Story County

Story County IA Radio Communications Study

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Table of Contents

Executive Summary

Elert and Associates (E&A) was retained by Story County to evaluate the public safety radio communications systems used by the County, City of Ames, and Iowa State University (ISU) users. Meetings were set up with representatives of most agencies and entities to gain information concerning system operation, communications difficulties, and features needed to communicate effectively. Any future system must provide the level of interoperability enjoyed on the current system.

The voice radio system currently used by Story County is a Motorola Privacy Plus Specialized Mobile Relay (SMR) system originally installed in the early 1980s to provide repeater service to many commercial users. The system owner, Electronic Engineering (EE), equipped 800 MHz SMR sites at Alleman and Ames to serve Story County users. In recent years, EE added a third site at ISU, updated repeater elements, and provided some technology refresh where possible. Story County rents the use of the EE infrastructure on a per field terminal unit basis. All frequency licenses are held by EE. The cost to use the system is extremely low, and for the service it provides, it is a great financial deal for the users. In fact, it is almost free; the only real cost increase is that of the subscriber units.

The Motorola Privacy Plus system platform is no longer available and no longer supported by the manufacturer. EE advises that subscriber units are still available with the necessary firmware load to operate on the system. Story County system users report that the system does however provide basic voice communications and interoperability for users, but it must be noted that the system does not meet today's standards for a public safety grade system. There are public safety grade subscriber radios that can operate on the system but they come at a higher cost than users have previously paid.

Most users have experienced some form of outage, but only in a few instances have users chosen to abandon the system. In E&A's opinion, the system is running on borrowed time; although EE may do its best to keep it operational, failure of the aging infrastructure components will ultimately render the system useless.

The state of the art in public safety communications systems today is digital, and the technology offers many more features than Story County's current system provides, with huge improvements in interoperability and failover capability. Due to the requirements of public safety for a mission critical communications system the cost is higher for this type of system over that of a non-public safety grade system and associated subscriber units. The State of Iowa has plans to build statewide standards-based 700 MHz APCO P25 voice and broadband wireless mobile data systems, but these projects have not been funded and the timelines are unknown. Story County wants to be interoperable with a future P25 State voice system, but unless a modern public safety grade radio communications system is built by or for Story County, P25 features will not be available to the County.

Although the County prefers to continue the rental practice in place today for its services, the costs of such networks meeting public safety standards—such as those recommended by SAFECOM—and considered designed for mission critical needs are much higher than the current system platform, and the user community is generally limited to government and public safety users. Systems are engineered for portable operation utilizing multiple sites. Dispatch should have direct control of the repeater transmitters using microwave or other point-to-point mission critical technologies. In addition, when it comes to patching of talk channels, the console system becomes part of the overall system solution.

The cost of new public safety grade systems equal to what a replacement system would require is several millions of dollars. The operational life of the infrastructure should be about 15 to 20 years, but technology advancements may happen much faster and limit the life to 10 to 15 years assuming routine software upgrades are maintained. It is estimated that even if the County chose to rent at a per-unit cost of 10 times the current level, it may take the system operating vendor eight to ten years to break even for the investment. The County must be in a position to commit to a long-term contract with a vendor to make leasing work for both parties. E&A estimates that any fee structure over $55 per unit per month is not a viable alternative. Regardless, whether the decision is to rent or own, Story County should immediately develop the necessary needs justification documents to use in grant applications as they become available.

As previously stated, the State of Iowa has plans for a Statewide 700 MHz mobile voice network, but does not have the funding in place for build out. The State had received a conditional waiver to build a 700 MHz broadband data network and applied for a grant to build out the initial portion of the network, which includes Story County but was not awarded funding to get the project started. If this build-out would take place, the sites required for broadband data will likely provide Story County with the coverage needed for countywide portable voice operation, as broadband sites would be spaced closer together than a mobile voice radio system requires.

One option for a public/private partnership involves a P25 system built only for Story County. On a per unit basis this option would carry a higher cost than a system that spans into the neighboring county. The cost of use would be spread over approximately1400 field units. A second option would be to join a neighboring P25 network. A similar effort is in process for Polk County/City of Des Moines/ Westcom with about 2500 field units but no decisions have been made on a plan to move ahead. If this group does move forward it would appear that it may be a very suitable fit for Story County. All indications are that this group would invite Story to join the network as it may actually reduce the monthly cost to all users. The total number of users would then be expanded to 3900 users and radio infrastructure components like sites and system control equipment could be shared over the entire system. Interoperability would then exist among all users.

It should however be noted the cost of P25 field units may prove to be the largest obstacle for non-public safety users within the County. An alternate solution would be to split public safety and non-public safety users into two separate systems. Public safety would pursue a more expensive P25 solution while non-public safety use a replacement technology as the system used today does. Costs could be shared for the towers and base station site systems such as the shelter, tower, microwave, generator, fencing, etc.

E&A recommends that Story County take the necessary steps to replace the existing systems with a countywide portable-based P25 platform by preparing an RFP for a countywide portable based P25 system to be provided for exclusive use of the County, city and ISU users of Story County and serviced for a user fee per unit to be determined by the outcome of the RFP. The County should immediately develop the necessary documents to use for grant applications as they become available, to reduce the cost.

If Polk County, City of Des Moines and Westcom decide to move forward with their plans Story County should consider joining this system as there should be significant savings doing so over a Story County only partnering option or an outright purchase. At their option Story may want to release their own RFP for purchase or lease of a solution that provides the interoperability desired and P25 capability for Story County public safety users to establish a benchmark.

Project Description

This project involves providing radio and systems communications consulting and planning services for the Story County E911 Board as requested in the RFP and detailed in our proposal response of October 19, 2009.

The Scope of Services is to analyze existing conditions and future requirements for an interoperable radio network in the county and to comply with the state and federal standards.

Current System

There are three dispatch centers in Story County. The County itself has a center in Nevada, Ames has a center in Ames City Hall, and ISU has one at the Armory. The County has its dispatch console central electronics interfaced to several control stations that access the Alleman tower or Ames tower as backup. The Ames and ISU dispatch console positions are interfaced to the same central electronics at City Hall. The ISU positions are remotes of the Ames system. Like at the County, control stations are controlled via the console system. Each talk group used by the console represents a control station programmed for that group. As they use control stations, the console positions do not have priority into the system, and they cannot overtake a transmission in progress. Like all other field units, they must wait for the channel to clear prior to transmission on any specific group.

The current Motorola Privacy Plus Specialized Mobile Relay (SMR) system infrastructure was originally installed in the early 1980s to provide repeater service to many commercial operators prior to the build out of the cellular telephone infrastructure. Story County used the primary site at the Alleman and the Electronic Engineering Ames site. Later the ISU site was installed to provide additional coverage on the ISU campus.

All County users make up about 1,400 field units on the system. There are also non-public safety users on the system. Each uses different group codes, so users cannot hear each other's conversations, although they both use channel resources. All three sites serving Story County are really standalone trunked repeater systems.

Each base repeater site consists of a site controller, multiple repeater stations, and an antenna system. Over several years of use, RF stations have replaced the original equipment. The control equipment hardware has not required replacement due to age, although failures may have occurred in parts of the control system. Unlike the RF portion of the system, which may use stations compatible with analog transmission, the control system must be compatible with the operating system used in the original design of the control system. Some items, like radio programmers, may be able to use relatively recent computer hardware to run the original programming software, but the controller system is likely limited, and if still usable, has not been supported by the manufacturer in over a decade. It is not understood if there was ever the option to upgrade the current system. Several years after the original infrastructure installation, Motorola discontinued the Privacy Plus system and replaced it with another product. During this period, the Privacy Plus platform was supported by Motorola, but compatibility with a new system platform may have been limited. If the user community was not demanding the features of the new system, there would be little reason to perform a system upgrade and potentially require users to upgrade field equipment.

E&A believes the current system is running on borrowed time, and although EE may do its best to keep it operational, failure of the aging infrastructure components will ultimately render the system useless. In addition, there does not seem to be any short term fixes other than hope failure does not occur.

A block diagram of the current system can be found in Appendix 2. Selected pictures of the system can be found in Appendix 3.

Coverage and Operation

Story County communications are totally dependent on the specific coverage of a single site to provide that system the coverage needed for a call. If one of the three sites does not possess the necessary coverage characteristics, another site must be chosen by the operator. Most talk groups have a primary and secondary site in case of failure of the primary site. The system was not designed for the communications requirements of Story County. It was designed to encompass as many potential users as possible to maximize the profitability of the SMR operation. If the number of users increased, additional channels were added to handle the traffic.

Users choose one repeater site for communications and all users to receive a call must be on the same site. If any user were to switch to one of the other sites, no other users would hear a call unless scan is enabled on their field terminal unit. Priority scan is not available in the system. The suggested number of scanned groups is limited to three to reduce the scan time. This is one important feature a public safety grade system should have.

County users generally use the Alleman site, as this site has the greatest antenna height and has the best coverage of the three sites across the County. It is located in Polk County, about 12 miles south of Ames. This site is equipped with 15 channels. Most of the Ames area users use the Electronic Engineering site near Lincoln Way and I35. This site is equipped with 10 channels. The ISU site is installed on the roof of Science Hall II with equipment in a small room on the top floor. This site is equipped with 5 channels.

Having these three sites is good for backup but due to the method of back up can get in the way of normal communications, as users of the system must know how and when to change channels and to which site. During non-programmed events, this issue makes the system problematic and can get in the way of emergency communications.

Dispatch operations occur on two separate console systems. The County has a dedicated system at their dispatch center in Nevada. Ames has a system at the Ames dispatch in City Hall. The consoles at ISU are an extension of the Ames system and connected via fiber links. The console screens are set up to be nearly identical. The County and Ames centers could back up each other in case of failure.

Effects of a Repeater Site Failure

If a site controller fails, all units assigned to that site will revert to a fail soft mode. This mode places each user on a predetermined channel so communications can continue in conventional mode. It is unknown if the system has failed in this fashion, but users have heard non-public safety[1] users on the system. This indicates that the system may have reverted to the fail soft mode. According to EE, fail soft channels for Story County users are unique and it has been four years since the last fail soft event.

As this trunked radio system is not supported by the manufacturer, there will be a time when parts are no longer available in the marketplace. If the controller is lost and cannot be repaired, County users must have a plan to operate on the sites that remain which could mean a huge loss of coverage in some areas. As the Alleman site and Ames site have the greatest coverage, parts would likely be taken from ISU and this site would be eliminated from the system altogether. The other two sites would need to pick up all traffic. For users dependent on the coverage of the ISU site, a plan should be formulated in advance to minimize the impact though the use of the other two trunking sites or the use of conventional repeater operation from the ISU site. These plans need to be in place for other users as well, in the case of a failure at the other sites. Everyone will hear everyone else, so channel sharing has to be worked out in advance, along with priorities that could affect life safety.

Interoperability

Interoperability is a huge system advantage. Common groups are programmed into disparate field units to enable units to communicate when and if the need arises. To gain real interoperability today, all users must operate on the same repeater, as the repeaters are not interconnected. In reality and as stated, EE provides three trunked radio systems.

[1] The reference to non-public safety users are the private user (i.e. farmers) that have nothing to do with the County but have use of the channel resources of the trunked radio system. Each of these users have the capability to use channels resources and although the system has priority for public safety users it may impact the non-public safety users on the system. Also if in the event that the system goes into Failsoft mode all users have equal access and may monitor all the traffic on the channel.

Story County has interoperability with users within the County but the interoperability stops at the County boundary as the system is not compatible with any other frequency band (VHF or UHF) and the system protocol is unique for those using 800 MHz equipment. Although dispatch may have some access to other communications systems in the area for most if not all unit to unit field communications is limited to the Story County system. Units outside Story County may be able to communicate directly with the dispatch centers but not directly with field units without intervention with a dispatch center.

A common radio platform is only part of the interoperability challenge. There are multiple areas concerning interoperability planning and technology such as uniting with governance, standard operating procedures, training/exercises and usage to develop complete interoperability plan. Each of these areas will have to be developed from an agency level to a regional level plan to enhance interoperability.

There are some coverage issues involving each of the three existing sites. Users need to understand the coverage limitations that exist to choose the appropriate group for interoperable communications. Thus, if users expect interoperability using the present system, then they must operate on a group that is on their radio assigned to the same site and be located in areas covered by this site. In other words, each base station is a separate site with its own coverage and only dispatch can talk to all three sites. This is also the case with new modern P25 trunking technologies where individual sites operate independently. If the coverage of the selected site is not optimal for the needed interoperability, then interoperability will not exist unless a multiple site trunking system is deployed.

Generally, when interoperability is needed, it is needed quickly and must be readily available to the user community. Thus, it is typical to place interoperability talk groups or channels in a preprogrammed location that all users can easily get to. In questioning users of the present system, it took some real digging to find anyone who readily knew how or what interoperability existed on the system. This is both a training and a technical issue.

Evolution of Trunked and Digital Radio Systems

The Story County radio communications platform is an early commercial trunked radio system manufactured by Motorola. These systems were marketed to commercial operators who provided community repeater service to users in their area as pre cursor to cellular. In most areas the demand for radio service was very high and in many metro areas the need for frequencies drove them higher and higher in frequency. Depending on the market community repeaters operated at UHF or 900 MHz but the demand for additional channels continued to grow. In response the FCC reclaimed the high end of the rarely used UHF television band set up frequency blocks at 800 MHz and originally licensed them in sets of 5, 10 or 20 channels. These channels were set up for commercial operators that wanted to provide radio service to the public using new trunked radio technology.

Trunking improves the usage of each channel as it allows the channels to be shared among a number of user groups allowing more users to be effectively using each channel and improving efficiency. The FCC used Specialized Mobile Relay (SMR) as the term for this service. All major manufacturers of radio systems developed their own signaling format and sold these systems to commercial operators. As operators expanded their systems regionally there was a need to expand the capabilities of the radio units beyond that local repeater coverage area into other coverage areas. In addition repeater interconnect was added to provide a means using the radio service as a mobile telephone. Third party vendors started to offer other capabilities not provided by the manufacturers. Some examples are system scan and multisite connection capabilities.

Public safety viewed the technology as a way to gain additional public safety channels and provide better communications service for their users. No longer would each agency or service be required to have their own radio channel for operation. Talk group assignments would separate calls from different agencies, communications between agencies could be provided with the assignment of a talk group and the number of talk channels that could be set up were higher than imagined. In addition fewer radio channels could be utilized for the same communications traffic.

The public safety community attempted to provide some guidelines for operation with the early APCO Project 16 standard but since all manufacturers used different signaling methods no two systems could communicate directly with each other. Conventional channel operation was needed to provide interoperability. There were many other items that APCO Project 16 did not address. In the end a public safety standard was needed. Public safety users were locked into a single vendor once the system platform was chosen. Manufacturers were assured that new or replacement field units needed to be purchased through them only.

In the late 1980’s APCO Project 25 study group started as an effort to provide a common air interface (CAI) such that multiple vendors could produce field units. This effort was backed by several federal agencies in an effort to improve interoperability as all vendors would be required to follow a single standard. A large portion of this effort involved developing the methods used to efficiently digitize the human voice for transmission in a narrow channel used by Land Mobile Radio (LMR). In addition system features were developed to provide radio system features such as voting and simulcast.

In the case of simulcast digital operation set physical limits as to maximum site spacing (~7 miles). As this relatively short distance forces the number of sites (and the infrastructure cost) to increase much higher than in an analog system further engineering was required to provide a solution. Linear modulation provided the ability to nearly double the distance to the range of 10-12 miles in most cases.

P25 systems are used in the US and other countries today but the effort continues today to further expand the standards to allow the infrastructure of different manufacturers to communicate. Today, work continues to make use of an Inter-SubSystem Interface (ISSI) to allow various manufacturer systems to interoperate, console systems other than the original manufacturer system to operate in P25 mode using a Console Sub-System Interface (CSSI) and other future modifications. Another new advancement is P25 Phase 2 which will provide double the capacity of the infrastructure by using TDMA (Time

Division Duplex) to share channel bandwidth with two voice channels on the same frequency.

Other efforts are underway to digitize voice for transmission over narrow LMR channels. These other technical platforms are now marketed to non-public safety markets. SMR and private operators that started with analog systems have a digital replacement in most bands. These systems also have the ability to use the bandwidth more efficiently and provide the ability to employ new features like automatic vehicle location (AVL) and short message service (SMS) without the need for additional RF bandwidth. Further advancements include trunking and wide area operation where calls can be routed over an internet connection worldwide.

Many of these non-public safety grade systems are marketed to campus environments for business, school districts and colleges. Public safety is not the target market for these systems as many of the radio system features needed are not available. It should however be noted these platforms are not being built to the same standards as typically required by public safety. A couple of these new technologies include the Motorola MOTOTRBO and the Kenwood NEXEDGE.

Story County System History

The infrastructure is a 1980s vintage, and although the firmware for field units and repeaters continues to be available, the system infrastructure is no longer supported and uses elements that are no longer available. Features that were once supported for public safety with this system—like direct console connect to the infrastructure—are no longer supported.

The County has leased the use of the system since the early 1980s. The County's users have enjoyed leasing at a very modest rate. Some users have also leased radios to use on the system. The radios used are getting old, and a stock pile of used radios allows system users to continue to use field terminals at the low rate. New radios are much more expensive to buy or lease, as they are public safety grade radios that have a unique firmware load that may allow backward operation on this outdated platform. These new radios can also operate on new systems, however, if properly purchased and programmed.

The current system has served County users well and provided interoperability among the user groups. The system is not capable of being upgraded to any current system platform, however. The 1980 technology is several generations past that used in today's trunked radio systems.

Terminals

Current terminal equipment is not necessarily limited to legacy products, but if the County wants to achieve compatibility to the standards-based APCO P25 digital platform and if it is possible due to the limited memory space this would be a special product that would undoubtedly involve limitations to the manufacturer's ability to stand behind its operation. This would not be desirable to the County or the manufacturer.

It should be noted that Motorola has recently introduced an upgrade path to the existing system using their MOTOTRBO product. Field units may be replaced with new radios that will operate in the Privacy Plus and conventional analog mode with the capability of moving to a digital format in the future. A complete change of radio infrastructure and user equipment would be required. The digital system is proprietary to Motorola and is not compatible with P25. Field units are not capable of P25.

Ames and ISU Site

E&A was able to view the system infrastructure at the Ames and ISU site locations (see photos at the end of this report). The Ames (EE) site has a backup generator in the case of commercial power failure. Upon power failure, all infrastructure equipment would lose power until the generator was online and producing stable power. Commonly this would be within 30 seconds. The antennas for the system are mounted at the top of the structure. Cables enter the shelter through a standard cable entry port. Repeaters are mounted in equipment cabinets surrounding the antenna combining and multicoupler systems.

The ISU equipment was in a room on the top floor of Science II. The cabinets are on wheels to allow closer spacing between cabinets, as the space is small. Cable exits the room through holes drilled into the wall material. The antenna is mounted on the roof of the penthouse. A fan in the room provides air flow to the controller equipment.

PSAP Operations

The 800 MHz control station equipment for the County is located in racks, with the central electronics bank of the console, CAD, 911, and other dispatch center electronics. Control stations are neatly placed with power supplies on rack trays, and cables are neatly routed. RF transmission line cables have surge protection devices (SPD) as they come into the room. SPDs should be placed where RF cables enter the building to reroute surges to ground and place as much distance as possible between a surge and other electronics. The cable entry port was not observed. Several 800 MHz directional antennas are mounted on the short tower placed on the roof.

The 800 MHz control station equipment at the Ames City Hall is located on the top floor in a penthouse location. About 20 control stations are placed on rack trays, with power supplies and the RF transmission lines run overhead and to the outside. A number of directional antennas are mounted on two horizontal pipes clamped to vertical pipe sections that hold other antennas. The radios are controlled via wire line from the console central electronics located near the dispatch room. All ISU radios are also located at City Hall. A fiber connection links the console positions at ISU to the central electronics at Ames. Ames and ISU share a console central electronics bank (CEB).

County Paging

Story County pages rural Fire departments and EMS unit via a multisite VHF system. The primary VHF site is located on the Heartland elevator located between Nevada and Ames just north of Lincoln Way. Elert was advised that there are fill-in sites in Story City and Zearing. Paging is reported to be activated by dispatch via an UHF control point link between the Story County LEC and three UHF transceivers located at the Heartland elevator, Story City and Zearing. The paging transmissions may also sent on the County Fire group on the 800 MHz system using simul-select on the console. Upon receiving this link signal the VHF paging transmitter is activated and the link paging tones generated by the console equipment are sent to the paging sites. The UHF transceivers pass the received paging tones to the VHF transmitter. A back-up paging system is located at the 6th street County Courthouse in Nevada with control from the console system at County dispatch.

Paging Issues/Problems

There have been difficulties with paging reported by the rural Fire departments. Although some failures appeared to be due to extreme weather conditions some Fire department personnel do not trust the paging system performance. Antenna and equipment failures have taken place and the primary system was moved to another location on site at the Heartland elevator.

Inconsistent operation appears to plague the paging system. Elert suspects that the UHF link used to relay the paging tones to the VHF paging transmitter(s) are possibly being slightly distorted creating inconsistent operation. Whatever the cause it must be determined and corrected to gain confidence back in the paging system.

Elert’s research indicates that the antenna location information for the Heartland site is in excess of 1 mile in error. The fill sites do not appear to be licensed and no license was found for the frequency reported to be used on the UHF link.

Public Safety vs. Non-PS Radio Technology

With the rigors placed on voice radio equipment today by public safety radio users the term mission critical is generally used to define the hardware, software and the supporting system. This has come to mean the system has to work every time and every where the PTT button is pressed and further the transmission is heard to allow a response. This definition was used by the designers of what has come to be known a APCO P25.

A large number of manufactures are now developing products to work using this standard. To meet the rigors of usage the portables, mobiles and core infrastructure has been hardened to insure a drop to the pavement, a drop into a pool of water, or even use in a hazardous environment will not hold back the system from working. There is however a cost to this mission critical design. The major public safety system manufacturers today include EADS, EF Johnson, Harris, Motorola, and Tait Radio while others might list Icom, Vertex, and Kenwood to a lesser degree of acceptance.

For non-public safety grade equipment one pays the price of less reliability and not as durable a product from the subscriber radio to the infrastructure. It is also much harder to share the system with an adjacent agency as this non-PS radio technology is typically classified as business-grade equipment and not developed to the level of public safety needs. Thus if one needed to make a comparison of wireless voice technology at the bottom would be common cellular and then business band with public safety at the top. Even to the users the expectation is that cell calls will drop while the police needs to know the radio will work in a life safety situation every time.

A non-mission critical radio system, one that can suffer outages and missed calls, might be better defined as a business-industrial system. The component parts are not created to the same reliability or expected life of continued 24x7 operation and thus the cost of a such a system is much less to build and operate.

Generally, these non-public safety systems are proprietary as mutual aid users are seldom supported or expected to be supported on the system. Companies such as Icom, Kenwood, Vertex and Motorola manufacture this grade of equipment. They are however generally not directly interoperable with P25 hardware. The subscriber units cannot operate P25 as if they did they would also carry the higher price due to licensing. In some locations in the country business industrial grade systems are used for public safety primarily due to the cost.

SAFECOM

Several years ago the Department of Homeland Security retained SAFECOM to produce materials to assist agencies with interoperability planning. SAFECOM produced a interoperability continuum to assist in the development of interoperability planning by providing steps along each facet of the continuum to determine where you were overall in your interoperability effort and provide visibility to the next step. The following graphic (see Figure 1) was produced by SAFECOM and shows the interoperability continuum at several different levels.

As you review the continuum you can determine where you are within each of the areas. A SAFECOM guide that includes additional details is found at the end of this report.

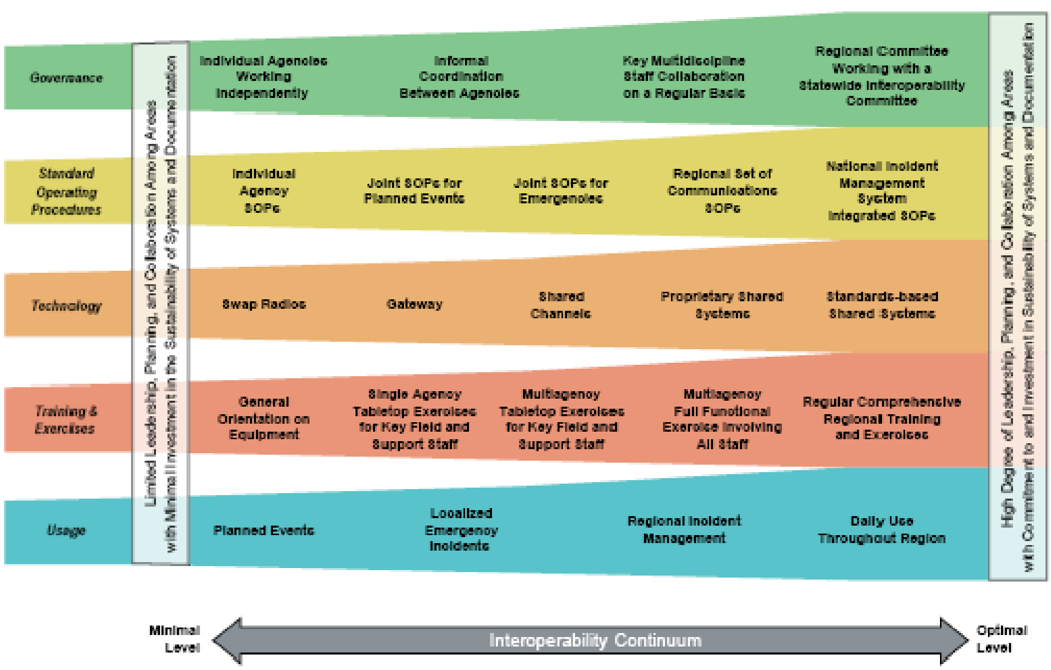


Figure 1 - The SAFECOM Continuum

Public Safety System Features

Although one site may be used by the County for mobile communications, portable communications commonly requires multiple sites. Satellite receiver sites distributed across the county will increase a portable's chance of being heard by dispatch and provide the clearest repeated signal to the field. The current system in use by Story County is not capable of this common RF enhancement method. If a portable has problems hearing the outbound repeater signal, multiple transmitter sites can be employed. If frequencies are bountiful, each site could use a different frequency. Field units would need to scan to ensure reception of a signal and potentially may need to be manually selected to find the best site or to transmit to the closest site. This type of operation places the burden on the user. To lift this burden, simulcast is generally used. Simulcast uses the same frequencies at all repeater sites to provide better coverage. Operationally, all sites appear to function as a single site. Like satellite receivers and voting, the current platform used by Story County is not capable of simulcast nor are most of the non-public safety grade systems previously described.

Another common characteristic of the modern day public safety communications system is direct control of the transmitter by dispatch. Currently all consoles are operating mobile stations on a power supply, and these units communicate with the repeaters. Like any other field unit, they can only transmit or receive. Direct control of the repeater transmitter by a console allows operation in the duplex mode, where dispatch can be transmitting to the field while listening to a user in the field at the same time. Public safety grade systems expect this capability today, as the radio console is an extension of the radio system and not considered an add-on.

Satellite Receivers and Voting

The current system has three sites, but any user can use the coverage capabilities of only one site at any one time. Public safety systems are generally portable based. An officer leaves the mobile radio in the squad and must be able to perform all communications tasks with a portable radio. Public safety systems must be designed to work well with both mobile and portable radios. The receivers of the portable radio have as much sensitivity as a repeater receiver, but the portable transmitter power output is a fraction of the repeater and there is certainly an antenna height difference to overcome.

To enhance and attempt to balance the received coverage for public safety communications, multiple receiver sites are used to hear the low power portable transmitter signals. All received signals are sent to a single location, where they are compared and the best audio is chosen by a comparator (also called a voter). The voted audio is used to send to the dispatch consoles and to the repeater for retransmission. Backhaul is required to carry the audio signals to the voter and back to the repeater (or repeaters, in the case of simulcast). In public safety systems, backhaul is usually microwave, but other forms of point-to-point communications can also be considered, such as RF links, telephone lines, or fiber optic cable.

Satellite receiver systems allow the portable to transmit throughout the coverage area without regard to the radio site closest to them. In the current system, the portable must be able to be received by the repeater site chosen. The current system does not have the ability to employ satellite receivers. This limits portable performance to a single site.

Scan Features

For transmitters, multiple sites provide additional sources of signal for field terminal units. The Story County system configuration has three tower sites, but the user can only benefit from the signal received from the tower site selected by the radio. From the radio system viewpoint, all of the talk group assignments are unique as there are really three independent trunked radio systems. The operating procedures for the use of talk groups provide the backup expected by the user community, but it seems much of the user community may not know how to use this feature effectively during emergency or unplanned special events.

Utilizing scan provides the ability for the user to hear multiple talk groups, be they on any repeater site, and then to quickly transition to the backup (or alternate) channel (talk group). However, the time it takes to scan may also mean the call is not heard by the user, so while effective communications can/may continue without interruption, that is not always the case. There's also a possibility of missing a call if scanning is in use. A priority scan feature places the selected group or channel into the scan list several times scan per cycle to ensure that they checked for activity at a higher rate. Priority scan may also switch the user radio to the selected group or channel while receiving a non-priority call in progress.

Any user in the system can select the alternate group, transmit, and communicate to the users of the selected talk group, provided that all of the users scan the alternate channel and are not involved in a current call on another talk group. The number of talk group assignments in the current system is large—well over one hundred talk groups are established. Talk groups programmed into radios provide agency communications among the user group members, including a dispatcher. Unit programming allows users to leave their talk group to communicate with another talk group or scan other talk groups.

Unfortunately, the scanning function is not able to revert to the user's main talk group automatically with current field terminals once the conversation is completed. Units transmit on the last channel selected for transmit, and many times the user does not reselect their primary talk group when returning to scan, thus potentially talking on the wrong group or missing a call altogether. As a result, responses from the field may appear on unrelated channels. Scan activation that reverts to the primary talk group whenever activated is desired and this feature is typically programmable on modern P25 system field terminals.

System scan also creates issues with receiving and listening to the primary talk group depending on the site that the talk group is using. The current trunking system uses a control channel to accept requests for service and sends the necessary information to units in the field about calls in progress. Any idle unit in the field listens to the control channel and waits for calls to initiate. Normally, once a call is in progress, a radio decodes a talk group it should listen to and the unit changes to the channel as instructed and listens to the call. If scanning, the radio will scan the control channel, listen to the talk groups in process, and jump to the next site if it determines that no call is for them. During this period, if a call should start on the primary site, the user would miss all or part of the call. This is an attribute of multisite operation. Multicast operation would transmit calls over multiple sites using different channels and simulcast transmits calls over the same channels. Multicast and simulcast requires additional control equipment to distribute call information. For further details see the sections below.

On the current system it is recommended that the user scan no more than three talk groups to minimize the potential of missing calls due to system scan, as if any of the scanned talk groups reside on another site, calls can be missed. These problems have been addressed in APCO P25 systems via the design and control system.

Multiple Site Systems

Multiple site systems usually enable field units to cover a larger area than a single site can reliably service. This is done by strategically placing repeater antenna sites using repeaters with unique frequencies in areas of weak or no coverage of any other existing radio sites. The "base" location or area where dispatch is located can be directly connected via a backhaul infrastructure like microwave or wire line or through a control station. The control station has an antenna that can receive and transmit to all sites in the system; though scanning may be needed to make the control station in this system work. Alternatively, the base site could have multiple control stations that each have only one talk group so calls are not missed. Field units would need to use scan as they traveled through the total coverage area so they could receive calls.

These problems have been addressed in APCO P25 systems via the design and control system.

Multicast Systems

Multicast is a method where transmitters on unique frequencies positioned at multiple sites carry the same audio information to sufficiently cover a larger area. A backhaul system such as microwave or wire line would be used to deliver the audio information to and from the site to a central location. Since all sites use different RF frequencies, the parameters of the transmitted signals do not need any special processing in order to provide wide area operation. Sites are chosen like a multisite system design. Since each site operates on different frequencies, field units must scan each of the sites to ensure they find the strongest signal. Most control channel scan functions use signal strength as a parameter in their scan function, but do not usually look at all sites before stopping at a valid site. It may stop on a site that is not the best one but one that meets the scan criteria. Some radio models have unique scan algorithms to take advantage of this type of operation. Multicast is very inefficient, as it uses multiple frequency resources to transmit the same message. In a lot of cases, the lack of available frequencies does not allow this type of system operation. The receivers in a multicast environment would use a single frequency and would vote the best received signal for retransmission to all field units. To work properly, field units need to automatically associate with the best site so users do not have to be aware of where they are located or the channel to select for a different location.

Simulcast

In the simulcast method, multiple repeater sites operate on the same frequency and transmit simultaneously to provide larger coverage footprints, but they use only a single transmit frequency. Unlike multicast, the RF signal parameters must be kept very close to each other. When a receiver hears multiple sites, their signals must appear like they are from the same site to every location in the coverage area. If frequency, deviation, or arrival times are not close, then distortion will result and the call may not be understood or, as in digital, may not be processed and will be dropped. In digital operation, there is also a limitation in site spacing, where the maximum distance between sites may be less than 10 miles in some situations. Some vendors use an alternate modulation method to extend this distance, but it is not available from all vendors. Results of poor design may be distorted or non-existent talk out audio to the subscriber and in some cases an out of coverage alarm.

Priority

A multiple level priority scheme is built into the P25 system. It allows dispatchers to overtake a transmitter while listening to a call on the same group. Each talk group on the radio system can be programmed as to its priority level, thus making it possible for some talk groups to force others to wait when the system is busy. When a field unit requests a channel on a specific talk group and all voice channels are being used, the controller compares the priority of the new caller to those calls in progress to determine who has priority. From a field unit perspective, emergency and “man down” calls are assigned the highest priority. Other groups would be assigned priority dependent on the job function.

Digital and Analog

Communications can be sent over the air modulating the frequency at an audio rate (analog) or digitized using one of many digitizing methods and sent over the air digitally. The transition from analog to digital operation provides the operator with noise free communications to the edge of the coverage area. Digital (which includes P25) operation has inherent system performance advantages, as the digital signal can be decoded in weaker signal areas, but unlike analog, it can provide audio free from noise. The user community perceives coverage to be better. In digital systems, the audio will not get noisy as in analog systems. The coverage ends abruptly. The audio is either clear or there is no audio at all. The perceived coverage improvement by some suggests that it is about equal to the loss that narrow banding inflicts.

Digital technology slightly improves coverage, assuming all other system parameters remain constant due to processing gain. At the edge of the coverage area the digital information is either decoded and the audio is present or the digital information is not decoded and no audio is present. Entering a building usually reduces signal levels quickly, and as each interior wall or level is passed, the signal level can drop several dB, to the point where a radio can no longer decode. If the signal loss surpasses the signal level required to decode the digital signal recovered, audio can transition from good to none very quickly and without warning. Various issues related to performance in weak signal areas is one of the reasons fire departments are slow to adopt P25 digital trunked operation and why if they do, they continue to use simplex on scene as recommended by SAFECOM.

Tones that may be used for alerting such as evacuations in a Fire event do not work well in some types of digital encoding. A vocoder, which is short for voice encoder, is designed to digitize voice. A P25 vocoder digitizes voice for transmission over a narrowband channel while suppressing background noise and provides additional bits for error correction. Tones commonly used in Fire departments for evacuation, emergency and other forms of alerting are not voice and are processed as background noise in a P25 vocoder and the output audio at the receiver is at best distorted. Although there will be an improved vocoder used in P25 Phase 2 it will not solve this issue.

The March 2010 APCO P25 Statement of Requirements document suggests that digital codes may be used to activate tones built into the field terminal units but does not list it as a requirement for P25 field terminal units. Some vendors of terminal units offer this capability but since it is not a P25 requirement no standard will apply and vendors may implement it differently. Ames Fire reports that they currently uses an external device for this purpose but desires to have this functionality via radio in the future.

Dispatch Operations

The current console system uses discrete audio inputs and outputs from control stations to provide audio to console electronics. A conventional VHF channel can use any model radio to interface to the console electronics. To gain all of the possible advantages of a trunked radio system, it is imperative the radio console is designed to match the capabilities of the radio system and become an integral part of the system. This generally means the console system is of the same manufacturer as the radio system or a radio console designed specifically to interoperate with the system. The ability to direct how users operate and patch trunk groups is vastly improved using the matching console system. There is no standard console interface to a P25 system today. Most P25 manufacturers have developed their own console systems that are integrated with the P25 system. There has been some work done on a Console Sub System Interface (CSSI) to allow other console systems to control a P25 infrastructure, but there is little interest from the P25 infrastructure vendors for such an interface. However, one vendor of trunked radio technology was showing two different console manufacturers operating over its P25 network using a pre-standard CSSI successfully at the 2010 APCO Conference.

Electronic Logging System

The logging (or sometimes called call recording) system is also uniquely designed to interoperate with the trunked radio system, as it must track the various voice conversations as the controller moves the channels. As systems move to digital operation, so too must these devices provide digital recording and playback capability of the trunked traffic and many of the digital calling features such as UID, Group and Status in clear or digital encryption modes. Various recording/logging systems operate on various P25 systems and in some cases expect to make use of the CSSI.

Encryption

Unique to APCO P25 digital is the ability to easily incorporate security of the voice channels through the use of standards-based encryption such as AES or DES, with DES generally winning out due to cost. The Federal government generally uses AES, which is a higher level of encryption but is more costly.

OTAP and OTAR

Two other features of P25 trunked radio related to the ability of over-the-air reprogramming and over-the-air re-keying are OTAP and OTAR. These features allow a system to remotely touch radios to upload new settings and to reprogram new encryption keys without bringing the subscriber terminal back into the shop.

Backhaul

Direct control of the repeater transmitter by a console allows operation in the duplex mode, where dispatch can be transmitting to the field while listening to a user in the field at the same time. All sites require interconnectivity to backhaul all of the control and audio for operation. Backhaul would consist of microwave or other point-to-point technologies to provide the necessary communications.

Non-public safety digital radio platforms have been designed for use in business, education and campus environments. These systems employ connectivity between sites to allow users to communicate over multiple sites. In many cases sites in these applications are not adjacent and the connectivity medium used is wire line. These systems often use the internet to connect sites as required.

Due to the importance of communications in a public safety system dedicated network systems are generally used to carry this traffic and not the internet. Although wire line and fiber can be used both can be interrupted in construction incidents anywhere along their route to their destination. Microwave is commonly used to provide connectivity. Regardless of the method there is an increased cost to doing this.

System Coverage

Background

Electronic Engineering built two SMR sites in the area, which provided coverage to the majority of Story County. In recent years, repeater elements of the system have been updated and a third site was installed at ISU. Since the main site is located in Polk County, only a portion of the antenna’s pattern (~90 degrees) is serving Story County. The height of antennas (at 1,100 feet) certainly offers coverage countywide, but the area covered within the County is estimated to be 95.8% for mobile and only 83.9% for portable outdoors when the design target signal level is -105dBm and greater (indicated by orange, yellow, or green on the following prediction maps created by E&A). Based on information received by the Sheriff's department, the areas of marginal coverage for both mobiles and portables are Maxwell, Zearing, and Story City. Each of these areas exhibits weak signal strength for talk-out and talk-in.

E&A's Analysis

The current coverage does not meet the County's requirements, as two other sites are employed to improve coverage. This method gets in the way of interoperability. This may be satisfactory for an SMR system, but most public safety system designs generally attempt to provide 95% reliability over 95% of the county.

Predictions were generated using FCC-licensed ERP data. Antenna heights use FCC or heights provided by service personnel. Predictions assume portable at-the-hip operation unless noted. Portable operation assumes that a six-watt portable unit is worn on the hip, and body losses are considered in the calculations. Reliability is also considered in the predictions, such that the signal level predicted will meet this level 95% of the time. In the predictions below, the County border is the thick violet line, and roads are a dark gray. The predictions use 100 meter terrain and clutter (environment) databases. Every ~328 x ~328 foot square represents a terrain elevation with a given height above mean sea level and a loss factor that represents the land use. Land use includes forest, agricultural, urban, and industrial, among others. Each category is assigned a loss value.

The map below represents the environmental information considered in the predictions.

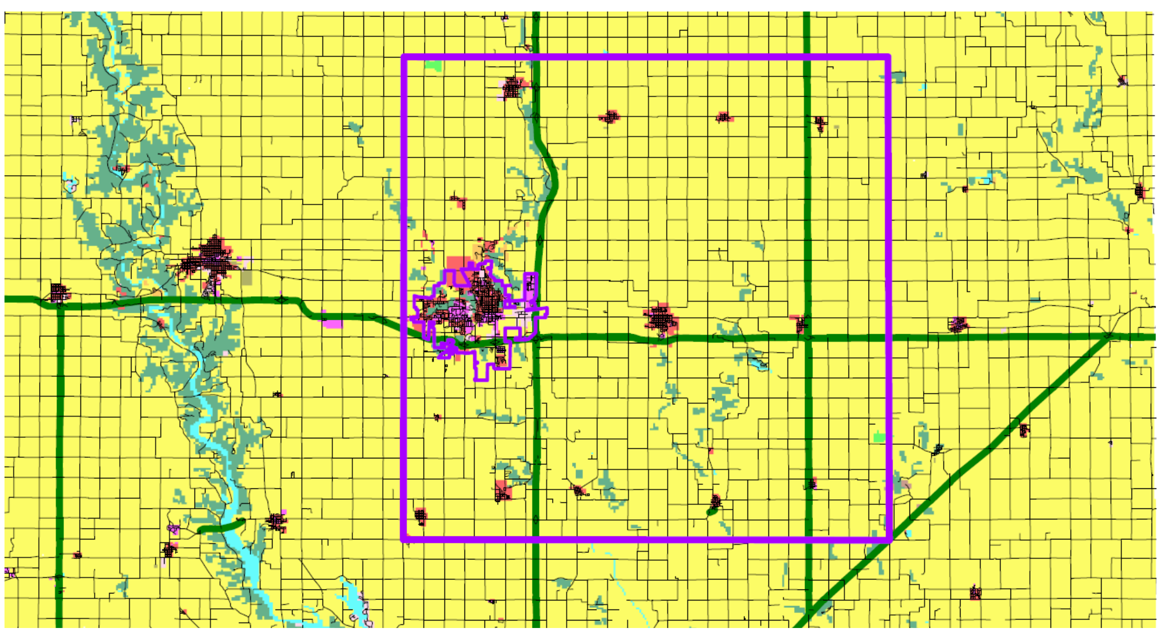


Figure 2 - Story County Clutter Data

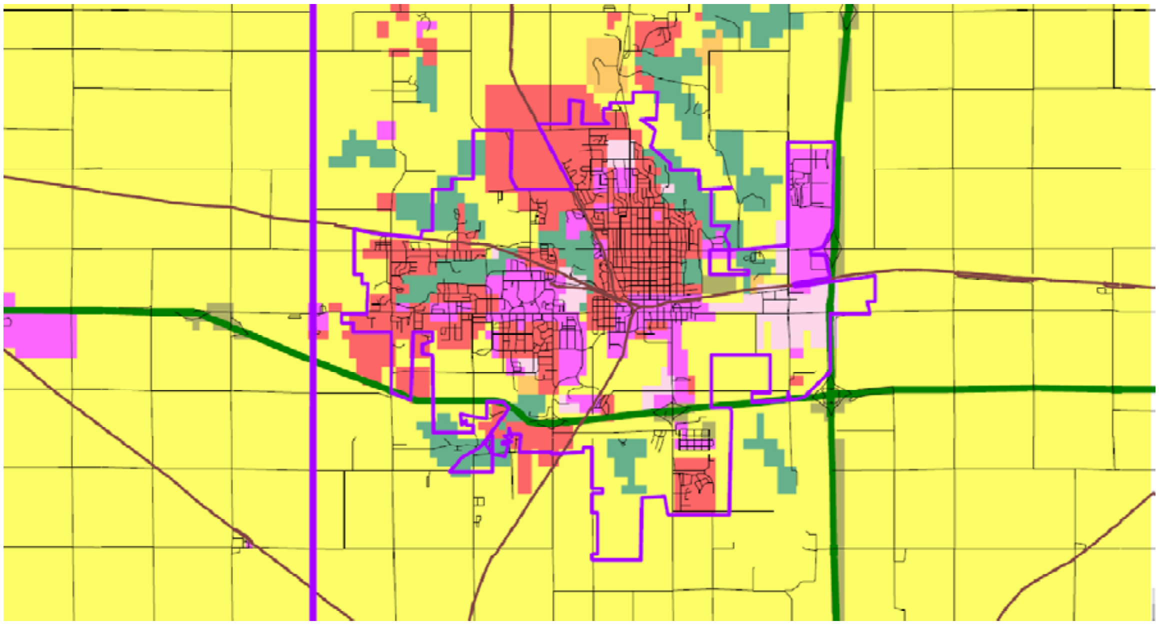
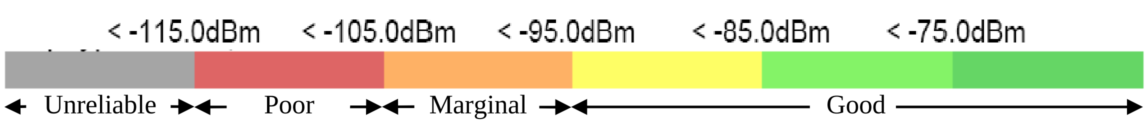


Figure 3 - City of Ames Clutter Data

To the left is the key for the different types of clutter data considered. Each has a loss factor that is used in the coverage prediction calculations. All predictions are of outdoor coverage. Indoor operation is subject to additional loss factors, including the materials used for construction and size of the structure.

Predictions use five colors to represent a reliable predicted signal level and assume that antenna systems are in ideal condition. As shown below, the two shades of green and yellow represent a good level of signal. Orange and red represent marginal to poor performance, while dark gray represents a level that drops below a value considered enough to provide consistent performance for public safety operation[2]. The small red circles represent tower/antenna sites. The borders of Story County and Ames are shown in violet lines. Talk-in performance assumes a three-watt portable, body losses associated with on-the-hip performance, and reliability of 95%.



Although signal may be reaching the ground over a wide area, the ability to predict a reliable grade of service for the user is accomplished by adding a margin to the predicted

[2] Communications at this level of signal may be possible, but not at the 95% reliability factor used for the prediction.

signal level. Predictions use terrain and ground clutter information to estimate where the RF signal will provide signal and at what level. To predict 95% reliability within the County, about 6dB of additional signal level is added to the predicted level.

The predictions below represent the performance of current Story County sites. Coverage indicated includes a reliability factor, which makes each prediction conservative in nature, but the estimates should be close to the coverage that a user would observe. The predictions should be close to communications condition experienced in the summer season, when trees are fully leaved. Coverage likely improves in the fall and winter months, when leaves no longer attenuate the radio signals as they have fallen from the trees.

Alleman Tower: Story County Coverage – Portable Operation

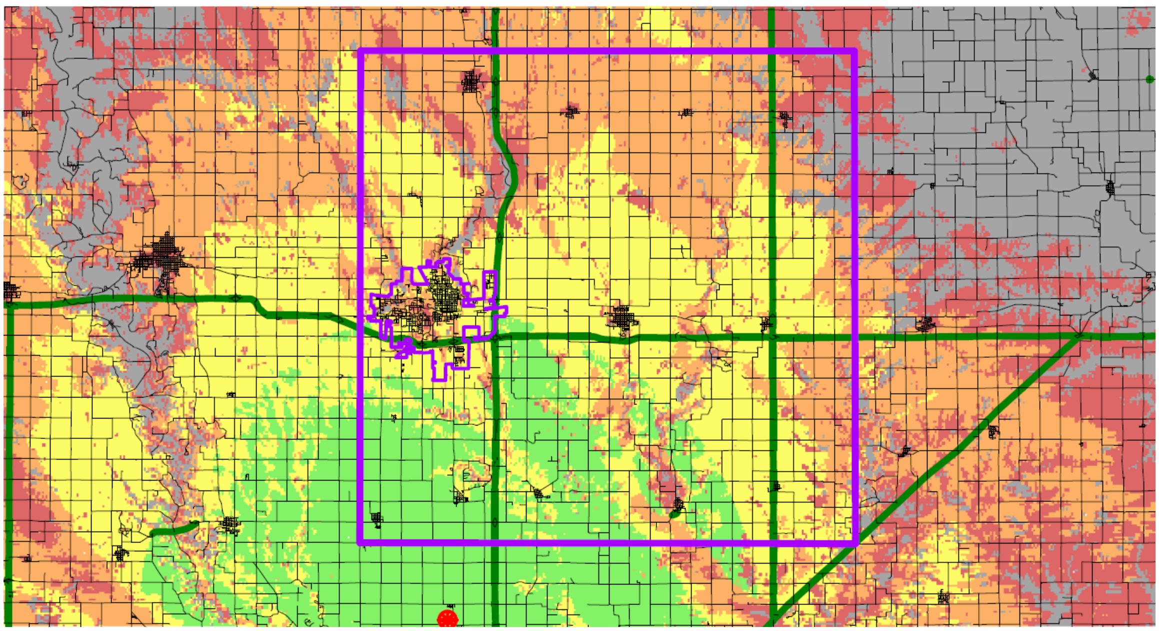


Figure 4 - Repeater to Portable Coverage Prediction from the Alleman Tower

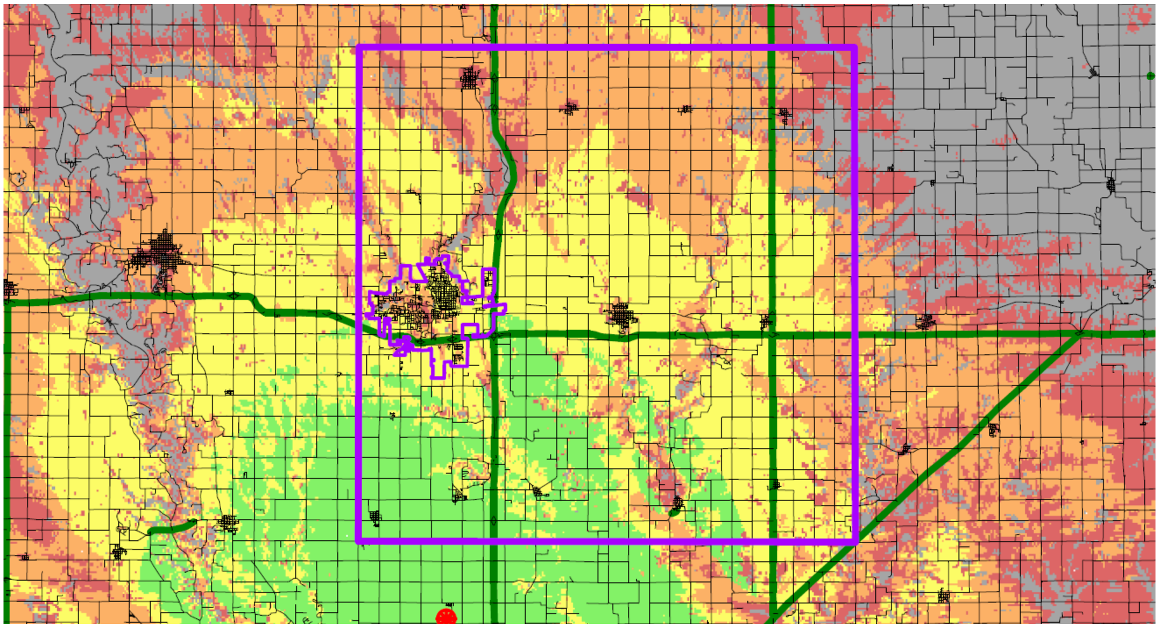


Figure 5 - Portable to Repeater Coverage Prediction to the Alleman Tower

Alleman Tower: Story County Coverage – Mobile Operation

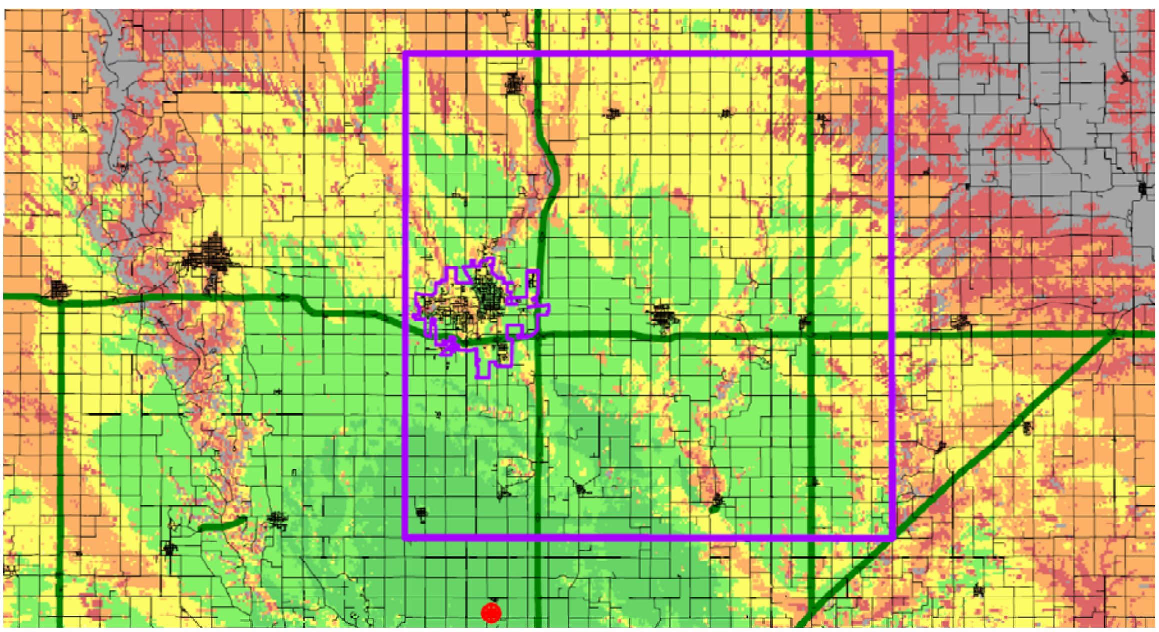


Figure 6 - Repeater to Mobile Coverage Prediction from the Alleman Tower

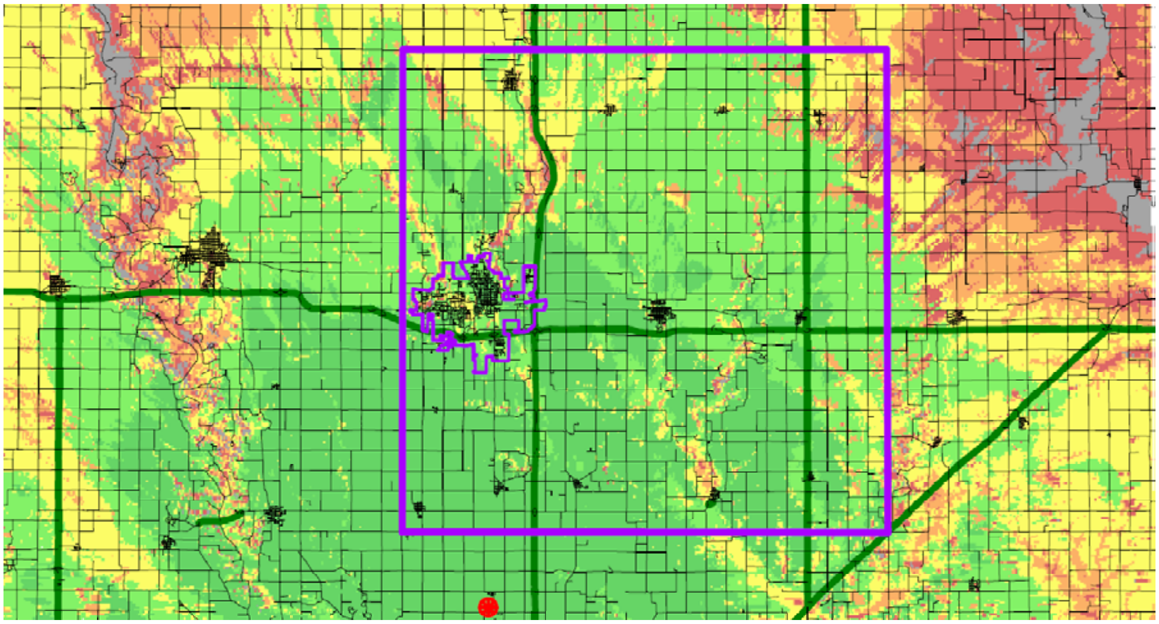


Figure 7 - Mobile to Repeater Coverage Prediction to the Alleman Tower

Ames Tower: Story County Coverage – Portable Operation

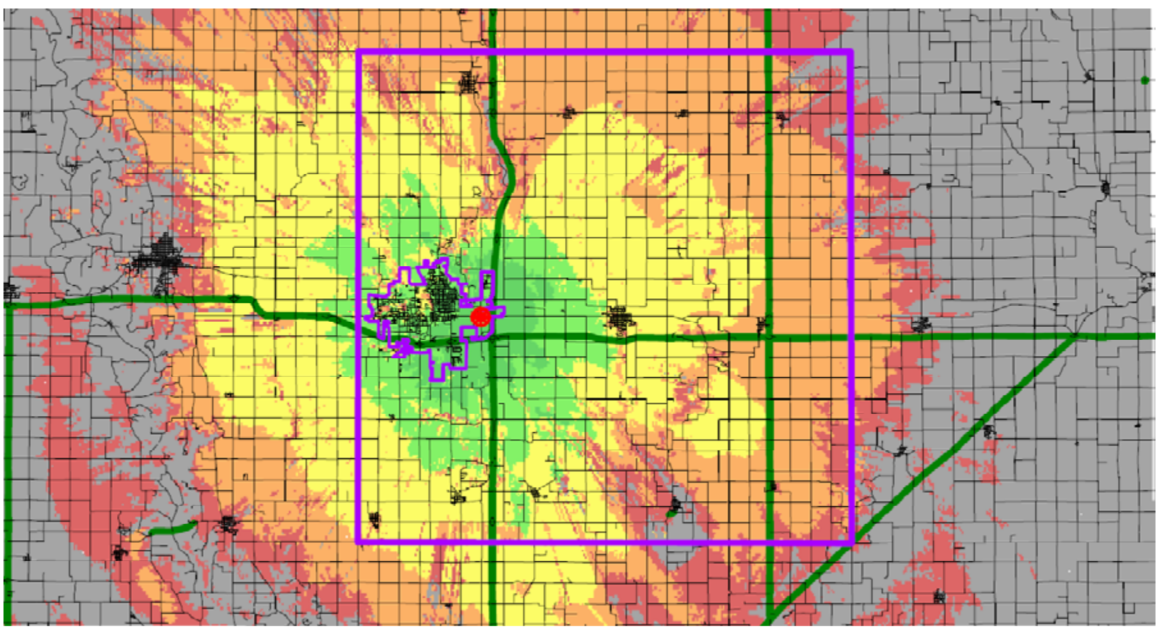


Figure 8 - Repeater to Portable Coverage Prediction from the Ames Tower

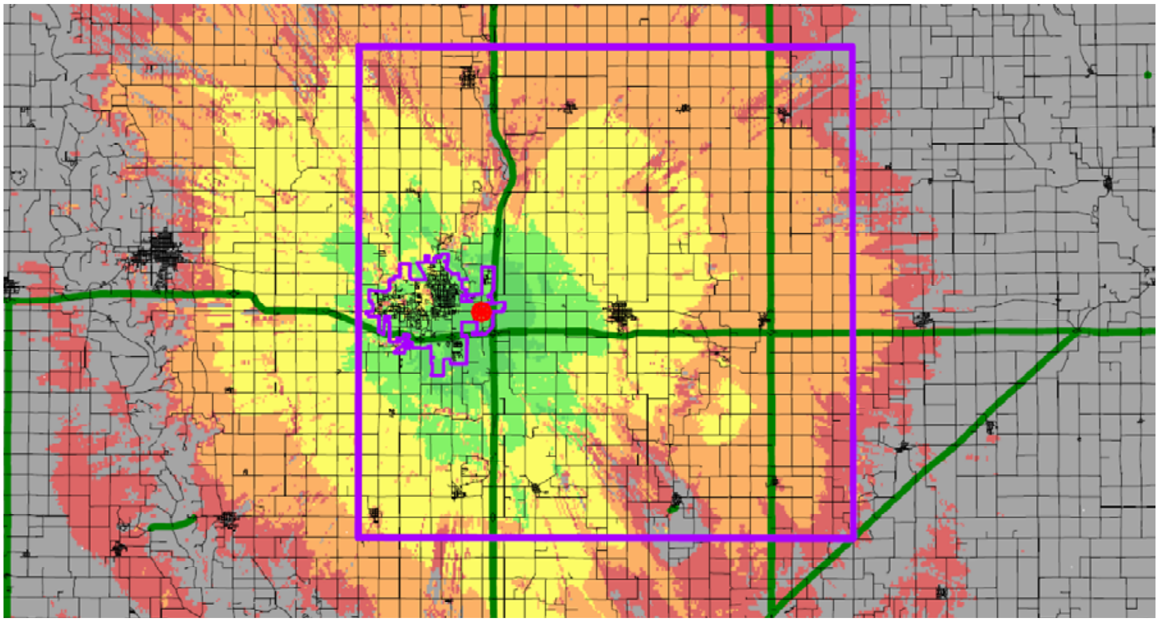


Figure 9 - Portable to Repeater Coverage Prediction to the Ames Tower

Ames Tower: Ames Coverage – Portable Operation

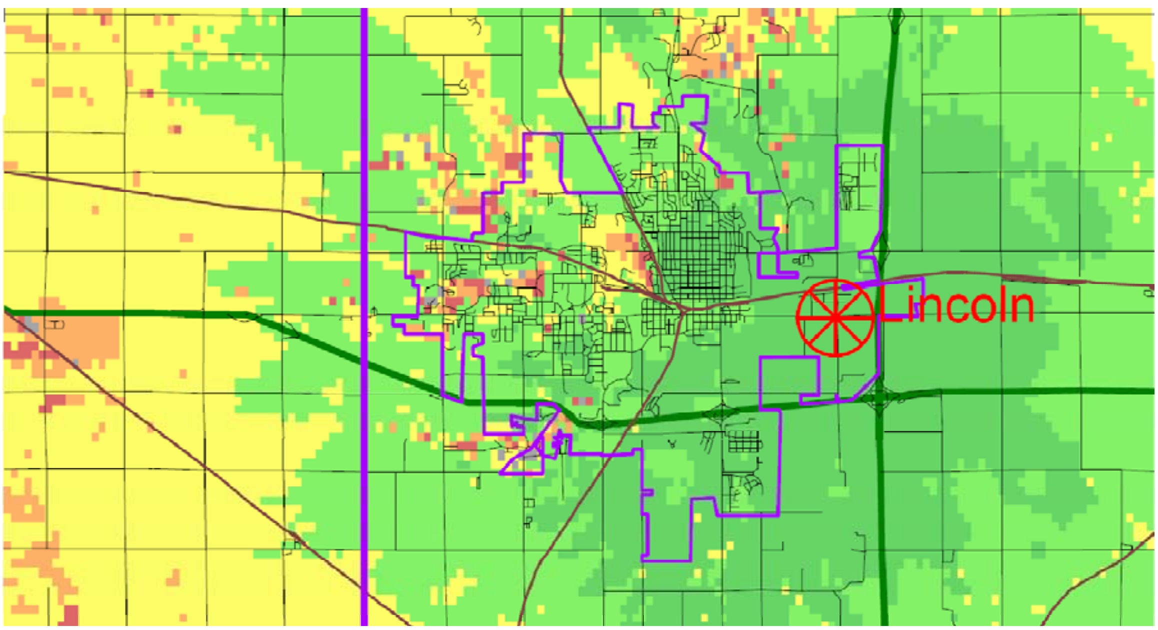


Figure 10 - Repeater to Portable Coverage Prediction from the Ames Tower

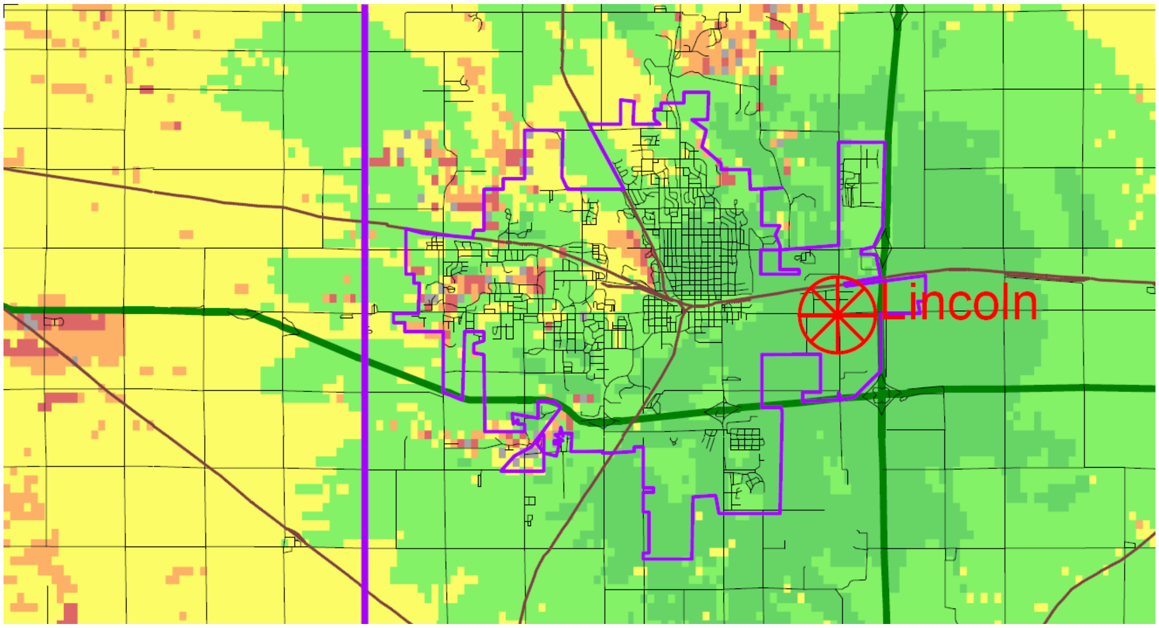


Figure 11 - Portable to Repeater Coverage Prediction to the Ames Tower

ISU Site: Ames Coverage – Portable Operation

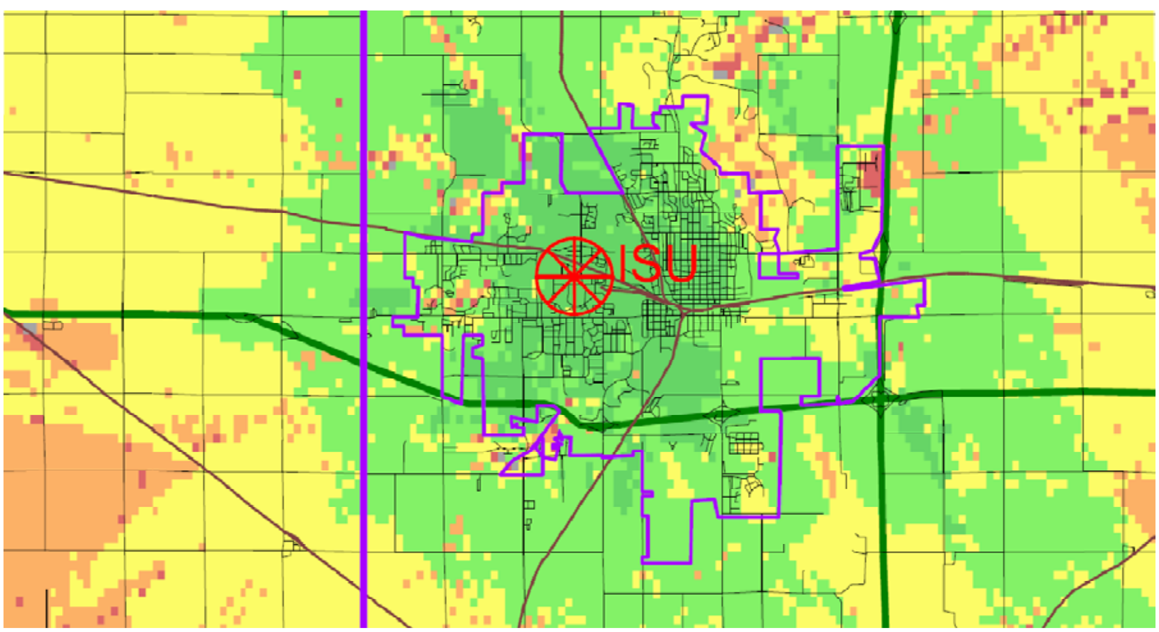


Figure 12 - Repeater to Portable Coverage Prediction from the ISU Site

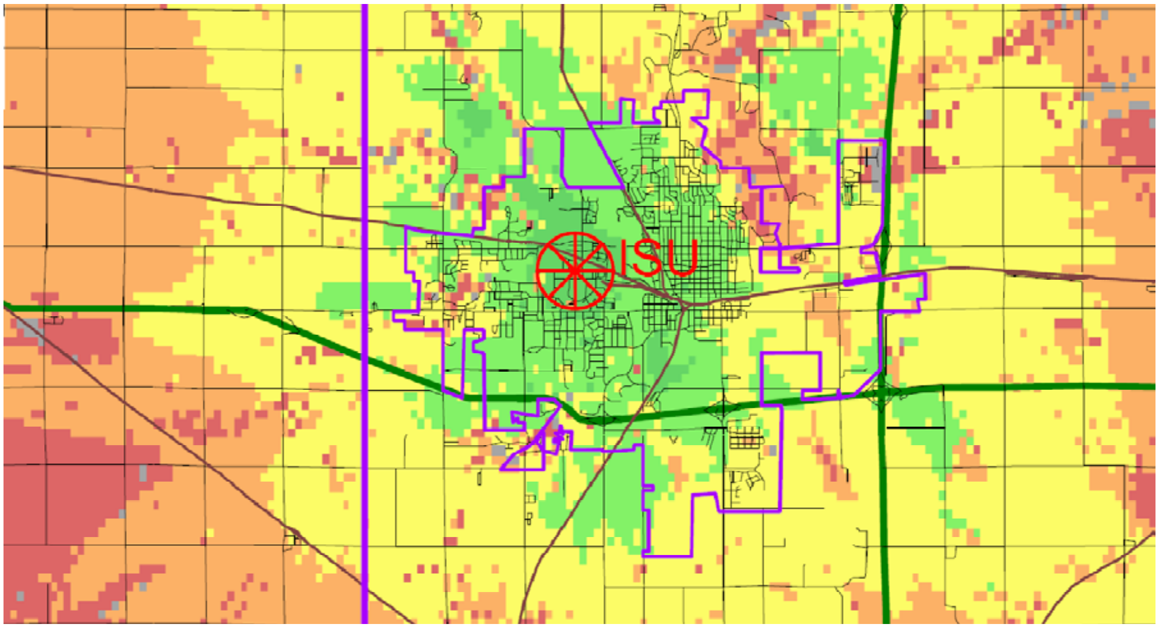


Figure 13 - Portable to Repeater Coverage Prediction to the ISU Site

The next prediction represents a system configuration to improve areas of weak or no coverage from exiting towers within Story County using information from the FCC Antenna Structure database.

Four-Site Simulcast Prediction

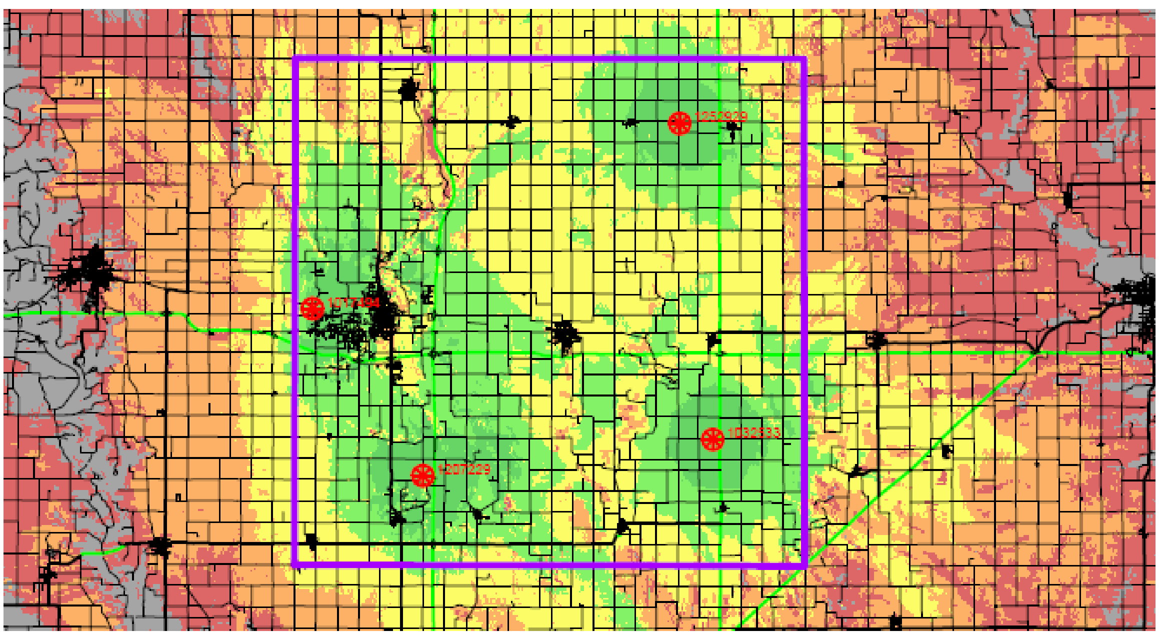


Figure 14 - PTOO with 93.8% signal level above -95dBm

The above illustration represents what a four-site simulcast trunked radio system could look like for Story County and, as noted, providing portable coverage countywide.

FCC / Frequencies

Currently Story County uses a commercial SMR trunking system which as noted is not considered a public safety grade system. As such the channels used are licensed to Electronic Engineering as a private entity. If Story County no longer uses a vendor owned SMR service new channels must be acquired. In the 800 MHz band there are channel sets that are only available for public safety use and channel sets that are shared by public safety, SMR and business industrial users. There are also NPSPAC channels released by NEXTEL as a result of rebanding. Rebanding has been in process for years and still continues to take place.

To minimize potential interference for public safety NPSPAC channels require the use of special technical parameters that provide additional RF protection that result in a reduction of coverage as compared to other 800 MHz channels. In more rural environments using non-NPSPAC frequencies can reduce the number of sites needed to provide coverage as these channels can operate on higher power and use other antenna systems.

Story County has about 1400 total field terminals. As a general rule of thumb the FCC authorizes one repeater channel (pair) for every 100 field units. Using this criteria Story could justify 14 channels[3]. Once licensed the FCC expects construction to be reported within one year. This date may be extended but the FCC will take assignments back if the construction date is not reported or waivers are not requested prior to the construction deadline. This generally stops an entity from obtaining and then hording frequencies.

Elert believes that Story County should consider advanced system options that are intended for public safety operation such as offered by P25 trunking. Although conventional operation remains viable in some applications trunking systems provide more talk channels and utilizes the assigned RF channels more efficiently with no user intervention. With conventional operation users could hear other on channel traffic, find it difficult to monitor specific traffic and would be required to monitor the channel prior to a transmission. With a trunking system each transmission can take place on a different channel reducing or eliminating the chance of interference and the ability to monitor with simple receivers. With trunking users no longer need to monitor the channel prior to transmission.

With the exception of Polk County Sheriff most other agencies in the area use VHF or UHF conventional systems. Although VHF and UHF are not limited to conventional operation trunking systems require a set of frequencies that can be grouped as a set at one or more sites. Due to a lack transmit and receive channel splits (especially at VHF) it is difficult to assemble a working set of trunking channels. 700 and 800 MHz bands were planned to be used by repeaters and finding a set of channels that operate without interference is much easier to do.

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[3] P25 cost estimates are based on 10 channels. If found to be needed to handle system loading in the future the system should be able to expand to 14 channels.

It is assumed that Story has no intention to step back to a conventional VHF or UHF system. The VHF band has no bandwidth readily available and UHF for the most part is limited as well. In Iowa the 700 and 800 MHz bands tend to remain somewhat open.

The cost of ownership for any of these systems is separated by a relatively small cost factor. A required trunking controller, the heart of a trunked radio system, with a backup controller is about a million dollars. This controller is not required in a conventional system. Simulcast is many times used in a system such as the one for Story County and this technology also is generally more expensive in the digital mode than analog due to minimum site spacing. However digital has an inherent system gain over a similar analog system design thus better overall performance than analog.

800 MHz

The current 800 MHz frequencies utilized by Story County are licensed by Electronic Engineering (EE). Public safety frequencies would be licensed by Story County. There are six NPSPAC channels[4] allocated for use by Story County in the Iowa State 800 MHz plan. 800 MHz channels are also assigned to public safety use from ~854 to ~860 MHz. Electronic Engineering (EE) estimates the total number of Story County units to be 1,400. The number of frequencies that should be considered for a P25 system for Story County is no more than 14 or 100 units per frequency. For budgeting purposes, 10 channels used, for trunking is more efficient than conventional channels. EE does not have a method to estimate the current channel usage of the system. The FCC would likely allow Story County to license 14 channels.

700 MHz

700 MHz frequencies could also be considered for the voice system. The 700 MHz band has restrictions similar to 800 NPSPAC frequencies as related to the RF power that goes beyond the coverage area (county border) must be restricted. On the plus side, current field terminals are available that work on both 700 and 800 MHz bands. Potentially a common infrastructure could use channels from both bands. On the negative side, if a site requires the use of both 700 and 800 MHz channels then a dual antenna system is necessary thus a higher cost.

VHF & UHF

With the exception of Polk County Sheriff most other agencies in the area use VHF or UHF conventional systems. Although VHF and UHF are not limited to conventional operation trunking systems require a set of frequencies that can be grouped as a set at one or more sites. Due to a lack transmit and receive channel splits (especially at VHF) it is difficult to assemble a working set of trunking channels.

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[4] National Public Safety Planning Advisory Committee - NPSPAC channels have restrictions on RF power radiated outside the area of operation. These original channels are being rebanded to another portion of the 800 MHz band.

As to terminal units, dual band radios are available from multiple manufacturers that would allow some users to operate on both VHF or UHF and 700/800 MHz.

In a very few systems VHF and UHF have been chosen for wide area P25 trunking projects. Channels in these bands are very difficult find and coordinate. The State of Wisconsin is building a statewide mobile VHF network but needed to utilize federal government frequencies in order to do so. The VHF and UHF frequency bands are not organized to efficiently support modern P25 digital systems and are not recommended for use.

Digital Radio Technologies

There are multiple digital radio technologies in use today. Although analog is still in use enhancements to communications technology have been in digital systems. Digital systems provide voice and data capability and users experience superior overall voice quality over an area covered by the repeater site. In public safety applications P25 technology is encouraged to improve interoperability among public safety systems users whenever possible. Many grant programs are based on the purchase of P25 equipment in order to assist in this effort.

Not all public safety agencies have the ability to move to a P25 platform. In this case the purchase of P25 compatible field units is encouraged and many grant programs are based on the purchase of P25 equipment. Some of these are analog systems engineered to provide portable coverage across the operational area and employ many of the public safety system features including satellite receivers, voting and simulcast. Microwave or fiber is used to interconnect sites. With analog the issue of encryption continues to be a problem as does user IDs though both are possible with add-on equipment.

In higher populated areas P25 trunking is normally employed for these new systems. The P25 platform provides clear digital audio and trunking allows many user groups to efficiently share available channels. Microwave or fiber is used to interconnect sites.

The question must be asked, does P25 offer a fit for all users? Although interoperability is very important to Story County users there may be a consideration to split public safety users and public service users into separate communications systems. Public safety could continue toward a P25 long term solution and the public works agencies could adopt an update to the present solution. In the interim all County users could choose to adopt the latest digital platform of the current system and migrate to P25 in the future. Long term interoperability groups could be established that would link the systems together. This is not a perfect interoperability solution but it may be considered due to system costs

The following are descriptions of the current digital technologies available in the market place. Each description compares their features with the present system in use by Story County. Some of these platforms are not considered viable for public safety. They are being described here because if Story County is looking for an “apples to apples” comparison to what is in place today, this discussion would offer such a comparison.

Kenwood NEXEDGE and Motorola MOTOTRBO

Kenwood NEXEDGE and Motorola MOTOTRBO are lower cost digital systems that provide digital operation at lower costs than P25, but since there is no standard, each system operates on its own proprietary digital platform.[5]

Applications for such systems include non-mission critical communications, including voice, data, and AVL in single or multisite systems. Users include local government, school districts, and campuses applications. These systems offer many digital features such as unit identification and noise-free operation.

MOTOTRBO uses time division multiple access (TDMA), where two calls share the 12.5 kHz channel in time, turning their transmitters on and off many times per second and alternately using the channel. Kenwood uses frequency division multiple access (FDMA) and uses a discrete 6.25 kHz channel for each call. For two calls the system Kenwood requires two 6.25 kHz channels.

Some public safety users have considered these technologies to decrease costs, but they can do so only if features not supported by these technologies are not required or if alternative procedures can be implemented. Kenwood's NEXEDGE system is available in VHF and UHF bands only. The Motorola MOTOTRBO system added the 800 MHz band to VHF and UHF and recently added 900 MHz. It is Elert's understanding that analog versions of the MOTOTRBO mobiles and portables support the Privacy Plus platform which is currently used by Story County. In October 2010 Motorola introduced their latest version of the MOTOTRBO platform that will provide multiple-site trunking capabilities. Thus it may be possible to make use of this product as a bridge between the Privacy Plus system and a future non-public safety trunked radio system.

Neither MOTOTRBO nor NEXEDGE platform supports voting or simulcast operation. Overlapping sites use different frequency sets to prevent interference the same way the Privacy Plus System does today. A system would require the use of the scan feature when units move within the coverage area the same as is done today. It is very important to note that field terminal units are not compatible with P25.

The Motorola MOTOTRBO and Kenwood NEXEDGE systems can support analog or digital operation and are intended for campus systems that may have multiple locations. Sites are linked with IP networks and can provide communications in and among the locations. Technically the MOTOTRBO system uses a 12.5 kHz narrowband channel and the NEXEDGE uses a 6.25 kHz channel. In digital MOTOTRBO has two digital channels while NEXEDGE has one. Neither are P25 compatible although certain NEXEDGE field units can be reprogrammed to operate P25[6] rather than NEXEDGE

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[5] Using MSRP information Elert estimates that a replacement of the current system using MOTOTRBO technology utilizing the enhancements available would cost about $2.7M and replacement of all field units about $2.5M.

[6] NEXEDGE is not available at 800 MHz.

protocol. It is an either or programming. Both of these products offer some form of encryption in the digital mode. Trunking is only available using digital.

To summarize, in applications where site overlap multiple channels must be used and the terminals must depend on scan to receive calls. The systems are not engineered to support public safety operations although they may be considered for such applications in certain cases where portable operation is very dependable with a single site. A single site would not be sufficient to serve the entire county.

Harris OpenSky®

OpenSky® is an IP-based, high performance integrated digital voice and data network. It uses a four slot time division multiple access (TDMA) scheme to provide narrowband equivalency to 6.25 kHz. Each field unit has an IP address and the system operates similar to a local area computer network. The system supports many public safety features including but not limited to Emergency, priority calling and AES digital encryption. This system offers over the air programming (OTAP) and over the air rekeying (OTAR). This system is proprietary and is not compatible with P25.

TETRA

TETRA is a European digital radio communications system for public safety use and has not been adopted in the United States primarily due to the P25 effort. It uses a four slot time division multiple access (TDMA) scheme. The system operates similar to a cell phone system but has emergency and group calling capabilities to support public safety operations.

APCO P25

The system currently employed by Story County users was the state of the art in the early 1980s, but is over 30 years old now. Many trunking enhancements have been made to system architecture and technology since then, and APCO P25 is the standard most public safety entities place in use today. APCO P25 is recognized across the nation and throughout the world for its design capabilities, which focus uniquely on the needs of public safety.

Advancements in public safety systems have been implemented in radio systems, but not until APCO P25 was there a set of standards that provided a common air interface such that there were multiple choices in vendors. Prior to these standards, users were locked into a specific vendor for their proprietary product.

The observations made concerning the current system in no means reflect that an error was made in the selection of the current system. P25 has been in the works for 21 years, and only in the last five years has it been implemented fully at numerous locations throughout the world. The decision made nearly 30 years ago seems to have been well thought out and future-minded at that time.

Testing ensures that basic P25 capabilities are available from multiple vendors offering field terminals. Interoperability is key to today's communications, and P25 functionality provides this capability. To gain interoperability with the planned 700 MHz narrowband P25 system the State is looking at, the terminal units will also have to support this band (assuming a replacement system operates on 800 MHz). Johnson County is doing this today with its new system, and Linn County is also planning this kind of operation with a demand for interoperability.

A P25 system based on 700 MHz as the State of Iowa seems to be looking at (as per the posted studies and recommendations) will need to have more repeaters than a typically designed 800 MHz system due to constraints placed on the use of 700 MHz. The requirements also include a required upgrade path. Thus, most local systems outside of huge metro areas tend to stay with the 800 MHz band as it is quite stable and expected to be over the longer term.

The State of Iowa is making plans to construct a statewide 700 MHz P25 trunked radio platform, but unlike other states does not mandate that field terminal equipment purchased with grant funds must be capable of P25 operation. This may change going forward. Few if any field units in Story County are capable of P25 operation.

P25 Phase 1

APCO Project 25 (P25) is an open system standard that provides improved voice quality for public safety radio communications across the coverage area by transmitting digitally coded voice. It also offers features not available in most analog systems, including unit identification, priority, emergency call, digital encryption, and status messaging. User groups can be formed that cannot be monitored unless terminals are programmed to do so.

P25 currently operates in the Phase 1 mode, where field terminals can operate in an analog (for backward compatibility) or digital (P25) mode in a standard channel. At 800 MHz this is a 25 kHz channel but for 700 MHz, UHF and VHF this is a 12.5 kHz channel. At 700MHz there is mandate to provide 6.25 kHz equivalency by 2017. P25 Phase 2 would meet this requirement (see below).

Since P25 is a standard, many vendors provide “compatible” products that in theory should be able to be used on any P25 infrastructure. Although basic operation should be compatible, each vendor has implemented the standard using their interpretation of the specifications. This has led to some inconsistencies and has led to a testing suite in order to ensure compatibility. Most system owners have approved field units for the user community to choose from to reduce a chance of failure. Time will tend to reduce the compatibility risk, but enhancements to P25 will be implemented soon and may increase issues due to compatibility.

There are several initiatives started to obtain compatibility on the infrastructure side as well. The Inter-Sub-System Interface (ISSI) is the most popular of these standards, which allows disparate P25 trunked radio system networks to share infrastructure between networks. Each network would operate under its own control, but users could roam into the other network and communications brought back to the home dispatch. This feature is being envisioned by Linn County to connect both to their neighbor in Johnson County and with the planned State 700 MHz system once that rolls out. A less popular console standard has also been started, which would allow one manufacturer's console to operate on a different manufacturer's radio network. Others include data, telephone, and network management.

P25 Phase 2

Within Phase 2 of the APCO standards there is work going on to allow each channel to be split into two, thus potentially doubling the capacity of the system without additional frequencies. This alternate technology (Time Division Multiple Access or TDMA) will be used to provide the two voice paths per channel where each channel consumes a timeslot. As long as all participating terminal units are equipped for Phase 2, a call will use one half of the channel capacity of Phase 1. If all terminals do not support Phase 2, the system will automatically use the full channel as identified in Phase 1, thus offering backward compatibility to Phase 1.

Console Selection

The effort to upgrade/update the console equipment for the County's three dispatch centers should be driven by the radio system platform embraced by the County. As Story aspires to a P25 platform a system that will support P25 appears to be the appropriate choice. The issue is that all current vendors produce their own P25 consoles that closely integrate features with the trunked system.

Console only vendors will likely provide a P25 compatible product but cannot do so until the console sub system interface (CSSI) that would provide a standard for the interconnection is complete their products can be tested. Two vendors, Zetron and AVTEC both have released a CSSI interface which were demo'd at the APCO conference this year.

Therefore any effort to enhance the current console system with a P25 compliant replacement may have compatibility issues once P25 system is chosen unless the manufacturers of the P25 and console are the same firm or it can be determined both the radio and console vendor support CSSI.

Console connectivity to an alternate trunking system for public works could be via control stations as it is done today or via direct connectivity if supported. Direct connectivity would require links from the dispatch console equipment to the RF infrastructure. This leaves the grant opportunity for an upgrade to the County's dispatch consoles in limbo until a decision is made concerning their plans for new radio technology.

Technology Comparisons

The table below demonstrates how these technologies compare on a variety of areas as shown on the left side of the table.

Story County System Solutions - Pros & Cons

Included In Feature Set	Y - Yes			
	N - No			

	System Type			
Item	Existing SMR Technology	New SMR Technology	Public Safety P25 Standard	Regional P25
VHF	N	Y	Y	N
UHF	N	Y	Y	N
700 MHz	N	N	Y	YN
800 MHz	Y	Y	Y	Y
900 MHz	N	Y	N	N
Analog	Y	Y	N	N
Digital	N	Y	Y	Y
P25	N	N	Y	Y
Trunked	Y	Y	Y	Y
Simulcast	N	N	Y	Y
RX Voting	N	N	Y	Y
Cost	+	+	-	+
UID	Y	Y	Y	Y
Priority	Y	Y	Y	Y
Scan	Y	Y	Y	Y
Priority Scan	N	Y	Y	Y
Failsoft	Y	Y	Y	Y
Local Interop	Y	Y	Y	Y
Regional Interop	N	N	Y	Y
State Interop	N	N	Y	Y
Federal Interop	N	N	Y	Y
Multi-Site	Y	Y	Y	Y
Multicast	N	Y	Y	Y
Digital Encryption	N	N	Y	Y
Unit Disable	YN	Y	Y	Y
Regional P25	N	N	Y	Y

State of Iowa 700 MHz

The State of Iowa has adopted both a 700 MHz frequency plan for voice and a 700 MHz broadband plan. Studies were completed for each of these technologies though from what can be determined there is no defined rollout plan. Elert is presently involved in two county systems in Iowa and both have or will be purchasing subscriber equipment capable of operating on a 700 MHz narrowband system when it is built. This requires the public safety subscriber radios to be dual band in that the systems being developed are 800 MHz and not 700 MHz. The rationale for using 800 MHz is the cost of the infrastructure is far less with 800 MHz than 700 MHz. One might ask why not just move to 700 MHz and try to share with a future state system. The issue is the FCC has said that any 700 MHz system developed today must be willing to change to a sub narrowband solution when so dictated in the future which would be a future cost that is yet to be determined. If the state had a plan it was pursuing then this option may be worthwhile and in the future it may be.

Elert has met with the Iowa Statewide Interoperability Coordinator. Although a plan has been submitted there has been no further development as funding has not been approved for the project. A potential plan to partner or participate in the State's plan for a 700 MHz voice system is described on page 29 of the Elert report. The lack of detail is due to the fact that until the State has no funding for such a project. The details of such an arrangement have not been determined. Once funded the system will be likely designed by a vendor who will guarantee coverage for mobile operation. The selection of a vendor will be preceded by the selection of a consulting firm to produce the specifications. In addition the rules for participation will be determined, vetted and appropriately distributed by the ISICSB to agencies throughout the State. These rules will determine what is expected of any entity participating in the statewide system.

Voice System

The Iowa Statewide Interoperable Communications System Board (ISICSB) has a master plan for voice that provides 95% mobile coverage across each county in Iowa. This plan provides an eleven-channel simulcast system to cover the Story County region. Three sites fall in or close to the boundaries of Story County as part of the plan shown in the Homeland Security and Emergency Management Region 1 mobile coverage prediction (see Figure 15). Two sites are very close to the eastern border corners, and the third is in Ames. Story County could consider using these sites chosen, but the plan does not guarantee that the State will actually use these sites once the implementation is underway.

Due to the population and the proximity to Des Moines, it is likely that the Story County region will be one of the first to be built out, but at the present time there are no plans in place to do so.

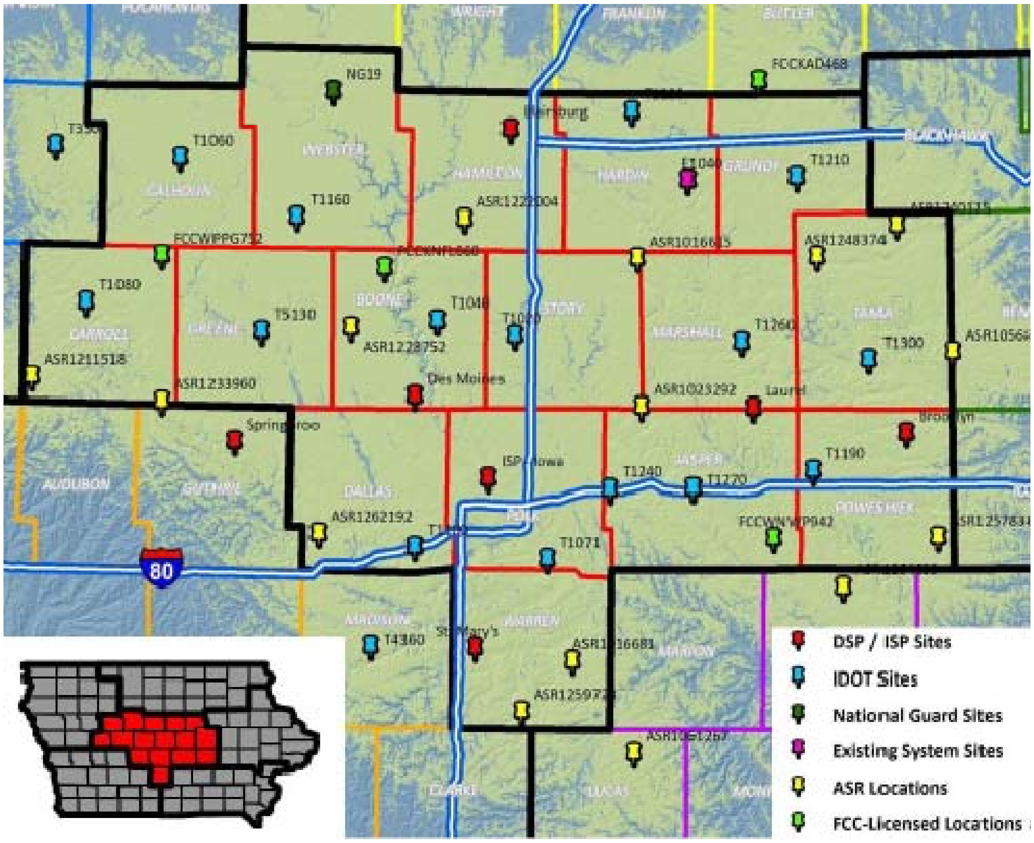


Figure 15 - HLM&EM Region 1, which includes Story County (from Master Plan p. 146)

Although the terms of such participation are yet to be determined, Story County would likely be able utilize towers and microwave infrastructure secured or constructed by the State to support their own P25 system. Alternatively, Story could join the State P25 voice network and add sites to provide portable coverage throughout Story County. Although Story would still need to provide stations equipment and microwave components to support their portion of the infrastructure, sharing resources with the State would lower the total cost of the infrastructure to Story County.

At present, the State is not moving forward on the mobile voice system, as the funding mechanisms are not in place. It is unknown when this may change. A block diagram of a four site system configuration is shown in Appendix 4.

Data System

In October of 2009, the ISICSB requested a waiver from the FCC for a 700 MHz Statewide integrated public safety communications system, to include a broadband network. In May of 2010, the FCC issued Order 10-79, which conditionally granted this request, along with requests from twenty other entities for 700 MHz Interoperable Public Safety Wireless Broadband Networks. The networks must be compatible and be available to all eligible public safety agencies.

ISICSB has applied for a grant for the State's initial 700 MHz broadband network build out. Story has been named as one of the counties to be part of the initial network.

Possible Shared Tower Infrastructure

If Story County could utilize the State's 700 MHz wireless broadband data network infrastructure, the cost for a new Story County system may be reduced significantly. A700 MHz broadband network will utilize more sites than a 700 MHz voice system to cover the same area. Making the assumption that voice sites would be shared with broadband data means that the 700 MHz broadband system would provide additional sites that Story County can utilize to obtain the necessary coverage for portable voice operation. The backhaul infrastructure needed would be provided through the State's broadband build out. Story would need to provide the necessary equipment to provide connectivity to its portion of the network.

Sharing infrastructure could lead to complex agreements on the maintenance and responsibility. These issues would need to be raised and agreed to prior to construction. In many cases, these issues will need to be transformed into policies that become part of a participation plan for entities to join or become part of the State network.

A State partnership will require that Story likely take on ownership of any portion of the system that is needed to support the operations of the County to provide portable coverage. This will include the P25 infrastructure plus any microwave to interconnect these sites into the system. Depending on the vendor of the infrastructure Story may have limited control of some operational features. Story may certainly benefit from the site costs that will be provided by the State system but as there have been no set policies established Story may find that the State wishes to recoup their investment and ongoing costs with rent generated from other users. Story will need to bear the cost of the additional infrastructure that Story will need to support their portion of the system. This would include any item that may need to be expanded to allow Story to add their channels.

As trunking shares the infrastructure among users the number of additional channels should be less than a normal Story site but likely more than the channels provided by the State. Maintenance of the Story portion of the system would need to be worked out with the State. The State would have a system maintenance program and it would likely be best that Story be folded into this program. If not Story would likely be asked to pay for some portion of the State system where Story uses State's sites plus Story only sites. Updates and upgrades would need to be negotiated with the vendor and like maintenance should be folded into the program to ensure compatibility. Story has the opportunity to shape some of these issues to their advantage as a initial partner in this effort and be considered exempt from policies that may be instituted later in a State build out.

Own vs. Lease

Owning the system should ensure that the system is properly maintained and any troubles are immediate tended to and repairs are made. Ownership also forces the County to have someone or some department within the County understand the system in great detail such that decisions can be made on the operation, programming, updates and upgrades that will be required during the system's lifetime. On average maintenance will cost the County about 10% of the system's value every year or $700K using a system estimate of

$7M infrastructure cost. This figure should cover all personnel and the cost of replacement parts used in one year for the infrastructure. While an advantage sometimes may also be considered a disadvantage in terms of providing maintenance even if it is purchased from an outside vendor as an owner the County will be able to have maintenance done on your timetable and not another's. If one firm does not do an adequate job another may be found. The largest advantage to owning a system is control.

The cost for new systems is on the order of several million dollars, as stated above. For this comparison, it is assumed that a complete P25 trunked radio system including backhaul must be built. The investment in such a network would require a payback that is not realistic for a private investor in today's financial environment without a long-term commitment from the users. Thus, a standalone system to be developed by a commercial vendor would have to be financially justified to their creditors. It is estimated that even if the County were to choose to rent at a per-unit cost, this cost could easily be 10 times or more the current level being paid today and could require a commitment in excess of a decade. Initial calculations indicate it would take the operator over eight years to break even based on better than 1,400 users, but only if the infrastructure is heavily discounted. Thus, this option may not be a viable alternative without assurances to the vendor of long-term commitment. In addition, the costs of updates and upgrades need to be considered, and it is likely that the monthly fees will escalate over time. Also, user radios would likely need to be purchased for all 1,400 users which carries a price tag higher than the radios in use today.

As stated above, the cost of new public safety grade systems is several millions of dollars. The operational life of the infrastructure hardware should be about 15 to 20 years. Some radio replacements may need to be done over this time. Field terminal units would be replaced as needed. Advancements and improvements in P25 may eventually impact infrastructure components. It is unknown when this may happen, but it may happen in 10 to 15 years. An older platform may not be able to support advancement in system feature set until changes are made.

The investment in such a stand-alone network by a vendor would require a payback that is not realistic in today's world to almost any investment banker. It is estimated that the vendor would need the following in order to make it viable:

- A long-term commitment from the County (A term of 12 years is estimated)
- A lease price for system use that is about ten times the current level
- Existing infrastructure (digital microwave in place at most if not all sites) with favorable rates
- P25 system manufacturer's discounting of the infrastructure

Dependent on the above assumptions, the payback time for the vendor is estimated to be eight to ten years. Without existing infrastructure or manufacturer's discounts, it is anticipated that the lease rate per unit will exceed $55. If so, E&A recommends that the County purchase their system over the long term.

Initial estimates for leasing a P25 system range from $33 to $55 per unit per month with a long-term commitment that extends well beyond a decade with escalators to deal with inflation. P25 field units would need to be purchased from the vendor, and it would be expected that the manufacturer of a field unit would likely need to match the manufacturer of the infrastructure. Upgrades and updates to the entire system would need to be built into the price such that the system would be kept up to date. The lower costs assume that a significant portion of the backhaul and site infrastructure is already installed and can be reused.

The real cost of ownership needs to include maintenance of the infrastructure, which is about 10% of the cost of infrastructure per year. Maintenance plans for all field units would be implemented in either case. The maintenance contract would need to place guarantees on the service time dependent on the severity of the problem encountered. Spare components would need to be secured. When leasing from a firm there is a long term commitment and in the end the County does not have the leverage unless it is built into a contract.

If the per-unit cost to lease exceeds $55 per month (see Appendix 1 for calculations used), the recommendation is to purchase and own the network and use a local maintenance firm to provide maintenance and technical support. In either case, Story County should immediately develop the necessary documents to use for grant applications as they become available, to reduce the cost.

Regional Network Option- Sharing Technology

There are three clear advantages in sharing a radio system with an adjacent county. 1) One infrastructure to own and manage. 2) Interoperability is near perfect, 3) Some coverage may be possible to share as RF does not stop at the border of a county. There are however disadvantages also in that both counties need to agree on the plan and how to divide/share the cost of the system. The cost to provide coverage to a certain geographic area can clearly be divided among the user community as can the amount of channels provided in an area. A formula can also be developed to determine the best sharing model of the common equipment used to manage the system. Generally the metropolitan areas have more users while the rural areas less and this can also have an impact on the system size and development to expand capacity. One must however remember that each base station covers a certain area and there need to be enough base station to provide the coverage foot print. Thus if one are is twice the size of another, there would be the expectation of double the cost. Doubling the needed capacity is not double the cost but rather some percentage.

As an example of two adjacent counties Elert is working on in Iowa. From the propagation (coverage) analysis it is possible one of seven base station sites in one county could be shared with the adjacent county. However, the capacity of this site would have to be increase. The savings maybe $120,000 each or 1.5% of the overall system. If the main controller were to be shared or even the backup controller this could amount to another $500,000 or 6% of the coverall system cost. This assumes the design is for portable coverage. If the design is for mobile only coverage then the savings would be much greater as there would be fewer sites.

Elert has recently spoken with personnel from Polk County and the City of Des Moines concerning their efforts to enhance and expand the capabilities currently provided by RACOM. As this project has not been awarded any technical details learned are minimal but the ability for an adjoining county such as Story is expected to take minimal effort. Expansion of the network would require agreement by the owner but it is anticipated that monthly per unit system use costs could decrease which would make such an arrangement easier to justify. It is anticipated that there would need to be official buy-in from those who oversee such operations at the local level prior to an expansion of a network.

As for other surrounding counties using a conventional system it would be very difficult to replicate the interoperability currently enjoyed with a conventional system. Availability of frequencies would be an immediate issue. Once narrowband frequencies were released this would become somewhat easier. The cost of such a network would be somewhat lower but the users would not have the interoperability that a trunked radio system provides.

Public/Private Partnership Option

<u>EE vs. RACOM</u>

It is difficult to make a recommendation either way between these two organizations. Just as with other projects the results of an RFP can be surprising to the agency. The question will come down to the level of support versus cost. Today it seems as if RACOM has the larger organization but this could easily change based on how EE might respond to an RFP.

A public/private partnership solution could be provided by a RACOM, Electronic Engineering or via a manufacturer. The immediate savings would be cost of the equipment, installation and maintenance costs that would be rolled into a user fee per month. It is anticipated that Story County would be locked into a long term agreement of about a dozen years. As a part of the agreement Story would want to ensure that any updates, bug fixes, etc., and upgrades are part of their agreement and implementation of these would be scheduled such that the system remained current without disruptions of service. The vendor would also need to provide minimum down time guarantees along with potential penalties to ensure prompt service and minimal interruptions of service. Partnering with any firm that operates an adjacent network may lower the cost of the service. If Story could become a member of the Polk County/City of Des Moines/Westcom system the cost for all users may be reduced due to the sharing of resources. The basic equipment will still need to be provided to obtain the level of service but common hardware devices such as P25 controllers, common console equipment, alarm system and gateways could be shared among all users of the system. There also may be sites that could be used for coverage of both service areas.

In the case where a public/private partnership is limited to only Story County the costs of system elements like P25 controller, simulcast controller and gateways for local, regional and State legacy systems likely need to be purchased for exclusive use by the Story network. These costs would be spread over a smaller number of field units increasing the per unit cost of system use. Control over a County network will be more substantial than a partnership arrangement. Maintenance will spread over fewer field units than other partnerships. Management over the maintenance component will require more involvement from the County than the other partnership options. The County may find it more difficult and more costly to assign penalties to service outages. A County only system has fewer overall components but has all of the components to provide P25 service.

Cost

Preliminary predictions for a system as shown above for Story County indicate that about four sites would be required to provide public safety portable coverage throughout Story County. The investment required for a four-site, ten-channel, 800 MHz P25 simulcast system is estimated to be about $7M[7]. The figure assumes that everything would be new, including towers, consoles, satellite receivers at all dispatch centers, and redundant microwave. Some elements that make up these costs could be eliminated if facilities were available within the County. Using existing towers within the County would be an example. Another would be the utilization of an existing microwave network, if available.

Cost Estimates

The following table is comparison of ownership and cost estimates us the P25 system platform.

P25 - 4 site simulcast - 10 channels - 1400 field units					
Assumes simulcast and voting receivers at all sites					
		Ownership/Partnership Arrangement			
		Own	**State**	**County (12Y)**	**Public/Private (12Y)**
Infrastructure	**Hardware**	$ 7,300,000	$ 4,250,000		
	Updates @ 2%	$ 146,000	$ 85,000		
	Upgrades @ 3%	$ 219,000	$ 127,500		
	Est Lease/Rent per Unit	-	-	$ 40.45	$ 55.76
	Maintenance @ 5%	$ 365,000	$ 212,500		
	Yearly Support	$ 730,000	$ 425,000		
Field Units	**Mobile**	$ 1,775,000	$ 1,775,000	-	-
	Portable	$ 2,150,000	$ 2,150,000	-	-
	Est 7Y Lease/Rent	-	-	$47-$105	$47-$105
	Annual Maintenance	$ 196,250	$ 196,250	-	-

[7] Infrastructure components only. No site acquisition, project management support or contingency. A 14 channel system is estimated to increase the infrastructure cost to about $8M.

Cost Analysis

Choices to Story County are limited as some options are driven by others. The State of Iowa plans for voice or data networks are not currently funded and have no scheduled deployment. The decision on the Polk County/City of Des Moines/Westcom project has not been made and has been a moving target throughout this study. It is anticipated that a decision will be made after the election. If this group moves forward with their plans for a new trunked radio system to be leased from a vendor yet to be specified there is a very good chance that Story could strike an agreement to be added to this network.

The cost of the service per unit is anticipated to be five to nine times the cost of the current service ($33 to $55). At the moment there is no movement in either of these choices and both are out the County's control.

If Story County would join the potential adjacent network with Polk County and others as mentioned above field units would be required to be P25 digital. A public / private partnership would likely require county agencies to buy specific model field units. The cost of units would likely be $2,000+ for non-public safety and ~$4,000+ for public safety.

If the County owned their infrastructure or if Story could join a State network any approved units could be placed on the system. If so the minimum cost of a non-public safety user unit would likely be close to $1500 while law enforcement would be twice this figure. The costs of field units for commercial systems are about a $1,000. Some models will be less and other will be more dependent on their capabilities. Although leasing agreements may be available the cost of high end public safety units will be significantly higher and the estimated cost per unit may be three to six times than the cost enjoyed today.

A public safety field unit is usually ruggedized for harsh field environments. Lower cost units may have some of the properties but not all. Military specification testing standards for shock, vibration, rain, dust, immersion, temperature, etc., are commonly used to define the ruggedness of a particular model. Another high end feature includes intrinsically safe which is normally needed by Fire fighters when working in hazardous environments. Digital encryption can be added to provide secure communications when needed. These features may drive up the cost of field units by 25% to 50% even for the SMR system terminals as they are available as P25, MOTOTRBO or NEXEDGE.

Conclusion

The current radio system used for Story County communications has been utilized beyond its useful lifetime. The current system is no longer supported by its manufacturer and components needed for continued operation must be secured through used parts and aftermarket suppliers. Although the system has provided basic communications for a number of County and city departments the public safety sectors have had to work around it limitations and in Elert's opinion the County is running on borrowed time with its communications system.

Public Safety and First Responders require a higher degree of communication reliability at all times. A properly designed system will provide reliable portable operation countywide and direct control of the transmitters will allow dispatchers to take command of a voice channel whenever necessary. Satellite receivers and simulcast should be considered in any new system design to maximize portable performance. Current digital system platforms provide unit identification at dispatch and field terminals when desired. The interoperability desired within Story County will continue to be achieved through preprogrammed interoperability groups that will be activated when necessary to bring units together for special events.

A P25 platform would maintain this increased need for interoperability within the County and also would provide a standards based platform that will provide interoperability with Federal, State and neighboring county agencies.

Elert recommends Story County formulate its own plan for a countywide 700/800 MHz P25 system. The architecture of such a system may vary dependent on the available frequencies. Some assignments (NPSPAC channels) have stringent regulations as to the power that can be radiated outside the area of operation. As the State has yet to be able to move forward due to funding of a voice system but are hopeful of a grant opportunity for the broadband data system Story needs to plan for no State assistance but be ready to utilize State resources if they become available.

Although Story County agencies have leased their current communications system over a significant period for a new system that meets the needs of public safety the County may need to make a commitment of 12 to 15 years to make a venture possible by any firm if leasing is the solution. If via a RFP the cost to County agencies were to exceed $55 per terminal unit then a direct purchase should be considered. In any case Story County should prepare justification documents for the new system to be prepared for grant opportunities that may arise.

If Polk County, City of Des Moines and Westcom decide to move forward with their plans Story County should consider joining this system as there should be significant savings doing so over a Story County only partnering option or an outright purchase. At their option Story may want to release their own RFP for purchase or lease of a solution that provides the interoperability desired and P25 capability for Story County public safety users to establish a benchmark.

Next Step

Assuming Story County accepts the recommendations of Elert & Associates and makes the decision to move forward with a complete detailed design that would cover the radio system infrastructure, the console system, backhaul system and subscriber units E&A stands ready to assist. This decision would involve making decisions related to funding and then a move to creating a specification document to allow a request for proposal to be developed.

Appendix 1 – Calculations for Projected Lease Cost

Calculations assume that the vendor receives a 35% discount on the infrastructure.

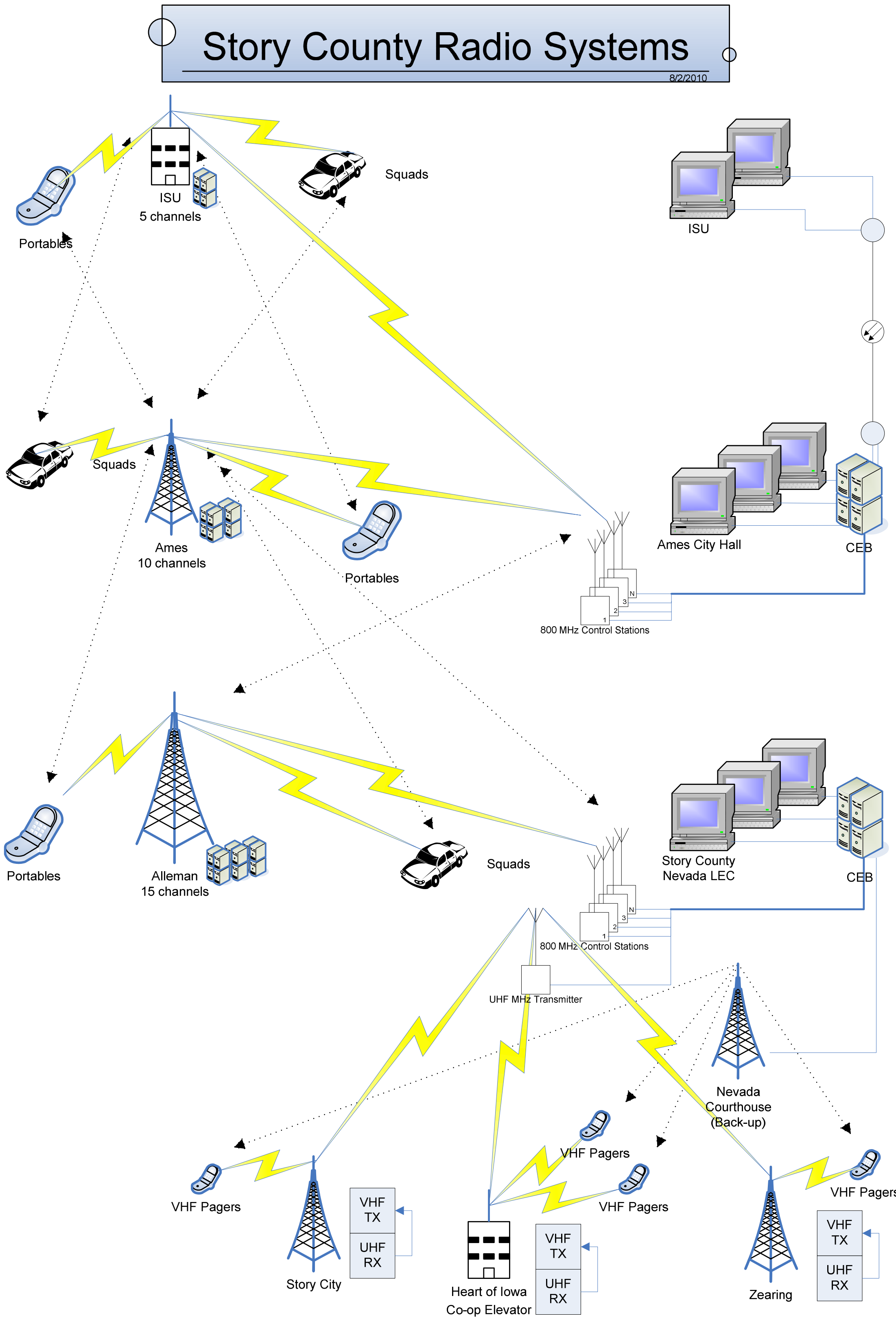
Year -->	1	2	3	4	5
Interest Rate	3.25%	3.25%	3.25%	3.25%	3.25%
Units on System	1400	1400	1400	1400	1400
$ per month	$ 55.00	$ 55.00	$ 55.00	$ 55.00	$ 55.00
Total $ per month	$ 77,000.00	$ 77,000.00	$ 77,000.00	$ 77,000.00	$ 77,000.00
Total $ per Year	$ 924,000.00	$ 924,000.00	$ 924,000.00	$ 924,000.00	$ 924,000.00
$ Remaining	$ 4,739,858.77	$ 4,249,904.18	$ 3,746,826.06	$ 3,230,197.91	$ 2,699,579.34
Interest @ 0.0325%	$ 154,045.41	$ 138,121.89	$ 121,771.85	$ 104,981.43	$ 87,736.33
Lease Payments	$ 924,000.00	$ 924,000.00	$ 924,000.00	$ 924,000.00	$ 924,000.00
Maintenance @ 6%	$ 280,000.00	$ 282,800.00	$ 285,600.00	$ 288,400.00	$ 291,200.00
Total Debt/(Profit)	$ 4,249,904.18	$ 3,746,826.06	$ 3,230,197.91	$ 2,699,579.34	$ 2,154,515.67

Year -->	6	7	8	9	10
Interest Rate	3.25%	3.25%	3.25%	3.25%	3.25%
Units on System	1400	1400	1400	1400	1400
$ per month	$ 60.00	$ 60.00	$ 60.00	$ 60.00	$ 60.00
Total $ per month	$ 84,000.00	$ 84,000.00	$ 84,000.00	$ 84,000.00	$ 84,000.00
Total $ per Year	$ 1,008,000.00	$ 1,008,000.00	$ 1,008,000.00	$ 1,008,000.00	$ 1,008,000.00
$ Remaining	$ 2,154,515.67	$ 1,510,637.43	$ 848,733.15	$ 168,216.97	$ -
Interest @ 0.0325%	$ 70,021.76	$ 49,095.72	$ 27,583.83	$ 5,467.05	$ -
Lease Payments	$ 1,008,000.00	$ 1,008,000.00	$ 1,008,000.00	$ 1,008,000.00	$ 1,008,000.00
Maintenance @ 6%	$ 294,100.00	$ 297,000.00	$ 299,900.00	$ 302,800.00	$ 305,800.00
Total Debt/(Profit)	$ 1,510,637.43	$ 848,733.15	$ 168,216.97	$ (531,515.98)	$ (702,200.00)

Year -->	11	12	13	14	15
Interest Rate	3.25%	3.25%	3.25%	3.25%	3.25%
Units on System	1400	1400	1400	1400	1400
$ per month	$ 65.00	$ 65.00	$ 65.00	$ 65.00	$ 65.00
Total $ per month	$ 91,000.00	$ 91,000.00	$ 91,000.00	$ 91,000.00	$ 91,000.00
Total $ per Year	$ 1,092,000.00	$ 1,092,000.00	$ 1,092,000.00	$ 1,092,000.00	$ 1,092,000.00
$ Remaining	$ -	$ -	$ -	$ -	$ -
Interest @ 0.0325%	$ -	$ -	$ -	$ -	$ -
Lease Payments	$ 1,092,000.00	$ 1,092,000.00	$ 1,092,000.00	$ 1,092,000.00	$ 1,092,000.00
Maintenance @ 6%	$ 308,800.00	$ 311,800.00	$ 314,900.00	$ 318,000.00	$ 321,100.00
Total Debt/(Profit)	$ (783,200.00)	$ (780,200.00)	$ (777,100.00)	$ (774,000.00)	$ (770,900.00)

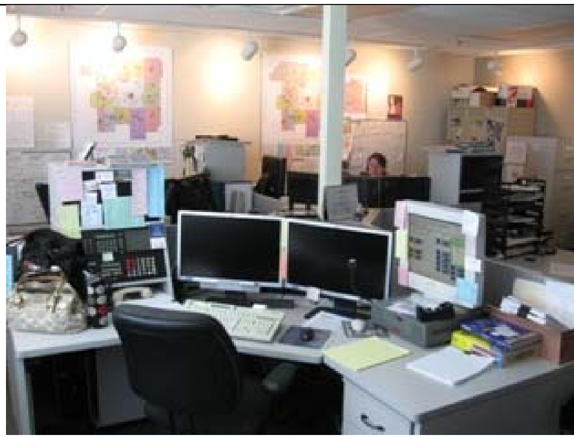
Year -->	16	17	18	19	20
Interest Rate	3.25%	3.25%	3.25%	3.25%	3.25%
Units on System	1400	1400	1400	1400	1400
$ per month	$ 70.00	$ 70.00	$ 70.00	$ 70.00	$ 70.00
Total $ per month	$ 98,000.00	$ 98,000.00	$ 98,000.00	$ 98,000.00	$ 98,000.00
Total $ per Year	$ 1,176,000.00	$ 1,176,000.00	$ 1,176,000.00	$ 1,176,000.00	$ 1,176,000.00
$ Remaining	$ -	$ -	$ -	$ -	$ -
Interest @ 0.0325%	$ -	$ -	$ -	$ -	$ -
Lease Payments	$ 1,176,000.00	$ 1,176,000.00	$ 1,176,000.00	$ 1,176,000.00	$ 1,176,000.00
Maintenance @ 6%	$ 324,300.00	$ 327,500.00	$ 330,700.00	$ 334,000.00	$ 337,300.00
Total Debt/(Profit)	$ (851,700.00)	$ (848,500.00)	$ (845,300.00)	$ (842,000.00)	$ (838,700.00)

Appendix 2 –Story County System Bock Diagram



Appendix 3 –Story County, Ames, and ISU Infrastructure

County



Ames Police Department / City Hall



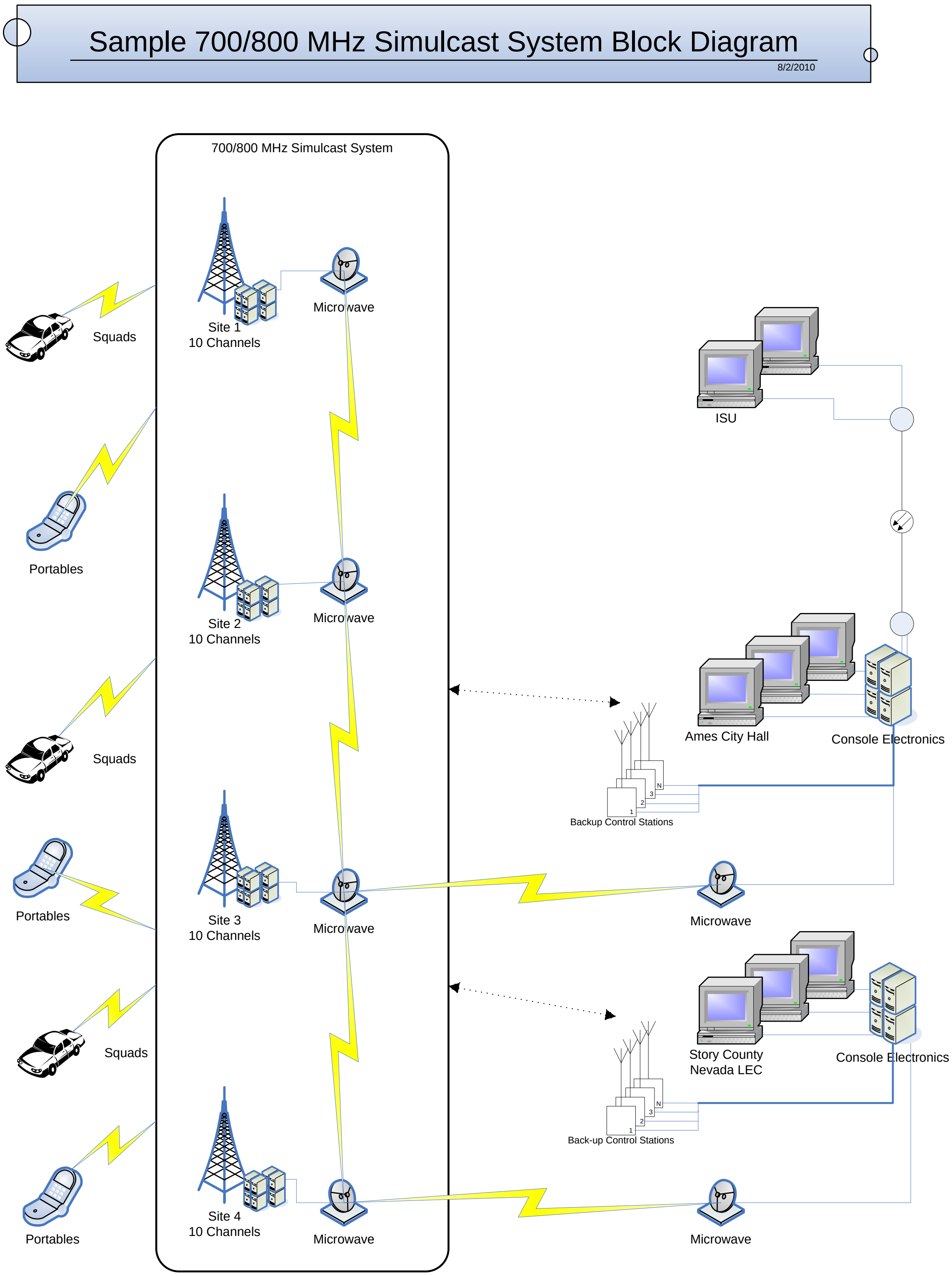


Ames Repeater Site


KOHLER
KOHLER
FAST RESPONSE II

ISU Repeater Site

Appendix 4 – P25 Simulcast Block Diagram



Appendix 5 – SAFECOM

SAFECOM RECCOMMENDATIONS

The following pages are a SAFECOM publication concerning the SAFECOM Continuum. Below is the SAFECOM website for further reference.

http://www.safecomprogram.gov/SAFECOM/

Improving Interoperability Through Shared Channels

U.S. Department of Homeland Security

Homeland Security

SAFECOM

Contents

Executive Summary

Communications interoperability refers to the ability of emergency response agencies to talk across disciplines and jurisdictions via radio communications systems, exchanging voice or data with one another on demand, in real time, when needed, and as authorized. This guide, *Improving Interoperability Through Shared Channels*, is designed for emergency response officials at all levels of government who have an interest in improving communications interoperability in their community or region, yet face the challenge of determining the technical solutions that best meet their needs. Such a challenge can seem overwhelming, as there is a variety of technical options for improving interoperability. To complicate matters further, a combination of technical solutions is required.

Furthermore, it is important to understand that technology is only a piece of the interoperability solution. For a technical solution to be successful, areas of governance (often the most difficult challenge of all), standard operating procedures (SOPs), training and exercises, and the promotion of routine usage must also be addressed.

This guide is intended to create an awareness of one type of technical solution—shared channels, commonly referred to as interoperability channels—that can help communities or regions achieve an improved level of interoperability through existing systems and resources. The guide will help the emergency response community understand the level of effort, resources, and key actions to implement a shared channel solution. Ultimately, it will provide officials with the information to help decide whether a shared channel solution makes sense for their region. The guide does this by:

- Providing an overview of the technical options available for improving interoperability
- Defining the shared channel solution
- Highlighting key questions that should be asked when considering implementation of a shared channel solution
- Describing the technology considerations that may affect a shared channel solution
- Outlining the key actions in implementing a shared channel solution

> **Communications interoperability** refers to the ability of emergency response agencies to talk acrossdisciplines and jurisdictions via radio communications systems, exchanging voice and/or data with one another on demand, in real time, when needed, and as authorized.

This document, *Improving Interoperability Through Shared Channels*, is a living document subject to periodic revisions. Future versions will provide greater detail on the actions involved in implementing a shared channel solution, essentially providing “how to” guides for responsible officials.

Why Is It Difficult To Identify the Technical Solutions that Best Meet Your Needs?

Each agency, community, and region has unique communications interoperability needs and requirements. However, no "one size fits all" technical solution exists that simultaneously meets this diverse range of needs. As a result, localities and regions must employ multiple technical solutions to meet their interoperability requirements. Officials charged with improving interoperability face a difficult challenge in determining not only which solutions are best, but which ones are also affordable given limited funding. This task can seem overwhelming. A range of technical solutions exists. A wider range of solutions, manufacturers, and products exist. A brief overview of the broad technical solutions available to improve interoperability, as outlined in the Technology Lane of the Interoperability Continuum, is in Figure 1.

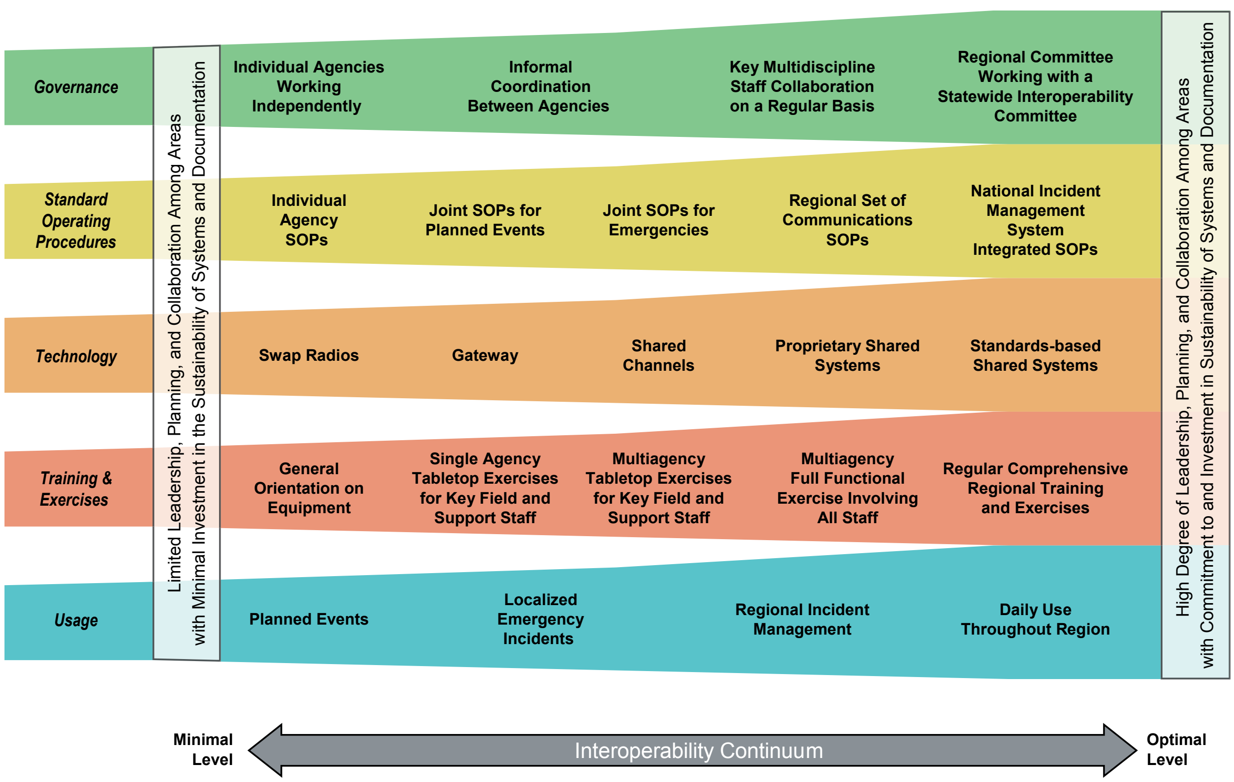


Figure 1

The Interoperability Continuum framework depicts the five critical elements of interoperability success—governance, standard operating procedures, technology, training/exercises, and usage. All of these are necessary to successfully establish effective interoperable communications. Emergency response organizations can use this tool to assess their current level of interoperability and to determine what elements are lacking or need further development.

The specific technological solutions that the Interoperability Continuum identifies are outlined in the section that follows.

Swap Radios

Swapping radios can either involve emergency responders using radios from a compatible set of radios, called a radio cache, where available, or an agency providing one of its radios to a responder from another agency. The solution of swapping radios can achieve a basic level of interoperability; however, it can be time-consuming, management-intensive, and may only provide limited results. In addition, it is often best suited for command and control activities, unless a radio is available for every emergency responder.

Gateways

Gateway systems offer improved interoperability by connecting two or more radio networks. This allows users on one network to communicate with users of another network. This solution is limited by: (1) Gateways can be inefficient because, for each common talk path, they require one channel per interconnected network; (2) A gateway's effective geographic coverage may be limited to the area common to all systems participating in that link, unless the network uses designated common interoperability channels not inclusive to an individual participant or response agency; and (3) They often require significant time to set up or turn on; an emergency incident may be over before a supporting link can be established.

Shared Channels

Channels consist of frequencies, or pairs of frequencies for repeaters, licensed by the Federal Communications Commission (FCC). Shared channels, commonly referred to as interoperability channels, achieve an improved level of interoperability by establishing common channels over which multiple jurisdictions or disciplines can communicate. This solution can be achieved using existing systems and resources, as long as these channels are programmed into each piece of conventional, non-trunked radio equipment, and as long as radios operate in the same frequency band. Trunked systems must also be in the same band and be from the same, or compatible manufacturer, for shared talkgroups to be effective. Limited availability of spectrum and channel/talkgroup congestion can limit the effectiveness of this solution.

Proprietary Shared Systems and Standards-Based Shared Systems

Shared systems refer to the use of a single radio system infrastructure to provide service to most agencies within a region. With the proper planning, standards-based, regionally shared systems can provide optimal interoperability in functionality for users of the system in the region. However, this type of solution can be costly to construct. Proprietary shared systems force users to procure one manufacturer's product and eschew any open competition.

These technical solutions each have benefits and limitations. None can solely provide the highest interoperability. A combination of these solutions is required to best accommodate the communications needs of a region or community. However, this guide highlights the shared channel solution, because it can be achieved using existing systems and limited resources.

What Are Shared Channels?

Shared channels are common radio channels or talkgroups that are established and programmed into radios prior to an incident to provide a conduit for interoperable communications among agencies. This solution can be achieved using existing systems and resources as long as these channels are programmed into each piece of conventional, non-trunked radio equipment, and the radios operate in the same frequency band. Trunked systems must also be in the same band and be from the same or compatible manufacturer for shared talkgroups to be effective.

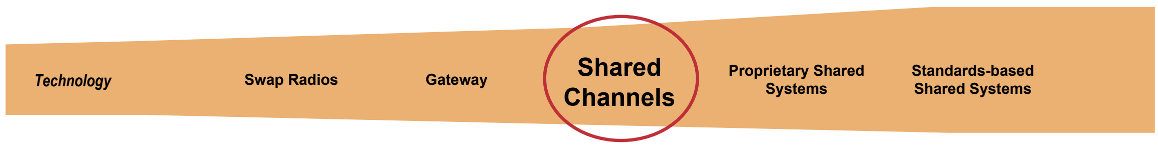


Figure 2

The above definition refers to shared channels and talkgroups synonymously, which is not always the common practice. “Shared channels” are generally identified as a solution for conventional radio systems—systems in which specific channels are assigned to specific groups of users. “Shared talkgroups,” on the other hand, are often defined as a solution between different, compatible trunked radio systems—systems in which channels are pooled among all users under an automated, priority-based system of channel resource sharing. In both cases, shared channels and talkgroups must operate in the same frequency band. This document uses the terms “shared channels” and “shared talkgroups” interchangeably, except where specifically distinguished.

The development and execution of a shared channel solution requires understanding the effort, resources, and key actions involved—which are outlined in the remainder of the document. However, a number of key questions and technology considerations should be addressed first to decide whether a shared channel solution should be considered at all.

Deciding To Share Channels Regionally: Key Questions

A shared channel solution should be considered when a region can answer the following questions affirmatively.

1. ***Does your region have, or have the ability to establish, a governance structure that can oversee an emergency response interoperable communications effort?***

   Governance means establishing a shared vision and an effective organizational structure to support a project or initiative. The proper governance structure is important to the success of any interoperability solution. Establishing a common governance structure will improve communication, coordination, and cooperation across the region and across disciplines that are essential to achieving a shared channel solution for interoperability. A governing body should consist of local, tribal, state, and Federal organizations as well as representatives from all pertinent emergency response disciplines within an identified region. Typically, an overarching governance group will identify operational and technical working groups to handle the finer details of a shared channel solution.

2. ***Does your region have the ability to assess its current communications capabilities?***

   To fully understand the level of effort needed to implement a shared channel solution, a region must have, or be able to develop, an understanding of its current communications technology, gained through a comprehensive assessment. A state or local emergency response community often has the technical elements to become interoperable, yet has not fully assessed its capabilities or engaged in the coordination needed to make capabilities operational. Further, when conducting an assessment, regions should determine whether they have enough channels available to allow offering a channel for shared use without reducing the effectiveness of other operations. Finally, regions should assess whether they are using available national interoperability channels. Existing national interoperability channels can be used as part of a region's shared channel solution. The Association of Public-Safety Communications Officials—International provides a draft list of all public safety-designated interoperability channels, in all bands, at: http://www.apco911.org/frequency/siec/documents/documents.htm.

3. ***Are the agencies in your region open to sharing resources such as spectrum?***

   Development and implementation of a shared channel solution requires, above all, coordination and cooperation. If agencies in a region are open to sharing resources and working cooperatively to achieve an improved level of interoperability, a shared channel solution can prove feasible and extremely effective. However, conflicts between agencies, resulting from competing values, objectives, and authorities, can often obstruct working together for a solution. A community or region must determine whether the differing agencies are capable of cooperating and sharing. Development and execution of a shared channel solution may be achieved inexpensively compared to other technology solutions, such as a regionally based, shared system, which can cost tens of millions of dollars. For regions lacking the resources for a solution requiring substantial funding, a shared channel solution is a potential option—if agencies within the region operate in the same frequency band and are open to sharing resources.

4. ***Can your region dedicate the required resources?***

   While development of a channel plan can be very cost-effective, it does not come without expense. The resources and costs for the successful development and implementation of shared channels can include:

   - **Time and Commitment.** Above all, this effort requires considerable time from and the commitment of the identified stakeholders and leadership to properly plan for, develop, implement, manage, and use the shared channel solution.
   - **Radio Programming.** Once shared channels/talkgroups are agreed on, all radios must be programmed to include these resources. If a community or region does not have the ability to program its radios, it may have to locate a qualified service center to do so.
   - **Technology Procurement.** In some cases, agencies will have to purchase technologies (such as gateways) to provide connectivity among disparate systems in a region.
   - **Channels/Talkgroups.** Some disciplines and jurisdictions may need to share one or more channels in order to help the region identify and designate shared interoperability resources. A willingness to dedicate channels/talkgroups to the region will enhance the safety of the emergency response community and the citizenry it serves.

Technology Considerations

A shared channel/talkgroup solution can improve the level of interoperability for a region if the member systems are compatible and operate in the same frequency band. When evaluating the potential use of a shared channel solution, system planners will consider the following:

- System mode: conventional or trunked
- System type: digital or analog
- Manufacturer: vendor, trunking technology, and proprietary or non-proprietary components

- o Frequency band: VHF, UHF, 700 MHz[1], or 800 MHz

To make a shared channel/talk group solution possible, the groups of users who plan to share a channel or talkgroup must operate on compatible systems. This means all systems must be able to operate in an analog mode or support compatible digital and trunking standards. For example, a shared channel solution could be possible if all users operate conventional analog systems in the VHF band. Another solution might include users from multiple jurisdictions operating on shared talkgroups with compatible, 800 MHz digital trunked systems.

In some cases users will operate on different bands or use incompatible digital technology. For example, if one group of users operates on an 800 MHz, digital trunked system and another operates on a conventional analog system in the VHF band, then shared channels/talk groups would not be possible. Interoperability would have to be accomplished using a different solution, such as a gateway.

A gateway solution, like a shared channel/talkgroup solution, can achieve interoperability by creating connectivity among groups of users operating on disparate systems and frequency bands. However, a gateway solution is less efficient than shared channels because it requires the use of two or more frequencies, as opposed to the sharing of one. Still, when disparate systems preclude a shared channel/talkgroup solution, the use of a gateway to patch systems offers a practical solution.

In addition to system compatibility, a shared channel/talkgroup solution must have frequencies available for shared use. When identifying frequencies available for shared use, regions should consider whether national interoperability channels are available for use. Without the ability to obtain or identify frequencies for shared use, this solution will not work.

Finally, regions should be aware of three significant FCC mandates and actions that will affect operations in the VHF, UHF, and 800 MHz bands.

- Narrowbanding: The FCC has mandated that the emergency response community operating on wideband (25 kHz) channels operating below 512 MHz move to narrowband (12.5 kHz) channels by January 1, 2013. The aim is to promote more efficient use of spectrum resources.
- Rebanding: The FCC has mandated the rebanding of the 800 MHz band to separate commercial wireless provider channels from public safety channels and to prevent interference. The FCC has established a schedule, and plans to migrate to the new channels by 2008.
- 700 MHz: 24 MHz of the 700 MHz spectrum band will be released in February of 2009 for use by the emergency response community. The FCC has designated approximately ten percent of the 700 MHz public safety spectrum for nationwide interoperable communications.

These mandates may affect channels shared in the bands mentioned. Regions will need to plan accordingly to prevent disruption of their channel sharing. Further information about these issues can be found in the Additional Resources—Spectrum Information section at the end of this guide.

[1] As specified in the Deficit Reduction Act of 2005 (Pub. L. No. 109-171), 24 MHz of the 700 MHz spectrum band will be released for use by the emergency response community in February of 2009. The Federal Communications Commission (FCC) has designated approximately 10 percent of the 700 MHz public safety spectrum for nationwide interoperable communications.

Key Actions for Developing and Implementing Shared Channels

Technology, while only once piece of a robust interoperability solution, is critical. The development and implementation of a shared channel solution involves a number of technical considerations. As the Interoperability Continuum indicates, success in each of the elements of the Continuum is necessary to develop a successful solution and to ensure its proper use and implementation. The following are the key actions, which incorporate all elements of the Interoperability Continuum, to take when developing a shared channel solution to improve interoperability.

Action 1 Establish a Governance Structure and Gain the Proper Leadership Commitment

A number of challenges[2] can affect any effort to improve interoperability through shared channels. A proper governance structure, however, can address and overcome these challenges. To develop the proper governance structure to lead the development and implementation of shared channels, the following actions should be taken:

- Establish key relationships with high-level representatives who have decision-making authority and who represent agencies that need to be included in the shared channel plan—including multi-disciplinary and multi-jurisdictional agencies across all levels of government (local, tribal, state, and Federal).
- Develop a locally-driven governance structure that incorporates key stakeholder organizations and ensures an appropriate level of local practitioner membership and input.
- Elect a leader who is familiar with the communication needs and technology capabilities in the region, and has the ability to identify potential funding resources.
- Establish a working group made up of representatives from each agency sharing channels to ensure each agency is a part of the entire decision-making process.

In addition to forming a governance structure to lead the effort, it is important to gain support and commitment from political leadership across the region. The governing body should:

- Establish relationships with local administrators and elected officials (e.g. mayors, council members, and county executives) to gain policy and resource support. Long-term support for maintenance, upgrades, and eventual replacement is essential to overall success. If possible, the use of legislation to gain authority and funding for the governance structure overseeing interoperability efforts is desirable.

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[2] The National Task Force on Interoperability identifies five key challenges to interoperability—incompatible and aging communications equipment, limited and fragmented funding, limited and fragmented planning, lack of coordination and cooperation, and limited and fragmented spectrum. Each of these challenges can affect an effort to improve interoperability through shared channels.

Action 2 — Conduct an Assessment of Operational Needs

Gather information from the entire user community on operational needs that will be included in the shared channel/talkgroup solution. The information should include:

- Mission objectives
- Interoperability needs (who needs to talk to whom and under what circumstances). Should include multi-disciplinary and multi-jurisdictional needs.
- User expectations
- Organizational structure and operations (which should incorporate the National Incident Management System structure)
- Any existing communications problems
- Identify specific types of emergencies that have historically required or will likely require interoperable capabilities

Action 3 — Conduct a Technical Assessment of the Communications Systems and Resources of the Region

To develop a shared channel/talk group solution, a region must first understand its communications capabilities, resources, system capacity, and limitations. Such a baseline will help a region identify what channels/talkgroups it may have available for interoperability, and whether changes or upgrades to existing systems are needed. A technical assessment should include:

- Identification of all regional communications systems currently in use, including type (analog or digital), mode (conventional or trunked), frequency band, and manufacturer (if proprietary)
- A database of all FCC radio licenses in the region
- Identification of all channels/talkgroups in use and purposes of use (including national interoperability channels)
- Identification of capabilities by site, including the identification of site users
- Coverage, or the system footprint of all areas covered
- Capacity, or the number of channels/talkgroups that radios in the existing systems can handle and frequency capacity of the radios
- Current interoperability capabilities with other systems

Action 4

Agree Upon Channels To Be Shared and the Policies and Procedures To Govern Use

Once a region has conducted a full operational and technical assessment, the participating agencies can identify resources that may be shared, provided that sharing is agreed to by the licensee. In some circumstances, agencies may need to share some of their own resources to help the region identify and designate interoperability channels/talkgroups. In addition, the region should ensure it has an awareness of all available national interoperability calling and tactical channels.

Policies and procedures must be established to govern the use of the agreed upon shared channels. These policies and procedures should determine when the use of shared channels is needed and authorized. These policies and procedures should incorporate the following principles:

- **Flexibility**. Regions can conduct extensive planning efforts to prepare for the range of variables that may affect a response effort. However, unforeseen circumstances will undoubtedly occur. It is important that the established policies and procedures allow for flexibility so the emergency response community can adjust to unforeseen circumstances accordingly.
- **Autonomy**. Individual agencies should be allowed to maintain a level of autonomy as long as it does not affect interoperability across the region. Agencies should know their communications needs best and should have authority to pursue those needs.
- **Standard Channel Nomenclature**. When differing agencies have programmed different names for the same channel into their radios, operational confusion during incident response can result. This confusion can delay response and hinder interoperability at an incident, endangering life and property. Potential confusion can be prevented by agreeing upon standard channel naming conventions across a region and by programming radios accordingly. The FCC's 700MHz National Coordinating Committee has developed a common interoperability channel nomenclature scheme. It encompasses all nationally designated interoperability channels in all bands, and has been implemented in many areas. This scheme is a recommended best practice for regions.
- **Plain Language**. When using shared interoperability channels, it is important to use plain language, as opposed to signals and codes. Not all jurisdictions recognize the same signals and codes. Misunderstood codes endanger lives. Plain English removes potential confusion and increases safety.
- **Discipline**. Because many users have access to shared channels, it is easy for radio discipline to break down. Overcrowding can occur, causing interference among transmissions. Protocols must be established to manage the volume of radio traffic on shared channels during an incident. Policies and procedures should incorporate communications features of the Incident Command System included in the National Incident Management System. These policies must be reinforced through regular and frequent training and exercises.

Action 4 cont'd

Agree Upon Channels to be Shared and the Policies and Procedures to Govern Use

- **Licensing Options.** When implementing a shared channel solution across a region[3], it is important to understand the applicable rules and regulations from the FCC (and National Telecommunications Information Administration for Federal users). For example, channels such as 154.280 MHz (fire response) and 155.475 MHz (law enforcement) are limited to interagency use only.

Action 5

Create a Regional Channel/Talkgroup Plan Incorporating the Agreed Upon Shared Channels and Policies and Procedures

A channel/talkgroup plan is a tool for organizing a region's available emergency response interoperability resources. It can help ensure that all end users know the purpose of the channels/talkgroups, how to access them, who should be allowed access, and how and when authorization for access and use should occur. Ideally, a plan serves as a tool for identifying and managing the use and sharing of spectrum resources for improved interoperability through shared channels. For trunked systems, the planning document for shared talkgroups (a "talkgroup plan") will be built around each agency's "fleet map." Tables 1 and 2 provide templates for identifying and documenting shared channels and shared talkgroups within a channel/talkgroup plan.

Primary Use	Frequency	Channel Name	Description	License Holder

Table 1

Primary Use	System ID	Talkgroup ID	Talkgroup Name	Description

Table 2

[3] 47 C.F.R. Part 90 contains the rules and regulations for Private Land Mobile Radio Services, which provides for the internal communications needs of emergency response organizations and other non-commercial users of two way radio services. Information on 47 C.F.R. Part 90 can be found at: http://wireless.fcc.gov/rules.html.

Action 6 Develop a Regional Memorandum of Understanding (MOU)

Develop a regional Memorandum of Understanding (MOU), agreed upon by all agencies incorporated in the regional channel plan. The MOU should include:

- **Governance Structure.** The governing body should have the proper authority to successfully develop, lead, and implement the interoperability solution.
- **Roles and Responsibilities.** Establish the roles and responsibilities of the governing body tasked with implementing a shared channel solution.
- **Support.** The MOU should establish the necessary support—leadership, people, and funding—to ensure the effort has the resources necessary for success.
- **Cost-Sharing Plan.** The availability of resources varies greatly from agency to agency and community to community. Where funding is needed to provide connectivity between agencies and jurisdictions, communities may need to develop a cost-sharing plan.
- **Designated Shared Channels.** It is important to document the channels/talkgroups designated for use, and to ensure that all rules and regulations are followed.
- **Policies and Procedures for Use of Shared Channels.** Policies and procedures must govern the use of shared channels/talkgroups.
- **Regional Channel Plan (or Talkgroup Plan).** The plan should provide users with a quick reference guide of available shared channels and purposes of channel use.
- **Enforcement.** A mechanism for monitoring and enforcing adherence to the MOU by participating agencies must be in place.

Action 7 Program Radios

All user radios in the region must be programmed with the shared channels/talkgroups. This will require:

- **Radio Technicians.** If a region does not have technicians on staff, then it will need to procure services from their local vendor.
- **Process and Schedule.** To implement a shared channel solution, users must give up their radios for a time, for the purpose of programming the radios. Regions should plan to minimize the impact of such programming to ongoing emergency response operations.

Action 8 — Train and Exercise on the Use of Shared Channels/Talkgroups

Proper training and regular exercises are critical to the implementation and maintenance of any interoperability solution, including shared channels/talkgroups. An interoperability solution fails to be a true solution if the end users do not know how to use it. Despite the fact that radio communications are a critical resource for the emergency response community, training on the use of communications equipment is often overlooked. To successfully implement a shared channel/talkgroup solution, a community or region should consider the following actions:

- Commit resources to manage a program, providing training and exercises on the use of shared channels/talkgroups.
- Identify and deliver guidelines and requirements for regional training and exercise.
- Ensure regular training—should occur at least twice per year.

Success will be assured by regular and comprehensive exercises that address realistic shared channels/talkgroups scenarios.

Action 9 — Regularly Use Shared Channels/Talkgroups

It is important that shared channels/talkgroups are regularly used so that the emergency response community becomes familiar and comfortable with their use. Ideally, communities will use interoperability equipment and procedures daily. However, problems can often preclude regular use. Common problems include:

- Emergency responders do not regularly use interoperability solutions.
- Day-to-day operations do not always use interoperability equipment.
- First responders from different jurisdictions and disciplines may not interact daily.

To encourage regular use of shared channels/talkgroups, the solution should:

- Reflect operational needs.
- Institutionalize regular use and review of shared channel/talkgroup policies and procedures.
- Train and exercise regularly on the use of shared channels.

> Optimal usage, as defined by the Interoperability Continuum, includes regular use of interoperability systems for managing routine and emergency incidents, user familiarity with the operation of the interoperability solution, and routine coordination with multiple disciplines and jurisdictions.

Future Versions

Future versions of this guide are under development. They will provide further detail on key actions to implement a shared channel solution. These versions will provide, among other items, a roadmap to guide regions.

Additional Resources—Spectrum Information

A shared channel solution for interoperability depends on the use, sharing, and management of spectrum resources. Because spectrum is a finite resource in great demand, its use and availability are highly regulated. The FCC regulates spectrum designated for use by state, local, and non-Federal entities engaged in emergency response activities. The National Telecommunications and Information Administration (NTIA) regulates use of spectrum by Federal Government agencies. Evolving rules, regulations, and policies established by these bodies govern the use of spectrum. These mandates can affect interoperability in general, as well as the interoperability specifically achieved through shared channels. Table 3 displays public safety spectrum by band and range. The resources in the sections that follow provide other spectrum related information—including information on rules, regulations, and policies.

Frequency Band	Frequency Range
High HF	25-29.99 MHz
Low VHF	30-50 MHz
High VHF	150-174 MHz
Low UHF	450-470 MHZ
UHF TV Sharing	470-512 MHz
700 MHz	764-776/794-806 MHz
800 MHz	806-869 MHz

Table 3

FCC Spectrum Information

FCC General Public Safety
The following link provides information on the spectrum used by the public safety community:
http://wireless.fcc.gov/publicsafety/

FCC Narrowbanding/Refarming
Narrowbanding, also known as "refarming," refers to rules developed by the FCC to ensure more efficient use of spectrum. Information on the rulemaking related to this can be found at:
http://wireless.fcc.gov/services/index.htm?job=operations&id=private_land_radio

FCC 700 MHz Spectrum
The following site provides information on the 700 MHz public safety spectrum and the rules governing its use:
http://wireless.fcc.gov/publicsafety/700MHz/

FCC 800 MHz Band Reconfiguration
The following sites contain information on the 800 MHz public safety spectrum, including rules of use and guidelines for reconfiguration:
http://wireless.fcc.gov/publicsafety/800MHz/bandreconfiguration/index2.html
http://wireless.fcc.gov/publicsafety/800MHz/

FCC National Coordination Committee (NCC)
The FCC established the NCC to address and advise the commission on the operational and technical parameters for use of the 700 MHz band. The NCC's charter expired on July 25, 2003. Information about the NCC and its work can be found at:
http://wireless.fcc.gov/publicsafety/ncc/

FCC Rules and Regulations
FCC rules and regulations can be found at the site below. The site includes 47 C.F.R. Part 90, containing the rules and regulations for private land mobile radio services, which provide for the internal communications needs of emergency response organizations and other non-commercial users of two way radio services:
http://wireless.fcc.gov/rules.html

FCC Frequency Coordination
The FCC has certified specific associations to perform the coordination process for those applying for spectrum licenses. A list of certified associations is at:
http://wireless.fcc.gov/publicsafety/coord.html

NTIA Spectrum Information

NTIA Office of Spectrum Management (OSM)
The NTIA's Office of Spectrum Management (OSM) manages Federal Government use of the radio frequency spectrum:
http://www.ntia.doc.gov/osmhome/osmhome.html

NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook)
This manual includes narrowband requirements for land mobile spectrum allocated to the Federal Government:
http://www.ntia.doc.gov/osmhome/redbook/redbook.html

Other Spectrum Information

Association of Public-Safety Communications Officials (APCO)-International Spectrum Issues Page
APCO-International was established to enhance public safety communications. The following page provides information related to public safety spectrum issues:
http://www.apcointl.org/frequency/issues.htm

APCO-International Draft List of All Standardized Public Safety Designated Interoperability Channels
Currently, there exist national interoperability channels that can be used as part of a region's shared channel solution. APCO-International provides a draft list of all public safety designated interoperability channels in all bands:
http://www.apco911.org/frequency/siec/documents/documents.htm

Computer Assisted Pre-Coordination Resource and Database System (CAPRAD)
The CAPRAD tool provides automated features to assist in management, assignment, and application for interoperability channels:
http://caprad.nlectc.du.edu/cp/index.jsp

National Public Safety Telecommunications Council (NPSTC)
NPSTC is responsible for implementing the recommendations of the FCC's NCC. Spectrum related information can be found on its site:
http://www.npstc.org/index.jsp

The Department of Homeland Security (DHS) established the Office for Interoperability and Compatibility (OIC) in 2004 to strengthen and integrate interoperability and compatibility efforts in order to improve local, tribal, state, and Federal emergency response and preparedness. Managed by the Science and Technology Directorate, OIC is assisting in the coordination of interoperability efforts across DHS. OIC programs and initiatives address critical interoperability and compatibility issues. Priority areas include communications, equipment, and training. As communication programs of OIC, SAFECOM and DM, with its Federal partners, provides research, development, testing and evaluation, guidance, tools, and templates on communications-related issues to local, tribal, state, and Federal emergency response agencies.

Homeland Security

SAFECOM