of land in the State of Nebraska, their presence is Iowa is significantly less, amounting to about 1,800 acres. However, the WinnaVegas Casino located in Iowa plays a significant role in the economy and revenue for the tribe.

Public safety communication is provided by several VHF mobiles and a single VHF transmitter site. This transmitter site provides coverage for most of the reservation and some coverage into the Iowa region. Current planning of Woodbury's 800 MHz P25 trunked system expansion may allow for tribal use.

5.4 Public Safety Answering Points

The E911 system is primarily a local government and communications industry responsibility. Iowa's E911 system has adopted two paths: (1) a network for wireless E911 and (2) a different network for wireline E911. This is a common solution path adopted across many other states as well. The State of Iowa has developed two distinct approaches to E911 management, oversight, and operations. The approach taken with wireless E911 includes more involvement and management at the state level, while the wireline E911 is one of general local control.

While some vulnerability exists in the Iowa E911 system, it is adequately operational for today's E911 calls within each local jurisdiction. The State's wireless E911 network functions appropriately and allows for the movement of wireless E911 calls throughout the State as necessary. Further details, strengths, and weaknesses of the current E911 environment can be found in the following subsections.

5.4.1 Wireless E911

The State of Iowa oversees all aspects of the wireless E911 system. This includes implementation, management, analysis, and evaluation of system performance. When wireless E911 became available, methods and processes did not mirror wireline E911 implementation. The State of Iowa determined that it was in their best interest to install wireless E911 service in a more controlled environment than wireline E911 had developed over the years. In order to expedite the deployment of wireless E911 service in the State without causing hardship to individual PSAPs and while minimizing cost to the State, it was essential that the State play a strong role in the deployment process of wireless E911.

The State determined that a single selective router (SR), a Qwest 5ESS SR located in Des Moines, would be used to handle all wireless E911 calls in the State. Trunks linking each PSAP throughout Iowa to the Qwest SR allow all wireless E911 calls to be received and processed by the single routing point. While this configuration provides for maximum flexibility, it also presents a single point of failure since there is no known redundancy in the SR network (i.e., no known network diversity). In short, wireless call processing is handled by a single integrated network that connects all PSAPs, including the six State Patrol dispatch centers, for the purposes of answering, processing, dispatching, and transferring of the wireless E911 calls.

Wireless calls by their nature are mobile and the wireless carriers' service area generally does not follow PSAP jurisdictional boundaries. Routing decisions for wireless E911 calls are usually based on an estimated location for the E911 caller; and the location of a wireless E911 caller is not permanently associated with a specific PSAP as with a wireline caller. Many E911 calls initiated with wireless devices are not initially routed to the correct PSAP. During the processing of the call it may become apparent (from direct conversation with the caller or from updated location information for the call) that a different PSAP would more appropriately to handle this call instead of the PSAP to which the call was originally routed. This results in the need to manually transfer the call to a PSAP that can more appropriately handle the incident. Since all PSAPs in the State are connected to the same SR in Des Moines, wireless calls can be transferred to any other PSAP in the State; including both the voice and data elements of the wireless E911 call. The wireless E911 structure is illustrated in Figure 12 – Wireless E911 network configuration.

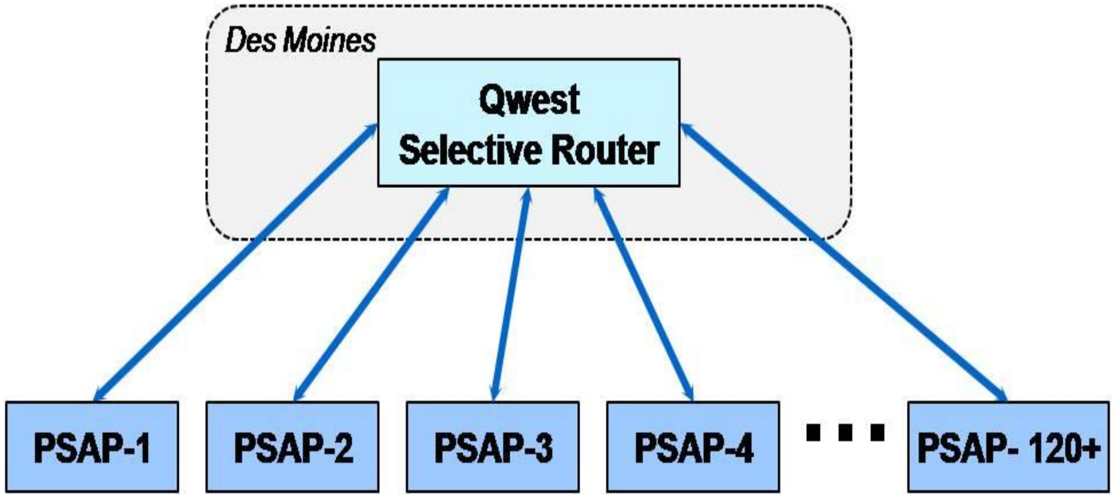

Figure 12 – Wireless E911 network configuration

The wireless E911 call data elements consist of the wireless caller's callback number, an identification of the wireless service provider, the cell tower processing the E911 call, and location information (latitude/longitude). During the initial stages of the E911 call, location data may be that of the cell tower receiving the emergency call. Often during the processing of a wireless E911 call, more specific location information may be received by *rebidding* data from the position determining equipment (PDE). Often, this rebid for more accurate location data may also result in a necessary transfer to another PSAP for dispatch.

In anticipation to Phase II needs, which allows call takers to receive both the caller's wireless phone number and the actual location information, the State has installed mapping systems at each PSAP. This functionality has provided for a highly functional wireless Phase II implementation, positioning Iowa well for Phase II and VoIP, which uses similar methodologies in processing emergency calls.

5.4.2 Wireline E911

The structure of wireline E911 communications consists of a combination of network and Customer Premise Equipment (CPE) configurations which has evolved across the State as each independent local authority has deemed appropriate to serve its citizens. Therefore, local wireline E911 is not totally integrated or interconnected; resulting in islands of PSAPs that are grouped and interconnected to the same SR. These groups of PSAPs are able to transfer wireline E911 calls between them but not to other PSAPs outside of their particular group. This lack of flexibility is manageable as the voice of a caller can be transferred outside a particular group, but is limited as well because data elements associated with a 911 call are not automatically transferred and must be passed verbally to the receiving PSAP. The result of this structure is diminished or missing call details.

The majority of PSAPs throughout the State of Iowa process calls via the SR network operated by Qwest. Answering equipment on each PSAP premise varies according to local needs and funding availability. When necessary, a PSAP will transfer callers to the appropriate jurisdiction. If certain network elements exist, both the voice and data components of the call will be transferred. If the destination PSAP is not on the same SR network as the transferring PSAP, some of those critical call elements are lost.

The network of tandem switches carries the E911 call from the local central office to the nearest unit of government operating a 911 center. This may be a county or a city/municipal jurisdiction or even an agency within a city such as a police or fire department. For the most part, each PSAP in the State determines how its network will be configured using one of three possible options:

- Selective router network (Qwest)
- On premise customer owned switch (Livermore Telephone Company-LTC)
- Direct trunked (not really a "network" but rather a configuration option)

Most of the PSAPs are connected to a Qwest tandem even though they may have a switch on premise (LTC) or have purchased their own CPE from Qwest or NG 911, Inc. This CPE is used for receiving and answering the E911 calls at the PSAP. The configuration implemented by a PSAP for wireline E911 impacts its functionality, its connectivity to other PSAPs, its ability to transfer data elements associated with a voice call, and its back-up capabilities. As such, each configuration has its own set of vulnerabilities, which will be discussed in the following section.

5.4.2.1 Selective Router Network

A Qwest selective router network is in place connecting most of the PSAPs throughout the State even if they do not use Qwest CPE. Qwest reported that 56 of the PSAPs throughout Iowa are designated as *Qwest PSAPs*, which simply means that they have purchased or contracted for CPE from Qwest in addition to the E911 network itself. In Iowa, Qwest manages and operates eight Qwest SRs strategically located throughout the State. Seven of the SRs are DMS 100's and the eighth is a Lucent 5ESS switch. The seven DMS SRs are located in: Cedar Rapids, Council Bluffs, Davenport, Des Moines, Marshalltown, Mason City, Sioux City and Cedar Falls; while the 5ESS is located in Des Moines. Figure 13 – Selective router network depicts Qwest's network configuration.

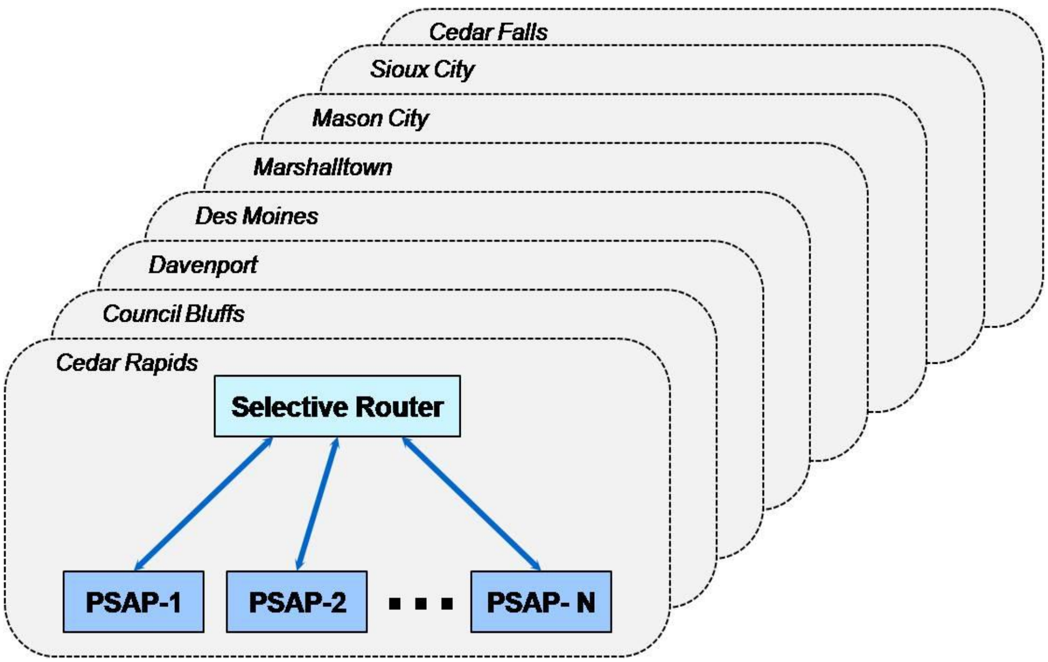

Figure 13 – Selective router network

A group of PSAPs associated with a specific SR can transfer both the voice of the caller and the data associated with the call (phone number of the calling party [ANI] and the address or location of the caller [ALI]) to other PSAPs connected to the same SR. Centralized Automatic Message Accounting (CAMA) trunks are used to transport E911 calls through the selective router network. It should be noted that SRs are not interconnected with each other. The following is a description of strengths and weaknesses associated with this configuration:

Current functionality assessment

- **Strengths**

  Selective routing places the functionality for call control features, such as transfer, call store and forward, and callback in the SR itself. Any PSAP connected to the SR can transfer voice and data to any other PSAP on the same SR. This approach has certain redundant functions. SRs appear to be functioning adequately for the current network.

- **Weaknesses**

  Not all PSAPs are connected to the same SR. As such, transfer capabilities are limited. While SR's have redundancy built into the hardware, potential vulnerabilities exists in that no full SR redundancy (e.g., routing diversity, standby SR) is currently deployed.

Transfer capabilities

- **Strengths**

  Transfer capabilities permit any PSAP connected to the same SR to transfer both voice and data to one another. SR provide call control functions not present in other systems such as the ability to initiate a transfer of the voice **and** data elements of the E911 call to another PSAP sharing the same SR.

- **Weaknesses**

  Not all PSAPs are interconnected to the same SR. While the ability to transfer calls to non-neighboring PSAPs on other SRs (or other network configurations) is possible, only the voice element will transfer. That is, the data elements of the call such as ANI and ALI will not transfer with the voice call. In this configuration, the limitation of only being able to transfer to another PSAP using the same SR will become even more of a constraint as the need to move data will increase over time.

Area code limits

- **Strengths**

  The Qwest survey responses describe an 8-digit ANI, which consists of a 0-3 designation (for up to four area codes) plus the customer’s 7-digit telephone number. Calls from other areas codes not resident in the State, such as those from VoIP, which may be from any 10-digit number, are processed via the wireless network.

- **Weaknesses**

  An 8-digit ANI, as opposed to a 10-digit ANI, limits the number of area codes that can be processed by the SR. As more area codes are necessary in a given area served by the SR, calls with 8-digit ANI may not be processed with adequate callback number information. Demand for numbers, changes in dialing plans, and calls received from anywhere outside the local area code will present challenges to the E911 network. Future networks will have to take into consideration the ability to receive calls from many different areas.

Alternate and conditional routing

- **Strengths**

  Alternate and Conditional Routing is the capability of the PSAP to route E911 calls to an alternate location under certain prescribed conditions such as: *all 911 trunks are busy*, *911 trunks are out of service*, or *PSAP is out of service*. Currently SR network PSAPs enjoy a fairly robust method of routing a call should service levels be compromised due to busy conditions or outages.

- **Weaknesses**

  Decisions on when and how to invoke conditional routing cannot be made as situations occur nor can it be modified and adjusted with changing needs or situations. That is, conditional routing arrangements are predetermined and are only invoked when the conditions occur; other situations that may warrant alternate routing are not programmed, and while they may be accomplished, the speed and flexibility to undertake re-routing is cumbersome and complex.

5.4.2.2 On Premise Customer Owned Switch

The Livermore Telephone Co. (LTC) has deployed Telident 911 NCS™ switches, which are owned directly by the PSAPs they serve. LTC reports that seven PSAPs are part of the LTC network.

These PSAPs (Buena Vista, Floyd, Emmet, Crawford, SAC, Mitchell, and South Central Iowa) purchased Telident 911 NCS™ 911 controllers, which function as mini-switches and reside on the PSAP premise. With this configuration, the PSAP is responsible for maintaining the integrity of the E911 ALI database. Even though the PSAP owns the switch, they are still connected to a Qwest tandem and receive their 911 calls through a tandem selective router. This configuration is illustrated in Figure 14 – LTC network configuration.

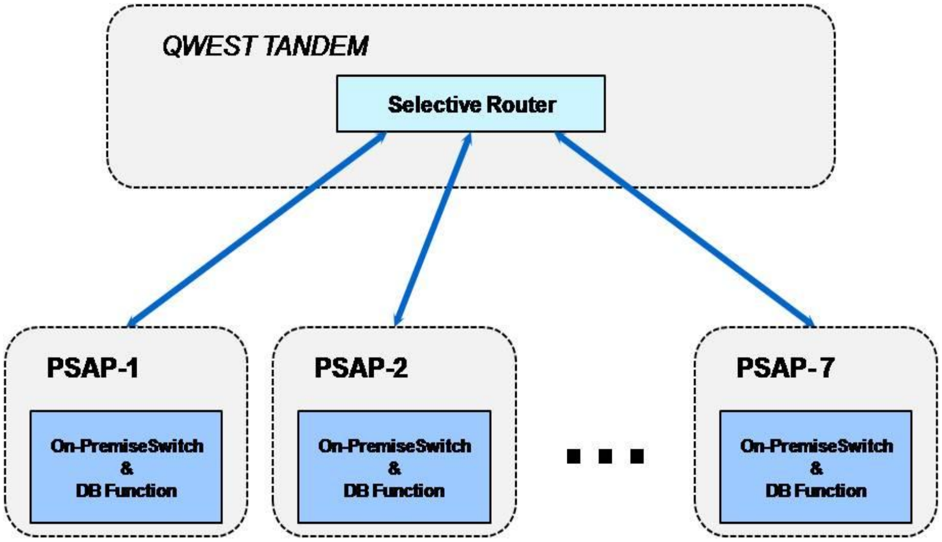

Figure 14 – LTC network configuration

CAMA trunks are also used in the LTC network to transport the calls from the SR to the PSAP. The following is a description of strengths and weaknesses associated with this configuration:

<u>Current functionality assessment</u>

- **Strengths**

  In this network configuration each PSAP owns the switch which acts like a mini SR within the PSAP facility. Therefore, each PSAP is provided with more control over their equipment and database. Given that the PSAPs using this configuration take responsibility for database maintenance, access to local information is more accessible and under the jurisdiction of the PSAP. Survey results indicated no reported weaknesses operating in this 911 network configuration.

- **Weaknesses**

  Since each PSAP is fully responsible for the E911 database, in-house processes and personnel must be in place to conduct the work associated with that maintenance. Capital investment is the responsibility of the specific PSAP or local government managing the entity. Upgrades and replacement is the responsibility of the entity.

<u>Transfer capabilities</u>

- **Strengths**

  Transfers to other PSAPs are possible, but only voice will transfer.

- **Weaknesses**

  PSAPs cannot transfer the voice call data elements such as a caller’s number or address to another PSAP. Islands of PSAPs are a problem as the transfer of information associated with a 911 call cannot be moved freely in the network. When PSAPs are not connected to a network (or in the case of NG911 a network of networks) the sharing of data becomes problematic. PSAPs using this network today did report limitations of transferring call associated data (e.g., ALI) to other PSAPs who need that information.

<u>Area code limits</u>

- **Strengths**

  The LTC survey responses describe 8-digit ANI which consists of a 0-3 designation (for up to four area codes) plus the customer’s 7-digit telephone number. Calls from other areas codes not resident in the State, such as those from VoIP, which may be from any 10-digit number, are processed via the wireless network.

- **Weaknesses**

  An 8-digit ANI, as opposed to a 10-digit ANI, limits the number of area codes that can be processed by the SR. As more area codes are necessary in a given area served by the SR, calls with an 8-digit ANI may not be processed with adequate callback number information. Demand for numbers, changes in dialing plans, and calls received from anywhere outside the local area code will present challenges to the E911 network. Future networks will have to take into consideration the ability to receive calls from many different areas.

Alternate and conditional routing

- **Strengths**

  Alternate and Conditional Routing is the capability of the PSAP to route E911 calls to an alternate location under certain prescribed conditions such as: *all 911 trunks are busy*, *911 trunks are out of service*, or *PSAP is out of service*. The Telident NCS™ system provides for conditional routing to other PSAPs via dedicated trunks or Plain Old Telephone Lines (POTS). PSAPs using this type of 911 system tend to consider the internal control of the system as an advantage. Access to the E911 switch is limited by trunk capacity and is generally commensurate with population being served by the PSAP. Redundancy is present in the switch itself.

- **Weaknesses**

  Decisions on when and how to invoke conditional routing cannot be made as situations occur, nor can it be modified and adjusted with changing needs or situations. That is, conditional routing arrangements are predetermined and are only invoked when the conditions occur; other situations that may warrant alternate routing are not programmed and while they may be accomplished, the speed and flexibility to undertake re-routing is cumbersome and complex. Vulnerabilities in the switch and any trunk outages will take the PSAP out service for an entire population of the PSAP area; re-routing or back-up opportunities are generally more limited with this type of system.

5.4.2.3 Direct Trunked

A Direct Trunked System is fairly rare. In this configuration, the E911 trunks from local central offices in the communities of the PSAP jurisdiction are brought directly into the PSAP and are displayed on the answering equipment so the PSAP can determine the originating community of the E911 call. With a direct trunked system, the circuits do not go through a SR and the E911 database is managed and operated locally.

Current functionality assessment

- **Strengths**

  Direct trunked systems are generally used by smaller-sized PSAPs serving localized areas or jurisdictions. This simple configuration is generally adequate for operations that have a minimal need to process data rich calls. PSAPs using this type of configuration are not connected to a network.

- **Weaknesses**

  Given the fact that PSAPs are not connected to a network, they are a standalone operation in which call control functions are limited. This is considered unsophisticated technology, but is generally adequate for small jurisdictions.

Transfer capabilities

- **Strengths**

  Transfers to other PSAPs are possible, but only voice will transfer.

- **Weaknesses**

  PSAPs cannot transfer the voice call data elements such as a caller's number or address to another PSAP. *Islands* of PSAPs are a problem as the transfer of information associated with a 911 call cannot be moved freely in the network. When PSAPs are not connected to a network (or in the case of NG911 a *network of networks*) the sharing of data becomes problematic. PSAPs in this network today did report limitations of transferring call associated data (ALI) to other PSAPs who need that information.

Area code limits

- **Strengths**

  Direct Trunked systems are simple in that they only support the 7-digit ANI associated with the local central office. Calls from other areas codes not local to the switch, such as those from VoIP, which may be from any 10-digit number, are processed via the wireless network. No area code is resident on the direct trunk, just the local central office.

- **Weaknesses**

  A direct trunked system transmits 7-digit ANI, as opposed to a 10-digit ANI, and limits the number of area codes that can be processed by the PSAP. As more area codes are necessary in a given area served by the PSAP, calls may not have adequate callback number information.

Alternate and conditional routing

- **Strengths**

  Direct trunked systems receive calls from the local central offices in their jurisdiction directly.. PSAPs using this type of 911 system tend to consider the internal control of the system as an advantage. Access to the E911 switch is limited by trunk capacity and is generally commensurate with population being served by the PSAP.

- **Weaknesses**

  Access to 911 is limited to the number of trunks and therefore limits the number of simultaneous calls from a particular community The number of trunks is generally based on the population served and application of probability theory for the number of 911 calls expected at any given time. If a trunk is out of service, access to 911 is limited to the remaining trunk(s). If the service between the local central office and the PSAP is interrupted, calls will not reach the PSAP. Vulnerabilities and trunk outages will take out service for an entire population of the PSAP area. It should be noted that re-routing or back up opportunities are generally more limited with this type of system

5.5 Data Communications

The majority of public safety professionals in the State of Iowa perform database inquires, such as driver information and outstanding warrants via voice communications with the agency dispatchers performing the database search and relaying the results to the field units. This process is time consuming, inefficient, and effectively precludes certain data inquiry practices that have proven very effective.

Iowa's current data communications environment is an example of *data islands* in which local jurisdictions focus on their particular data needs with less priority on systems capable of crossing jurisdictional boundaries. Most data users participating in the survey indicated the most prominent use of data services was paging, telemetry, text messaging, and form-driven data. Such applications are consistent with low bandwidth spectrum typically licensed to public safety agencies.

Given the lack of data-centric spectrum, many agencies have opted to use alternate commercial service providers such as Sprint, Verizon, AT&T, and US Cellular. While there are significant differences between these service providers, they all provide significant throughput enhancements when compared to agency owned narrowband mobile data networks. However, other factors like data formats, security, and uniformity of coverage across jurisdictional boundaries remain a source of frustration.

The results of the user survey indicated that as public safety agencies look into future data needs, applications requiring high bandwidth such as large file transfers, high-quality photos, and even real-time video will be expected. This requires a data solution that exceeds the data handling capability of the narrow band channel integrated voice and data offerings. Multiple technologies and frequency band solutions were considered for application to the data service needs of Iowa. This is further explored in section 8.4: ISICS Wireless Data Network Design.

6. Interoperability

The overarching driver for the ISICS development goes beyond simply supporting operable communications, but extends to the need for effective interoperability across the myriad of first responders in the State of Iowa and adjacent states. Interoperability can be defined as:

The ability for public safety and public services to talk and/or share data in real time on demand, when needed, and when authorized

6.1 Interoperability within Iowa

In Iowa, interoperability requirements include communications between agencies at all levels such as local, State, federal, and agencies from neighboring states. Traditionally, jurisdictions and agencies have built stand-alone systems that meet their individual agency needs. However, the deployment of independent non-integrated systems throughout the State has created situations that hamper inter-jurisdictional, and interdisciplinary (police, fire, EMS, transportation, etc.) communications. In Iowa, radio communication interoperability among state and local agencies is accomplished through limited conventional channel resources used for statewide interoperability.

User needs and existing system survey results indicated while there is a mixture of system architectures and frequency bands in use throughout the State, a majority of the agencies use VHF high-band (151-162 MHz) frequencies for their current communications. With the majority of users throughout the State operating on the same frequency band, greater opportunities for interoperability exist between agencies.

The user surveys sought to determine general trends across the Iowa local and state agencies regarding which agencies or disciplines they normally need to interoperate. The results of these user surveys regarding the needs of local agencies are summarized in Figure 15 – General agency interoperability. These indicate the collective need to interoperate with a particular agency type or discipline, on a routine basis and on an emergency basis. In general there is a strong need indicated to routinely interoperate with public safety agencies at the local and state levels.

Additionally there is a strong need indicated for interoperability on an emergency basis with public safety agencies at the local, state, and federal levels.

State and federal emergency management agencies were indicated to be interoperable communication candidates for local agencies with the emphasis placed upon emergency situation needs versus routine day to day operations. Responses also indicated a relatively strong need to interoperate with non-traditional public safety agencies such as utilities and the medical community, both on a routine day-to-day basis and during emergency situations.

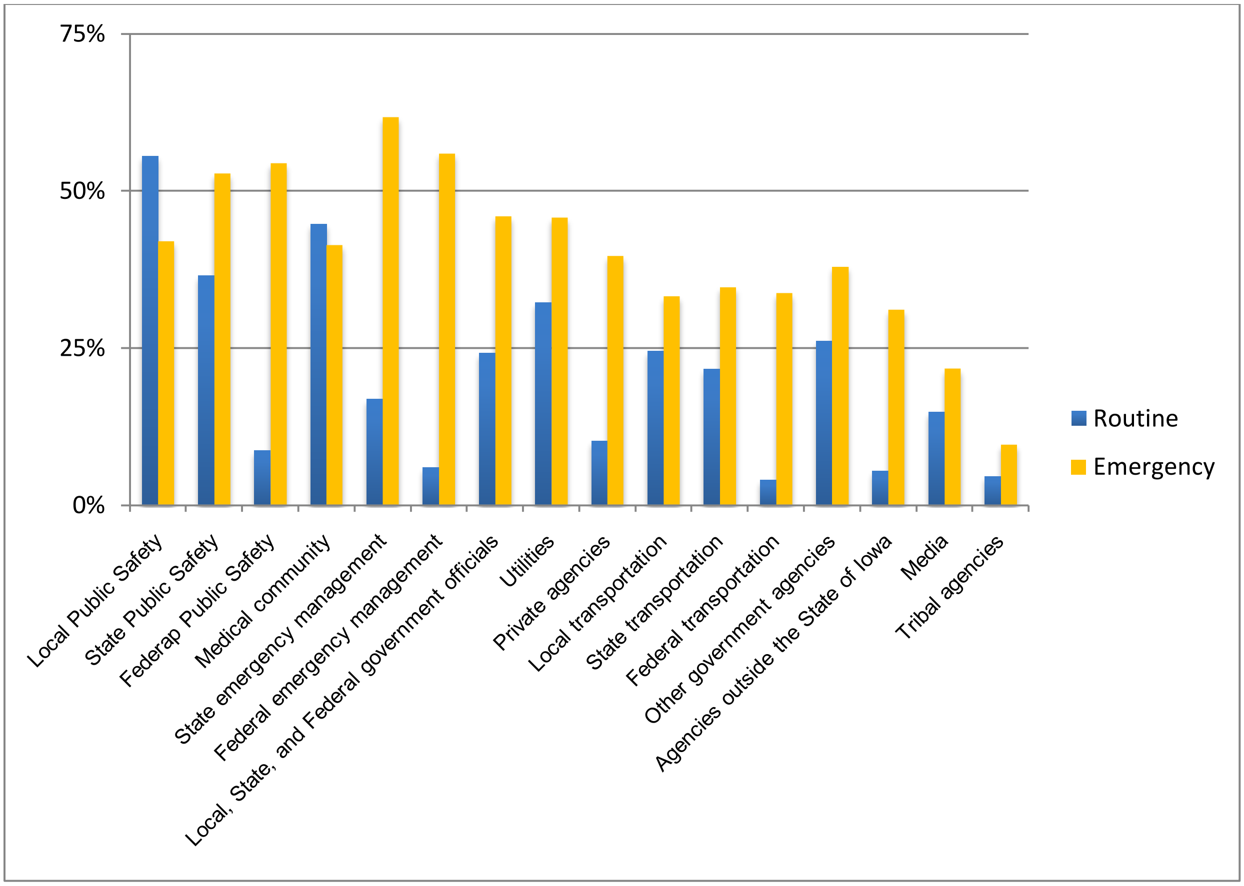

Figure 15 – General agency interoperability

Further analysis of survey data indicated that users required voice services (e.g., dispatch or telephone) to be capable of interoperating on average with members from approximately six other agencies on a routine basis. However, users required data services (e.g., text messaging, data file, image or video sharing) to be interoperable with only approximately three other agencies on average.

State agency responses indicated a strong need to interoperate with local and state public safety agencies as well as the state transportation agencies on a routine basis. In emergency situations, the state agencies indicated a strong need to interoperate with not only the public safety and state transportation agencies, but also federal agencies (e.g., public safety, transportation, and emergency management), government officials, emergency management, the medical community, utilities, and agencies outside the State of Iowa. This is illustrated in Figure 16 – State agency interoperability.

Both the state and local agencies responses indicated a general need to interoperate with public safety agencies routinely and in emergency situations. Additionally there was a general need for both state and local agencies to interoperate with emergency management agencies on an emergency basis. The state agencies indicated a general need to interoperate with a broader collection of agencies especially on an emergency basis, than did the local agencies.

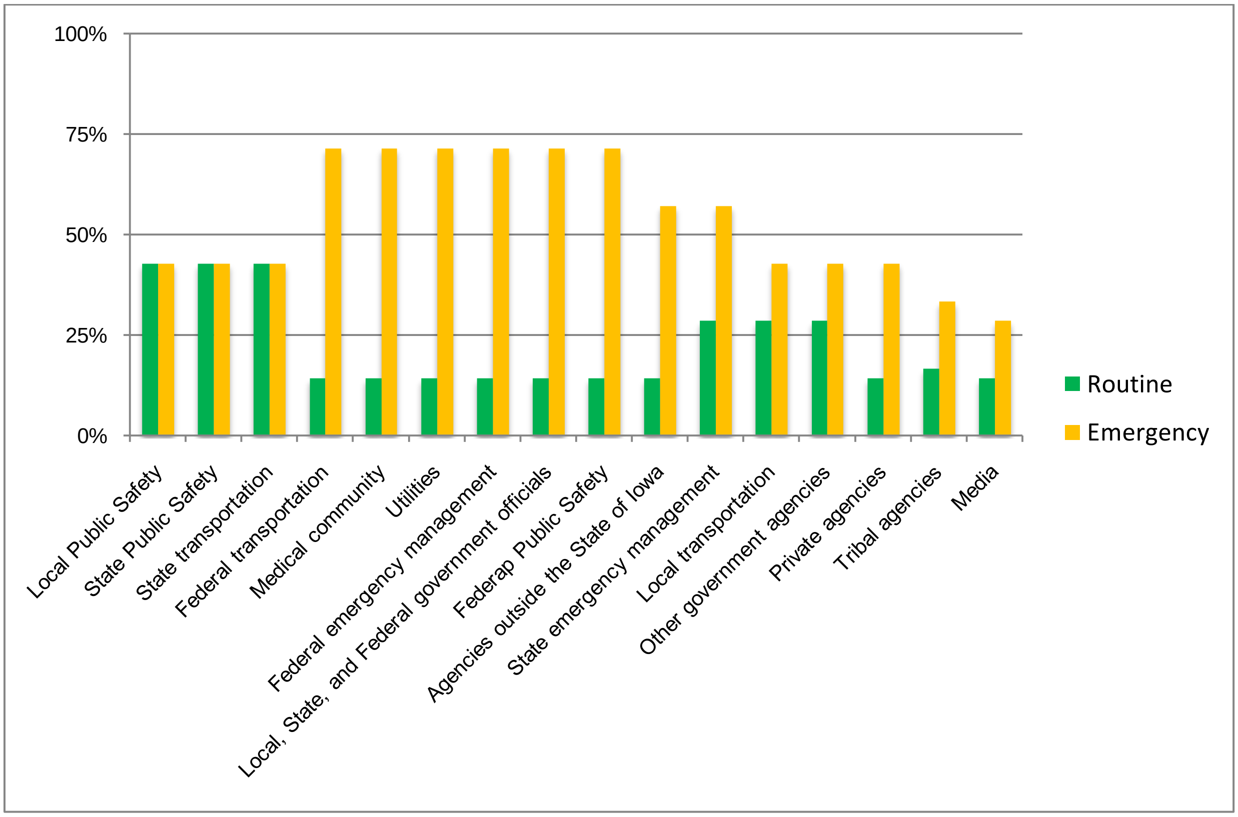

Figure 16 – State agency interoperability

Over 90% of the respondents indicated a need to interoperate with users from other agencies at least occasionally. Less than 3% of the respondents indicated never having a need to interoperate with other agencies. In order for ISICS to support seamless interoperations across state, local, and federal agencies as well as adjacent states and non-traditional public safety stakeholders, it must support seamless roaming throughout the State.

While there was marginal indication of the need for data sharing among those agencies surveyed, the overwhelming majority of users throughout the state indicated the need for voice service (dispatch voice or telephone) interoperability. This is illustrated in Figure 17 – Service type used during times of interoperation.

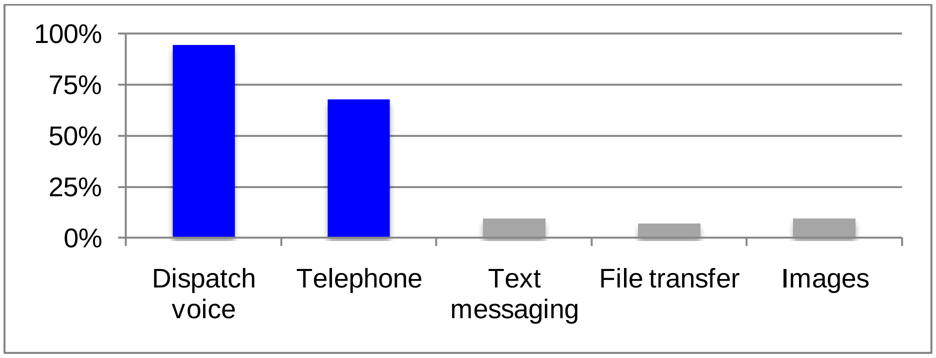

Figure 17 – Service type used during times of interoperation

Figure 18 – Reported interoperability issues show the areas identified by the public safety user community that complicate interoperable communications. The primary issues can be grouped into three major categories: (1) different radio systems, (2) different data systems and (3) generally unreliable communications.

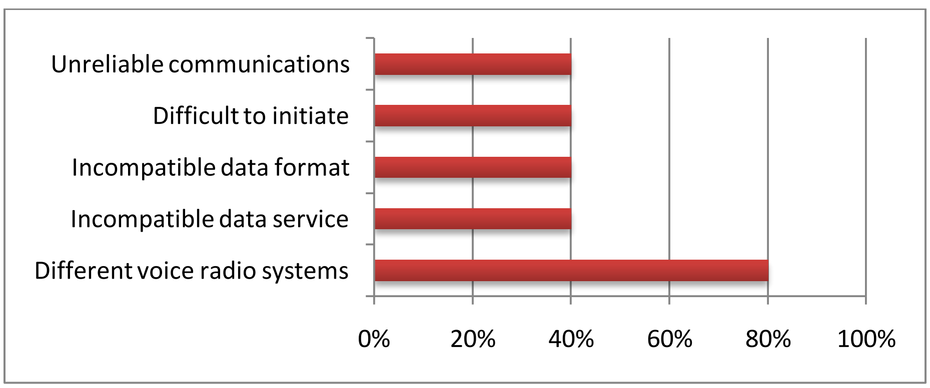

Figure 18 – Reported interoperability issues

The predominant issue with current communications across agencies is that of operating disparate radio systems. In this scenario, the differences in the air interface and signaling protocols between radio systems makes the ability to interoperate difficult at best. Additional issues were reported for data interoperability, relating to incompatible data services and data formats. Despite these inherent issues with initiating and maintaining the inter-agency communication, there is still a need to interoperate across different radio systems.

As indicated in Figure 19 Reported problems during interoperable agency communications, the main problems reported during current interoperable communications include basic unreliable communications between the agencies, often related to coverage issues and the unavailability of communication resources to suitably support the communication.

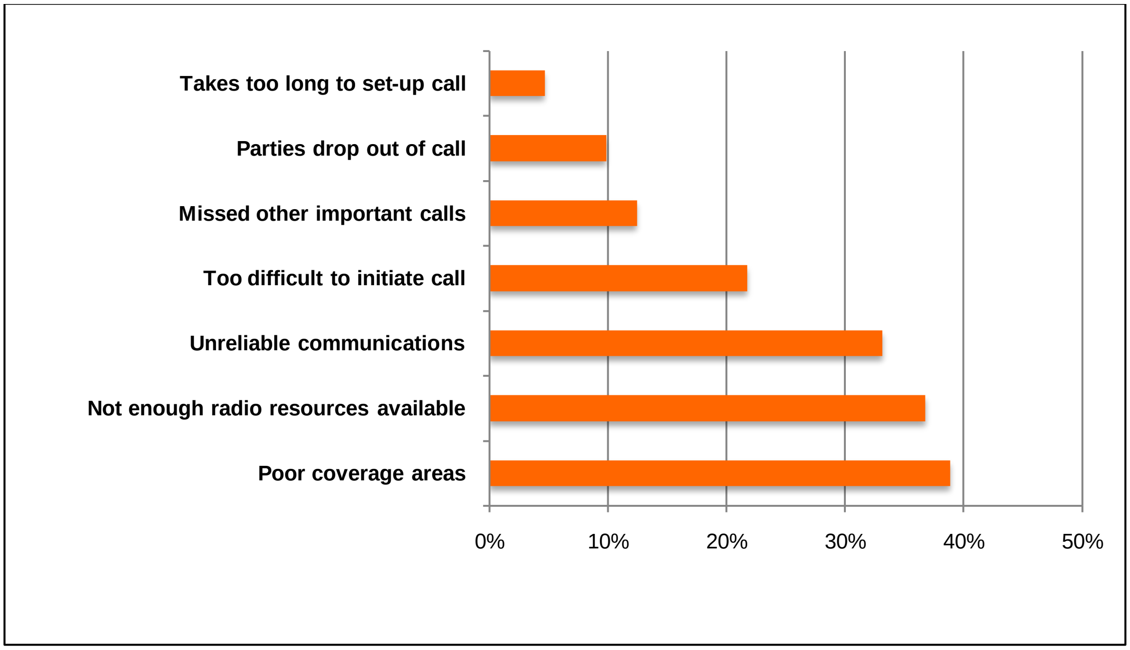

Figure 19 – Reported problems during interoperable agency communications

6.2 Interoperability with Adjacent States

Public safety professionals along the Iowa state borders should know and understand adjacent states' interoperability plans and how they affect interoperability for the State of Iowa. Over many years, Iowa and the adjacent states have established interoperability channels for use within each state. Figure 20 – Iowa adjacent states illustrates the states adjacent to Iowa.

The 700 and 800 MHz bands have common interoperability channels that were identified by the FCC as part of its rule making process. Although these channels often carry different names or mnemonics, the frequencies used for these channels are firmly established within each state. In addition, each state has established interoperability channels in the VHF and UHF frequency band. Nevertheless, the rules established by each state differ to some extent in the implementation and usage of these channels. As a result, many public safety organizations petitioned the National Public Safety Telecommunications Council (NPSTC) to re-examine the channel naming conventions.

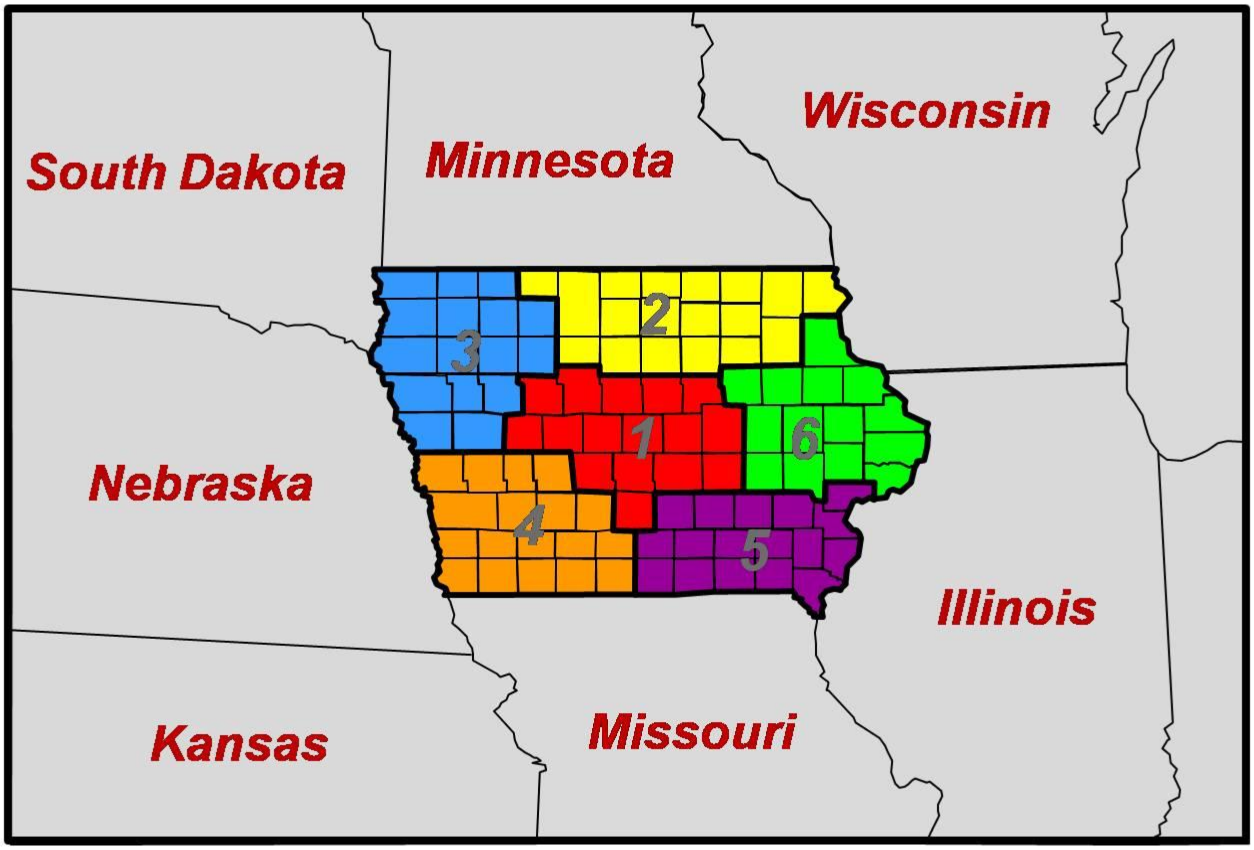

Figure 20 – Iowa adjacent states

The NPSTC Governing Board approved the final recommendations for common naming conventions in June 2007. In addition to providing standardized names for interoperability channels, the frequencies for these channels are also identified. These channels meet all of the narrowband requirements set out by the FCC for implementation by January 1, 2013. The NPSTC plan and recommendations were accepted by DHS and adopted by SAFECOM to become the standardized national naming conventions for interoperability channels. The SAFECOM continuum is discussed in more detail in Section 9 of this report. The new NPSTC Channel Naming Report can be found in the following Web address: www.npstc.org. A summary of the interoperability plans for Iowa's six adjacent states can be found in Appendix B.

6.3 Interoperability with Federal Agency Users

Being able to interoperate with federal users presents significant challenges due to the constraints under which these agencies operate. Federal users operate on specific radio channels administered by the National Telecommunications and Information Administration (NTIA) that are set aside for federal use. Unless specifically authorized by the NTIA and sponsored by the federal agency, state and local users are prohibited from operating on these channels. Obtaining authorization to operate on the NTIA channels is problematic and very difficult to obtain. In rare circumstances and generally for planned events, over specific time periods, has this been possible. Radio communications among federal users also carry unique requirements that include 12.5 kHz channels, encrypted audio and data, and some limitations not required by the FCC. Federal agencies will not share encryption codes and thus other agencies would only be able to communicate with federal users via a federal agency supplied radio unit. The operational constraints imposed by Federal agencies also vary with each agency.

One methodology for interoperating with federal users uses state, tribal or local FCC regulated VHF/UHF interoperability channels. These can be programmed into the federal user radios. Using the local interoperability channels, the federal user's communications can then be patched into state and local users' systems thereby providing an interoperational interface with limited functionality. Alternatively, a cache of radio equipment that operates directly on state and local systems can be deployed to federal users. Unless there is a change in the regulatory and operational constrains imposed on federal users, interoperability can only be achieved at the most basic level.

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7. System Needs Analysis

ISICS is conceived as a unified statewide wireless communication system to be used by Iowa's state and local agencies. State, local, and municipal agencies may use this system for primary day-to-day radio communications. Local and municipal first responders will be able to use this system to interoperate with state and other agencies, especially in times of emergency. The system will provide voice, low-speed data, broadband data, and video service interoperability among its primary users and other public safety agencies to support day-to-day, mutual aid, and task force operations. The system will be highly reliable, fault tolerant, spectrally efficient, easily scalable, and meet the operational expectations for public safety first responders.

Establishing a functional ISICS design consists of the tailoring of general communications systems concepts to address the unique needs of the system users. This defines the system characteristics, such as functionality, and growth potential. The system is framed by some trends in technology and a base set of assumptions regarding the communication system characteristics. As illustrated in Figure 21 – Design methodology, the main sources of information analyzed for the ISICS system design includes technology trends, baseline system assumptions, and user needs.

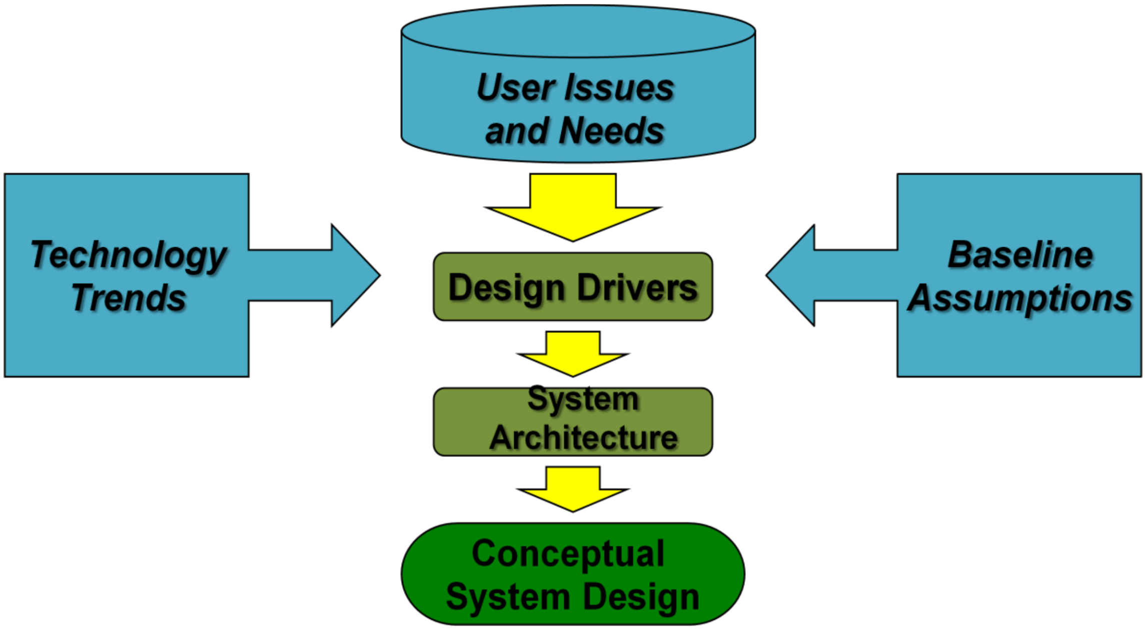

Figure 21 – Design methodology

- **Technology trends**

  The technology trends are a collection of general industry directions that apply to the development of systems.

- **Baseline assumptions**

  These assumptions articulate characteristics to generally define the boundaries and major attributes describing the expected nature of the desired system. These define a framework around which the system should be designed.

- **User needs**

  The users' issues and needs are factors that are derived from the survey responses and interviews. These capture the main items that are important to the current and future set of radio users.

The information from the technology trends, baseline assumptions, and user needs is combined to produce a set of design drivers that define the characteristics and attributes of ISICS. The design drivers are used to structure the system architecture and the overall system design.

7.1 Technology Trends

The following items are key considerations with regard to defining a new communication system. These address directions in system technology and trends that can frame user expectation.

7.1.1 Migrating Toward Digital Technology

Public safety wireless networks are migrating toward digital technology. The main reasons for this migration to digital networks are the improved quality of audio, encryption capabilities, and convergence of voice and data services that these digital networks afford. With the current digital voice technology it is possible to receive very good voice signaling in areas where comparable analog voice signaling would be suffering from noise signal corruption. In general, new vendor product lines feature digital equipment and systems.

7.1.2 Pooling Channel Resources Using Trunked System Technology

Public safety agencies are pooling resources to create shared trunked networks. With the advancement of technology and the scarcity of spectrum, the policy of the FCC is to encourage public safety users to migrate to LMR networks built on trunked technology. Agencies applying for three or more channels in the 700 MHz and 800 MHz bands are required to build trunked LMR networks.

Conventional operation

On a simple conventional system, users are arranged by physical frequency or channel. Each user is assigned to a specific channel they have selected on their radio. Everyone who has selected this channel is a talkgroup member of the channel. Each user shares the channel with all the other uses that have this channel selected, and can in general talk to anyone else who has the same channel selected. Multiple separate channels can exist in the conventional network to support the different groups of users, but each user is dedicated to use only the channel selected on their radio. Multiple subgroups of users can be accommodated on the specific channel (e.g., fire, fire rescue), but only one user group may talk on the channel at a time. When additional capacity is needed, another base station with a different frequency needs to be installed and the new users assigned to that new channel.

As depicted in Figure 22 – Conventional network example, user groups E and F are allocated to Channel 2. If a user in Group F is talking, then Group E must wait (is blocked) until Group F is done using Channel 2, even if Channel 1 or Channel 3 is available (e.g., no one from Groups A, B, C, or D, or Groups G, H, or I are currently talking). If the user group E believes this poses an operational problem, then system capacity must be expanded to include a fourth channel dedicated to group E.

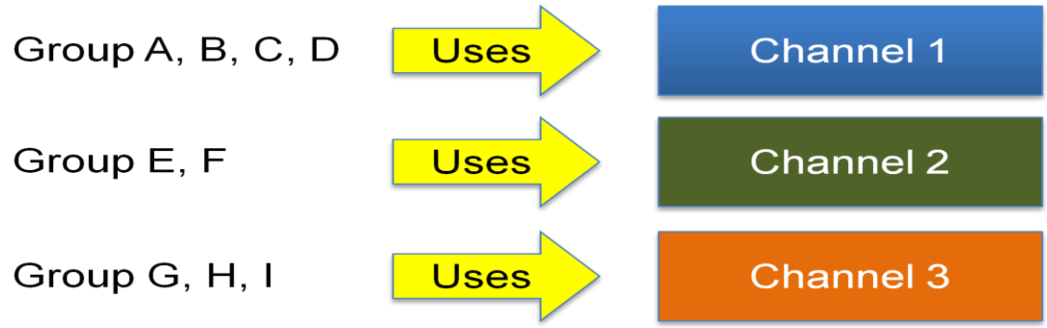

Figure 22 – Conventional network example

Trunked operation

The basis of a trunked system is a pool of communication radio resources that are automatically shared by a large number of radio users. The radio users are capable of using any of the radio resources or channels of the pool of resources.

On a trunked network, radio users are assigned to talkgroups that equate to virtual channels. The talkgroup is a collection of users who are to share a communication. These talkgroups are not attached to any particular channel as in a conventional system, but instead can be associated with any of the available channels of the system as needed. Unlike a simple conventional network, these talkgroups are private. Only users who are authorized in the talkgroup will hear the conversation.

There are basically two types of channels in a trunked system, control channels and traffic channels. Normally while idle, radio units monitor a designated special channel called the control channel. The control channel is the medium to convey the current status of the radio system, indicating the current assignment of traffic channels to talkgroups, and receiving requests for call service from the users. When a radio user wants to make a call, the user's radio initiates a call request on the control channel. The trunked system controller will determine the needs for this call request and assign an available traffic channel from the pool of communication resources. The assignment is sent on the control channel to all the idle radio units, and appropriate action is taken to use the assigned traffic channel by the authorized radio units. There is no fixed physical mapping of talkgroups to specific channel resources; a talkgroup may be assigned to any of the available channels at any given time.

In Figure 23 – Trunked network example the trunked network is composed of a control channel and two traffic channels. In this example users for Groups A, B, C, D, E, F, G, H, and I are all assumed to be idle and monitoring the control channel (i.e. no conversation taking place). When someone wants to talk, by pressing the push to talk (PTT) button on the radio, the trunked controller will dynamically allocate an available channel to the talkgroup for the duration of the call. At the end of the call, the user's radios (in the talkgroup) return to the control channel until someone in that group wants to talk again, at which point the group is allocated an available traffic channel.

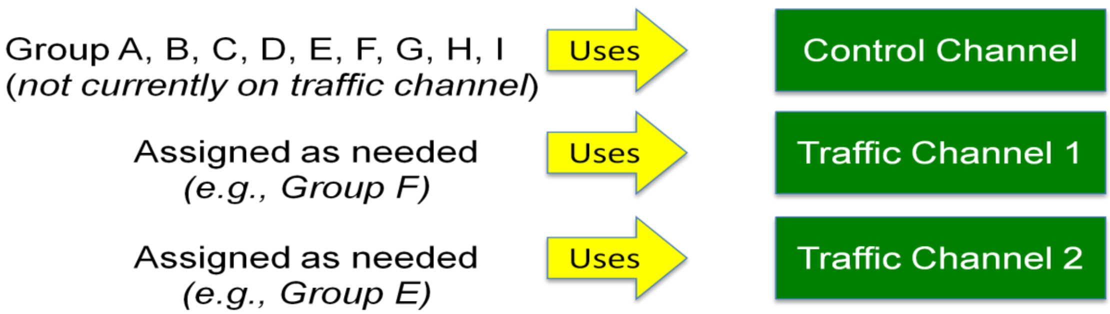

Figure 23 – Trunked network example

In this example, assume a user in Group F is currently talking (Group F is assigned to traffic channel 1). The other groups are idle and monitoring the control channel. If a user in Group E wants to make a call, Group E is allocated another available traffic channel, Channel 2. If a user from Group A now makes a request for service, there are no other available traffic channels to allocate, and the trunked controller will queue the request from Group A until either Group F completes its use of traffic channel 1 or Group E completed its use of traffic channel 2. Group A will then be assigned to whichever of these channels becomes first available. The more channels there are in this shared pool, the more efficient the trunked network becomes, similar to telephone networks, with a large number of telephone subscribers assigned to a limited number of telephone trunks.

7.1.3 Standards Promote Nationwide Interoperability

The Association of Public-Safety Communications Officials (APCO) has worked with several agencies for the development of a digitally trunked radio system specification, Project 25, tailored to public safety needs. Their objective was to make the resulting specification a nationwide standard for digital public safety land mobile radio that addresses maximizing spectrum efficiency, ensuring competition in life cycle procurements, promoting effective and efficient inter- and intra-agency communications, and providing user friendly equipment and operations. Many agencies participated in this endeavor including the National Telecommunications and Information Agency (NTIA), National Association of State Telecommunications Directors (NASTD), National Communications Systems (NCS), and Department of Defense (DoD).

Project 25 (also known as P25) is a suite of standards that outlines public safety wireless communication equipment interoperability and compatibility requirements. These include support for common air interface (CAI), voice-to-digital, trunked operation, data interface, encryption, and telephone interconnect standards between all TIA/EIA 102 compliant digital base and subscriber units. The P25 trunked system standard has defined many open system interfaces to provide direction for inter-vendor operations and flexible system configurations. These interfaces are illustrated in Figure – 24 APCO P25 general architecture.

The main system interfaces are:

- **Common Air Interface**

  CAI defines the over the air protocol between the subscriber units and the fixed end infrastructure. CAI is the core element of the P25 standard that assures interoperability of P25 digital radio equipment from different vendors.

- **Console Subsystem Interface**

  CSSI defines a standard interface between a dispatch center and the radio infrastructure.

- **Fixed Station Interface**

  FSI defines a set of mandatory messages supporting digital voice and data operations between a fixed station and the radio infrastructure.

- **Inter Subsystem Interface**

  ISSI defines a set of messages to support linking of P25 systems together to form a wide area solution. This interface is the key element for interoperability between P25 systems, supporting mobility management, service transport, wide area call control, and inherent end to end security of signaling information.

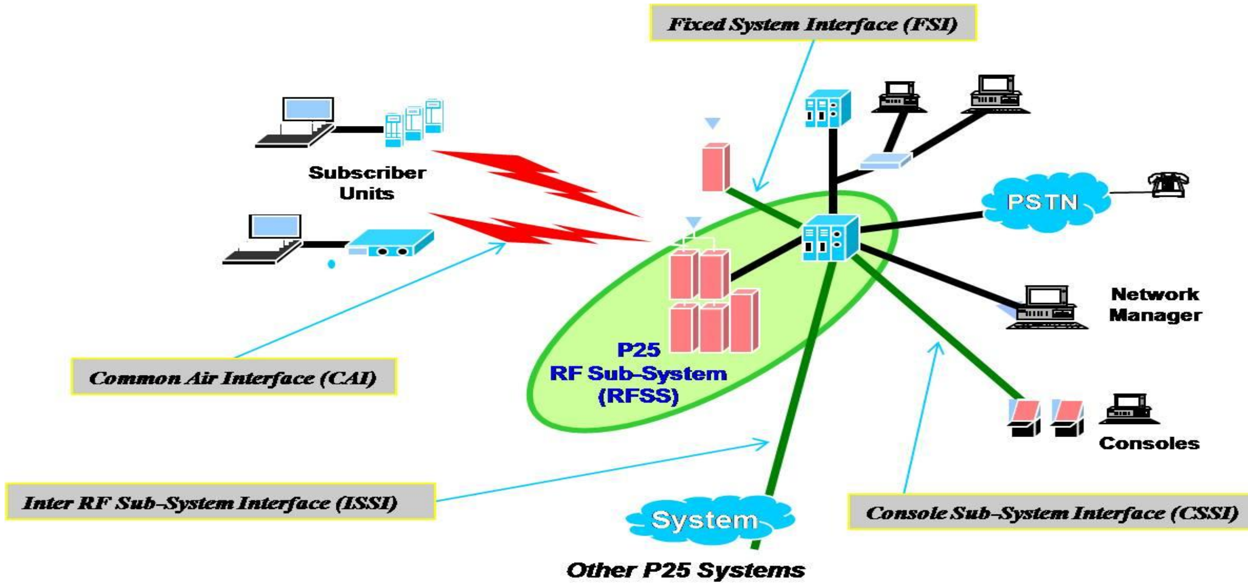

Figure 24 – APCO P25 general architecture

A standards-based communication system approach promotes inherent capability for interoperation and common operability. This helps to control build out costs for the network with a unified approach to system growth.

7.1.4 Spectral Efficient Voice Channels

The FCC continues its focus on making the radio usage more spectrally efficient, targeting reduction of the channel bandwidth carrying a voice signal. Where channels of 25 kHz were typical in the past, the current direction is to have voice signaling occupy a fraction of that old bandwidth. To that end, the FCC has mandated that all channels in the VHF and UHF frequency bands (below 512 MHz), must comply with a narrow bandwidth restriction of 12.5kHz by the year 2013. This will directly affect all but the 800 MHz-based systems in Iowa.

With the movement to smaller bandwidth channels, there is a companion trend to further compress voice signals into digital representations that fit in the more spectrally efficient channels. The digitization of the voice while tending to represent vocal energies suitably, does sometime introduce unwanted artifacts to the recovered voice signal (or suppress some desired side artifacts in the analog version) that makes the recovered voice signal less desirable in some speech environments (e.g., high ambient noise levels). Different vendors provide solutions unique to their system offerings that mitigate this issue.

7.1.5 Broadband Data Channel Structures

While the movement for voice channels is toward smaller and smaller bandwidths for voice service channels, there is a movement to wider bandwidth channels to accommodate the broadband data service needs. Increasing the bandwidth allows more information to be sent through the channel at any given time, and thus allows support of more data users in a given area, and data services that are demanding of bandwidth and data throughput, such as full-motion video.

7.1.6 System-Of-Systems Approach

As the communication needs become more sophisticated, and the communication systems become larger and more complex, the support of single monolithic system architecture is becoming ever more expensive and complex. An alternative system approach based on an Internet system view supporting a peer-to-peer, system-of-systems architecture is becoming common. Here, collections of smaller autonomous systems based on a common architecture are interconnected across a wide area to accomplish a communication network solution. The P25 trunked system architecture is an example of a peer-to-peer, system-of-systems approach. This system approach can address the unique local user operational needs while collectively fulfilling the overall wide area interoperable communication needs for the network.

7.1.7 700 MHz Spectrum Designated For Nationwide Public Safety Use

With the designation of the 700 MHz spectrum for nationwide public safety use, there is a substantial block of radio spectrum that is clear of interference sources (e.g., commercial and other non-public safety user groups), that are found in the other frequency bands. There is an inherent interoperability opportunity with adjacent states and even on national levels through adoption of the 700 MHz band for Iowa's state and local communication needs. As more agencies across the nation move to the 700 MHz band for their communication need, there will be economies of scale from the national movement to supply and support equipment capable of this spectrum usage.

7.1.8 700 MHz Provides Better In-Building Penetration

Moving to equipment that operates in the 700 MHz frequency band provides better opportunity for in-building penetration and radio coverage over current lower frequency VHF equipment. As frequency increases, the wavelength of the radio wave decreases. Buildings and other physical obstructions are more transparent to the shorter wavelength 700 MHz radio waves, allowing them to pass through with less attenuation than the lower frequency wavelengths associated with VHF transmissions.

7.1.9 Increasing Reliance on Data for Day-To-Day Operations

Public safety agencies are increasingly reliant on data services for their day-to-day communications. Low bandwidth applications such as automatic vehicle location (AVL), paging, and text messages are now commonplace. A slow speed data network that can share the traditional public safety voice spectrum can support these applications. With the limited bandwidth of the public safety voice communication systems, only very low throughputs and transfer rates can be achieved. This is adequate for the applications listed above, since these are generally not demanding of bandwidth nor requiring real-time response operation.

There is a general trend toward more use of data services to compliment and supplement voice communications. There is even a view that data services can supplant some voice communications. Text messages in place of voice paging or simple voice calls to verify information are examples of ways data communications can augment or replace classic voice communications.

7.1.10 High Speed Wireless Networks Are Covering Larger Areas

As high speed wireless networks, such as 3G, and Wi-Fi become more common and cover larger areas, the number of types of applications they can support increases. General user expectations of what can be accomplished over a wireless data network are growing as well. The ability to send high quality images and video streams between mobile devices is becoming commonplace and fuels expectations of how this can be applied to enhance public safety operations. Streaming video to a vehicle and accessing databases for building blueprints are some higher tier applications that are becoming popular with public safety. These applications require a high speed wireless network to provide the transport to deliver these services.

7.1.11 Wireless Data Technology Leadership

While public safety has provided the technology leadership for high-reliability voice communication systems, wireless data technology leadership is coming from the commercial market service providers. Commercial wireless data services advance the technology to better address large audiences of wireless data users who have expectations of taking their wired data experience mobile. The commercial wireless providers are not encumbered by the need to fit the data service in a channel with a narrow bandwidth as public safety providers have been. They address data service needs in an environment that supports advancing the wireless data service offering in what appears to be ever wider bandwidths. The public safety environment concentrates on the voice service capability, and the accompanying need to support more voice conversations over a limited channel size.

The narrowing of the voice channel bandwidths, while good from the standpoint of increasing spectral efficiency for voice signaling, is not conducive to supporting higher bandwidth data services. For a given channel bit rate capacity, narrowing of the bandwidth requires increasing the signal to noise ratio. This translates into requiring an increase in transmitted signal strength, reduction in noise components, and reduction in overall transmission coverage area.

Data service needs of the public safety user are outpacing the channel bandwidth capability of an integrated voice and data solution that is constrained to relatively small narrowband channels. The technologies being promoted for advanced cellular services in 3G and 4G networks provide a framework for the direction of dedicated public safety data networks of the future. The needs of the public safety community can be addressed through adopting the broadband service directions of the commercial service providers.

7.1.12 Real Time Wireless Data Support Is Becoming Reality

Wireless data networks evolved from circuit switched operation to providing packet data services to the cellular networks, and are now embarking upon redefining the networks to be an inclusive IP centric packet data network. In the past, data networks suffered because their core networks were not IP centric, thus lacked management control of the transfer of information on those networks. It was impractical to differentiate service for specific types of applications or even groups of users, which is a necessary component of a data network suitable for public safety usage. The various networks through which a data packet would travel handled the processing of that data packet in its own fashion. This led to major issues of latency and made support of demanding time sensitive or high throughput data services problematic. With the advent of all-IP network architectures found in 4G networks such as LTE and WiMAX, there is the opportunity to provide a Quality of Service (QoS) component to the management of the data service streams. This allows select applications to be given priority for the data network resources; this can also be used to grant special priority to a class or group of users on the network. The support of QoS mechanisms is a necessary component of a data network suitable for public safety usage.

7.1.13 The Proliferation of Wireless Handheld Integrated Devices

With the proliferation of cellular capable devices and computer/IP-phone capability in homes there is a growing trend toward using the video and data capabilities of these devices and IP networks to supplement emergency calls to Public safety agencies. For example, someone making an E911 call from his or her cell phone to report a fire can actually provide video information regarding the incident itself. This information would be useful to determine the best course of action to address the incident. This information could be relayed from the E911 dispatch position to the actual units in the field to provide needed information.

7.1.14 IP Networking and High Bandwidth Transport Support

With support of IP-based transactions becoming more common with wireless communication systems, the transport network needs to be able to handle IP networking transactions without impacting the associated delivery of the packets with latency or data corruption.

The communication backhauls of the past were generally associated with handling low bandwidth analog voice signaling and low speed data streams. The direction for communication systems and associated backhaul needs is toward high bandwidth digital capability to support the various demanding high throughput data services (e.g., full motion video) and digitized voice. The site backhaul network can easily become the bottleneck to advanced data services if insufficient bandwidth is allocated.

7.2 Baseline System Assumptions

The State of Iowa recognizes the importance of real time voice and data communications capabilities for public safety agencies and the direct correlation of these communication capabilities to minimizing loss of life and property. First responders must be able to communicate with each other to provide immediate and coordinated assistance in times of emergency. Key to this is the support of interoperable communications across the various public safety disciplines, levels of government, and neighboring States.

There are a number of general characteristics of the Iowa Statewide Interoperable Communication System that are to define the system functional boundaries, needs, and directions. The conceptual design of the ISICS network described in section 8 uses these assumptions, described in the following subsections, as a framework upon which to build the design of the ISICS system.

7.2.1 Core Voice Service Based On P25 Trunked Standards

Standards-based solutions are a key component to enhancing interoperability and making the ISICS network approach feature rich, flexible and scalable, thereby extending its life cycle. Standards-based solutions encourage cost competitive equipment sourcing from multiple vendors and also benefit from general economies of scale employing technologies used across multiple industry venues.

The APCO Project 25 (P25) Trunked system is a standards-based communication system solution that addresses the needs of public safety users. This is a suite of standards (TIA 102 series) to define such aspects as the radio air interface, trunking functionality, network management, physical interfaces, etc. The P25 trunked system standard has defined many open system interfaces to provide direction for inter-vendor operations and flexible system configurations.

The trunked system approach provides levels of fault tolerance to the overall communication system. With a pool of channel resources available for assignment to any user of the system, the failure of a single channel resource will not cause the communication system to cease functioning. Other channels from the pool of resources can still be assigned to handle the communication needs. Even in the event of a catastrophic network failure of the P25 trunked system, there are fallback modes of operation that can still provide a level of service to users currently using the system.

The P25 trunked architecture is designed for ease of expansion from adding more system users, to adding more channels for handling new user loads, to adding sites so the overall communication system will provide greater coverage and loading capability.

With the support of standardized interfaces and functions, the P25 trunked architecture enables multiple compliant vendor products to be integrated into a cohesive system solution.

7.2.2 Use of the Public Safety Allocated 700 MHz Spectrum

The ISICS solution should use the public safety block of channels in the 700 MHz radio spectrum (764-776 MHz and 794-806 MHz). These channels are dedicated by the FCC for the nationwide use of public safety users fostering ease of interoperability between disparate systems through the use of a common frequency band. With this band of frequencies dedicated to public safety use, there is no interference from commercial or non-public safety entities.

7.2.3 Statewide Microwave Network as a Common Transport Backbone

The ISICS network is to be supported by a statewide dedicated microwave network that provides a common digital transport for the voice, data, and video elements of the communication system. The transport backbone is a pivotal element of the ISICS network and as such should be managed by the ISICSB. Existing state microwave sites may be reused as nodes for the ISICS transport network. The configuration of the microwave transport network is to be resilient to faults, with the employment of various ring and star topologies to form a fault tolerant network architecture. To complement the microwave network, and to act as a backup network, the wireline, fiber-based Iowa Communication Network (ICN) should be considered. The bandwidth capabilities of the ICN can be matched to the high bandwidth needs of some advanced communication services, shifting some of the bandwidth needs away from the microwave network.

7.2.4 State and Local Shared System Approach

The ISICS design is to be a communications system dedicated to supporting all Iowa public safety agencies; the ISICS is not designed to address only State agencies. ISICS is to be a public safety communication system spanning the State of Iowa that is capable of supporting state and local public safety agencies in a statewide, fully interoperable mode. These agencies, by complying with the ISICS common platform design, support direct radio-to-radio interoperability with other ISICS compliant state and local agency users.

The local agency will be able to maintain normal day-to-day operations after joining the ISICS network. The local agency will still control local resources, affording a level of local autonomy similar to that experienced when the local agency was a separate communication system.

If the current ISICS site configuration does not satisfy the needs of the local agency, sites can be added to the ISICS network. These can be completely new sites or can be reuse of existing local agency sites, upgraded to be compliant with the ISICS common platform attributes. Either method will provide a greater build out of the ISICS network, enhancing both local and state agency communications.

7.2.5 Phased System Rollout

With the scope of the ISICS network addressing the needs across the entire State of Iowa it is impractical to consider the ISICS implementation as a single one step approach. The ISICS network will be implemented in sections across the state, with each of the sections interworking with the other sections, and building one upon the other until the statewide ISICS network is complete. The various phases for these implementation sections will be driven by a multitude of conditions: funding, regional prioritization, agency prioritization, local agency participation, etc. A baseline phased approach addresses implementation loosely along the lines of the HLS&EM regions in Iowa.

7.2.6 Support Legacy System Interoperability

While it is believed that the best solution for statewide interoperable communications involves the conversion to a common standards-based platform for all communications across the state, some existing local legacy communication systems may not be converted to the ISICS format initially. Agencies operating on these legacy systems may desire to interoperate with the users on the ISICS network. This would be addressed at lower levels of interoperability, typically using gateway structures to interconnect the ISICS and legacy communication systems, or through the use of special legacy radio compatible subscriber units. Schemes to address how legacy users can interoperate with the ISICS network users will also identify the drawbacks of such schemes. This is a key issue for consideration as the ISICS network is being phased into existence. During this time, ISICS users may need to interoperate with the legacy systems employed in areas not yet converted to ISICS operation.

Voice traffic from disparate systems may be interconnected through specially assigned interoperability groups (or channels) via gateway solutions. For example this interconnection may be accomplished through a patch operation at a dispatch console position, or it may use special hardware that allows signaling from a channel in one system to be presented at a channel in a different system. These solutions generally take voice input from one source and transpose it appropriately to be presented to a different receive target. These gateway solutions cannot address direct radio-to-radio interoperability since the radios are still operating on their different native frequencies and air interface protocols that are only supported by the native system channels. The use of gateway technology does not address instances when a radio is outside the service area of its native system and cannot detect its native over the air signaling. Generally gateway solutions are not appropriate for at-scene communications which requires direct radio-to-radio interoperability for the most efficient and effective inter-agency / inter-jurisdictional communications.

Alternatively, visiting users may be provisioned from a cache of compatible subscriber units to afford direct radio-to-radio interoperable communications in the visited areas.

The added expense of maintaining this cache of compatible subscriber units is an extra consideration for the legacy system management.

7.2.7 Advanced Data Services Support

There is a general trend toward inclusion of data intensive functions with the day-to-day public safety user operations. Whether this is form driven data entry, e-ticket applications, Web-based functions, or even real time video streams, there is the need for a foundation to support the current and future data services for the public safety users in Iowa, to work in conjunction with the voice-based services. The statewide system should provide a basic data service throughout the state with additional support of various tiers of advanced data service capability as need demands. These should be standards-based data solutions to enable ease of interoperability between users. The mobile data device should be capable of automatically roaming from data service to data service as they move across the state. The user experience should be unified and as transparent as possible with regard to which particular data service tier is currently being used.

7.2.8 Next Generation E911 Initiatives

The E911 network is currently based on voice networking technology, and is still voice centric. There is a growing contingent of E911 callers (e.g., cellular users) with the ability to send not only voice messaging, but also supplementary data messaging in the form of text, images, sound files, or video. The next generation E911 systems are expected to make this the norm by embracing IP networks as their basis, which not only supports voice messaging, but also provides the vehicle for supporting this advanced multimedia messaging (incorporating text, images, video, etc.). In addition to current cellular users, IP-based home telephones, and potentially ancillary IP-based reporting entities (e.g., vehicle collision detection systems) could generate these data messages. A basic understanding of the Department of Transportation standard driven Next Generation 911 initiatives are key to defining how the E911 systems of Iowa will need to adapt to support future E911 operations.

7.3 User Needs and Issues

FE employed extensive interview and survey activities to identify and understand the specific needs of state and local agencies operating in the State of Iowa. Survey questionnaires were used to address issues of E911 and dispatch needs and operations, radio system users operable and interoperable communication needs, and document attributes of existing radio systems in the State. ***FE*** augmented and supplemented this information with data collected directly from group and individual interview sessions with local and state agency user groups. This collective data was analyzed by ***FE*** to craft the user needs that describe the needs of the state and local users. The information and conclusions obtained from these survey and interview activities are contained in this section.

7.3.1 Voice Communications

As noted in Figure 25 – Most critical communications mode, voice service is still the primary communication service used across the communication systems in Iowa. Over 60% of respondents indicated voice communications as the most critical mode of operation, with more than a third of the respondents indicating voice and data were equally important. The ISICS design must provide excellent voice communications.

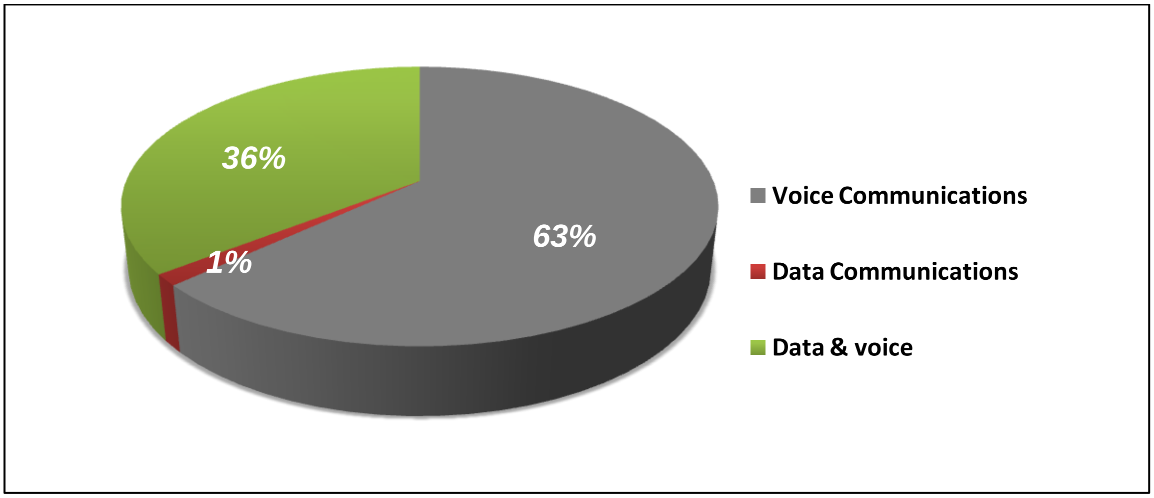

Figure 25 – Most critical communications mode

It is no surprise that voice service is currently the most used service on the communication systems. While the data related services are expected to grow in usage over the next five years, voice service remains the most used service for day-to-day communications.

Voice communication (dispatch and telephone) is still the primary mode of interagency communication. This is indicated in Figure 26. At present data centric communication represents the least used interoperable service among the communication users (typically less than 10% of respondents indicated using data messaging).

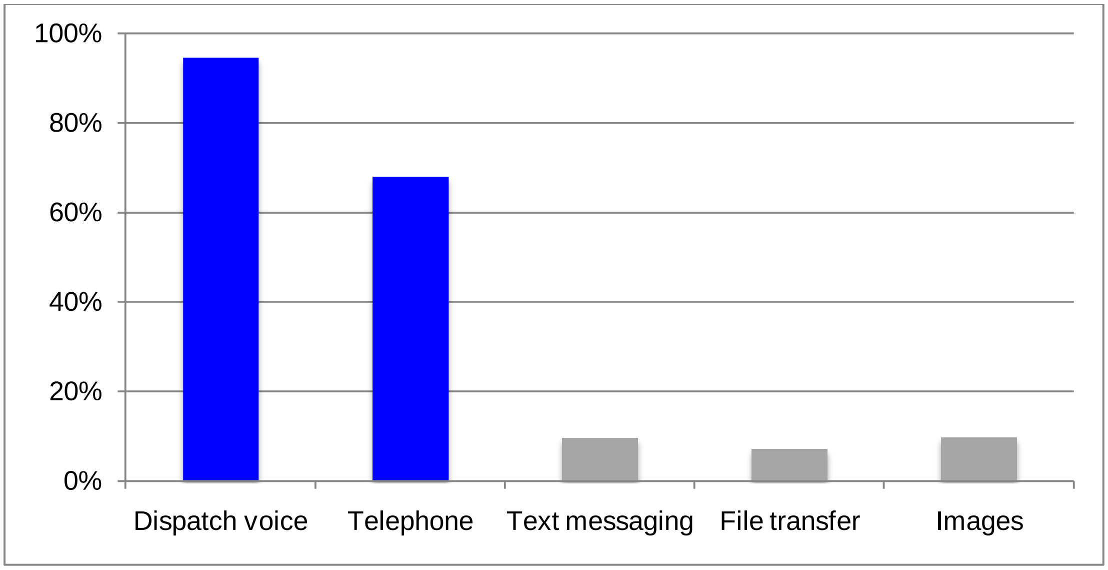

Figure 26 – Agency interoperability service usage

Coverage is a main attribute of the radio system that radio users often apply to define the qualitative value of the radio system. In terms of the user community, coverage is the geographic area in which operational radio service can be facilitated. Radio system users have developed a sense of required operational coverage from personal experience with their currently deployed radio systems. The general goal for the ISICS system regarding voice service coverage is to match or exceed the coverage afforded by existing systems. Coverage for the communication system is divided into the following categories:

- **Mobile coverage**

  Mobile coverage is defined as that supported for vehicle-mounted radio communications. Here the radio unit is fixed with a relatively strong transmit signal feeding a vehicle mounted antenna system, enhancing general radio performance.

- **Portable coverage**

  Portable coverage is defined as that supported by handheld radios in open space (e.g., typically on the street or outside buildings). Portable coverage is characteristically more demanding than mobile coverage from the aspect that the handheld radio receive and transmit characteristics are diminished (e.g., less transmit power, compact antennas) compared to those of the vehicle mounted mobile radio.

- **Portable In-building coverage**

  In-building coverage refers to the use of typically handheld portable radio units within buildings or structures. The in-building coverage is generally the most demanding since it must address the handheld radio characteristics in an environment such as a reinforced building structure which itself typically hampers useable radio signaling characteristics (e.g., radio signal attenuation, interference from electrical equipment).

The majority of survey respondents indicated satisfaction with current coverage for their service area. When segmenting the agency response per service area, the data shows an interesting trend in the satisfaction level:

- The state agency respondents were more satisfied with their coverage than the average respondent
- Those respondents with a city service area were more satisfied than the average respondent
- Those respondents with a county or multiple county service area were slightly less satisfied with their coverage than the average respondent

State agencies indicated that mobile-based voice coverage was their primary mode of communication, indicating greater mobile usage than the portable-based voice coverage, and almost two times greater usage than the in-building-based voice coverage. This is illustrated in Figure 27 – State agency reported coverage needs.

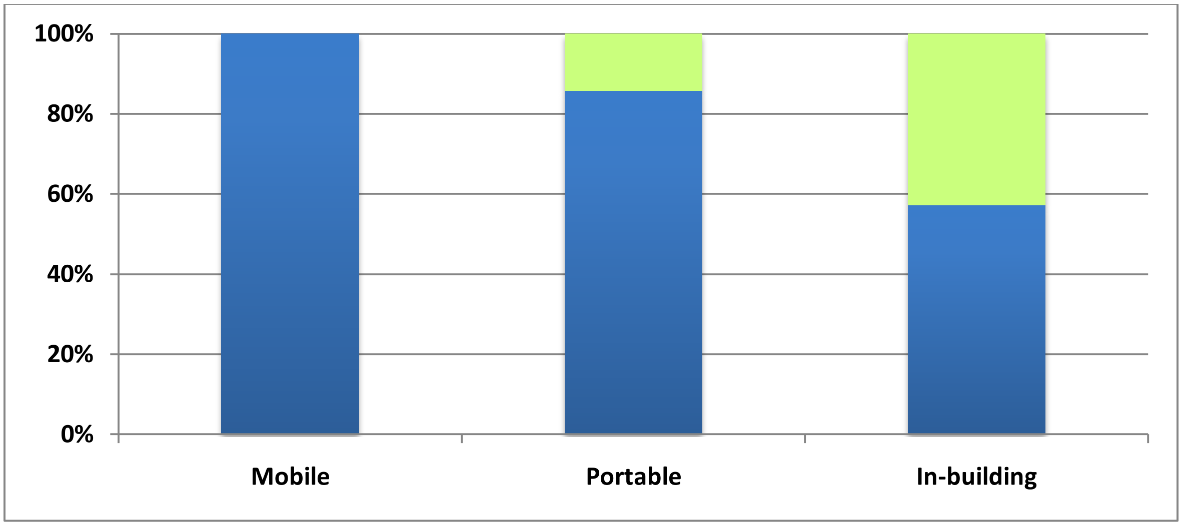

Figure 27 – State agency reported coverage needs

Mobile coverage requirements are expected to remain constant over the next five years, but a growing need for portable and in building coverage is anticipated for the future.

In contrast, local agencies tended to indicate that while mobile-based voice coverage is important; the need for portable base voice coverage is on the same order of magnitude of importance. This can be seen in Figure 28 – Local agency reported coverage needs.

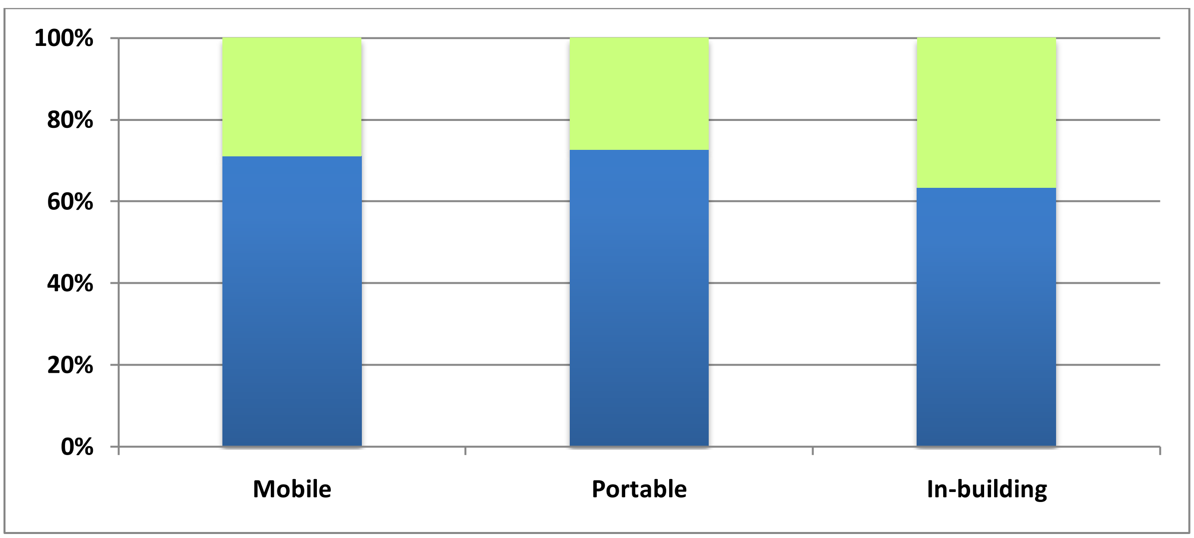

Figure 28 – Local agency reported coverage needs

While the responses regarding current coverage conditions were generally of the satisfied nature, there were still coverage related issues reported with the current system offerings. These were segmented into coverage problem areas and the type of problems encountered.

As noted in Figure 29 – Reported coverage problem areas, the reported coverage problem areas generally relate to in building support (e.g., portable coverage issue), and low area (e.g., terrain issue). The ISICS design needs to be flexible in its radio coverage configurations to provide for extra attention being given to regions with special terrain characteristics (e.g., valleys, hills).

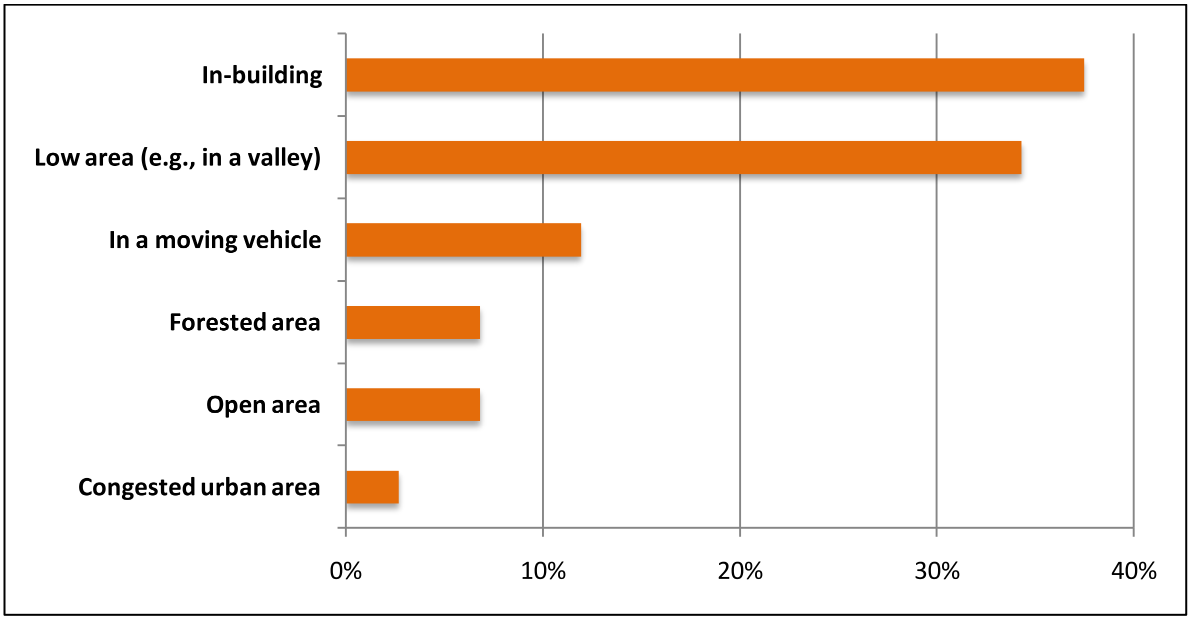

Figure 29 – Reported coverage problem areas

Based on the indications of the state and local agencies, a mobile-based coverage need is common to all agencies. The statewide mobile-based coverage is the main focus of the ISICS conceptual design.

While the focus remains on mobile-based coverage across the State, there are many indications that portable coverage especially in urban areas needs special attention in the ISICS conceptual design. The network design needs to provide expansion and flexibility characteristics to provide future support for portable and in-building coverage in specific urban areas.

More than 60% of survey respondents indicated having experienced problems of poor audio quality, and incomplete reception of messages, resulting in the need to repeat a message. This is illustrated in Figure 30 – Reported coverage related problems.

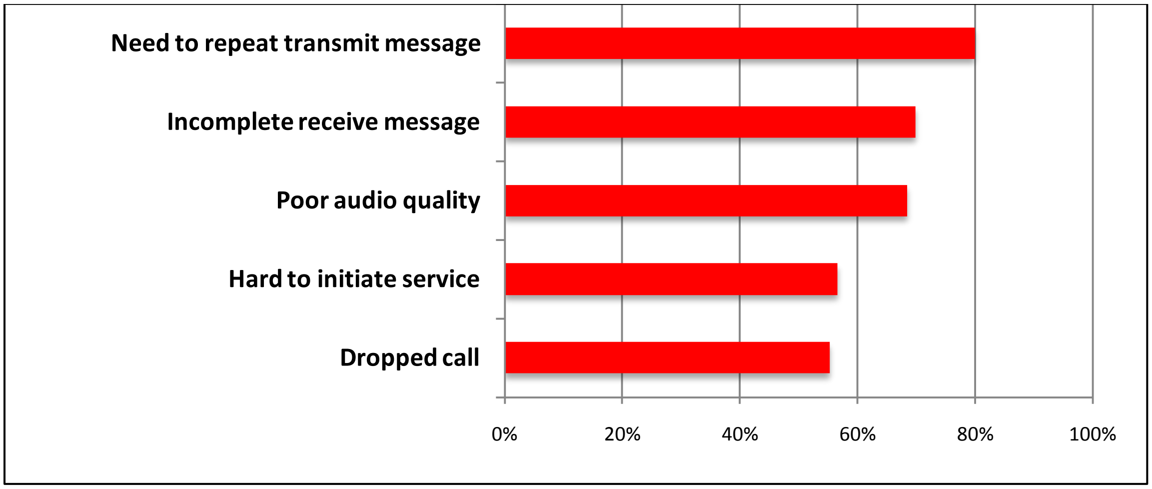

Figure 30 – Reported coverage related problems

When asked about the use of cellular systems to augment the voice dispatch system, nearly half of the respondents indicated they use cellular service occasionally in place of their current voice dispatch radio system.

The majority of respondents using cellular service indicated the reason for using the cellular service in place of the voice dispatch radio system was related to radio system unreliability. This can be seen in Figure 31 – Why use cellular service instead of dispatch radio. Additionally, about a third of the respondents also indicated the cellular service was used in place of the radio dispatch system because they perceived the cellular service as being more confidential than the radio dispatch system.

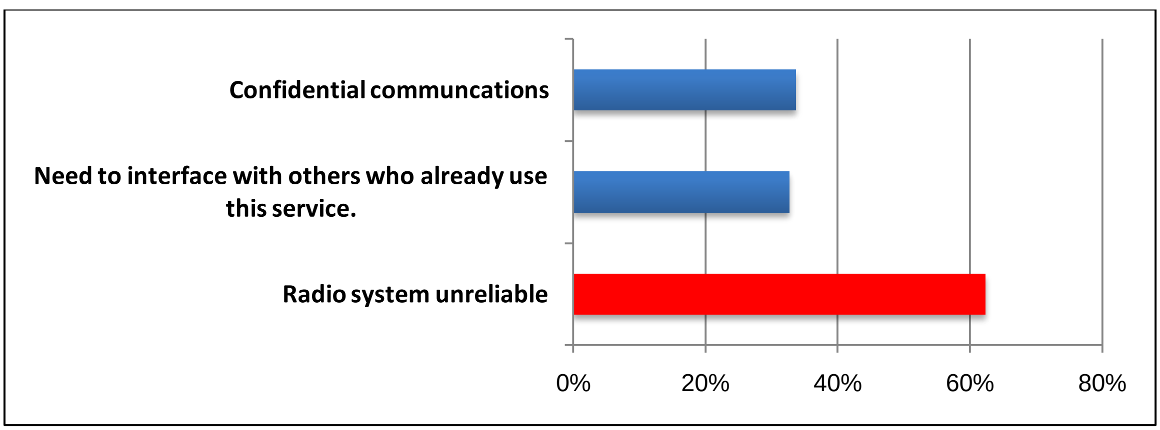

Figure 31 – Why use cellular service instead of dispatch radio

The majority of survey respondents indicated the use of alternative voice services, such as cellular, was the usual mode of initiating calls outside of their assigned jurisdiction;

nearly twice as likely to occur as normal subscriber or dispatcher initiated call modes. This can be seen in Figure 32 – How are calls initiated when outside of your jurisdiction.

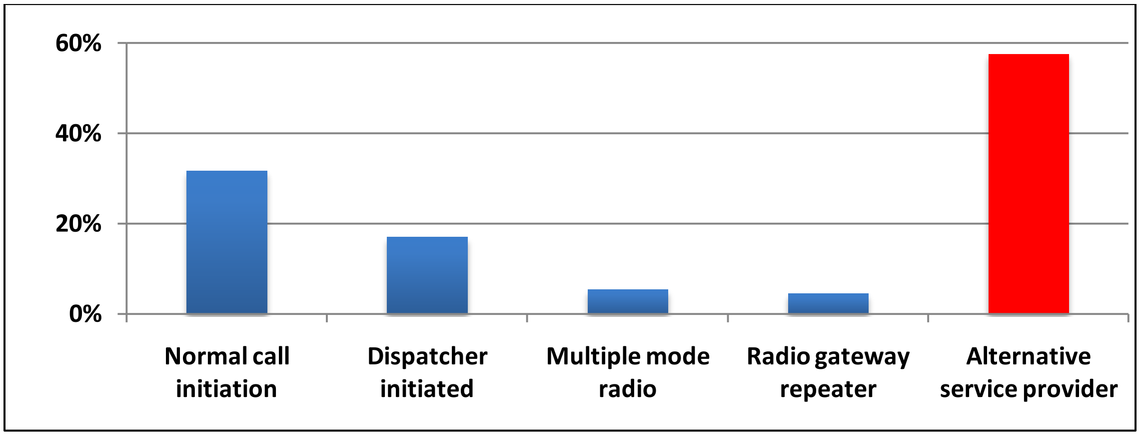

Figure 32 – How are calls initiated when outside of your jurisdiction

While the cellular networks have become ubiquitous in their availability and services provided, reliance upon these networks to correct deficiencies in the public safety communications network has a number of potential dangers. First and foremost, if the cellular system is used to augment poor coverage of the radio system, then radio system coverage should be addressed and not masked by the use of cellular support. Cellular network communications cannot provide some of the tools required for public safety communications, such as the following:

- There is no log of the conversation
- There is no easy method to include a group of radio users on the communications to share information
- There is no easy means to communicate to the dispatcher positions, other than making a telephone call into the dispatcher position

In addition, public safety users do not receive special priority for cellular service, and must contend with all the civilian cellular users in the area. Users outside of the radio system coverage area and working via cellular systems cannot be dispatched or even contacted in the same fashion as other radio users still connected to the radio system. The cellular network can be a useful backup communication service, but should not become a routine part of the communication offering due to poor radio system performance.

Finally, when asked how often there was a need to maintain agency dispatch communications when users roam outside of the agency jurisdiction, approximately one third (33%) of respondents indicated there was often a need, and over two thirds (66%) of respondents indicated a need for this at least sometimes. This can be seen in Figure 33 – Need for dispatch communications outside of agency jurisdiction.

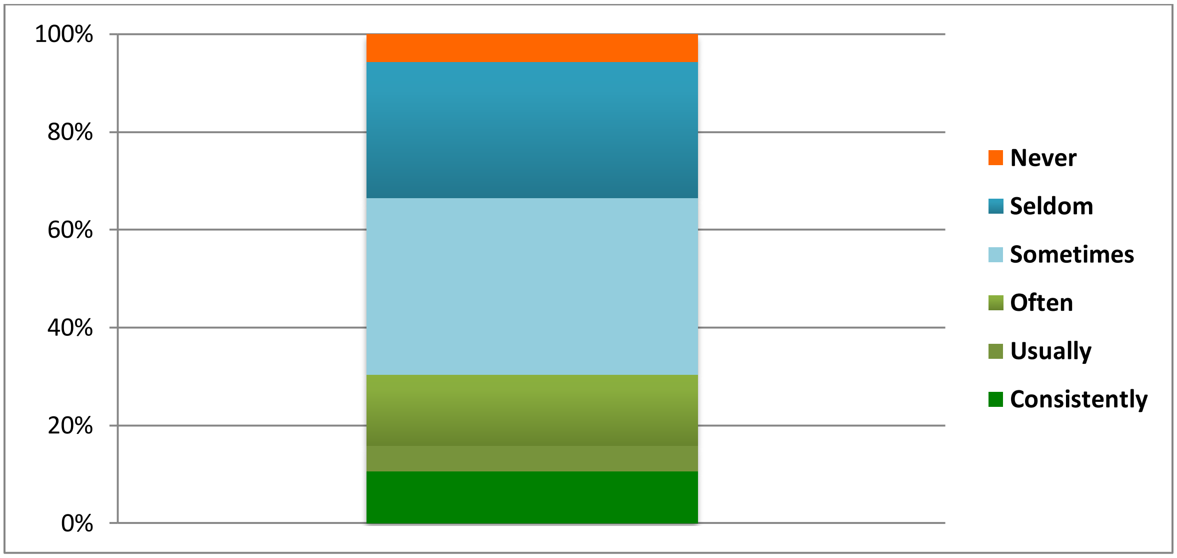

Figure 33 – Need for dispatch communications outside of agency jurisdiction

A very small group of approximately 6% indicated there was never a need to have dispatch communications outside the agency's jurisdiction. The capability to maintain dispatch communications outside of the agency jurisdiction is indicated to be a need for the ISICS offering.

7.3.2 Data Services

Public safety agencies throughout the nation are increasingly relying on data services for their day-to-day operations. Low bandwidth applications such as Automatic Vehicle Location (AVL), paging and text messages are now commonplace.

The user survey responses indicated about 25% of the public safety agencies in Iowa currently use some form of data service in their daily operations, with an additional 12% interested in possibly using data services in the future. Figure 34 – Future data service demand, shows survey respondents have an expectation that demand for data services will increase steadily or exponentially.

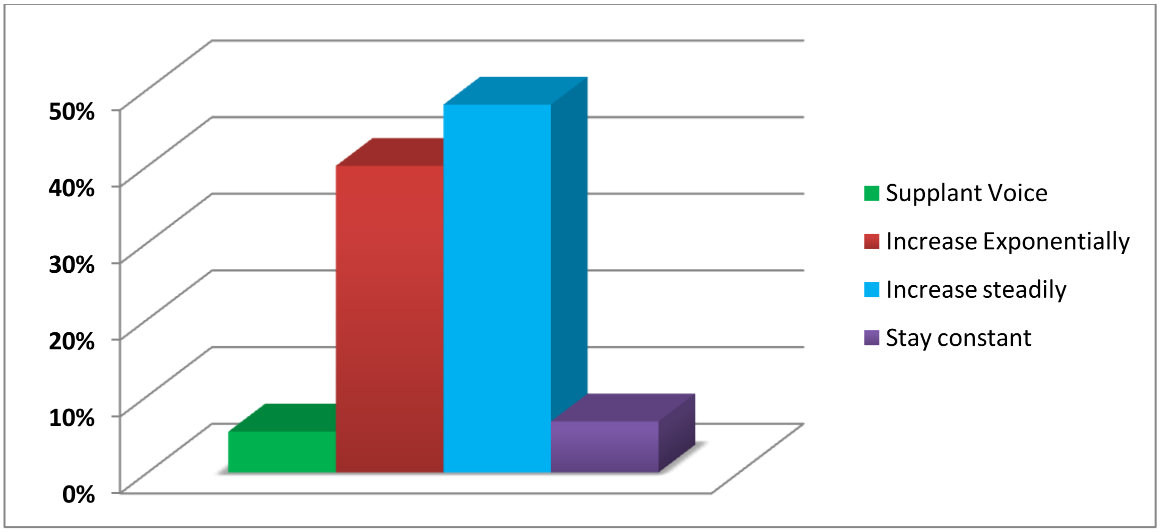

Figure 34 – Future data service demand

Respondents overwhelmingly agreed that data will be an important component for public safety agencies, though some respondents were unclear as to how data applications and services might evolve. When asked to compare the critical service nature of voice communication vs. data communication, over 60% of respondents validated that voice communications is currently more critical to public safety operations in Iowa than data communications. A true minority (only about 1%) indicated a current view that data communications is more critical than voice communications. The remaining 36% of respondents indicated voice and data communications were currently considered equally critical to their public safety operations.

Survey participants were asked to identify the primary use of data services by their agencies in today's environment. User survey responses indicated low bandwidth data service needs such as paging, text messaging, form-driven data, and telemetry are common. However, higher bandwidth demand applications (e.g., images, video) were also identified as currently being used. With the indication that current data usage in Iowa is primarily low bandwidth services like paging, telemetry and text messaging, current narrowband data networks owned by the public safety agencies work well. Most respondents indicated that they were generally satisfied with the current data network for these particular types of data services.

When asked to consider specific data application needs, it can be observed from Figure 35 – Data services current and future, demands for these data services will continue to increase. The largest increase in application demand is that of full motion video.

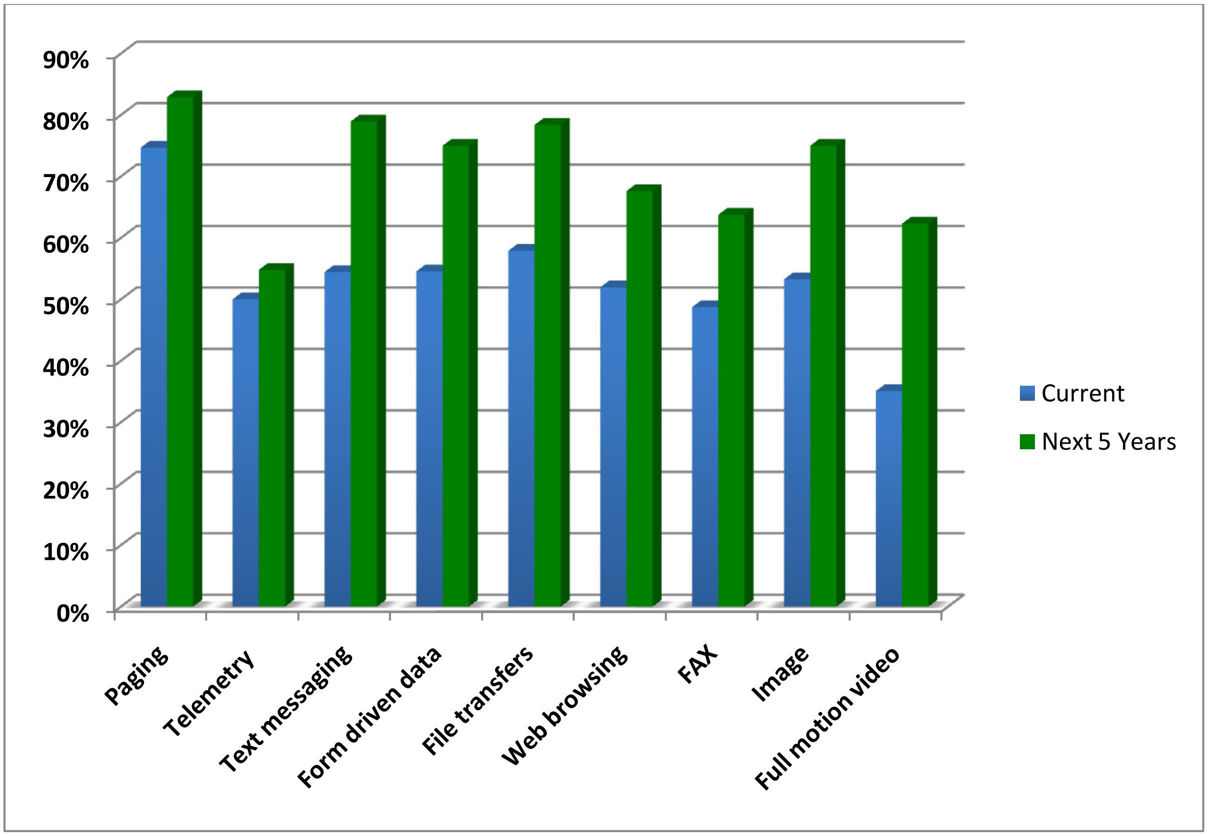

Figure 35 – Data services current and future

High demand services like full motion video, large file transfers, and high quality photo services were identified as being very or extremely important in the future. These applications and services will push or exceed the limits of the current public safety agency owned data networks and will require replacement with high bandwidth networks.

Approximately, 25% of agencies in Iowa today make use of some data service, either integrated into the voice system, or a separate system. While these seem to work for some applications, several agencies have found that supplemental data services are required due to many factors - from insufficient coverage to insufficient data throughput. These are illustrated in Figure 36 – Reported data system issues.

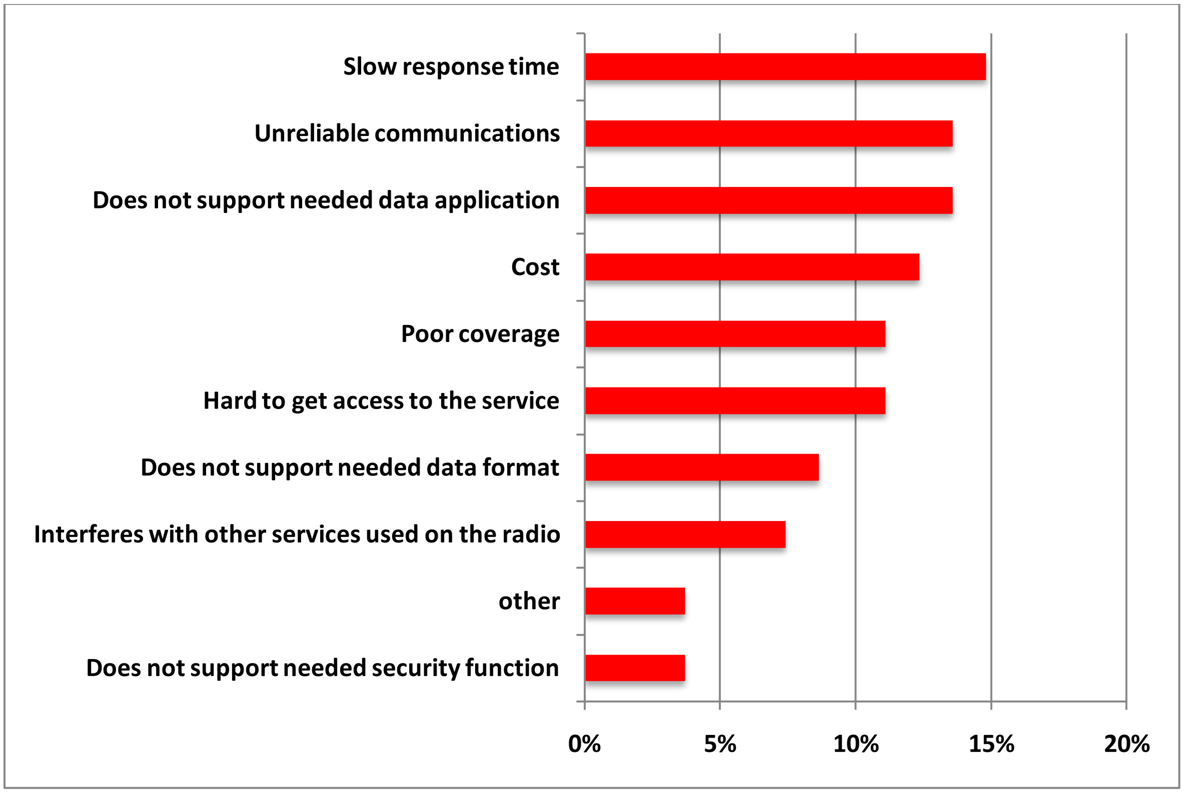

Figure 36 – Reported data system issues

Over 40% of these public safety agencies use data services from public wireless service providers like US Cellular, Sprint, and Verizon to make up for these insufficiencies. While there are some technical difficulties, the general satisfaction with these service providers during day-to-day operations is high.

Most public safety data applications today are typically supported by data networks that use traditional public safety voice spectrum. Because of this, only very low throughputs and transfer rates can be achieved, which works well for the lower tier, Tier 1 and Tier 2 applications listed in Figure 37 – Application bandwidth demand. As high speed wireless networks, such as 3G, and Wi-Fi are becoming more common and covering larger service areas, support for higher tier applications is increasing. Applications such as streaming video to a vehicle and accessing databases for building blueprints are but two of the newer applications that are becoming popular with public safety agencies.

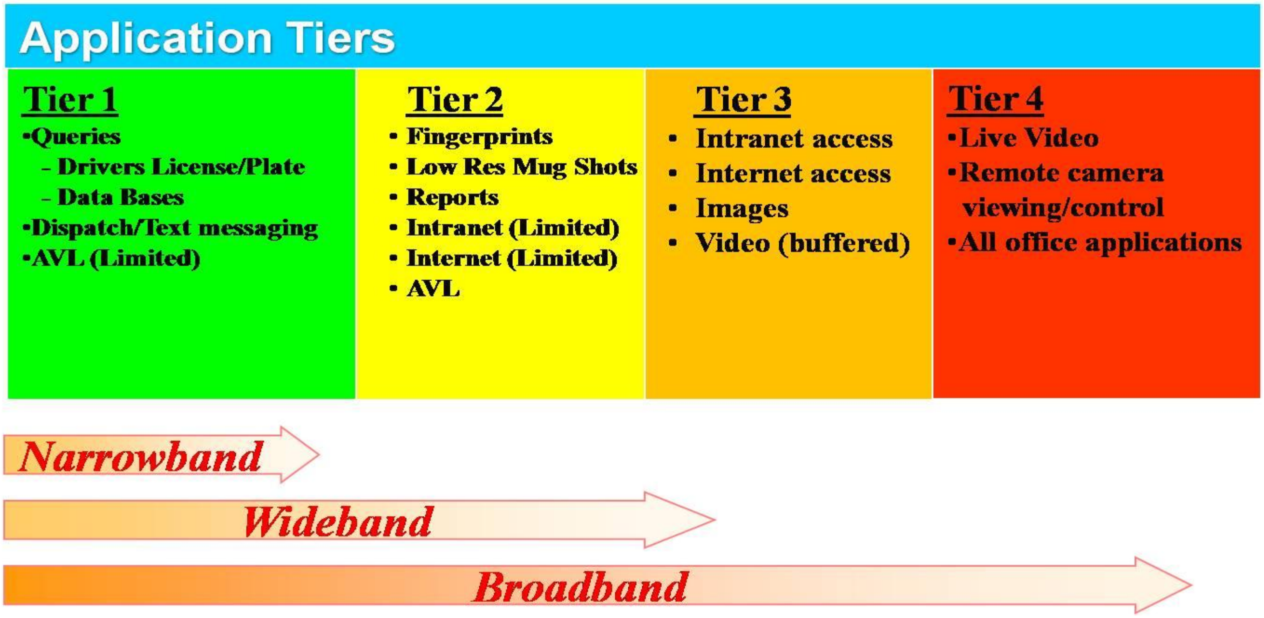

Figure 37 – Application bandwidth demand

Spectrum and regulatory issues remain a major roadblock for public safety broadband deployments. Since the commercial sector has not been limited to the same extent as public safety, these networks are attractive to public safety agencies. Additionally, service providers are responsible for building and maintaining the network with no capital costs to the public safety agencies. The problem with these networks is that the commercial service providers are not necessarily aligned with the needs of public safety, and as such, the commercial networks can become quickly overloaded with traffic since it is not prioritized for public safety use when a major incident occurs.

One reason that data traffic on commercial service providers' networks cannot be prioritized is that the service providers do not have an all IP core network. An all IP network can support Quality of Service (QoS) features that can prioritize traffic on the network and guarantee the network will not become overloaded for certain types of network traffic, like voice or video, or for certain users on the network. Individual services, like 3G, operate at the IP level, but many other pieces in the network do not. As such, true QoS cannot be provided. Next generation technologies such as LTE and WiMAX move the entire network to an all IP-based architecture. For their next generation implementation, 4G, service providers plan to migrate to these technologies because the all IP core approach enables QoS enhancements and better security schemes.

Commercial wireless service providers such as AT&T, Verizon, and Sprint are choosing LTE and WiMAX as their 4G networks. This is an advantage to users since each technology is interoperable between different service provider networks. For example, service providers that use LTE will allow their users to roam to another service provider network that is also using LTE. However, the interests of commercial service providers may not align with the interests of public safety agencies. As such, the likelihood that a commercial service provider can meet the long-term goals of public safety data use is minimized. In addition, implementation timelines may differ significantly from agency needs.

Given these facts, public safety organizations have begun constructing their own broadband wireless data networks with a variety of technologies and spectrum. The spectrum that is being used for these networks varies and is both public safety specific and non-public safety specific. Listed below are a few examples of public safety agencies building their own wireless broadband data networks.

- **Riverside, California**

  Riverside has a partnership with AT&T for their public safety broadband network using Wi-Fi technology. The city owns the equipment but AT&T operates and maintains the network. The network operates on two different frequencies, 2.4 GHz and 4.9 GHz. The 2.4 GHz frequency is unlicensed and for public access. The 4.9 GHz frequency is licensed public safety spectrum and is only for the city's use. Many wireless radios, commonly referred to as wireless nodes, are installed throughout the City on light poles and buildings and are what the general public and the city's agencies connect to for access to the network. The number of access points required for coverage in the city is very high, anywhere from 35 to 50 per square mile.

- **New York City, New York**

  The City of New York has a 3G network operating in licensed 2.5 GHz spectrum. This spectrum is not owned by the city, or even specific to public safety use, but is leased to the city. This spectrum is part of the Educational Broadband Service/ Broadband Radio Service (EBS/BRS) in the U.S. and is owned by educational entities. These entities were granted the spectrum for educational purposes, but now often lease it to other entities on a per license basis. Northrop Grumman designed, installed and maintains the network for New York City. The network is comprises many base stations installed on towers and buildings throughout the city and provides access to a variety of city agencies, with public safety having primary access. While this is a 3G implementation, it can be upgraded to 4G technology as it matures.

- **Washington, DC**

  Washington, DC, contracted with Alcatel-Lucent for a 3G public safety network called Capital Wireless Information Net (CapWIN). It operates in licensed 700 MHz D Block public safety spectrum. CapWIN is the first entity to be granted a waiver from the FCC to use 700 MHz D Block spectrum, but was only granted use of a small portion of the D block. CapWIN had an existing IP network using many software applications that were written specifically for the CapWIN network using open standards. In addition to the wireless 700 MHz 3G network, CapWIN can also be accessed by wired access and Cellular Digital Packet Data (CDPD). The CapWIN project is a regional effort involving the states of Virginia and Maryland, as well as Washington DC. The University of Maryland's Center for Advanced Transportation Technology operates the network.

The FCC's 700 MHz D Block broadband spectrum is allocated for public safety use for data networks. The FCC auctioned the license for D Block spectrum in 2008, but the block did not sell. The FCC is in the process of rewriting the rules for the license in hopes of a successful re-auction. In the mean time, many cities, counties and states want access to the spectrum today to build a broadband wireless data network. The City of Boston, the City of San Francisco, the State of New Jersey and several counties within Virginia have submitted requests for a waiver from the FCC that will allow them to use the D Block spectrum now for their wireless networks. In filing such a waiver, these entities are agreeing to support future standards for D Block when they are developed.

All of the networks listed above have been able to achieve near ubiquitous coverage over their respective city or region by installing a large number of access points and base stations.

7.3.3 Video Services

Video service is an example of a data service that can require high bandwidth of a data network. User survey responses indicated video service is being used to record incidents in the field in a local (in-car camera) video recording mode, and perform surveillance applications in a networked, online mode as depicted in Figure 38 – Current use of video.

Public safety agencies surveyed indicated they are currently using video on a regular basis in their field vehicles, with nearly half of the survey respondents indicating this as a prime use of video. Currently in-car video is typically captured and stored in the vehicle equipment, and later uploaded once the vehicle returns to the station. Video surveillance was indicated by over 40% of respondents as a major use of the video service. Video feeds can often provide public safety responders with invaluable situational information ahead of their arrival on site. With this information, they can get a better understanding of what is happening and formulate the most appropriate response.

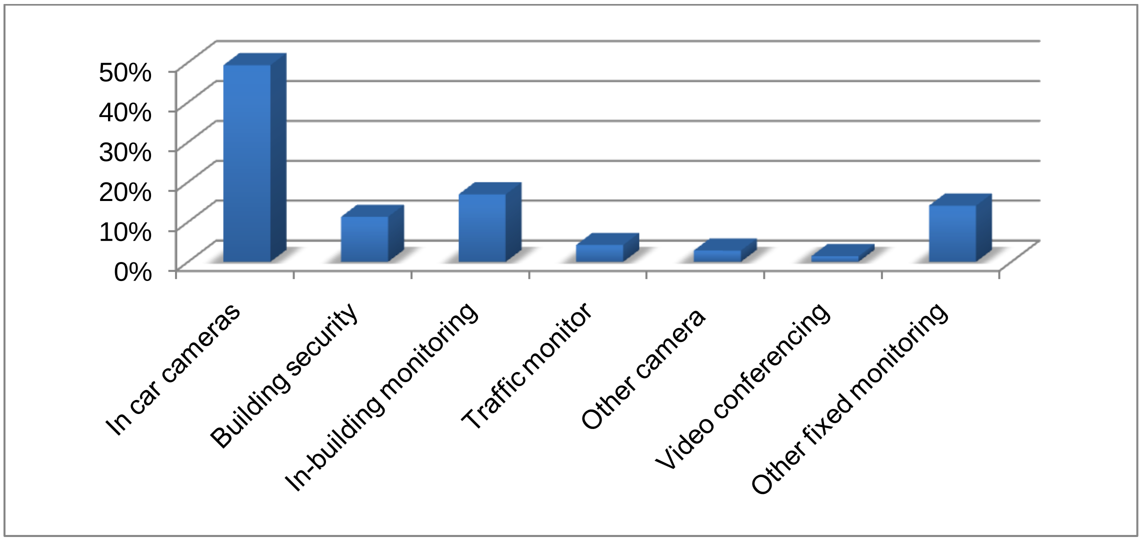

Figure 38 – Current use of video

The majority of respondents indicated while there was generally no major need currently for real time video support, it was expected that this would dramatically change over the next five years with nearly 60% indicating an expected need for real time video support as indicated in Figure 39 – Needs for real time video. In order to present the video in real time while still in the field, a high speed wireless broadband data network with fairly uniform coverage and guaranteed throughput is required.

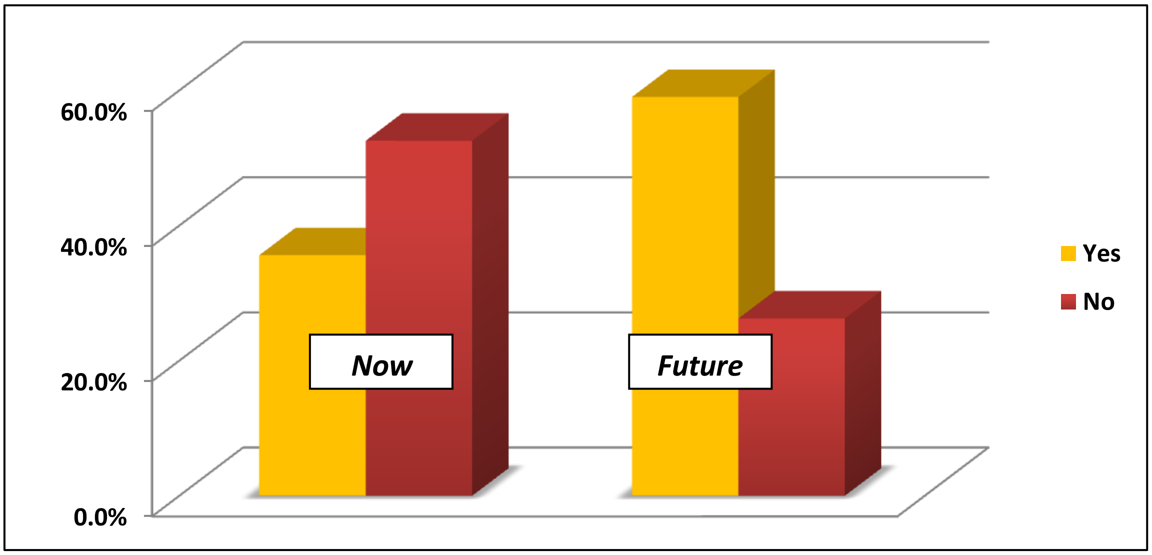

Figure 39 – Needs for real time video

There are public safety agencies elsewhere in the country that currently employ wireless streaming video, having implemented their own regional private wireless broadband data networks, like the one in New York City.

7.4 PSAP / E911

In order to process the E911 survey respondent information, PSAPs were grouped into the six HLS&EM regions and categorized by size – Small, Medium, and Large. The PSAP size categorization is defined as follows:

- Small PSAPs – Fewer than 4 positions
- Medium PSAPs – 4 through 7 positions
- Large PSAPs – Greater than 7 positions

The distribution of these PSAPs per HLS&EM region indicates that the vast majority of PSAP configurations deployed throughout the State of Iowa are relatively small. This is illustrated in Figure 40 – PSAP size per HLS&EM region. In fact the raw data indicates that the majority of small sized PSAP configurations deployed in Iowa consists of two positions.

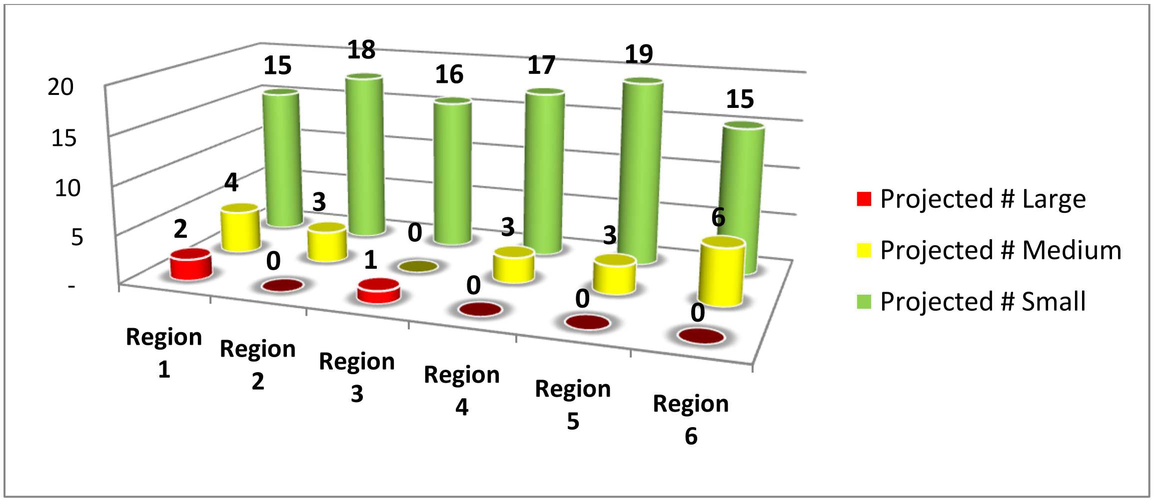

Figure 40 – PSAP size per HLS&EM region

While PSAPs are understood to be the answering point for 911 emergency calls, radio dispatch is an integral part of the PSAP design. Given that each PSAP is managed at the local level, radio dispatch equipment is also varied throughout the state. While many of the PSAPs use a computer-based dispatch solution, integration of 911 call taking equipment with radio dispatch equipment is minimal or nonexistent. Smaller PSAPs use a control station (radio on a desk) for radio dispatch purposes.

Call volume is an important factor that needs focused consideration when working in an interoperable environment. While there are significant variables that can affect call volumes per PSAP, a combined wireline and wireless average peak hour call volume was established for each PSAP size category and listed in Table 2 – Average peak hour call volume.

Table 2 – Average peak hour call volume

PSAP size	Call volume
Small	22 calls / peak hour / position
Medium	28 calls / peak hour / position
Large	48 calls / peak hour / position

On a statewide basis, the estimated peak hour call volume, assuming all PSAPs processed the peak hour load simultaneously, is 8,120 calls. This represents worst case conditions and includes call volumes of the June 2008 floods. The call volume distribution is illustrated in Figure 41.

HLS&EM Region-1 has the largest projected peak hour call volume in the State of Iowa. This is consistent with year 2000 census population data, which indicates that Polk County has the largest population center in the state. Nevertheless, there seems to be a fairly even peak hour call volume distribution across the remaining HLS&EM regions.

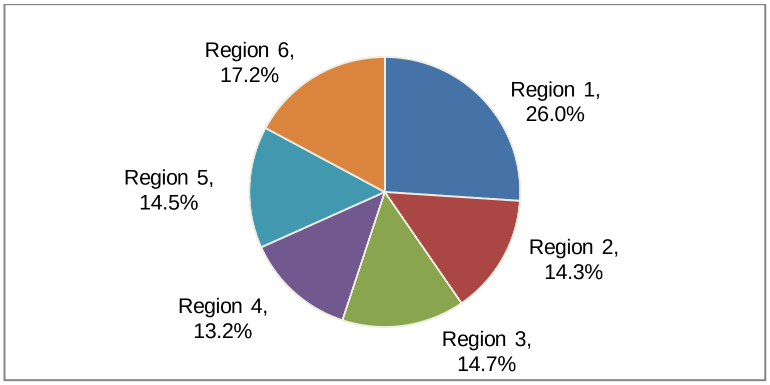

Figure 41 – Projected HLS&EM region peak hour call volume distribution

Increased coordination of services among jurisdictions is becoming more and more critical and necessary for agencies to do their job. Previously, these agencies may not have needed to interact much between their jurisdictions because they served only the citizens in homes and businesses in their local community. Now with the increased mobility of the public, the need for interoperability and interconnectivity is reaching significant proportions. As illustrated in Figure 42 – Wireline vs. wireless peak hour load, it is estimated that two thirds of peak hour calls originate from wireless calls.

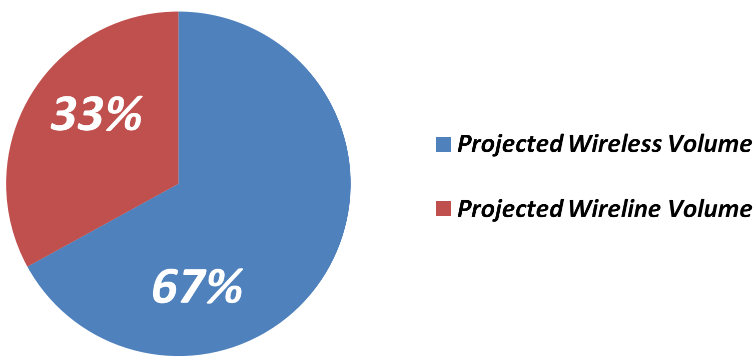

Figure 42 – Wireline vs. wireless peak hour load

Approximately 75% of survey respondents reported daily or weekly transfers of wireless calls while 50% reported daily or weekly transfers of wireline calls. This is consistent with overall trends given the mobile nature of wireless calls and the initial location data provided by the wireless system. Understanding the call transfer relationship between PSAPs is an important factor in defining bandwidth needs in a NG911 environment.

The Center for Disease Control (CDC) recent survey of communications trends in the US[1], reports that 14.5% of adults and 14.4% of children live in households with wireless telephones exclusively, this is shown in Figure 43 – Wireless only households**Error! eference source not found.**. The Cellular Telephone Industry of America (CTIA) describes that increased wireless service and more mobility of the calling public, has trended upward for the past 10 years with little sign of significant downturns on the horizon. This is illustrated in Figure 44 – Wireless subscriber growth.

[1] CDC **Wireless Substitution: Early Release of Estimates From the National Health Interview Survey, July-December 2007 by Stephen J. Blumberg, Ph.D., and Julian V. Luke, Division of Health Interview Statistics, National Center for Health Statistics**

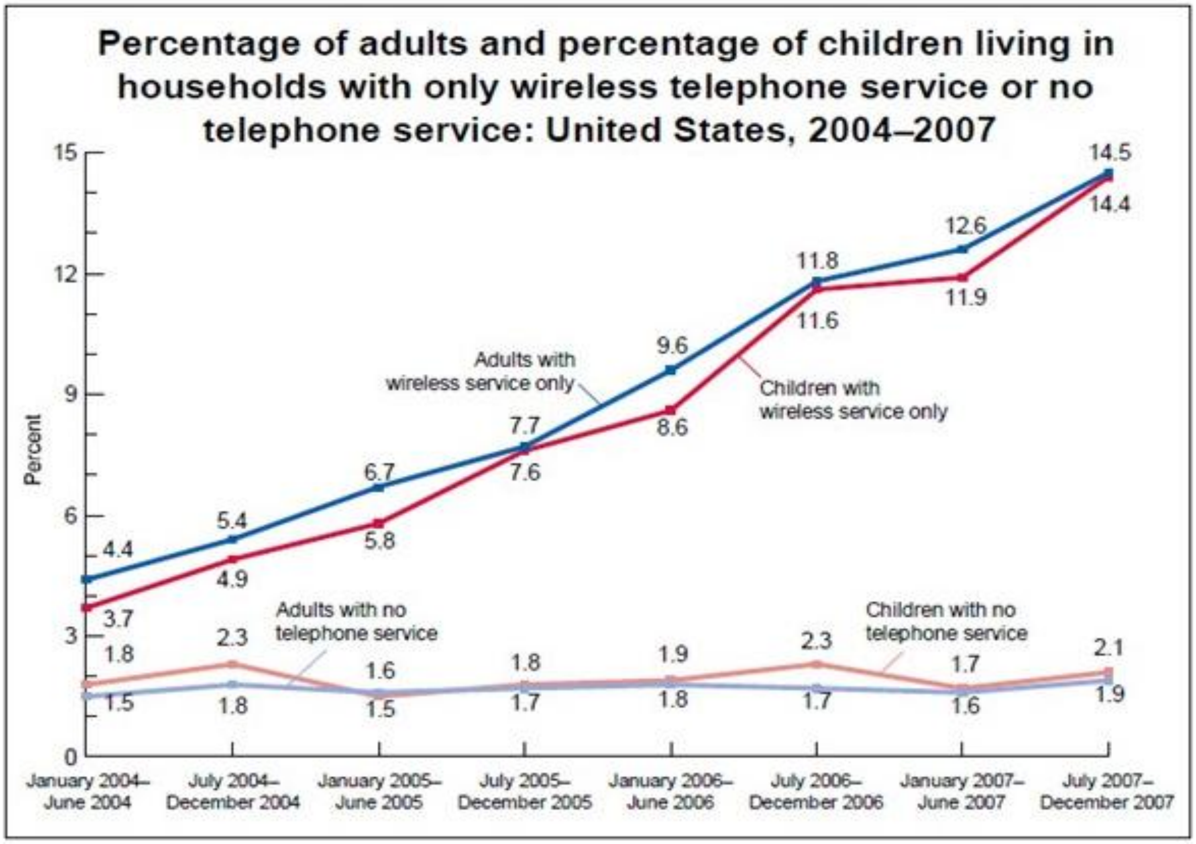

Figure 43 – Wireless only households (CDC Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July-December 2007)

The national wireless phone usage growth from December 2006 to December 2007 for adults was 22% while cell sites keep expanding at 13.5% year over year. Only nine states are reported as having over 20% wireless only households with Iowa reporting 22%.

Industry analysts also consistently report on the increasing popularity of VoIP service and ultimately emergency 911 calls. TeleGeography's GlobalComms Insight research service has released new research on the global broadband market that predicts there will be 700 million broadband subscribers worldwide by the end of 2013. The research also suggests that while landline decline will continue, growth in broadband and wireless will continue to offset the decline to some degree, and that the recession will not have a long-term impact on growth[2].

[2] ***TeleGeography's GlobalComms Insight***, May 27, 2009

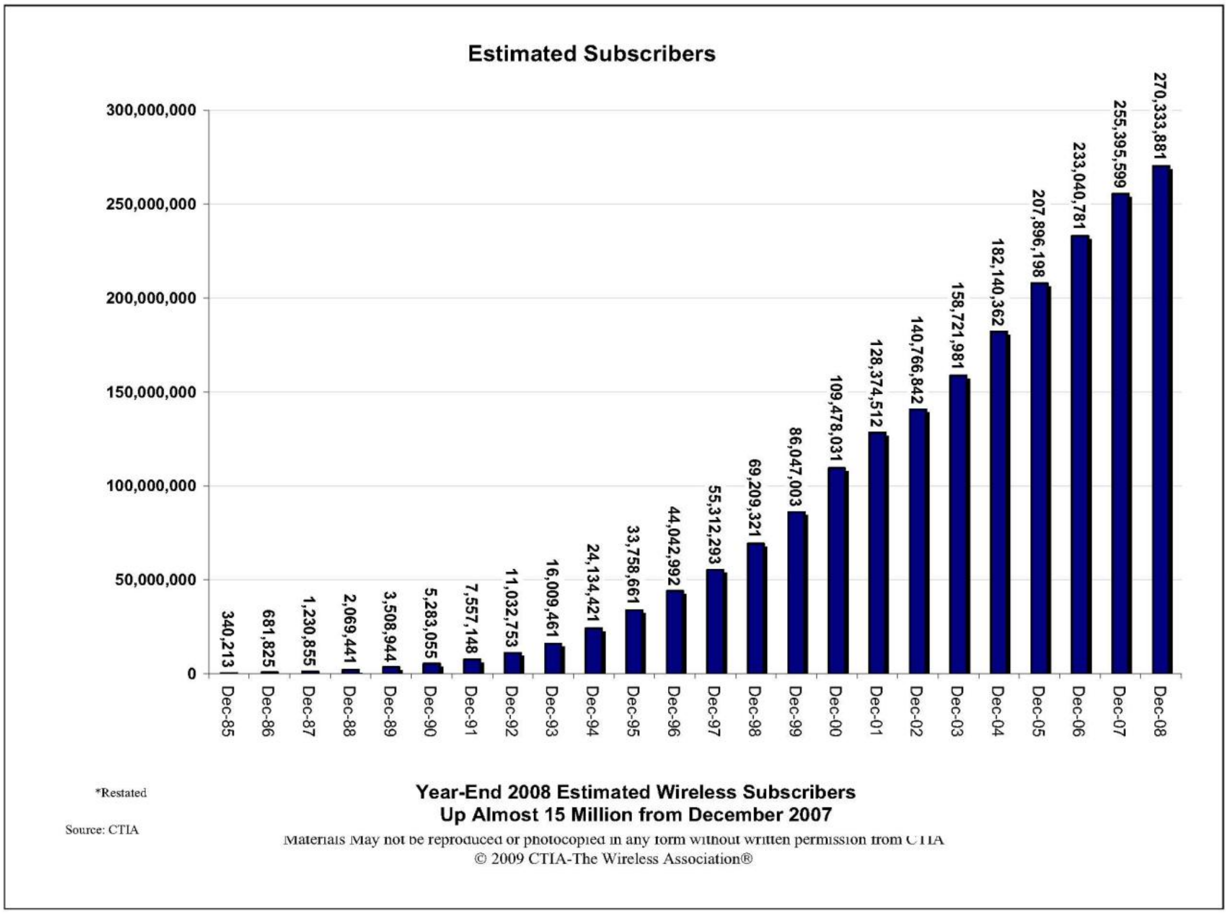

Figure 44 – Wireless subscriber growth (by written permission 2009 CTIA – The Wireless Association)

Nationwide trends indicate that wireless calls will continue to rise. Call transfers between PSAPs will rise accordingly. With the increase of portable communications devices like smart phones, PDAs, and pocket computers; supplemental data availability such as video, photos, and text will also increase.

7.5 Design Drivers

The combination of general trends and user needs and concerns, expressed through the data gathering activities of the survey and interview process, are the key substance to be incorporated in the overall system design. These are tempered by the baseline system assumption set to provide a framework for the communication system. These are represented in a set of requirements or design drivers used to sculpt the overall system architecture and design.

7.5.1 Network Architecture Constructs

The following items address the general high level architectural attributes that need to be included in the ISICS network approach.

Peer-to-peer architecture

The overall network is to employ a peer-to-peer architecture to allow for increased flexibility and system reliability. The control and data functions are distributed in nature, allowing placement of the functional elements across the network, with the ability to segment the network and its functions on a geographic or operational basis as needed.

No single point of system failure

Failures of system elements shall be addressed as graceful degradation of system performance if not handled automatically with redundant network elements. For example the loss of a radio channel resource at a site reduces the number of simultaneous conversations supported at that site, but still allows the site to handle requests for service in a normal manner.

Flexible network architecture

This design addresses flexible network architecture, employing IP network technologies to enhance the reliability, flexibility, and adaptability of the communication network. This supports a modular approach to the network elements to allow ease of expansion of system elements as well as providing a framework for resilient fault tolerant operation. The network supports the integration of heterogeneous system topologies as needed to support the needs of terrain and users. This includes support for single site, receiver site, multicast multi-site, and simulcast multi-site topologies.

7.5.2 Transport Network Backbone Drivers

These items address the framework for the common transport that central to the statewide ISICS network.

Ubiquitous IP transport backbone

The transport network backbone provides the cohesive interconnect between the various network elements, as well as being the transport medium for the voice, data, and video service payloads across the communication network. This transport network is IP centric, supporting the common IP networking functions (routing, border control functions, etc.). The use of IP technologies makes the network design more resilient to upgrades in the future due to its open standards approach, and allows the ability to capitalize upon the vast general industry utilization of the similar IP technologies.

Dedicated digital microwave network

The transport network is primarily composed of a dedicated digital microwave network, redundant and fault tolerant in nature. This approach provides advantages of cost and reliability over alternative leased line approaches. The microwave network connects the primary network nodes, providing redundant paths to handle individual network failure occurrences between any of these network nodes. The primary network nodes would include network system control and data centers, state agency radio sites, and state agency dispatch centers. Other network nodes, such as local agency radio sites, or local agency dispatch centers may be also connected via the microwave network with the inclusion of additional microwave hops to accommodate these nodes, or via intermediate links to microwave hops on the existing transport backbone. The existing state microwave network nodes may be potential nodes for the ISICS microwave transport network.

The microwave network design will incorporate appropriate topologies (ring, star, spur, etc.) to address the reliability and network interconnect needs. The bandwidth needs of each of the microwave links shall be predicated upon the expected network traffic for that particular network node.

Optical fiber-based transport backbone supplement

As a secondary transport network, the Iowa Communications Network (ICN) shall be employed to provide connectivity to local entities that cannot directly connect with the microwave network. The ICN shall also be used as a primary transport for the high bandwidth data payloads (including video) to off-load much of this demand from the microwave network. Points of presence for the ICN shall be extended where necessary to facilitate use of the optical fiber network.

The ICN shall also be linked to the microwave transport network to provide alternative and backup paths to the microwave network in the event of massive microwave network failures.

7.5.3 Interoperable Communications Drivers

These are the key elements that are contributing to the interoperability capability of the ISICS network and identifying pertinent functionality that needs to be included.

Standards-based solutions

Standards-based solutions are key components to making the ISICS network approach feature rich, flexible and scalable, thereby extending its life cycle. Through the use of standards supported solutions there is a common foundation for interoperable equipment and operations across the network. Being standards driven means that compliant products from multiple vendors should be directly interoperable. Standards-based solutions encourage cost competitive equipment sourcing from multiple vendors and also benefit from general economies of scale employing technologies used across multiple industry venues.

Key to the overall voice communication interoperability across the ISICS network is the adoption of the APCO P25 trunked standards suite (ANSI/TIA 102 series). This defines a common air interface protocol that bounds the manner in which a radio unit supports radio communications in the network, as well as a set of standard defined communication services and functionality in the trunked procedure definitions.

The data network is likewise a standards driven solution, in the broadband data system environment. With the definition of a common unified platform for the data service support, the ease of sharing information and the ability to interoperate with other ISICS users is addressed.

Common statewide spectrum

Another facet of the common platform and an element in convergence for the statewide interoperable communication support involves using a common frequency band across the State. For the ISICS network this means using a common set of frequencies from the 700 MHz public safety band (763-758 MHz and 793-895 MHz) with compatible channel bandwidths. All the voice and data communications throughout the State of Iowa are supported by the set of 700 MHz channels allocated to public safety use. This supports ease of roaming across the ISICS network throughout the State using the same subscriber unit. The use of 700 MHz also affords an opportunity for direct radio-to-radio interoperation with 800 MHz units. In addition, there is 10 MHz of spectrum available (2 x 5 MHz blocks) for use by the broadband data services in the 700MHz band. By supporting a common communications platform across the ISICS network, the ability to intercommunicate across agencies on the ISICS network is greatly improved.

Compliance to FCC narrowband mandate

The FCC has mandated the transition to narrowband operations (12.5 kHz), which applies to all jurisdictions that hold a valid FCC public safety radio license for radio channels below 512 MHz (VHF and UHF). Although this mandate has been widely published and is apparently well known, there are many jurisdictions within Iowa that are unaware of the impact that this ruling will have on their day-to-day operations.

In November 1992, the FCC released Docket 92-235 which started a process whereby the FCC could make more efficient use of the VHF and UHF radio spectrum currently used by public safety agencies throughout the nation. The rule making was initiated in response to numerous public safety requests for additional radio channels in the bands below 512 MHz. Further, the FCC released Docket 99-87 in December 2004, and Report and Order 05-69 in March 2005, setting forth specific deadlines to transition radio system to narrowband operation. The first deadline took effect January 1, 2005, and the final deadline is January 1, 2013.

Many first responders feel that the FCC will not carry through with their mandate because it will have too great an impact on all public safety users at a time when budgets are being cut or closely reviewed. It would be prudent to remember that public safety groups lobbied the U.S, Congress and pushed the FCC very hard to acquire new spectrum due to the lack of radio channels necessary to support their needs. Some agencies considered requesting that the FCC waive these rules for a period of time in order to allow them to plan for and obtain funding for the transition

Since issuing its public safety narrowband ruling, the FCC has consistently indicated that there will be no extension period granted for the transition to narrowband operations. In fact, the FCC has ruled that the existing wideband licenses held by public safety jurisdictions will be terminated and become invalid on Jan. 1, 2013.

Public safety jurisdictions that have not already made the narrowband transition are faced with decisions that will require serious consideration and play a significant role in their long term planning and funding. Some of the agencies within the state have already updated to narrowband radio equipment. This equipment is capable of both wideband and narrowband operation but many (if not most) continue to operate in a wideband mode in order to maintain interoperability with those neighbors who have not yet acquired narrowband radios.

For those who have not updated their equipment to narrowband, time is of the essence. One of the most affected categories of users in the state is the rural fire departments. These first responders frequently receive very little funding from the county or state and have few options. Nevertheless, the FCC mandate applies equally to all.

Unified system addressing

The ISICS network will support unique P25 addresses for every user on the ISICS network to identify the user initiating or involved in communications on the network. The user identity is portable with the user across all elements of the ISICS network, and is compatible with other P25 networks as well. Similarly every talkgroup on the ISICS network will have a unique P25 group identity that allows separating its communication needs from other groups active on the network. The talkgroup identity is also portable across the ISICS network, and other compatible P25 networks.

All the P25 addressing will be under a single network identity for the ISICS network. A Wide Area Communication Network (WACN) identity in the P25 addressing space will be assigned to the ISICS network. Provisioning and management of the ISICS P25 identities will be the domain of the ISICS network manager.

Common applications and data formats

Even though an IP network is inherently interoperable, this is not always the case with applications used on the network. Many applications require a specific method or special software for a client to access it. For example, some databases and video servers can only be accessed with a specific software or protocol. When jurisdictions use different applications or services, they are not always able to access data from other jurisdictions. If applications are not standardized, the client devices may not be able to communicate, even though they are all on the same IP network. The best approach to this is using applications and services that are based on open standards and allowing access by common software clients, such as a web browser.

Legacy user interoperable support

The ISICS user shall be able to interoperate with legacy system users. One approach is the use of infrastructure gateway functions to connect ISICS and legacy voice paths. In this manner, an ISICS talkgroup is essentially assigned to represent a legacy user/group. This ISICS talkgroup is connected through the gateway device (e.g., console patch function) to an appropriate talkgroup for the legacy user/group. (In a legacy conventional system this would equate to a specific channel, while in a legacy trunked system this would equate to a legacy talkgroup identity.)

Multiband radio devices (700/UHF or 700/VHF) offer another mode of interoperability with legacy systems. The ISICS multiband user radio could be programmed to support communications with the legacy system. When the ISICS user selects the legacy system mode, the radio would essentially join the legacy system and become fully operational on the legacy system resources. During this time, the ISICS user would no longer be part of the ISICS network and may miss important ISICS-based communications.

<u>Seamless roaming across the network</u>

A key element to statewide interoperability is not only the ability to transfer communications between various geographic areas or across various agencies, but to provide easy movement of users across the ISICS network while retaining seamless home agency communications.

There is an ever-growing need for users to participate in communications beyond their classic jurisdictional boundaries for day-to-day events and as part of tactical activities that could temporarily reallocate user resources across areas of the State. The ISICS network is designed to support freedom of movement of authorized ISICS units around the State of Iowa by supporting a common communication platform statewide. This includes using a common frequency band, a common air interface protocol, and common service processing operations across the ISICS network statewide. Users may freely roam to other areas of the ISICS network and be capable of participating in communications.

For efficient channel resource utilization when dealing with calls that span multiple sites, there is a need to track the current location, at a site level, for each group identity on the network. Additionally, the current location for each individual user needs to be tracked, at the site level, to determine how calls should be appropriately routed to that individual as they move from site to site. An active call involving that individual will continue to include that individual as they move to a different site, basically a “follow me” roaming call operation.

7.5.4 Statewide Coverage

The radio coverage design goal for the ISICS network is to provide each county a level of 95% geographic mobile public safety grade coverage at a minimum. That is, a mobile user would be able to attain a delivered audio quality (DAQ) of 3.4 voice quality communications across at least 95% of each county in Iowa. DAQ of 3.4 is defined as “speech understandable with repetition only rarely required with some noise/distortion;” this is a typical requirement for mission critical public safety agencies[3].

[3] TIA TSB 88-A defines levels of audio understandability over a radio system as DAQ levels. This is a scale from DAQ 1 to DAQ 5 with DAQ 1 indicating Unusable audio, speech present but not understandable, and DAQ 5 indicating Perfect audio, no distortion or noise discernible. DAQ 3.4 has been defined as typical mission critical public safety radio system audio quality.

As a point of comparison, the current VHF statewide LEA communication achieves the mobile-based 95% coverage goal in only 19 of the 99 Iowa counties. The existing State DPS and DOT VHF tower sites should be considered as potential radio sites for the ISICS network implementation. Additional sites will be identified as necessary to accomplish the overall coverage goal.

While the initial coverage goal is for mobile-based coverage, the ISICS network design must be flexible and adaptable to enable supporting necessary coverage enhancements as they become important to the ISICS user base.

7.5.5 Local User/System Autonomy

During the discussion with the local agency users, there was a recurring theme regarding the issue of local system autonomy. There was a general feeling that joining the ISICS network would remove the ability to manage the local agency resources as a local entity. There were concerns that funding normally allocated to the maintenance and improvement of the local agency communication would be diverted to state agency needs and would not be available for local area needs. Additionally, there were concerns that joining the ISICS network would require local agencies to consolidate their operations, with their chief concern in the area of consolidation of dispatch center facilities and operations. The local agency representatives were wary of surrendering their current mode of operation when joining the ISICS network. To support the local and state agency operations as separate entities it is important for the ISICS network to afford various levels of management of system resources. In this way there can still be a level of management equivalent to the current local agency management, even though the agency is using shared ISICS resources. The different levels of system management must be able to negotiate operations on a local and state level for the good of all concerned.

Support prioritization of users and groups

While the ISICS network supports seamless roaming of authorized ISICS users across the network, the network must allow local agencies to retain the same priority level in their home jurisdiction as experienced when the local agency functioned on an independent legacy system. This means that in general, local agency users should be granted access priority over non-local agency users who have roamed into the local agency jurisdiction. This prioritization assignment can be altered to address high priority network users or events, such as in the event of an emergency, where higher access priority would be normally granted to users involved in the emergency communications.

The normal operation for the local agency operating on the ISICS network should be minimally impacted by the roaming user population as they access the local resources.

Network management at network, region, and local levels

The ISICS network management should be tiered to allow separate local, regional, and network-wide management focal areas. In this manner, local agency management entities can concentrate on the management of the local agency resources (e.g., IDs, groups, channels) without the need to be overly concerned with the resources outside of their jurisdiction. The local management entity would only be concerned with resources outside the home jurisdiction when local users are allowed to roam or are restrained from roaming across the ISICS network. The local manager would monitor the local operations for the local agency resources (performance, status, fault reports, etc.) and be able to direct actions accordingly.

Similarly the regional management entities would be concerned with multiple local agency jurisdictions of the network (e.g., city or county level) and would be responsible to negotiate shared resources across the agencies on a regional basis.

Finally, the network wide management entity would oversee the general management and health of the ISICS network. Here the negotiation is across the entire network.

7.5.6 Dispatch Center

Dispatch center directly connected to the ISICS network

Dispatch operators in the ISICS network are recognized as unique radio users on the system, attached to a special radio site that always has channels available for communication use. These radio users (dispatch operators) generally do not roam in the ISICS network and remain registered to the dispatch center. The dispatch operators comply with the common radio operational support for voice and data communications, but do so utilizing an IP network connection in place of the typical RF connection for other radio users.

Each dispatch operator is assigned at least one unique trunked identity in the ISICS addressing space to uniquely identify the dispatch operator in the network. This user identity is assigned special attributes (e.g., priority, service authorization) to allow the normal console dispatch operations. The dispatch operator position typically has more talkgroup affiliations than other radio users.

Dispatch center connected via ISICS radio

As an alternative to having the dispatch center directly connected via an IP network to the ISICS network, standard ISICS radio paths can be used to facilitate the dispatching functions with control station devices.

The control station dispatch position will have ISICS compatible radio units to allow voice and data operations with other ISICS network users. The control station dispatch position is assigned a unique user identity in the ISICS user addressing space to identify the dispatcher, and ascribe special attributes (e.g., priority, service authorization) to this user. The control station dispatcher position is actually tracked to a real radio site in the ISICS network and operates in a similar manner to other typical ISICS voice and data users.

Since this control station dispatch operation is not directly connected to the IP network as the typical wired dispatch center, the performance and capabilities will be less than those of the IP connected dispatch center. Multiple radio units may be necessary to approximate the operational capability of the typical IP-based dispatch center.

E911 calls enhanced with supplementary data

The dispatch operator positions need to be able to handle supplementary data messaging delivered by E911 callers. With the continued growth of wireless and IP-based telephony, there is a growing opportunity to experience data messaging (e.g., text, images, video) to accompany classic voice communications to the E911 center. (The recent test system in Black Hawk County to address inclusion of text messaging to E911 calls is a limited example of this supplementary data capability.)

Dispatches augmented with supplementary data

The dispatch operator may desire to send more than voice information to a dispatched unit in the field to assist in handling the event. This can be in the form of supplementary data information received from the actual E911 caller reporting the event, or may be ancillary information that the dispatcher believes would be useful to the dispatched field unit (e.g., maps, photographs, building blueprints, hazardous material information). This information can be useful to the dispatched field units and thus there needs to be a way for this information to be presented to the ISICS network.

7.5.7 NG911 Support

The ISICS network is not being designed to function as the Next Generation 911 (NG911) network, even though both are basically IP networks trying to address improved interoperability between network users. The ISICS network is addressing the radio communication side of the dispatch environment, while the NG911 network is addressing the E911 access network side.

Sizing IP interfaces for NG911 network

The NG911 network is an IP-based network that supports the DOT NG911 standards directions. The NG911 standard is still evolving, but general information regarding the interface needs for the NG911 system can be estimated using current legacy E911 call rate information and typical industry IP messaging attributes. This information can gauge the size of the NG911 network.

Support sharing of NG911 data with field units via ISICS

With the NG911 network being IP centric, there is a common vehicle for supporting advanced multimedia data streams. With the growing number of wireless and IP capable mobile devices, the opportunity for supplemental data messaging with the E911 calls is ever increasing. There is a need for the NG911 elements to be able to transfer multimedia data messaging to the ISICS network for sharing with ISICS network users.

7.5.8 Support for Advanced Wireless Data Services

IP-based network

The network must be IP-based from client device to core network servers. An all IP network infrastructure has several advantages; it is inherently interoperable since all devices communicate via IP, regardless of the medium that is used to connect to the IP network. A device can connect to an IP network using for example, Wi-Fi, WiMAX, Ev-DO or LTE and still be able to communicate with any server or service on the IP network. Since IP networks are packet based, network traffic can be routed to any location, or contained to a very limited area. Connections between various services and applications are logical and do not require any physical connection to each other, unlike proprietary solutions offered by some vendors. The packet-based architecture is also what makes Quality of Service (QoS) possible.

The network must support QoS to help manage peak network traffic. By supporting QoS, differentiation of services and users can be implemented to maximize the use and effectiveness of the network. During peak network traffic times, QoS will ensure that priority traffic, like streaming video, continue to function correctly. In a QoS environment, each packet on the network is tagged with an identifier that allows the QoS mechanism to decide how important that packet is and when to send it.

A wireless technology that supports high bandwidth and low latency will be required for services such as large file transfers, and streaming video. High bandwidth is needed to effectively stream medium and high resolution video, to support high frame rates similar to television and movies (24 plus frames per second), and to transfer large files in an acceptable amount of time. Latency, the time it takes a packet to get from the client to its destination on the network, must be low for applications like real time video.

Seamless data service to user

The primary objective of a wireless network for Iowa is for users to be mobile. Most wireless technologies in use today support mobile users, but some do not. Technologies like Ev-DO, UMTS and LTE support mobility inherently. WiMAX did not support mobility initially, but has since been rewritten to support it. Other technologies like Wi-Fi do not support mobility very well, and are better suited for fixed or nomadic uses, where the data service connection is not necessarily maintained when users roam to different access points.

Multiple service tiers

The ideal would be for the ISICS network to provide ubiquitous high bandwidth, low latency data service equivalent to the voice communication coverage in the state. Since this will be a phased offering, there may be areas of adequate coverage by the broadband offering, and many areas with inferior coverage. Multiple tiers of data service may be required based on throughput capability to provide some level of data service for those areas not suitably covered by the broadband network offering. Narrowband integrated data should be offered throughout the voice coverage area as a minimum data service offering. Where the broadband service offering overlaps this narrowband offering, the broadband service can be freely used. Alternatively existing commercial wireless data offerings (e.g., cellular, Wi-Fi) can be used where available to augment the narrowband integrated data offering.

Adaptive service capability

A data service offering composed of multiple tiers must be as transparent and seamless as possible to the data user in the field to be. The data user does not need to be aware of which data service tier is currently being used, and should not need to take manual action to select a data service offering in the area. The data user device should determine, based upon the current signaling conditions and the current data service need of the user, which available data service offering would be the best match.

7.5.9 Video Support

Use of IP-based technologies

The video system should use IP-based technologies to take best advantage of the capabilities of existing and future networks. This applies to the various fixed and mobile video cameras, as well as the video network elements (e.g. video servers).

Use the transport network for interconnecting video elements

The ISICS transport backbone will support the interconnection of the various elements of the video systems. This being an IP-based network, it is compatible with the IP-based technologies for the various video elements.

Aggregate video sources at common network video server

The video streams are to be provided to a common logical point of management in the ISICS network. This video server will function as the aggregate point for the various video streams. This server will be the gateway for video information to be shared with other ISICS network entities (e.g., dispatch positions, field radio units).

These video streams will be supported from multiple video sources. The video sources can be IP devices that are directly connected to the ISICS IP network, or video devices that provide the video streams as data messaging over the ISICS data service offering.

8. ISICS Conceptual Design

The ISICS, illustrated in Figure 45, consists of ISICS Radio Network, ISICS Wireless Data Network, and ISICS Dispatch Network, all interconnected via an IP-based ISICS Transport Network. The ISICS is really a network of networks to provide statewide availability for voice, and data services.

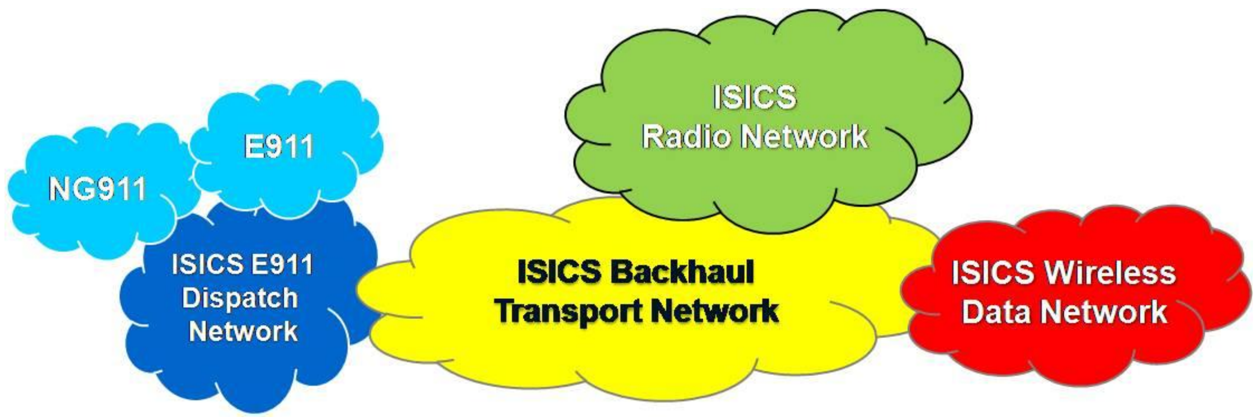

Figure 45 – Network of networks

The ISICS Radio Network primarily supports the statewide voice communication needs as an APCO P25 trunked system in the 700 MHz public safety spectrum. The main elements of this network include RF infrastructure, subscriber devices, call controllers, and switching network.

The ISICS Wireless Data Network supports the wireless data communication needs. This is provided as a tiered approach sharing the 700 MHz public safety spectrum with a low bandwidth narrowband data solution, and a high bandwidth broadband data solution. This combines the TIA standards-based integrated P25 data solution with the 3GPP standards-based 4G Long Term Evolution (LTE) broadband data offerings. The main elements of this network include RF infrastructure, subscriber devices, and data controllers.

The ISICS E911 Dispatch Network supports the interface between the E911 centers and the ISICS network. Information captured from the E911 caller provided through the E911 (PSTN-based) network and the NG911 (IP-based) networks may be shared with the radio dispatch positions that interface to the ISICS network. The radio dispatch positions use the ISICS radio network and ISICS wireless data network to perform the necessary dispatch communications between the field responder units.

The ISICS Transport Network provides the cohesive interconnect between each of these networks (Radio, Wireless Data, and Dispatch) as well as the intra-network connectivity for all the elements of each of those networks.

The ISICS Transport Network is a fault-tolerant, self-healing IP-based architecture composed of dedicated microwave and wireline segments that interconnect each of the elements of the ISICS network. In this fashion, information and control can span the entire statewide network. This allows the potential for physical separation of controlling and controlled elements to afford better system resiliency.

8.1 ISICS Logical Architecture

The ISICS network is composed of four main elements, the Radio Network, the Dispatch Network, the Data Network and the Transport Network. This is illustrated in Figure 46 – ISICS logical architecture.

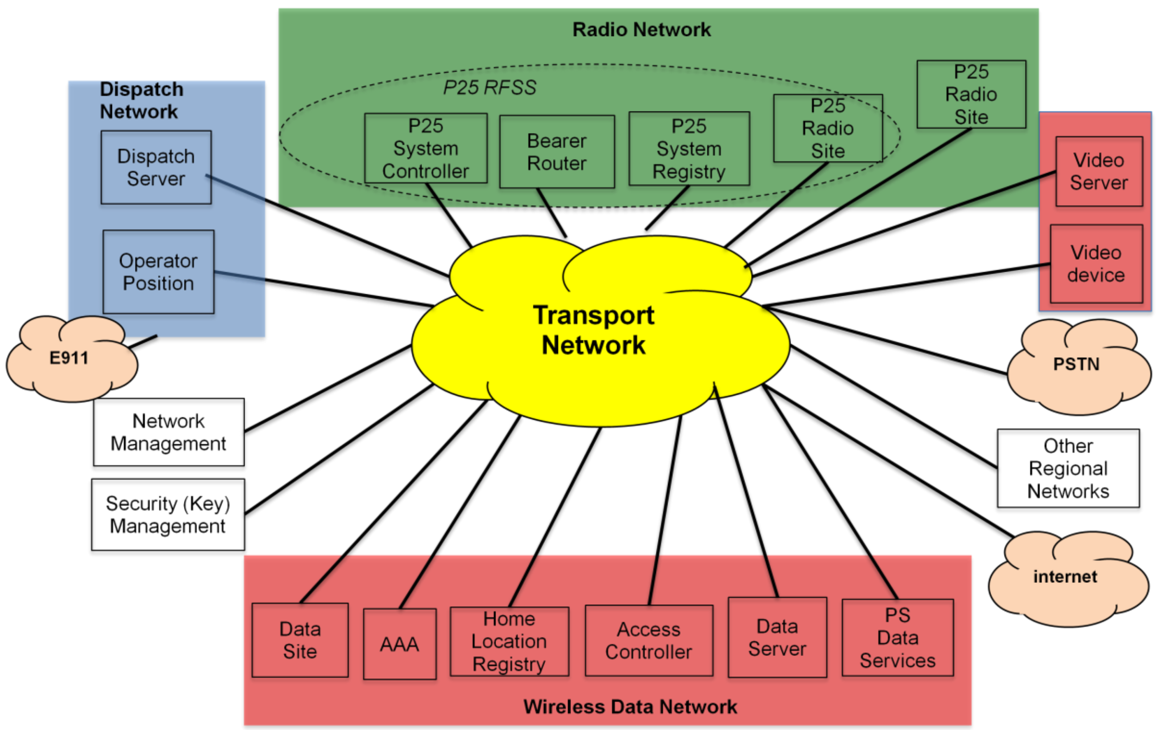

Figure 46 – ISICS logical architecture

8.1.1 Radio Network

The radio network provides the basic voice service support for the ISICS network. This is based on the open standard P25 trunked system.

P25 system controller

The P25 system controller is the overall P25 trunked call supervisor and resource manager for the radio network. The P25 system controller functions may be centralized or distributed across the radio network. This network element handles voice service requests with regard to authorization, authentication, call processing, and resource management. The P25 system controller utilizes the user capability, authorization, and authentication information in conjunction with current call activity and resource availability on the ISICS network as it processes the user requests for voice service.

The P25 system controller interfaces with the other elements of the ISICS network through the transport network.

Bearer router

The bearer router provides the switching interconnects fabric for the radio voice network. The bearer router function may be centralized or distributed across the ISICS Radio Network. The bearer router interconnects the radio sites and the dispatch positions to share call voice information. The general function for the bearer router is to route voice signaling from a source (radio site or dispatch position) to the appropriate destination (radio site or dispatch position) for the call. There may be multiple destinations that need to receive the same sourced voice information. The bearer router needs to be able to modify the necessary paths during a call as the members of the call roam to different sites of the ISICS network, and as new members of the call become active on the ISICS network.

The bearer router interfaces with the other elements of the ISICS network through the transport network.

P25 user registry

The P25 user registry maintains the database attributes (e.g., priority levels, authorized services, roaming parameters) and the current network location for users and talkgroups of the ISICS Network. The registry database may be centralized or distributed across the radio network. The user and talkgroup P25 identities are used as entry keys to the attribute and location information, and can be used to direct inquires to specific partitions of a distributed registry database.

The location tracking information is maintained at a site level, reflecting the current location of a user and any talkgroup membership to be used to route call information for the user and talkgroup. For example, the current locations of the individual members of a talkgroup are used to determine the sites that need to be included in a talkgroup call, e.g., sites currently supporting affiliated talkgroup members.

P25 radio site

The P25 radio site provides the interface between the P25 compliant trunked subscriber unit and the ISICS radio network infrastructure. The P25 radio site oversees the management and operation of the P25 channels (control channel and traffic channels) and equipment to support trunked operations at the site. This includes but is not limited to: creating appropriate outbound channel streams, processing received channel signaling and presenting appropriate information to the other elements of the network.

Status of the operational condition of the elements of the P25 radio site and alarm conditions are reported to the P25 system controller and network manager for additional processing.

The radio site is capable of assuming a standalone trunked operational mode in the event the site interface fails and the site is isolated from the ISICS network. In this mode the radio site handles call activity at this site as a local event. The radio site will assume the call processing responsibility, and directly assigns call requests to available channel resources at the site, but there is no opportunity to have this call extend to other sites of the ISICS network.

The radio site communicates with the other elements of the ISICS network through the transport network.

8.1.2 Dispatch Network

The dispatch network handles the operator positions and provides the direct interface to the radio network and wireless data networks to enable end-to-end communications to the field radio units. This also interfaces the input from the E911 sources to the dispatched field radio units as appropriate.

Dispatch server

The primary functions for the dispatch network involve managing the current status of the operator positions at the dispatch center, sourcing voice to the ISICS network for pertinent call activity, and accept destination voice information from the ISICS network for pertinent call activity.

Operator positions

The operator positions provide the ability to initiate, join, or monitor calls on the system. This applies to both the voice calls on the radio network and data transactions on the wireless data network.

The dispatch network elements communicate with the other elements of the ISICS network through the transport network.

8.1.3 Wireless Data Network

The wireless data network handles the data centric communications for the ISICS network.

Data server

The various data service offerings (e.g. narrowband, broadband) are managed by this element. This tracks the current operational state for each of the data users on the network, and determines the best method of conducting a requested data activity.

Access control

Determining who is allowed access and to what degree data service is to be made available to the individual data users.

Data site

The basic function of the data site is to provide the interface between the data service compatible subscriber devices and the data infrastructure.

Home location registry

The location tracking information is maintained at a site level, reflecting the current location of a user and how subsequent data traffic is to be routed to the data user.

8.1.4 Transport Network

The transport network allows all the elements of the ISICS network to interconnect to each other in a standards-based IP centric manner. The transport network is fault tolerant and provides uninterrupted service to the elements connected to the network.

8.1.5 Network Management

The provisioning and management of the various elements of the ISICS network are accomplished through the network management system. There are multiple levels of management from local to network wide. Fault reports, usage reports, and other operational status information are presented through the network management system. The network management system is interconnected to the other elements of the ISICS network through the transport network.

While this represents the logical grouping of each ISICS network element, real world implementation would tend to combine these elements into functional groups that could be used to determine physical placement of the supporting hardware.

The resulting functional groupings as illustrated in Figure 47 – Functional grouping of network elements, are: Radio Site, Dispatch Center, Control Site, and the Transport.

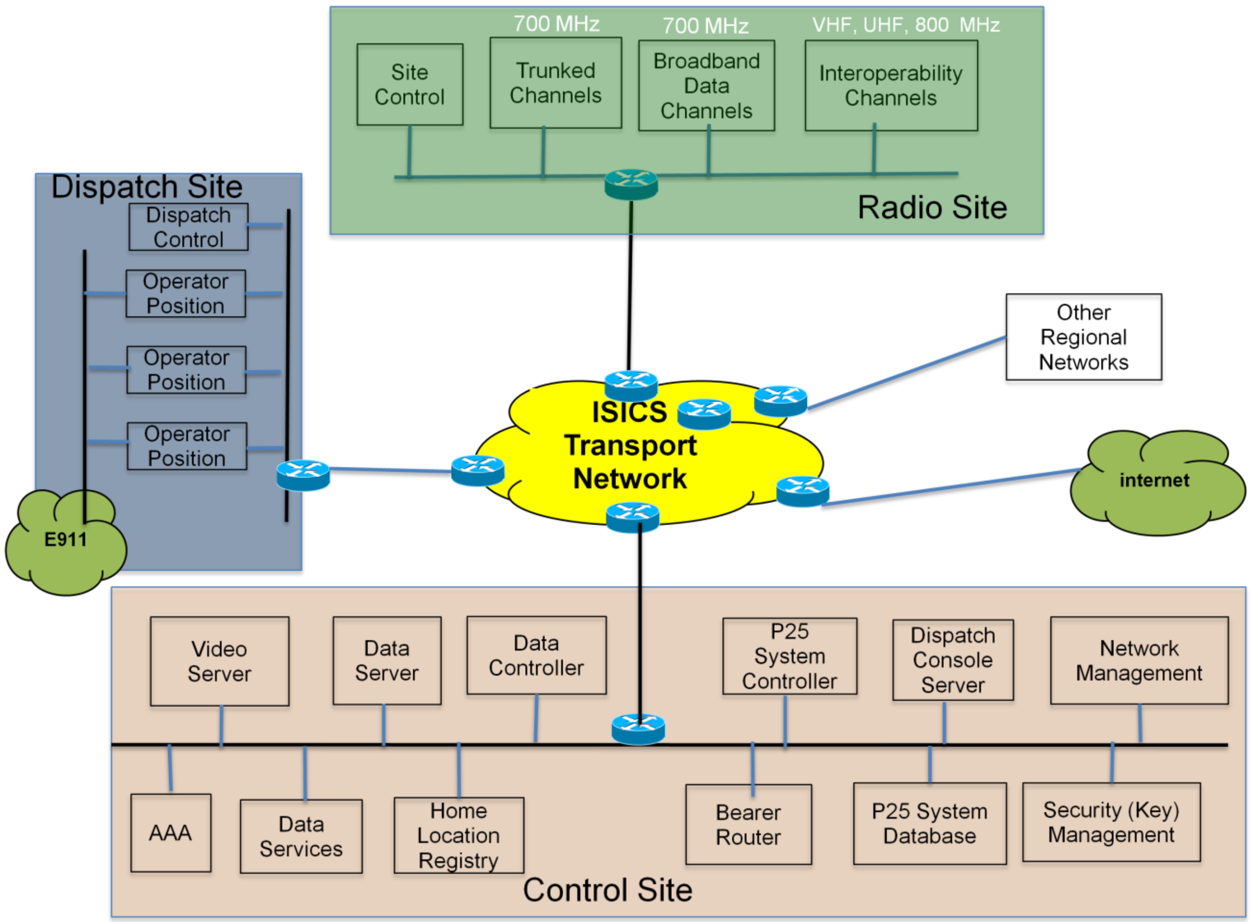

Figure 47 – Functional grouping of network elements

Control site

The control site is the collection of functionality necessary to support the voice and data communications of the ISICS network. While this is displayed as a single collection of various network elements, this can actually be partitioned and distributed across the ISICS network as multiple instantiations to satisfy operational, or geographic needs. For instance the elements that generally are related to voice communications (e.g., P25 system controller, bearer router, P25 user registry) may be co-located or even integrated into common processing units, separate from the other system functions associated with the data, dispatch, or network management. The elements related to the voice communications could be parsed individually across the network instead of being grouped if that is desired from the network topology. Alternatively, the functions may be parsed in various other ways, such as co-locating the voice and data control elements in one area, while locating the database intensive elements in a different area of the network. The transport network is the common interconnection fabric to allow the various network topology choices.

Radio site

The radio site is the collection of elements necessary to support the voice and data communications with the subscriber devices in the field. There are control functions at the radio site to manage the various channels at the site (P25, broadband data, interoperable). Normally the radio site is functioning under the supervision of the elements of the control site through communications across the transport network. The radio site is capable of assuming some local communication processing capability in the event of a catastrophic failure (e.g., loss of all site link paths) and can support trunked communication to the subscriber units currently affiliated with that radio site.

There are typically multiple radio channels located at a radio site. The expected user load for that site location determines the number of channels at the site. The radio site should provide the capacity to add at least two additional channels at a site. This would involve the need for physical space, antenna and combiner network ports, and appropriate cabling support.

There are multiple radio sites in the ISICS network to provide for the coverage needs of the voice and data communication systems.

The radio site needs to support an appropriate tower structure to meet the antenna needs for the radio network, wireless data network, and the microwave transport network. Additionally the tower needs to be structurally secure against extremes of temperature, wind conditions, ice conditions, and be appropriately grounded to mitigate lightning and static electricity conditions.

Dispatch site

The operator positions at the dispatch site interact with the radio network and wireless data network in a fashion similar to radio users interfacing to the radio sites. The key difference is that the operator positions are directly connected to the radio network through the IP transport network and not through the RF interface to the radio site. There is typically one or more operator positions at a dispatch site, dependent upon the expected call load for that location. The network has the ability to support multiple dispatch site locations, local or state agencies, as separate network elements in the ISICS network.

Transport network

The transport network connects each of the network elements providing interconnect paths between the elements. The transport backbone is fundamentally a collection of microwave paths between all the major elements of the network. The radio sites and the microwave sites are typically co-located to share the tower structures. There are multiple paths provided to the major elements of the network to provide fault tolerant communications. To supplement the microwave network there are interconnections to wireline fiber network (ICN) that primarily acts as alternative paths for the network elements and to augment the bandwidth needs of the transport network.

8.2 Regional Approach

The ISICS network can support segmentation to create regions of functionality. By segmenting the ISICS network into smaller regional areas a number of key system aspects are addressed. Having separate control functions addressing a portion of the overall network resources, translates into less impact on the overall network in the event of failure conditions and thus improves the overall reliability of the communication network. Each regional control structure is less complex and needs to interface to fewer network elements than would be needed in a single network control structure approach, thus the cost of the control infrastructure can be reduced. The interconnection of the network elements when addressed at a regional level becomes a more manageable effort. Lastly, the segmentation affords improved performance through the ability to parse communication needs on a geographic or organizational basis.

Each state agency included in this study divides its operations among regional districts. However, the district boundaries, even among divisions within the same agency, do not necessarily match each other. Figure 48 – State agency partitioning examples, provides a brief view of some examples of how the state is partitioned within some major agencies in the State of Iowa.

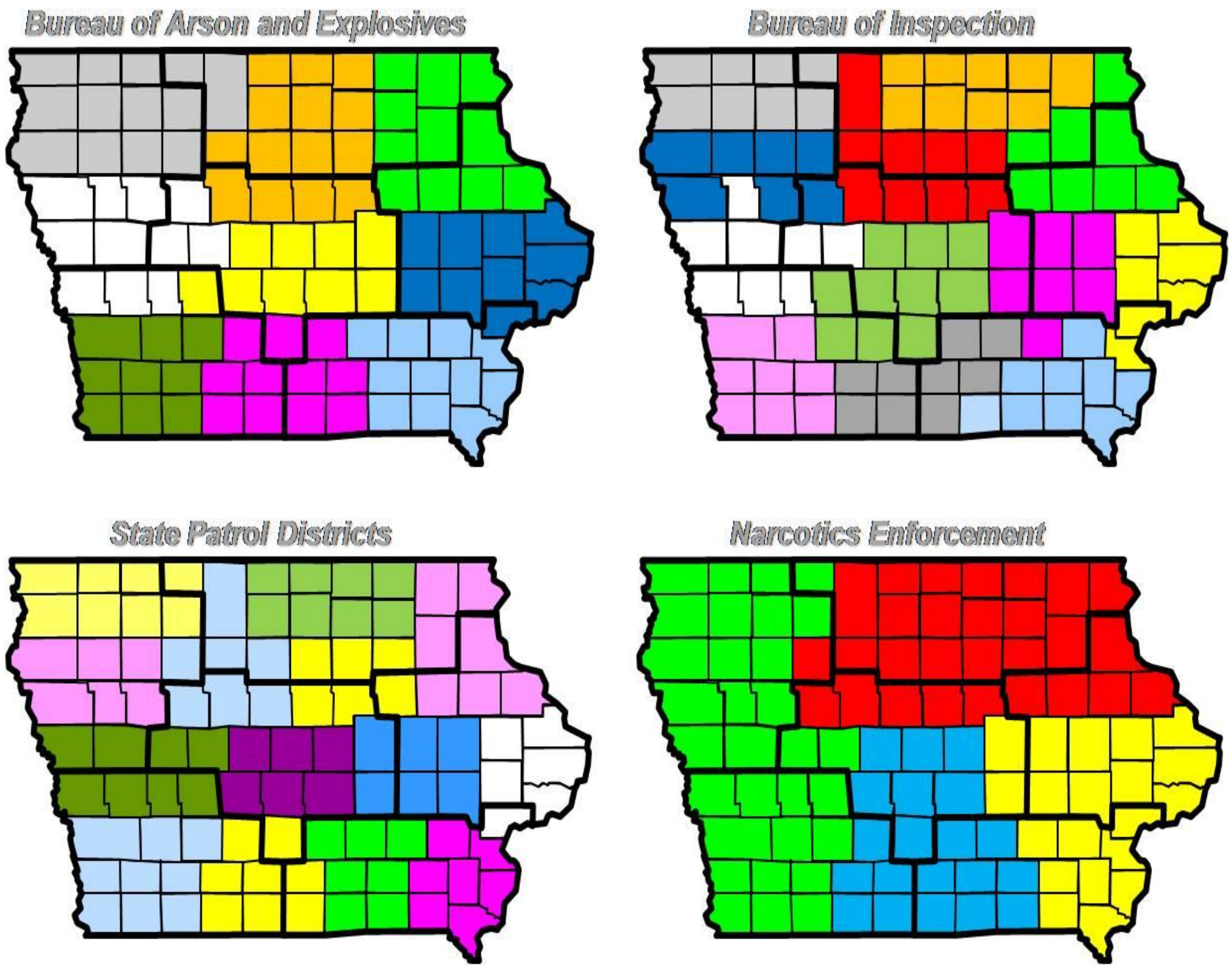

Figure 48 – State agency partitioning examples

In order to keep proper perspective, all district maps are overlaid with the six Homeland Security and Emergency Management (HLS&EM) regions. Given the high recognition of these six HLS&EM regions among federal, state, and local agencies, ***FE*** recommends that the ISICS network be composed of regions structured to follow this statewide partitioning approach.

The following system descriptions reflect segmentation into three geographic regions, approximately of equal size - Western, Central, and Eastern. As shown in Figure 49 – ISICS regions, the ISICS network regionalization combines the HLS&EM Regions into three regional networks: an Eastern regional network (HLS&EM 5 and 6), a Central regional network (HLS&EM 1 and 2), and a Western regional network (HLS&EM 3 and 4).

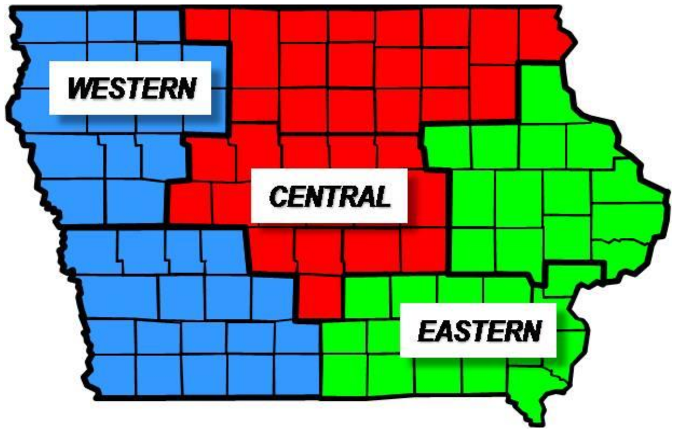

Figure 49 – ISICS regions

Each of the regions is interconnected to allow sharing of information, control, and communication payloads between the regions in support of multi-regional communications. Figure 50 – ISICS regional architecture provides visualization of the resulting regional architecture.

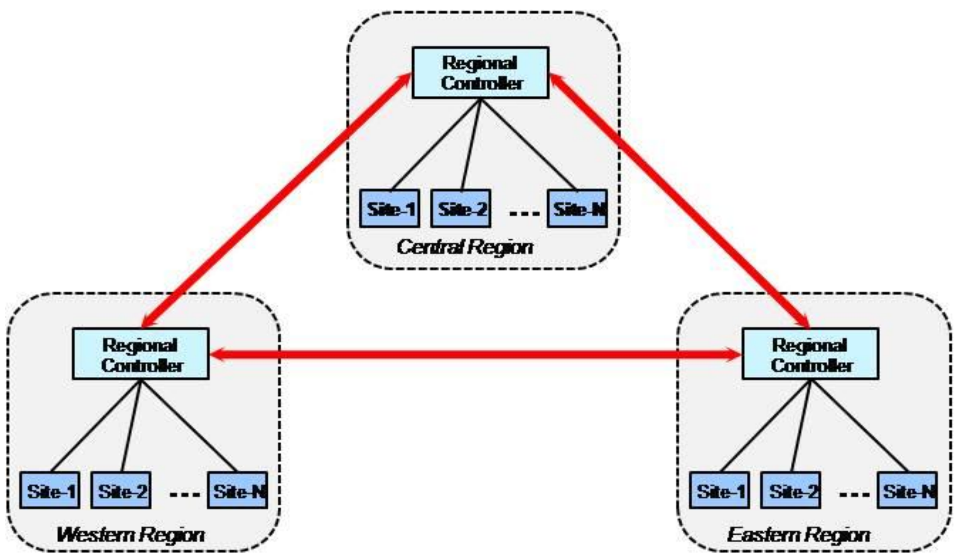

Figure 50 - ISICS regional architecture

This approach provides good distribution of the population centers throughout the state with each of the regions composed of IP centric control and signaling elements that handle communication needs for that region. Nevertheless, the actual network segmentation, with regard to number of regions and orientation of the regions, may be modified to address specific operational, organizational, or geographic needs.

8.3 ISICS Regional Radio Network Design

The ISICS radio network supports APCO P25 trunked system operation in the 700 MHz public safety spectrum. The radio network is composed of three regional communication networks interconnected by the ISICS Transport Network. Each of the regions itself is composed of IP centric control and signaling elements that handle basic voice communication needs for users currently located in that region. These regions are interconnected to allow sharing of information, control, and communication payloads between the regions in support of multi-regional communications.

The radio network is modular in design to afford ease of deployment and upgrade. Addition of network elements can expand, or better distribute the radio control functionality. The radio network modular design is depicted in Figure 51 – Radio network modular design.

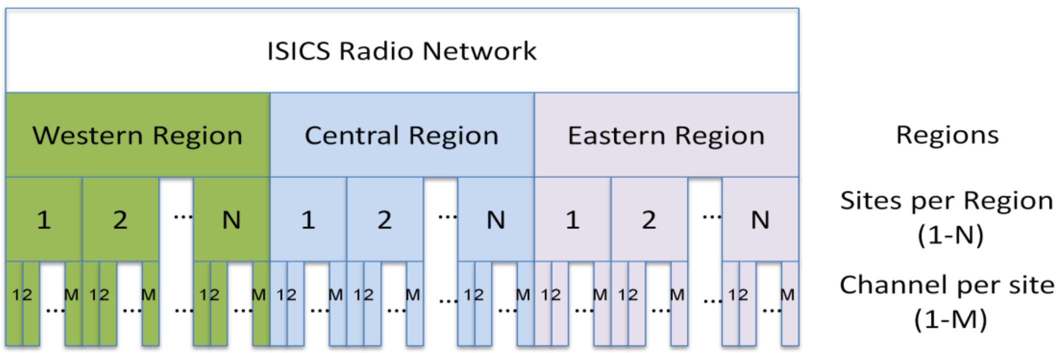

Figure 51 – Radio network modular design

Each regional network is composed of a number of sites (1 to N), with the actual number of sites in each regional network corresponding to the number of sites necessary to meet regional coverage needs. Each regional network controller manages its own set of sites, e.g., call processing and resource management. Each of the sites supports a number of channels (1 to M) that are used to support the voice operations. Each site manages its own set of channels, with the actual number of channels at a site dependent upon the predicted call loading at the site.

8.3.1 Regional Radio Network

The regional radio networks employ the APCOP25 trunking protocol via the APCO P25 Common Air Interface to further define an interoperable communication solution. Each Regional Radio Network is composed of one or moreP25 RF Sub-Systems (RFSS). These Regional Radio Networks support operation in the 700 MHz Public safety band using the common set of frequencies reserved for state agency use and additional county-based frequencies allocated for Iowa by the local Regional Planning Committee (RPC-15).

Each regional radio network is fundamentally composed of a regional Controller, Regional Location Registry, Bearer Controller, and one or more Repeater Sites with Local Site Controller, and Site Channels. These are illustrated in Figure 52 – Regional radio network.

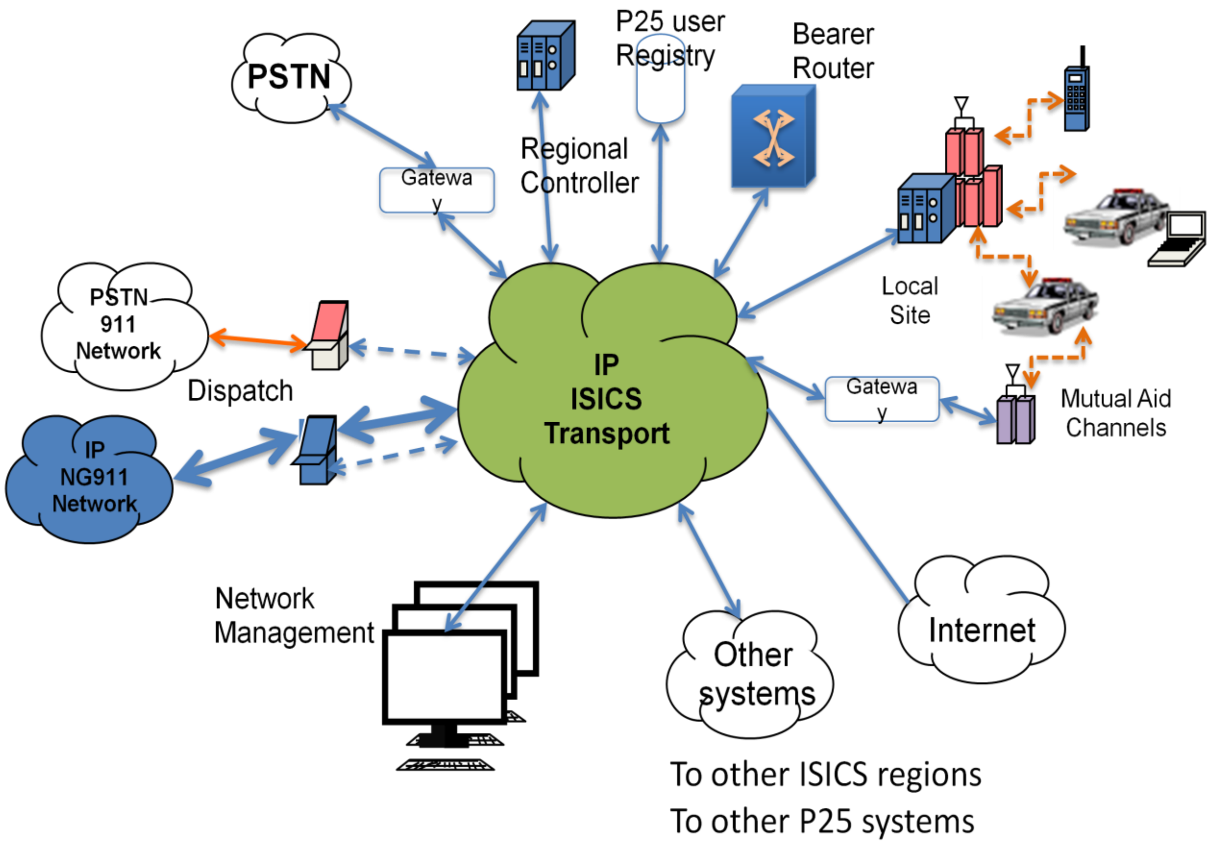

Figure 52 – Regional radio network

Regional controller

The regional controller is the overall P25 trunked call supervisor and resource manager for the regional radio network. The Regional Controller functions may be centralized or distributed across the Regional network. This network element handles voice service requests with regard to authorization, authentication, call processing, and resource management. The Regional Controller uses the user capability, authorization, and authentication information, in conjunction with current call activity and resource availability on the ISICS network as it processes the user requests for voice service.

P25 user registry

The P25 user registry maintains current location for users and group members of the ISICS Network. The registry may be centralized or distributed across the regional network. This information is maintained at a site level, reflecting the current location of the user and/or group membership to be used to route call information for the user. For example, the affiliated site locations of the individual members of a talkgroup are used to determine the sites that need to be included in a talkgroup call, e.g., sites currently supporting affiliated talkgroup members.

Bearer router

The bearer router is the interconnect control for the radio network. This can be a distributed networking function across the regional network. The bearer router matches the individuals and/or groups to be involved in a call with the current network location for those individuals and/or groups. The call voice information is routed to the appropriate endpoints of the network to enable the users and/or groups participation in the call. As any of the users and/or groups change location within the network, the location updates are made available to the bearer router which will determine if there needs to be any change to the existing paths for the call participants, be it to add a new path for the audio, or to drop a previous path. The bearer router also supports interfaces to dispatch network elements (dispatch operator positions) to present pertinent voice communication information.

Repeater site

The repeater site is composed of a local site controller that oversees the management and operation of the site elements, and channels (control channel and traffic channels) to support trunked operations. The local site takes commands from the regional controller to apply to call activity presented on the local site channels. The voice (payload) information to and from any of the channels at the site is routed to the site over the transport network from the bearer router. The sites may be configured as multicast standalone sites, or as a simulcast subsystem. The simulcast subsystem is actually a collection of repeater sites. Each uses the same set of channels and frequencies to provide a wide area coverage pattern in the area. The regional controller handles the simulcast subsystem as a single repeater site. The regional controller recognizes each of the multicast standalone sites as a single repeater site.

There is support for the statewide mutual aid channels that are part of the statewide conventional channel overlay that can be used to support intercommunication with non-ISICS users. Information can be shared on the ISICS network and the mutual aid channels via the transport network.

8.3.2 Backup Regional Controller

The RF sites across the State are controlled by one of three active regional controllers (one located in each of the regional radio networks) that handle the general voice service processing. Each of these regional controllers is fault tolerant in nature with co-resident redundant controller elements to automatically assume operations should the currently active controller element fail. Each of the regional controllers is connected to the network via the transport network.

As illustrated in Figure 53 – Backup regional controller, there is a backup regional controller, in addition to the active regional controllers, that resides geographically separate from any of the active regional controllers and is interconnected to the other network elements of the ISICS Network via the transport network.

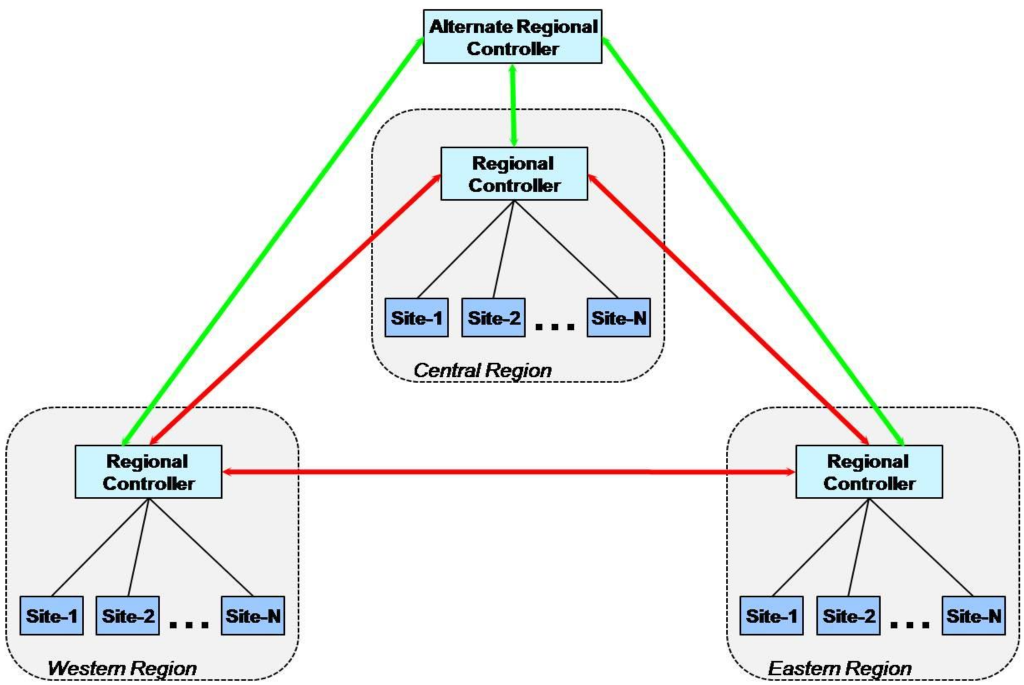

Figure 53 – Backup regional controller

This backup regional controller is ready to assume operation for any regional controller that catastrophically fails (e.g., complete failure at the physical location of the regional controller). The backup regional controller normally mirrors the current state of each active regional controller, and can assume control of ongoing calls at any of the active regional controllers without call interruption. Once the failed regional controller has been repaired and placed back in service, the backup regional controller will refresh the regional controller to the current operation status and relinquish operational control to the regional controller. The backup regional controller will assume the backup, standby mode again and refresh itself for the current status of the other regional controllers.

Alternatively instead of maintaining a separate backup controller, the existing regional controllers can be configured to assume a portion of the site load from a failed regional controller. This would require having excess capacity at each of the existing regional controllers, plus a mechanism to transfer the processing of select regional inputs to the other operational regional controllers, and then back again once the failed regional controller becomes operational again.

8.3.3 Site Configurations

The regional radio network is a mixture of simulcast and multicast site configurations. This is illustrated in Figure 54 – Simulcast and multicast configurations. The simulcast configuration is the most spectrally efficient wide area coverage configuration. The multicast configuration is capable of supporting more call load than a simulcast configuration under some roaming conditions due to the distributed nature associated with multicasting.

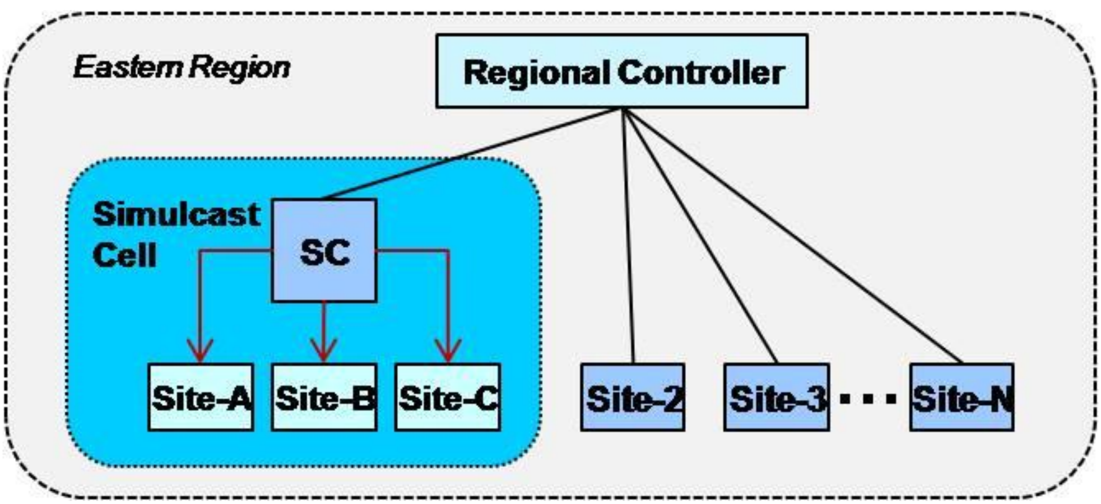

Figure 54 – Simulcast and multicast configurations

The simulcast site configuration is a collection of radio sites in a geographic area that allows a fixed set of radio channel frequencies to be reused at each of the radio sites to provide wide area coverage over that geographic area. This is referred to as a simulcast cell. The simulcast cell locally manages the collection of sites and projects a single site presentation to the regional controller. A call is broadcast on the same frequency at each of the radio sites simultaneously. This does not try to conserve the number of sites currently transmitting the call information (e.g., only broadcast when a valid user for the call is affiliated at the site), but instead conserves the number of channel frequencies being used to provide the wide area coverage for the call. Every operational site is always included in a call in the simulcast cell configuration.

The simulcast cell is composed of a simulcast controller, receiver voting network, and a number of radio sites with a local site controller and repeaters. The simulcast controller receives call commands and information from the regional controller and determines how these should be applied to each of the radio sites. The simulcast cell appears to the regional controller as a single radio site resource. The regional controller views the channel resources of the simulcast cell as a single set of channels to be used to support network communication needs.

The multicast site configuration is a collection of radio sites in a geographic area that allows variable numbers of channels from a common pool of channel frequencies to be supported at each of the radio sites. A call is broadcast on different channels (frequencies) across the necessary coverage area for the call. A channel at a site is only included in a call when a valid user is currently affiliated with the site in a multicast site configuration. Unlike simulcast technology, multicast sites do not share frequencies and as such may require, under the appropriate conditions, more channels to cover the same service area. Nevertheless, it represents a suitable solution for large service areas with less user densities spreading beyond the service area afforded by the site itself.

The simulcast configuration is the most spectrally efficient form of wide area coverage systems and has a number of additional benefits. The simulcast configuration affords a more concentrated and penetrating coverage over a given area than can be easily accomplished with non-simulcast sites. In addition to the combined transmit information from the simulcast cells reaching the radio units in the field, there is also the potential for enhancing the receive signal characteristics for transmit signals from the radio units in the field by acquiring the signal at multiple sites and processing the signal into the most valid representation of the transmitted signal. Nevertheless, implementation of simulcast technology is often more costly due to additional equipment used to achieve coordinated launch of the communication signals over a wide service area. Each particular technology solution has been paired with a particular service area according to the specific characteristics of the county being served. These are discussed in further detail on the coverage subsection of this document.

8.3.4 Coverage

The coverage contour for the ISICS radio system is designed for statewide coverage with a goal of 95% mobile coverage across each of the counties of Iowa. The coverage contour for the Radio Network is designed to afford a delivered audio quality (DAQ) of 3.4 statewide for mobile-based communications. DAQ of 3.4 is defined as speech understandable with repetition only rarely required with some noise/distortion; this is a typical requirement for mission critical public safety agencies.

Through the use of ***FE'****s* coverage modeling and analysis toolset, a representative statewide coverage prediction was accomplished for the State of Iowa in the 700 MHz band using 12.5 kHz bandwidth channels. This analysis started with consideration of the existing 28 Iowa DPS and 175 Iowa DOT tower sites as a core for the ISICS 700 MHz system. The 28 Iowa DPS sites were determined to support acceptable attributes (e.g., tower type, tower height) for the further coverage analysis. However, the attributes of the Iowa DOT tower sites did not fare as well. This is due to the fact that initial deployment of the Iowa DOT tower sites was based on local coverage needs and excluded statewide interoperability considerations. As a result, most of these sites contain very small towers (60ft – 120ft). Additionally, most of the towers are incapable of supporting the heavy loads associated with microwave dishes, 1 ¼ inch coaxial cable, and multiple antenna arrays. For the existing Iowa DOT site locations to be of optimal use in the development of the ISICS 700 MHz site allocation, the tower attributes were open to change. As such, the Iowa DOT tower sites attributes were modified to require that the tower structures physically support the antenna arrays associated with the radio network, wireless data network, microwave dish for the transport network, and all associated hardware. In addition, the overall height of the Iowa DOT tower was considered to be 300 feet to afford a greater general coverage area for each of these tower sites.

The analysis indicated that potential radio coverage from many of the existing Iowa DOT site locations shadowed the coverage from other Iowa DPS or other Iowa DOT tower sites and therefore did not add value as a site in the ISICS statewide coverage picture. Of the initial 175 Iowa DOT existing tower sites, 98 tower sites were determined to provide coverage advantage when used in the ISICS site allocation. Use of the existing 28 Iowa DPS tower sites along with the select 98 Iowa DOT tower sites did not suitably address the coverage goal of 95% mobile coverage in each of the 99 Iowa counties.

The ***FE*** coverage analysis process was used to determine where general locations for additional sites that provide suitable coverage across the state could be used. This process was performed on a county by county basis and determined to be in one of the following categories (in order of preference): existing local public safety agency radio tower, existing private/public radio tower (e.g., cellular), and new tower where no existing tower could be found. By referencing numerous FCC databases regarding information of existing radio towers in Iowa, ***FE*** determined that an additional 103 existing tower sites could be used, plus 35 new tower sites would be necessary to address the statewide coverage goal. The sites are grouped and represented in Table 3 – Summary of tower sites.

Table 3 – Summary of tower sites

Tower site category	Quantity
Existing State Agency	127
Existing Local Agency	73
Existing public / private entity	30
New Tower	35
Total:	**265**

In order to provide useful partitioning of the overall coverage analysis process, the State of Iowa was segmented into each HLS&EM region. As such, each county in each of these regions was uniquely addressed to achieve the desired mobile coverage goal. While the overall goal was focused on geographic coverage, consideration was also afforded to other important factors such as major roadway coverage and population coverage. This set of 265 sites will provide a collective mobile-based coverage for the State of 96% coverage on a geographic basis, 98% coverage of the population regions across the state, and 99% coverage of major roadways across the state. The complete list of chosen sites can be found in Appendix C. The result of the coverage prediction process is summarized in Table – 4 Overall coverage prediction by HLS&EM regions. More detailed information can be found in Appendix D and Appendix E.

It should be noted that 95 of the 99 counties have mobile coverage at 95% or better for geographic county coverage. Dubuque County was one of the counties that did not accomplish the coverage goal exactly; this county had a coverage value of 94%, but with the major roadway coverage at 96% and the population coverage at 97%, it was deemed to have adequate overall coverage.

Table 4 – Overall coverage prediction by HLS&EM regions

HLS&EM region	Geography	Major roadways	Population (2000 census)	Counties in the region	Counties at 95% mobile coverage goal
1	97%	99%	98%	16	16
2	96%	98%	98%	18	17
3	98%	99%	99%	16	16
4	96%	99%	99%	18	18
5	96%	99%	99%	17	17
6	95%	98%	98%	14	11
Total	**96%**	**99%**	**98%**	**99**	**95**

Three counties had unique terrain characteristics that require a disproportionately larger number of sites to address the coverage goal. These counties are identified with a star in Figure 55 Counties below 95% mobile coverage.

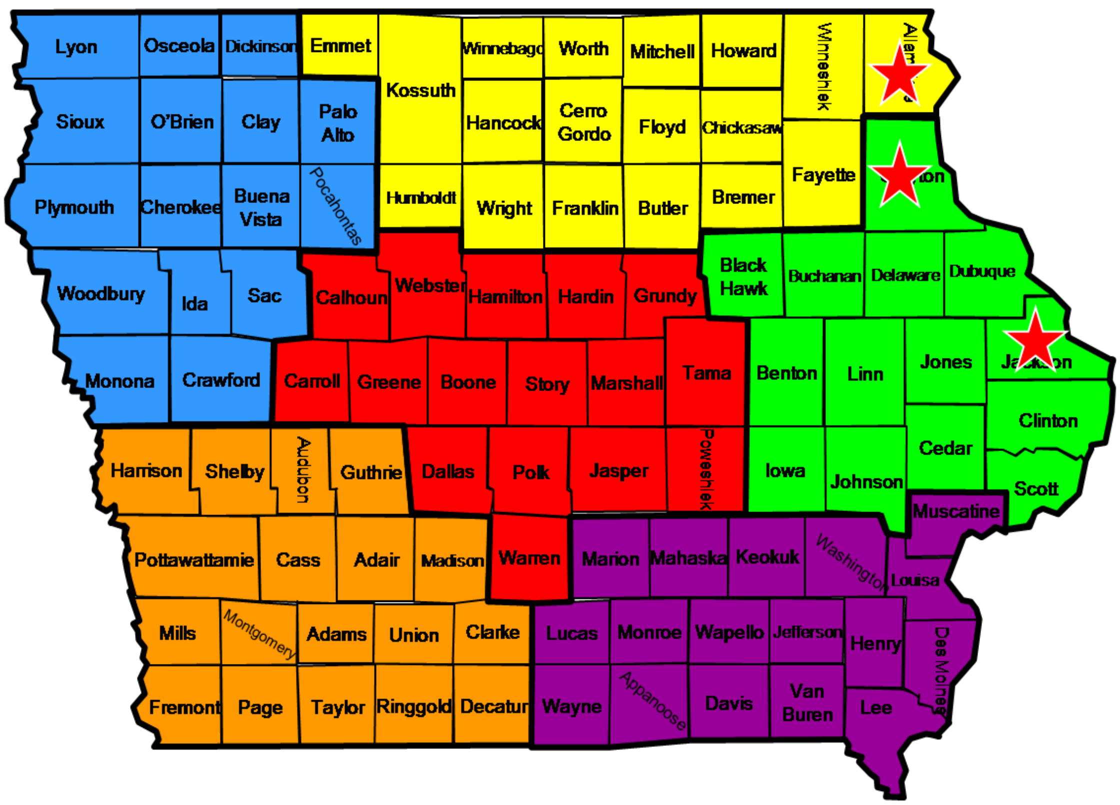

Figure 55 – Counties below 95% mobile coverage

While attempting to reach the coverage goal of 95% mobile coverage of the geographic area, it was determined that these counties, Allamakee, Clayton and Jackson, would require almost twice the typical number of sites when compared to other counties. Although the site allocations for these counties did not outwardly address the overall goal of 95% county coverage, when considering the other attributes of major roadway coverage, and population coverage, the site allocations did, for the most part, address these attributes, with almost 90% of the population in these areas being universally covered. Further investigation of these counties indicated diminishing returns with adding more sites to these areas. It was found that even doubling the number of sites in those counties did not generally accomplish the geographic coverage goal, and only slightly improved the other coverage attribute values (with the exception of Jackson County). Each of these counties requires significantly higher site costs when compared to other counties in the state. The coverage maps depicting conditions in these counties can be found in Appendix J. This information is summarized in Table 5 – Alternative site options.

FE recommends that these counties remain at the site level indicated in the 265 site plan, with the caveat that special attention be applied to these counties when the vendor detailed system design commences. To mitigate the terrain coverage issues in these counties ***FE*** also recommends that a simulcast multiple site approach be employed for these counties.

Table 5 – Alternative site options

County	Site Plan	Coverage			Site Count
		Geographic	Major Roadways	Population	
Allamakee	Original	74%	83%	91%	5
Allamakee	**Alternative**	**89%**	**91%**	**96%**	**10**
Clayton	Original	83%	92%	86%	5
Clayton	**Alternative**	**92%**	**96%**	**92%**	**10**
Jackson	Original	88%	95%	94%	5
Jackson	**Alternative**	**95%**	**98%**	**99%**	**9**

In addition to terrain considerations, the system design accounts for larger population concentrations that could benefit from the wide area coverage and spectral efficiency of a simulcast cell. Figure 56 – Location of simulcast candidate counties, shows, in yellow, the locations of counties within the State of Iowa that could benefit from deploying a simulcast solution.

The simulcast configuration affords a more concentrated and penetrating coverage over a given area than can be easily accomplished with non-simulcast sites. Deploying a simulcast solution will better position each of the indicated counties for future portable and in-building coverage needs.

The portable coverage across the State is not initially targeted to match the mobile coverage contour. The typical portable coverage provided by the selected sites needed to provide the desired mobile coverage is approximately 45% - 85% coverage per county. Some cities have a predicted portable coverage that far exceeds the general coverage in the county, such as Mason City in Cerro Gordo county with a county portable coverage of 77% and a city portable coverage of 99%. The potential need for future portable coverage enhancement has been addressed in the general ISICS network design with the ability to expand the network. Subsequent support for portable operation can be addressed as an ongoing modular upgrade operation for the network. The network can be upgraded with additional sites to provide needed area coverage enhancements. These additional sites may be reuse of legacy system site locations properly equipped to function in the ISICS network.

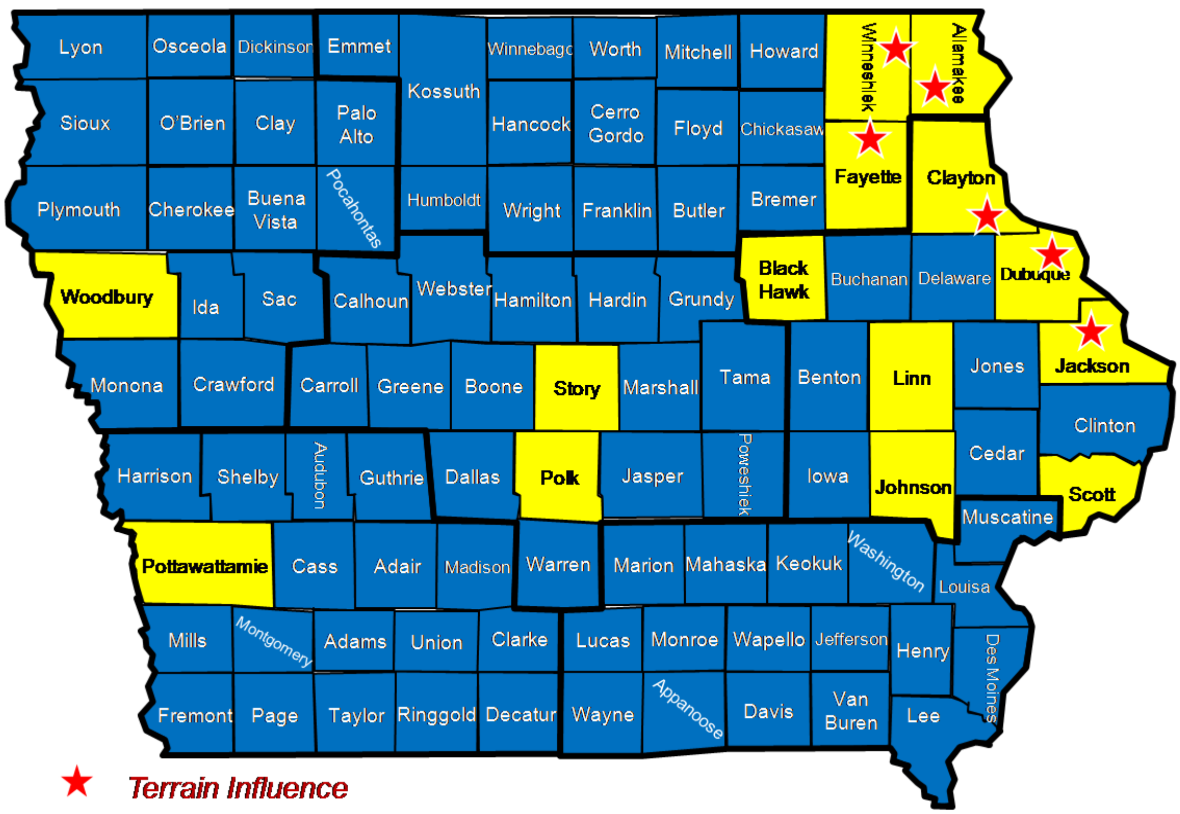

Figure 56 – Location of simulcast candidate counties

Table 6 lists each county recommended for a simulcast solution:

Table 6 – List of simulcast candidate counties

County name	Influence
Allamakee County	Terrain
Black Hawk County	Population
Clayton County	Terrain
Dubuque County	Terrain
Fayette County	Terrain
Jackson County	Terrain
Johnson County	Population
Linn County	Population
Polk County	Population
Pottawattamie County	Population
Scott County	Population
Story County	Population
Winneshiek County	Terrain
Woodbury County	Population

The ***FE*** team used the existing Iowa DPS tower site attributes to estimate coverage provided by the existing 28 Iowa DPS site VHF LEA radio system. This coverage prediction estimate indicated about 82% of the state was covered for the current VHF LEA offering. However, when the coverage in each of the 99 Iowa counties was individually considered for the same coverage goals as the ISICS system that is 95% mobile-based coverage per county, the currently deployed VHF system can achieve this goal in only 19 of the 99 counties (about 19%). Further, the ***FE*** team factored in the effects of converting the existing VHF wideband system to the mandated 12.5 kHz narrowband system will have on coverage. The general effect on the estimated coverage was a reduction of about 2db. The estimated number of counties that would satisfy the 95% mobile coverage requirement with an analog narrowband VHF system would decrease to 13 counties (about 13%). Further details can be found in Appendix G.

The following maps provide a visual representation of ISICS coverage predictions for each HLS&EM region, plus provide a summary of current wideband and potential narrowband VHF-based state LEA coverage estimates.

Total Counties	Number of counties that meet coverage goal		
	ISICS 700 MHz System	VHF LEA Wideband System	VHF LEA Narrowband System
16	16	3	2

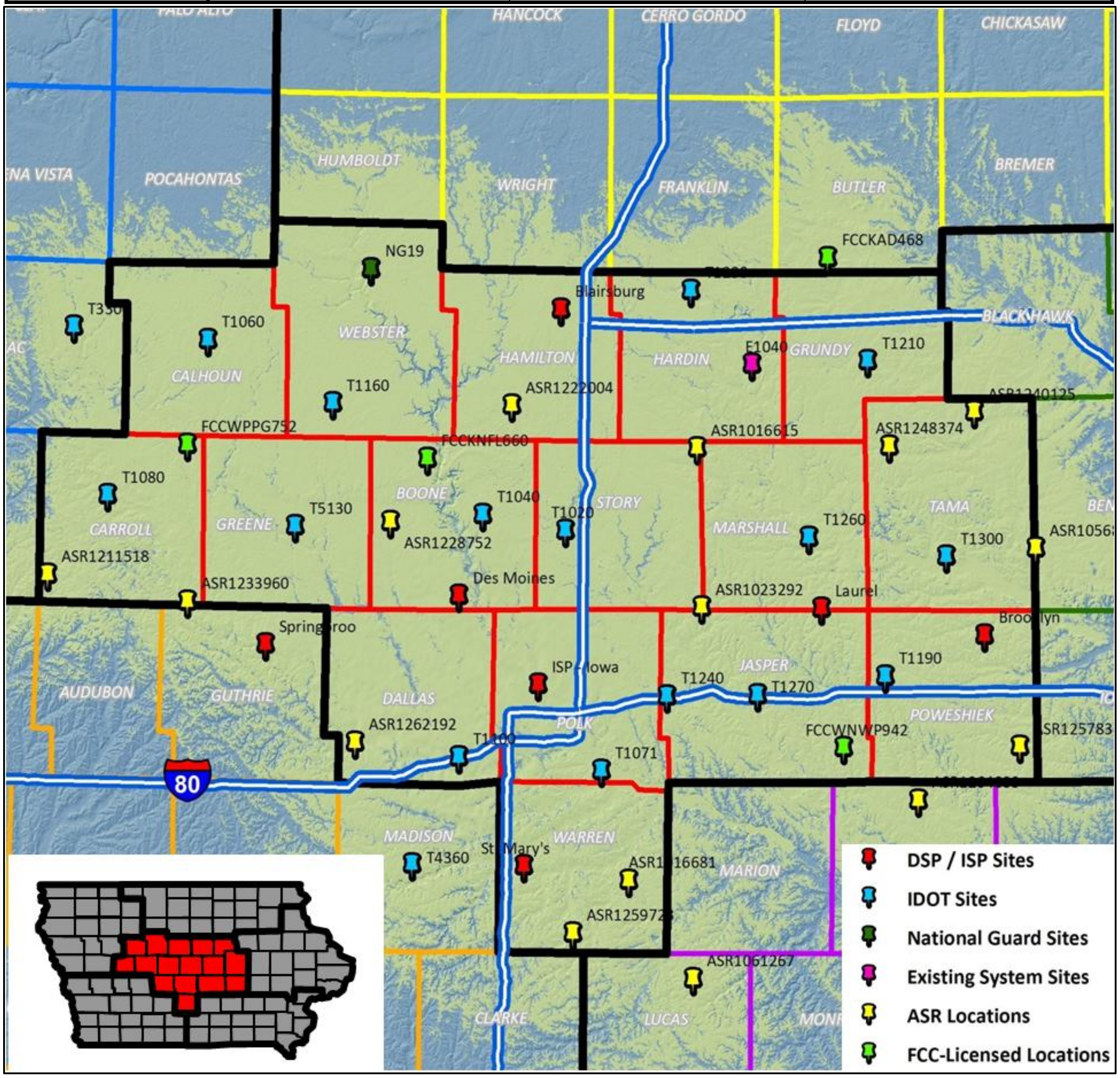

Figure 57 – HLS&EM region 1 at 95% mobile coverage

Total Counties	Number of counties that meet coverage goal		
	ISICS 700 MHz System	VHF LEA Wideband System	VHF LEA Narrowband System
18	17	3	2

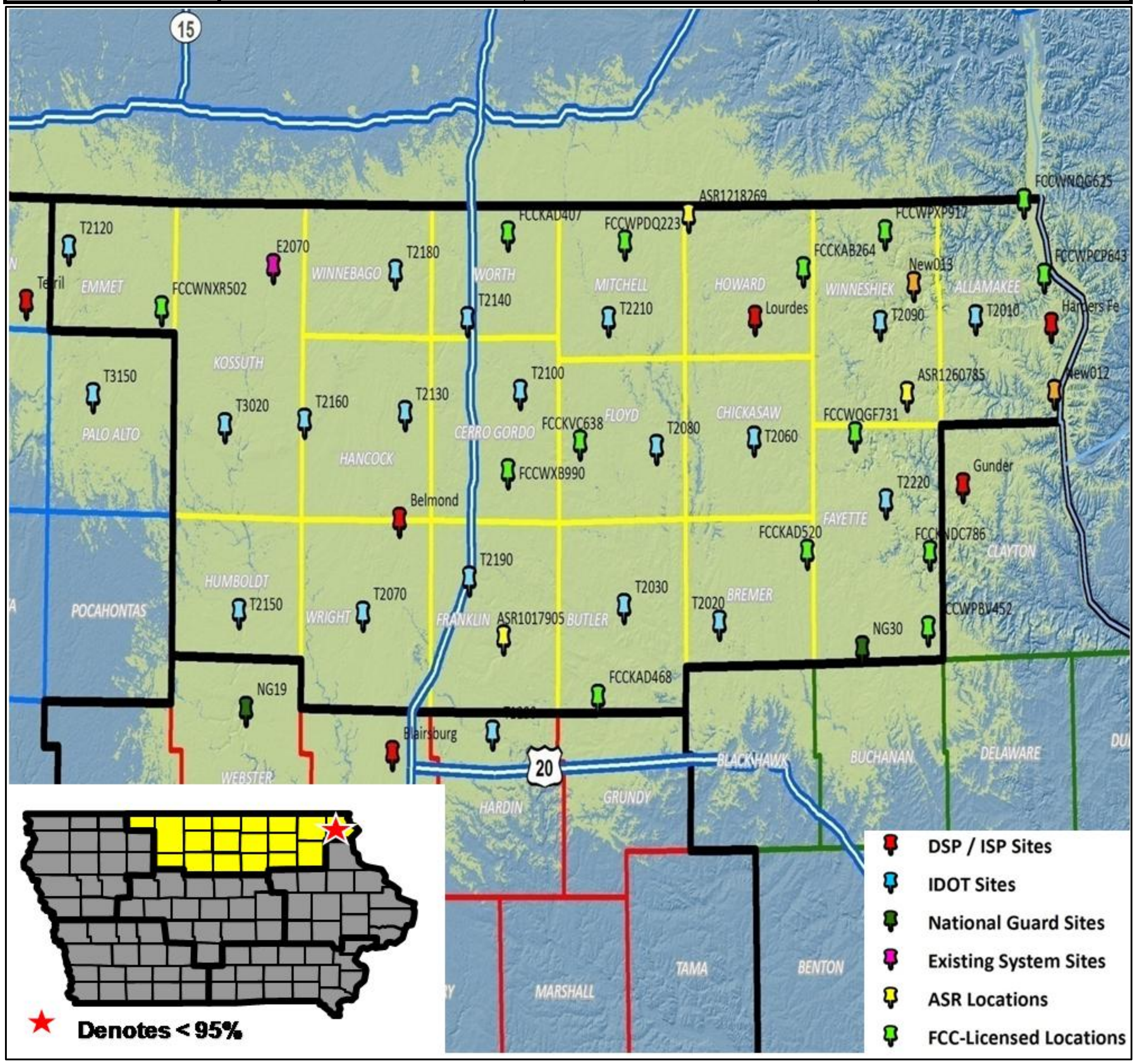

Figure 58 – HLS&EM region 2 at 95% mobile coverage

Total Counties	Number of counties that meet coverage goal		
	ISICS 700MHz System	VHF LEA Wideband System	VHF LEA Narrowband System
16	16	6	3

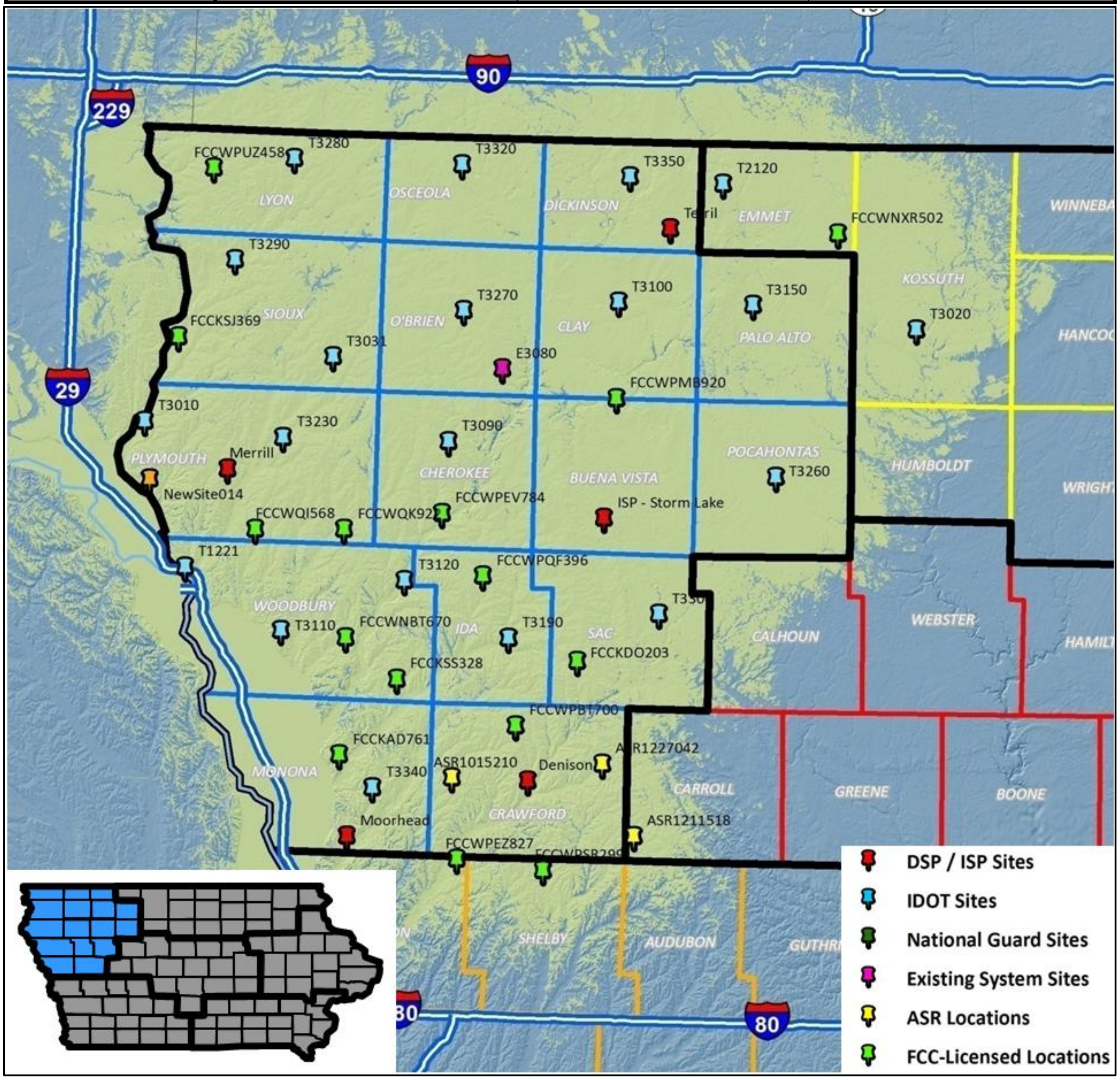

Figure 59 – HLS&EM region 3 at 95% mobile coverage

Total Counties	Number of counties that meet coverage goal		
	ISICS 700 MHz System	VHF LEA Wideband System	VHF LEA Narrowband System
18	18	2	1

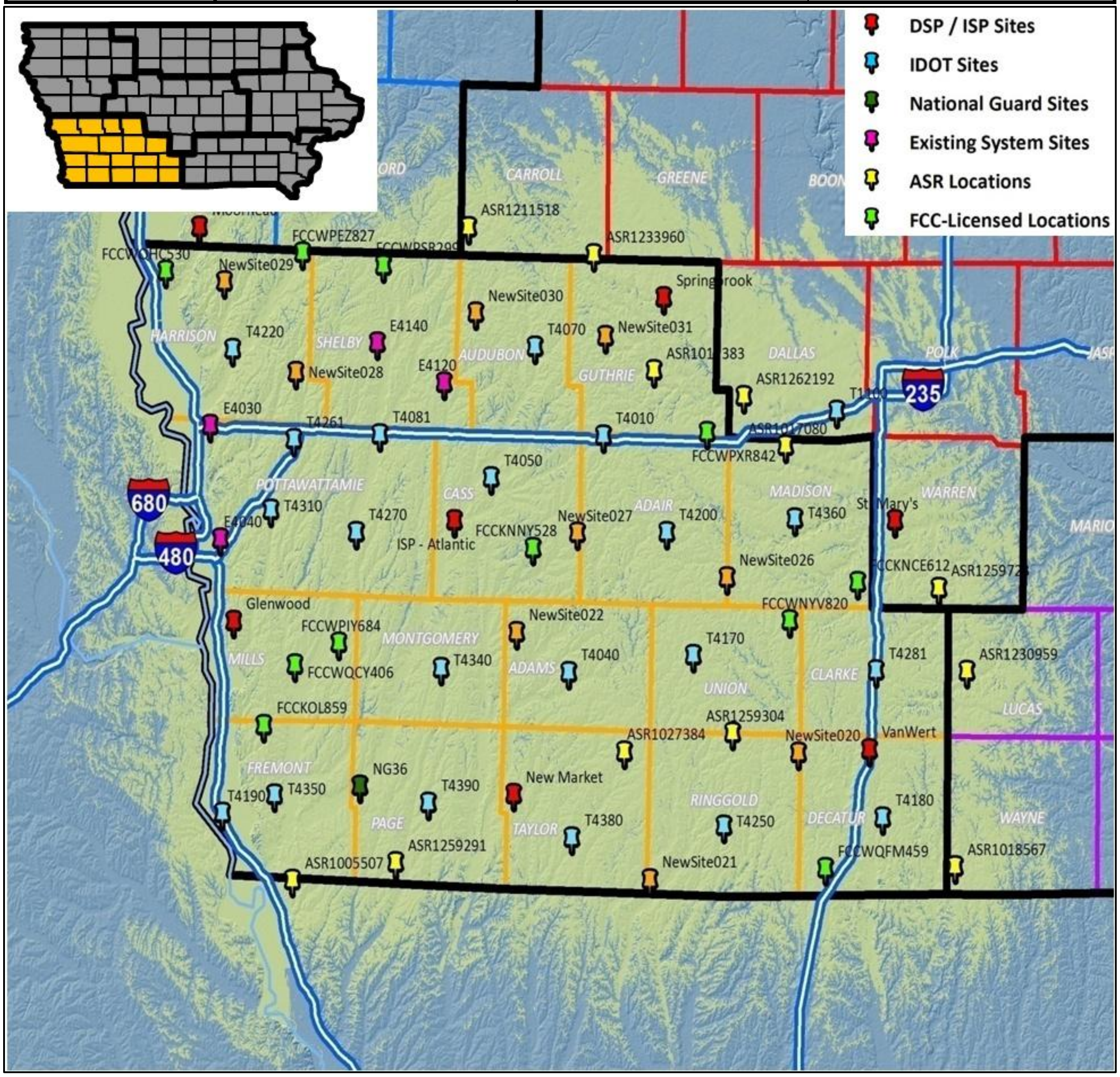

Figure 60 – HLS&EM region 4 at 95% mobile coverage

Total Counties	Number of counties that meet coverage goal		
	ISICS 700 MHz System	VHF LEA Wideband System	VHF LEA Narrowband System
17	17	3	3

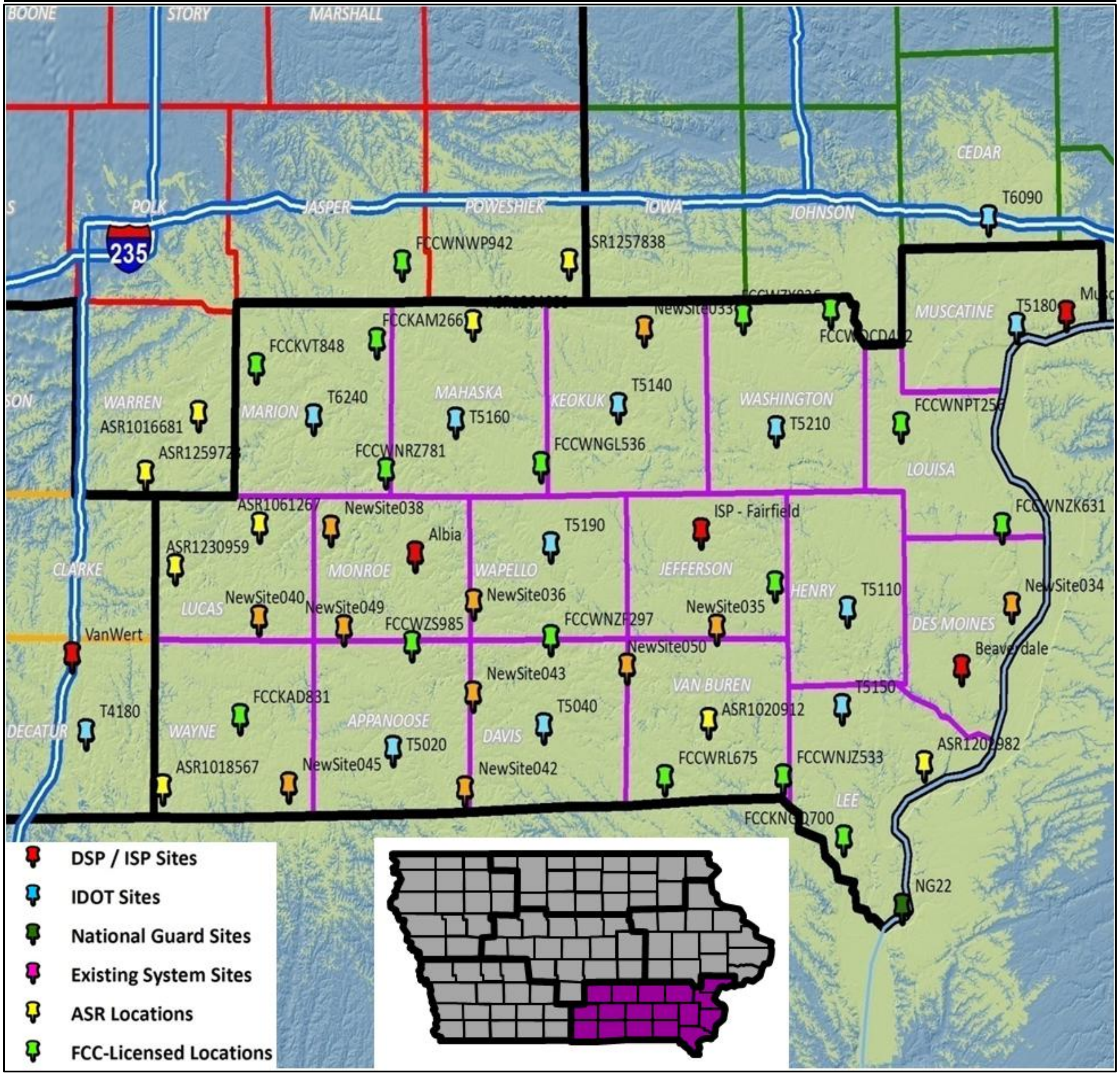

Figure 61 – HLS&EM region 5 at 95% mobile coverage

Total Counties	Number of counties that meet coverage goal		
	ISICS 700 MHz System	VHF LEA Wideband System	VHF LEA Narrowband System
14	12	2	2

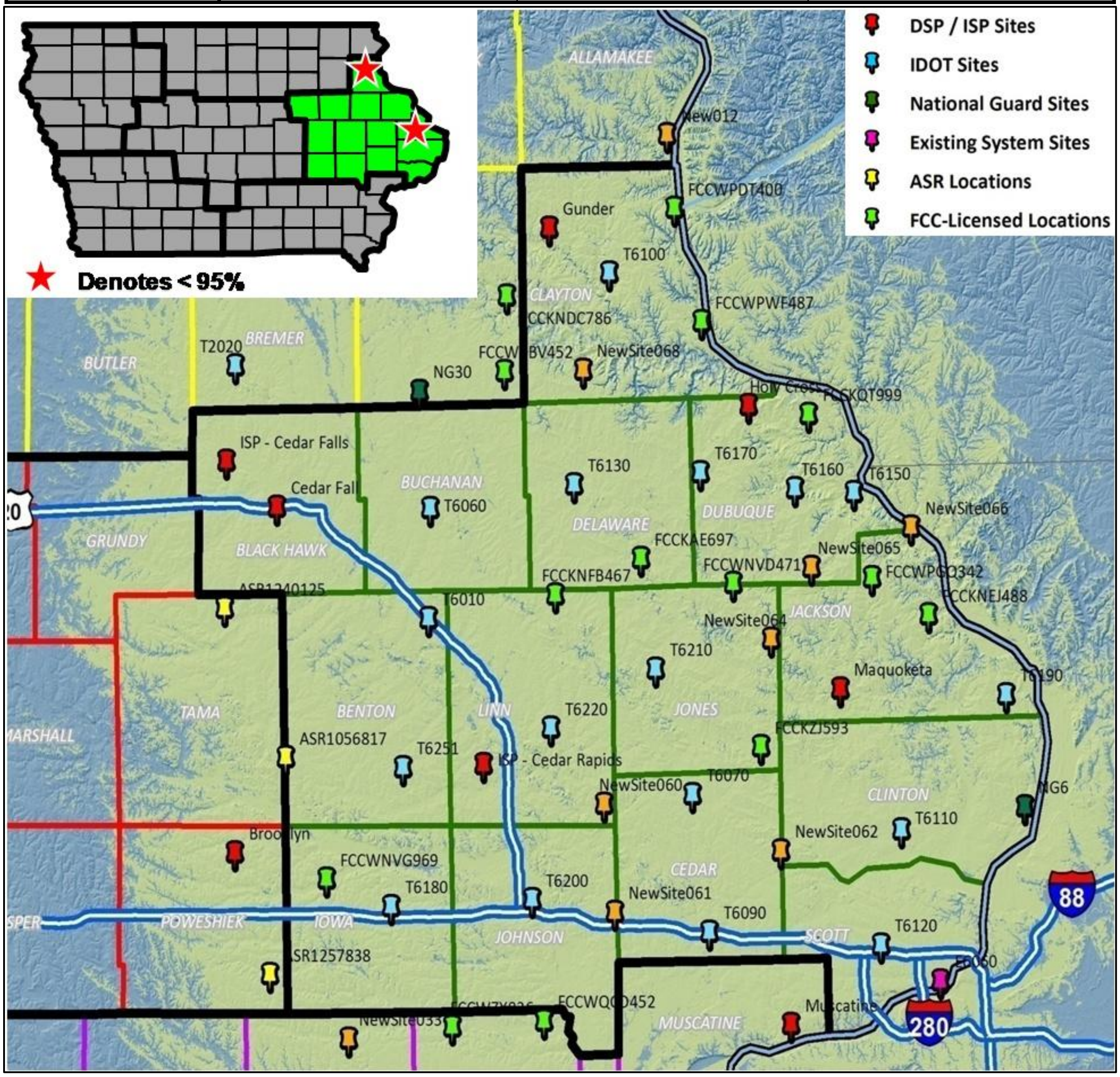

Figure 62 – HLS&EM region 6 at 95% mobile coverage

8.3.5 Site Channel Loading

Once ***FE*** completed the coverage modeling process and selected the tower sites required to support the 95% mobile-based county coverage goals, channel capacity required to support the estimated users was established. ***FE*** worked with local and state agencies to determine overall user counts each agency might add to the radio network. The overall statewide agency user population was determined to be about 26,400 users, composed of about 20,800 local agency users and about 5,600 state agency users. The distribution of the users across the HLS&EM Regions of the state is depicted in Figure 63.

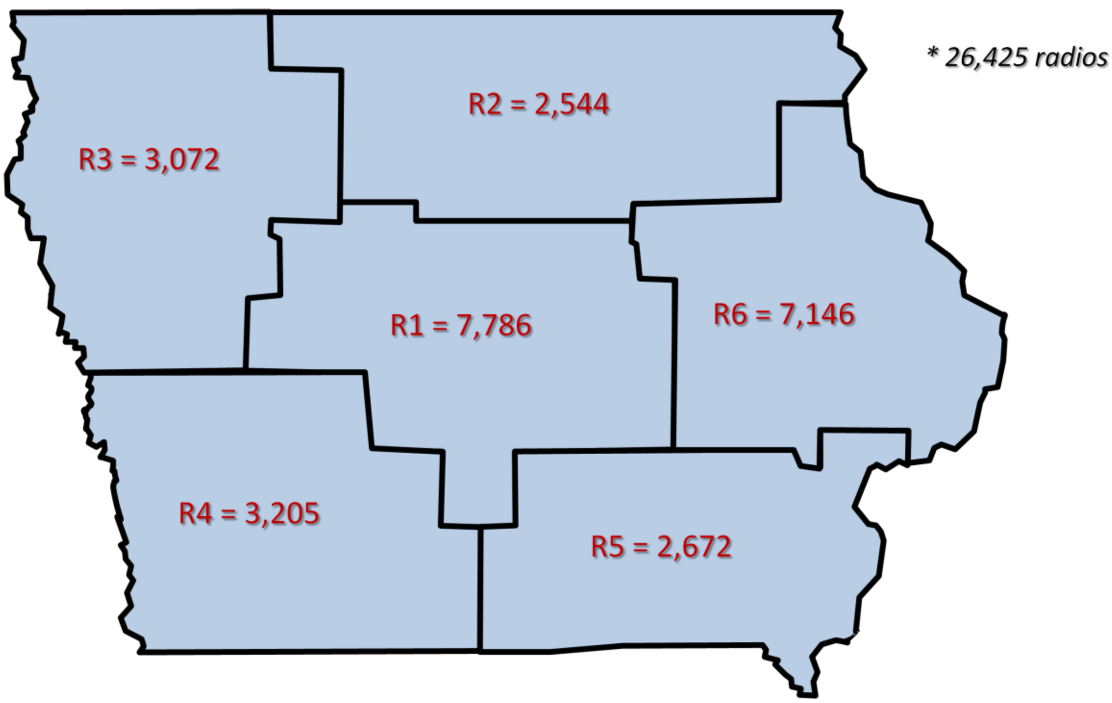

Figure 63 – Statewide radio distribution

In order to determine the capacity requirements for each site within the system, a representative distribution of mobile radio users was established at the county level. This is important given the fact that some counties are served by multiple sites and some sites serve multiple counties. As such, ***FE*** worked with state and local agencies to determine a representative distribution on a per county basis.

In addition to the capacity estimates for each county, ***FE*** determined which sites would provide coverage to each of the counties. This was accomplished by evaluating the coverage propagation studies performed during the preliminary radio site design. ***FE*** determined each county's estimated user potential on the proposed radio network by looking at user counts supplied by state and local agencies, establishing representative distribution of radios throughout the state, evaluating coverage propagation studies, and making certain assumptions for user roaming and future expansion.

After determining each county's estimated user potential, as well as how many sites would provide coverage within each county, the final task in capacity planning was to determine how many unique talk paths would be required at each tower site to support the estimated combined loading potential.

This was accomplished using an Erlang-C calculation for each county on a per site basis. The Erlang-C calculation method is a National Public Safety Telecommunications Council (NPSTC)-endorsed method for capacity planning. In 1996, a division of NPSTC known as Public Safety Wireless Advisory Committee (PSWAC) published a report detailing many of the specific parameters that should be used when planning for public safety trunked system capacity. ***FE*** adhered to the general guidelines and recommendations outlined in the PSWAC report when performing the capacity planning for the State of Iowa radio system. These parameters are outlined below:

- The capacity calculations use Erlang-C Blocked Calls Delayed queuing theory models for trunked communications channels
- The system capacity goal is a maximum 1% Grade of Service (GOS). That is, no more than 1% of all calls will be blocked by a busy system
- The PSWAC-recommended profile for public safety users suggests 0.665 calls per hour for each radio unit
- Each transmission (push-to-talk or PTT) has an average duration of five seconds
- It is assumed that each message (communication) will consist of three transmissions (PTTs) and the inter-transmission time is assumed to be a collective one second between the transmissions. This results in average call duration of 16 seconds. (Three PTTs per call x five second duration, plus one additional second of time between PTTs = 16 seconds per call.) Therefore, it is estimated that each unit will make 10.64 seconds worth of calls per hour (665x16).

In addition to the above parameters, certain assumptions must be made in order to properly determine the channel count needed to support the desired GoS. To begin, one needs to account for roaming unit impact. This is vital given the fact that users will move about the general service area and potentially impact channel access demands on particular sites, thus, potentially affecting the GoS during that particular time. As such, there is the need to account for the possibility of roaming users from adjacent counties. The assumptions regarding roaming were assumed on the aggressive side to better guarantee a suitable channel situation at the sites in the event of massive emergency situations. The movement of users from adjacent counties was deemed most likely, with the potential for roaming reducing with the distance away from the focal site. Additionally, it was assumed that state agency users might have a higher potential for roaming more often and further than typical local agency users. This manifests itself in unique roaming attributes being assigned to state agency users and local agency users in the following calculations.. This process is illustrated in Figure 64 and accomplished as follows:

- Commence with the number of local and state agency radio users for a particular county
- Add the potential amount of roaming units. The potential roamers for a given county were determined as follows:
  - For all counties immediately adjacent to the county of interest, 25% of their combined current state agency user load plus 10% of their combined local agency user load was considered for roaming impact
  - For all counties that were one county removed from the county of interest (i.e. two counties away), within the same HLS&EM Region, 10% of their current state user load plus 1% of local agency user load was considered for roaming impact
  - For all remaining counties within the same HLS&EM Region, 1% of their current state user load plus 0.1% of local agency user load was considered for roaming impact
- An anticipated agency growth factor over the next five years is now factored into the loading values. The five year growth factors used were 15% growth for local agencies and 12% for state agencies. This new number is used as a county's system loading potential.

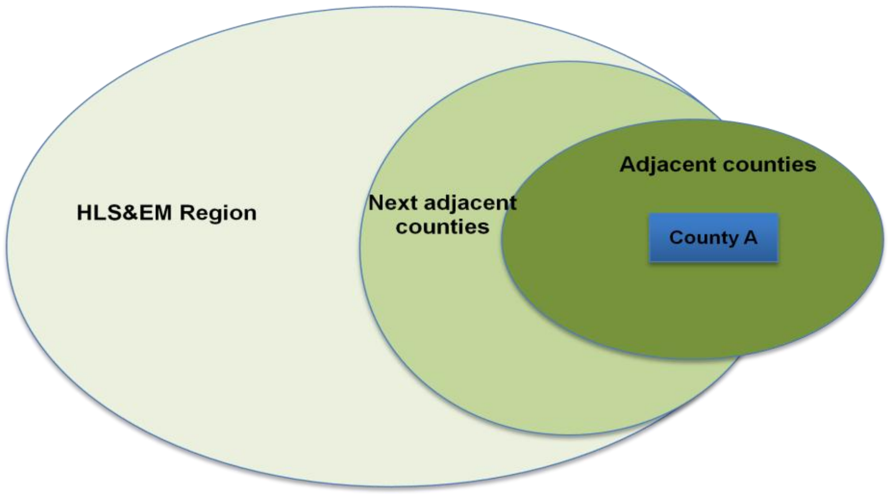

Figure 64 – Roaming units

Combining coverage analysis estimates with capacity estimates yields the talk paths needed to support the desired GoS.

The following is an example of Calhoun County Grade of Service calculations:

Table 7 – Calhoun GoS example

Grade of Service capacity calculations		
A. Total quantity of current user radios for Calhoun county	124	radios
B. Total Estimated Possible Roaming Units	226	radios
C. Current users + Roaming (A + B)	350	radios
D. Estimated expanded users + Expanded Roaming	396	radios
Channels needed to maintain less than 1% GoS	5	channels
Calculated GoS for the above quantities	**0.74**	**% GoS**

The above calculations show that five unique voice channels, spread out over the county's serving sites, should have enough capacity for the estimated expanded user counts plus roaming.

A list of channels required per site can be found in Appendix H.

8.3.6 Roaming and Mobility

The site loading expectations are impacted by the amount of roaming and subsequent mobility allowed of the radio user population. Here the term *roaming* refers to the ability of the radio unit to detect and register to compatible network sites, and the term *mobility* refers to the capability to extend normal communication services to coverage areas outside of a prescribed home set of sites.

The networked nature of the ISICS network now allows an easy means of extending the operational coverage area of a group or agency. Typically local agencies operate within a well defined local area of their home system. In the past when a user from one of these local agencies travelled outside of the normal jurisdictional coverage area, there would no longer be radio communication provided to that user. The user would not be able to initiate nor respond to radio communications for the home agency. (If properly equipped the user might be able to connect to a different radio system or mutual aid channel in the vicinity, and direct the call to be patched back to the user's home agency system.)

The ISICS network provides the ability for users to travel outside their normal jurisdictional coverage and still maintain communications with the home agency. Each user on the ISICS network is assigned a unique identity that is used to identify this user for each transaction that the user initiates on the network, and to identify the user as a unique target for pertinent communication. Each subscriber device will register on the ISICS network when it initially powers up and whenever it moves from one site coverage area to another site coverage area. This registration allows tracking of the subscriber device across the communication network coverage area, and can be used to determine which subscribers are currently active on the network. The registration information is used to appropriately route calls to this subscriber, that is, it determines which site of the radio network would have the greatest probability of connecting to this user.

The roaming user's subscriber device detects ISICS sites available in the vicinity and performs register operations on an available ISICS site. As part of the registration process the talkgroups that the user wants affiliated with this unit (e.g., home agency talkgroups) are registered with the network. Calls for the home agency for this unit would now be extended to this affiliated ISICS site, allowing the roaming user to hear and participate with the home agency as if it were still in the home jurisdictional area.

Roaming control

While support of seamless roaming and mobility is an inherent capability of the P25 trunked system, support of a large roaming subscriber population can have severe impacts on the local site and network wide communications operations. Roaming users from different home agencies congregating at a particular site could monopolize the local site resources and negatively impact the home users of this local site. Even if the roaming users do not initiate communications, the aspect of monitoring one of their home agency talkgroups at this roamed site uses local resources. There are also issues in normal processing of call requests when mobility across multiple sites needs to be considered. As members of a talkgroup roam to sites outside of the home site, the network will track the affiliation of the roamed site with this talkgroup and will include it in subsequent call processing for this talkgroup. A call for this talkgroup will require each of the affiliated sites be involved in the talkgroup. The call may not start until there is an available resource at each of the affiliated sites, even if there is only one roamed site that does not currently have sufficient channel resources to support this talkgroup call.

There are a number of potential schemes that can be employed to manage this impact of roaming users on the network.

Manage authorization of roaming

A fundamental scheme to control the impact of the roaming user population is to control which user identities are allowed to roam in the network. If a user is expected to generally perform normal operations only in a specific coverage area, then that unit should not be allowed to roam to a site location outside of that specific coverage area and expect to remain connected to the home coverage area communications. This can be accomplished with a list of preferred sites that the user radio will be directed to use. If none of the preferred sites are available but the subscriber device detects another ISICS site, it may attempt to register on that site but will not necessarily be able to monitor its current home communications.

Just as the subscriber units have authorization information to control their ability to roam, the sites can have authorization rules that are applied with a unit attempts to roam to that site. These authorization rules can cover the spectrum from denying any roamer activity, to allowing roamers on an emergency basis, to allowing full operation of the roamer on this visited site.

The local network manager for the user defines the user roaming authorization attributes to be used by the user subscriber device. These can be global attributes or specific to unique sites.

The local network manager for the site defines the roaming authorization rules to be used. These can be generally applied to all roamers, or can be uniquely defined for specific roaming user groups (e.g., home agency).

Manage mobility service offerings

A user may be allowed to freely roam across the ISICS sites, perhaps with a predefined preference for specific sites associated with the normal operational coverage area for the user, but the capability that the user has at each of the sites may be managed individually. For instance, the user may be allowed to participate in full home agency communications at any of the preferred sites for that user. This would mean that all current home agency calls would follow the user as they move about the set of preferred sites. For the sites outside of the preferred list, the user may request full service capability, but will be restricted to what the site is authorized to provide to the roaming user. There could be roaming agreements between the roamers home site and this visited site defining the level of operation to allow the roamed user. This again can cover the spectrum from denying anything but emergency service, to allowing initiation of home agency service, to allowing full operation of the roamer on this visited site.

The local network manager for the user defines the user mobility authorization attributes to be used by the user subscriber device. These can be global attributes or specific to unique sites.

The local network manager for the site defines the roaming authorization rules to be used. These can be generally applied to all roamers, or can be uniquely defined for specific roaming user groups (e.g., home agency).

Priority levels

The P25 trunked system provides the ability to assign priority levels to users or talkgroups. In this manner there is a hierarchy of access priority afforded. If two or more service requests are competing for a remaining channel resource, the service request with the greatest priority can be granted the channel resource, while other service requests are queued for the next available resource. This is a general mechanism to differentiate the normal day to day communications from the high priority emergency calls. Three priority levels are suggested to address both the normal and emergency categories of events, and to act as a means of controlling use of local resources by roaming users. The following are suggested priority levels:

- **Highest** – Emergency
- **Medium** – Normal
- **Low** – Roamer

This way the users of the agency when assigned the priority level of normal can generally first use the resources associated with a local agency. The roaming units currently affiliated with this local area, could be assigned the priority level of roamer, and would need to wait for the higher priority service requests to be processed prior to their service request. Of course the priority levels can be adjusted as need and operations dictate. If a roaming user or group is to be given equal access to the local site resources, then they could be assigned as a normal priority level.

Shared roamer talkgroup

Additionally, to conserve the number of resources that can simultaneously be operated by roaming users, the roaming users can be assigned local "roamer" talkgroups that are shared by a number of current roaming groups at this site. The standard mode of operation to handle a roaming talkgroup is to treat that talkgroup as an equal participant on the site. That talkgroup would be assigned a resource for its sole use to participate in calls for that group which span the ISICS network. The roamer group assignment would be shared by all the roaming users that do not have the authorization to be assigned a unique roaming talkgroup at this site. In this way a single channel resource would be used by the roaming traffic in that site. The negative aspect of this approach is that the channel is acting like a community repeater channel in which all the groups would hear the activity for the other roaming groups active on this site. When it becomes critical for a roaming group to have access to the resources of the site without sharing the channel with the other roaming talkgroups, this roaming talkgroup can be granted access to this site using a unique talkgroup only associated with that roaming talkgroup, and thereby separating itself from the collective roamer talkgroup.

Home call processing with roamer consideration

Allowing mobility for a talkgroup can at time encounter the situation of blocking a new talkgroup call request because one of the affiliated sites for the talkgroup membership currently does not have an available channel resource for the call. If a talkgroup member at this blocked site is important to the call, then it is necessary to include that site in the call coverage, but this is not always the case. Special consideration should be given to alternative blocked call process schemes to handle multiple site situations. Some possible considerations are:

- Process the call even though all sites are not included (potential to miss a portion of the communication at blocked sites)
- Process the call if a prescribed set of necessary users are included (e.g., dispatcher, agency leader)
- Process the call if a prescribed set of necessary locations are included (e.g., home site)
- Reclaim currently assigned resources at the blocked site to assign to this call

8.4 ISICS Wireless Data Network Design

8.4.1 Candidate Technologies

Six primary technologies were considered for this system design: P25 data, 3G cellular, 2.4 /4.9 GHz Wi-Fi, 2.5 GHz WiMAX and 700 MHz LTE. Each of these technologies has various advantages and disadvantages that were considered for a wireless mobile data network for the State of Iowa.

P25 Data

In addition to the voice service support, the P25 trunking standard offers data support over a 9.6 kbps raw rate data channel over the radio network. The data packets can be encrypted using the standard supported encryption schemes similar to the voice encryption. During a voice call, the data transmission can be moved from a data channel to sharing the channel being used for the voice call to support simultaneous voice and data operation. The data throughput on the shared voice channel is limited, with supplemental data signaling supported from/to a user of only around 100 bps. This limited mode data signaling allows the user to participate in ongoing voice calls while still transacting some supplemental data operations, instead of requiring separate radio devices to allow the user to be simultaneously on a voice channel and a separate data channel of the radio network.

This narrowband data solution does not address the high bandwidth needs of a broadband solution, but it does offer a number of key general advantages. First, this solution is integrated with the P25 voice solution, thereby essentially sharing the coverage area of the voice solution. This is a standards-based solution that works with the voice channel allocations, and as such does not require special infrastructure equipment. Since this service integrates with the voice service, there is the potential to support voice and data operations with the same radio device.

A higher capacity Mobile Data Service is available through the use of larger bandwidth channels in the 700 MHz band. Here 25 kHz channels are used to essentially construct dedicated data channels of 100 kHz bandwidth or more. These wider channels can support data throughput orders of magnitude greater than the integrated P25 data solution using the standard 12.5 kHz bandwidth channel. The data service on these channels is separate from the voice service, but can be supported by a common radio platform. Simultaneous voice and data operation requires separate radio devices for the voice and data operations.

While the P25 integrated data solution is not one to address the needs of high bandwidth data, its extensive coverage capability and native integration with the voice services makes it a common element and low tier offering for the total wireless data solution.

3G Cellular

The 3G cellular networks offer a ubiquitous footprint in Iowa, and support seamless mobility. While the throughput for the data service is far less than a broadband network, typically falling in the area of 300-500 kbps, there are a number of major issues which make this a poor choice for dedicated public safety use.

A key concern with the 3G cellular systems is not technical, but deals with the fact that the cellular network is a commercial endeavor that aims to satisfy the largest segment of paying consumers. There is no special classification for the user set of public safety users, thus the public safety users must contend for data service with the other commercial cellular users. Additionally, the cellular networks have classically been nearly unusable during emergency or disaster events, with the demand for service from the commercial users far exceeding the capacity of the networks. This inability to use the network especially in time of need is counterproductive to the public safety operational need.

Latency can be very high on 3G systems compared to fixed line systems. Where this might not be an issue for applications like instant messaging and email, it could very well be an issue for applications like streaming video.

The current 3G implementations do not support differentiated services that would allow for prioritizing different grades of users or services on the network. Without this type of a mechanism, the "best effort" approach is used for all data processing and can severely impact the operational value of demanding data functions like full motion video.

Generally the interests of commercial service providers are not aligned with the interests of public safety agencies, and a commercial service provider is unlikely to meet the long term goals of public safety data use. A commercial service provider's primary focus is gaining revenues from subscribers, and the State would be viewed as just another group of subscribers for additional sources of revenue. The interests of State public safety are not a priority of the service provider, so the public safety agency will have no control over coverage areas, backhaul capacity, network expansion or technologies used. This, along with relatively low system capacity due to commercial over-subscription, will limit the types of applications and services that can be implemented. This technology was not chosen as a solution for the public safety high bandwidth data needs of Iowa.

2.4 GHz Wi-Fi

The most common wireless data technology today is 2.4 GHz Wi-Fi. Wi-Fi can be found in laptops, phones, PDAs and other devices to allow these devices to connect to any Wi-Fi network. The 2.4 GHz spectrum that Wi-Fi typically operates in is an unlicensed spectrum with very low power output requirements set by the FCC. Operation in unlicensed spectrum is highly undesirable for Public Safety use. The data rates that can be achieved with Wi-Fi, however, are very high which makes it very useful for high bandwidth applications such as large file transfers and streaming video. Because of the low power output, application of the technology is relegated to small coverage areas, the primary uses for Wi-Fi is typically in-building or in fixed outdoor places such as parking lots. Municipal-wide, ubiquitous Wi-Fi networks have been built, but these networks are typically plagued with high latency and low available backhaul, rendering these networks nearly unusable. The relatively small coverage area of an access node for Wi-Fi results in a very large number of access nodes required providing even a modest regional coverage area. A statewide endeavor would require the deployment and management of tens of thousands of access nodes. It is for these reasons that Wi-Fi was not chosen as the technology for a wireless mobile data network.

4.9 GHz Wi-Fi and WiMAX

Another technology solution is Wi-Fi or WiMAX operating in the 4.9 GHz frequency band. This portion of the radio spectrum has been allocated by the FCC as licensed spectrum to public safety organizations. This is a major advantage over 2.4 GHz Wi-Fi since licensed frequencies are not impacted by interference as much as unlicensed frequencies. The data rates that can be achieved with 4.9 GHz equipment are also very high. Unfortunately, the same low power limitations have been required by the FCC making 4.9 GHz Wi-Fi suitable for short distances only, measured in feet, similar to 2.4 GHz Wi-Fi. While the public safety designated 4.9 GHz spectrum would seem ideal for public safety data network use, the limited power and range associated with using this spectrum has a limiting effect on the deployment of wide area broadband systems operating in this frequency band.

There are currently several 4.9 GHz spectrum license-holders throughout the State of Iowa, listed in Table 8 – 4.9 GHz license holders in Iowa. While broadband data applications are supported, most of these instantiations are used for point-to-point links and not supporting mobile data users.

Table 8 – 4.9 GHz license holders in Iowa

Black Hawk County E911
Cerro Gordo County
Charles City Area Development
City of Bettendorf
City of Cedar Rapids
City of Davenport
City of Des Moines
City of Indianola
City of Marshalltown
City of North Liberty
City of Sioux City
City of Waukee
Delaware County
Dubuque County 911 Center
Iowa Homeland Security Region #5
Plymouth County
Polk County
Poweshiek County
Tama County Sheriff
Waterloo Police Department

The lower power outputs make this technology virtually unusable for a statewide or wide area wireless mobile data network.

2.5 GHz WiMAX

WiMAX is a successor technology to Wi-Fi and has higher power outputs that allow for much more distance to be covered than Wi-Fi. Initially, WiMAX was specified as a fixed, not mobile, technology. This was changed to allow WiMAX to accommodate mobile clients, making it a choice by some cellular carriers (e.g., Sprint) for their 4G networks. WiMAX can operate in several different frequency bands such as 2.5 GHz, 3.65 GHz and 4.9 GHz. The primary choice, though, is 2.5 GHz because of the higher power output limits.

700 MHz LTE

The newest technology for wireless mobile data networks is Long Term Evolution (LTE). LTE is the favored technology for service providers' 4G networks. The primary frequency band that LTE is operating in is 700 MHz, which is the spectrum recently acquired by major service providers. The 700 MHz band is attractive for mobile data networks because of its long range and good building penetration compared to 2.4 GHz and 4.9 GHz Wi-Fi and 2.5 GHz WiMAX. Part of the 700 MHz band, the D block, is set aside for a nationwide public safety wireless mobile data network. The goal of this network is to achieve nationwide coverage and have an interoperable network. Since the primary technology being developed for the major service providers is LTE, it is likely that LTE will be the chosen technology for the D Block public safety network. In June 2009 press releases from the Association of Public-Safety Officials (APCO), the National Emergency Number Association (NENA) and the National Public-Safety Telecommunications Council (NPSTC) all endorsed their support for LTE as the technology of choice for a nationwide interoperable public safety network.

A summary of the candidate data solutions is shown in Figure 65 – Summary of candidate data solutions. Since 700 MHz LTE has such a large coverage area (when compared to other wireless data solutions), high data rates, and is the current favored technology by service providers and public safety organizations, it was chosen as the recommended technology for a wireless mobile data network in Iowa.

	3G	LTE – 4G	WiMAX – 4G	WI-FI	P25
Avg Data Rate	700 kbps	10 Mbps	5 Mbps	12 Mbps	6 – 25 kbps
Peak Data Rate	3.1 Mbps	20 Mbps	15 Mbps	54 Mbps	<100 kbps
Frequencies	1.8 GHz 1.9 GHz	700 MHz	700 MHz 2.5 GHz 4.9 GHz	2.4 GHz, 5 GHz / 4.9 GHz	700 MHz
Cell Size	medium	Medium	medium	small	large
Licensed	yes	yes	yes	no / yes	yes
Potential Technology Deployment	Statewide	Statewide	Statewide	Local	Statewide

Figure 65 – Summary of candidate data solutions

8.4.2 Wireless Broadband Data Solution

The ISICS wireless broadband data solution is optimally a dedicated public safety overlay data network that can follow the general coverage contour of the ISICS radio network. This broadband data solution employs the 3rd Generation Partnership Project (3GPP) standard, commonly referred to as Long Term Evolution (LTE) system technology, and occupies the 700 MHz D Block band allocated for public safety broadband service. LTE can operate within a variety of channel sizes in this band and can reliably provide 5 Mbps to 20 Mbps to the mobile client. The ISICS broadband data solution may assume the form of a dedicated Iowa state-owned public safety broadband network, or a commercial broadband data offering that supports dedicated service for Iowa public safety users. (This is in contrast to a commercial broadband data offering that only provides service acess to public safety users as it would to any other system customer, and does not afford special broadband access and operability to the public safety user population.)

System Components

The primary components of an LTE system are the base station, access controller, Authentication, Authorization and Accounting (AAA) servers, and data service servers. The access controller along with the AAA functions provides the overall management of the user access to the LTE network. The base station is the interface between the compliant LTE subscriber devices and the data network. Various data services are available to the LTE data users as data network servers.

At a three-sector tower site, a base station will connect to each of the three sector antennas on the tower. Each antenna will connect directly into a slot on the base station with no splitters or multiplexers. The base station will then connect to the ISICS transport network using an IP network connection. Each of the base station sites is connected to the access controller (ASN-GW) via the IP transport network. The access controller controls access to the network, as well as configuration of the base stations. The controller also handles subscriber routing and mobile client system access on the network. Before access is granted to a mobile client, the following authentication is performed:

- Each client device has a unique identifier, or Electronic Serial Number (ESN), that must be recognized by the access controller to allow access to the network
- Each user on the system must enter log on information that must be verified by Iowa's authentication servers

Each data application server that will be accessed on the LTE network will be connected logically via the IP network to the LTE network and does not have to be physically connected to the access controller or to any other piece of the LTE network.

Coverage and Spectrum

Each base station provides coverage over approximately a two-mile to a six-mile radius, depending on factors such as terrain, foliage density, buildings and other structures. This would cover an area 12.5 square miles to 113 square miles. A base station can support hundreds of concurrent client device connections and allows client devices to seamlessly roam between base stations..

Base stations are typically implemented with three sector antennas. Depending on the amount of spectrum available, each sector may have its own channel. Mobile clients connected to that sector use the same channel; it is not necessary for each client to have its own channel. This is possible through the use of LTE's Time Division Duplex (TDD) technology. Time slots are given to each client in the same channel; no two clients are transmitting at the same time to the same sector. The blocks in the 700 MHz D Block spectrum have two 5 MHz channels available.

LTE uses different modulation formats to adjust for degrading signal conditions. The formats are QPSK, 16QAM and 64QAM, with QPSK having the lowest data rate and 64QAM having the highest data rate. An LTE base station and client will dynamically change modulation formats to maintain a data connection when signal conditions degrade.

Testing and Performance

A number of LTE trials have been conducted by the LTE/SAE Trial Initiative (LSTI) with non-D Block equipment showing smooth handoff between LTE cell sites at highway speeds using an uninterrupted High Definition video conference as the test application. The test achieved 100 Mbps upload and 50 Mbps download throughput results (under excellent radio conditions and with a single user in the cell).

There are a number of LTE products that are undergoing trials from major telecommunications equipment vendors Nortel, Nokia, Ericsson, Alcatel-Lucent, and Motorola. Since LTE is a global standard expected to achieve at least the same footprint as the Global System for Mobile Communications (GSM) family standards in deployment worldwide today, it is expected that significant economies of scale will result in the availability of many low-cost *interoperable* LTE end user devices.

Multiple Wireless Networks

Until the availability of a ubiquitous LTE broadband wireless data network to provide both the coverage and data rates necessary, it is assumed that multiple wireless data networks will be used. There are already low speed narrowband data networks, cellular services, 4.9 GHz networks, and commercial services in use in various areas throughout Iowa. To handle the multiple networks, a physical device functioning as a mobile router or a logical software switch on the data device (e.g., laptop computer) will be needed to control and maintain connections to the different wireless networks.

Low speed, wide area networks like P25 data can be used for low bandwidth applications such as AVL, Computer Aided Dispatch (CAD) and text messaging. These networks cover an area very similar to the voice network.

On the other hand, high speed networks, such as a 2.4/4.9 GHz Wi-Fi “hotspot” networks can support almost any application. They work well for streaming video and administrative updates to computers. These networks cover a very small area, measured in feet, but could be leveraged in areas like police stations or fire stations.

A public safety LTE network may not initially have the coverage area of the public safety voice network, but it is much larger than a hotspot. Data speeds are also much higher than the integrated voice and data wide area network and can be comparable to a hotspot network, supporting virtually the same applications as a hotspot network.

In order to achieve a cost effective solution for wireless data, there needs to be a balance between wide-area low speed and mid-area high speed solutions. With this approach, an overlay of different wireless data services can be used in conjunction with the wireless mobile router and/or software switch. The collection of wireless data services may include commercial offerings of LTE that can support the public safety user needs. While the ultimate goal is the availability of high throughput data service, this is not always feasible and as illustrated in Figure 66 – Wireless data overlay, a layered approach will increase the availability of data services throughout the State.

In this layered approach an ISICS user shall have access to the narrowband P25 integrated data service as a minimum across the entire coverage area, and can be accessed for typical data activity. There will be areas of the ISICS coverage that also support higher speed data services that can be accessed by the ISICS user to transact higher speed data activity. These higher speed data services may be provided by commercial/private/public wireless data networks, or from the ISICS broadband data network. The use of the mobile router allows for a seamless transition between these different data services for the ISICS user.

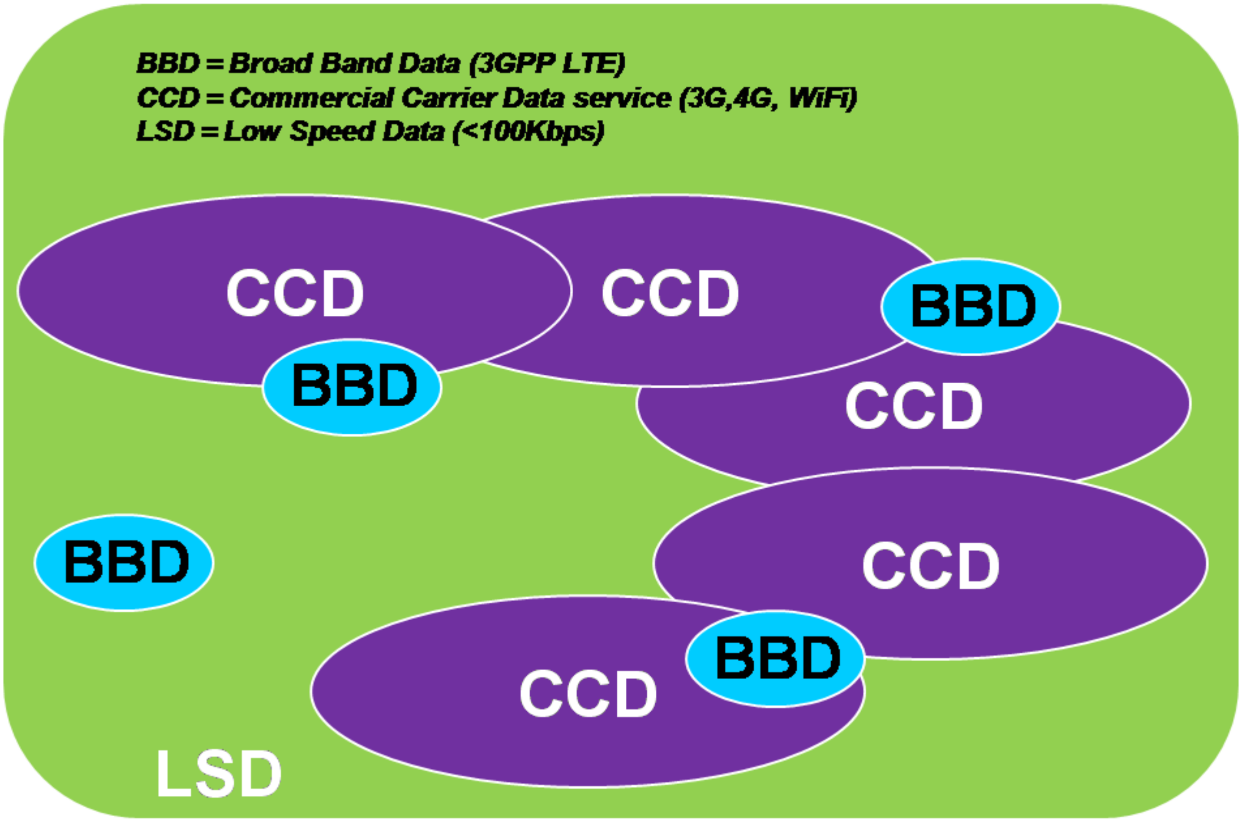

Figure 66 – Wireless data overlay

Applications on the mobile client use a software-based switch, or mobile router, to select connections to multiple wireless data networks, such as low speed data offering of public safety P25 integrated voice and data solution, commercial carrier data offering of a Wi-Fi hotspot or 3G, and broadband data offering of the public safety LTE solution. As illustrated in Figure 67 – Mobile router, the switch is configured for each wireless data service, enabling the mobile client to roam between the different networks with no user intervention.

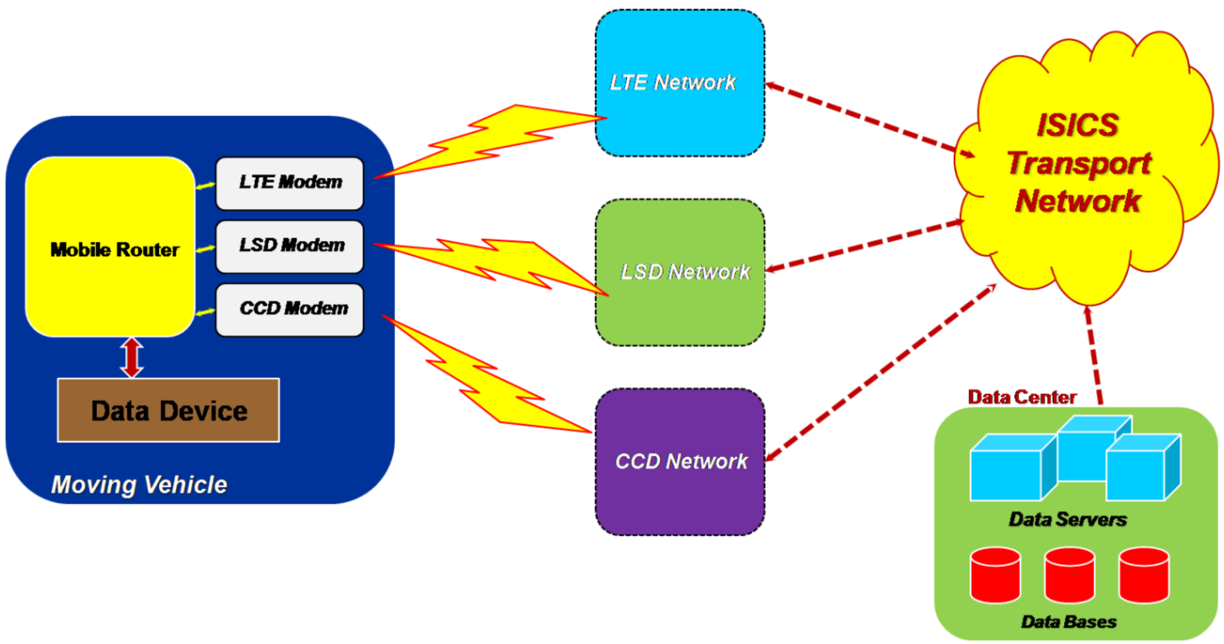

Figure 67 – Mobile router

The mobile router automatically limits the use of an application over certain network types, preventing applications that require higher bandwidth (e.g., Tier 2 and above) from using the low bandwidth (Tier 1) wireless data service. The mobile router sets up a virtual private network (VPN) session enabling mobile client applications access to databases and other services on the host local area network (LAN). Since the mobile router retains logon information for each wireless data service, users do not have to log on each time the mobile client connects to a new network. The mobile router maintains VPN connectivity after a user roams between wireless data services. Even after roaming to another wireless data service, the mobile router maintains an application's connection to databases and other services on the host LAN. Server-based network administration software, residing on the host LAN, provides remote control and management of the mobile router software. The VPN also provides data security and encryption services. The overall goal is for the wireless data user to gain access to data services made available to public safety personnel regardless of the wireless data network available at the time.

LTE transport network needs

Substantial backhaul capacity is required for each LTE base station to support high bandwidth applications. A baseline for backhaul requirements is 1 Mbps per user on each base station or 15 Mbps, whichever is greater. It should be noted that this is the equivalent of 10 T1 connections. Backhaul support of these large bandwidth demands can be accomplished via network segmentation and ICN interconnectivity to offload the heavy data traffic associated with real time video.

The LTE system will require a supporting IP-based backhaul infrastructure with a minimum bandwidth capacity to support the peak number of users. As an example, it can be stipulated that the total number of users in Polk County would be approximately 850, with 561 peak users[4]. There are many different types of data traffic, and with each there is a certain amount of bandwidth required. Simple web browsing and database queries are common uses of data and require very little bandwidth, but streaming video can require much more bandwidth. Since there are many types of data traffic and different ways that applications can be used, it can be difficult to allocate a specific amount of bandwidth per user. Experience has shown that in service provider subscriber networks with over subscription, users are typically allocated hundreds of kilobits of bandwidth. Since a public safety network is much more demanding and critical than a typical subscriber model network, a recommended minimum amount of backhaul for the county would be 1 Mbps per user. It is assumed that 5-10% of the capable data users in an area will be participating in a data session. With a population of 424,778[5] in Polk County, and an estimated worst case number of 561 possible peak concurrent users in the area, the LTE wireless data system for the County will require about 14 Mbps to each base station. It is recommended to overbuild the backhaul infrastructure to accommodate future growth.

The initial deployment of the broadband data network targets usable coverage in the major metropolitan areas, major roadways, and specifically identified locales throughout the state. In areas where the broadband data coverage is minimal or not available, the high speed broadband data services, if available at all, will be processed as a slower throughput data service across the integrated data service of the radio network.

<u>LTE client devices</u>

Currently, the client devices are not external modems similar to the low speed, wide-area network modems currently used by public safety. Laptop cards will be available for connecting the mobile clients to the LTE network. These laptop cards will be similar to the PCMCIA cards used with service providers' networks, like the Verizon or Sprint cards. Both the Verizon/Sprint cards and the LTE cards can be connected to the laptop at the same time. The LTE card plugs directly into the laptop and there are currently no

[4] Total user counts are based on two units for every 1,000 population, for a given geographic area; 66% of each count will be assumed for total concurrent system users. Counts used are based on estimated 2008 census data.

[5] 2008 estimated census data

external parts to the system. The radio and antenna are integrated into the card, but could provide for an external antenna if manufacturers see a demand for it.

8.4.3 Paging

Paging was indicated as a popular data application in current agency operations. Migration to P25 digital modulation schemes does not support the traditional tone paging systems. The vocoder technology in P25 is optimized for voice and does not guarantee the tone fidelity that is needed for reliable tone-activated paging. No tone and voice pagers using P25 digital modulation are available.

There are number of possibilities to satisfy the paging function need for the various public safety agencies:

- Retain the current paging service and equipment, and possibly upgrade voice paging to alphanumeric paging. (This could afford better reliability and the ability to review past page information. This is compatible with CAD operation.) If the equipment is functioning on frequencies below 512 MHz, there will be the need to transition to a solution that meets the FCC narrowband mandate for 2013. A separate voice call could be placed over the ISICS voice network to the appropriate talkgroup of subscriber devices for the agency being alerted, or directed to an individual user of that agency (private call); there would be no direct relationship between the page information and separate voice call other than verbal indication from the dispatcher.
- Use a text messaging function over a cellular provider. This would be similar to the alphanumeric pager operations, but would be using the user's current cellular device and not require an extra paging device. The text message function can be used by the CAD system for dispatch operation. A separate voice call could be placed over the ISICS voice network to an appropriate agency talkgroup of subscriber devices being alerted, or directed to an individual user of that agency (private call); there would be no direct relationship between the page information and separate voice call other than verbal indication from the dispatcher.
- Use a text messaging function over the ISICS data network. This can be accomplished over the entire coverage area of the ISICS network. This would be similar to the alphanumeric pager operations, but would require the users to have their ISICS subscriber device available. A separate voice call could be placed over the ISICS voice network to appropriate subscriber devices for the agency talkgroup being alerted, or directed to an individual user of that agency (private call).

- Directly use private call/call alert trunking functions over the ISICS voice network. As an alternative to classic two-tone paging, the trunked systems offer the Private (individual) Call and Call Alert call types, which may be used to supplement or replace the voice paging operations over trunked radio systems. The Private Call is a dispatch call that addresses a single user on the system and allows a confidential voice conversation between the call initiator and that individual. The Call Alert function allows alerting an individual on the system that someone (typically the dispatcher) wants to speak to them. If the target individual is available, then the answer function will allow a call to be established on a voice channel. If the target is not capable of answering the call request at this time, there will be an indication of the call attempt and allows the called party to answer the call later; this is akin to the Caller ID function on telephone services, which allows you to see who has called and allows you to initiate a return call to the initial caller. A separate voice call could be placed over the ISICS voice network to appropriate subscriber devices for the talkgroup for the agency being alerted.

If the need is to page the individual when they are not in possession of a suitable ISICS subscriber device, then obtaining dedicated paging service from a private or commercial paging system, or replacing the paging operation with a text message function targeting a portable data capable user device (cellphone, PDA, etc.) is advisable.

8.5 Dispatch Network

The ISICS E911/dispatch network is actually separate networks that are interfaced by the dispatch operator at the public safety access point (PSAP). As illustrated in Figure 68 – ISICS and 911 networks there is the front end E911 network, and the back end ISICS radio network. The front end E911 network currently uses 911 trunks on the public switched telephone network (PSTN) and in the future will rely on an IP centric network for Next Generation 911 (NG911) operation. The back end network currently interconnects to the desired repeater to monitor activity of field radio units, and to transmit dispatcher information to the field radio units.

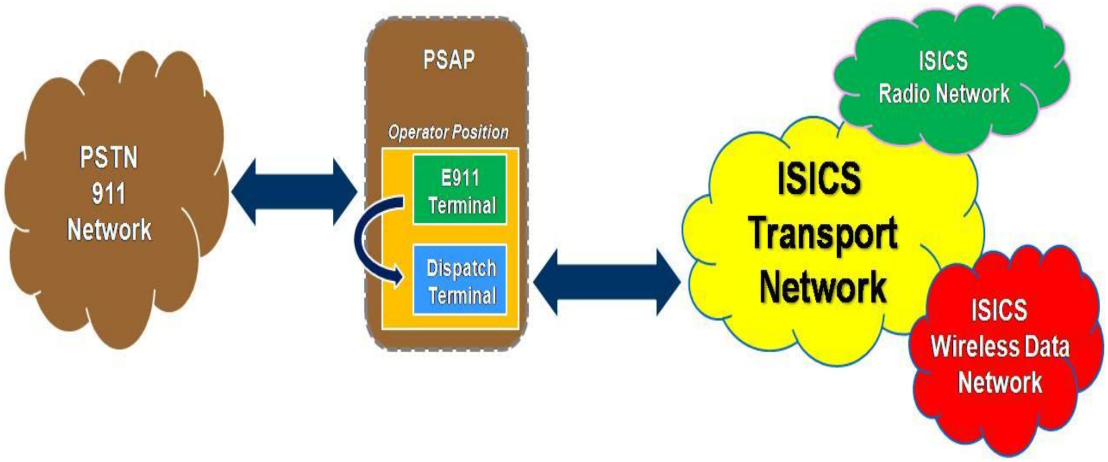

Figure 68 – ISICS and 911 networks

In the ISICS Network, the dispatcher position assumes the role of an active, uniquely identified member of the ISICS network, and interfaces to the ISICS radio network and wireless data network via a standard IP-based interface. In this fashion each operator position is essentially treated like a radio user, but with special capabilities and authorization over the typical radio user. Since the transactions between the dispatch operator and the radio network are not transacted via RF paths, the availability of the operator position is relatively constant.

The dispatch center is treated in a similar fashion to a radio site in the ISICS network; that is, radio users (operator positions) are tracked to this location (dispatch center) with each dispatch center being connected to a bearer controller in the ISICS radio network. Similar to other radio users, each operator position can be affiliated with one or more talk groups and can then monitor and initiate activity in the affiliated talkgroups. The major physical differences between the dispatch center and radio sites are that the users of the dispatch center generally are stationary (e.g., do not move to other dispatch centers), and that the connection between the dispatch center users and the ISICS network is via an IP path through the ISICS transport network. Even though the operator positions currently are relatively stationary, support of mobility of operator positions for future flexibility is an inherent feature of the ISICS network. Since the operator positions are treated as radio identities on the ISICS network, there is basic support for moving an operator position (identity) from one dispatch center to another, as easily as a radio unit moving from one site to another.

Each operator position is assigned at least one unique radio identity on the ISICS network. The radio identity is used to uniquely identify the operator position initiating a service request. The identity is used to verify appropriate authorization and capability to make the service request, and is used in the subsequent service grant information to the dispatch positions and other appropriate radio field units.

As IP technology becomes more pervasive in the civilian user community there will be more opportunity for standard voice centric E911 calls to become supplemented with non-voice information. The potential for text, images, and streaming video are becoming available to wireless and IP-telephony devices. As Next Generation 911 becomes a reality there will then be an IP network conduit into the PSAPs allowing free flow of the voice and supplemental data information. The dispatch operator can use this information to appropriately dispatch and inform field units of specific event particulars. Additionally, some or all of the received supplemental data can be made directly available to the field units. The operator positions are members of the ISICS Broadband Data Network and as such have the ability to transact data messages to radio units in the field, or other dispatcher positions. There is also the potential for the operator positions to access authorized external IP networks to allow appropriate interaction to facilitate dispatch functions.

8.5.1 Next Generation 911

It is expected that the NG911 system architecture will be based on open, non-proprietary standards and technology. While standards for NG911 remain undefined, adaptability and flexibility will remain major considerations. Such flexibility will support upgrades to the architecture as IP data standards related to 911 networks evolve.

The overarching goal of NG911 is to provide a more direct capability to request help and share critical data with emergency responders from any location and any communications device. In addition, call takers at the PSAP will be able to transfer emergency calls to other PSAPs and forward the location and other critical supplemental data, such as text messages, images, video, with the call. Interfacing the NG911 network with the ISICS system would allow for these data element to be forwarded to first responders in the field.

Emergency response increasingly requires seamless voice interoperability across dissimilar systems and the ability to exchange relevant data across many functional or operational boundaries, i.e., across a city, across professions, and across regions or states. While an incident may be purely local, event data or knowledge necessary to respond intelligently may reside elsewhere. Nowhere is this truer than in a major terrorism incident or other mass disaster where the numbers of responders, victims and issues are most likely to be large.[6] Managing events that require multi-agency responses by augmenting voice communications with data services will have a defining impact on accuracy and efficiency.

Traditional emergency communications have been voice-focused while "data" meant entering information into a computer system after an event or incident. Real time data sharing to support incident response has become more common in recent years, but almost always is limited and confined to the members of a particular profession (e.g. police or fire mobile data units communicating with their headquarters and then to distant data bases for limited purposes, e.g. NCIC)[7]. However, advancement in data technologies, demands of homeland security and new commercial products which produce data for emergency response are changing emergency response agencies views to the way information is shared.

While the sharing of information and interoperable communications are critical components of an effective emergency response, there needs to be an infrastructure in place to support this need. Nevertheless, the current E911 system relies on telecommunications service providers for routing calls to the appropriate PSAP with systems created in the 1970s and designed for the preeminent media of the time, voice, and as such cannot handle the challenges of multimedia communication in a wireless, mobile society. Today's communications environment demands a technology solution based on today's IP centric and standards-based world.

US DOT NG911

The US DOT has undertaken the development of the Next Generation 911 (NG911) system to accommodate this changing communications environment. Text, data, images, and video are increasingly common in personal communications and are critical to future public safety advances. The NG911 initiative leverages progress from the Secretary of Transportation's *Wireless E911 Initiative*. The NG911 project establishes the foundation for public emergency services in a wireless environment and enables an enhanced 911 system compatible with any communications device.

The US DOT's core vision for NG911 is that this new "system of systems" will provide the foundation for public emergency services in an increasingly mobile and technologically diverse society and ultimately enable Enhanced 911 (E911) calls from

[6] Network Reliability and Interoperability Council VII, Future Emergency Communications Architecture by 2010, Focus Group 1D, December 6,2004, pg12

[7] *US Dept of Homeland Security, SAFECOM Statement of Requirements issued 2004, Volume 1, v1.2, section 4.4 pg 14*

most types of communication devices. While standards for NG911 remain undefined, implementation of such a system should allow for the following:

- Faster and more robust information delivered to both responders and the general public as the result of making a 911 call
- Better and more useful forms of information (text, images, and video) from any networked communications device
- Greater transfer capability of 911 calls between geographically dispersed PSAPs and from PSAPs to remote public safety dispatch centers if necessary
- Increased aggregation and sharing of data, resources, procedures, and standards to improve emergency response
- Promotion of increased coordination and partnerships within the emergency response community[8]

The US DOT's NG911 project will enable the real time sharing of information across the processes and functions of fixed enterprise and mobile environments to make emergency response more informed, safer for the participants, and more effective in outcomes. The primary guiding principle in this effort is to empower emergency staff by providing access to information needed, where it is needed, and when it is needed. While this goal is in line with the ISICSB vision of interoperability, the ISICS itself will not serve as a NG911 platform. Nevertheless, the ISICS network is to provide a means for sharing content rich information that such a system can provide with radio users throughout the network.

It is of critical importance that the ISICSB understand what the future of 911 has to offer and prepare for the future implementation of NG911. While these standards are yet to be devised, it is clearly understood that the system must permit future technologies to be woven into the system without requiring wholesale replacement. Although future advances in technology cannot be predicted with certainty, the design principles of the system support quick adaptation of emerging technologies. The system needs to support "plug and play" functionality of new devices or applications that meet the design standards of NG911, either through existing IP access networks or directly to the Emergency Services IP network. The NG911 System design must also support the diverse nature of PSAPs throughout the state.

[8] NG 911 System Preliminary Concept of Operations, December 2005, section 1.7

While there are many functional interfaces into the NG911 network, this document will focus on the three primary interfaces and associated services that provide for agency interoperability.

Legacy E911 network support

Most PSAPs throughout the State of Iowa interconnect to the E911 network via a legacy architecture that is based on circuit switched technology – developed in the 1970s. Legacy technology includes wireline, wireless, and Voice over Internet Protocol (VoIP) devices connected through existing telephony switching and routing technologies to non-IP-enabled PSAPs.

Legacy 911 networks will continue to produce traffic and must be connected to the NG911 network to allow for transparent interconnection between basic and enhanced 911 callers and the NG911 network. As such, interconnection to the legacy 911 access network will be required for a Next Generation system. This is illustrated in Figure 69.

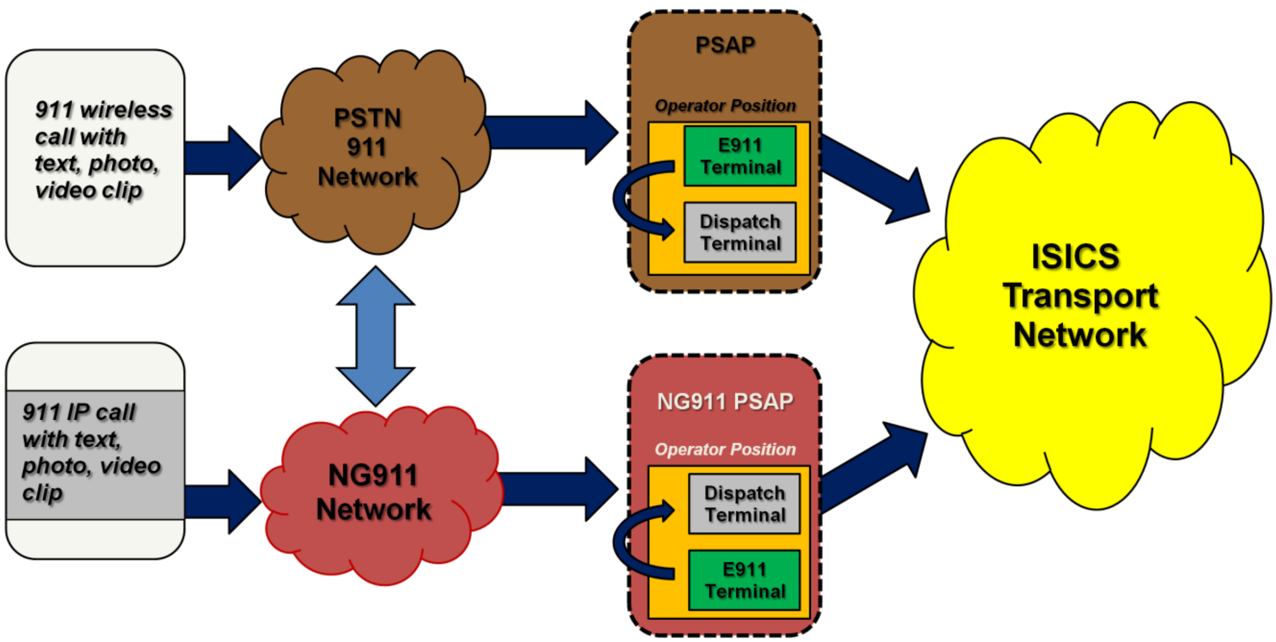

Figure 69 – PSAP to 911 network interface

The Legacy Access Network is primarily made up of centralized automated message accounting (CAMA) trunks that are configured to directly access the PSAP from a tandem office. The legacy network is built with traditional PSTN-based circuits. Enhanced 911 service was created when selective routers were added to route calls to the correct PSAP. These selective routers are owned and maintained by individual telecommunications companies and are typically assigned to large geographic areas.

IP-based NG911 network support

While today's legacy E911 architecture follows a rigid structure imposed by yesterday's technology, the next generation network consists of an IP core that will enable end-to-end seamless delivery of traffic throughout the network. The entire NG911 architecture is based on Internet Engineering Task Force (IETF) ratified standards throughout the design. This ensures a standardization of network structures, data, and routing protocols.[9] This is important for all services and agencies related to an E911 response since it will provide for a more robust network design that supports better information about the incident and provides the information in a timely manner. In addition, it will also allow for greater transfer capability between PSAPs to link ancillary responses to the incident. As participating NG911 networks become more common, the ability to connect seamlessly across several diverse backbone connections is vital to providing an end-to-end solution. A network built on the concept of an IP-enabled system of systems will provide flexibility in connecting NG911 partners and will efficiently route information across the system.

Data sources are grouped into two major categories: Public Source and Private Source. The following section provides some practical applications for real time data that might aid in an emergency response as issued in the FCC NRIC VII Report.[10]

Public Sector Source

- Real time video from mobile phones forwarded to first responders
- Hazmat alarms from fixed facilities which should include location of facility, hazmat material location, temperature information, live video feed to responders and PSAP, and any alarm triggered equipment response at the facility such as flushing, ventilation or release of cleanup or anti hazmat system
- Automated Extended Defibrillation (AED) activation information when available and if patient is monitored at home, all data on the patient including past and current condition and any allergies
- Ability to automatically receive power outage information in the PSAP and at the field level consisting of a map showing coverage of the area affected
- Remote access to interior video surveillance cameras by exterior responder units

[9] US DOT NG 911 Architecture Analysis Report, Version 1.0 | November 2007, Pg 76

[10] Network Reliability and Interoperability Council VII, Future Emergency Communications Architecture by 2010, Focus Group 1D, December, 2004

Private Sector Source

- Telematics information (e.g. On Star or ATX) to include the number of occupants, speed upon impact, position of the vehicle (roll over), air bag status, load information (hazardous materials)
- Weather information associated with a crash site
- Ability to display and relay hazardous materials plume data associated with a hazmat spill or incident
- The ability to map the location of a missing at-risk person (Alzheimer patients), missing children, and probation/parolees with electronic monitors
- Burglary alarm call information should include location and facility information receive live feeds from a camera inside the structure in both dispatch and the field during the course of the event (from activation till closure of the call)
- An electronic manifest showing contents of a vehicle involved in an accident with connectivity to electronic DOT Hazmat Response Guide information in both the field and dispatch

NG911 to ISICS interface

The NG911 system will allow interconnectivity into the ISICS network and enable the transfer of NG911 data through the IP network out to the responders in the field. Among the benefits of this type of system is that every resource connected to the network will be visible to every other resource. That will be a tremendous asset to E911 dispatchers and field responders alike.

In addition, the ability to create a transparent system of systems without relying on a particular type of equipment, device, legacy system or protocol is very beneficial in the NG911 design. The primary focus is to allow access into the network from any device and transfer that information through the system to a call taker or responding field unit. This is important to responders and PSAPs alike because it would provide more robust and useful information for 911 and field responders, increase the coordination of response agencies for more effective outcomes, and allow for more capabilities to transfer event information to agencies that need it. The following section provides some practical applications for real time data in the field[11]:

[11] Network Reliability and Interoperability Council VII, Future Emergency Communications Architecture by 2010, Focus Group 1D, December, 2004

Response Agencies

- Transfer location/mapping information to field units, and to other agencies via the ISICS network
- State DOT road sensor information to PSAP and responder including road conditions, speed sensors, and live video feed
- Weather related siren information including location, direction and severity
- Homeland Security information or AMBER Alert information including maps, photos and pertinent data
- Video feeds from law enforcement aircraft, including infrared/heat information to both responders and the PSAP
- Real time video feeds from field to PSAP, Incident Command Post, etc.

Integrating Data from Multiple Sources

- Aircraft information to include passenger numbers, cargo manifest, fuel amounts, speed at impact, video feed from the scene of event to PSAP and responding units while en route, plus the ability to forward all of that data to a medical facility or incident command center
- Fire alarm information should include a map of the building with marker of water flow information or where smoke detectors were activated, location of heat detectors and actual temperatures, and any hazardous materials information associated with the facility

8.5.2 NG911 Bandwidth Estimates

The more information that can be made available on a call increases the chances of there being a positive outcome to an incident or event. While there is always the possibility of information overload, public safety professionals can craft protocols for effective use of the appropriate information. The ultimate goal is to provide a technical advantage that can lead to the betterment of the call outcome.

The NG911 System must be capable of providing sufficient bandwidth as well as transport facilities to deliver these calls and associated data (video, photo, text, etc.) to the correct PSAP with no call blockage throughout the network. During the survey process, PSAPs were asked to provide ***FE*** with useful data such as peak hour 911 call volumes, number of positions, and other useful attributes. Combining this data with some industry information related to the “size” of various media (voice, video, images, and text) was used to arrive at a predicted peak bandwidth for the PSAPs in Iowa.

Based on the call volume data collected during the survey process, a conservative approach of bandwidth analysis was performed to insure more than adequate support of NG911 in the state. In order to perform this analysis, the PSAPs were segmented into the following three basic categories:

- **Small** – PSAPs containing up to three operator positions (survey indicates 100 PSAPs)
- **Medium** – PSAPs containing between four and seven operator positions (19)
- **Large –** PSAPs containing eight or more operator positions (three)

Further analysis of the received data was performed to establish peak hour 911 call volumes for each PSAP category. This analysis indicates that on average a small PSAP would experience a peak hour 911 call volume of 43 calls, a medium PSAP would have a volume of 131 calls and large PSAPs would experience 477 calls per peak hour.

A worst-case estimation would consider all the calls occurring simultaneously during this peak hour. A more realistic approach is to assume that about 30% of the calls would occur simultaneously. It was estimated that most of the calls would still be of the voice messaging type, and that only about 15% of these calls would be supplemented with data messaging. It is estimated that 5% would contain video, 5% would contain text and 5% would contain still images. Industry norms were used to estimate the size of the additional data and all voice traffic was assumed to arrive at the PSAP using Voice over IP (VoIP). Using these assumptions, the bandwidth requirements are estimated as follows:

- **Small PSAP** – 4.5 Mbps (equivalent to three T1s)
- **Medium PSAP** – 13 Mbps (equivalent to nine T1s)
- **Large PSAP** – 38 Mbps (equivalent to 25 T1s)

It is assumed that the content was sent by a 911 caller and arrived through the NG911 network. If the information was to be forwarded to the field, as illustrated in Figure 70 – PSAP to ISICS interface, then each PSAP to ISICS network link would require the above bandwidth to support extending the data out to the field. Field personnel as well as other PSAPs with access privileges may view data forwarded into the ISICS network.

A dispatch center directly connected into the ISICS network will require additional bandwidth to support other functions such as network management, radio dispatch operations, and remote system functions. Nevertheless, these bandwidth requirements can be used by the State of Iowa for the purposes of planning the NG911 network.

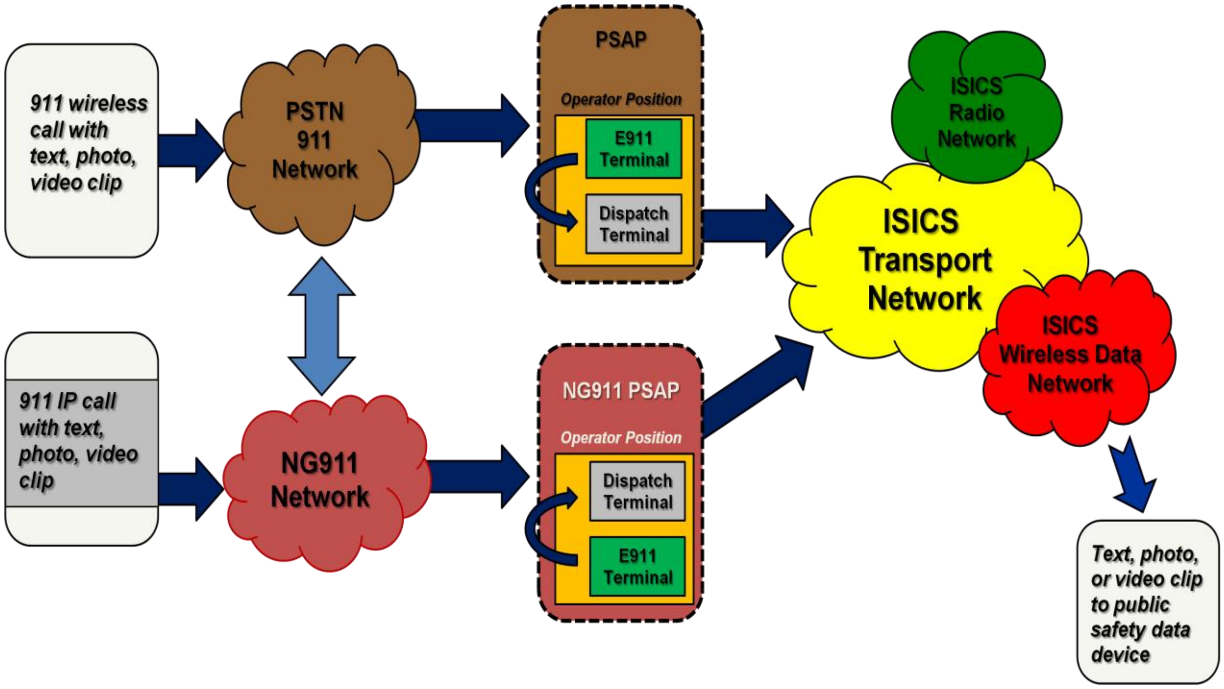

Figure 70 – PSAP to ISICS interface

In an effort to regionalize the bandwidth requirements needed to support the NG911 network, call volume was analyzed to determine bandwidth needs at each HLS&EM region. The following bandwidth estimates should provide some guidance to the state in the planning of future NG911 deployment efforts:

- **Region 1** – 169 Mbps (equivalent to 110 T1s)
- **Region 2** – 112 Mbps (equivalent to 73 T1s)
- **Region 3** – 103 Mbps (equivalent to 67 T1s)
- **Region 4** – 107 Mbps (equivalent to 70 T1s)
- **Region 5** – 116 Mbps (equivalent to 76 T1s)
- **Region 6** – 129 Mbps (equivalent to 84 T1s)

While design of the NG911 system is not within the scope of ISICS network, the information provided here should be used by the State of Iowa in planning the overall network size required to support the peak call volume as reported for the current E911 system. A network designed to this kind of capacity will ensure that the E911 Network-to-PSAP and PSAP-to-PSAP interfaces will be capable of handling a worst case scenario from a network perspective. There are many aspects of the NG911 solution that require special consideration. At a minimum, the State of Iowa should also consider the following:

- Examine various options of implementing the network infrastructure. These options would include:
  - A State developed, maintained and managed network
  - A service provider developed, maintained and managed network
  - A hybrid solution where some aspects of the network are State run and others are service provider run
- Account for a thorough network design that takes into account all of the redundancy, security and bandwidth requirements that are a part of NG911
- An implementation planning process that will provide for the coexistence of legacy PSAPs and infrastructure components with NG911 PSAPs and infrastructure
- Considerations of the implementation plan would include roll-out options such as state-wide, region by region or PSAP by PSAP
- Evaluation of the then current standards and best practices that various industry groups such as NENA, APCO, DoT and CTIA have arrived at with regard to NG911
- Determination of exactly what data the State does and does not want to allow to be passed over the NG911 network

Providing connectivity to the PSAPs into the ISICS network will fulfill, in part, the vision of sharing information with field personnel. That is, providing network connectivity between the PSAPs and the ISICS network will commence the first step in the overall interoperability process which will eventually allow for PSAPs to share data with other PSAPs or field personnel.

Prior to deployment of a NG911 solution, the successful interconnection between the dispatch centers and the ISICS network itself will lead the way to providing next generation data to field personnel. Figure 71 illustrates that data sourced from a device in the public realm (e.g. PDA or cell phone) can enter the ISICS interoperability realm via NG911 interface to the PSAP, be forwarded to a data center via the ISICS transport network, and then be accessed by handheld wireless devices in the field via the ISICS wireless data network. In addition, this information could be accessed by another PSAP connected to the network.

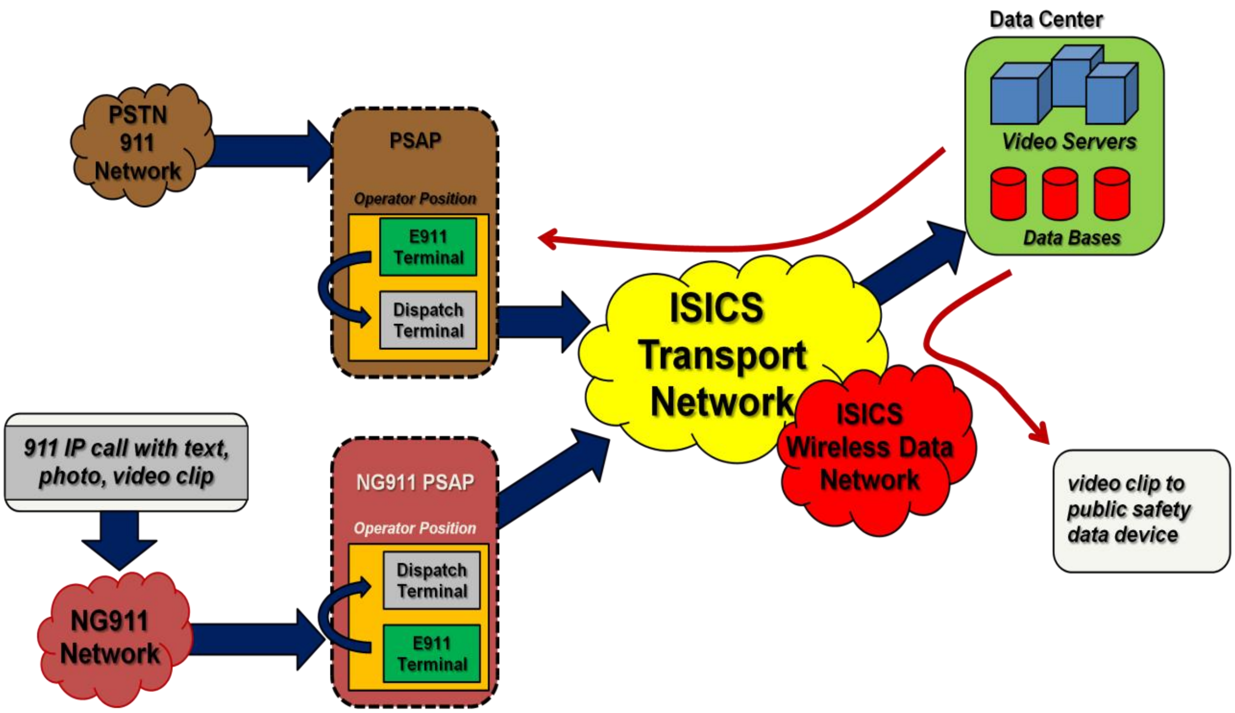

Figure 71 – PSAP to data center

While most PSAP managers consider interconnection into the ISICS network a simple path (use service provider T1s), several options remain available for achieving this connectivity goal. However, each alternative has positive and negative ramifications. The following is a synopsis of the options available:

Leased T1 links

Typical site connectivity is done through the implementation of leased T1 circuits. However, these circuits use technology developed for voice communications and represent a bottleneck in today's data centric world. In addition, monthly recurring costs, link quality issues, and repair time make it a poor choice.

Microwave network

A microwave path would increase the link reliability (when compared to leased T1) but require additional upfront cost. Specifically, the PSAP would have to provide a tower, microwave equipment, and equipment shelter. Nevertheless, the PSAP would have full control of this link, no recurring costs, and manage it as deemed necessary.

Optical fiber (ICN)

The State of Iowa has a significant investment in a State-owned optical fiber network called the Iowa Communications Network (ICN). This network is capable of supporting the large bandwidth requirements associated with NG911 services. However, the ICN does not have a point-of-presence (POP) where needed and would require additional investment to extend the optical fiber to each PSAP throughout the state.

Wireless point-to-point

With the availability of licensed broadband spectrum in the 4.9GHz band, a broadband point-to-point connection could be established to extend the ICN or microwave network to the PSAP. While there are certain distance limitations with this approach, a properly engineered link could satisfy the need for broadband connectivity with the added benefit of location flexibility.

The transition from the legacy 911 system to an IP-based network will require a complex planning effort and detailed architecture. The NG911 network is intended to be an IP-enabled network built on a flexible, robust platform with built in security to diminish system risks. The US DOT reports state that the National Emergency Number Association (NENA) has recommended in its i3 document, as well as the Internet Engineering Task Force (IETF) through the Emergency Context Resolution with Internet Technologies (ECRIT), and Network Reliability and Interoperability Council (NRIC) documentation, that an IP network is the desired platform for the NG911 System.[12] This NG911 platform will rely on common data communication standards to ensure and protect delivery of information. The physical network will also use telecommunications standard configurations that are made up of the wires, gateways, routers, and equipment to transmit and receive traditional communications signals.

The ISICS network will provide for the “back end” of NG911 interoperability; that being the inter-communication between PSAPs and responders in the field and the responder to responder communications. Development of applications for such a network is only the beginning. As the network evolves, the system of systems approach to the NG911 System will enable more development of public safety specific applications that have not been available before. Since NG911 will provide for the “front end” of interoperability, a separate initiative will be necessary to design and implement the NG911 network which involves Iowa’s citizens, PSAPs, vendors, and service providers.

12 US DOT NG 911 Architecture Analysis Report, Version 1.0 | November 2007

8.6 Transport Network Design

The ISICS transport network is composed of IP routers, switches, and border control functions (e.g., firewalls) to support ubiquitous interconnection of the ISICS Network elements. The transport network is composed of communication ring and star configurations to physically connect to the network elements. In order to provide redundant connectivity, there are multiple paths to each of the network elements.

8.6.1 Segmented Transport Network

The transport network is composed of dedicated microwave sub-networks and fiber based wireline sub-networks. The dedicated microwave portion of the transport network is primarily used to interconnect all the major network nodes for the state agencies. The microwave network is established as multiple loops and rings to provide redundant paths to each of the network nodes. The optical fiber-based wireline sub-network is based upon interconnections via the Iowa Communications Network (ICN). The ICN is used as backup and auxiliary sets of transport paths to augment and supplement the microwave network connections. As illustrated in Figure 72 – Transport segmentation, for the current network segmentation example there is a separate transport sub-network for each of the three regions, Western, Central, and Eastern. Each of the regional sub-networks is connected to the other regional sub-networks to provide a complete statewide transport network.

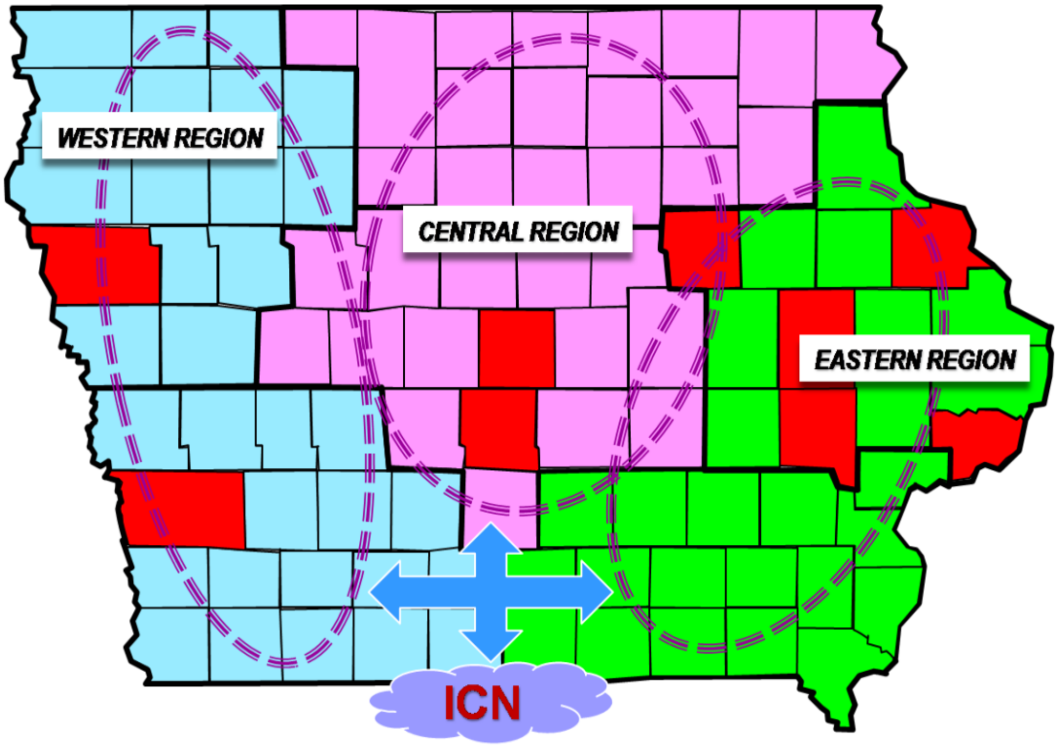

Figure 72 – Transport segmentation

Each of these sub-networks is itself a collection of sub-networks that provide the multiplicity of paths to each of the network elements in that region. There are multiple paths to each of the network nodes. These sub-networks are managed to provide continuous connectivity for all the network elements. Additionally, each of the regional transport sub-networks is interconnected to allow passing information between the sub-networks across the ISICS network. Each of the regional transport sub-networks may be isolated from another sub-network to prevent cascading network failures from affecting all the transport sub-networks.

8.6.2 Digital Microwave Network

The ISICS transport network is primarily composed of a network of dedicated digital microwave paths to support interconnects to the ISICS network elements. This includes connections to radio tower sites, dispatch centers, and control sites. All the state agency related sites are interconnected via the microwave backbone. Typically the microwave site equipment coexists with the radio site, but there are instances in which an intermediate microwave hop, a microwave relay link to connect network nodes, is necessary. Each of the state agency radio sites is interconnected via microwave paths, with multiple routes connecting each of the network nodes.

The microwave network will provide the necessary interconnection of all system components. The conceptual design assumes that all equipment used in the system will use Internet Protocol (IP) connections. Therefore the microwave subsystem will be composed of microwave radios, multiplex equipment, and other items such as Synchronous Optical Network (SONET) switches. Appropriate data communication equipment such as routers, switches, and other local area network (LAN) equipment would be included to support the general IP networking operations. The radio network equipment will essentially plug into the microwave transport subsystem.

The ***FE*** team performed analysis of potential microwave network sites and topologies to afford appropriate network interconnect. Each of the microwave sites was gauged for applicability with regard to clear line of sight (LOS). LOS is not quite enough as the microwave signal naturally disperses in a conical pattern. As a result portions of the signal may reflect off bodies of water, buildings, and other solid objects and can interfere with the primary signal through multipath fading distortions of the transmitted signal. Additional attention is required in the form of addressing the Fresnel ellipse, surrounding the direct microwave path. In consideration of LOS and Fresnel zone clearance, antenna position and tower height are important considerations in the microwave path selection and network design.

Figure 73 shows typical microwave interconnections between the radio sites of the network. For example, Tower Site 1 is shown connecting to Tower Site 2; Tower Site 2 connects with Tower Site 3, etc. There is the potential for a tower site to connect to multiple other tower sites, as shown with the connection of Tower Site 3 to the local Site A and the microwave relay site (to facilitate further connection to tower Site 4). Tower Site 3 is also at an access point to the fiber base wireline network, and acts as a microwave interconnect point between the microwave and wireline networks. Additionally, the inclusion of connections to the ICN provides additional redundancy paths for the node interconnects.

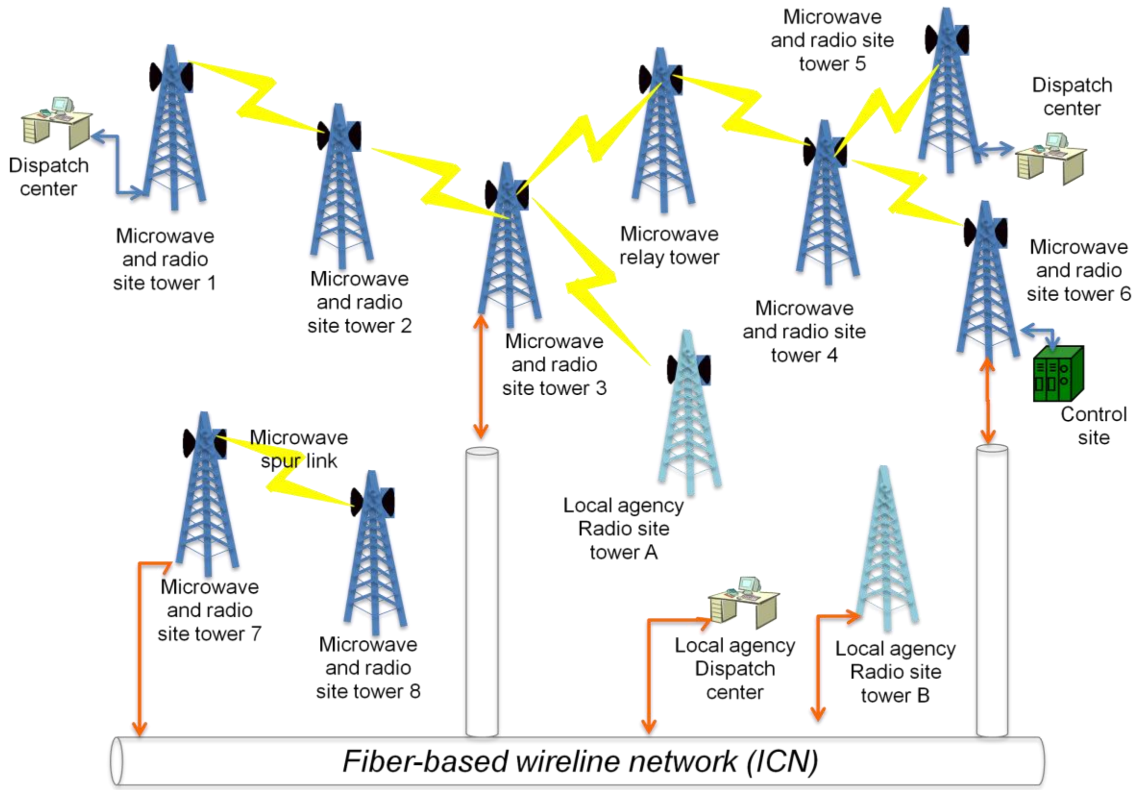

Figure 73 – Sample microwave network

While most of the projected radio sites in the coverage profile were found usable as microwave sites using 6.7 GHz microwave channels, some sites displayed Fresnel issues that were mitigated with the movement to 11 GHz microwave channels. Additionally there was the need to include additional microwave relay links to interconnect some of the network nodes. The summary of the microwave network paths can be found in Table 9 – Microwave transport network summary.

Table 9 – Microwave transport network summary

Nodes / Paths	Quantity
Number of microwave sites	271
Microwave paths using 6.7 GHz	316
Microwave paths using 11 GHz	6
Total number of paths	**322**

The detailed microwave network topology can be found in Appendix I.

8.6.3 Wireline Transport Network

While the primary connection fabric for the transport backbone is to be the dedicated microwave network, there are transport uses for a wireline fiber-based network alternative. The fiber-based Iowa Communications Network (ICN) shall be employed to provide connectivity to local entities that cannot directly connect with the microwave network. The ICN shall also be used as the main transport for much of the high bandwidth non-voice payloads (including video) to off-load this demand from the microwave network. Points of presence for the ICN shall be extended where necessary to facilitate use of the fiber network.

As depicted in Figure 73 – Sample microwave network, the ICN can be used to interconnect local agency nodes to the ISICS network when these nodes cannot easily connect directly with the microwave network. For example, while local Site A can support direct connection and inclusion in the statewide microwave network, local Site B is not suitable for connection to the microwave network. Instead local Site B is connected to the ICN that in turn connects to the microwave network at various access points (e.g., Tower 3 and Tower 6). Each of the local sites is an active member of the ISICS network, and can interoperate across the transport backbone.

The ICN shall also be linked to the microwave transport network to provide alternative and backup paths to the microwave network in the event of massive network failures on the microwave network. Again referring to Figure 73 – Sample microwave network, there are multiple access points (e.g., Tower 3, Tower 6) to allow interconnection of the ICN to the microwave network. Should a problem occur in the microwave paths between Tower 3 and Tower 6, information may be transported across the ICN in a seamless fashion.

The ISICS transport network will provide ICN wireline interconnect with at least four microwave sites. These sites are identified in table 10. This provides alternative connectivity for the microwave portion of the transport network

Table 10 – ICN site presence

Microwave site	Site name	Location
ISP - Iowa	Joint Forces Headquarters	Camp Dodge
NG6	National Guard	Clinton
NG22	National Guard	Keokuk
NG36	National Guard	Shenandoah

Additionally as needed, the ICN access point will need to be extended if it currently does not conveniently exist in the vicinity of the network node to be interconnected. This will be addressed on a per case basis as local agencies decide to join the ISICS network.

8.6.4 ISICS Transport Bandwidth Needs Estimates

The ISICS transport network interconnects all the network elements of the ISICS network. This includes the radio sites, dispatch sites and control sites. Each of these major categories of nodes will be addressed in the following estimations.

Site link

The site link needs to support the handling of information relating to voice and data operations using this site. The types of things that need to be considered for the site link are:

- Digitized voice signaling per allocated traffic channel
- P25 integrated data signaling per allocated user at the site
- P25 trunked control and status
- Broadband data signaling per allocated user active at the site
- Site management (including site downloads, site status, alarms, diagnostics, software updates, etc.)

It is assumed that each voice path requires 27 kbps, with a separate receive and transmit voice path for each trunked channel. The P25 trunked control and status can be addressed with a 64 kbps channel.

To facilitate timely downloads of operational information and software updates, there is the need for a 128 kbps link to each site. This link grows in size as the number of channels increase at the site. It is assumed that this would double with each addition of five channels to the site. The P25 integrated data signaling is based on the 9.6 kbps channel capacity of the P25 common air interface.

The broadband data signaling is dependent upon the type of data services and payloads being employed. A worst case data usage involves full motion video operations. These can impact the system at a raw rate of about 1.5 Mbps per video stream. Typically compression schemes achieving at least 3:1 compression can be employed, reducing the throughput need to 500 kbps. This will be used for the broadband data service need estimate. Additionally the use of this type of data service is not projected to be continuous, and is estimated to be at most 5% of the data service activities for a data user. For bounding the bandwidth need at a worst case, it will be assumed that the link needs to support 500 kbps for each active data user, assuming there is simultaneous use of the video data service. Table 11 summarizes the predicted link bandwidth need for various sized radio systems.

Table 11 – Average peak hour call volume

Site parameters	Required Bandwidth (kbps) to support the following loads:		
	7 trunked channels 2 P25 data channels 10 broadband users	**12 trunked channels 2 P25 data channels 20 broadband users**	**24 trunked channels 4 P25 data channels 50 broadband users**
Voice	224	504	1064
Control signaling	64	64	64
P25 Data	38.4	38.4	76.8
Site management	128	256	512
Radio site total	528	936	1864
Broadband data total	5000	10000	25000
Site total	**5528**	**10936**	**26864**

For a seven-channel trunked system, operating as four voice channels, two integrated data channels, and a control channel, the site link bandwidth need is estimated to be about 500 kbps. With the assumed ten simultaneous broadband data users there is an additional 5 Mbps of bandwidth need, totaling about 5.5 Mbps site bandwidth need..

As the system expands to a 12-channel trunked system (nine voice channels, two integrated data channels, and a control channel), the site link bandwidth estimate becomes about 900 kbps. With the assumed 20 simultaneous broadband data users there is an additional 10 Mbps of bandwidth need, totaling about 10.9 Mbps site bandwidth need.

As the system expands to a 24-channel trunked system (19 voice channels, four integrated data channels, and a control channel), the site link bandwidth estimate becomes about 1.9 Mbps. When the assumed 50 simultaneous broadband data users are included, there is the expected need for 25 Mbps of additional bandwidth, totaling about 27 Mbps site bandwidth need.

Dispatch center link

The dispatch center link bandwidth is a combination of the traffic generated by the E911 calls received at the associated PSAP, and the current trunked traffic that is being monitored by the operator positions of the dispatch center.

There was analysis of the expected E911 busy hour call rate, with this being segmented into three categories of dispatch centers - small, medium, and large.

- A small dispatch center was defined as one with less than four operator positions. The category of small accounts for 100 dispatch centers in the state. The E911 call rate for the small category was determined to be 43 calls during the busy hour. These calls do not all occur simultaneously, but for the purpose of estimating the bandwidth need, it is assumed 30% occur simultaneously.
- A medium dispatch center was defined as one with between four to seven operator positions; there are 19 medium sized dispatch centers in the state. The E911 call rate for the medium category was determined to be 131 calls during the busy hour. It was assumed for this estimate that 30% of these calls occur simultaneously.
- A large dispatch center was defined as one with more than seven operator positions. The E911 call rate for the large category was determined to be 477 calls during the busy hour. It was assumed for this estimate that 30% of these calls occur simultaneously.

The bandwidth estimates for the voice needs are summarized in Table 12 – Bandwidth estimates for voice (Kbps), for each of the dispatch center size categories. To provide a representative heavy load, it was assumed that 50% of the possible monitored talkgroups were active at the dispatch center simultaneously.

Table 12 – Bandwidth estimates for voice (Kbps)

PSAP Attributes	Small	Medium	Large
Number of PSAPs in this category	100	19	3
Range of positions in this PSAP category	<4	4 – 7	> 7
Typical # of positions	2	5	12
Calls / busy hr. / PSAP	43	131	477
Peak calls / busy sec. / PSAP	12.9	39.3	143.1
Monitored talkgroups	15	40	70
Estimated Voice bandwidth (kbps)	**571**	**1660**	**4987**

In general, small PSAPs would require a link bandwidth of approximately 600 kbps, medium PSAPs would require 1600 kbps, and large PSAPs would require 5 Mbps of bandwidth.

In addition to this voice need, it is assumed that data messaging will occur on at least some the E911 calls received, especially when considering the all IP environment of the Next Generation 911 networks. For estimation purposes, it is assumed that 5% of the E911 calls received would have supplementary data in the form of video streams. If this data was to be forwarded to field dispatched units in order to supplement the dispatch operations, the bandwidth requirements would certainly increase. Table 13 – Bandwidth estimates for data (kbps), provides the bandwidth requirement for each PSAP category:

The video bandwidth need is based on the receiving data messaging on the E911 calls, and this information is to be presented to the dispatched field units to supplement the dispatch operation.

Table 13 – Bandwidth estimates for data (kbps)

PSAP Attributes	Small	Medium	Large
Number of PSAPs in this category	100	19	3
Video bandwidth needed	**2592**	**7776**	**20736**

The estimate indicates a total (voice and data) need for approximately 3 Mbps for a small size PSAP, about 9 Mbps for a medium size PSAP, and about 26 Mbps for a large size PSAP.

8.7 General ISICS Attributes

8.7.1 System Availability

The ISICS Network is designed in a fault tolerant modular topology, composed of fault tolerant IP centric control elements, and redundant resource elements, all connected over a fault tolerant IP network. Figure 74 – Network topology illustrates how the modular approach follows a general hierarchy of network, region, and site applied to the network topology.

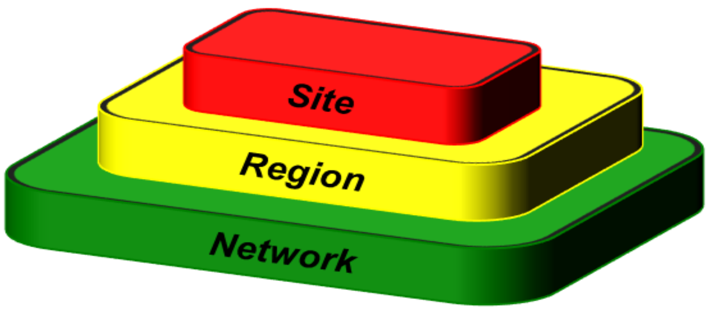

Figure 74 – Network topology

The ISICS Network is divided into separate regions each with its own set of regional controlling entities and communication resources. In this manner a failure within a region does not compromise the communications for the other regions. Similarly the regions are composed of separate sites, with each site having its own set of local controlling entities and local communication resources. A failure of a site is contained to impacting that site area only, and does not compromise the communications for the other sites of the region.

With the use of standard IP interconnection technologies, the physical location constraint for various elements of the network is removed, requiring only adequate IP connectivity. This allows distribution of the various elements of the ISICS network to afford additional fault tolerance via geographic separation of the elements.

<u>ISICS radio network</u>

There are various levels of fault tolerance built into the ISICS radio network design. At the network level the radio network is composed of separate regions of radio coverage. Each region is autonomous and acts as a peer-to-peer communication system on the radio network. Each of the regions is controlled from a fault tolerant regional controller. The regional controller oversees all the call processing and resource management for its region. There is also at least one backup regional controller available on the ISICS network, shadowing each of the regional controllers. Should there be a catastrophic failure of the active regional controller at a region (e.g., physical failure such as a building collapse), the backup regional controller can assume operations for that failed regional controller, maintaining all active calls for that region.

Each region is composed of radio sites that are connected via the transport network. There are multiple network paths or site links for each of the radio sites. Should a site link fail, the site specific information transfer is still available on the backup site link with no interruption to the ongoing site service. Should all network connections for a radio site fail (multiple simultaneous failure condition), the site will be isolated from the rest of the ISICS network. This radio site is still operational at the radio/RF level, and will assume a local mode of operation to maintain some degree of call processing for those users in the vicinity of this site. All authorized users in the area are still capable of trunked communications with other local users, but there is no longer the potential for calls extending into other radio sites or regions of the ISICS network. Of course the subscriber units on this failed site may scan for another usable site in the vicinity and roam to that site for continued ISICS network operation. If no other site is available, then the user can at least maintain local communication to other users in the vicinity.

Each of the radio sites is composed of multiple shared repeaters (channels). One level of fault tolerance deals with the availability of the control channel resource at the site. At least one of the channels at a site is designated for special operation as the control channel for this site. All the transactions for requesting and assigning calls to the available voice resources at the site are conducted via the control channel. Should the designated control channel resource fail, another of the channels at this site is promoted to the control channel operation (through actions of the local site controller). The subscribers at this site will change their control channel operations to use this new control channel at the site and will continue otherwise normal trunked operations.

Another level of fault tolerance deals with the other channels at a site. If a non-control channel fails, either from physical repeater equipment failure or by backhaul network failure, the radio site can continue normal operations for this site, just with a reduced number of available communication resources and a subsequent increase of channel loading across the remaining channels. In this manner, the normal trunked communication processing can be retained at a site even when there is a physical resource failure.

If the radio site controller fails completely, another mode of fault tolerance can place each of the radio site channels into a conventional mode of operation with the local users designated to particular channels for this mode of operation. The current radio users on this site will revert to the conventional mode of operation on a designated channel and may continue the conventional controlled communications. (The subscriber units on a failed site can scan for other available sites in the vicinity and roam to one of these to maintain normal ISICS network operations instead of remaining on the failed site in limited communication mode.)

ISICS transport network

The ISICS transport network is an IP-based network. The primary connections to a majority of the elements of the ISICS network are provided via a dedicated microwave network. Each of the elements of the ISICS network has multiple paths available on this microwave network to maintain information and signaling flows should there be a problem on one of the paths to the element. Additionally, there are backup paths over alternative wireline-based IP networks for major elements of the ISICS network to maintain their operation should there be a catastrophic failure of the microwave network.

The transport network will detect problems on a path and switch to the alternative path without disrupting the information flows on the paths. If all paths on the microwave network are in fault, the transport network will use the backup network connections available. Once the microwave paths become operational again, the transport network will resume use of those paths as the primary information paths.

ISICS wireless data network

The ISICS data services are supported by the narrowband P25 integrated voice and data capability and supplemented over the broadband data network . The broadband data network is a distributed wireless network architecture employing fault tolerant cellular technologies. The coverage contours for each of the sites overlaps the adjacent sites such that the failure of a single site will not remove the data service from that vicinity. Typically the subscriber device will search for the best available network (e.g., based on needed throughput, services, cost, etc.). If the chosen data service becomes unavailable, then the subscriber device will resort to another data service available in the area and will continue the data operation, though potentially with less throughput or with limited data service attributes. As the availability of better data service offerings occurs, the subscriber device will switch operation to the better data service offering and continue processing the data operation. This is seamless to the data user (except for the potential data operational speed as perceived by the data user).

8.7.2 System Expansion

The ISICS Network is designed for support of easy upgrade and expansion. Modular architecture scales easily – adding new channels, new sites, or new agencies is intuitive and cost effective. With the basic IP interface support for the elements of the network, new elements can be easily added to the network.

Users

With vast user addressing available, new users are easily added to the network. The new user is assigned an unused User ID from the P25 User ID space associated with the ISICS network identity. (The P25 addressing provides for about 16 M individual user identities that can be assigned on the ISICS network.) This User ID is then provisioned and authorized for service on the ISICS network by the network manager. Additionally the network manager assigns this new user to an appropriate existing talkgroup or defines a new talkgroup. The addition of new users to the ISICS network will require evaluating the anticipated site loading. Additional channels and or sites may be necessary to handle new anticipated user loads.

Talkgroups

The P25 talkgroup address space is vast and can handle creation of new talkgroups to address new agency or group communication needs. (The P25 talkgroup address space supports about 64K unique talkgroups per P25 system.)The Network Manager assigns an available talkgroup address to this new talkgroup, and provisions the new talkgroup. The Network Manager assigns appropriate users to the newly created talkgroup. For this talkgroup to be used in the network, appropriate user subscriber devices need to be programmed with the new talkgroup information.

Sites

The radio system will have the ability to add additional sites to expand and support future enhanced coverage needs.

Channels

The radio system will have the ability to add additional channels to expand and support future growth and loading needs.

Dispatchers

The dispatch positions can support adding additional groups for support to be handled in the normal fashion. Additional dispatchers can be added to the network by attaching a dispatch element to the network via the console interface.

8.7.3 Network Management

The network management allows seamless multi-agency network sharing with independent management of subscribers. In this way the ISICS Network can provide seamless statewide operation while providing local autonomy for local agencies regarding management of those local users. The communication network will have multiple levels of management control available, in a hierarchy from the jurisdictional, to the regional, to the state levels. The state management level oversees all the functions of the network. The regional management level oversees all the functions of the network at the regional basis, which includes issues involving multiple jurisdictions or agencies within the region. The jurisdictional management level deals with the management of the local jurisdictional or agency users. Areas of management include talkgroup population, user access privileges, security assignments, failure reports, usage reports, performance reports, etc.

Agencies and radio systems on the ISICS Network can maintain their autonomy with the other agencies on the network. This is accomplished through the appropriate partitioning of communication need and operation between the agencies. Individual channels are no longer allocated to individual agencies to demarcate their operational arena, but instead channels are shared among the individual agencies on the network. The talkgroup assignments to the user groups are now considered virtual channels. The sharing of the channels is done with privacy afforded the other users of the network through the judicious assignment of talkgroups. Users assigned to a talkgroup are the only individuals authorized to participate in calls for that talkgroup. All users not associated with a talkgroup currently active in a call will not hear any call activity (privacy).

Network management of a trunked network includes maintaining network components, upgrading network components when necessary, managing encryption capabilities, managing and operating over-the-air features, optimizing performance, and managing intersystem interoperability. Compared with conventional network management, trunked network management requires more complex network configuration and planning. Allocating and managing talkgroups on a trunked network has a greater importance, since, if done improperly, it can degrade network performance and capacity to a great degree, similar to assigning too many users to a conventional channel. To control misuse that may lead to network overloading, such as unauthorized or overly long telephone and person-to-person calls, network management has to establish a conversation time-out feature, or use network accounting. Key elements of the network management system are:

- Local Administration Database
- Real time Airtime Usage
- Real time monitoring of network element status
- Hierarchical updates on error conditions
- Real time status of network usage
- Real time alarm management (provides easy and intuitive maintenance)
- Simple Network Management Protocol (SNMP) support allows interfacing with higher level network management systems

8.7.4 Security

For public safety personnel the ISICS P25 over-the-air digitized voice provides a measure of protection against unwanted eavesdroppers. The system also has encryption capabilities for public safety personnel that meet stringent requirements. Security for information sent over the radio channels in the P25 system is provided via a set of supported encryption schemes, and the associated mechanisms to manage the security encryption elements. Encryption in P25 can be applied to either voice or data communications and equally applies to both trunked and conventional systems. The IMBE™ vocoder produces a digital bit stream for voice messages that is relatively easy to encrypt. Major advantages of the P25 encryption design are that encryption does not affect speech intelligibility nor does it affect the system's usable range. Both of these advantages are major improvements over encryption previously used in analog systems. Encryption requires that both the transmitting and the receiving devices have an encryption key, and this key must be the same in each unit. This may be done using a Key Loader. Most P25 subscriber equipment is available with the optional capability of storing and using multiple keys. In this way a unit could use one key for one group of users and use a separate key for another group of users. System management of keys may be done in a Key Management Facility, or KMF. In the U.S. there are four general "types" of encryption algorithms.

- Type 1 is for U.S classified material (national security)
- Type 2 is for general U.S federal interagency security

- Type 3 is interoperable interagency security between U.S. Federal, State and Local agencies
- Type 4 is for proprietary solutions (exportable as determined by each vendor and the U.S. State Department)

The P25 common air interface (CAI) supports use of any of the four types of encryption algorithms. There is currently standardization for two different Type 3 encryption processes. One encryption process is the U.S. Data Encryption Standard, or DES algorithm, which uses 64-bit Output Feed Back and is denoted as DES-OFB. Another encryption process is the Advanced Encryption Standard (AES) that is a 256-bit algorithm.

P25 also includes a standardized Over The Air Rekeying (OTAR) function. OTAR is a way to greatly increase the utility of encryption systems by allowing transfer of encryption keys via radio. This remote rekey ability, controlled from a Key Management Facility, or KMF, means that radios no longer have to be physically touched in order to install a new or replacement key into a radio. OTAR signaling is sent as Packet Data Units over the common air interface. Optionally, multiple encryption keys can be stored in P25 radio equipment. In order to identify the keys, they are stored with an associated label called a Key Identifier or KID. The type of algorithm to be used with the key is identified by an Algorithm ID or ALGID. AES and DES-OFB encryption solutions were verified by a National Institute of Science and Technology (NIST) laboratory as compliant with the security requirements of the Federal Information Processing Standard (FIPS).

The encryption process can be applied to both the traffic channel operations (protecting the voice or data payloads on the channel) and the control channel signaling (obscuring the identity information for the calls occurring on the system).

Should a radio unit be stolen, there is a scheme available which allows for the subscriber unit to be made inoperable for the thieves. The identified stolen unit can be placed in “disable” mode remotely over the radio network. The unit identity would first be flagged as a stolen unit in the user database records. When the radio next attempts to register on the system, the registration process causes a “radio disable” command to be sent to the subscriber device.

9. Migration Schemes

Throughout the history of public safety communications, agencies have collaborated and developed an approach acceptable to all participants. Originally, it was the simple practice of using radios from an available cache of system capable radios at the scene of a joint operation. Then with technology improvements, channels designated for interoperability were patched together via consoles or gateways. More recently, states or regions have established interoperable approaches that range from interconnecting radio channels over a wide area that agencies can use for interoperability, to complete systems that agencies can share. In the latter approach, the standards-based shared system not only provides for interoperability, but also becomes the means of achieving operability.

In order to provide a methodology for defining interoperability solutions, the U.S. Department of Justice defined the SAFECOM Interoperability Continuum. The SAFECOM Continuum, illustrated in Figure 75 – SAFECOM continuum was adopted by the U.S. Department of Homeland Security. It defines distinct levels of interoperability based on combinations of factors including technology, governance, standard operating procedures, training and exercises, and usage. This national effort promotes common interoperability solutions among public safety agencies.

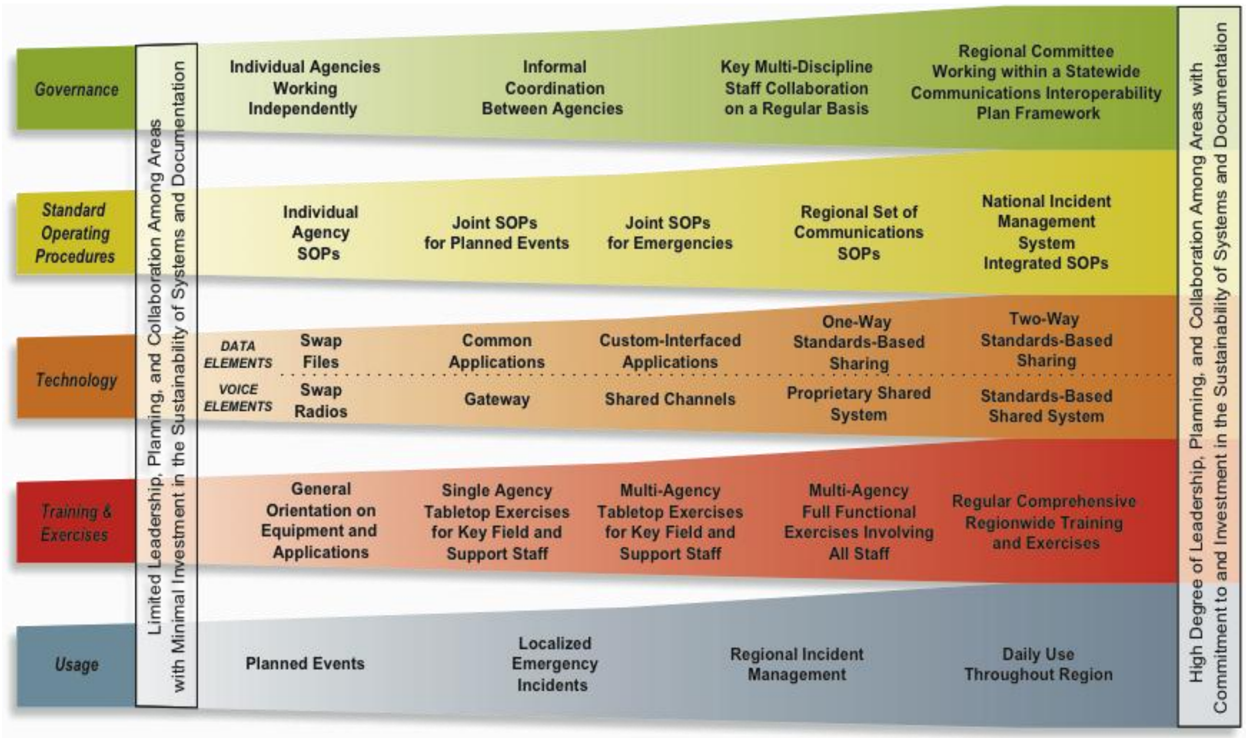

Figure 75 – SAFECOM continuum

According to the technology track of the SAFECOM Continuum, the technical solutions available to address interoperability are characterized by the following levels of maturity:

[Least mature]	***Level 1*** - Swapping radios (e.g., cache of radio units)
	Level 2 - Gateways
	Level 3 - Shared channels
	Level 4 - Proprietary shared systems
[Most mature]	***Level 5*** - Standards-based shared systems

Emergency responders understand the ramifications associated with operating in the least mature level (level 1) of the SAFECOM continuum. Requiring first responders to take time to swap radios, which may not be conveniently staged, or requiring dispatchers to configure patches or gateways to provide interoperability, delays response time and may put both citizens and responders at risk. Managing multiple radios or cell phones in order to coordinate assistance is a complicated reality for some first responders often causing messages to be misunderstood or even unheard. As such, focus from the matters at hand is shifted to managing communications.

While the implementation of ISICS represents the highest level of interoperability in the SAFECOM continuum (Level 5), local entities will be presented with the opportunity to individually join the network on a voluntary basis. Each entity will have the flexibility to consider their current infrastructure investment and make one of the following choices:

- Partner with the State and join the newly designed statewide system (ISICS)
- Partner with the State and directly interface their current P25 compatible system assets into ISICS
- Keep non-compatible infrastructure equipment and use available technologies to access ISICS taking into consideration the level of interoperability possible and associated limitations with the given approach
- Take no action and simply swap radios when needed

Implementing ISICS will provide benefits far beyond its main purpose of achieving interoperability from the local level all the way up to the state level. It will provide for the consolidation of resources while maintaining independence and autonomy during day-to-day operations. This cooperative use of assets provides interoperability among agencies as well as significant cost saving opportunities during a time of fragmented and limited funding, by avoiding the construction and maintenance of multiple disparate communications networks. In addition, ISICS will be available to non-traditional partners such as schools, hospitals, and will foster an environment of collaboration and unity around the common goal of interoperability.

Since agencies will have the ability to join the ISICS network on a voluntary basis, migration schemes have been developed to help establish what level of interoperability can be achieved within a given approach. These levels of interoperability will follow Levels 2 through 4 of the SAFECOM continuum. Agencies screened through ***FE's*** outreach interview and survey process identified four major agency categories that need to be addressed with specific migration schemes. These are identified and addressed in the following subsections.

9.1 Agency Migration

This category represents agencies that do not actually own the communications system currently used in day-to-day operations. These agencies might use any technology available in their operational area, from conventional VHF repeater systems to P25 trunked radio systems. These systems may be owned by the city, county, state, or even an LMR service provider (e.g., Electronic Engineering or RACOM). It should be noted that commercial service providers use non-standards-based proprietary protocols in their systems as currently deployed. These agencies have the following five migration options available:

- **Directly join the ISICS network**

  The ISICS system has been design to achieve a grade of service (GoS) of 1% or better. This was achieved by evaluating the baseline load (users on each site) and determining the number of channels needed to maintain channel availability to users in the field.

  Once an agency indicates intent to directly join the system, this loading analysis must be redone to determine if additional channel resources will be required at the radio sites. Once this is addressed, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. Coordination with the ISICS maintenance team is needed to program the radios and gain access to the system. To facilitate the transition process, agencies might choose to deploy dual band and/or dual mode radios capable of operating on the current system and the P25 standards-based ISICS radio network.

- **Interface with the ISICS network via gateway**

  In order to provide a means to interoperate with the ISICS network without relocating from the current system or requiring the replacement of user radios, a gateway solution could be implemented by the system owner. While a gateway can provide for basic patching of voice communications, certain limitations associated with this solution confine it to a lower level of the SAFECOM continuum. Gateways might provide adequate interoperability as long as agency users remain within their native service area and minimal simultaneous emergencies occur.

- **Interface with the ISICS network via standards-based Inter RF Subsystem Interface (ISSI)**

  In order to provide a means to interoperate with the ISICS network without relocating from the current system, the service provider could choose to upgrade the system to a P25 standards-based system. In this case, interoperability with the ISICS system can be achieved via the standards-based system to system interface known as ISSI. However, this approach would require the replacement of user radios with P25 radios or dual mode radios that allows user access to the proprietary system and simple migration to the upgraded P25 system.

- **Purchase their own radio site and attach it to the ISICS network**

  An agency may choose to purchase a standards-based P25 trunked standalone site or radio subsystem (e.g. simulcast cell) and interconnect it into the ISICS network. While the ISICS system would view the subsystem or site as its own, the agency will retain management rights and may choose tower site placement based on agency specific needs. In addition, the agency can choose to have as many general use channels as deemed necessary. While this approach provides the agency with autonomy in choosing the subsystem parameters (e.g. site location, number of channels), it also saves the cost of implementing the master switching center since the ISICS network will provide these services in the regional controller.

  Finally, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. Since the agency's site or subsystem is to be attached to the ISICS network, coordination with the ISICS maintenance team is needed to program the radios and gain access to the system.

- **Purchase their own standards-based P25 radio system and attach it to the ISICS network**

  An agency may choose to purchase a standards-based P25 standalone radio system (e.g. complete system with master switching center) and interconnect it into the ISICS network via standards-based system to system interface (ISSI).

  Since the new system will interface with the ISICS system at the standards interface level, the agency will retain full autonomy and control of its local resources. Therefore, the agency can choose to have as many general use channels as deemed necessary and select site locations based on local needs. However, this approach differs from the previous approach (*purchase their own radio subsystem and attach it to the ISICS network*) in that a complete system must be implemented at the local level and attached to the ISICS network for the purposes of interoperability. As such, the cost of implementing the master switching center (ISICS regional controller) must be included in this approach.

  As before, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. Since the agency's system is to be attached to the ISICS network, coordination with the ISICS maintenance team is needed to program the switching centers and user radios to gain access to the system.

9.2 Migration from Conventional System

This category represents agencies that own the communications system currently used to support agency operations. A large portion of the agencies screened through ***FE's*** outreach interview and survey processes identified conventional VHF as the current system configuration used to support day-to-day communications. To a lesser degree, similar UHF systems were also identified.

With such a large portion of public safety agencies throughout the state operating on the same frequency band, greater opportunities for interoperability between agencies exist. Agencies interviewed identified the existing ability to communicate directly to neighboring agencies in the field using VHF interoperable frequencies. This indicates that many agencies operate at the Level 3 of the interoperability continuum. However, this wide use of the VHF band also brings more interference problems inherent to the congested VHF band. A large portion of VHF users interviewed by ***FE*** had experienced some interference issues.

Agencies owning a conventional radio system have the following four migration options available:

- **Directly join the ISICS network**

  The ISICS system has been designed to achieve a grade of service (GoS) of 1% or better. This was achieved by evaluating the baseline load (users on each site) and determining the minimum number of channels needed to maintain channel availability to users in the field.

  Once an agency indicates intent to directly join the system, this loading analysis must be redone to determine if additional channel resources will be required at the radio sites. Once this is addressed, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. Coordination with the ISICS maintenance team is needed to program the radios and gain access to the system. To facilitate the transition process, agencies might choose to deploy dual band radios capable of operating on the current system and the P25 standards-based ISICS radio network.

- **Interface with the ISICS network via gateway**

  In order to provide a means to interoperate with the ISICS network without relocating from the current system or requiring the replacement of user radios, a gateway solution could be implemented by the system owner. While a gateway can provide for basic patching of voice communications, certain limitations associated with this solution confine it to the lower level of the SAFECOM continuum. Gateways might provide adequate interoperability as long as agency users remain within their native service area and minimal simultaneous emergencies occur. Further coordination with ISICS engineers could result in mutually agreed upon regional interoperability talkgroups.

- **Purchase their own 700 MHz radio site and attach it to the ISICS network**

  An agency may choose to purchase a standards-based P25 trunked standalone site or radio subsystem (e.g. simulcast cell) and interconnect it into the ISICS network. While the ISICS system would view the subsystem or site as its own, the agency will retain management rights and may choose tower site placement based on agency specific needs. In addition, the agency can choose to have as many general use channels as deemed necessary. While this approach provides the agency with autonomy in choosing the subsystem parameters (e.g. site location, number of channels), it also saves the cost of implementing the master switching center since the ISICS network will provide these services in the regional controller. Since the agency's site or subsystem is to be attached to the ISICS network, coordination with the ISICS maintenance team is needed to program the radios and gain access to the system.

  Finally, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. In order to facilitate the transition process, agencies might choose to deploy dual band radios (700/VHF or 700/UHF) capable of operating on the current system and the P25 standards-based ISICS radio network.

- **Purchase their own 700 MHz standards-based P25 radio system and attach it to the ISICS network**

  An agency may choose to purchase a standards-based P25 standalone radio system (e.g. complete system with master switching center) and interconnect it into the ISICS network via standards-based system to system interface (ISSI).

  Since the new system will interface with the ISICS system at the standards interface level, the agency will have full autonomy and control of its local resources. As such, the agency can choose to have as many general use channels as deemed necessary and select site locations based on local needs. However, this approach differs from the previous approach (*purchase their own radio site and attach it to the ISICS network*) in that a complete system must be implemented at the local level and attached to the ISICS network for the purposes of interoperability. The cost of implementing the master switching center (ISICS regional controller) must be included in this approach. Since the agency's system is to be attached to the ISICS network, coordination with the ISICS maintenance team is needed to program the switching centers and user radios to gain access to the system.

As before, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. In order to facilitate the transition process, agencies might choose to deploy dual band radios (700/VHF or 700/UHF) capable of operating on the current system and the P25 standards-based ISICS radio network.

9.3 Migrating from Proprietary 800 MHz Trunked System

This category represents agencies that own the communications system currently used to support agency operations. Specifically, the system is identified as a trunked communications system operating in the 800 MHz band using proprietary protocols. Agencies owning this type of radio communications system have the following four migration options available:

- **Directly join the ISICS network**

  The ISICS system has been design to achieve a grade of service (GoS) of 1% or better. This was achieved by evaluating the baseline load (users on each site) and determining the minimum number of channels needed to maintain channel availability to users in the field.

  Once an agency indicates intent to directly join the system, this loading analysis must be redone to determine if additional channel resources will be required at the radio sites. Once this is addressed, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. Coordination with the ISICS maintenance team is needed to program the radios and gain access to the system. Joining ISICS at this juncture implies that mobile-based coverage is sufficient for the particular agency needs. To facilitate the transition process, agencies might choose to deploy dual mode radios capable of operating on the current system and the P25 standards-based ISICS radio network.

- **Interface with the ISICS network via gateway**

  In order to provide a means to interoperate with the ISICS network without relocating from the current system or requiring the replacement of user radios, a gateway solution could be implemented by the system owner. While a gateway can provide for basic patching of voice communications, certain limitations associated with this solution confine it to the lower level of the SAFECOM continuum. Gateways might provide adequate interoperability as long as agency users remain within their native service area and minimal simultaneous emergencies occur. Further coordination with ISICS engineers could result in mutually agreed upon regional interoperability talkgroups.

  In addition, deployment of dual mode 700/800 MHz radios capable of operating on the current system and the P25 standards-based ISICS radio network will allow access into the ISICS radio network when agency users roam outside of the native service area.

- **Upgrade or purchase their own radio site and attach it to the ISICS network**

  An agency may choose to purchase a standards-based P25 trunked standalone site or radio subsystem (e.g. simulcast cell) and interconnect it into the ISICS network. While the ISICS system would view the subsystem or site as its own, the agency will retain management rights and may choose tower site placement based on agency specific needs. In addition, the agency can choose to have as many general use channels as deemed necessary. While this approach provides the agency with autonomy in choosing the subsystem parameters (e.g. site location, number of channels), it also saves the cost of implementing the master switching center since the ISICS network will provide these services in the regional controller. Since the agency's site or subsystem is to be attached to the ISICS network, coordination with the ISICS maintenance team is needed to program the radios and gain access to the system.

  Finally, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. Acquiring dual mode 700/800 MHz radios capable of operating on the current system and the P25 standards-based ISICS radio network will ease the migration process.

- **Upgrade or purchase their own standards-based P25 radio system and attach it to the ISICS network**

  An agency may choose to purchase a standards-based P25 standalone radio system (e.g., complete system with master switching center) and interconnect it into the ISICS network via standards-based system to system interface (ISSI).

  Since the new system will interface with the ISICS system at the standards interface level, the agency will have full autonomy and control of its local resources. As such, the agency can choose to have as many general use channels as deemed necessary and select site locations based on local needs. However, this approach differs from the previous approach (*purchase their own radio site and attach it to the ISICS network*) in that a complete system must be implemented at the local level and attached to the ISICS network for the purposes of interoperability. As such, the cost of implementing the master switching center (ISICS regional controller) must be included in this approach. Since the agency's system is to be attached to the ISICS network, coordination with the ISICS maintenance team is needed to program the switching centers and user radios to gain access to the system.

  As before, the agency must acquire standards-based P25 subscriber radios that meet specific agency needs. Acquiring dual mode 700/800 MHz radios capable of operating on the current system and the P25 standards-based ISICS radio network will ease the migration process.

9.4 Migrating from Standards-based P25 Trunked System

This category represents agencies that own the communications system currently used to support agency operations. Specifically, the system is identified as a standards-based P25 trunked communications system operating in the 800 MHz band. Agencies owning this type of radio communications system have only one migration option:

- **Interface with the ISICS network via standards-based ISSI**

  Interoperability with the ISICS system can be achieved via the standards-based system to system interface known as ISSI. However, this approach would require 700/800 MHz dual band radios that allow user access to the both systems.

9.5 Data Migration

For those users currently using a data service there are a number of migration paths depending upon what type of service is currently being used and the desired data environment need for the user in the ISICS network.

Current data service types can be defined as:

- **Low speed integrated voice/data service**

  This is typically provided as a feature of the private legacy radio system that is used for voice service. The service area for this data offering is generally directly related to the voice service area. Sometimes it is a completely separate system of radio equipment, possibly only sharing the spectrum band between the voice and data service. This is generally owned by the radio provider, and as a private data system does not contend with non-public safety users. Special equipment is necessary to access and use this data service. Typically data transfer rates are on the order of <19kbps. Specialized data applications can be easily supported across this private network. Data terminals on this data service can directly access the local public safety servers and interface to general public safety data ports.

- **Medium speed cellular data service**

  This typically is provided by a cellular service provider (or a reseller of cellular service). The service area for this data service is generally large, approximating the cellular voice service area. The public safety users generally contend with non-public safety users for access to the data service. Typical data transfer rates are on the order of 150-400 kbps. Appropriate data modem devices (e.g., cellular modem cards) and suitable cellular service subscription (authorization) are necessary to access the cellular service. General data applications and IP based applications are available over this network. Need to invoke virtual private network (VPN) tunneling to provide secure connections to public safety data servers or applications.

- **High-speed data service**

  This level of data service is typically provided by public or private local access point (e.g., hotspot) networks. This can be provided by a public entity (e.g., commercial business) or by a private entity (e.g., police station). Special equipment is necessary to access and use this data service. An appropriate modem device (e.g., WiFi card) is necessary to access the data access point.

Users may need subscription service or special authentication/authorization to access the data network. The typical data transfer rates are on the order of >1Mbps. General data applications and IP based applications are available over this network. Need to invoke virtual private network (VPN) tunneling to provide secure connections to public safety data servers or applications.

The data tiers are loosely defined as follows:

- **Low tier: Non-demanding, non-real time**

  This tier supports non-demanding data needs, with no expectation of real-time, interactive responsiveness. Typically this domain includes general use of text-based services (e.g., text messaging, email, fixed format forms) with little need for imaging or video. Simple web browsing can also be supported, though the general throughput is not sufficient for content rich websites. Use of specialized web browsers for the limited data service is advisable. Specialized data terminal devices accessing the shared voice and data P25 system are the general access devices.

- **Mid tier: Moderate throughput; interactive**

  This tier supports some demanding, interactive data operations. Though real-time responsiveness is generally not available (typically the service supports best effort). This domain includes the use of text based services, seeking a faster response time than afforded on the low tier environment, plus some imaging and moderate quality video. Web browsing can be supported with acceptable throughput rates to facilitate normal access to content rich websites. These services are typically provided by a dedicated broadband service, cellular service, or equivalent. This can be provided by 3G cellular data service (e.g., CDMA EV-DO, UMTS), WiFi hotspots. Appropriate cellular or mobile broadband data subscriber device (e.g., smartphone, PDA), or modem card for computer terminal is necessary. Limited differentiation of service is available to provide better quality of service to the public safety user.

- **High tier: high throughput; low latency**

  This tier supports demanding data services from either the necessary level of real-time interactivity, or the amount of information being transferred. This domain includes the uses from the low and medium tier environments, plus allows for high definition imaging and video service approaching real-time, full motion video, and can support real-time interactive service functions. Service can be prioritized by user or application type to optimize the service experience of the public safety user. This can be provided by public safety capable 4G broadband data service (e.g., LTE). Appropriate mobile broadband data subscriber device (e.g., Smartphone, PDA), or modem card for computer terminal is necessary to access the data service.

The ISICS wireless data network melds all three tier environments to provide data service to the public safety users. At any location within the ISICS network area there may be multiple data service offerings available. The narrowband (low tier throughput) P25 integrated data solution is ubiquitously available across the entire ISICS service area. There may also be cellular or other public/private medium tier data networks available. There may also be the ISICS broadband LTE data network available. For a data user to make optimal use of the ISICS wireless data network, the mobile router should be used to insulate the data user from needing to manually track and select a data network to use. The mobile router is aware of the data services available in the area and will choose the appropriate service to match the current needs of the data user. The mobile router continues to monitor the conditions of the available data services and switches data services as the data user need warrants.

Data users that need to only perform services at the low tier (P25 data) can simply install the P25 data terminal and forego the need for the mobile router.

Data users that need service beyond that offered by the low tier offering should install a mobile router to optimize performance as the data service environment changes for the data user in the field. The mobile router should be equipped with the appropriate system access devices (e.g., radios, modems) for the anticipated data services to be used by the data user device.

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10. Phased Implementation

Although the transition to ISICS encompasses many tasks, it lends itself to an orderly process that can be overseen by a partnership of the ISICSB, state and local agencies, project consultants, and the contractor selected via competitive procurement. In general, this process begins with obtaining funding approval, developing detailed plans, and assembling the necessary resources.

Beyond the hurdles of funding approvals come the tasks of proposed system design evaluation, procurement, installation, long-term support and sustained participation across the public safety community.

10.1 Planning and Approval

The planning and approval phase started with the development of the ISICS Master Plan and achieves a major milestone in the overall planning process. The next step is public, political, and continuing scrutiny of the Plan. Public awareness is probably the most significant factor in gaining support for ISICS. In order for ISICS to succeed, migration to the system by as many user agencies as possible will be a significant plus. But funding decisions must be made at the state, city, and county levels before all the pieces can be put into place. The members of ISICSB are a key resource in initiating a campaign to bring the issues in this Plan to the public's attention. While some of the technical ideas behind the ISICS system design are somewhat complex, the need for effective public safety is something every citizen—and certainly every city council and county board member—can understand.

In order to achieve the vision of interoperability and the benefits associated with the implementation of a statewide interoperable communications system, stakeholders, influencers, and policy makers must remain engaged at all levels of the planning process. Outreach activities will remain a critical factor with direct impact on the success of the project. Therefore, the ISICSB should maintain an effective outreach program that communicates the vision of interoperability, fosters free and open exchange of information, keeps potential stakeholders informed of project related activities, and encourages private/public partnership participation – all with the goal of increasing the effectiveness of the ISICS deployment. The planning and approval process will culminate when funding is approved by the Iowa legislature.

10.2 Procurement and Implementation

Given the complexities of successfully deploying a statewide communications system of this magnitude, the ISICS rollout should be partitioned into several phases that account for limited financial resources, functional building blocks, the initial proof of concept, and logical expansion of the system.

The system design presented in this Master Plan partitions the State into three geographic regions - Western, Central, and Eastern. While this approach provides for a good distribution of the population centers throughout the State, it presents a challenge in selecting which particular region should be used as proving grounds. Since it is unrealistic that a particular region could be deployed in a single phase, it is of critical importance to commence the system deployment in such a way as to allow for the general proof of concept to take place in a limited area. Nevertheless, this limited area should be significant enough as to allow for real world system loading, multi-agency use, and overall day-to-day demands of public safety agency usage. This approach will allow the ISICSB to evaluate the effectiveness of the system design, the technology used, and overall system functionality via mutually agreed to acceptance tests plans. Figure 76 shows the location of the limited area that fits this description, which encompasses Polk, Story, and Jasper counties.

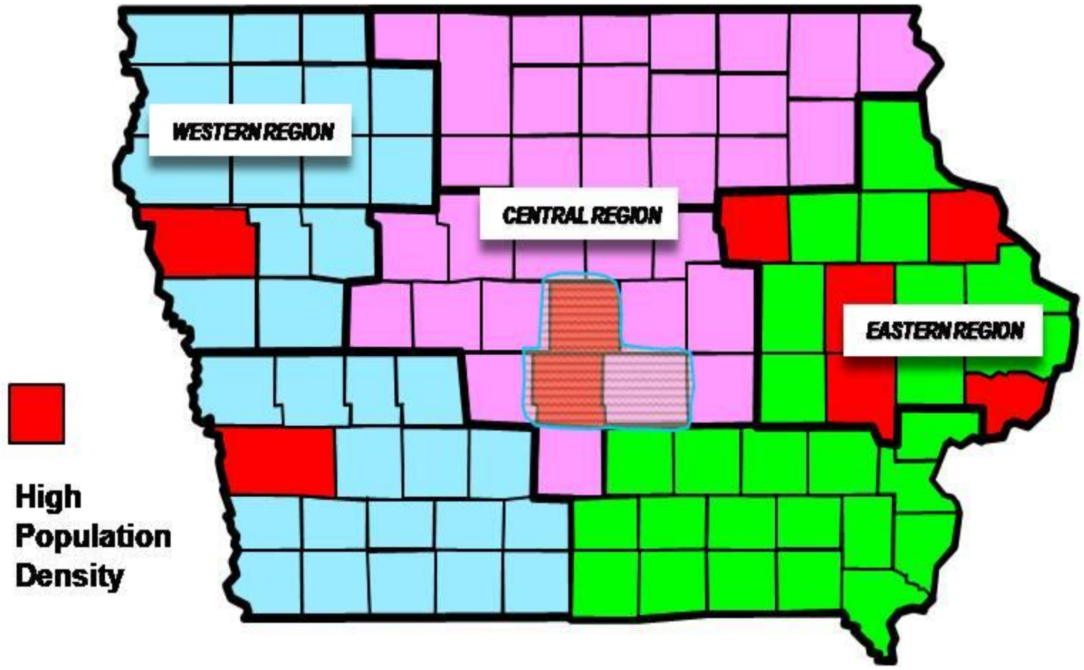

Figure 76 – Initial system deployment service area

10.2.1 Implementation Phase 1

Initial system deployment in Polk, Story, and Jasper Counties represents the largest combined population center, large channel loading scenario, and multi-agency use that can be achieved in a limited geographic area. In addition, it allows for the proof of concept to take place across several technology structures eventually to be deployed throughout the State of Iowa.

The relatively large population being served in the initial system implementation phase represents large channel loading characteristics, higher density of clustered structures, and the potential for added portable coverage requirements in targeted areas. Specifically, Polk and Story Counties should be served by separate simulcast cells while Jasper County is served by the deployment of multicast sites. The initial system structure is illustrated in Figure 77.

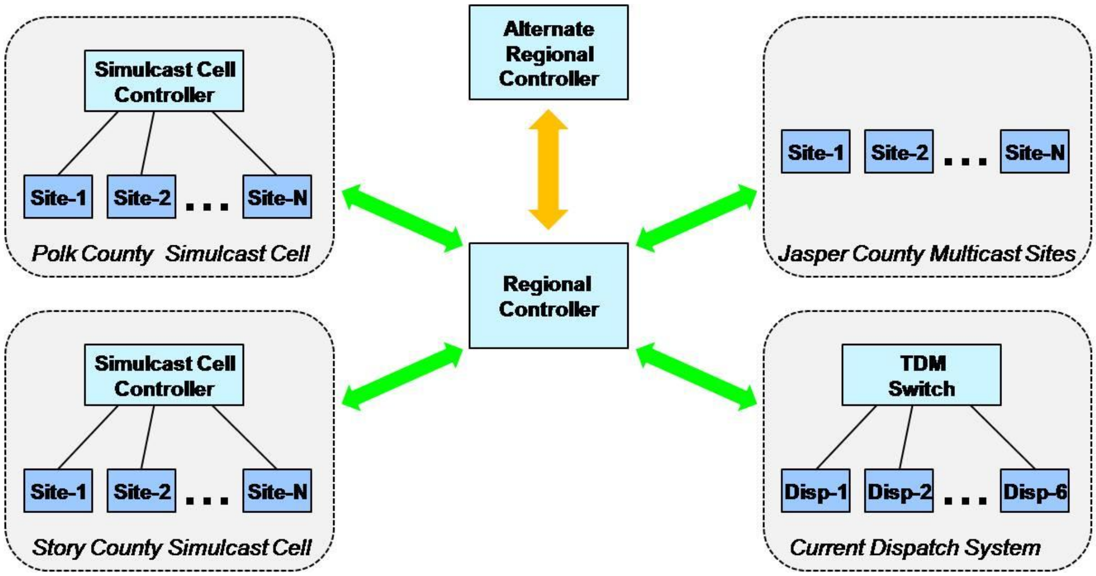

Figure 77 – Initial system structure

The current dispatch structure should remain unchanged with minimal upgrades needed for the regional controller interface. This implies that current radio resources should remain operational while the new 700 MHz P25 trunked system becomes active. Radio dispatchers at each of the six DPS dispatch centers will have new trunking resources available. That is, in addition to the conventional resources normally seen by dispatch operators (e.g. Fire, LEA, EMS, and point-to-point), new 700 MHz trunking resources will now be available. This structure will allow for the interoperation of all available resources.

The Regional Controller should be collocated with the Des Moines dispatch center equipment currently housed in the Des Moines National Guard Armory. However, the alternate regional controller should be housed at a separate location and interconnected via ICN fiber link. Such physical separation will provide for protection against catastrophic site failures. The resulting logical structure is illustrated in Figure 78.

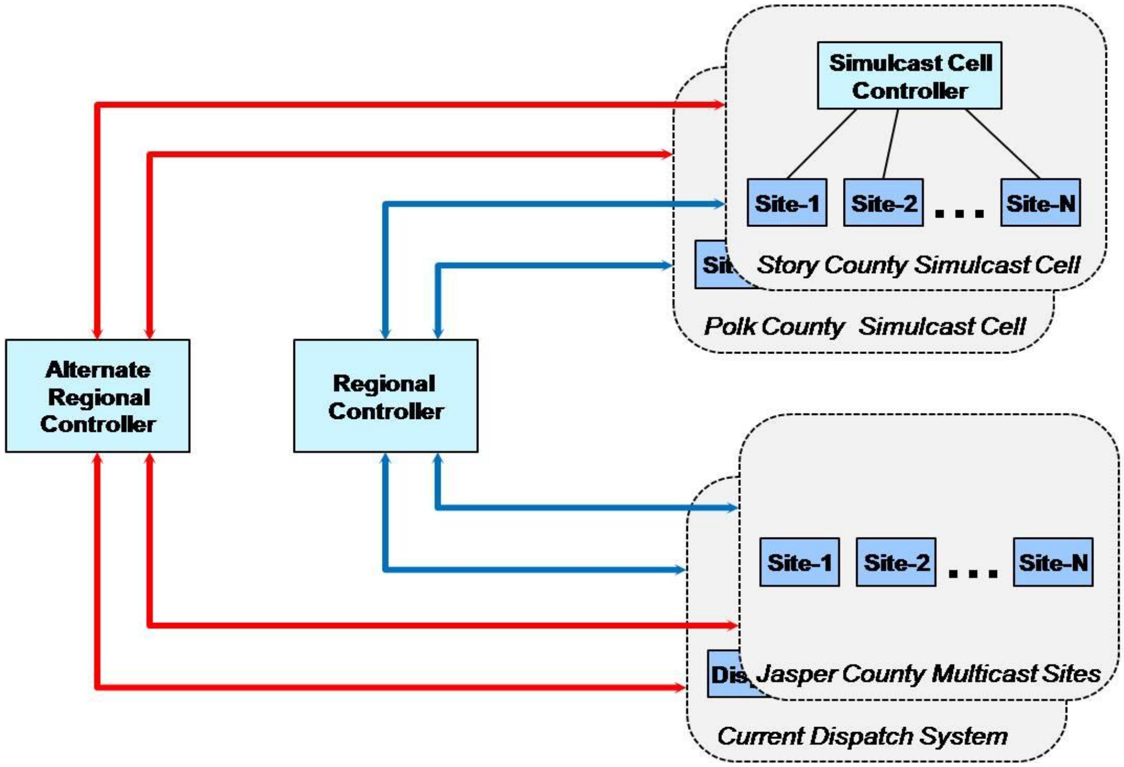

Figure 78 – Initial system logical structure

The initial system deployment phase should also account for the prolonged support of current radio resources. Given the fast approaching FCC mandate to move current VHF/UHF users into narrowband operation by 2013 and the fact that deploying a statewide P25 trunked solution is a multi-year long term endeavor, the state and local agencies should prepare for the migration into narrowband operation. Migration to narrowband operation will have no effect on the system architecture and is simply a reflection of the fact that complete deployment of a statewide solution before the FCC mandated deadline is highly unlikely. In addition, the continual support of these conventional resources will allow for a statewide VHF overlay of mutual aid channels for those entities that decide not to join the statewide interoperable P25 trunking system. Nevertheless, it should be clearly understood that switching over to VHF/UHF narrowband operations will have the impact of reduced site coverage. Agencies with strong dependence of these systems will experience coverage related issues at the fringe areas served by such systems. Given the fact that agencies will require migration to narrowband VHF, a plausible solution is for such agencies participating in this phase to invest in dual band radios (700/VHF). This approach will allow for support of the phased deployment of the ISICS system while support of current VHF overlay continues into the future.

While the initial phase accounts for only three counties in the Central Region, interconnecting the sites chosen should be done in such a fashion as to support additional system growth and expansion. This microwave backhaul transport system should allow for enough bandwidth to support future data services such as wireless data and the forwarding of data from NG911 services to data subscribers in the field. This initial system deployment, known as Phase I, should consist of the following elements:

- Simulcast cell for Polk County - three sites and 24 channels per site
- Simulcast cell for Story County - three sites and 11 channels per site
- Multicast sites consisting of the following configuration:
  - Two sites with four channels per site
  - One site with five channels
  - One site with seven channels
  - One site with nine channels
- Updated consolidated dispatch subsystem consisting of six dispatch centers
- Regional controller for the Central Region
- Alternate regional controller
- Microwave backhaul transport system

The focus of this phase is the proper limited deployment of the voice radio system and the validation of the proof of concept. As identified in the user needs analysis, the need for interoperable voice communications far outweighed the need for data services. While the goal is to support wireless data services, the data elements supported in this phased implementation address basic data needs (low speed data). Higher speed data services should be introduced as optional sub-phases to be deployed at future times as funding priorities allow for the deployment of such services.

10.2.2 Implementation Phase 2

The purpose of this phase is the expansion of the voice communications system and the microwave backhaul transport network that interconnects the overall ISICS system. As illustrated in Figure 79, Phase 2 expands the service area to include all the remaining counties in HLS&EM Region 1. Such expansion will allow for the contiguous use of the 700 MHz band across a significantly larger geographic area.

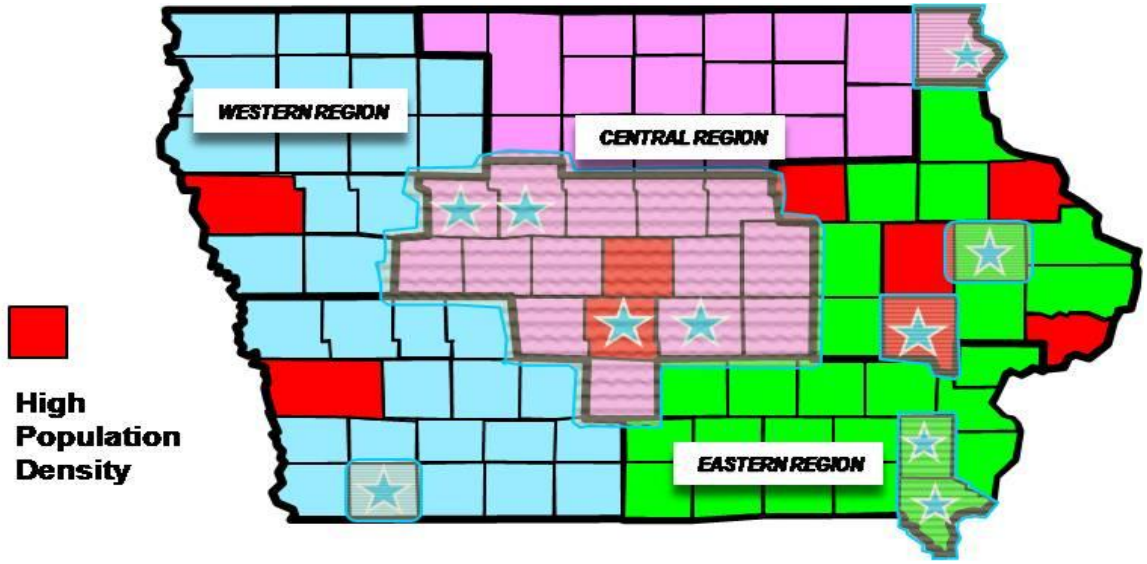

Figure 79 – Phase 2 system deployment service area expansion

While the main goal for this phase is the full system expansion throughout HLS&EM Region 1, six additional counties will be included in this expansion. Phase 2 should include the following elements:

- Initial simulcast cell for Linn County - two sites and 14 channels per site
- Simulcast cell for Johnson County - three sites and 10 channels per site
- Simulcast cell for Allamakee County - five sites and six channels per site
- Multicast sites consisting of the following configuration:
  - 14 sites with three channels per site
  - 20 sites with four channels per site
  - Eight sites with five channels per site
  - Four sites with six channels per site
  - One site with seven channels
  - One site with eight channels
- Microwave backhaul transport system

The purpose for including six additional counties is exclusively linked to providing communications to all Iowa Department of Corrections facilities throughout the State in this phase of the ISICS system expansion. These counties are identified in Figure 79 with a star. Such inclusion will allow for a common DOC user experience throughout the State. The counties outside the central region will eventually migrate to their home region once the system is expanded and each region has its own regional controller installed and operational.

Given the fact that the additional six counties included in this phase are geographically separated from HLS&EM Region 1, these counties will become *microwave islands* that need to be interconnected into the currently-deployed ISICS system. That is, while outside of their regional system, they would interconnect into the central region controller via multiple microwave hops. Therefore, the ICN could be used to support this phase as an alternative approach.

Once this system expansion is completed, all 16 counties within HLS&EM Region 1 will be ready for local users through direct system access. Local agencies and the correctional facilities located in the additional six counties included in this phase (Allamakee, Jones, Johnson, Page, Henry, and Lee) will have the ability to join the ISICS system directly. In general, multicast sites should be used for this system expansion phase with the exception of Allamakee and Johnson Counties, which require simulcast technology to address issues of terrain and large population areas.

10.2.3 Implementation Phase 3

While continual system expansion of the central region is necessary, it is of equal importance to commence ISICS operations in the next highest population region. As illustrated in Figure 80 the focus of this phase is to start the initial deployment of the Eastern Region system with all 14 counties within HLS&EM Region 6 being included in this phase.

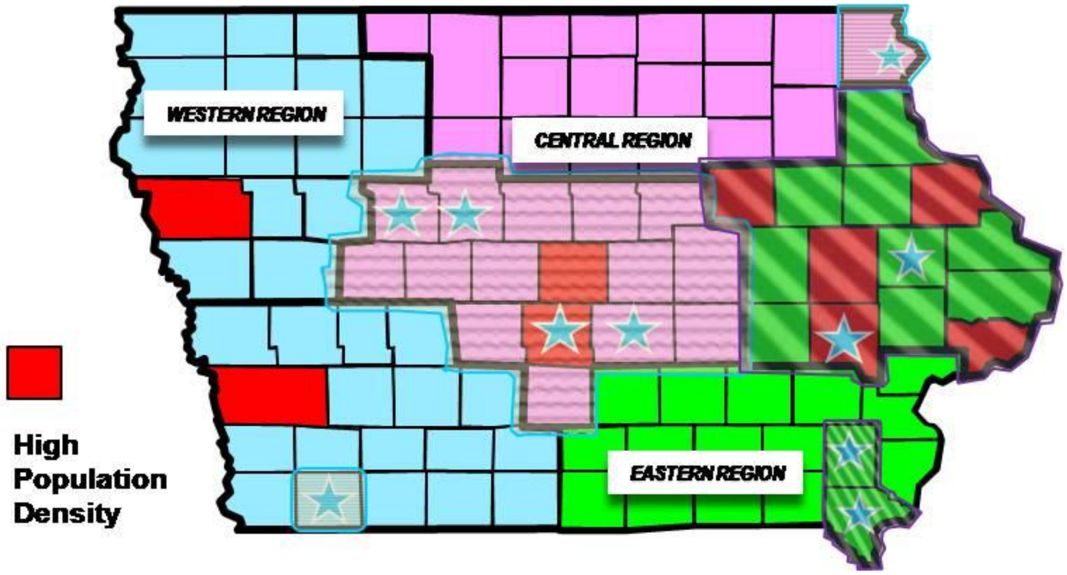

Figure 80 – Phase 3 system deployment service area expansion

The Eastern Region will have its own regional controller which will reside at the Cedar Falls DPS dispatch facilities. Once the Eastern Region controller becomes operational all radio sites and dispatch systems physically located in the Eastern Region, but previously linked to the Central Region controller, should be migrated into their own regional controller. The radio sites requiring migration to the new Regional Controller are contained in Jones, Johnson, Henry, and Lee counties.

Special consideration should be given to the following four counties within HLS&EM Region 6 that border the Mississippi River: Clayton, Dubuque, Jackson, and Scott. These counties have difficult terrain conditions and relatively large population centers. As a result, these counties should be served by simulcast cells. In addition, a simulcast cell should serve Black Hawk and Linn Counties given the large population density in the City of Waterloo and Cedar Rapids, respectively.

The alternate regional controller will remain housed in a different location and interconnected via ICN optical fiber link. As with the Central Region controller, the physical separation will provide for protection against catastrophic regional controller site failures. The resulting logical system structure is illustrated in Figure 81.

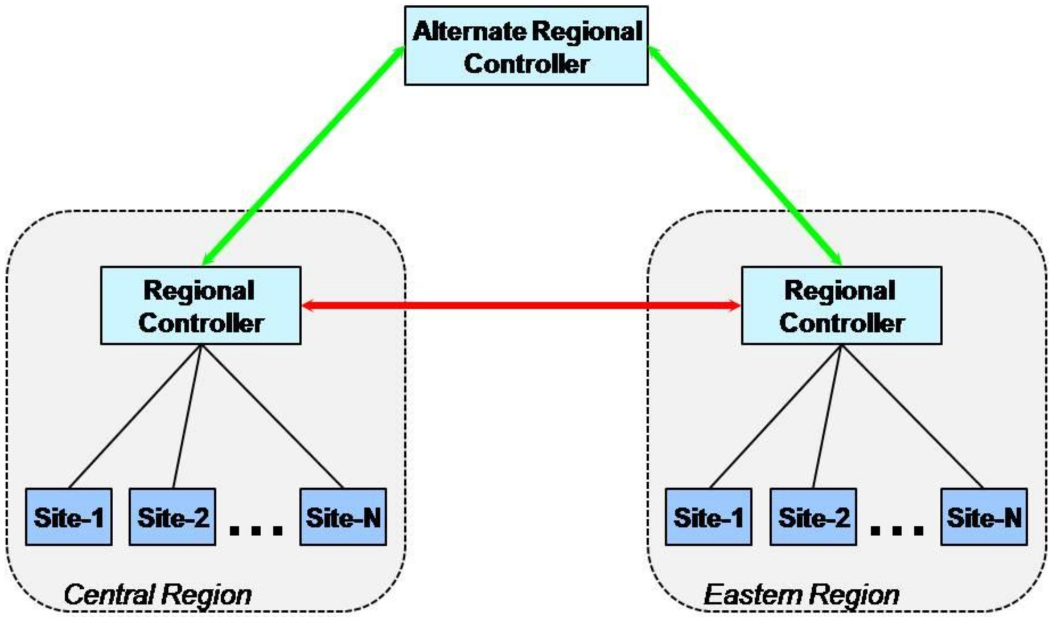

Figure 81 – High level regional sub-systems

While the main goal for this phase is the full system expansion throughout HLS&EM Regions 1 and 6, the secondary outcome is the initial segmentation of the system via site assignments to specific regional controllers. Phase 3 should include the following elements:

- Simulcast cell expansion for Linn County – two sites and 14 channels per site
- Simulcast cell for Black Hawk County - two sites and 14 channels per site
- Simulcast cell for Dubuque County - six sites and 11 channels per site
- Simulcast cell for Scott County - two sites and 11 channels per site
- Simulcast cell for Clayton County - five sites and nine channels per channel
- Simulcast cell for Fayette County - three sites and nine channels per site
- Simulcast cell for Jackson County - five sites and seven channels per site
- Multicast sites consisting of the following configuration:
  - Seven sites with three channels per site
  - Three site with four channels
  - Two sites with six channels per site
- Regional Controller for the Eastern Region
- Microwave backhaul transport system

The completion of this phase will mean that a major milestone in the ISICS deployment process has been achieved. At this point in time, HLS&EM Regions 1 and 6, plus

Allamakee, Page, Henry, and Lee counties represent ISICS service availability to over 60% of Iowa's population.

10.2.4 Implementation Phase 4

The focus of this phase is to start the initial deployment of the Western Region system with all nine state line counties within HLS&EM Regions 3 and 4 being included in this phase. Six additional counties are included to provide for ISICS system continuity between the active portions of the regional subsystems. That is, this approach will provide for service continuity between the western, central, and eastern regions. As described in the system design section of this document, the Western Region will have its own regional controller and will reside at the Storm Lake DPS dispatch facilities. Once the Western Region controller becomes operational, all radio sites and dispatch systems physically located in the Western Region but linked to the Central Region controller should be migrated into their own regional controller. The radio sites requiring migration to the new regional controller are contained in Page County.

In addition to commencing the ISICS build-out in the Western Region, further coverage footprint will be provided in the central and eastern regions as well. The purpose of these regional expansions is to provide for continuous availability of the ISICS system throughout the eastern Iowa border. The completion of this phase will signify ISICS service availability to over 80% of Iowa's population.

As noted in Figure 82 the northeastern sector of the Central Region will be expanded to include the following five counties: Howard, Winneshiek, Chickasaw, Bremer, and Fayette. In addition, the Eastern Region will be expanded to include the following four counties: Muscatine, Louisa, Des Moines, and Washington. As a result, there will be greater service availability throughout the eastern border of the State.

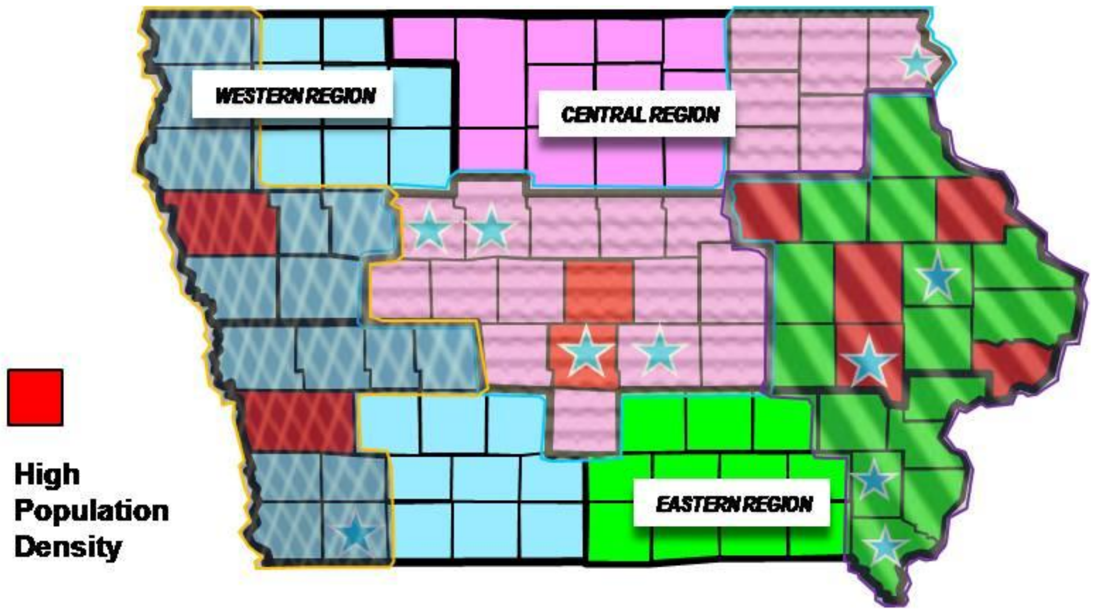

Figure 82 – Phase 4 system deployment service area expansion

Special consideration should be given to Woodbury and Pottawattamie Counties that border the Missouri River in the Western Region. These counties have relatively large population centers and slight terrain difficulties. As such, these counties should be served by simulcast cells. However, of the counties included for the Central and Eastern Region expansion, Winneshiek and Fayette Counties have terrain characteristics that require a simulcast cell structure. That is, the technology selection for these counties is mainly influenced by terrain characteristics, not population densities.

As in previous phases, the alternate regional controller will remain housed in a different location and interconnected via ICN fiber link. As with the Central and Eastern Region controllers, the physical separation will provide for protection against catastrophic regional controller site failures. The resulting logical system structure is illustrated in Figure 83.

As previously mentioned, each operational region will have its own microwave backhaul transport system configured as three intersecting bidirectional loops. Each regional controller is connected to its respective regional microwave backhaul system. Nevertheless, these regional controllers will have access to each other and facilitate the roaming of users throughout the three regions – Western, Central, and Eastern. This approach will keep normal operations on the microwave system while using the ICN fiber system to support alternate or backup controller functionality.

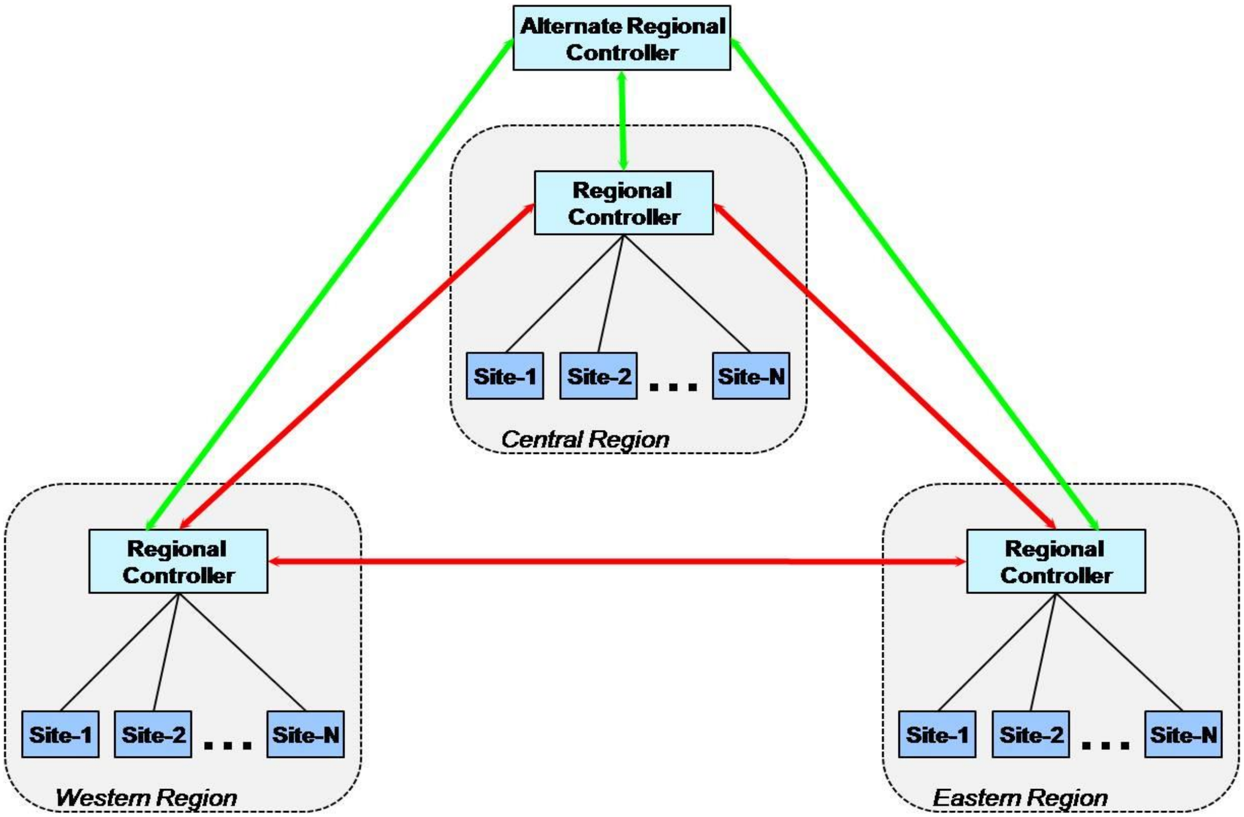

Figure 83 – High-level regional sub-systems architecture

The primary benefit achieved from this system expansion phase is the contiguous availability of the 700 MHz band throughout the middle of the State from both east and west state boundaries. In addition, it allows for further segmentation of the system via site assignments to specific regional controllers. That is, after completion of the Phase 4 system expansion, the system will have achieved the logical segmentation desired.

The Phase 4 system expansion should include the following elements:

- Simulcast cell for Woodbury County - four sites and 11 channels
- Simulcast cell for Pottawattamie County - six sites and 11 channels
- Simulcast cell expansion for Fayette County - two sites and nine channels
- Simulcast cell for Winneshiek County - five sites and six channels
- Multicast sites consisting of the following configuration:
  - 48 sites with three channels per site
  - Six sites with four channels per site
  - Five sites with five channels
  - Two sites with six channels per site

- Regional Controller for the Western Region
- Microwave backhaul transport system

While ICN connectivity will no longer be required for the areas previously considered *microwave islands* in Henry, Lee, and Page Counties, ICN connectivity should be retained as an available alternate link. In addition, the ICN will be used to link the Western Region controller with the alternate regional controller.

10.2.5 Implementation Phase 5

The focus of this phase is to complete ISICS deployment in the northern counties of the State. As illustrated in Figure 84 this includes all remaining counties in the northern section of the Western and Central Regions. Completion of this phase will provide for service continuity between the Western, Central, and Eastern Regions on the northern section of the State.

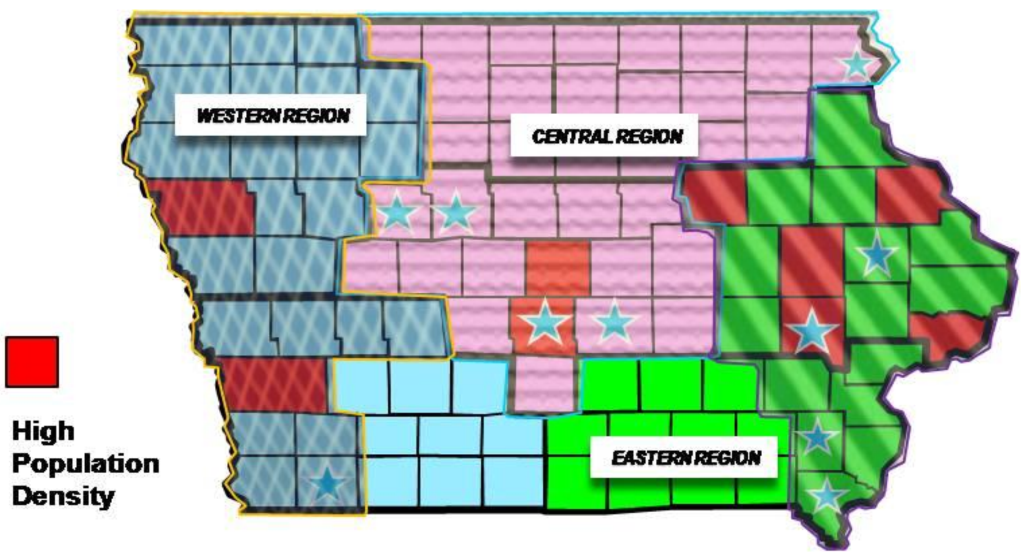

Figure 84 – Phase 5 system deployment service area expansion

The northeastern sector of the Western Region will be expanded to include coverage for eight additional counties while the northern sector of the Central Region will include 12 additional counties.

The Phase 5 system expansion should include the following elements:

- Multicast sites consisting of the following configuration:
  - 15 sites with three channels per site
  - Seven sites with four channels per site

- Four sites with five channels per site
- Three sites with six channels
- Two sites with seven channels
- One site with eight channels

- Microwave backhaul transport system

The counties included in this phase can be served without the need for simulcast technology. All new radio sites will be logically linked to their regional controller as designed.

10.2.6 Implementation Phase 6

The focus of this phase is to complete ISICS deployment in the southern counties of the State. As illustrated in Figure 85, this includes all remaining counties in the southern section of the Western and Eastern Regions. Completion of this phase will provide for service continuity between the Western, Central, and Eastern Regions of the State.

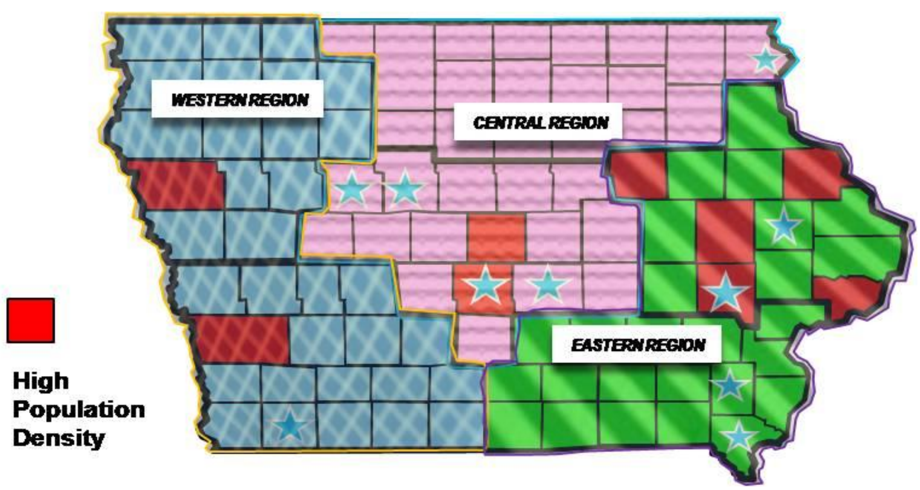

Figure 85 – Phase 6 system deployment service area expansion

This final system expansion includes coverage for nine additional counties in the southern sector of the Western Region and 11 additional counties in the Eastern Region.

The Phase 6 system expansion should include the following elements:

- Multicast sites consisting of the following configuration:
  - 33 sites with three channels per site
  - 14 sites with four channels per site
  - One site with six channels

- Microwave backhaul transport system

The counties included in this phase can be served without the need for simulcast technology. As with the northern expansion (Phase 5), all new radio sites will be logically linked to their regional controller as designed.

10.3 Ongoing Operations and Growth

On the heels of system installation will be ongoing operations and growth. In this phase, careful attention to several strategic activities will pay off in long term cost control and functionality. Among these activities are contract performance monitoring, continued encouragement of local participation, and deployment of advanced capabilities over time.

System maintenance concerns (e.g., routine service, equipment updates, and fault recovery) are major considerations to retain an operable communication system. This includes the service training, certification, and actual maintenance operations for both the infrastructure equipment and the fielded subscriber devices. The annual cost of system maintenance is expressed as a percentage of the total equipment cost (infrastructure and fielded subscriber devices), and is assumed to be 5% annually for ISICS.

11. Cost Analysis

In order to accomplish a cost analysis for the ISICS network certain basic assumptions were employed. These are summarized as follows:

- ISICSB managed system
- All 700 MHz P25 trunked sites
- Mobile based voice coverage
  - 95% geographic coverage per county
- Combination of multicast and simulcast technology
- Reuse existing tower facilities where possible
- Design for combined State and local user population (approximately 26,000 users) with expansion to support additional loading
  - 12% State growth factor per county over five years
  - 15% local growth factor per county over five years
- Dedicated transport microwave system interconnecting sites and network elements
- Subscriber costs are not included in the cost estimates detailed in this section, but need to be accounted for in each jurisdiction's ISICS budget.

From past experiences, sizing of a network directly impacts the overall cost. This includes the number of users to be serviced by the network as well as the coverage constraints of the network. For the ISICS network, the network sizing has the following cost drivers:

- Site Count – Driven by 95% mobile coverage per county
  - Equipment shelters
  - Towers
  - Site improvements
- Channel Count – Driven by estimated public safety user population
  - 26,000 State and local users
  - Grade of Service (GoS) = 1%
  - Minimum of 3 channels per site

Reduction in the coverage requirements or initial user population to be supported may reduce the overall cost of the ISICS network. However, a reduction in these requirements may be accompanied by a reduction in performance and functionality. The following cost analysis assumes the basic cost assumptions are still in effect.

Given the complexities of deploying a statewide communications system, the ISICS rollout has been segmented into six phases that account for potentially limited financial resources, functional building blocks, the initial proof of concept, and logical expansion of the system. Each phase contributes to the final goal of full statewide coverage and interoperability.

In following the phased implementation strategy, ***FE*** provides estimated pricing information for the six implementation phases. The estimates provided in this section are based on current and historical data derived from similar procurements in comparable jurisdictions. It is important to understand that although budgetary cost estimates have been provided, these estimates include several design assumptions that will be refined during the final design process of the communications system. Other market factors and system capability decisions made during the final design phase may have a significant impact on the actual cost of new technology. For this reason the cost ranges provided should be used for planning and budgetary purposes only. That is, the estimates provided are conservative in nature and should be viewed as budgetary cost list rather than a negotiated cost. A summary of the estimated budgetary costs associated with each phase are provided below.

Table 14 – Phased cost summary

Implementation phase	Estimated budgetary cost
Phase 1	$24M
Phase 2	$64M
Phase 3	$63M
Phase 4	$97M
Phase 5	$41M
Phase 6	$47M
Total	**$336M**

There are five cost categories used when estimating the overall project cost. These categories and associated costs are summarized in Table 15.

Table 15 – Cost category summary

Implementation cost category	Estimated budgetary cost
Site infrastructure	$96M
Communications equipment	$91M
Backhaul transport	$76M
Project management, engineering, implementation	$48M
Contingency and spares	$25M
Total	**$336M**

The budgetary cost estimates provided, include the following design assumptions that have been applied to all six implementation phases:

Site infrastructure cost

The site selection process was based on propagation studies that defined the coverage goal of 95% mobile coverage for each county within the State of Iowa. In addition, path studies were performed to determine how each site could be provided with microwave connectivity. As outlined in the design section of this document, an estimated 265 radio sites are needed to achieve this goal. In addition, six microwave relay sites are needed to support the conceptual system design.

As outlined in Table 3 (Section 8.3.4) the selected tower sites include state agency sites, local agency sites, private sites, and new (Greenfield) sites. The following assumptions were used to establish an infrastructure cost estimate:

- DPS towers and equipment shelters will be reused, but some costs will be incurred associated with needed improvements.
- IDOT sites will require new 300 ft. towers and new equipment shelters.
- Greenfield sites will require new 300 ft. towers and new equipment shelters.
- Private towers and equipment shelters will be reused, but some costs will be incurred associated with needed improvements.
- 75% of local agency towers and shelters will require new 300 ft. towers and associated equipment shelters.
- New towers will be evenly divided between guyed towers and self supporting tower structures

Material and labor costs associated with tower, grounding, shelter, battery, generator, and security work have been included in the total site infrastructure cost. The replacement towers and additional site costs represent a significant portion of the total cost. Alternative approaches such as tower build/lease programs may be explored as a possible means to provide substantial cost saving to the overall project. Site acquisition costs (land, fees, etc.) are not included.

Communications equipment

The equipment cost includes base stations, regional controllers, trunking controllers, simulcast and/or multicast equipment, etc. The antenna equipment hardware at each site includes an adequately sized combining and multi-coupling system, tower top amplifier, transmit and receive antennas, 1-1/4 inch transmission lines, tower clamps, lightning protection, and standard racks. The total antenna equipment cost assumes that adequate 700 MHz frequencies exist and no more than one transmit antenna is required per site.

Backhaul transport

A substantial portion of the ISICS system cost is in the microwave connectivity. The microwave cost is based on a licensed turnkey, loop technology design. This type of configuration provides a level of redundancy and reliability recommended for public safety communications systems. Imbedded in the total microwave cost are dollar amounts for the backhaul antenna, networking, monitoring, and test equipment.

Project management, engineering, and implementation

The cost associated with this category includes engineering time, system optimization, and project management involvement during the deployment and implementation of the system. This cost is estimated to be approximately 18% of the system cost.

Contingency and spares

A system deployment of this magnitude requires special consideration for unexpected costs and time associated with resolving field issues. It is typical for system deployments to include spares that cover all major system components. This helps resolve issues quickly while failed components are sent for repair or replacement. This cost is estimated to be approximately 9% of the system cost.

Subscriber costs

Subscriber units are a key component to any wireless communications network and are a significant implementation cost element. However, because subscriber costs will be driven by individual jurisdictions' implementation plans, the ISICSB chose to focus this analysis on the infrastructure cost elements. Subscriber costs are not included in the estimates below, but need to be accounted for in each jurisdiction's ISICS budget. For future budget planning, the following subscriber unit cost estimates can be used:

	Mobile Subscriber Unit Cost	Portable Subscriber Unit Cost
High-tier	$5000	$5000
Mid-tier	$4375	$2500
Low-tier	$2500	$1875

To determine the subscriber cost estimate one should use the following equation:

Subscriber Cost = Mobile Subscriber Cost + Portable Subscriber Cost where:

Mobile Subscriber Cost = (# of high tier mobiles) x ($5000) + (# of mid-tier mobiles) x ($4375) + (# of low-tier mobiles) x ($2500)

Portable Subscriber Cost = (# of high tier portables) x ($5000) + (# of mid-tier portables) x ($2500) + (# of low-tier portables) x ($1875)

System maintenance costs

The annual cost of system maintenance is assumed to be 5% of the total equipment cost (infrastructure and fielded subscriber devices), and is to be compounded at a 3% rate over a ten year period. (The maintenance costs are not included in this cost summary due to subscriber population variability from the various unique jurisdiction implementation schedules. This cost should be considered for future budget planning.) Further costing details for each implementation phase is provided in the following subsection.

11.1 Implementation Phase 1 Summary

Table 16 – Phase 1 items included

ITEM	NUMBER OF SITES	NUMBER OF CHANNELS
Polk County simulcast cell	3	24
Story County simulcast cell	3	11
Multicast sites	2	4
Multicast sites	1	5
Multicast sites	1	7
Multicast sites	1	9
Updated consolidated dispatch subsystem	6	n/a
Regional controller (Central region)	1	n/a
Alternate regional controller	1	n/a
Microwave backhaul transport system	12 hops	n/a

Table 17 – Phase 1 estimated cost

ITEM	ESTIMATED COST
Communications Equipment	$12M
Backhaul Transport	$4M
Site Infrastructure	$4M
Project Management, Engineering, and Implementation	$3M
Contingency and Spares	$1M
Total	**$24M**

11.2 Implementation Phase 2 Summary

Table 18 – Phase 2 items included

ITEM	NUMBER OF SITES	NUMBER OF CHANNELS
Partial Linn County simulcast cell	2	14
Johnson County simulcast cell	3	10
Allamakee County simulcast cell	5	6
Relay sites	1	0
Multicast sites	14	3
Multicast sites	20	4
Multicast sites	8	5
Multicast sites	4	6
Multicast sites	1	7
Multicast sites	1	8
Microwave backhaul transport system	60 hops	n/a

Table 19 – Phase 2 estimated cost

ITEM	ESTIMATED COST
Communications Equipment	$17M
Backhaul Transport	$14M
Site Infrastructure	$19M
Project Management, Engineering, and Implementation	$9M
Contingency and Spares	$5M
Total	**$64M**

11.3 Implementation Phase 3 Summary

Table 20 – Phase 3 items included

ITEM	NUMBER OF SITES	NUMBER OF CHANNELS
Linn County simulcast cell expansion	2	14
Black Hawk County simulcast cell	2	14
Dubuque County simulcast cell	6	11
Scott County simulcast cell	2	11
Clayton County simulcast cell	5	9
Fayette County simulcast cell	3	9
Jackson County simulcast cell	5	7
Relay sites	2	0
Multicast sites	7	3
Multicast sites	3	4
Multicast sites	2	6
Regional controller (Eastern region)	1	n/a
Microwave backhaul transport system	52 hops	n/a

Table 21 – Phase 3 estimated cost

ITEM	ESTIMATED COST
Communications Equipment	$20M
Backhaul Transport	$12M
Site Infrastructure	$17M
Project Management, Engineering, and Implementation	$9M
Contingency and Spares	$5M
Total	**$63M**

11.4 Implementation Phase 4 Summary

Table 22 – Phase 4 items included

ITEM	NUMBER OF SITES	NUMBER OF CHANNELS
Woodbury County simulcast cell	4	11
Pottawattamie County simulcast cell	6	11
Fayette County simulcast cell expansion	2	9
Winneshiek County simulcast cell	5	6
Relay sites	2	0
Multicast sites	48	3
Multicast sites	6	4
Multicast sites	5	5
Multicast sites	2	6
Regional controller (Western region)	1	n/a
Microwave backhaul transport system	98 hops	n/a

Table 23 – Phase 4 estimated cost

ITEM	ESTIMATED COST
Communications Equipment	$24M
Backhaul Transport	$22M
Site Infrastructure	$30M
Project Management, Engineering, and Implementation	$14M
Contingency and Spares	$7M
Total	**$97M**

11.5 Implementation Phase 5 Summary

Table 24 – Phase 5 items included

ITEM	NUMBER OF SITES	NUMBER OF CHANNELS
Relay sites	1	0
Multicast sites	15	3
Multicast sites	7	4
Multicast sites	4	5
Multicast sites	3	6
Multicast sites	2	7
Multicast sites	1	8
Microwave backhaul transport system	46 hops	n/a

Table 25 – Phase 5 estimated cost

ITEM	ESTIMATED COST
Communications Equipment	$8M
Backhaul Transport	$10M
Site Infrastructure	$14M
Project Management, Engineering, and Implementation	$6M
Contingency and Spares	$3M
Total	**$41M**

11.6 Implementation Phase 6 Summary

Table 26 – Phase 6 items included

ITEM	NUMBER OF SITES	NUMBER OF CHANNELS
Multicast sites	33	3
Multicast sites	14	4
Multicast sites	1	6
Microwave backhaul transport system	62 hops	n/a

Table 27 – Phase 6 estimated cost

ITEM	ESTIMATED COST
Communications Equipment	$10M
Backhaul Transport	$14M
Site Infrastructure	$12M
Project Management, Engineering, and Implementation	$7M
Contingency and Spares	$4M
Total	**$47M**

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12. Funding Strategies

The ISICS implementation will require considerable investment of both time and capital. The ability to obtain necessary funding represents one of the greatest challenges and risks to a statewide project of this scope. Funding the procurement and implementation of ISICS can be accomplished through a number of alternative approaches such as capital appropriations, issuance of bonds, and vendor lease-purchase agreements. Other options include federal grants or the redirection of existing state revenue resources.

Examples of primary revenue sources of other states implementing a statewide solution consist of taxes, targeted surcharges, and user fees. These include sales tax, gross receipts tax, and other consumption taxes such as motor fuels, alcoholic beverages, and tobacco products. Other sources include traffic infraction revenues, license renewal fees, utility fees, telecommunications surcharges, and fees for use of state services. While these approaches have been used by other states, applicability to the State of Iowa remains to be ascertained.

Often, combinations of these sources over several budgetary cycles will build a comprehensive funding strategy covering the entire life cycle of the system. While the current economic environment presents additional challenges for the development of a successful funding strategy, it also offers opportunities for federal grant funding, and creative financing from vendors at relatively low cost that might not be offered during healthier economic times.

It is important to recognize that strategic planning of such a system must look beyond the initial design, procurement, and implementation phases with an eye towards identifying funding for continuing obligations for operations, maintenance, administration, and system renewal that extends throughout the life of the system.

The approach that Iowa employs to fund the ISICS network will be unique to its deployment. The following examples show similar procurement and implementation funding strategies for significant statewide technology programs around the country.

12.1 Michigan

System Architecture: 800 MHz P25 digital trunked radio system

Coverage Goal: Approximately 97% statewide coverage for mobile radios

Funding Methodology:

- State Building Authority Funds ($184M)
- State General Fund ($50M)

Comments:

Michigan funded the implementation of its public safety communications system through a combination of state appropriations and federal grant money. Existing state revenue resources were redirected to fund the public safety communications system implementation and operations. Federal grant awards were used as seed money to fund the initial project kickoff and additional phases were funded with 911 surtax dollars. Members or users of the system pay a one-time activation fee of $25 per radio and a recurring subscriber fee of $200 for each radio per year providing a revenue source for maintenance and operations.

In 1994, the Michigan Legislature approved funding for the new system, through the issuance of bonds from the State Building Authority (SBA). The SBA issued tax exempt securities. The SBA assumed title of the entire system, land fixtures and property. The State of Michigan entered into a long term lease with the SBA and each year the State Legislature appropriates sufficient funds to pay the lease. State lease payments are used to retire bond debt.

In the fall of 1995, Michigan commenced phase one construction. The initial phase deployment areas of southeast Michigan, including the Detroit, Jackson and Lansing areas were completed in 1997. Phase two was completed and brought online in 1998, covering all of southwest Michigan. The completion of phase three, the northern Lower Peninsula followed in 2000. The project was completed in late fall of 2002 upon completion of the Upper Peninsula as part of the fourth and final phase.

12.2 Oregon

System Architecture: VHF/700 MHz hybrid P25 digital trunked radio system

Coverage Goal: Coverage for mobile radios

Funding Methodology:

- Certificates of Participation
- General Fund
- Federal Funds

- User Fees

Comments:

The Oregon Wireless Interoperable Network (OWIN) has completed project planning and received funding from state agencies and the state legislature totaling over $347 million. Oregon is currently in the process of developing an RFP for the procurement of the first of three phases of the statewide system deployment.

12.3 Minnesota

System Architecture: 800 MHz P25 digital trunked radio system

Coverage Goal: Approximately 95% statewide coverage for mobile radios

Funding Methodology:

- Bonds
- Federal Homeland Security Grant ($6M)
- Reallocation from state highway fund
- 911 surtax collected on all wired and wireless telephone lines per month ($.03)

Comments:

The Minnesota Departments of Transportation (Mn/DOT), Public Safety (DPS), Natural Resources (DNR), and Administration (DOA), partnered to develop a plan that included the design and implementation of a shared public safety radio system throughout Greater Minnesota. The state transportation department financed a percentage of the cost through general obligation bonds with money reallocated from the state's highway fund. Additional funding for capital costs came from a monthly 911 surtax on wired and wireless telephone lines of $.03.

In June of 2003, the state legislature appropriated $27 million for another system expansion phase. The Department of Homeland Security provided an additional $6 million in federal grant money for communities in Minnesota to acquire interoperable equipment to operate on the shared trunked radio system.

12.4 Virginia

System Architecture: VHF P25 Integrated Voice and Data (IV&D) trunked system

Coverage Goal: Approximately 93% statewide coverage for mobile radios

Funding Methodology:

- Bonds

Comments:

The Statewide Agencies Radio System (STARS) program facilitates communications of 21 participating state agencies by upgrading the existing Virginia State Police land mobile and microwave radio networks. STARS creates an integrated, seamless, statewide, Project 25 (P25) wireless voice and data communications system designed to meet communications and interoperability needs of these agencies.

Virginia used a seven-phase regional implementation approach as part of the STARS Program, similar to the proposed six phase implementation plan for Iowa's communication systems. The Commonwealth of Virginia approved $159 million in bonds to fund the initial implementation phase in 2005. Additional bonds have been issued to fund successive implementation phases. The final completion phase is expected to be completed in 2011.

12.5 North Carolina

System: 800 MHz P25 digital trunked radio system

Coverage Goal: Statewide 95% on-street portable coverage

Funding Methodology:

- Grants
- Law Enforcement Terrorism Prevention Program grants ($8.8M)
- State Homeland Security Grants ($21.5M)
- Urban Area Strategic Initiative Grant ($1.04M)
- NC Legislature ($500K)

Comments:

The State of North Carolina began an initiative in 2005 to replace the outdated radio systems statewide with the Voice Interoperability Plan for Emergency Responders (VIPER) statewide system. The strategy is to phase the system into communities across the state over approximately five years. The state has already used $55 million from Homeland Security funds and the governor has asked the General Assembly to appropriate more than $60 million over the next two years.

12.6 Florida

System Architecture: Statewide 800 MHz EDACS trunked radio system

Coverage Goal: Approximately 95% statewide coverage for mobile radios

Funding Methodology:

- Privately-owned radio system providing statewide LMR coverage on a fee for service basis
- $3.00 State Radio System surcharge assessed on all traffic citations

Comments:

The Statewide Law Enforcement Radio System (SLERS) is a public/private partnership in which the vendor owns and operates the communications network. The vendor received a $40 million initial payment with recurring yearly charges derived from motor vehicle and vessel registration surcharges (estimated at $15M to $18M annually).

The contract provides for revenue sharing in two ways:

- For the initial term of the contract (20 years), the State receives 15% of all net revenues received from third-party tenants on towers conveyed to the vendor from the State. After the initial term, the State receives 50% of all net revenues received from third-party tenants collected by the vendor for use of the same towers for an additional 30 years.
- For any third-party subscribers using the radio system, the State receives 5% of the gross revenue collected by the vendor

Joint Task Force agencies must provide radios for their users, dispatch center facilities, equipment, and other expenses. There is no charge to the Joint Task Force agencies for use of the system.

12.7 Illinois

System Architecture: Statewide 700/800 MHz P25 digital trunked radio system

Coverage Goal: Approximately 95% statewide coverage for mobile radios

Funding Methodology:

- Privately-owned radio system providing statewide LMR coverage on a fee for service basis
- Illinois Fund for Infrastructure, Roads, Schools, and Transit (FIRST) state funds
- Increased license renewal fee

Comments:

The State Radio Communications for the 21st Century (STARCOM21) is a public/private partnership in which the vendor owns and operates the communications network. This includes the responsibility for maintaining a service level that meets the expectations of public safety users. The system is structured to allow each agency to have complete responsibility for its dispatch centers and be in control of its own radio communications.

Any government agency that joins the system is responsible for purchasing subscriber radio equipment and additional infrastructure if user needs surpass that of initial system design. Additional fees for joining the STARCOM21 network are:

- A monthly user fee for each radio that joins the network
- A onetime activation fee, assessed to users that join the network

The initial system investment was made via Illinois FIRST (Fund for Infrastructure, Roads, Schools and Transit) funding. In addition, legislation was passed that increased the fee on license renewals to pay for infrastructure improvements.

12.8 Grant Opportunities

In creating a comprehensive funding strategy, federal grant opportunities may fund parts of the statewide project directly or can be used to replace existing funding commitments allowing for the reallocation of those budgetary resources to the ISICS project. Below is a sample of recent grant programs allocations for fiscal year 2009 that illustrate grant programs that may be available in the future to fund communications equipment and training:

- **RUS Broadband Initiatives Program (BIP)** will make available loans and grants for broadband infrastructure projects in rural areas

- **NTIA Broadband Technology Opportunities Program (BTOP)** provides grants to fund broadband infrastructure, public computer centers and sustainable broadband adoption projects
- **Interoperable Emergency Communications Grant Program (IECGP)** includes $48.6 million for planning, training, exercises and equipment to states, territories, local and tribal governments to carry out initiatives identified in statewide communication interoperability plans (SCIPs) and to improve interoperable emergency communications for responding to natural disasters and acts of terrorism
- **State Homeland Security Program (SHSP)** provides $861.3 million to strengthen and build state, territorial and local preparedness capabilities through planning, equipment, training and exercise activities
- **Urban Areas Security Initiative (UASI)** includes $798.6 million to enhance regional preparedness by strengthening capabilities in 62 high-threat, high-density urban areas across the country. The seven highest risk urban areas will compete for about $439 million, or 55 percent of available funds, while the remaining areas will compete for about $359 million, or 45 percent of the funds.

  DHS announced FY 2009 targeted allocations under SHSP and UASI for the first time. This is the result of direct stakeholder feedback and will assist states and urban areas in writing investment justifications (IJs) that reflect available grant resources. The department will continue to use the peer review process and applicants' effectiveness scores in determining final allocations.
- **Metropolitan Medical Response System Program (MMRS)** has $39.8 million to be evenly distributed among 124 MMRS jurisdictions to enhance and sustain comprehensive regional mass casualty incident response and preparedness capabilities
- **State Homeland Security Program Tribal (SHSP Tribal)** includes about $1.7 million to tribal applicants to build preparedness and response capabilities and to implement homeland-security plans
- **Freight Rail Security Grant Program (FRSGP)** offers $15 million to target resources for security plans, vulnerability assessments, employee security awareness training and GPS tracking systems for railroad cars transporting toxic inhalation materials

Additional federal grant opportunity information may be found at http://www.fema.gov/government/grant/index.shtm. More than $27 billion in federal grant opportunities have been awarded since 2002 and present a significant funding opportunity for the State of Iowa.

13. Summary

The ISICSB selected ***FE*** to develop an overall strategy for a statewide interoperable communications system design and implementation plan for public safety users in Iowa. The system, referred to as the ISICS, will provide voice, data, and enhanced 911 communications capability for public safety entities across the State of Iowa.

Pivotal to this system offering is the integrated communication architecture supporting a mesh of radio sites across the State of Iowa as the statewide communications framework. This framework supports day-to-day public safety communications for state and local agency users, provides a path for ease of communication system enhancements and equipment upgrades, and provides the underlying capability supporting interoperation between the various public safety agencies in Iowa.

The following key goals drove the ISICS conceptual design presented in this Master Plan:

- Provide a common wireless system for public safety entities
- Provide a migration path to a unified statewide communication system
- Provide a communication system architecture adaptable to the functional demands of the public safety stakeholders
- Provide ease of interoperable communications
- Support statewide seamless roaming
- Support wide area communications

The following paragraphs highlight the major elements presented in the ISICS Master Plan:

Migrate state and local agencies to a unified 700 MHz trunked system

The ISICS conceptual design provides statewide public safety grade communication support (DAQ=3.4) for mobile-based operation across 95% of each county. The conceptual design supports channel loading for approximately 26,000 public safety users across the State. The conceptual design is flexible and adaptable. Additional channel resources may be added to support increases in the user populations. Additional site resources may be added to support enhanced coverage needs for specific locations.

Support P25 trunked standard

Trunking is the most spectrally efficient system configuration available. The P25 standard is designed to satisfy the public safety user needs and has a rich feature set. The P25 Trunked Phase 1 standard, with inclusion of P25 ISSI Scope 1 feature support should be considered the minimum P25 standard level for the ISICS. The ISICS supports a future migration path to Phase 2 standards (embracing multiple standardized interfaces and narrowband capabilities for 6.25 kHz equivalency).

Build out the ISICS communication system as a joint effort between state and local agencies

Investigate various funding schemes and rollout schedules to leverage costs and optimize system usefulness. A primary consideration should be the reuse and integration of existing state and local communication resources to minimize overall ISICS timeline and capital expenses.

Build out a statewide transport network

This network should support IP networking technologies to leverage industry directions. The ISICS radio sites, control sites, and dispatch sites are to be primarily interconnected via a dedicated microwave network. This transport network needs to be available to interconnect elements of the ISICS network. The build out of the transport network needs to keep pace with the overall ISICS voice and data build out. The ICN can be used as a supplemental transport path to the microwave network.

ICN to provide broadband data transport support

The broadband data network elements are to be connected primarily via the ICN. The ICN is interconnected with the statewide microwave network and is an integral part of the ISICS offering.

Provide communication interoperability to legacy communication systems

Provide support for the local mutual aid channels such that communications will always be possible between legacy users accessing a mutual aid channel frequency and users of the ISICS network. Talkgroups would be allocated in the ISICS network to alias the local mutual aid channels; gateway technology would be used to provide the connection between the mutual aid channel and the ISICS network.

Narrowband requirement

A key concern for the majority of the existing VHF and UHF systems in Iowa is the need to comply with the fast-approaching FCC mandate that all communications systems operating in the VHF and UHF frequency bands migrate to narrowband emissions prior to January 1, 2013. It is advisable that conversion of existing affected systems toward ISICS compliance should be considered as a recommended solution to addressing the FCC narrowband mandate. The conversion of these systems to a 700 MHz based system is a possible step in the direction of the ISICS solution.

Ubiquitous data service

The ISICS network supports P25 narrowband data service across the coverage area of the ISICS network. This level of service is available to all ISICS users. Additionally, there may be higher capacity/speed data service offerings available to the ISICS users at various locations in the coverage area. These other data services may be provided by public/private service providers or through the ISICS broadband data offering. The data service user will be able to move seamlessly between the different data service offerings with the use of a mobile router that handles the physical connections to the various data services.

Adopt a broadband data solution in the 700 MHz spectrum for public safety use

To enhance the public safety broadband data service offering, the 3GPP LTE 4G standard or its equivalent should be provided. This may employ a commercial LTE system that supports public safety grade data services, may be a separate private public safety LTE network supported by the Iowa public safety agencies, or a combination of both. The consideration of partnering with public carriers, private service providers, or other state organizations (e.g., ICN) is advisable to mitigate data network capital expenses in the creation of a suitable broadband data solution for the statewide public safety community.

Upgrade wireline dispatch centers for P25 trunked operation and IP service capability

The dispatch centers should be upgraded to comply with P25 operations. Additionally the dispatch centers should be upgraded to support IP interfaces and functions. This allows ease of interface of the dispatch center to the ISICS network and also sets the foundation for support of Next Generation 911 information transfers.

Governance and stakeholder interests need to be addressed

In order for ISICS to succeed, more than technology needs to be addressed. As outlined in the SAFECOM Interoperability Continuum, interoperability must be addressed at the statewide level with regards to technology, governance, standard operating procedures (SOP), training, and system usage. As the creation of ISICS moves forward, emphasis on the establishment of regional committees representing stakeholder interests statewide should be prioritized.

There is a need to focus the future Iowa public safety communication system directions toward a common interoperability solution and away from independent non-integrated systems throughout the State that hamper inter-jurisdictional and interdisciplinary communications. The ISICS design creates an environment that fosters ease of interoperability between agencies operating in various geographic areas. Implementing ISICS will allow state and local entities to communicate and share information in real time, provide for the consolidation of resources, and maintain a level of independence and autonomy during day-to-day operations.

Although the migration to ISICS encompasses many complex tasks, it can be achieved through an orderly process and partnership of the ISICSB, state and local agencies, project consultants, and the system contractor selected via competitive procurement. This Master Plan recommends that the ISICS be deployed in several phases that take into account limited financial resources, functional building blocks, the initial proof of concept, and logical expansion of the system. In addition, costs estimates associated with each phase have been included to aide for planning and budgetary purposes. The estimates provided are based on current and historical data derived from similar procurements in comparable jurisdictions.

The ability to obtain necessary funding or financing represents one of the greatest challenges and risks to a statewide project of this scope. The procurement and implementation of ISICS can be funded through several approaches such as capital appropriations, bond issues and vendor lease-purchase agreements and may be supplemented with federal grants or the redirection of existing state revenue resources. Often, combinations of these sources are used over several budgetary cycles. While the approach that Iowa employs to fund the ISICS network will be unique to its deployment, FE has provided examples of how similar procurement and implementation strategies addressed funding for significant statewide technology programs around the country.

Implementing ISICS will provide benefits far beyond its main purpose of achieving statewide interoperability. It will provide for the consolidation of resources while maintaining independence and autonomy during day-to-day operations. This cooperative use of assets provides interoperability among agencies as well as significant cost saving opportunities across the State during a time of fragmented and limited funding, by avoiding the construction and maintenance of multiple disparate communications networks. In addition, ISICS interconnectivity will be available to other entities such as schools, hospitals, and other private enterprises fostering an environment of collaboration and unity around the common goal of interoperability.

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Appendix A: Glossary of Acronyms

16QAM	Quadrature Amplitude Modulation with 16-point constellation
3G	3rd Generation Cellular System
3GPP	3rd Generation Partnership Project
4G	4th Generation Cellular System
64QAM	Quadrature Amplitude Modulation with 64-point constellation
AAA	Authentication, Authorization, and Accounting Server
AES	Advanced Encryption Standard
ALI	Automatic Location Identification
ANI	Automatic Number Identification
ANSI	American National Standards Institute
APCO	Association of Public-Safety Communication Officials
AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
CAI	Common Air Interface
CAMA	Centralized Automatic Message Accounting
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CPE	Customer Premise Equipment
DAQ	Delivered Audio Quality
DES	Data Encryption Standard
DNR	Department of Natural Resources
DoC	Department of Corrections

DoD	Department of Defense
DOT	Department of Transportation
DPS	Department of Public Safety
EBS/BRS	Educational Broadband Service/ Broadband Radio Service
EMS	Emergency Management Services
ESN	Electronic Serial Number
Ev-DO	Evolution Data Optimized
FCC	Federal Communication Commission
GHz	giga Hertz (1 billion hertz)
GoS	Grade of Service
GSM	Global System for Mobile communications
HLS&EM	Homeland Security and Emergency Management
HLSEMD	Homeland Security and Emergency Management Division
ICN	Iowa Communication Network
IDOT	Iowa Department of Transportation
IDPH	Iowa Department of Public Health
IEEE	Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISICS	Iowa Statewide Interoperable Communication System
ISICSB	Iowa Statewide Interoperable Communication System Board
ISSI	Inter Sub System Interface
kbps	kilo bit per second (1 thousand bits per second)
kHz	kilo Hertz (1000 Hertz)

LAN	Local Area Network
LEA	Law Enforcement Agency
LMR	Land Mobile Radio
LOS	Line of Sight
LTC	Livermore Telephone Company
LTE	Long Term Evolution
Mbps	Mega bit per second (1 million bits per second)
MHz	mega hertz (1 million hertz)
NCIC	National Crime Information Center
NG911	Next Generation 911
NPSTC	National Public Safety Telecommunications Council
OTAR	Over the Air Rekeying
P25	APCO Project 25
PDA	Personal Data Assistant
PDE	Position Determining Equipment
Phase II	providing information that is more precise to PSAPs, specifically, the latitude and longitude of the caller
POC	point of contact
PSAP	Public Safety Answering Point
PSIC	Public Safety Interoperable Communications
PSTN	Public Switched Telephone Network
PTT	Push to Talk
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying

RFSS	RF Sub System
RPC	Region Planning Committee
SONET	Synchronous Optical Network
SR	Selective Router
SSB	Single Side Band
T1	data circuit that runs at 1.544 Mbps
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TIA	Telecommunication Industry Association
TIA	Telecommunication Industry Association
UHF	Ultra High Frequency
VHF	Very High Frequency
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WACN	Wide Area Communication Network
WiFI	IEEE 802.11-wireless LAN (WLAN)
WiMAX	Worldwide Interoperability for Microwave Access (IEEE 802.16)
WLAN	Wireless Local Area Network

Appendix B: Interoperability Summary for Iowa's Adjacent States

While the interoperability channels identified in the NPSTC plan are being used nationwide as the template for common channels and naming conventions, a significant amount of disparity exists among Iowa's adjacent state's interoperability planning and implementation strategies. By adopting the channels identified in the NPSTC plan, individual states can be assured that public safety users will obtain fundamental interoperability. At the present time Iowa's adjacent states are not closely following these guidelines. Nevertheless, it is recommended that Iowa adopt this plan and implement these channels, with their assigned names. By having these common channels installed in all radios within the State, Iowa can assure compliance with the plan and ultimately be confident that users within the State will have channels available to them during emergency situations.

Missouri

The State of Missouri established operating parameters for the FCC designated multi-discipline interoperability channels set aside by the FCC in the UHF and VHF public safety radio bands. The term *multi-discipline* infers that these channels are to be used for all public safety users to communicate to users within their disciplines and for cross-discipline communications between other public safety users (police to fire, fire to local government). There are no channels set aside for individual disciplines, as different incidents require varying amounts of participation from public safety first responders. These channels are most effective when used as a shared resource at the scene of an incident by the incident commander. Previously allocated FCC interoperability channels assigned for inter-system sharing (police mutual aid, fire mutual aid, etc.) within certain disciplines should continue to be used by Missouri's first responders to facilitate communications within their respective discipline.

The Missouri State Interoperability Executive Committee (SIEC) requires these channels be used under an incident command management structure where channels are used as resources to accomplish the communications function at each individual incident. Eligible entities within the Public Safety Radio Pool include, but are not limited to, agencies under the following categories per *FCC Regulations Section 90.20* for fire, highway maintenance, emergency medical, forestry/conservation, police, special emergency, and local government. The following is a synopsis of statewide interoperability channels used in the State of Missouri:

- **VHF interoperability channels**

  There are six specific frequencies used for this purpose - VCALL, MTAC, and four VTAC channels.

- **UHF interoperability channels**

  There are five specific frequencies used for this purpose – UCALL and four UTAC channels. These can be used for base-to-mobile or mobile-to-mobile communications.

- **700 MHz interoperability channels**

  There are 34 specific channels identified by the FCC for interoperability purposes. These channels are broken into 6 categories; 7CALL, 7TAC, 7DAT, 7LAW, 7EMS, and 7FIRE for use during emergencies. 7CALL channels are used for hailing a dispatcher or on-incident commander. 7TAC channels are for use in tactical situations by any public safety discipline. 7DAT channels are for use with mobile data communications. 7LAW, 7FIRE and 7EMS channels are discipline specific for use during emergencies or planned events by multiple jurisdictions. However, it is understood nationally, that all of the 700 MHz interoperability channels are available during emergency operations for use by any public safety jurisdiction, under the control of an incident commander, regardless of discipline. Specific channel information and configuration can be found in the NPSTC Channel Naming Report.

- **800 MHz Interoperability channels**

  There are five specific frequencies used for this purpose – 8CALL and four 8TAC channels. These can be used for base-to-mobile or mobile-to-mobile communications.

The FCC, per the *Third Report and Order, 00-348* dated October 10, 2000, allowed mobile operation to be on these interoperability channels without an individual mobile license provided the user is otherwise licensed under Part 90 of the FCC's rules. In its recommended channel parameters, the Missouri SEIC has also limited use of these channels to mobile only operation. To use these channels in Missouri, a memorandum of understanding (MOU) must be executed with the SIEC.

<u>Nebraska</u>

The Nebraska SIEC was formed on November 26, 2001, by Governor Johanns indicating the State's intent to administer interoperability spectrum, and to represent

Nebraska's interoperability interests. The purpose of the SIEC is to adopt the statewide mutual aid frequency plan and facilitate improvements to interoperable communications through shared frequencies and coordination of communications assets during emergencies. Membership is open to all public safety officials and stakeholders with an interest in Nebraska's public safety communications interoperability.

Coverage areas are established through SIEC's approval and local agreement to manage, operate and maintain shared communications through interoperability protocols. Unlike Missouri, which mandates interoperable channel usage, local jurisdictions in Nebraska have the flexibility to establish alternative mutual aid frequencies and coverage areas, and to interconnect designated statewide mutual aid channels to other resources (a practice not common in other states), as governed under the statewide interoperability plan or regional interoperability plan.

The state of Nebraska is in the process of building a new IP-based trunked P25 interoperable statewide radio system operating in the VHF band. When completed, this system will provide for interoperable communications for all state agencies while supporting conventional users through statewide mutual aid resources. Mutual aid base channel assignments in Nebraska are simplex stations controlled by local PSAPs. These public safety radio channels are also for mobile-to-mobile on-the-scene ground communications. First responders will be directed to *off-base channel* operating in the local area for ground communications. These conventional resources are as follows:

- **VHF Interoperability channels**

  There are five specific frequencies used for this purpose – VCALL and four VTAC channels. However, jurisdictions in Nebraska have the flexibility to establish alternative mutual aid frequencies and to interconnect designated statewide mutual aid channels.

- **UHF Interoperability channels**

  There are five specific frequencies used for this purpose – UCALL and four UTAC channels. However, jurisdictions in Nebraska have the flexibility to establish alternative mutual aid frequencies and to interconnect designated statewide mutual aid channels. UHF interoperability channels are simplex stations controlled by local PSAPs but repeater operation may be activated when controlled under agreement with the state frequency manager.

- **700 MHz Interoperability channels**

  Nebraska's 700 MHz system is currently in the planning stages. As such, there are currently no interoperability channels in use on this particular frequency band.

- **800 MHz Interoperability channels**

  There are five specific frequencies used for this purpose – 8CALL and four 8TAC channels. Ground channel assignments in this band are talk-around using base transmit frequency. This would be in cases where no repeater is in operation, or for incident command ground assignments. Temporary repeater operation is allowed, but is secondary to fixed operations (FB2T station class).

It should be noted that mutual aid frequency assignments in Nebraska are shared and not discipline specific. The statewide plan establishes a statewide coverage overlay that is intended to complement existing local systems that are already in use for daily operations. Mutual aid frequencies are available resources for assignment and use by local jurisdictions on an as needed basis. RF coverage areas provide a *minimal* capacity for dispatch coordination, and therefore must be used with command and control discretion.

South Dakota

The State of South Dakota operates a 54 site digital trunked VHF statewide radio system which provides for statewide interoperability. This system links state agencies, county agencies, and municipalities, with the exception of some campus facilities that do not have a need to interoperate with the other agencies in the State. South Dakota Fire Mutual Aid 1 (154.2650 MHz) and Fire Mutual Aid 2 (154.2950 MHz) are the most commonly used mutual aid frequencies.

- **VHF Interoperability channels**

  Interoperability in this frequency band is accomplished through the statewide interoperable radio system. As such, the nationally recognized VCALL and VTAC channels are secondary in nature and used primarily for interoperability with adjacent states and communications in areas not well covered by the statewide system.

- **UHF Interoperability channels**

  While the four nationally recognized channels used for this purpose (UCALL, and UTAC-1 through UTAC-3) are available for use throughout the state, there are very few UHF users in the State resulting in minimal usage of these channels. In general, UHF users also have VHF equipment and use the VHF interoperability channels to communicate with other jurisdictions during emergency incidents.

- **700 MHz Interoperability channels**

  There are currently no interoperability channels in use on this particular frequency band.

- **800 MHz Interoperability channels**

  There are currently no interoperability channels in use on this particular frequency band.

South Dakota has emergency mobile site equipment that operates in the VHF band and includes limited 800 MHz channels. This equipment includes back up repeaters, multi-coupler/combiner racks, a mobile tower site, and cache radios, to use in the event of communications site failure or a major incident. South Dakota's voice traffic is transported via a proprietary trunking system. The State has identified a plan to bring an open standard P25 compliant system online by 2012. All subscriber units will be updated and able to operate on the new system before implementation. Future radio equipment will include 600 new P25 compliant radios for state agencies and an upgrade of 11,000 radios at the local level. This system will serve public safety jurisdictions across the state, including Sioux Falls and Rapid City.

Minnesota

The Statewide Radio Board (SRB) was created by the Minnesota legislature in 2004 to implement a statewide interoperable public safety radio and communication system plan. That plan evolved out of the implementation of a region-wide interoperable radio system in the Minneapolis/St. Paul metropolitan area in 2001. At the time the SRB was created, the statewide public safety radio system was given the name of Allied Radio Matrix for Emergency Response (ARMER). The ARMER system is a major element of Minnesota's long term interoperable communication planning, but not the only element. There is an immediate and pressing need for interoperable public safety communication planning among all emergency responders and the SRB is a broad forum representing all public safety disciplines from across the State.

The ARMER system is an 800 MHz digital trunked system which allows frequencies to be pooled and shared. Agencies have access to a greater number of frequencies than would have been available if each constructed stand-alone systems; financial savings were also achieved. The backbone is owned by the Minnesota Department of Transportation (MnDOT).

- **VHF Interoperability channels**

  Interoperability in this frequency band is currently implemented at the local and regional level. Minnesota uses multiple frequencies for this purpose, which do not necessarily match the nationally recognized VCALL and VTAC channels. Minnesota is currently evaluating the possible deployment of standardized VHF interoperability channels on a statewide basis.

- **UHF Interoperability channels**

  Interoperability in this frequency band is currently implemented at the local and regional level. Minnesota uses multiple frequencies for this purpose, which do not necessarily match the nationally recognized UCALL and UTAC channels. Minnesota is currently evaluating the possible deployment of standardized UHF interoperability channels on a statewide basis.

- **700 MHz Interoperability channels**

  Minnesota's 700 MHz system is currently in the planning stages. There are currently no interoperability channels in use on this particular frequency band.

- **800 MHz Interoperability channels**

  There are five specific frequencies used for this purpose – 8CALL and four 8TAC channels. These can be used for base-to-mobile or mobile-to-mobile communications.

Wisconsin

While there are large communications systems within the State of Wisconsin, the State itself does not have an interoperable statewide solution. Wisconsin employs three mutual aid channels that are available statewide. These channels are known as Mutual Aid Radio Channel (MARC), Wisconsin Police Emergency Radio Network (WISPERN), and Interagency Fire Emergency Radio Network (IFERN). These are used for public safety agencies, law enforcement, and fire response respectively.

- **VHF Interoperability channels**

  Interoperability in this frequency band is currently implemented at the local and regional level. Wisconsin uses multiple frequencies for these purposes, which do not necessarily match the nationally recognized VCALL and VTAC channels.

- **UHF Interoperability channels**

  Interoperability in this frequency band is currently implemented at the local and regional level. Wisconsin uses multiple frequencies for these purposes which do not necessarily match the nationally recognized UCALL and UTAC channels.

- **700 MHz Interoperability channels**

  The State RPC (Region 45) has submitted and gained approval of the 700 MHz channel plan which includes interoperability channels. These channels follow the nationally recognized channel assignments and naming conventions, which include 34 specific channels identified by the FCC for interoperability purposes. These channels are broken into six categories – 7CALL, 7TAC, 7DAT, 7LAW, 7EMS, and 7FIRE for use during emergencies. 7CALL channels are used for hailing a dispatcher or incident commander. 7TAC channels are for use in tactical situations by any public safety discipline. 7DAT channels are for use with mobile data communications. 7LAW, 7FIRE and 7EMS channels are discipline specific for use during emergencies or planned events by multiple jurisdictions. However, it is understood nationally, that all of the 700 MHz interoperability channels are available during emergency operations for use by any public safety jurisdiction, under the control of an incident commander, regardless of discipline. Specific channel information and configuration can be found in the NPSTC Channel Naming Report.

- **800 MHz Interoperability channels**

  There are five specific frequencies used for this purpose – 8CALL and four 8TAC channels. These can be used for base-to-mobile or mobile-to-mobile communications.

<u>Illinois</u>

The State of Illinois operates a 700/800 MHz statewide P25 trunked system called STARCOM21. This allows for interoperability among state agencies, counties, and cities that have joined the system. Three essential VHF mutual aid channels are used for interoperability throughout the State. These channels are known as the Illinois State

Patrol Emergency Radio Network (ISPERN), the Interagency Fire Emergency Radio Network (IFERN), and the Illinois Radio Emergency Assistance Channel (IREACH).

- **VHF Interoperability channels**

  Interoperability in this frequency band is currently implemented at the state level but these channels do not necessarily match the nationally recognized VCALL and VTAC channels.

- **UHF Interoperability channels**

  Interoperability in this frequency band is currently implemented at the local and regional level. Illinois uses multiple frequencies for these purposes which do not necessarily match the nationally recognized UCALL and UTAC channels.

- **700 MHz Interoperability channels**

  The State RPC (Region 13) does not currently have an FCC approved 700MHz channel plan. However, their working plan includes the nationally recognized channel assignments and naming conventions. As such, there are no 700MHZ interoperability channels currently deployed along the Iowa border. There are 34 specific channels identified by the FCC for interoperability purposes. These channels are broken into six categories; 7CALL, 7TAC, 7DAT, 7LAW, 7EMS, and 7FIRE for use during emergencies. 7CALL channels are used for hailing a dispatcher or incident commander. 7TAC channels are for use in tactical situations by any public safety discipline. 7DAT channels are for use with mobile data communications. 7LAW, 7FIRE and 7EMS channels are discipline specific for use during emergencies or planned events by multiple jurisdictions. However, it is understood nationally, that all of the 700 MHz interoperability channels are available during emergency operations for use by any public safety jurisdiction, under the control of an incident commander, regardless of discipline. Specific channel information, mnemonics and configuration can be found in the NPSTC Channel Naming Report.

- **800 MHz Interoperability channels**

  There are five specific frequencies used for this purpose – 8CALL and four 8TAC channels. These can be used for base-to-mobile or mobile-to-mobile communications.

Appendix C: Proposed ISICS Site Plan

Appendix C

Proposed ISICS Site Plan

The following table summarizes site information on the 265 sites identified to provide desired 95% mobile coverage at DAQ = 3.4 across the counties of Iowa. These sites include reuse of existing DPS and IDOT sites as well as identifying other potential sites to be included in the network. (*These sites are possible sites that could be used for the statewide communication system, the actual sites that are determined at the time of system implementation may be different than these listed.)*

EXISTING DPS AND IDOT TOWER SITES	
Site Designation	**Site Name**
Albia	Albia
Beaverdale	Beaverdale
Belmond	Belmond
Blairsburg	Blairsburg
Brooklyn	Brooklyn
Cedar Fall	Cedar Falls
Denison	Denison
Des Moines	Des Moines
Glenwood	Glenwood
Gunder	Gunder
Harpers Ferry	Harpers Ferry
Holy Cross	Holy Cross
ISP - Atlantic	ISP - Atlantic
ISP - Cedar Falls	ISP - Cedar Falls
ISP - Cedar Rapids	ISP - Cedar Rapids
ISP - Fairfield	ISP - Fairfield
ISP - Iowa	ISP - Iowa Guard Armory
ISP - Storm Lake	ISP - Storm Lake
Laurel	Laurel
Lourdes	Lourdes
Maquoketa	Maquoketa
Merrill	Merrill
Moorhead	Moorhead

EXISTING DPS AND IDOT TOWER SITES	
Site Designation	**Site Name**
Muscatine	Muscatine
New Market	New Market
Springbrook	Springbrook
St. Mary's	St. Mary's
Terril	Terril
Van Wert	Van Wert
T4010	Adair maintenance
T4040	Adams tower
T3010	Akron
T3020	Algona base tower
T2010	Allamakee tower
T3031	Alton
T1020	Ames Comm
T5020	Appanoose tower
T4050	Atlantic base tower
T4070	Audubon remote
T4081	Avoca
T4380	Bedford
T6010	Benton tower
T1040	Boone tower
T2020	Bremer tower
T6060	Buchanan tower
T2030	Butler tower
T1060	Calhoun tower
T1071	Carlisle
T1080	Carroll base tower
T6070	Cedar remote tower
T6090	Cedar tower
T3090	Cherokee remote tower
T2060	Chickasaw tower
T2070	Clarion
T3100	Clay tower
T6100	Clayton tower
T6110	Clinton tower
T3110	Clm Hill remote
T3120	Correctionville

EXISTING DPS AND IDOT TOWER SITES	
Site Designation	**Site Name**
T4170	Creston tower
T2080	CVTC
T1100	Dallas scale east bound
T6120	Davenport base tower
T5040	Davis tower
T4180	Decatur tower
T2090	Decorah
T6130	Delaware tower
T2100	District 5
T6150	Dubuque base tower
T6160	Dubuque remote tower
T6170	Dyersville base tower
T3150	E-burg remote
T2120	Estherville remote
T4190	Fremont scale northbound
T2130	Garner
T1160	Gowrie
T4200	Greenfield tower
T1190	Grinnell
T1210	Gundy Center
T1221	Hamilton
T2140	Hanlontown
T5110	Henry remote tower
T2150	Humboldt remote
T3190	Ida Grove
T1230	Iowa Falls
T6180	Iowa tower
T6190	Jackson remote tower
T1240	Jasper scale west bound
T5130	Jefferson
T6200	Johnson tower
T6210	Jones remote tower
T5140	Keokuk tower
T2160	Kossuth remote tower
T2180	Lake Mills remote
T2190	Latimer

EXISTING DPS AND IDOT TOWER SITES	
Site Designation	**Site Name**
T5150	Lee scale tower
T3230	LeMars
T6220	Linn tower
T4220	Logan remote
T5160	Mahaska repeater tower
T6240	Marion Co. tower
T1260	Marshalltown
T4250	Mount Ayr
T5180	Muscatine tower
T4261	Neola
T6251	Newhall
T1270	Newton
T4270	Oakland
T2210	Osage
T4281	Osceola base
T3260	Pocahontas
T4310	Pottawattamie remote
T3270	Primgar remote
T4340	Red Oak remote
T3280	Rock Rapids
T3290	Rock Valley
T3300	Sac City
T3320	Sibley remote
T4350	Sidney
T3340	Soldier remote
T3350	Spirit Lake
T1300	Tama
T5190	Wapello tower
T5210	Washington remote tower
T2220	West Union
T4360	Winterset remote
T4390	Yorktown remote

EXISTING LOCAL TOWER SITES	
Site Designation	**Site Name**
E1040	Hardin County Sheriff's Office
E2070	Lakota Fire
E3080	Sutherland
E4030	Loveland (US Cellular)
E4040	Memorial
E4120	Elk Horn
E4140	Landfill Tower
E6060	Riverdale Fire
FCCKAB264	County of Howard
FCCKAD407	County of Worth
FCCKAD468	County of Butler
FCCKAD520	County of Bremer
FCCKAD761	County of Monona
FCCKAD831	County of Wayne
FCCKAE697	County of Jones
FCCKAM266	City of Pella
FCCKDO203	City of Sac City
FCCKNCE612	City of Truro
FCCKNDC786	City of Wadena
FCCKNEJ488	County of Jackson
FCCKNFB467	City of Coggon
FCCKNFL660	City of Pilot Mound
FCCKNGQ700	Township of Des Moines
FCCKNNY528	County of Cass
FCCKOL859	City of Tabor
FCCKQT999	County of Dubuque
FCCKSJ369	County of Sioux
FCCKSS328	City of Sioux City
FCCKVC638	City of Rockford
FCCKVT848	City of Pleasantville
FCCKZJ593	City of Oxford Junction
FCCWNBT670	City of Anthon
FCCWNGL536	Township of Cedar
FCCWNJZ533	City of Farmington
FCCWNPT256	County of Louisa
FCCWNQG625	Town of New Albin

EXISTING LOCAL TOWER SITES	
Site Designation	**Site Name**
FCCWNRZ781	Town of Bussey
FCCWNVD471	City of Cascade
FCCWNVG969	City of Ladora
FCCWNWP942	City of Sully
FCCWNXR502	County of Emmet
FCCWNYV820	City of Lorimor
FCCWNZF297	Wapello County Conservation
FCCWNZK631	City of Morning Sun
FCCWPBT700	City of Schleswig
FCCWPBV452	City of Arlington
FCCWPCP643	City of Lansing
FCCWPDQ223	County of Mitchell
FCCWPDT400	County of Clayton
FCCWPEV784	County of Cherokee
FCCWPEZ827	City of Dunlap
FCCWPGQ342	County of Jackson
FCCWPIY684	County of Mills
FCCWPMB920	County of Clay
FCCWPPG752	County of Carroll
FCCWPQF396	County of Ida
FCCWPQI544	City of Lockridge
FCCWPSR299	Shelby County Emergency Management
FCCWPUZ458	County of Lyon
FCCWPWF487	City of Guttenberg
FCCWPXP917	County of Winneshiek
FCCWPXR842	Stuart Police Dept
FCCWQCD452	County of Washington
FCCWQCY406	City of Malvern
FCCWQFM459	City of Lamoni
FCCWQGF731	Fayette County IA E911 Services
FCCWQHC530	Little Sioux Fire Dept
FCCWQI568	County of Plymouth
FCCWQK922	County of Plymouth
FCCWRL675	County of Van Buren
FCCWXB990	Mercy Medical Center of North Iowa
FCCWZS985	Town of Moravia

EXISTING LOCAL TOWER SITES	
Site Designation	**Site Name**
FCCWZX836	County of Washington

PUBLIC / PRIVATE TOWER SITES	
Site Designation	**Site Name**
ASR1005507	American Towers Inc
ASR1015210	NW Iowa Power Company
ASR1016615	Electronic Engineering Company
ASR1016681	Verizon Wireless (VAW) LLC
ASR1017080	Holland and Knight LLP
ASR1017383	Central Iowa Power Cooperative
ASR1017905	Corn Belt Power Cooperative
ASR1018567	ANR Pipeline Company
ASR1020912	State of Iowa - DOT
ASR1023292	MCC Iowa LLC
ASR1027384	City of Lenox
ASR1056817	US Cellular
ASR1061267	Burlington Northern and Santé Fe
ASR1202982	State of Iowa - DOT
ASR1211518	Manning Municipal Communication and TV
ASR1218269	Dairyland Power Cooperative
ASR1222004	US Cellular
ASR1227042	Communication Enhancement LLC
ASR1228752	Communication Enhancement LLC
ASR1230959	RSA 2 Limited Partnership
ASR1233960	US Cellular
ASR1240125	SBA Towers II LLC
ASR1248374	US Cellular
ASR1257838	Holland and Knight LLP
ASR1259291	Tower Acquisition LLC
ASR1259304	RSA 2 Limited Partnership
ASR1259723	Verizon Wireless (VAW) LLC
ASR1260785	US Cellular
ASR1262192	US Cellular
ASR1264833	Iowa Wireless Services Holding

NEW TOWER SITES	
Site Designation	**Site Name**
New012	New Site 012
New013	New Site 013
NewSite014	New Site 014
NewSite020	New Site 020
NewSite021	New Site 021
NewSite022	New Site 022
NewSite026	New Site 026
NewSite027	New Site 027
NewSite028	New Site 028
NewSite029	New Site 029
NewSite030	New Site 030
NewSite031	New Site 031
NewSite033	New Site 033
NewSite034	New Site 034
NewSite035	New Site 035
NewSite036	New Site 036
NewSite038	New Site 038
NewSite040	New Site 040
NewSite042	New Site 042
NewSite043	New Site 043
NewSite045	New Site 045
NewSite049	New Site 049
NewSite050	New Site 050
NewSite060	New Site 060
NewSite061	New Site 061
NewSite062	New Site 062
NewSite064	New Site 064
NewSite065	New Site 065
NewSite066	New Site 066
NewSite068	New Site 068
NG19	Iowa National Guard – Fort Dodge
NG22	Iowa National Guard - Keokuk
NG30	Iowa National Guard - Oelwein
NG36	Iowa National Guard - Shenandoah
NG6	Iowa National Guard - Clinton

Appendix D: Predicted ISICS County Coverage by HLS&EM Region

HLS&EM Region 1 (16 counties)

County Name	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
	Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Boone	1476.792	1413.9764	**96**	482650	476499	**99**	26224	25955	**99**
Calhoun	1471.689	1445.0238	**98**	478289	476198	**100**	11115	11078	**100**
Carroll	1475.0343	1426.734	**97**	480797	464776	**97**	21421	21252	**99**
Dallas	1525.0923	1465.2657	**96**	845238	833001	**99**	40750	40521	**99**
Greene	1473.2118	1431.4077	**97**	469198	464673	**99**	10366	10315	**100**
Grundy	1292.8896	1270.1772	**98**	379664	372204	**98**	12369	12256	**99**
Hamilton	1488.8529	1449.2925	**97**	822351	817183	**99**	16438	15878	**97**
Hardin	1468.7972	1430.1279	**97**	545127	538916	**99**	18812	18716	**99**
Jasper	1889.9973	1800.3951	**95**	878870	862298	**98**	37213	36735	**99**
Marshall	1480.3074	1452.0385	**98**	614951	611761	**99**	39311	39246	**100**
Polk	1528.4457	1475.2125	**97**	1333919	1314210	**99**	374601	365004	**97**
Poweshiek	1510.5284	1466.8372	**97**	693159	681072	**98**	18815	18624	**99**
Story	1477.3267	1428.921	**97**	659305	649419	**99**	79981	78467	**98**
Tama	1866.0618	1807.6122	**97**	607827	605350	**100**	18103	17833	**99**
Warren	1479.0844	1405.1579	**95**	876811	864294	**99**	40671	39773	**98**
Webster	1854.3168	1776.8322	**96**	723747	713098	**99**	40235	39531	**98**
TOTAL	**24758.4276**	**23945.0118**	**97**	**10891903**	**10744952**	**99**	**806425**	**791184**	**98**

COUNTY AVERAGE	**97**	**COUNTY AVERAGE**	**99**	**COUNTY AVERAGE**	**99**
COUNTIES OVER 95%	**16**	**COUNTIES OVER 95%**	**16**	**COUNTIES OVER 95%**	**16**

HLS&EM Region 2 (17 counties)

County Name	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
	Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
*Allamakee	1700.3358	1261.0485	**74**	528349	437938	**83**	14677	13276	**90**
Bremer	1130.5818	1116.9576	**99**	513008	510518	**100**	23325	23311	**100**
Butler	1499.8689	1480.5747	**99**	460230	460230	**100**	15305	15262	**100**
Cerro	1492.7408	1485.9288	**100**	603443	602439	**100**	46447	46415	**100**
Chickasaw	1305.3717	1262.8792	**97**	408229	393115	**96**	13095	12602	**96**
Emmet	1043.4583	1035.3744	**99**	331829	329037	**99**	11027	11002	**100**
Fayette	1899.5796	1799.9739	**95**	745528	735496	**99**	22020	21110	**96**
Floyd	1294.2666	1253.3535	**97**	370739	367908	**99**	16900	16732	**99**
Franklin	1500.6222	1488.2292	**99**	579644	572658	**99**	10704	10597	**99**
Hancock	1487.5488	1482.8669	**100**	457287	457056	**100**	12100	12089	**100**
Howard	1225.6758	1201.1976	**98**	279206	277158	**99**	9932	9859	**99**
Humboldt	1131.9183	1087.344	**96**	343533	332998	**97**	10381	10216	**98**
Kossuth	2545.2063	2493.6741	**98**	812103	807446	**99**	17163	17143	**100**
Mitchell	1222.9948	1208.439	**99**	374727	373729	**100**	10874	10852	**100**
Winnebago	1046.0178	1035.1476	**99**	260327	260327	**100**	11723	11723	**100**
Winneshiek	1795.4379	1685.5371	**95**	557537	539710	**97**	21270	20720	**97**
Worth	1041.9597	1039.6998	**100**	633634	633634	**100**	7909	7906	**100**
Wright	1497.6981	1464.4233	**98**	387288	379713	**98**	14334	14029	**98**
TOTAL	**25861.283**	**24882.649**	**96**	**8646641**	**8471110**	**98**	**289186**	**284844**	**98**

COUNTY AVERAGE	97	**COUNTY AVERAGE**	98	**COUNTY AVERAGE**	98
COUNTIES OVER 95%	16	**COUNTIES OVER 95%**	17	**COUNTIES OVER 95%**	17

HLS&EM Region 3 (16 counties)

County Name	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
	Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Buena Vista	1489.7196	1480.4451	**99**	532704	532704	**100**	20411	20411	**100**
Cherokee	1484.5275	1453.6665	**98**	397361	394695	**99**	13035	12655	**97**
Clay	1475.6499	1456.542	**99**	406008	403669	**99**	17372	17365	**100**
Crawford	1841.3406	1784.3409	**97**	577405	574497	**99**	16942	16850	**99**
Dickinson	1052.3925	1041.3684	**99**	339282	339282	**100**	16424	16410	**100**
Ida	1110.8016	1083.4073	**98**	352317	352019	**100**	7837	7805	**100**
Lyon	1518.3936	1477.359	**97**	461454	452678	**98**	11763	11599	**99**
Monona	1794.3363	1719.9945	**96**	608592	595695	**98**	10020	9917	**99**
O'Brien	1486.269	1480.0968	**100**	454839	454839	**100**	15102	15038	**100**
Osceola	1035.828	1028.4976	**99**	330408	330408	**100**	7003	6978	**100**
Palo Alto	1475.9333	1405.9899	**95**	340250	339085	**100**	10147	10046	**99**
Plymouth	2232.1655	2196.1692	**98**	636817	628674	**99**	24849	24681	**99**
Pocahontas	1488.9825	1461.6531	**98**	511895	510114	**100**	8662	8649	**100**
Sac	1488.1563	1446.4575	**97**	550789	545430	**99**	11529	11370	**99**
Sioux	1987.4889	1933.0002	**97**	844439	821649	**97**	31589	31181	**99**
Woodbury	2263.5935	2182.5288	**96**	1014699	989876	**98**	103877	103578	**100**
TOTAL	**25225.5786**	**24631.5168**	98	**8359259**	**8265314**	99	**326562**	**324533**	99

COUNTY AVERAGE	**98**	**COUNTY AVERAGE**	**99**	**COUNTY AVERAGE**	**99**
COUNTIES OVER 95%	**16**	**COUNTIES OVER 95%**	**16**	**COUNTIES OVER 95%**	**16**

HLS&EM Region 4 (18 counties)

County Name	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
	Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Adair	1473.228	1424.1663	**97**	440268	436734	**99**	8287	8223	**99**
Adams	1091.7261	1049.9463	**96**	319610	317845	**99**	4482	4366	**97**
Audubon	1139.994	1085.8779	**95**	251480	249922	**99**	6830	6690	**98**
Cass	1453.707	1402.2396	**96**	791645	781275	**99**	14684	14521	**99**
Clarke	1106.0955	1051.9875	**95**	369101	368728	**100**	9133	8836	**97**
Decatur	1379.5839	1313.0748	**95**	521898	518127	**99**	8689	8651	**100**
Fremont	1323.8235	1291.3344	**98**	736551	729643	**99**	8010	7943	**99**
Guthrie	1527.6681	1483.0857	**97**	637045	633135	**99**	11309	11170	**99**
Harrison	1799.2368	1739.8314	**97**	690927	663961	**96**	15666	15446	**99**
Madison	1446.4575	1382.0948	**96**	374617	373476	**100**	14019	13692	**98**
Mills	1128.4839	1100.5308	**98**	548460	547680	**100**	14547	14317	**98**
Montgomery	1086.7203	1039.5702	**96**	347784	338719	**97**	11771	11681	**99**
Page	1378.8063	1325.8971	**96**	476659	470739	**99**	16976	16852	**99**
Pottawattamie	2463.1694	2340.4463	**95**	1546420	1527303	**99**	87704	87187	**99**
Ringgold	1391.1021	1336.4677	**96**	461422	460918	**100**	5469	5389	**99**
Shelby	1519.155	1485.4427	**98**	454085	449700	**99**	13173	13129	**100**
Taylor	1384.8571	1342.0647	**97**	459253	458130	**100**	6958	6942	**100**
Union	1094.1156	1048.4316	**96**	311414	308892	**99**	12309	12199	**99**
TOTAL	**25187.9301**	**24242.4898**	**96**	**9738639**	**9634927**	**99**	**270016**	**267234**	**99**

COUNTY AVERAGE	**96**	**COUNTY AVERAGE**	**99**	**COUNTY AVERAGE**	**99**
COUNTIES OVER 95%	**18**	**COUNTIES OVER 95%**	**18**	**COUNTIES OVER 95%**	**18**

HLS&EM Region 5 (17 counties)

County Name	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
	Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Appanoose	1327.7358	1273.6844	**96**	472754	469484	**99**	13721	13551	**99**
Davis	1300.8843	1247.7321	**96**	323802	323203	**100**	8541	8492	**99**
Des Moines	1106.9541	1057.6656	**96**	444557	428801	**96**	42351	41463	**98**
Henry	1121.9716	1066.8348	**95**	367278	365738	**100**	20336	20059	**99**
Jefferson	1128.2976	1089.0288	**97**	299351	299351	**100**	16181	16108	**100**
Keokuk	1498.2489	1428.6213	**95**	773145	764601	**99**	11400	11166	**98**
Lee	1386.801	1321.8147	**95**	767396	764108	**100**	38052	37565	**99**
Louisa	1069.7103	1044.0009	**98**	352160	351670	**100**	12183	12147	**100**
Lucas	1117.2979	1071.7515	**96**	450434	450432	**100**	9422	9374	**99**
Mahaska	1482.6158	1445.8014	**98**	544057	541995	**100**	22335	22210	**99**
Marion	1480.429	1422.6597	**96**	693559	688932	**99**	32052	31864	**99**
Monroe	1114.5519	1061.5212	**95**	319424	318612	**100**	8016	7839	**98**
Muscatine	1162.7793	1136.908	**98**	615338	607900	**99**	41722	41475	**99**
Van Buren	1257.3954	1201.5459	**96**	438202	434860	**99**	7809	7707	**99**
Wapello	1121.0643	1077.8184	**96**	370406	368863	**100**	36051	35761	**99**
Washington	1475.5608	1424.5551	**97**	683835	674885	**99**	20677	20592	**100**
Wayne	1359.3987	1292.4198	**95**	440542	436688	**99**	6730	6661	**99**
TOTAL	**21511.6967**	**20664.3636**	**96**	**8356240**	**8290123**	**99**	**347579**	**344034**	**99**

COUNTY AVERAGE	**96**	**COUNTY AVERAGE**	**99**	**COUNTY AVERAGE**	**99**
COUNTIES OVER 95%	**17**	**COUNTIES OVER 95%**	**17**	**COUNTIES OVER 95%**	**17**

HLS&EM Region 6 (14 counties)

County Name	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
	Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Benton	1856.6658	1794.1176	**97**	938950	917993	**98**	25308	24577	**97**
Black Hawk	1474.1514	1465.6707	**99**	888720	885847	**100**	128012	127986	**100**
Buchanan	1478.6064	1464.6906	**99**	587272	585771	**100**	21081	21040	**100**
Cedar	1501.9911	1479.149	**98**	503632	503632	**100**	18187	18180	**100**
* Clayton	2045.9952	1704.1995	**83**	734828	674663	**92**	18678	16147	**86**
Clinton	1826.2422	1736.1702	**95**	753365	734994	**98**	50149	49588	**99**
Delaware	1493.7615	1435.5792	**96**	538518	514069	**95**	18404	18044	**98**
Dubuque	1594.2744	1501.5618	**94**	726201	694227	**96**	89143	86111	**97**
Iowa	1517.5999	1445.5665	**95**	561237	557600	**99**	15671	15414	**98**
* Jackson	1677.8826	1482.8265	**88**	677437	639959	**94**	20296	19069	**94**
Johnson	1606.7808	1544.0948	**96**	801863	798730	**100**	110999	110163	**99**
Jones	1482.3567	1426.1022	**96**	581844	580382	**100**	20221	19661	**97**
Linn	1862.0767	1804.0482	**97**	1003349	999798	**100**	191701	190708	**99**
Scott	1210.7637	1162.6902	**96**	1005608	979274	**97**	158668	153334	**97**
TOTAL	**22629.1484**	**21446.467**	**95**	**10302824**	**10066939**	**98**	**886518**	**870022**	**98**

COUNTY AVERAGE	**95**	**COUNTY AVERAGE**	**98**	**COUNTY AVERAGE**	**97**
COUNTIES OVER 95%	**12**	**COUNTIES OVER 95%**	**12**	**COUNTIES OVER 95%**	**12**

Appendix E: Predicted ISICS Coverage by County

County Name	HLS&EM Region	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
		Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Adair	4	1473.228	1424.1663	**97**	440268	436734	**99**	8287	8223	**99**
Adams	4	1091.7261	1049.9463	**96**	319610	317845	**99**	4482	4366	**97**
* Allamakee	2	1700.3358	1261.0485	**74**	528349	437938	**83**	14677	13276	**90**
Appanoose	5	1327.7358	1273.6844	**96**	472754	469484	**99**	13721	13551	**99**
Audubon	4	1139.994	1085.8779	**95**	251480	249922	**99**	6830	6690	**98**
Benton	6	1856.6658	1794.1176	**97**	938950	917993	**98**	25308	24577	**97**
Black Hawk	6	1474.1514	1465.6707	**99**	888720	885847	**100**	128012	127986	**100**
Boone	1	1476.792	1413.9764	**96**	482650	476499	**99**	26224	25955	**99**
Bremer	2	1130.5818	1116.9576	**99**	513008	510518	**100**	23325	23311	**100**
Buchanan	6	1478.6064	1464.6906	**99**	587272	585771	**100**	21081	21040	**100**
Buena Vista	3	1489.7196	1480.4451	**99**	532704	532704	**100**	20411	20411	**100**
Butler	2	1499.8689	1480.5747	**99**	460230	460230	**100**	15305	15262	**100**
Calhoun	1	1471.689	1445.0238	**98**	478289	476198	**100**	11115	11078	**100**
Carroll	1	1475.0343	1426.734	**97**	480797	464776	**97**	21421	21252	**99**
Cass	4	1453.707	1402.2396	**96**	791645	781275	**99**	14684	14521	**99**
Cedar	6	1501.9911	1479.149	**98**	503632	503632	**100**	18187	18180	**100**
Cerro Gordo	2	1492.7408	1485.9288	**100**	603443	602439	**100**	46447	46415	**100**
Cherokee	3	1484.5275	1453.6665	**98**	397361	394695	**99**	13035	12655	**97**
Chickasaw	2	1305.3717	1262.8792	**97**	408229	393115	**96**	13095	12602	**96**
Clarke	4	1106.0955	1051.9875	**95**	369101	368728	**100**	9133	8836	**97**
Clay	3	1475.6499	1456.542	**99**	406008	403669	**99**	17372	17365	**100**

County Name	HLS&EM Region	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
		Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
* Clayton	6	2045.9952	1704.1995	**83**	734828	674663	**92**	18678	16147	**86**
Clinton	6	1826.2422	1736.1702	**95**	753365	734994	**98**	50149	49588	**99**
Crawford	3	1841.3406	1784.3409	**97**	577405	574497	**99**	16942	16850	**99**
Dallas	1	1525.0923	1465.2657	**96**	845238	833001	**99**	40750	40521	**99**
Davis	5	1300.8843	1247.7321	**96**	323802	323203	**100**	8541	8492	**99**
Decatur	4	1379.5839	1313.0748	**95**	521898	518127	**99**	8689	8651	**100**
Delaware	6	1493.7615	1435.5792	**96**	538518	514069	**95**	18404	18044	**98**
Des Moines	5	1106.9541	1057.6656	**96**	444557	428801	**96**	42351	41463	**98**
Dickinson	3	1052.3925	1041.3684	**99**	339282	339282	**100**	16424	16410	**100**
Dubuque	6	1594.2744	1501.5618	**94**	726201	694227	**96**	89143	86111	**97**
Emmet	2	1043.4583	1035.3744	**99**	331829	329037	**99**	11027	11002	**100**
Fayette	2	1899.5796	1799.9739	**95**	745528	735496	**99**	22020	21110	**96**
Floyd	2	1294.2666	1253.3535	**97**	370739	367908	**99**	16900	16732	**99**
Franklin	2	1500.6222	1488.2292	**99**	579644	572658	**99**	10704	10597	**99**
Fremont	4	1323.8235	1291.3344	**98**	736551	729643	**99**	8010	7943	**99**
Greene	1	1473.2118	1431.4077	**97**	469198	464673	**99**	10366	10315	**100**
Grundy	1	1292.8896	1270.1772	**98**	379664	372204	**98**	12369	12256	**99**
Guthrie	4	1527.6681	1483.0857	**97**	637045	633135	**99**	11309	11170	**99**
Hamilton	1	1488.8529	1449.2925	**97**	822351	817183	**99**	16438	15878	**97**
Hancock	2	1487.5488	1482.8669	**100**	457287	457056	**100**	12100	12089	**100**
Hardin	1	1468.7972	1430.1279	**97**	545127	538916	**99**	18812	18716	**99**
Harrison	4	1799.2368	1739.8314	**97**	690927	663961	**96**	15666	15446	**99**
Henry	5	1121.9716	1066.8348	**95**	367278	365738	**100**	20336	20059	**99**
Howard	2	1225.6758	1201.1976	**98**	279206	277158	**99**	9932	9859	**99**

County Name	HLS&EM Region	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
		Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Humboldt	2	1131.9183	1087.344	**96**	343533	332998	**97**	10381	10216	**98**
Ida	3	1110.8016	1083.4073	**98**	352317	352019	**100**	7837	7805	**100**
Iowa	6	1517.5999	1445.5665	**95**	561237	557600	**99**	15671	15414	**98**
* Jackson	6	1677.8826	1482.8265	**88**	677437	639959	**94**	20296	19069	**94**
Jasper	1	1889.9973	1800.3951	**95**	878870	862298	**98**	37213	36735	**99**
Jefferson	5	1128.2976	1089.0288	**97**	299351	299351	**100**	16181	16108	**100**
Johnson	6	1606.7808	1544.0948	**96**	801863	798730	**100**	110999	110163	**99**
Jones	6	1482.3567	1426.1022	**96**	581844	580382	**100**	20221	19661	**97**
Keokuk	5	1498.2489	1428.6213	**95**	773145	764601	**99**	11400	11166	**98**
Kossuth	2	2545.2063	2493.6741	**98**	812103	807446	**99**	17163	17143	**100**
Lee	5	1386.801	1321.8147	**95**	767396	764108	**100**	38052	37565	**99**
Linn	6	1862.0767	1804.0482	**97**	1003349	999798	**100**	191701	190708	**99**
Louisa	5	1069.7103	1044.0009	**98**	352160	351670	**100**	12183	12147	**100**
Lucas	5	1117.2979	1071.7515	**96**	450434	450432	**100**	9422	9374	**99**
Lyon	3	1518.3936	1477.359	**97**	461454	452678	**98**	11763	11599	**99**
Madison	4	1446.4575	1382.0948	**96**	374617	373476	**100**	14019	13692	**98**
Mahaska	5	1482.6158	1445.8014	**98**	544057	541995	**100**	22335	22210	**99**
Marion	5	1480.429	1422.6597	**96**	693559	688932	**99**	32052	31864	**99**
Marshall	1	1480.3074	1452.0385	**98**	614951	611761	**99**	39311	39246	**100**
Mills	4	1128.4839	1100.5308	**98**	548460	547680	**100**	14547	14317	**98**
Mitchell	2	1222.9948	1208.439	**99**	374727	373729	**100**	10874	10852	**100**
Monona	3	1794.3363	1719.9945	**96**	608592	595695	**98**	10020	9917	**99**
Monroe	5	1114.5519	1061.5212	**95**	319424	318612	**100**	8016	7839	**98**
Montgomery	4	1086.7203	1039.5702	**96**	347784	338719	**97**	11771	11681	**99**

County Name	HLS&EM Region	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
		Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Muscatine	5	1162.7793	1136.908	**98**	615338	607900	**99**	41722	41475	**99**
O'Brien	3	1486.269	1480.0968	**100**	454839	454839	**100**	15102	15038	**100**
Osceola	3	1035.828	1028.4976	**99**	330408	330408	**100**	7003	6978	**100**
Page	4	1378.8063	1325.8971	**96**	476659	470739	**99**	16976	16852	**99**
Palo Alto	3	1475.9333	1405.9899	**95**	340250	339085	**100**	10147	10046	**99**
Plymouth	3	2232.1655	2196.1692	**98**	636817	628674	**99**	24849	24681	**99**
Pocahontas	3	1488.9825	1461.6531	**98**	511895	510114	**100**	8662	8649	**100**
Polk	1	1528.4457	1475.2125	**97**	1333919	1314210	**99**	374601	365004	**97**
Pottawattam	4	2463.1694	2340.4463	**95**	1546420	1527303	**99**	87704	87187	**99**
Poweshiek	1	1510.5284	1466.8372	**97**	693159	681072	**98**	18815	18624	**99**
Ringgold	4	1391.1021	1336.4677	**96**	461422	460918	**100**	5469	5389	**99**
Sac	3	1488.1563	1446.4575	**97**	550789	545430	**99**	11529	11370	**99**
Scott	6	1210.7637	1162.6902	**96**	1005608	979274	**97**	158668	153334	**97**
Shelby	4	1519.155	1485.4427	**98**	454085	449700	**99**	13173	13129	**100**
Sioux	3	1987.4889	1933.0002	**97**	844439	821649	**97**	31589	31181	**99**
Story	1	1477.3267	1428.921	**97**	659305	649419	**99**	79981	78467	**98**
Tama	1	1866.0618	1807.6122	**97**	607827	605350	**100**	18103	17833	**99**
Taylor	4	1384.8571	1342.0647	**97**	459253	458130	**100**	6958	6942	**100**
Union	4	1094.1156	1048.4316	**96**	311414	308892	**99**	12309	12199	**99**
Van Buren	5	1257.3954	1201.5459	**96**	438202	434860	**99**	7809	7707	**99**
Wapello	5	1121.0643	1077.8184	**96**	370406	368863	**100**	36051	35761	**99**
Warren	1	1479.0844	1405.1579	**95**	876811	864294	**99**	40671	39773	**98**
Washington	5	1475.5608	1424.5551	**97**	683835	674885	**99**	20677	20592	**100**
Wayne	5	1359.3987	1292.4198	**95**	440542	436688	**99**	6730	6661	**99**

County Name	HLS&EM Region	GEOGRAPHIC AREA			MAJOR ROADWAYS			POPULATION (2000 Census)		
		Total Geographic Area (sq km)	Geographic Area Covered >= DAQ 3.4	% Area Covered	Total Length of Major Roadways (ft)	Major Roadways Covered >= DAQ 3.4	% Roadways Covered	Total Population in County	Population Covered >= DAQ 3.4	% Population Covered
Webster	1	1854.3168	1776.8322	**96**	723747	713098	**99**	40235	39531	**98**
Winnebago	2	1046.0178	1035.1476	**99**	260327	260327	**100**	11723	11723	**100**
Winneshiek	2	1795.4379	1685.5371	**95**	557537	539710	**97**	21270	20720	**97**
Woodbury	3	2263.5935	2182.5288	**96**	1014699	989876	**98**	103877	103578	**100**
Worth	2	1041.9597	1039.6998	**100**	633634	633634	**100**	7909	7906	**100**
Wright	2	1497.6981	1464.4233	**98**	387288	379713	**98**	14334	14029	**98**

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Appendix F: List of Participants

Adair County Conservation Board	Adair County Sheriff's Office	Adams County Sheriff	Adel Police Dept.
Algona Fire Dept.	Allamakee County 911 Center	Alta Fire Dept.	Altoona Fire Dept.
Altoona Police Dept.	Ames Police Dept.	Anamosa Area Ambulance Service	Ankeny Police Dept.
Aplington Police Dept.	Appanoose County Sheriff's Office	Arcadia Fire Dept.	Area Emergency Medical. & Transportation Service, Inc.
Arlington Fire Dept	Arthur Community Fire Dept.	Atlantic Fire Dept.	Atlantic Police Dept.
Audubon County 911 Center	Badger Fire And Rescue Agency	Barnum Fire Dept.	Battle Creek Community Ambulance Service
Beaman Conrad Emergency Response Team	Belmond Fire Dept	Benton County 911 Center	Boone County 911 Center
Bremer County Sheriff's Office	Brooklyn Volunteer Fire Dept.	Buchanan 911 Center	Buena Vista County Sheriff's Dept.
Buena Vista Regional Medical Center	Calhoun County 911 Center	Calhoun County Sheriff's Office	Calmar/Ossian Police Dept.
Carroll City/County Communications Center	Carroll County Ambulance Service	Carson Fire And Rescue	Cedar Rapids 911 Center
Centerville Fire Dept.	Centerville Police Dept.	Cerro Gordo 911 Center	Charter Oak Fire Dept.
Cherokee County 911 Center	Cherokee County E 911	Cherokee County Emergency Management	Chester Fire Dept.
Chickasaw County 911 Center	City Of De Soto	City Of Granger	City Of Lake City
City Of West Des Moines Fire Dept.	Clarinda Police Dept.	Clarinda Regional Health Center	Clarke County 911 Center
Clay Township Fire And Rescue	Clayton County 911 Center	Clayton County Sheriff Dept.	Clinton County 911 Center
Clive Fire Dept.	Coin Fire And Rescue	Coon Rapids Police Dept.	Coralville Fire Dept.
Coralville Police Dept.	Correctionville-Anthon Police Dept.	Council Bluffs Fire Dept.	Council Bluffs Police Dept.
Crawford County 911 Center	Crawfordsville First Responders	Creston- Union County PSAP	Criminal And Juvenile Justice Planning

Dallas County 911 Center	Davenport 911 Center	Davis County 911 Center	Dayton Police Dept.
Decorah Police Dept.	Deep River Volunteer Fire & 1st Response	Defiance Fire And Rescue	Delaware County 911 Center
Delaware County Sheriff's Office	Denison Fire Dept.	Denver Police Dept.	Des Moines Police Dept.
Dexter Fire And Rescue	Dickinson County 911 Center	Dickinson County Emergency Management	Dike Fire Dept.
Dixon Fire Dept.	Dow City-Arion Fire Dept.	Dows Rural Fire Dept.	Dubuque 911 Center
Earlham Fire Rescue	East Peru Volunteer Fire Dept.	Eddyville Vol. Fire & Rescue Dept.	Edgewood Fire Dept.
Eldridge Police Dept.	Eldridge Volunteer Fire	Elgin Fire Dept.	Elkhart Fire Dept.
Emmet County 911 Center	Estherville Police Dept.	Fairfield 911 Center	Fayette County 911 Center
Floyd Co. Center	Fort Dodge Fire Dept.	Fort Dodge Police Dept.	Fort Madison Police Dept.
Fredericksburg Fire Dept	Fremont County 911	Galva Fire and First Responders	Gilmore City Ambulance Service
Ginnell Fire	Glidden First Responders	Goldfield Fire Dept.	Grand Mound Volunteer Fire Dept.
Green County 911	Greene Volunteer Fire Dept.	Grinnell Fire Dept.	Grinnell Fire Dept./Poweshiek County Emergency Management
Grinnell Police Dept.	Griswold Rescue	Grundy County Sheriff	Guthrie And Adair County EMAs
Guttenberg Ambulance Service	Halbur Fire Dept.	Hamilton County 911 Center	Hampton Police
Hardin County Sheriff's Office	Harlan Township Fire Dept. (A.K.A. Maynard Fire Dept.)	Harrison County E911	Hawarden Fire, Rescue & EMS
Hawarden Police Dept.	Henry County 911 Center	Hinton Police Dept.	Howard Co. 911 Center
Humboldt County Communications Center	Ida County 911 Center	Indiana Township Fire Dept.	Ionia Fire Dept.
Iowa Air National Guard	Iowa City Police Dept.	Iowa County 911 Center	Iowa Dept. Of Natural Resources
Iowa Dept. Of Public Safety	Iowa Dept. Of Public Safety - Iowa State Patrol Communications	Iowa Dept. Of Transportation	Iowa DPS, Division Of Criminal Investigation
Iowa Falls Fire Dept.	Iowa Falls Police Dept.	Iowa Law Enforcement Academy	Iowa State Patrol

Iowa State Patrol Communications	Iowa State Patrol Communications - Atlantic (Lewis)	Iowa State Patrol Communications - DMS	Janesville Fire Rescue
Jasper County 911 Center	Jasper County Sheriff's Office	Jewell Fire And Rescue	Johnson County 911 Center
Johnston Fire Dept.	Johnston Police Dept.	Jones County Sheriff Dept	Keokuk Police Dept.
Knoxville Police Dept.	Kossuth Co. 911	Lakota Ambulance	Lakota Fire Dept.
Lee County 911 Center	Lidderdale Fire Dept.	Lime Springs Fire Dept.	Linn County 911 Center
Madison Co 911 Center	Mahaska County E911 Center	Malcom Volunteer Fire Dept.	Manilla Fire Dept.
Manning Fire & Rescue	Maquoketa/Jackson County 911	Mar-Mac Unified Law Enforcement District	Marathon Fire Dept.
Marion County PSAP	Marion Iowa Police Dept	Marshalltown Communication Center	Marshalltown Fire Dept.
Marshalltown Police Dept.	Maysville Volunteer Fire Dept.	McCausland Volunteer Fire Dept.	Medic Ems
Melbourne Fire Dept.	Midwest Ambulance	Milford Community Fire Dept.	Mills County 911
Mitchell County 911 Center	Mitchellville Iowa Police Dept.	Monona County E-911	Monroe County Sheriff's Office
Monroe Fire And Rescue	Montgomery County	Moorhead Fire Dept.	Muscatine County Joint Communications
Nashua Fire Dept.	New Albin Fire Dept.	New Hartford Ems	Newell Police Dept.
Newton Fire Dept.	North Liberty Police Dept.	Northeast Iowa Medical Transport, Inc.	O'Brien County Sheriff' Office
Onawa Volunteer Fire Dept.	Orient Rural Fire District	Osceola County Sheriff's Office	Oskaloosa Fire Dept.
Ossian Fire Dept	Otho Fire And Rescue	Otho Police Dept.	Ottumwa Police Dept.
Palo Alto County 911 Center	Palo Alto County Emergency Management Agency	Parkersburg Ambulance Service	Paullina Ambulance Service
Pella Fire Dept.	Percival Fire And Rescue	Perry Police Dept.	Pleasant Hill Fire Dept.
Pleasantville Emergency Services	Plymouth County Sheriff's Office	Pocahontas County Sheriff's Office	Polk City Police Dept.
Polk County Communications	Postville Volunteer Fire Dept.	Pottawattamie County Conservation	Pottawattamie County Emergency Management Agency

Pottawattamie County Sheriff's Office	Pottawattamie County Volunteer Fire/Ems Dept.	Poweshiek County	Princeton Police Dept.
Readlyn Police Dept.	Renwick Ambulance Service	Ringsted Fire Dept.	Riverdale Fire Dept.
Rock Valley Police Dept.	Rockwell City Fire Dept.	Rockwell City Police Dept.	Sanborn Fire Dept.
Scott County Sheriff's Office	Shelby Co Ema/911	Shelby Co Sheriff's Office	Shelby County ESA
Sheldon Emergency Management Agency	Sidney Police Dept.	Sioux Center Police Dept.	Sioux City Fire Dept.
Sioux County Sheriff's Office	Sioux Rapids Fire Dept.	South Central Iowa Regional E911 Administration	St Lucas Fire Dept.
State Center Fire & EMS	State Center Police Dept.	Story County Sheriff's Office	Sumner Volunteer Fire And Rescue
Tama County Communications Center	Taylor County Emergency Management	Tiffin Fire Association	Tripoli Ambulance Service
Truro Fire And Rescue	Underwood Vol. Fire & Rescue	Union Co. LEC	Union County Emergency Management Agency
Urbandale Police Dept.	Vail Volunteer Fire Dept.	Van Buren county	Walnut Creek Fire Dept.
Walnut Fire & Rescue	Warren County 911 Center	Washington County Ambulance	Washington County Sheriff's Office
Waukon Police Dept.	Waverly Fire Dept.	Waverly Health Center	Wayne County 911 Center
Webster City Police Dept.	Webster County Sheriff's Office	West Liberty Fire	Westcom Emergency Communications
Whittemore Fire & Ambulance	Windsor Heights Fire Dept.	Windsor Heights Police Dept.	Winnebago County Law Enforcement Center
Winneshiek Medical Center	Winterset Fire Dept.	Woodbury County Communications	

Appendix G: Predicted LEA VHF Coverage Using Existing Iowa DPS Tower Sites

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Adair	4	1473.228	753.0003	**51**	1473.228	618.4593	**42**
Adams	4	1091.7261	802.1106	**73**	1091.7261	729	**67**
Allamakee	2	1700.3358	1466.343	**86**	1700.3358	1410.8256	**83**
Appanoose	5	1327.7358	719.6688	**54**	1327.7358	618.2892	**47**
Audubon	4	1139.994	834.1218	**73**	1139.994	732.7179	**64**
Benton	6	1856.6658	1811.3383	**98**	1856.6658	1769.9471	**95**
Black Hawk	6	1474.1514	1474.038	**100**	1474.1514	1473.8922	**100**
Boone	1	1476.792	1430.4033	**97**	1476.792	1400.328	**95**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Bremer	2	1130.5818	1051.9308	**93**	1130.5818	993.4164	**88**
Buchanan	6	1478.6064	1288.8639	**87**	1478.6064	1175.796	**80**
Buena Vista	3	1489.7196	1465.9137	**98**	1489.7196	1456.7607	**98**
Butler	2	1499.8689	948.915	**63**	1499.8689	762.5826	**51**
Calhoun	1	1471.689	842.2542	**57**	1471.689	669.4569	**45**
Carroll	1	1475.0343	1152.2087	**78**	1475.0343	985.1706	**67**
Cass	4	1453.707	1381.374	**95**	1453.707	1345.7178	**93**
Cedar	6	1501.9911	1205.9117	**80**	1501.9911	1085.1246	**72**
Cerro Gordo	2	1492.7408	1211.7681	**81**	1492.7408	1074.465	**72**
Cherokee	3	1484.5275	1207.4832	**81**	1484.5275	1085.1084	**73**
Chickasaw	2	1305.3717	1229.6367	**94**	1305.3717	1175.6259	**90**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Clarke	4	1106.0955	696.8106	**63**	1106.0955	617.3982	**56**
Clay	3	1475.6499	1424.3202	**97**	1475.6499	1392.3414	**94**
Clayton	6	2045.9952	1892.2653	**92**	2045.9952	1831.8312	**90**
Clinton	6	1826.2422	1533.6459	**84**	1826.2422	1452.4758	**80**
Crawford	3	1841.3406	1835.4924	**100**	1841.3406	1826.2827	**99**
Dallas	1	1525.0923	1467.7443	**96**	1525.0923	1439.6049	**94**
Davis	5	1300.8843	642.9051	**49**	1300.8843	513.0378	**39**
Decatur	4	1379.5839	85.6494	**6**	1379.5839	38.394	**3**
Delaware	6	1493.7615	1139.3136	**76**	1493.7615	990.9297	**66**
Des Moines	5	1106.9541	1095.7842	**99**	1106.9541	1089.0045	**98**
Dickinson	3	1052.3925	1030.2957	**98**	1052.3925	1012.4352	**96**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Dubuque	6	1594.2744	1479.0438	**93**	1594.2744	1431.4725	**90**
Emmet	2	1043.4583	816.6015	**78**	1043.4583	716.1858	**69**
Fayette	2	1899.5796	1801.3671	**95**	1899.5796	1721.8979	**91**
Floyd	2	1294.2666	865.3311	**67**	1294.2666	689.7312	**53**
Franklin	2	1500.6222	1229.9688	**82**	1500.6222	1113.264	**74**
Fremont	4	1323.8235	873.909	**66**	1323.8235	752.9841	**57**
Greene	1	1473.2118	1305.234	**89**	1473.2118	1169.243	**79**
Grundy	1	1292.8896	1114.8516	**86**	1292.8896	1004.643	**78**
Guthrie	4	1527.6681	1433.0601	**94**	1527.6681	1381.3254	**90**
Hamilton	1	1488.8529	1472.9607	**99**	1488.8529	1463.4027	**98**
Hancock	2	1487.5488	1425.1949	**96**	1487.5488	1385.7561	**93**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Hardin	1	1468.7972	1072.2133	**73**	1468.7972	942.3459	**64**
Harrison	4	1799.2368	1576.7217	**88**	1799.2368	1504.5345	**84**
Henry	5	1121.9716	1024.5609	**91**	1121.9716	978.237	**87**
Howard	2	1225.6758	1211.9139	**99**	1225.6758	1205.6851	**98**
Humboldt	2	1131.9183	1015.7562	**90**	1131.9183	924.1938	**82**
Ida	3	1110.8016	928.3248	**84**	1110.8016	847.3734	**76**
Iowa	6	1517.5999	1173.4146	**77**	1517.5999	1077.7617	**71**
Jackson	6	1677.8826	1474.3458	**88**	1677.8826	1420.1487	**85**
Jasper	1	1889.9973	1484.2035	**79**	1889.9973	1353.7043	**72**
Jefferson	5	1128.2976	1117.4113	**99**	1128.2976	1109.8376	**98**
Johnson	6	1606.7808	1009.6569	**63**	1606.7808	867.2751	**54**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Jones	6	1482.3567	1234.2942	**83**	1482.3567	1128.1923	**76**
Keokuk	5	1498.2489	1185.2972	**79**	1498.2489	1098.5059	**73**
Kossuth	2	2545.2063	1121.8014	**44**	2545.2063	908.2287	**36**
Lee	5	1386.801	1005.4449	**73**	1386.801	930.6981	**67**
Linn	6	1862.0767	1693.5319	**91**	1862.0767	1625.2813	**87**
Louisa	5	1069.7103	856.4697	**80**	1069.7103	771.2415	**72**
Lucas	5	1117.2979	678.0672	**61**	1117.2979	590.2875	**53**
Lyon	3	1518.3936	1148.2479	**76**	1518.3936	1057.6737	**70**
Madison	4	1446.4575	1266.0706	**88**	1446.4575	1213.5825	**84**
Mahaska	5	1482.6158	1126.054	**76**	1482.6158	1025.9541	**69**
Marion	5	1480.429	918.1512	**62**	1480.429	795.8007	**54**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Marshall	1	1480.3074	1284.174	**87**	1480.3074	1195.0983	**81**
Mills	4	1128.4839	1099.3158	**97**	1128.4839	1081.3824	**96**
Mitchell	2	1222.9948	932.1804	**76**	1222.9948	788.9481	**65**
Monona	3	1794.3363	1698.084	**95**	1794.3363	1665.1169	**93**
Monroe	5	1114.5519	1082.4111	**97**	1114.5519	1063.7325	**95**
Montgomery	4	1086.7203	1025.8407	**94**	1086.7203	980.3916	**90**
Muscatine	5	1162.7793	1072.0674	**92**	1162.7793	1020.7377	**88**
O'Brien	3	1486.269	1366.0894	**92**	1486.269	1287.0009	**87**
Osceola	3	1035.828	964.0296	**93**	1035.828	892.2798	**86**
Page	4	1378.8063	1282.4001	**93**	1378.8063	1235.0151	**90**
Palo Alto	3	1475.9333	1054.458	**71**	1475.9333	878.6556	**60**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Plymouth	3	2232.1655	2147.7393	**96**	2232.1655	2089.2329	**94**
Pocahontas	3	1488.9825	1149.2037	**77**	1488.9825	928.3491	**62**
Polk	1	1528.4457	1356.7581	**89**	1528.4457	1268.3628	**83**
Pottawattamie	4	2463.1694	2199.3362	**89**	2463.1694	2106.9153	**86**
Poweshiek	1	1510.5284	1393.9532	**92**	1510.5284	1350.9908	**89**
Ringgold	4	1391.1021	295.3827	**21**	1391.1021	214.9497	**15**
Sac	3	1488.1563	1435.0527	**96**	1488.1563	1385.8372	**93**
Scott	6	1210.7637	994.7205	**82**	1210.7637	923.7078	**76**
Shelby	4	1519.155	1283.931	**85**	1519.155	1175.0994	**77**
Sioux	3	1987.4889	1666.6965	**84**	1987.4889	1550.6884	**78**
Story	1	1477.3267	1306.854	**88**	1477.3267	1172.9205	**79**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Tama	1	1866.0618	1756.7361	**94**	1866.0618	1687.6674	**90**
Taylor	4	1384.8571	1280.0024	**92**	1384.8571	1238.2794	**89**
Union	4	1094.1156	369.0846	**34**	1094.1156	275.9589	**25**
Van Buren	5	1257.3954	778.2966	**62**	1257.3954	688.7673	**55**
Wapello	5	1121.0643	981.7524	**88**	1121.0643	929.0619	**83**
Warren	1	1479.0844	1400.5062	**95**	1479.0844	1362.5658	**92**
Washington	5	1475.5608	1122.741	**76**	1475.5608	1034.9694	**70**
Wayne	5	1359.3987	307.6056	**23**	1359.3987	202.0626	**15**
Webster	1	1854.3168	1306.854	**70**	1854.3168	1080.2889	**58**
Winnebago	2	1046.0178	232.4214	**22**	1046.0178	122.2776	**12**
Winneshiek	2	1795.4379	1314.9702	**73**	1795.4379	1205.4744	**67**

County Name	HLS&EM Region	GEOGRAPHIC AREA (VHF WIDEBAND)			GEOGRAPHIC AREA (VHF NARROWBAND)		
		Total Geographic Area (sq km)	Wideband Coverage >= DAQ 3.4	% Area Covered (wideband)	Total Geographic Area (sq km)	Narrowband Coverage >= DAQ 3.4	% Area Covered (narrowband)
Woodbury	3	2263.5935	1515.3398	**67**	2263.5935	1307.34	**58**
Worth	2	1041.9597	209.6361	**20**	1041.9597	121.0869	**12**
Wright	2	1497.6981	1494.6606	**100**	1497.6981	1492.2549	**100**

Appendix H: Proposed ISICS Site Channel Loading

Site Designation	Site Name	Site channel size	Site link BW (kbps)	Multicast	Simulcast
Albia	Albia	3	304	Yes	
ASR1005507	American Towers Inc	3	304	Yes	
ASR1015210	NW Iowa Power CO	3	304	Yes	
ASR1016615	Electronic Engineering Company	11	712		Yes
ASR1016681	Verizon Wireless (VAW) LLC	4	360	Yes	
ASR1017080	Holland and Knight LLP	3	360	Yes	
ASR1017383	Central Iowa Power Coop	3	304	Yes	
ASR1017905	Corn Belt Power Cooperative	3	360	Yes	
ASR1018567	ANR Pipeline Company	3	360	Yes	
ASR1020912	State of Iowa	3	304	Yes	
ASR1023292	MCC Iowa LLC	11	712		Yes
ASR1027384	City of Lenox	4	360	Yes	
ASR1056817	US Cellular	8	360	Yes	
ASR1061267	Burlington Northern and	3	304	Yes	
ASR1202982	State of Iowa	3	360	Yes	
ASR1211518	Manning Municipal Communication and TV	4	360	Yes	
ASR1218269	Dairyland Power Cooperative	4	360	Yes	
ASR1222004	US Cellular	7	600	Yes	
ASR1227042	Communication Enhancement LLC	3	304	Yes	
ASR1228752	Communication Enhancement LLC	5	360	Yes	
ASR1230959	RSA 2 Limited Partnership	4	360	Yes	
ASR1233960	US Cellular	5	360	Yes	
ASR1240125	SBA Towers II LLC	4	360	Yes	
ASR1248374	US Cellular	4	360	Yes	
ASR1257838	Holland and Knight LLP	5	360	Yes	
ASR1259291	Tower Acquisition LLC	3	360	Yes	
ASR1259304	RSA 2 Limited Partnership	3	360	Yes	
ASR1259723	Verizon Wireless (VAW) LLC	4	360	Yes	
ASR1260785	US Cellular	6	360		Yes
ASR1262192	US Cellular	4	360	Yes	
ASR1264833	Iowa Wireless Services Holding	4	360	Yes	

Site Designation	Site Name	Site channel size	Site link BW (kbps)	Multicast	Simulcast
Beaverdale	Beaverdale	3	360	Yes	
Belmond	Belmond	6	416	Yes	
Blairsburg	Blairsburg	5	360	Yes	
Brooklyn	Brooklyn	6	416	Yes	
Cedar Falls	Cedar Falls	14	600		Yes
Denison	Denison	3	304	Yes	
Des Moines	Des Moines	4	360	Yes	
E1040	Hardin County Sheriff's Office	5	360	Yes	
E2070	Lakota Fire	3	304	Yes	
E3080	Sutherland	4	360	Yes	
E4030	Loveland (US Cellular)	11	600		Yes
E4040	Memorial	11	600		Yes
E4120	Elk Horn	3	304	Yes	
E4140	Landfill Tower	3	304	Yes	
E6060	Riverdale Fire	11	600		Yes
FCCKAB264	County of Howard	4	360	Yes	
FCCKAD407	County of Worth	3	360	Yes	
FCCKAD468	County of Butler	6	416	Yes	
FCCKAD520	County of Bremer	6	360	Yes	
FCCKAD761	County of Monona	3	304	Yes	
FCCKAD831	County of Wayne	3	304	Yes	
FCCKAE697	County of Jones	3	360	Yes	
FCCKAM266	City of Pella	5	360	Yes	
FCCKDO203	City of Sac City	3	360	Yes	
FCCKNCE612	City of Truro	3	360	Yes	
FCCKNDC786	City of Wadena	9	416		Yes
FCCKNEJ488	County of Jackson	7	600		Yes
FCCKNFB467	City of Coggon	14	712		Yes
FCCKNFL660	City of Pilot Mound	6	600	Yes	
FCCKNGQ700	Township of Des Moines	3	360	Yes	
FCCKNNY528	County of Cass	3	304	Yes	
FCCKOL859	City of Tabor	4	360	Yes	
FCCKQT999	County of Dubuque	11	600		Yes
FCCKSJ369	County of Sioux	3	304	Yes	
FCCKSS328	City of Sioux City	11	416		Yes

Site Designation	Site Name	Site channel size	Site link BW (kbps)	Multicast	Simulcast
FCCKVC638	City of Rockford	3	360	Yes	
FCCKVT848	City of Pleasantville	3	360	Yes	
FCCKZJ593	City of Oxford Junction	4	360	Yes	
FCCWNBT670	City of Anthon	11	416		Yes
FCCWNGL536	Township of Cedar	6	304	Yes	
FCCWNJZ533	City of Farmington	4	304	Yes	
FCCWNPT256	County of Louisa	5	304	Yes	
FCCWNQG625	Town of New Albin	6	1008		Yes
FCCWNRZ781	Town of Bussey	3	360	Yes	
FCCWNVD471	City of Cascade	5	304	Yes	
FCCWNVG969	City of Ladora	3	304	Yes	
FCCWNWP942	City of Sully	4	304	Yes	
FCCWNXR502	County of Emmet	7	304	Yes	
FCCWNYV820	City of Lorimor	4	304	Yes	
FCCWNZF297	Wapello County Conservation	4	1008	Yes	
FCCWNZK631	City of Morning Sun	6	360	Yes	
FCCWPBT700	City of Schleswig	4	712	Yes	
FCCWPBV452	City of Arlington	9	304		Yes
FCCWPCP643	City of Lansing	6	304		Yes
FCCWPDQ223	County of Mitchell	3	360	Yes	
FCCWPDT400	County of Clayton	9	360		Yes
FCCWPEV784	County of Cherokee	4	656	Yes	
FCCWPEZ827	City of Dunlap	4	304	Yes	
FCCWPGQ342	County of Jackson	7	416		Yes
FCCWPIY684	County of Mills	5	360	Yes	
FCCWPMB920	County of Clay	7	416	Yes	
FCCWPPG752	County of Carroll	7	360	Yes	
FCCWPQF396	County of Ida	3	360	Yes	
FCCWPQI544	City of Lockridge	6	416	Yes	
FCCWPSR299	Shelby Co Emergency Mgmt	3	304	Yes	
FCCWPUZ458	County of Lyon	3	304	Yes	
FCCWPWF487	City of Guttenberg	9	360		Yes
FCCWPXP917	County of Winneshiek	6	600		Yes
FCCWPXR842	Stuart Police Dept	3	360	Yes	
FCCWQCD452	County of Washington	10	360		Yes

Site Designation	Site Name	Site channel size	Site link BW (kbps)	Multicast	Simulcast
FCCWQCY406	City of Malvern	3	304	Yes	
FCCWQFM459	City of Lamoni	3	600	Yes	
FCCWQGF731-F	Fayette County IA E911 Service	9	416		Yes
FCCWQGF731-W	Fayette County IA E911 Service	6	600		Yes
FCCWQHC530	Little Sioux Fire Department	3	1176	Yes	
FCCWQI568	County of Plymouth	4	304	Yes	
FCCWQK922	County of Plymouth	3	360	Yes	
FCCWRL675	County of Van Buren	3	416	Yes	
FCCWXB990	Mercy Medical Center of North Iowa	3	304	Yes	
FCCWZS985	Town of Moravia	4	360	Yes	
FCCWZX836	County of Washington	3	1008	Yes	
Glenwood	Glenwood	3	1008	Yes	
Gunder	Gunder	9	304		Yes
Harpers Ferry	Harpers Ferry	6	304		Yes
Holy Cross	Holy Cross	11	1008		Yes
ISP - Atlantic	ISP - Atlantic	3	360	Yes	
ISP - Cedar Falls	ISP - Cedar Falls	14	304		Yes
ISP - Cedar Rapids	ISP - Cedar Rapids	14	600		Yes
ISP - Fairfield	ISP - Fairfield	3	600	Yes	
ISP - Iowa	ISP - Iowa Guard Armory	24	304		Yes
ISP - Storm Lake	ISP - Storm Lake	6	304	Yes	
Laurel	Laurel	5	304	Yes	
Lourdes	Lourdes	3	416	Yes	
Maquoketa	Maquoketa	7	304		Yes
Merrill	Merrill	3	304	Yes	
Moorhead	Moorhead	3	768	Yes	
Muscatine	Muscatine	3	656	Yes	
New Market	New Market	4	1176	Yes	
New012	New Site 012	6	600		Yes
New013	New Site 013	6	304		Yes
NewSite014	New Site 014	3	304	Yes	
NewSite020	New Site 020	3	360	Yes	
NewSite021	New Site 021	4	1008	Yes	
NewSite022	New Site 022	5	304	Yes	
NewSite026	New Site 026	4	1008	Yes	

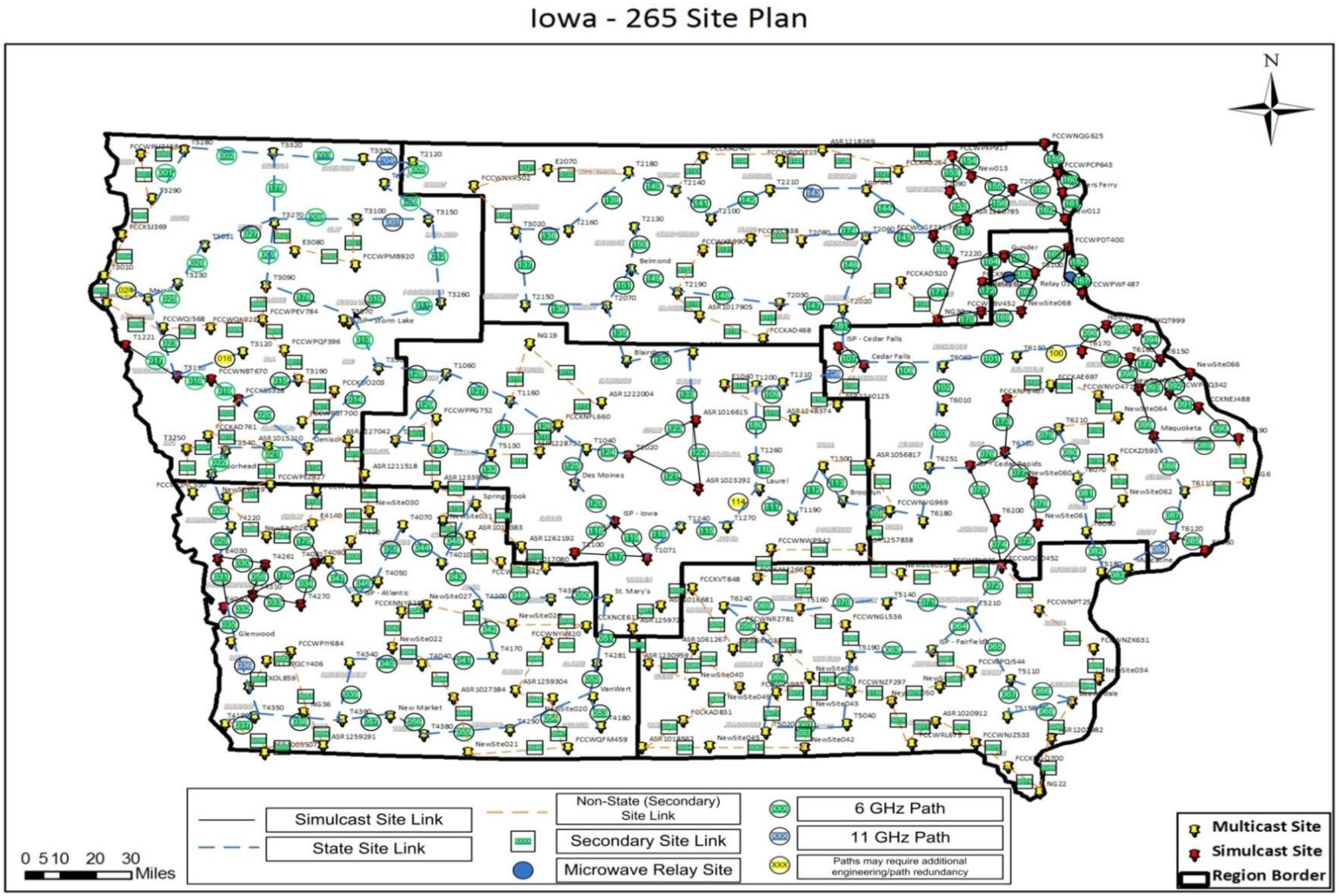
Site Designation	Site Name	Site channel size	Site link BW (kbps)	Multicast	Simulcast
NewSite027	New Site 027	4	304	Yes	
NewSite028	New Site 028	3	304	Yes	
NewSite029	New Site 029	3	360	Yes	
NewSite030	New Site 030	3	1008	Yes	
NewSite031	New Site 031	3	600	Yes	
NewSite033	New Site 033	3	360	Yes	
NewSite034	New Site 034	3	416	Yes	
NewSite035	New Site 035	4	600	Yes	
NewSite036	New Site 036	4	304	Yes	
NewSite038	New Site 038	3	416	Yes	
NewSite040	New Site 040	4	304	Yes	
NewSite042	New Site 042	4	360	Yes	
NewSite043	New Site 043	4	656	Yes	
NewSite045	New Site 045	3	360	Yes	
NewSite049	New Site 049	4	360	Yes	
NewSite050	New Site 050	3	600	Yes	
NewSite060	New Site 060	14	360		Yes
NewSite061	New Site 061	10	768		Yes
NewSite062	New Site 062	7	600	Yes	
NewSite064	New Site 064	5	304	Yes	
NewSite065	New Site 065	11	768		Yes
NewSite066	New Site 066	7	360		Yes
NewSite068	New Site 068	9	360		Yes
NG19	NG19	4	656	Yes	
NG22	NG22	3	416	Yes	
NG30	NG30	9	656		Yes
NG36	NG36	4	656	Yes	
NG6	NG6	3	304	Yes	
Springbrook	Springbrook	3	600	Yes	
St. Mary's	St. Mary's	4	304	Yes	
T1020	Ames Communication	11	304		Yes
T1040	Boone tower	4	768	Yes	
T1060	Calhoun tower	4	600	Yes	
T1071	Carlisle	24	304		Yes
T1080	Carroll base tower	3	824	Yes	

Site Designation	Site Name	Site channel size	Site link BW (kbps)	Multicast	Simulcast
T1100	Dallas scale east bound tower	24	304		Yes
T1160	Gowrie	4	304	Yes	
T1190	Grinnell	3	768	Yes	
T1210	Gundy Center	3	600	Yes	
T1221	Hamilton	11	304		Yes
T1230	Iowa Falls	3	360	Yes	
T1240	Jasper scale west bound tower	9	304	Yes	
T1260	Marshalltown	3	304	Yes	
T1270	Newton	4	304	Yes	
T1300	Tama	4	360	Yes	
T2010	Allamakee tower	6	304		Yes
T2020	Bremer tower	4	304	Yes	
T2030	Butler tower	4	768	Yes	
T2060	Chickasaw tower	5	600	Yes	
T2070	Clarion	4	1008	Yes	
T2080	CVTC	3	304	Yes	
T2090	Decorah	6	1176		Yes
T2100	Dist 5	3	1176	Yes	
T2120	Estherville remote	4	304	Yes	
T2130	Garner	3	1992	Yes	
T2140	Hanlontown	5	600	Yes	
T2150	Humboldt remote	6	416	Yes	
T2160	Kossuth remote tower	5	304	Yes	
T2180	Lake Mills remote	6	656	Yes	
T2190	Latimer	3	304	Yes	
T2210	Osage	3	304	Yes	
T2220	West Union	9	304		Yes
T3010	Akron	3	360	Yes	
T3020	Algona base tower	3	600	Yes	
T3031	Alton	3	600	Yes	
T3090	Cherokee remote tower	4	304	Yes	
T3100	Clay tower	5	304	Yes	
T3110	Clm Hill remote	11	360		Yes
T3120	Correctionville	3	416	Yes	
T3150	E-burg remote	3	360	Yes	

Site Designation	Site Name	Site channel size	Site link BW (kbps)	Multicast	Simulcast
T3190	Ida Grove	3	360	Yes	
T3230	LeMars	3	304	Yes	
T3260	Pocahontas	8	304	Yes	
T3270	Primgar remote	4	304	Yes	
T3280	Rock Rapids	3	304	Yes	
T3290	Rock Valley	3	304	Yes	
T3300	Sac City	3	304	Yes	
T3320	Sibley remote	5	360	Yes	
T3340	Soldier remote	3	360	Yes	
T3350	Spirit Lake	3	304	Yes	
T4010	Adair maintenance	5	360	Yes	
T4040	Adams tower	3	360	Yes	
T4050	Atlantic base tower	3	360	Yes	
T4070	Audubon remote	3	304	Yes	
T4081	Avoca	11	360		Yes
T4170	Creston tower	3	304	Yes	
T4180	Decatur tower	3	1176	Yes	
T4190	Fremont scale north bound	3	824	Yes	
T4200	Greenfield tower	3	656	Yes	
T4220	Logan remote	3	416	Yes	
T4250	Mount Ayr	3	1008	Yes	
T4261	Neola	11	656		Yes
T4270	Oakland	11	768		Yes
T4281	Osceola base	3	360	Yes	
T4310	Pottawattamie remote tower	11	304		Yes
T4340	Red Oak remote	3	768	Yes	
T4350	Sidney	3	360	Yes	
T4360	Winterset remote	3	304	Yes	
T4380	Bedford	3	304	Yes	
T4390	Yorktown remote	3	360	Yes	
T5020	Appanoose tower	3	1008	Yes	
T5040	Davis tower	3	360	Yes	
T5110	Henry remote tower	4	360	Yes	
T5130	Jefferson	3	1992	Yes	
T5140	Keokuk tower	3	304	Yes	

Site Designation	Site Name	Site channel size	Site link BW (kbps)	Multicast	Simulcast
T5150	Lee scale tower	3	1992	Yes	
T5160	Mahaska repeater tower	3	360	Yes	
T5180	Muscatine tower	3	304	Yes	
T5190	Wapello tower	3	304	Yes	
T5210	Washington remote tower	3	1008	Yes	
T6010	Benton tower	8	304	Yes	
T6060	Buchanan tower	4	768	Yes	
T6070	Cedar remote tower	3	304	Yes	
T6090	Cedar tower	4	360	Yes	
T6100	Clayton tower	9	360		Yes
T6110	Clinton tower	3	600	Yes	
T6120	Davenport base tower	11	360		Yes
T6130	Delaware tower	3	360	Yes	
T6150	Dubuque base tower	11	416		Yes
T6160	Dubuque remote tower	11	360		Yes
T6170	Dyersville base tower	11	304		Yes
T6180	Iowa tower	3	600	Yes	
T6190	Jackson remote tower	7	304		Yes
T6200	Johnson tower	10	360		Yes
T6210	Jones remote tower	4	304	Yes	
T6220	Linn tower	14	416		Yes
T6240	Marion Co. tower	3	600	Yes	
T6251	Newhall	6	416	Yes	
Terril	Terril	3	600	Yes	
Van Wert	Van Wert	3	304	Yes	

Appendix I: Proposed ISICS Microwave Transport Network Topology



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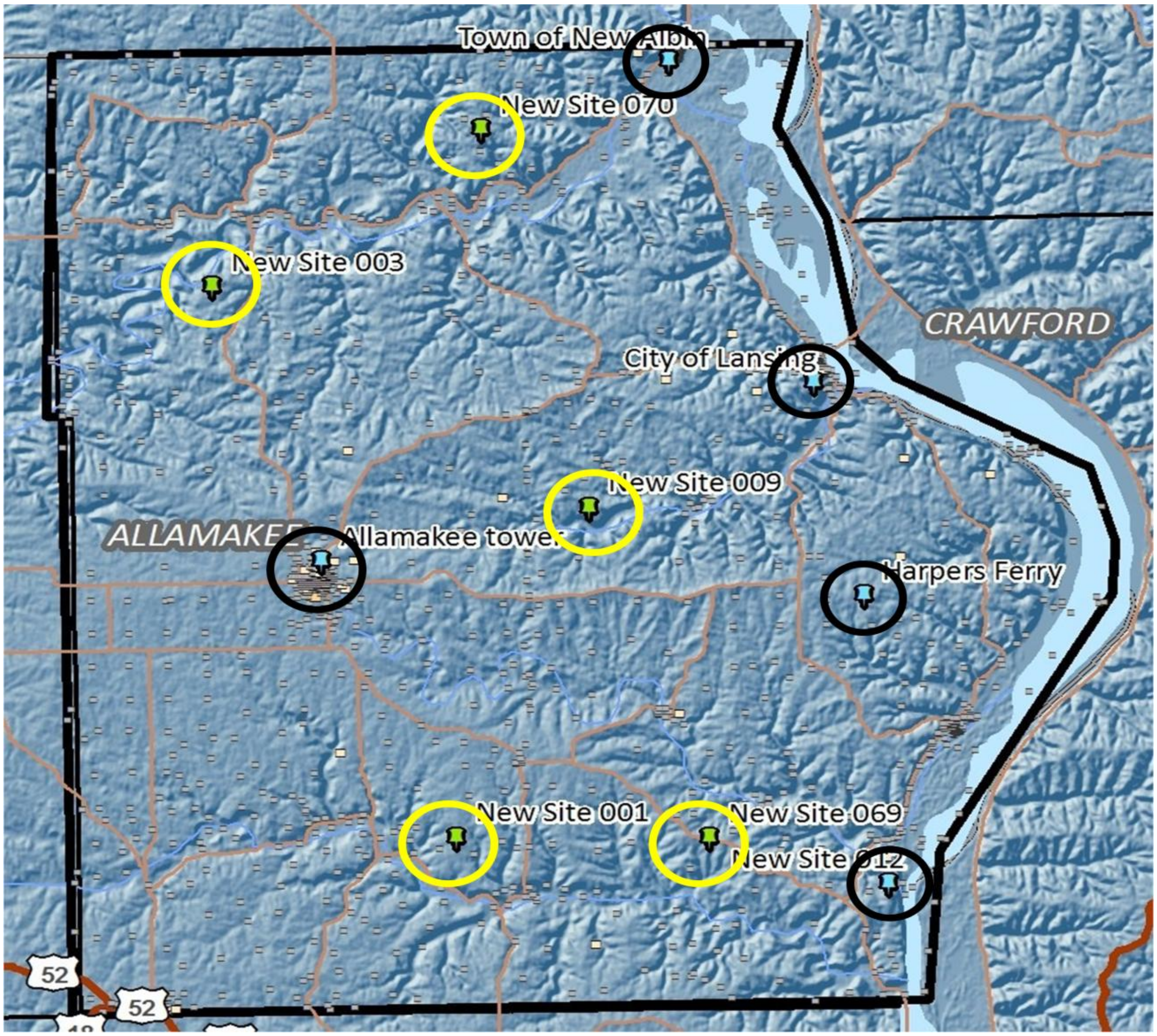
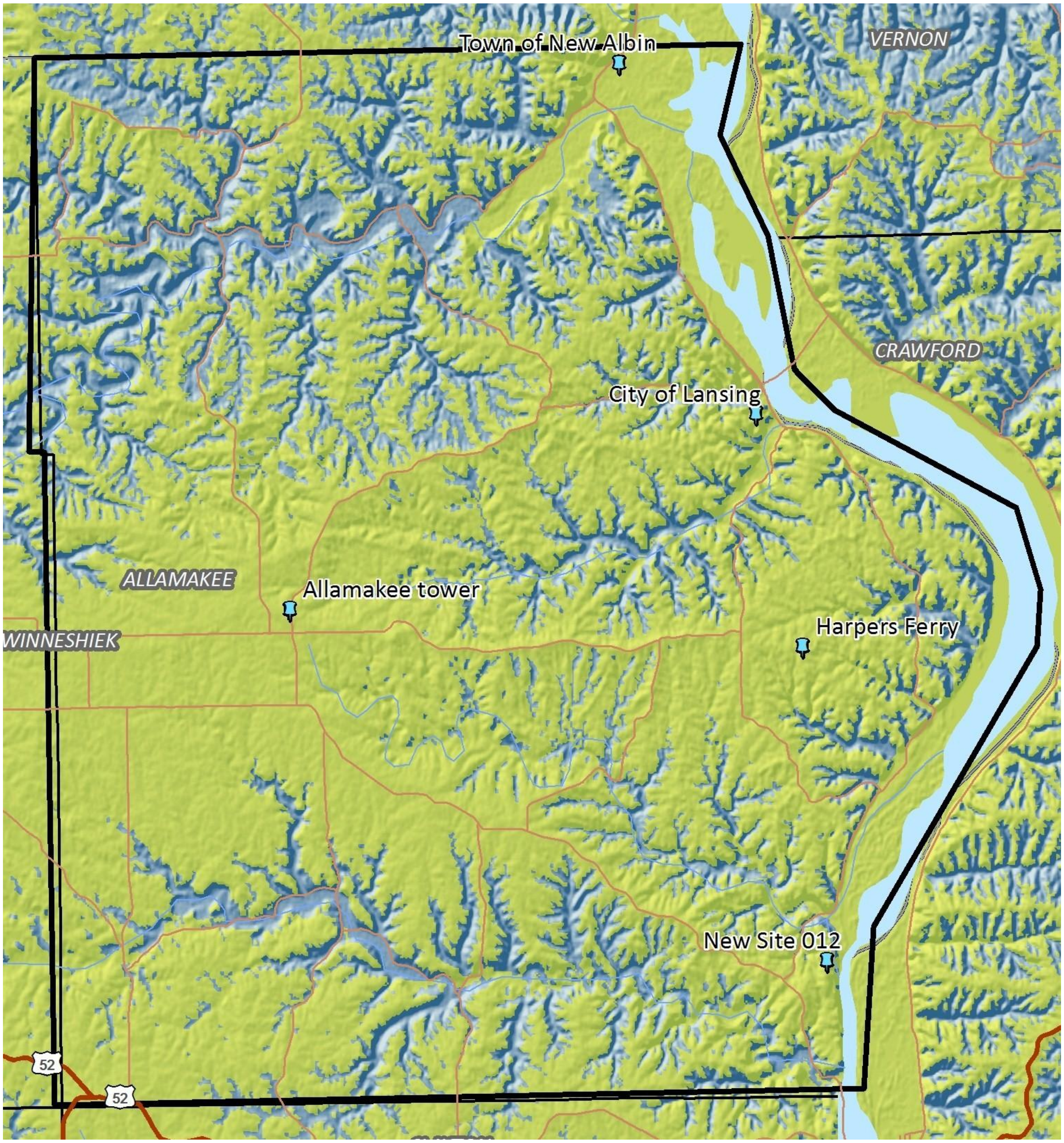
Appendix J: Special County Coverage Maps – Allamakee, Clayton, Jackson

Allamakee County Coverage

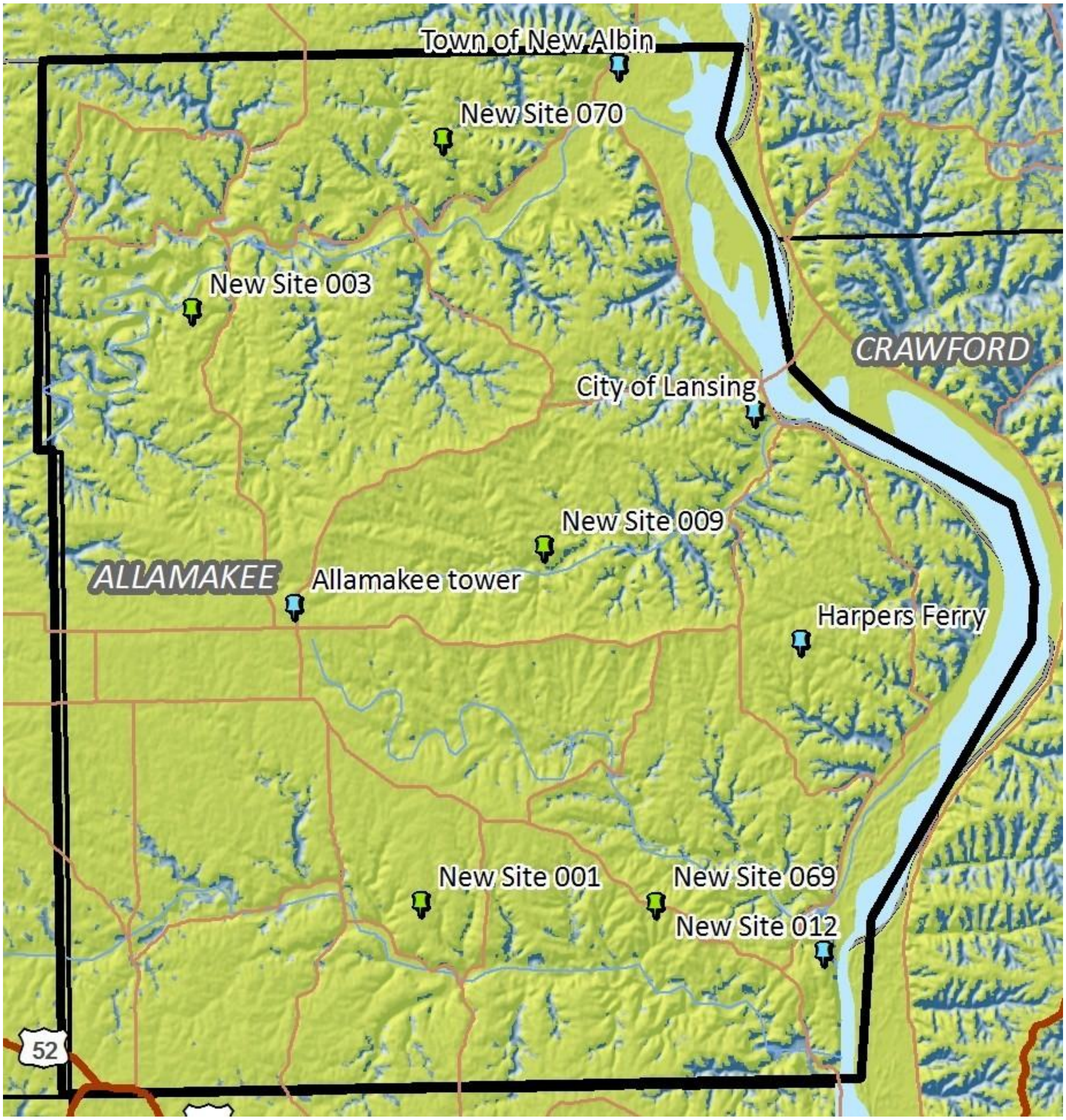


COVERAGE	5 SITE DESIGN (black circles)	10 SITE DESIGN (yellow circles)
Geographic	74%	89%
Major roadways	83%	91%
Population	91%	96%

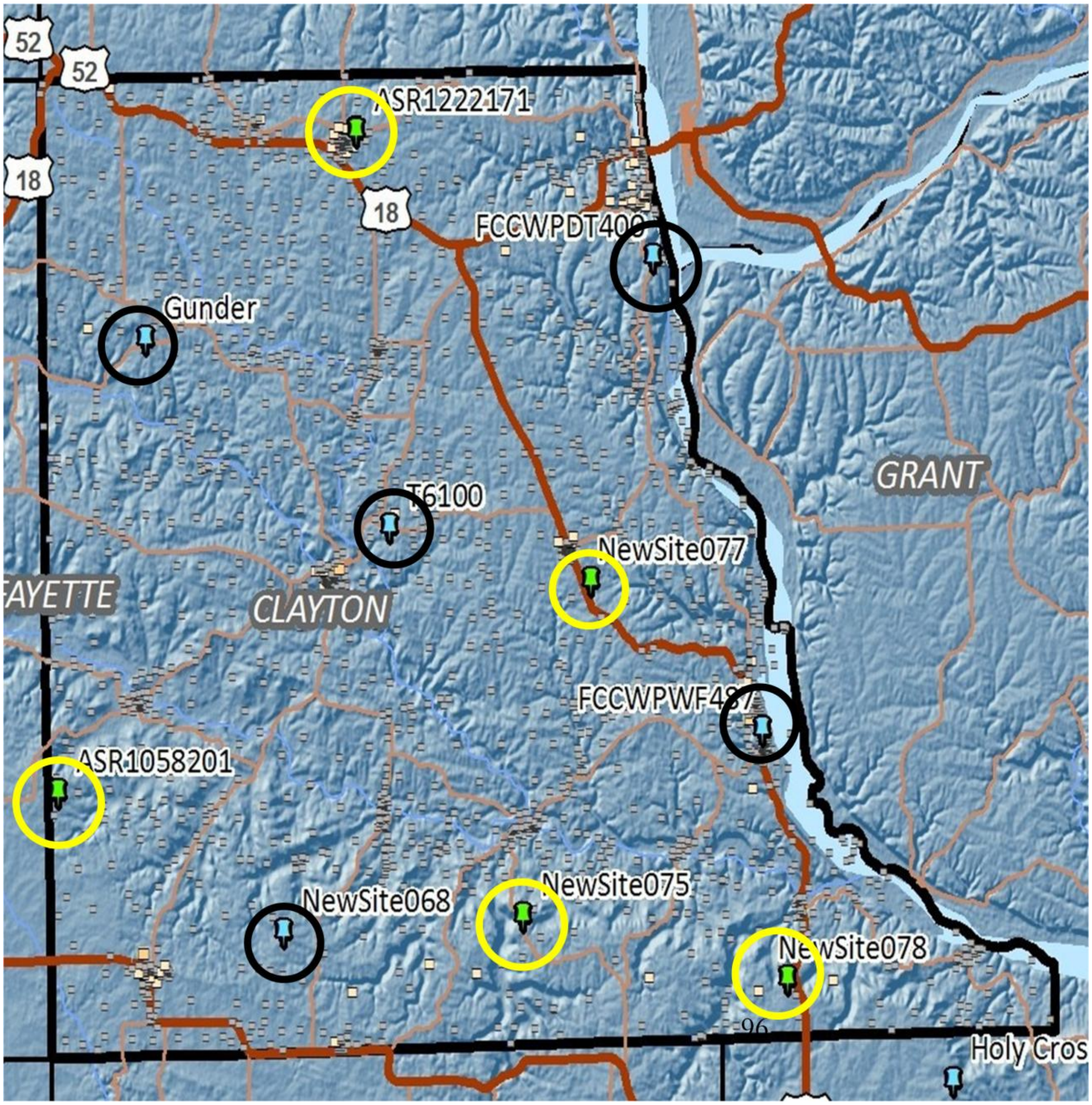
Allamakee County – 5 Site Design



Allamakee County – 10 Site Design

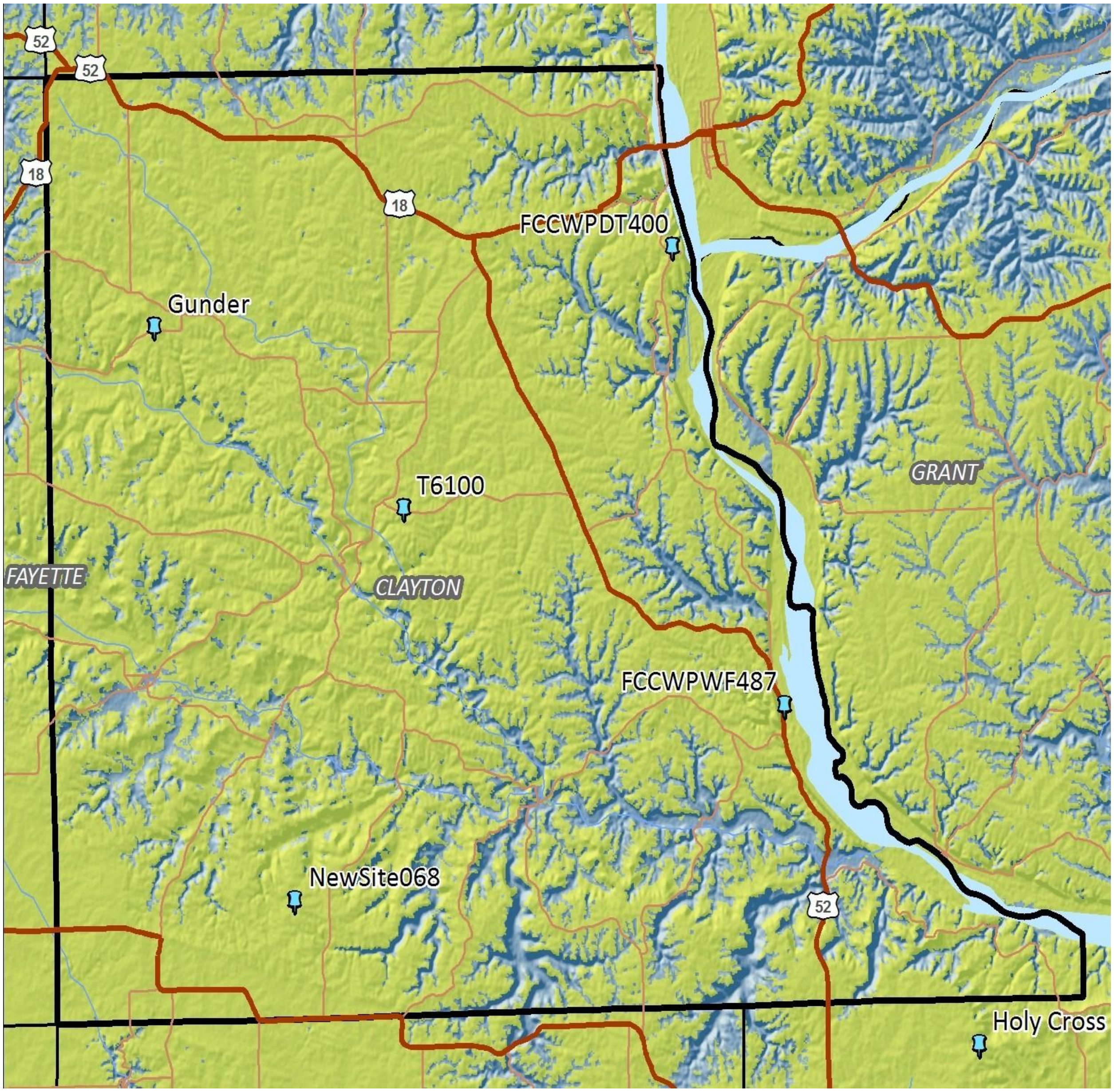


Clayton County Coverage

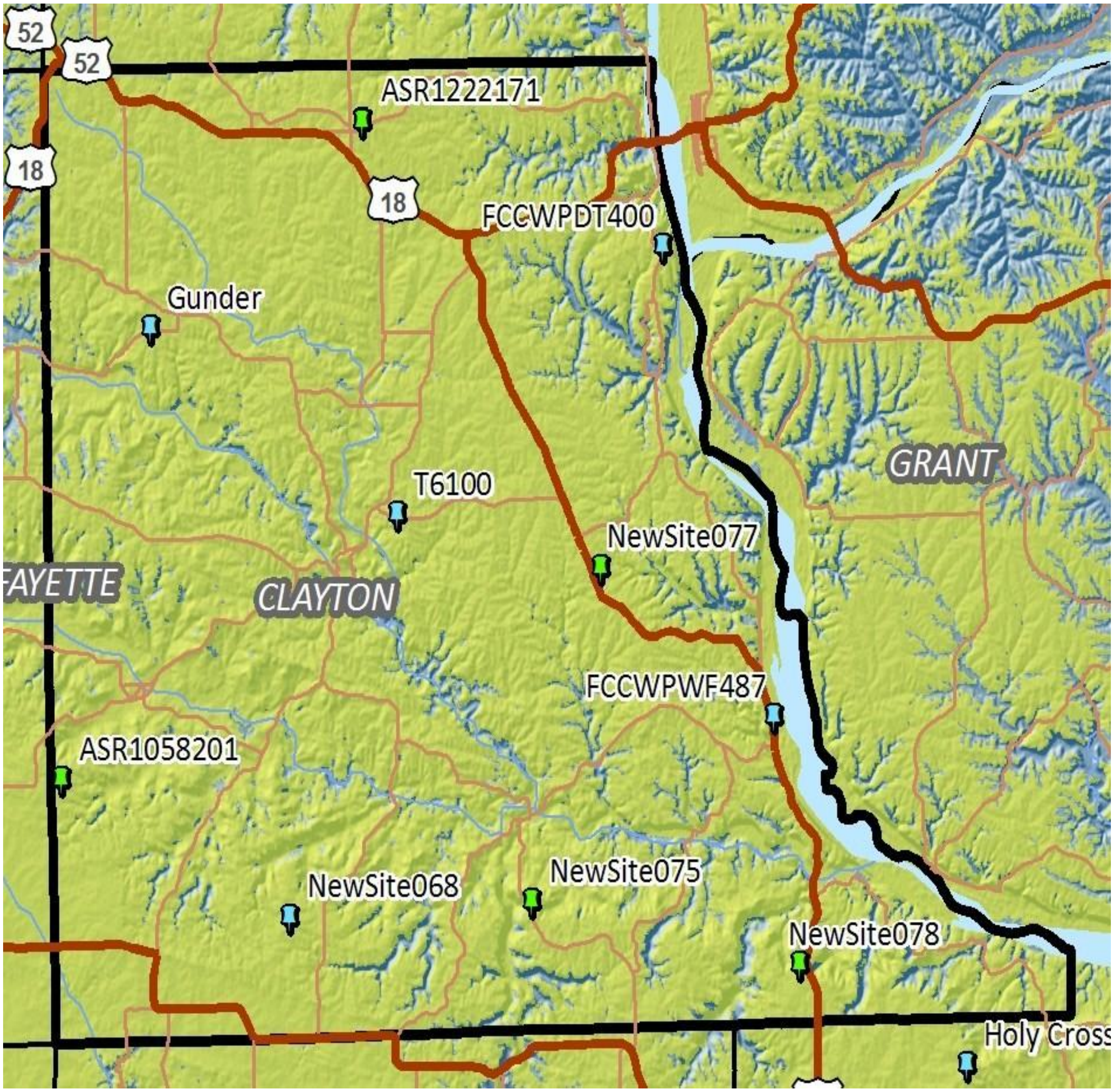


COVERAGE	5 SITE DESIGN (black circles)	10 SITE DESIGN (yellow circles)
Geographic	83%	92%
Major roadways	92%	96%
Population	86%	92%

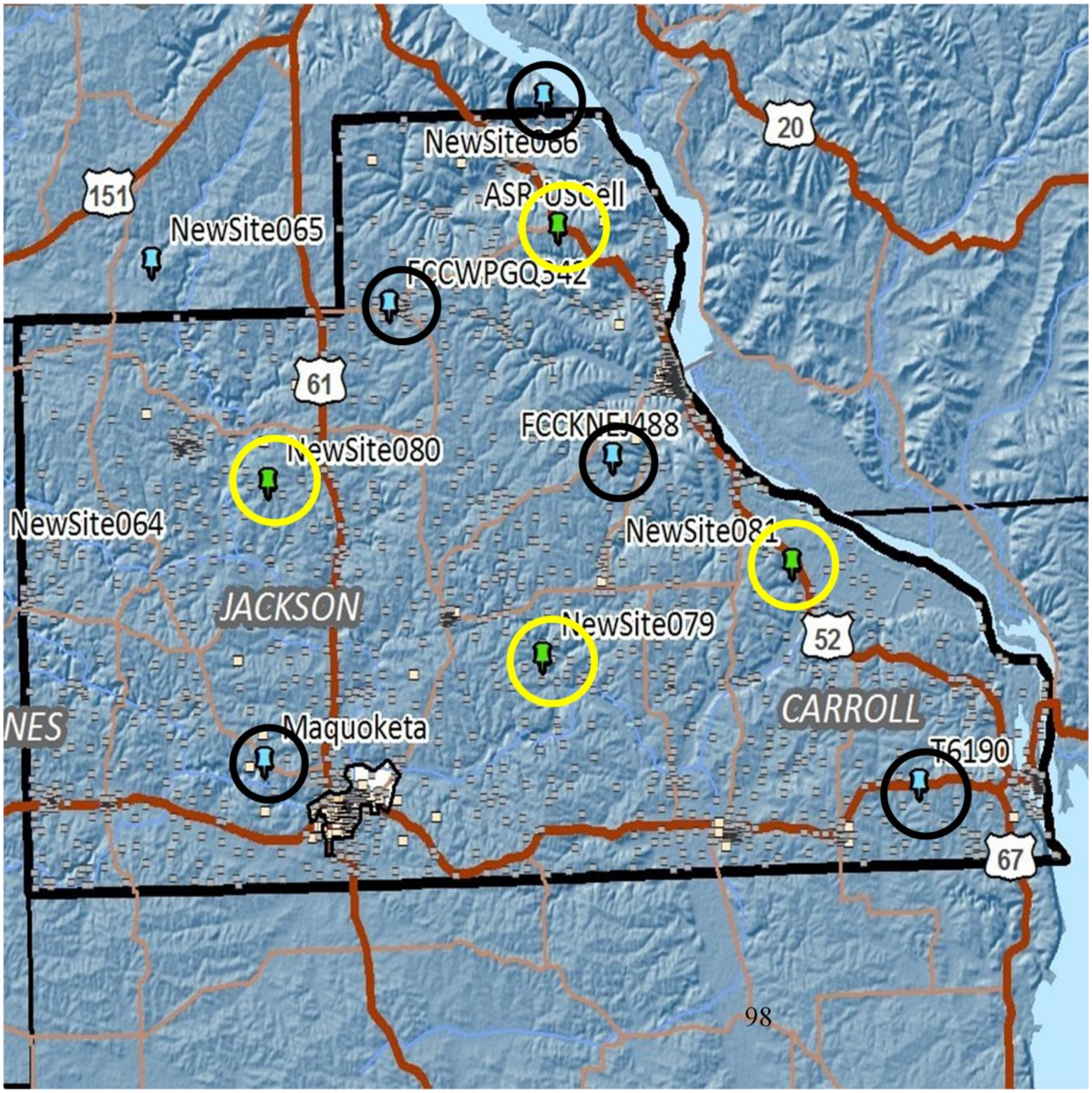
Clayton County – 5 Site Design



Clayton County – 10 Site Design

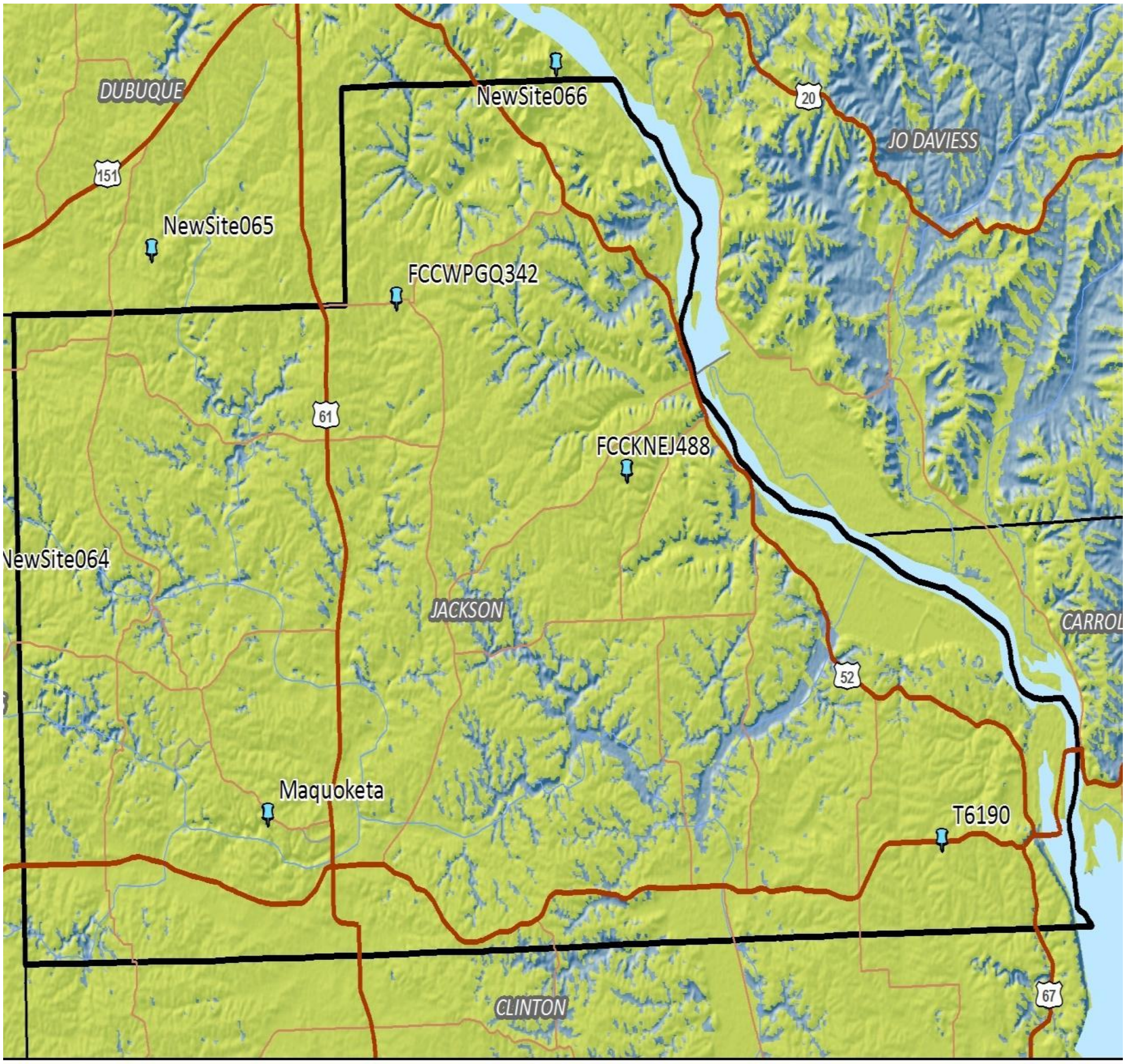


Jackson County Coverage

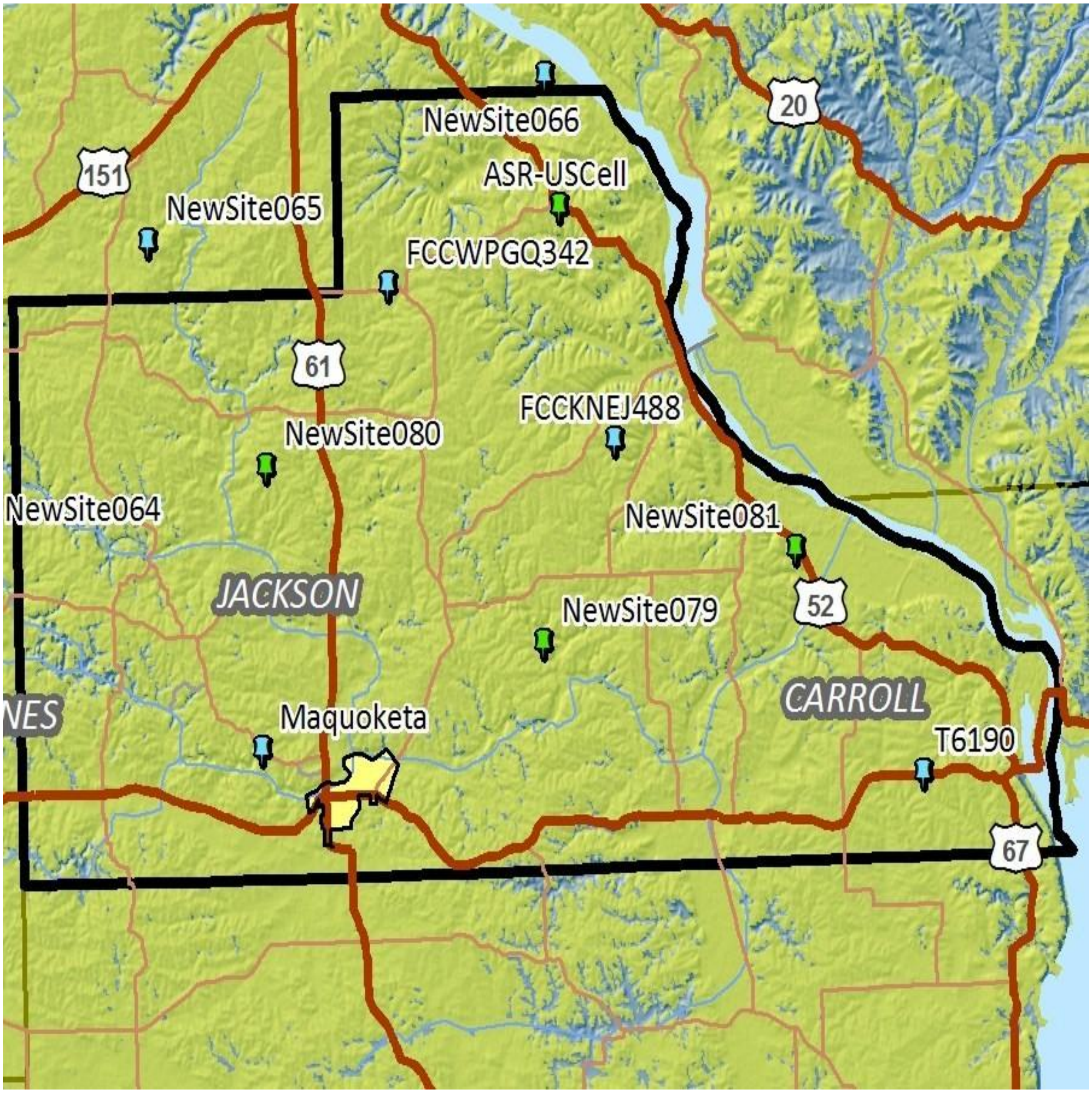


COVERAGE	5 SITE DESIGN (black circles)	9 SITE DESIGN (yellow circles)
Geographic	88%	95%
Major roadways	95%	98%
Population	84%	99%

Jackson County – 5 Site Design



Jackson County – 9 Site Design



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