City of La Crosse, WI

Public Safety Radio System Assessment Report

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Problem Statement

The City of La Crosse, WI has retained Elert & Associates' services to develop a complete assessment for an enhancement to the City's aging 800 MHz trunked radio system, which supports Police, Fire, EMS, and other emergency users, as well as public works and transportation services. The study should also include the requirements of the La Crosse County 911 dispatch center, which dispatches for the City of La Crosse. This study must have a focus on interoperability with La Crosse County, the State of Wisconsin's WISCOM, and Minnesota's ARMER systems that border the City. The study also contains best practices for communications and recommendations with budgetary estimates.

Executive Summary

The City of La Crosse currently uses six 800 MHz frequency pairs for its Motorola SmartNet trunked system, which provides radio communications for City agencies. Police and Fire are dispatched by La Crosse County 911. The County uses a Motorola Gold Elite radio console system that is interfaced directly to the City of La Crosse's trunked repeater stations via a fiber optic connection. The City of La Crosse wants to update its system with a standards-based P25 communications infrastructure and ensure interoperability with La Crosse County, the State of Wisconsin WISCOM P25 radio system, and the State of Minnesota P25 ARMER system (which borders the City). Mobile data users obtain network connectivity via Verizon air cards. This study is intended to present the potential options for the City to choose and point out the differences between systems and the requirements for interoperability.

The City of La Crosse wants to transition to an up-to-date system platform to ensure interoperability with the two state networks that surround the City and the conventional system that is used in La Crosse County and also provide interoperability as needed with other regional agencies. Nationally, public safety has adopted the digital P25 standard for radio communications. Due to the fact the City operates on 800 MHz while La Crosse County, the state and adjacent counties operate VHF, interoperability is a major concern.

E&A recommends that the City adopt the P25 platform using 800 MHz to replace its current voice communications system independent of the other P25 systems in the area by employing a multisite simulcast transmit and multisite voted receiver design to improve portable (handheld) coverage. An independent system means the city would have full management responsibility through full control of features and enhancements. It is also recommended that the system provide interoperability portals or gateways into the two State P25 systems in the area, selected channels servicing the La Crosse County communications system, and other adjacent county systems as required to provide interoperability for users. By developing the system in this way daily operation and interoperability will be maintained and enhanced within the jurisdictional area of the city. Multi-band subscriber radios are an option for use when communicating directly on the WISCOM network or leaving the city boundaries and operating on adjacent radio systems. No change is recommended for current mobile data connectivity.

This study provides multiple system design options that would utilize portions of the current La Crosse County microwave network, provide enhancements to some links, and establish new paths for new radio infrastructure sites. The recommendation includes the development of one or more green field (new) sites, thus providing improved coverage.

All field terminals (mobiles, portables, and control stations) in service today would be replaced with P25 trunking models of equivalent performance[1]. Additional control stations would be added for backup. Police and Fire units would have AES encryption capability. The system would be able to reprogram all field units and rekey encrypted units over the air.

Within the city boundary areas the P25 800 MHz radios would serve all users while providing interoperable communications among users and with gateways to VHF users on WISCOM or other conventional radio systems thus making for ease of use by the officers and other staff. The use of gateways would allow radio users to select a VHF interop channel on their radio while operating on the city's trunked system. When the user leaves the city boundaries or communicate directly on WISCOM for those who have the need an option of a multi-band radio should be considered though the use of this option does come with some negative impact with the primary issue being local dispatch can no longer reach this radio user until they return to 800 MHz system. These multi-band radios also come at a higher cost and are more complex.

Mixing voice and data within the same radio system has been found to be less than satisfactory. At one time this was considered though in implementation and use the negative aspects have outweighed the positives. Short message texts can however be used and integrated with voice with the proper dispatch console.

Four options are being offered in this assessment, with each option building on the previous one. **Option 3A** is recommend by Elert & Associates as providing the best solution overall. From a price perspective alternative features have also be estimated.

After careful modeling of the area for coverage and listening to user issues, the E&A recommended option consists of four base station sites and discontinued use of the present site at city hall. The four sites would be to use two existing county operational towers (Grandad and Lawton); the present US Cellular tower the city makes use of (14-61) and a new tower site to be developed on Conservatory land overlooking the north part of the City. These four sites together would increase coverage in the city from the mid 70 percent range to an estimated 98 percent in mid-tier buildings. (See Figure 49-52 for detailed coverage comparison predictions as compared to present coverage.)

By using P25 simulcast for the recommended solution these four sites will vastly improve the ability for users of the La Crosse public safety radio system as compared to the present single repeater site system. Due to the growth of the city and the geography of the area the users understand the inadequacies of the present system. These facts along with

[1] In 2008, some mobile units were upgraded to P25 capable. It is anticipated that trunking capability was not included. All cost estimates include the replacement of all current units in the City's inventory.

the knowledge the present system has reached its end of life only one conclusion can be reached and that is a forklift upgrade is required.

Option	Description of Improvement	Estimated Cost	Outcome
1	Develop site on City's north side Strengthen Grandad tower 6 Ch P25 to Lawton, North sites Add equipment shelter at Lawton 10 GHz MW Grandad to North 10 GHz MW Grandad to Lawton Satellite receiver system at LCPD 140 high-tier encrypted mobiles 69 high-tier encrypted portables 10 high-tier encrypted control stations 1 control station combiner 162 mid-tier mobiles 116 mid-tier portables 12 mid-tier control stations Over-the-air programming Over-the-air rekeying Console interface Alarm system	$6.609M	Two-site P25 simulcast trunking system 94.9% Talk-out 95.8% Talk-back
2	All items in Option 1 Add 6 Ch P25 to 14-61 site Update MW Grandad to 14-61	$7.029M	Three-site P25 simulcast trunking system 95.4% Talk-out 97.5% Talk-back
3A	All items in Options 1 and 2 Add 6 Ch P25 to Grandad site Add equipment shelter	$7.394M	Four-site P25 simulcast trunking system 98.5% Talk-out 98.9% Talk-back

3B	All items in Options 1 and 2 Develop site at Grandad Bluff Park Add 6 Ch P25 to Grandad Bluff Park 10 GHz MW Grandad Bluff Park to La Crosse County 911	$7.790M	Four-site P25 simulcast trunking system 97.8% Talk-out 98.0% Talk-back

Findings/Issues

Issues/Information Discovered through Interviews

Overview:

- The City has a single-site trunked repeater system located at City Hall.
- Sprint and U.S. Cellular are also located on the City Hall rooftop.
- The City developed an enhancement site for some added coverage to the far southeast portions of the area.
- Police is on the first floor of City Hall.
- Police and Fire are dispatched by La Crosse County 911.
- The Sheriff Department and dispatch is across the street.
- Connectivity between the trunking system in the City Hall and the Public Safety Answering Point (PSAP) is fiber using a RAD Data Communications mux.
- Motorola indicated that they do have a trade-up program for Gold Elite consoles to MC7500 consoles.
- The City operates 54 MC3000 desksets throughout various offices, allowing control station access to the radio system via 18 consolettes.
- Police and Fire experience coverage issues with the radio system.
- Mobile units work in and around the City but get weak coverage in the northeast, southeast, and in neighboring communities.
- Portables experience outdoor coverage issues in the northeast and southeast and indoor issues across the City.
- A number of users find it easier to use cell phones for communications where coverage is an issue.
- The City uses Verizon cell cards for data.

La Crosse Center:

- Coverage is adequate when the facility is empty, but poor when occupied.
- Five talk groups are assigned to La Crosse Center.
- Security has 18 radios, Concessions has 13 and Maintenance has 12. All radios total 68.
- Noise is a huge issue.
- Reception is spotty on occasions dependent on location.
- An internal antenna was installed in the kitchen area in 2009.
- An internal antenna was installed in the arena at the end of 2011.[1]

Inspections:

- This area does not use radios currently.
- There is a staff of seven who use cell phones.
- After an event, a cache of radios would be used for communications, but there is no need for radios on a daily basis.

Parks:

- The Parks department generally uses cell phones for daily non-emergency functions.
- Parks has mobile units in their vehicles.
- There is a staff of eight.
- Gar said he saw little need for interoperability with other city staff except during emergency situations.
- They have two MC3000 remotes.

Transit:

- Radios fit their needs perfectly and thus they are heavy users.
- They continue to expand their routes into underserved areas such as Holmen, West Salem, Shelby, and possibly La Crescent.

[1] When interviewing Communications Services, we were advised there have not been any other antennas or other elements added.

- Coverage is generally OK. The West Salem area is weak.
- They use mostly mobiles. Portables are used by managers.
- Vehicles use phone handsets with PTT button and a cradle.
- Most communication is driver to driver. To reach the 911 PSAP, they switch to City 3.
- Four talk groups are assigned, though generally they use only three.
- They would like an easier way to talk privately between a driver and a supervisor.
- There are 20 buses with only 15 on the road at any one time.
- Some system busies occur but not often. Busies among their talk group are more prevalent.
- GPS would be useful.
- Most radios are very old (original to the system).
- The emergency button is not used.
- Transit operates base stations at two dispatch locations: Isle La Plume and Transit Center.
- Transmissions are not recorded.

Airport:

- There are numerous dead spots in the buildings, especially where security tends to operate.
- There is a base in the terminal with an antenna on the roof.
- Inside the terminal, portable units can receive but can’t get out.
- Dead spots also exist at the end of the runway.
- Twelve talk groups are assigned. Maintenance and Crashnet are the two primary talk groups used.
- They would like the Dispatch Center to monitor Crashnet. It is in the console, but the volume is turned down.
- Public Safety officers need to monitor both fire and police talk groups plus Crashnet.
- The emergency button is not used at the airport.

- Mostly original MTS–2000 radios.
- Need to monitor air channel at all times also.

Fire:

- Coverage throughout the city is the single biggest issue – especially to the northeast and southeast.
- In the past, they tried to always use repeater. Now they use talk-around.
- Talk around (TAR) has no emergency and is not recorded.
- In-building coverage is a huge issue.
- A vehicular repeater system is desired to enhance on-scene communications to improve in-building performance in large buildings
- Mobiles were updated to P25-capable radios in 2008.
- All portables are 1993 vintage MTS2000.
- Batteries (NiCAD) last only half a shift – spares are needed at every scene.
- Some rescue services still use VHF, as most surrounding communities are on VHF, so they maintain two radio systems.
- Fire could benefit from multiband mobile and portable radios for interoperability with area VHF systems.
- Use of 800 MHz is good, but they need a bridge to state fire VHF frequency for mutual aid.
- There is a statewide rescue team that uses VHF on WISCOM.
- Fire must have interoperability with EMS/ambulance services

Police:

- Coverage throughout the city is the single biggest issue – especially to the northeast and southeast where officers can have no radio coverage.
- Building penetration is also a huge concern.
- Interoperability with UWL, County of La Crosse, WISCOM, and Minnesota ARMER must be addressed.
- Police desires a multiband mobiles and portable radios for interoperability with VHF systems.

- The City has no access to VHF mutual aid channels, as they operate on 800 MHz and everyone except Minnesota operates on VHF. This is especially an issue when city officers need to communicate with La Crosse County, Wisconsin State Patrol, UW Police, adjacent counties and adjacent cities.
- Need an easy method of connecting to adjacent agencies.
- Would like to have assigned radios and not shared.
- Need a system that provides required communications when needed within the boundaries of the City.
- The backup is cell phones.
- Do use peer-to-peer voice via chat on the radios.
- Use cell phones as pagers.
- A vehicular repeater system would be beneficial for on-scene communications at large events
- Would like encryption, though what is in place does not work.

Public Works – Engineers:

- Engineers use cell phones.
- Engineering has five desk sets with only two turned on.
- Traffic personnel use radios – peer to peer.
- Use scan to monitor of PW groups.
- There is a need for six more mobiles.
- Channel 3 is used to contact dispatch.
- Dispatch (911) calls traffic directly.
- Use of cell phones continues to increase.

Public Works – Water:

- Heavy use of radios including desk sets.
- Would like to have connectivity to 13 wells, 10 waste locations, and 33 lift stations to support SCADA.

Public Works – Streets:

- Heavy user of radio system.
- Coverage is an issue to the northeast and southeast portions of the city (especially the landfill and business park).
- Need more mobiles.
- Would like an easier way to talk privately radio to radio.

La Crosse County 911 (Operated by La Crosse County):

- There are 29 talk groups available to dispatchers on Gold Elite console.
- There are 21 talk groups recorded in dispatch.
- Dispatchers only listen to City 3 and the Hailing Channel.
- Dispatchers typically will select Airport only if needed, as they do with City 1 and City 2.
- PD Main is multicast on 155.670 so the City of La Crosse can monitor.
- The 14-61 expanded coverage fire repeater is always patched to the fire talk group.
- The 14-61 expanded coverage PD repeater is patched as needed to their primary talk group.
- The 14-61 expanded coverage Public Works repeater is available to users but may never have been used as use takes a user off the main system.
- City of La Crosse has a coordination channel 155.995/158.760 that can be patched to the Events talk group if needed.
- An interoperability control station for ARMER is wired into the console system.

University of Wisconsin – La Crosse:

- The University recently installed a new base.
- They very seldom communicate with City of La Crosse PD.
- Can be patched by La Crosse County 911.
- Moving to a new Communications Center in August 2013.
- Use Wisconsin State Patrol system for mobile data.

Observations and Local Vendor Interview Information

- The City of La Crosse SmartNet system was installed in 1994 and is being maintained using used parts obtained from other decommissioned systems the vendor has been able to find on the used market.
- E&A Note: SmartNet systems are being replaced across the country as they are no longer supported by the manufacturer as having reached end of life a few years ago.
- The trunking system is a single site at the top of City Hall in downtown La Crosse that does not adequately provide coverage to the city boundaries.
- The antenna system uses two phased panel antennas each for transmit and receive oriented nearly 180 degrees apart from each other.
- The US Bank building is taller than City Hall and blocks portions of the La Crosse Center and the immediate area.
- A Bi-Directional Amplifier (BDA) was installed in the kitchen at the La Crosse Center to assist in improved indoor coverage. No other antenna systems are installed inside the building.
- Bluffs on the east side of the City block signals as the City expansion wraps around this terrain to the north and the south.
- Users experience extremely weak coverage on the northeast and southeast areas of the city.
- The 14-61 (US Cellular tower) site south and east of the City was developed to provide fill in coverage on the south side of the City with three channels for Police, Fire, and Public Works, though this site is not a direct extension of the trunked site.
- The 14-61 repeater frequency is the talk around (TAR) channel used for on-scene. If the repeater is used for communications during the same time frame, this could be problematic.
- The County Grandad site provides a conventional channel backup for use in the event that the trunking system fails.
- The present trunked system is interfaced to La Crosse County 911 dispatch console system via a single fiber optic connection.

Existing Radio Systems

800 MHz Trunking System

The City of La Crosse uses a six-channel Motorola SmartNet II analog trunking system for voice communications. The repeater system equipment is located in a shared equipment closet on the top floor of City Hall. The antenna system is located on the penthouse roof. A separate antenna system is used for transmit and receive. Each antenna system is composed of two RFS 10099 13 dB gain panel antennas oriented nearly 180 degrees in opposing directions—one pointed to the north and the other to the south. This site is described in further detail in City of La Crosse Site Documentation on page 67.

The decision to utilize 800 MHz was most likely made for two reasons. One being this frequency band tends to provide better in-building interoperability and the other that band was available for trunking. Both reasons are still valid.

Connectivity to dispatch is via a fiber link between the fifth floor of City Hall and the La Crosse County Public Safety Communications Center a few blocks to the south. The trunking system is interfaced into the La Crosse County 911 CENTRACOM Gold Elite console system. A total of 22 of the 49 system talk groups, the bulk of which are used by Police and Fire, are programmed into the console system and are also recorded. All talkgroup communications programmed into the console system can be initiated or received by each position.

The City's present radio system provides little to no portable coverage in the northern and southern areas of the City of La Crosse. The primary reason for the lack of coverage is due to the bluffs which block signal in both areas where growth has occurred. The estimated coverage for a portable in the City today is modeled to be 70% to 80% which tends to match reports by users.

Portable radios are worn on the belt and the antenna is close to the body. The antenna height is just over three feet above the ground. The orientation of the portable antenna changes dependent on user activity. These factors contribute to a poor antenna system and impact the overall performance of a portable. To compensate the design of system infrastructure is key to portable system performance.

The current system uses a single site. Propagation of signals is affected by terrain variation and signals can be blocked or attenuated by surrounding buildings and trees in the signal path. Signals are also reflected into an area and create phase cancellations. The outside signal level at any location is result of the multitude of signal paths that reach any particular location.

In-building portable coverage issues are experienced by users citywide. Although outdoor operation may offer satisfactory signal levels for communication the attenuation encountered when entering a building lower the level of signal. If the

signal level is reduced such that either the repeater can no longer decode the received signal from a field unit or the field unit cannot decode the repeater communications fail.

Mobile user coverage can be weak in adjacent communities. Unlike portables, mobiles are equipped with an antenna system which is usually mounted on the roof of a vehicle about five feet or higher from the ground and is usually vertical. This provides a good antenna system for operations. Signals from the City Hall site are being blocked by terrain or attenuated by natural obstacles or buildings in the areas of weaker coverage for mobiles. A multiple site infrastructure that provides mobile coverage into adjacent areas is required to provide mobile operation.

Although some field units have been updated, most of the City's field units are in need of replacement. As Motorola SmartNet is not a long-term solution, the City must consider transitioning to an updated radio system platform. The supporting vendor informed Elert that today they are only able to maintain the present system by acquiring previously used hardware that has been decommissioned by others.

Since the State of Wisconsin (WISCOM) and the State of Minnesota (ARMER) both use P25 digital systems, the City should consider the P25 platform to ensure interoperability moving forward. ARMER is 800 MHz, while WISCOM is generally VHF. It should also be noted that the current City system is analog.

800 MHz Conventional

The Grandad site is equipped with one conventional channel repeater to provide a backup channel if the main system is not available for communications. As this channel does not provide the channel capacity use of the channel should be limited. The simplex (direct unit to unit) talk-around channel would also be used as well as other backup forms of communications during these times.

The main trunked communications system has very limited system coverage in the southern portions of the City. To offer some improvement conventional repeated channels are located at the 14-61 tower site to provide backup and additional coverage. The 14-61 US Cellular site has three separate repeaters for Police, Fire, and Public Works. Dispatch has access to these 800 MHz repeater channels via microwave link. When units move to these channels, they leave the trunking system and cannot be called except through the conventional channel. Each of these channels has a permanent patch to the corresponding talk group, though the user must switch channels on their radios. There is a slight improvement in coverage with the addition of this site, 75% to 85% for portable operation. This is a workaround but complicates how officers use their radios as they need to know where and when to change channels to these expansion channels. If the user happened to forget to change channels back to normal use, then an interoperability issue occurs.

A talk-around channel is also used on scene in some cases to allow communications, though dispatch does not have the capability to monitor talk around. If the user happened to forget to change channels or is involved in an operation that makes this change difficult, then an interoperability issue occurs.

Mobile Data

The City of La Crosse does not use Land Mobile Radio (LMR) channels for mobile data. Verizon air cards are for their mobile data system. The other options for mobile data using available technology today are limited though there are solutions on the horizon that should be considered in near future. Trying to put any amount of data over a primarily voice network has not proven to be a good solution. The new national FirstNet may begin to be rolled out in the next couple of years and its development primarily is being focused on high speed data though voice is also being given consideration with a gateway to P25 voice radio systems.

Public Works – Water SCADA System

The water department of the La Crosse Public Works operates a combination license-free 900 MHz multisite radio system and leased wire line system to monitor and control the various well and lift stations operating in the City. SCADA provides a proven reliable low speed data collection and control scheme that could in the future share bandwidth with a mobile data system. Attempting to mix this data need with voice on a single system is not recommended.

City of La Crosse Channels

WPCJ394, Expiration Date 04/05/2015

Loc 1 – City Hall – 43–48–42.9N, 091–15–11.5W, 37m (121.4')
Loc 2 – Control Station, WI, 6.1m
Loc 3 – Mobile – 32 km around Loc 1

1 – 856.2125 MHz, FB2C, 193W ERP, WBA – Interconnect
1 – 856.7375 MHz, FB2, 193W ERP, WBA
1 – 857.2125 MHz, FB2, 193W ERP, WBA
1 – 858.2125 MHz, FB2, 193W ERP, WBA
1 – 859.2125 MHz, FB2, 193W ERP, WBA
1 – 854.2125 MHz, FB2C, 193W ERP, WBA – Interconnect

2 – 811.2125 MHz, FX1, 10W ERP, WBA
2 – 811.7375 MHz, FX1, 10W ERP, WBA
2 – 812.2125 MHz, FX1, 10W ERP, WBA

2 – 813.2125 MHz, FX1, 10W ERP, WBA
2 – 814.2125 MHz, FX1, 10W ERP, WBA
2 – 809.2125 MHz, FX1, 10W ERP, WBA

3 – 811.2125 MHz, MO, 35W, WBA
3 – 811.7375 MHz, MO, 35W, WBA
3 – 812.2125 MHz, MO, 35W, WBA
3 – 813.2125 MHz, MO, 35W, WBA
3 – 814.2125 MHz, MO, 35W, WBA
3 – 809.2125 MHz, MO, 35W, WBA

WPCJ395, Expiration Date 06/07/2013

Loc 1 – Control Station, WI, 6.1m
Loc 2 – Grandad Bluff – 43–48–42.9N, 091–12–46.5W, 37m (121.4')
Loc 3 – Mobile – 32 km around Loc 2
Loc 4 – 14–61 Site – 43–46–25.0N, 091–07–29.0W, 45.9m (150.6')

1 – 810.2125 MHz, FX1, 35W ERP, WBA
2 – 855.2125 MHz, FB2C, 310W ERP, WBA – Interconnect
3 – 810.2125 MHz, MO, 35W, WBA
3 – 855.2125 MHz, MO, 35W, WBA
3 – 809.9625 MHz, MO, 35W, WBA
3 – 810.9625 MHz, MO, 35W, WBA
3 – 811.9625 MHz, MO, 35W, WBA
4 – 854.9625 MHz, FB2, 163W ERP, WBA
4 – 855.9625 MHz, FB2, 163W ERP, WBA
4 – 856.9625 MHz, FB2, 163W ERP, WBA

Voice Systems

All city agencies that require two-way voice communications use the single-site 800 MHz trunking system located on top of the City Hall building. Police and Fire agencies are dispatched by the La Crosse County 911. Other City talk groups may be monitored by La Crosse County 911 but do not have dispatch responsibilities for those groups. This PSAP uses a Motorola Centracom Gold Elite console system directly interfaced to the Motorola SmartNet trunking system on the fifth floor of City Hall via a fiber optic run that is installed between the two buildings.

La Crosse County 911 records all Police and Fire talk groups and other selected City talk groups. None of the conventional channels including the talk around channel are recorded. Communications channels that are recorded are shown in the tables below.

Table 1 and 2 contain lists of the City of La Crosse talk groups and conventional radio channels that are programmed into field terminals and the dispatch console system at the La Crosse County 911. Talk groups/channels that are recorded are also indicated. Type 'A' talk groups are announcement groups. The announcement group is used to simultaneously communicate to all talk groups found under the announcement group. Dispatch uses announcement groups for Police and Fire only. Most of the talk groups/channels share similar acronyms between field units and console. The City channels/talk groups recorded by La Crosse County 911 were provided by the County during an E&A visit.

Table 1

TYPE	TALKGROUP	FIELD UNITS	CONSOLE (3/23/12)	
		DISPLAY	DISPLAY	REC
A	**ALL CITY**			
TG	ALL CITY 1	CITY1	CITY 1	Y
TG	ALL CITY 2	CITY2	CITY 2	Y
TG	ALL CITY 3	CITY3	CITY 3	Y
TG	PD / FD / SPECIAL EVENTS	EVENTS	EVENTS	Y
A	**AIRPORT**			
TG	CRASH (Announce Group)	CRASH	CRASH	
TG	MAINTENANCE	MAINT		
TG	ADMINISTRATION	ADMIN		
TG	AIRPORT PD / FIRE	PD / FD		
TG	ALL AIRPORT	AIRPRT		
A	**LA CROSSE CENTER**			

TYPE	TALKGROUP	FIELD UNITS	CONSOLE (3/23/12)	
		DISPLAY	DISPLAY	REC
TG	MAINTENANCE	MAINT		
TG	CONCESSIONS	CONCES		
TG	SECURITY	SECUR		
TG	CONVENTION 1	CONV1		
TG	CONVENTION 2	CONV2		
A	**FIRE**		**FIRE GROUP**	
TG	FIRE 1	FIRE 1	FIRE 1	Y
TG	FIRE 2	FIRE 2	FIRE 2	Y
TG	FIRE 3 (RESCUE)	RESCUE	FIRE 3	Y
TG	HAZMAT	HAZMAT	HAZMAT	Y
TG	INSPECTORS	INSPEC	INSPECTION	
TG	TRAINING	TRAIN	TRAINING	Y
TG	MOSCAD DISP. AUDIO	MOSCAD	MOSCAD Audio	Y
TG	FIRE EMERGENCY	EMERG		
A	**POLICE**		PD GROUP	
TG	POLICE MAIN	MAIN	PD MAIN	Y
TG	DATA	DATA	PD DATA	Y
TG	POLICE 1	PD 1	PD 1	Y
TG	POLICE 2	PD 2	PD 2	Y
TG	POLICE 3	PD 3	PD 3	Y
TG	INVESTIGATIVE	INVEST		
TG	SURVEILLANCE	SURV		
TG	EMERG RESP TEAM	ERT	ERT	Y
TG	EMERGENCY TG	EMERG	LCPD EMERGEN	Y
A	**DEPT OF PUBLIC WORKS**			
TG	ADMINISTRATION / ENG	DPWENG		
TG	STREETS	HWY	STREETS	Y
TG	INSPECTION	INS		
TG	MAINTENANCE	MAINT		
TG	PARKS	P&R		
TG	WASTEWATER	WWU		
TG	WATER	WAT		
TG	ADMINISTRATION 2	DPW2		
TG	ENGINEERING 2	ENG2		

TYPE	TALKGROUP	FIELD UNITS	CONSOLE (3/23/12)	
		DISPLAY	DISPLAY	REC
TG	STREETS 2	HWY2		
TG	INSPECTION 2	INS2		
TG	PARKS 2	P&R2		
TG	WASTEWATER 2	WWU2		
TG	WATER 2	WAT2		
A	**MTU**			
TG	MTU MAIN	MAIN		
TG	MTU APPLE	APPLE		
TG	BUS TO BUS	B-B		
TG	MTU ADMIN	ADMIN		

A – Announcement Group

Table 2

	CONVENTIONAL CHANNELS	FIELD UNITS	CONSOLE (3/23/12)	
		DISPLAY	DISPLAY	REC
R	855.2125 / 810.2125	BLUFF	CITY BLUFF	
S	855.2125 / 855.2125	TAR		
R	854.9625 / 809.9625	14 / 61 DPW	PW 14 / 61	
R	855.9625 / 810.9625	14 / 61 FD	FD 14 / 61	
R	856.9625 / 810.9625	14 / 61 PD	PD 14 /61	

R – Repeated Channel

S – Simplex Channel

Field units communicate though the trunk radio system unless the lack of trunked system coverage forces them to operate in the conventional mode through repeaters at the Grandad or 14-61 sites or simplex through the talk around (TAR) channel. Interoperability within a department can occur when outside the trunked radio system coverage range.

La Crosse Center is equipped with a bi-directional amplifier (BDA) system to assist in providing coverage within a small portion of the building.

Paging

The City of La Crosse does not employ a paging system for alerting. The Grandad conventional repeater was used for paging Fire and other personnel at one time but today it is no longer used for paging. Some agencies reported the use of cell phones for alerting.

Mobile Data

The City uses Verizon for mobile data transmission. This system appears to service the City well. An alternative to the air cards used today would be dedicated land mobile channels. VHF and 800 MHz channel availability may be restricted due to the use of the channels for the statewide trunking networks in Wisconsin and Minnesota. UHF would be a potential band that may have spectrum available, but due to narrowbanding, the data throughput would be very limiting. If the City were to consider 700 MHz P25 Phase 2 infrastructure, the efficiency of the Phase 2 infrastructure channels could provide two full channels that could provide up to 38kbps data for the City's mobile data network though that also could change under new FCC rules relative to further narrowbanding this band.

A future system, FirstNet, utilizes LTE[1] and would provide another alternative for a mobile data network, but best case this is at least two years away if the system were to be built out in the La Crosse area. FirstNet will utilize the Band 14 portion of the 700 MHz spectrum. Additional information on mobile data can be found on page 92.

Public Works – Water SCADA System

The Water Department of the La Crosse Public Works operates a multisite system with a point-to-multipoint topology to monitor and control the various well and lift system stations operating in the City. In addition, there are a number of leased wire line connections supporting this system.

From the path study report done by Altronex Control Systems, the system is an MDS TransNET 900 system that is a Frequency Hopping Spread Spectrum (FHSS) platform operating on the 902 – 928 MHz license-free band. The report indicates that the weakest link receive signal strength indication (RSSI) is -85 dBm. The sites that cannot directly communicate with the Grandad repeater are blocked by terrain. The receiver specification for this system is -108 dBm at a 1 X 10^6 bit error rate (BER). This indicates that the weakest link of the system has 23

[1] LTE is an acronym for Long Term Evolution. LTE is a national wireless high speed data network currently under development. In most places it will likely be deployed at the state level with cellular-like wireless data service. More details on LTE can be found on page 91.

dB signal margin. From an RF design point of view, the system should work well, and if so, may continue to service the SCADA system for many years.

Most issues that occur in this band are from radio signal interference, as many devices from telephone systems to baby monitors use this band. FHSS provides isolation in frequency and in time so no specific frequency in the band is used for a long period of time and provides some immunity from interference. If interference is or becomes an issue, a licensed frequency pair on VHF, UHF, or 928-960 MHz could be considered. Equipment is also available in other unlicensed bands. These systems would use a topology identical to the existing system. It is anticipated that the current interface to RTU equipment is a relatively low speed serial data interface like RS 242, RS 422, or RS 485. Many RTU devices today use Ethernet, and there are wireless data products that also support Ethernet protocol.

Traditionally, wireless devices for SCADA have not used the 800 MHz trunking band. Cellular/PCS (and future LTE) are possible, but the ongoing cost of such a system as opposed to purchasing a private system is usually too high to justify. One potential that could be considered for this system would be to utilize the four proposed tower sites and point to multipoint technology to fixed locations in the 4.9 or 5.2 GHz bands. The microwave supporting the radio system could then be used as backhaul for the SCADA controls. This may offer a way to eliminate some of the lease lines.

Other Radio Systems

No other communications channels other than those in use for interoperability are known. City users on the 800 MHz trunking system have access to the Grandad and 14-61 (PD, Fire, and Public Works) conventional repeater channels. As the County operates on the VHF band, there are no directly interconnected communication channels. La Crosse County 911 advised that the PD Main talk group is patched to a VHF County channel, but it is one-way only. If required, La Crosse County 911 can patch one of the City talk groups to their Coordination channel if City and County units need to communicate directly.

City police and fire would prefer a solution that did not require dispatch intervention to allow instant interoperability. There are two methodologies to solve this issue with one being for the radio users to have multi-band radios and the other to set up bridged inter-band radio channels.

- With multi-band radios the user must switch to a different band to operate on the channel of the other user. On the surface this solution looks good but when the user is on this other band they are no longer monitoring their main channel and dispatch cannot reach them.

- With a bridged channel this means a talk group on the home system is created for the external VHF or 800 MHz channel or talk group. To make

this interlink work effectively both users move to this linked channel but under normal operation these channels go unused. The con, tying two normal channels together requires double the spectrum utilization.

Airport public safety personnel need to monitor the VHF Air channel at all times. Patching of this channel to a talk group will not provide the level of service needed during an event. This specific application requires two radios. A multiband radio will reduce the number of radios needed but even a multi-band radio can only listen to one channel at any one time. Patching the Air channel to a talk group with priority such that it is always heard by Airport public safety personnel would be required. During an event involving the Air Channel Elert recommends that procedures assign a person to coordinate communications with City of La Crosse Public Safety departments.

Coverage Issues

Police and Fire departments have reported numerous coverage issues. The northeast and southeast areas of the city are not covered well by the current trunking system. Fire reported many instances of indoor coverage issues throughout the City. The current City Hall single site directs RF power north and south, but buildings create reflections of the primary signal that result in cancellations, which thus create more dead zones. These reflections plus foliage also contribute to signal attenuation, resulting in the inability to effectively penetrate some structures as a result of a complex fading pattern.

Some of the reported areas are in the residential area within a mile of the transmitter site. Although specific details are unknown, it is anticipated that most issues are with portable in-building performance. The northeast and southeast areas of the city are blocked by terrain. The City has installed three conventional channels to provide limited improvement of service to Police, Fire, and Public Works on the south, but there is no such site covering the north.

Due to the mix of trunking and conventional radio technology, the means of improvement of coverage comes at a price that is related to operational ease. Coverage predictions for the current areas are found in Coverage Predictions on page 46.

The La Crosse City Fire department has cataloged locations where they have had problems communicating. Most problems appear to be associated with an out of range condition in that the radio cannot communicate with the repeater station. A map provided by the City showing the locations of the reported problems can be found on page 77 of this study. There are also reports of multiple dead areas within the airport, including inside areas where security tends to operate and at the end of the runway. Transit also reported that they experience weak areas in West Salem using mobile units.

Some time ago, La Crosse Center users reported communication difficulties within blocks of City Hall. These difficulties were attributed to excessive building penetration losses. To improve the in-building signal, a bi-directional amplifier (BDA) system was installed in the La Crosse Center complex. Antennas were installed on the rooftop and in the kitchen area. Even with the BDA system in place, however, communications issues continue to plague users. It was also reported that between events, communication appears to be better than when an event is taking place. There is a possibility that other radio systems could raise the noise floor and potentially introduce intermodulation products[1], but it would appear that this would be isolated and not reoccurring. The BDA should be channelized so only trunking channels are amplified. During on-site observations from the City Hall site it was noted that most of La Crosse Center is blocked by the U.S. Bank building.

Field Units

Agencies within the City of La Crosse are equipped with various models of Motorola mobile and portable radios units. The inventory can be found in Appendix 2 – City of La Crosse Inventory on page 76. Some units are equipped with P25 capability. The City of La Crosse was rebanded in 2007-2008. During this process, 39 portables and 94 mobiles were replaced with new units. Replacement was determined by whether the radios had the NPSPAC channel capability before the process and whether it could be flash updated to keep it after or if it had to be replaced. If it did not have the NPSPAC capability before, then it was just reprogrammed. For those users whose radios were not replaced, most radios are very old. The Fire department reports that batteries (NiCAD) do not last a complete shift, and spares are needed at the scene of each event.

The following mobile radios are included in the City of La Crosse inventory:

Qty	Model	P25 Capability
9	MCS2000	No
66	XTL SERIES	Yes with appropriate firmware installed
20	GTX MOBILE	No
136	MAXTRAC	No

The following portable radios are included in the City of La Crosse inventory:

Qty	Model	P25 Capability
213	MTS2000	No
4	GTX	No
36	XTS2500	Yes with appropriate firmware installed

[1] Intermodulation is the result of mixing of two or more frequencies and their harmonic frequencies. The result is several frequencies or products. If any of these products are close to a receiver frequency they can create interference.

3 MTX850 No

In addition to mobiles and portables the City has 18 Motorola XTL Consolettes[1] with 54 Motorola MC3000 remote control units[2] in the inventory. These remotes are installed throughout the City facilities. The XTL platform is capable of P25 operation with the appropriate firmware installed thus not requiring change-out for a future system utilizing P25.

Some users identified the need to communicate privately, unit to unit. The current system has the capability, but due to the impact on system capacity this feature is not implemented in the majority of field units. If this capability were to be used, the impact to capacity would need to be evaluated and policies in place to ensure minimal impact to overall system performance. If everyone had the ability to receive an individual call but only select units (i.e., supervisors) had the ability to initiate this type of call, this should limit any adverse impacts to system capacity.

Each department employs at least one RF control station at a fixed location for communications with other department personnel who operate in an office environment and do not carry a radio. As multiple personnel require access to radios, lower cost remote control devices are used to provide the ability to operate the RF control stations. Most remote control units (remotes) are similar to a telephone handset with a push-to-talk button to make a transmission. Multiple remotes can be interfaced to a single control station through a remote adapter, which provides the audio and control interface to the control station. Wire line connections are necessary to provide the connectivity between the remote and the control station equipment. The control station radio can be placed in virtually any location that will provide power, access to the wire lines, and a suitable antenna mounting location. Several agencies use remote control units to provide radio access to personnel who do not carry radios. The one limiting factor is that only one user per control station can communicate at a time.

The following graphs reflect the mobile and portable units currently in use by City agencies. It is anticipated that the majority of the field terminal units would be replaced in the transition to P25 operation.

[1] A Motorola XTL Consolette is a self-contained mobile radio and power supply for use on the system with a fixed antenna system. Operation is virtually identical to a mobile unit. Department users may refer to these units as base stations.

[2] A Motorola MC3000 remote control unit is a remote control commonly used with the Motorola consolette. The remote can be placed where it convenient for the user, wires connect the remote control to the RF unit or consolette. Multiple remotes can be connected to a consolette allowing multiple users to use the same radio saving on the number of consolettes and antenna required.

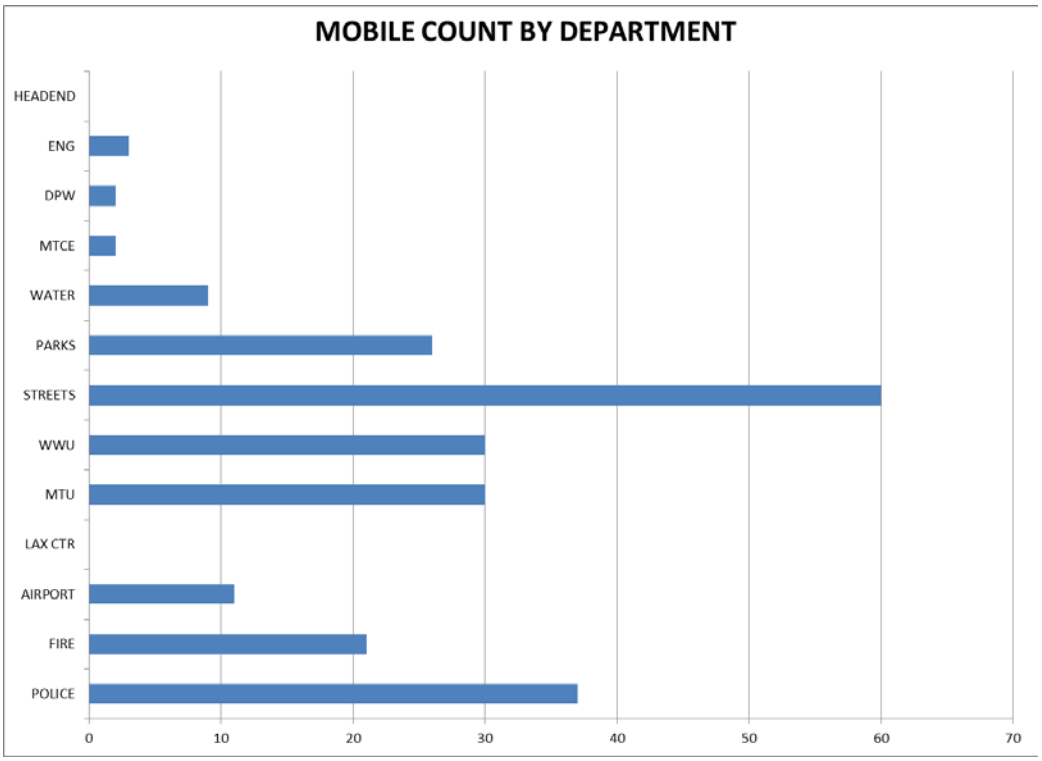


Figure 1: Mobile Count by Department

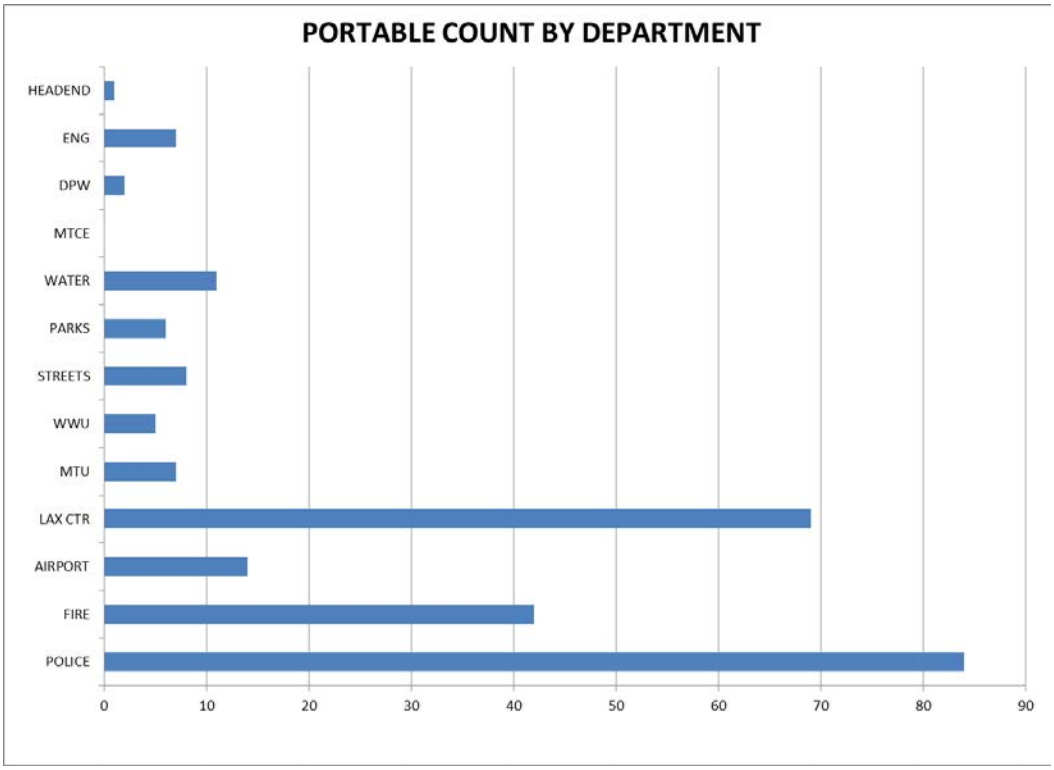


Figure 2: Portable Count by Department

Improvement Options for the City of La Crosse

There are multiple possible solutions for a radio system upgrade though throughout the country in cities of the size of La Crosse the use of trunked radio to satisfy these needs has become abundantly clear. La Crosse made this decision the last time the present system was developed and there are no reasons Elert can find to turn away from a trunked radio solution. In this past decision the solution was to move to 800 MHz operation and this band does offered better in-building penetration/coverage than VHF which is used by the County.

The biggest improvements the City can gain will be to move to a standards-based P25 digital operation and to have a system consisting of multiple base station sites that improve coverage for its public safety community. The following section describes some of the remaining issues and options:

APCO P25 Digital

As the City of La Crosse is situated on the Wisconsin–Minnesota border and both States have adopted P25 platforms for statewide voice communications, the City could chose to become a participant in either of these two systems. Minnesota is using Motorola infrastructure and Wisconsin is using EF Johnson. There are operating parameters established for both systems that would need to be accepted and adopted. There also would be political obstacles to overcome to participate in the Minnesota ARMER system. Although joining the ARMER system is assumed to be manageable, it may take additional time, resources, and political approvals. Both systems are engineered for mobile, not portable (handheld), coverage, so adoption would require additional sites to provide the desired portable coverage.

Minnesota is an 800 MHz trunked system (ARMER), and the Wisconsin system (WISCOM) is a VHF P25 trunked system. If the City chooses to participate in ARMER or WISCOM interoperability with only one other P25 system, infrastructure would be required. Becoming part of either system would force the City to adopt specific technology, as there is only one vendor for infrastructure for each. If WISCOM were chosen, the City of La Crosse infrastructure could still be 800 MHz, but the City would not be able to take advantage of any of the WISCOM system coverage unless the city also elected to use dual (multi-) band radios.

An alternative is to become an independent system and establish interoperability connections with both of these P25 systems. Pursuing this option will allow the City to consider all P25 system infrastructure approaches, resulting in proposals from most likely 4-5 vendors. EF Johnson, Harris, Motorola, Cassidian, and Tait offer P25 system infrastructure. Other, less known vendors also have P25 infrastructure. Each vendor designs their infrastructure to the P25 specification, but they each use different approaches, so infrastructure components are not interchangeable.

Most new P25 field units from any manufacturer will work on any other vendor's infrastructure due to the P25 air interface standards, but may be limited in the frequency bands for which they are designed to operate and features that may be vendor specific and outside the P25 specification.

The major manufacturers of P25 infrastructure vary in their system designs. As such, infrastructure can only use one vendor product. As the City of La Crosse recommendation is to continue use of 800 MHz channels, the infrastructure employed for the City would use this band. The WISCOM P25 system uses the VHF band, and the ARMER system uses the 800 MHz band. This does not prevent the City from using a WISCOM type platform with 800 MHz, but it does mean that both a VHF and 800 channel would be used if communicating anywhere on the system.

If an independently operating system is chosen and if the City chooses either the EFJ or Motorola platforms, the ability to become a participant in WISCOM or ARMER still remains in play (if it is in the best interests of the City). During the acquisition process, this could be suggested as an optional alternate, as has been the situation with other recent system designs. Depending on discounting at the time this could well become a valuable option.

For the most part, P25 users regardless of manufacturer can communicate on any vendors' infrastructure as long as the radio operates on the same band and has the necessary trunking firmware. High tier field radios available from some vendors today can operate in multiple bands and remove this band limitation. As WISCOM and ARMER operate on two different bands, this may be a consideration for the City of La Crosse to ease interoperability for some users. Interoperability can be achieved by other preplanned methods between networks but also have limitations in flexibility. The number of vendors offering a P25 multiband radio is limited to Thales, Harris, and Motorola at this time.

It is highly recommended that all routinely used channels in support of the needed interoperability should be designed into the system. As an example, a VHF repeater or base station could be set up and linked to an 800 MHz talk group. Then the 800 system user just moves to that talk group and the VHF user to the particular VHF channel and interoperability is seamless to both users. This is the method that would be used within the City boundaries.

800 MHz interoperability with the Mutual Aid Box Alarm System (MABAS) at VHF frequencies should be accomplished using vehicular cross band repeaters. Use of these systems would be under the control of the local incident commander. These stations would be portable and likely be built into a metal suitcase type enclosure or housed on a command vehicle.

P25 Phase 2 Trunking

P25 Phase 2 is another option for consideration as this solution splits each RF channel into two time slots, thus allowing two separate voice channels to operate in the space of one, as with the Phase 1 capability today. Elert & Associates is not aware of any Phase 2 system operating on VHF or UHF; rather, they typically operate using 700 or 800 MHz. This standard is still being finalized. Thus, any implementation today may require some change in the future.

Motorola and Tait Radio offer this capability[1] today in their infrastructure product currently, but it is expected that other manufacturers will offer this capability in the near future. Phase 2 will lower the number of RF channels needed for a specific capacity level as it increases system efficiency. The FCC has not yet forced P25 Phase 2 to be utilized.

On the positive side, Phase 2 would give the City of La Crosse additional channels without the need to license additional frequencies. The six existing channels would provide a control channel and ten voice channels or a control channel, six voice channels, and two additional 800 channels for other services.

On the negative side, Phase 2 radios are more expensive than Phase 1, and the cost of infrastructure can also be higher. To provide interoperability to Phase 1, at least one or two channels should remain Phase 1 only. Neither Minnesota nor Wisconsin utilize Phase 2 architecture.

Another aspect to P25 Phase 2 is that the system will always support P25 Phase 1 technology. If any P25 Phase 1 user in the system is a participant in a call, the system will only assign a channel capable of supporting that user. If a P25 Phase 2 system is implemented, the ability to operate in P25 Phase 2 mode will be dependent on the capabilities of the P25 users that are using it. ARMER is P25 Phase 1. Any user on the ARMER system that remains P25 Phase 1 will always use a full channel if they would affiliate with a P25 Phase 2 system. Thus, as stated, it would be recommended that some channels remain Phase 1 only. In fact, the control channel for Phase 2 is a Phase 1 channel.

Number and Location of Base Station Sites

Portable (handheld) and mobile system coverage is an issue for all users with areas in the northeast and southeast portions of the City, and indoor portable coverage problems are experienced citywide. To improve portable coverage, the signal density must be increased in areas that are blocked by terrain and other

[1] The P25 Phase 2 standard is yet to be released. Motorola offers their unique version of P25 Phase 2 as an alternative. When P25 Phase 2 is released an update would be required to provide compatibility with other P25 Phase 2 units. Tait offers infrastructure equipment today that is P25 Phase 2 ready and P25 Phase 2 ready field units are to be available in 2013 but their system will not operate in P25 Phase 2 mode until the standard is released and an update is installed in all system components.

buildings. No one site will cover the entire area. Multiple sites will be needed to provide increased signal strength throughout the service area. Three to four sites are anticipated to be needed to fully cover the city. Simulcast is recommended to provide citywide operation on the six channel set of RF frequencies licensed by the City today.

The current single trunked repeater base station site location is higher than most of the buildings, but communications issues still appear very close to the site. This indicates that the signal level on the ground is either weak due to blockage or the signals entering the area suffer from phase cancellation and cannot be successfully decoded by the receiver. Multipath and fading are common characteristics found in an 800 MHz system. One potential alternative would be to find a site that has a better 'look' into the City, while another is to use more than one base station site when the first option will not provide the coverage. Elert was unable to find a single location that could serve the entire city at the coverage levels desired.

Antenna height is a huge factor for range in a communications system, but height can also create interference issues for co-channel users. At 800 MHz, the short wavelength allows antennas to be engineered to shape the coverage pattern of an antenna. Antenna systems can also use electrical or mechanical beam-tilt to focus maximum radiated signal to the ground and not the horizon. Antenna systems at 800 MHz should be designed to place the main beam of the antenna across the service area. Modern antennas at 800 MHz provide control of the horizontal and vertical pattern to place signal where it is desired.

When multiple sites are utilized, there are two options: simulcast or multicast. With simulcast, all channels are transmitted from all base station sites and timed to deliver their signal as equal as possible to all terminals. This requires GPS receivers and care in the delivery of the signals to each site. The other option is multicast, though this option requires a set of frequencies for every channel at every site. Obtaining these frequencies may not be feasible in most areas of the country. Simulcast is not perfect, though it is a feasible solution if properly designed and implemented.

The best sites for the area will be from bluffs that are found east and west of the City. The 14-61 site predictions indicate that this site is able to cover the extreme south end of La Crosse and the Shelby area well but not a major portion of the City. The northeast portion of the City is blocked by the bluff. A new site could be developed on the Mississippi Valley Conservancy Property on the north end of the bluff to address this area. A tower on this property would require FAA approval though due to the height of the bluff the tower would only need to clear the trees and close by outcroppings. As there are other towers in the immediate area, approval should not be an issue, but there may be a limitation on tower height. Part of the City boundary is very close to the bluff, and there is a chance that the bluff may block a small area, but this site would cover the entire northern

portion of the City of La Crosse and Onalaska. The site would need to be fully developed compound with a self-supporting tower and shelter with generator.

One of the potential sites to cover the central portion of the City is Grandad Bluff Park[1]. It has an excellent view of the majority of the City from a height over 500 feet above the City. This allows signal to reach most of the City virtually unobstructed. The biggest issue with the site is the park location. The antenna system would need to be disguised and a suitable location found for the equipment and backhaul antenna. A disguised antenna may limit the type of antenna used and the ability to cover the areas below the park. Due to the height of the park location, the main beam of the antenna may pass over the areas close to the bluff. One of the offered options includes this site.

Building signal penetration in the City's downtown area could also still be a concern. It is over two miles from the park to the river. Larger buildings would likely shadow other buildings to the west. Although signals may bounce into these areas, the signal levels will decrease and may impact performance. A fourth site on the Minnesota side looking into the City from the west would provide an alternate signal source that would be beneficial for illuminating the City from the west. A fourth site on the Minnesota side of the river could also cover areas that the main beam misses from the park site. If this is the case, an alternative to the park site is the Grandad tower. The selected site is set back to east and is partially blocked by the bluff, but will reach the downtown area of La Crosse. This would eliminate the need to develop a second site, but all established sites would require tower studies, equipment shelters, and backup power systems. The site selected for modeling is the County's Lawton tower which is leased.

Although a system may be constructed to provide some enhanced degree of indoor penetration, facilities like the airport terminal and La Crosse Center should consider a distributed antenna system (DAS) to provide coverage throughout the facility. Once a new system is in place, testing should be done to determine the level of penetration. DAS antennas could be strategically placed within these locations to illuminate the desired areas. The DAS system would provide the filtering to remove external sources of RF noise and interference that may be entering the building via the setup crews, etc., for any event that may be taking place at La Crosse Center. The exact equipment requirements really cannot be determined until the new system is online. The current BDA should continue to provide some assistance when the transition is made to the new radio system platform. As the new radio system design may provide some additional building penetration, this must be considered in the design of the DAS system. Receive level testing could be done by using a control channel signal from the MN DOT

[1] Two Grandad sites are under consideration for repeater sites improving the City of La Crosse communications system. Grandad Park is located at the rim of the bluff and overlooks the City. The Grandad tower is owned by the County and is a key site for microwave connectivity regardless of the option chosen. The Grandad tower site is located about 1.3 air miles east of Grandad Park.

P25 system, which is just under five miles to the northwest. The cost estimate for improvements for a full BDA system supporting public safety is $1.00-$1.50 for every square foot of area that requires coverage, assuming a minimum of $15,000.

Operations

Some City agencies use cell phones for normal department communications. Cellular operation may be limited or unavailable during a catastrophic event, and any user unfamiliar with unit operation may not be able to use a portable or mobile unit to its full capability. Daily use of system equipment and periodic training is important to ensure utility at times when all other forms of communications may be down or when other system capabilities are required.

LCPD reported that portables radio units are shared by Police personnel. It is anticipated that programmable options set up by the current users will impact future users of any field unit. A change in user programming options may not be immediately recognized without reviewing the programming upon the start of each shift. The changes required could vary from day to day, making it difficult to have the radio perform with maximum utility for the user. An assigned radio generally makes more sense and also places responsibility on the user.

If desired, the system supervisors should be able to provide the ability to talk privately with a user in the field. As cellphone use may be limited while driving, the ability to provide this capability through the radio system may be desired. A private call between a driver and a supervisor was one of Transit's requests, but it could be utilized in any department. The ability to send text messages may be an alternate form of unit-to-unit communications for some department users.

Interoperability

Today, interoperability is a challenge, as the University of Wisconsin Police, surrounding communities, adjacent Wisconsin counties, and the State of Wisconsin utilize VHF. Interoperability can be achieved through a patch, but this requires assistance from La Crosse County 911. Since the County remains on VHF, they will be able to provide the majority if not all of the VHF interoperability required for operation. The City may desire the University of Wisconsin Police join the City's P25 system to establish common law enforcement communications within the City.

Interoperability gateways can provide the link to VHF if required. It is not recommended that most VHF channels be permanently linked to a talk group on the trunking system unless the traffic is very limited. These patches will reduce system capacity for trunking system users by utilizing trunked system channels for normal VHF channel traffic. Patches are normally enabled as required.

P25 to P25 interoperability will depend on the interface provided. The WISCOM system may provide an inter-subsystem interface (ISSI) that can pass P25 system

information, while ARMER currently uses a control station for interoperability with WISCOM. The capability of these interfaces will depend on the manufacturer of the equipment and the willingness to allow the interface.

If the new system were actually an extension of WISCOM or ARMER, then there would be natural interoperability with that system. Because ARMER is already connected to WISCOM with control stations, using WISCOM as a controlling entity could provide this link if authorized. ARMER has not yet authorized any direct system to system interoperability gateways rather they recommend the use of control stations.

Logging/Recording

Since P25 is a digital system, the signals that are sent over the backhaul to all elements of the system (including dispatch) are digital. The conversion to analog audio occurs at the dispatch console via a gateway. Loggers for P25 systems will decode the P25 protocol and record the audio digitally. Several talk groups of the City of La Crosse analog trunked system are currently recorded as analog because the console in use today is analog. To continue recording these groups when a P25 system is implemented, the P25 signal will need to be converted to analog audio. If any encrypted groups are recorded, the logger will need to be equipped with the appropriate decryption equipment and be included whenever keys are changed. This issue must be addressed in the final design.

Talk-Around

Today public safety often uses talk around (TAR) to establish communications on-site using the repeater transmit frequencies of the 800 MHz conventional channel repeaters located at the 14-61 site. In a new system design, it is anticipated that this need would decrease, as the system would provide increased coverage capabilities, but it may not completely remove the need to use TAR channels. Currently the TAR channels are not recorded, as on-scene events could occur anywhere and there are no receivers employed around the City to monitor this activity. In a new system design, if the TAR channel needs to be monitored and/or recorded, the infrastructure would need to be designed to support this requirement. Receivers programmed to the current TAR channel would be in the same area of the 800 MHz band used by the repeater transmitters, so the multicoupler system could not be used. The TAR channel could be the repeater input channel and the receive antenna system-multicoupler system could be used to receive backhaul to a voter and send recovered audio to La Crosse County 911 to be monitored and/or recorded as necessary.

Multiband Radios

Today the City users make use of analog 800 MHz trunking radios that only operate on the 800 MHz band. These units only support Motorola SmartNet

trunking and conventional 800 MHz. In conventional mode the radios make use of the fill-in repeaters located at the 14-61 site, the backup repeater at the County's Grandad tower and direct radio to radio.

As the move by the City would be to digital P25 trunked radios another option would be to acquire some or all multi-band radios thus providing support in one radio to operate on the area VHF channels also. The multi-band radio is physically larger, heavier and more costly than a single band radio though it does have advantages.

WISCOM and all Wisconsin counties in the area operate on VHF frequencies. Use of multiband radios would allow users to communicate directly with these systems improving interoperability. Today interoperability is limited to manual console patches with base stations that are set up to operate on these frequencies. Set-up of the patch requires dispatch intervention and there must be a VHF radio and associated antenna system to support the patch. Multiband radios can provide the user with numerous approved frequencies for the cost of programming.

Not all P25 vendors have multiband mobile and portable offerings but as P25 is a standard other vendor radios will operate on any P25 network. As WISCOM and ARMER system both operate on P25 but on different bands the utility of a multiband P25 radio would be beneficial to City of La Crosse public Safety personnel. Also La Crosse County and other surrounding Wisconsin counties operate on VHF conventional. If a unit were ever in one of these other networks that radio would be able to communicate with local departments.

The utility of multiband radios will be determined by department and the department interoperability requirement with other departments not using the same communications system.

It should be noted, once a user changes channels to communicate on another network or band the unit no longer receives calls on their default system and thus will lose contact with dispatch. The appropriate communications procedures must be developed and training of users concerning these procedures is a must to ensure consistent communications.

AVL

Automatic Vehicle Location (AVL) was also desired by Transit and mentioned by Fire staff as desired. AVL could be incorporated in a digital trunked system though the frequency of polling could affect channel capacity. AVL would require a GPS signal to be sent to a central site along with a time stamp to provide location information for City assets. Although this data could be sent through a trunked radio system, the major impact is to system capacity. The number of units requiring AVL and the update interval will drive the amount of airtime that would need to be dedicated to this service. If only Transit needs AVL with fifteen units on the road at peak hours, the impact to the system may be minimal. Modern

transit systems will track and update transit stations as to arrival time and potential location of Transit vehicles for those who use these services.

There are other methods to provide the AVL service that should be reviewed for this use.

Encryption

Encryption for P25 is digital, and although there are several versions, AES has become the standard digital encryption formant for public safety. Use of encryption requires policies to maintain security. All manufacturers offer AES and other lower levels of encryption. AES is recommended, and as there is a relatively significant cost related to the purchase, only units that absolutely need it should be equipped. Encrypted groups should be separate from clear groups. Any group that could run clear or encrypted will ultimately be a problem unless all units are equipped with encryption. A unit with encryption and operating in clear mode will still receive an encrypted call (assuming the correct codes are programmed), but any unit not equipped with encryption will not be able to determine that a call is in progress and can lead to communications issues.

Backhaul

Any system will require back haul to link sites, network management, and any directly connected console systems. The system backhaul can consist of microwave, fiber optic, or wire line (leased T1). Microwave is commonly used for radio systems, as it is very reliable and controlled by the owner. Both fiber and wire line connections run under ground and overhead, and although exclusively used for public safety purposes, they use utility routes and can be severed by construction activities. Today most networks use Internet protocol for communications rather than linear analog circuits.

Remote Field Unit Programming Options

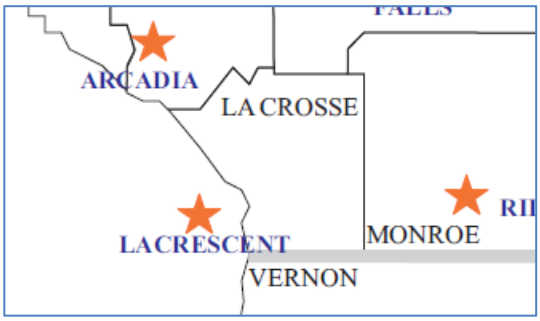
There are two remote programming options some users have considered and added via alternates in the acquisition process. The first option is Over The Air Programming (OTAP) and Over The Air Rekeying (OTAR). With both features there is an initial and an on-going support cost. The saving is measured by the fact field units can stay in the field and in use while not having these features mean the radio has to be brought to the shop for changes.

OTAP allows changes to the personality of the radio while OTAR allow the encryption key to be managed remotely. Both actions can occur over the air and while the radio is in normal operation.

P25 System Choices

WISCOM

The WISCOM network was built by the State of Wisconsin to provide statewide mobile coverage. The system uses the EF Johnson P25 platform, and sites are generally equipped with five channels and are interconnected by the State's microwave network. Some remote sites may have fewer channels, and in areas where the local community or county has chosen to join the WISCOM network, the number of channels at the site may be increased and the density of sites may be greater to provide portable coverage. There are no WISCOM sites within La Crosse County. Three sites service the County including one in Minnesota.



In a wide area, system units of the same talk group quite often reside in multiple sites. Activity on the talk group must be sent to all other units that use that talk group. Unlike other vendors, the WISCOM network does not use a central controller design. Each site communicates with other sites over the microwave network to provide call information. Trunking assignments are made locally and distributed to other sites along with digitized audio in the VoIP format. This differs from all other vendors that use central controllers. All talk group requests and digitized voice audio is sent to a regional or central location for processing for each transmission. The controller tracks the location of each member of the network and directs control information and digitized audio to each site that has a talk group member. The primary use of the WISCOM controller is to authenticate system users and set their priorities on the system.

WISCOM has made talk group and user ID assignments statewide to enable management of the statewide system. A fixed number is allocated for every county in the state. La Crosse County is allocated 500 talk groups and 100,000 unit IDs. For interoperability, City of La Crosse units would use talk groups assigned within those allocated, regardless of the radio vendor chosen. WISCOM does allow state users of the system to expand coverage locally using VHF, though it may be necessary to offer presently licensed frequencies for this use. More information on WISCOM can be found in *Appendix 4 – WISCOM*.

At its meeting on October 24, 2012, the Statewide System Management Group confirmed that the City of La Crosse would not pay user fees for its radios if it built a trunking system that was integrated with WISCOM. WISCOM has set rates of $50 per year per radio for users.

Connectivity to the existing La Crosse County 911 radio console would be via control stations as is the situation today thus not offering the full richness of the trunking capability available. EF Johnson does have a console offering also that could be proposed and thus provide direct connectivity.

ARMER

The Minnesota ARMER network uses the Motorola Astro 25 platform, which is P25. Like WISCOM, the network was designed to provide mobile coverage statewide. Each site is built with five channels, and many communities and counties have joined ARMER for local communications. Some were required to increase the channel count per site due to increased traffic, increase the number of local sites to improve portable coverage, or both. The network has six regions, and the region adjoining the City of La Crosse and La Crosse County is the Southeast (Rochester) region.

ARMER sites are generally equipped with five channels and are interconnected by the ARMER State microwave network. Some remote sites may have fewer channels, and in areas where the local community or county has chosen to join the ARMER network, the number of channels at the site may be increased and the density of sites may be greater to provide portable coverage. Elert & Associates understands that Houston County and Winona County in Minnesota are served by multisite network.

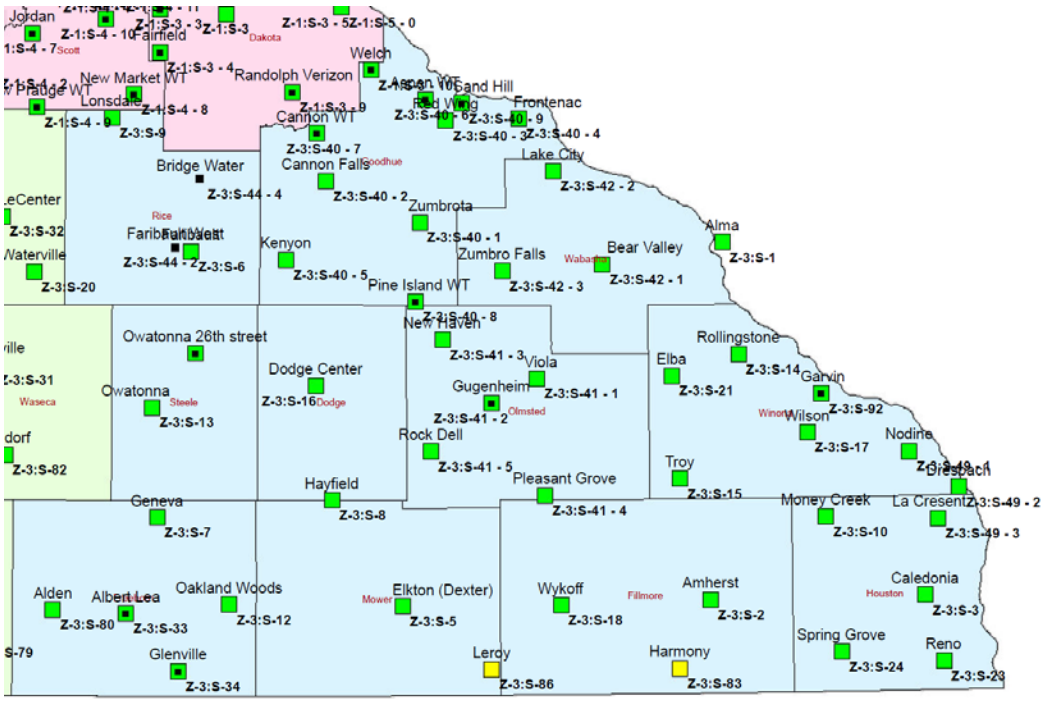


Figure 3: ARMER Southeast Region

If the City of La Crosse were to use the Houston County La Crescent site for coverage and additional channel capacity is warranted, additional repeaters would need to be added to this site. The map in Figure 3 indicates that Houston County has five sites. If the City became a participant in the ARMER network, the City of La Crosse would have its own simulcast system connected to the controller in Rochester, MN connected via City of La Crosse or County of La Crosse microwave and the ARMER microwave network. The City could potentially operate similarly to the State of Minnesota and use the adjacent sites for coverage. Whether or not additional channels would be necessary would be a question that would require further study and authorization from the ARMER authority. If the City system provides the majority of the City coverage, the requirement to move to the MN system should be minimal, but it would need to be approved. If the ARMER extension were to be possible then it would also be possible to support the Motorola line of radio consoles. A minimum of two T1 circuits to the La Crosse system and two to the dispatch center would be required. In addition, the dispatch console will require an upgrade to offer connectivity to the Rochester Zone Controller.

An Inter Sub System Interface (ISSI) is available from Motorola for interoperability to ARMER, but any use of State of MN resources by the City of La Crosse would require an agreement with the State of MN. No such agreement current exists and it may take additional time to get it in place. In addition, Elert is not aware of any implementation of an ISSI interface to ARMER thus this would also be new ground and approvals as an ISSI requires both entities to agree and support.

EF Johnson

The EF Johnson P25 trunked radio system infrastructure is named ATLAS™ and is unique as it uses distributed processing to control the trunking infrastructure. There is a logic unit for each trunked channel at each site. The logic unit assigned to the control channel processes call requests, and in a multi-site network distributes call signaling information as required to other sites where units of the same group are present. If the logic unit becomes disabled, another channel is assigned to be the control channel and takes over call processing. The system is IP based, and a backhaul network provides connectivity between sites along with any activity taking place on system sites. Field units are tracked as they move in and out of sites across a wide area network. All sites store unit site affiliation information on the users of the network.

A web-based network management system is used to configure and manage all system elements. EF Johnson produces the StarGate™ dispatch console for use in the P25 system. EF Johnson produces a gateway and interfaces to provide interoperability with other conventional or trunked radio systems. It is possible such a console might be proposed to replace the existing analog console thus

providing a full richness of services. EF Johnson recently introduced their simulcast system solution.

The EF Johnson simulcast solution has one master site and one or more remote sites. The master site provides the synchronization necessary for simulcast operation. Failure of the system control at this location will prevent simulcast operation just as any other simulcast system.

EF Johnson is P25 Phase 1 (FDMA) compliant. EF Johnson will have P25 Phase 2 (TDMA) infrastructure products in the future

The advantage of a distributed architecture is that if the backhaul should fail, the system is split into two radio networks, and the system will continue to trunk normally until the break in the backhaul is restored. The ability for the system to maintain user information is limited to the sites still connected via the remaining backhaul. After restoration of the backhaul, the user database for each site will need to update any users for sites lost during the outage. The time required may vary depending on the system load. Assuming the City adopts a multi-site simulcast system, this would impact the City of La Crosse only if it were a participant in the WISCOM network.

Interoperability with WISCOM would likely be accomplished through an EFJ gateway. Interoperability with ARMER would be via a gateway or an ARMER control station.

Other items concerning the EF Johnson network include the following:

- No ISSI interface required for interoperability to WISCOM
- Control station interface likely required to connect to Motorola dispatch console
- New EF Johnson dispatch console system could easily interface to existing County VHF system

Harris

The Harris P25 system is named P25^{IP} and uses a central processing architecture. Call requests are received, transported, processed, and distributed from the network switching server over the backhaul network. A backup of the network switching server can reside at a different location as long as it is connected to the backhaul network. The system can be set up as message trunked or transmission trunked. For transmission trunked, each PTT could utilize a different channel. For message trunked, the channel is held to allow a response to come back before returning the channel to the trunked channel pool for other talk groups. If the primary system is disabled, the backup server takes over. This unit will remain in service unless it is switched back manually or until it suffers a failure and it switches back to the other. Field units are tracked as they move in and out of sites

across a wide area network. All site affiliation information is stored at a central database on the network. A web-based network management system is used to configure and manage all system elements. Harris produces the Maestro™ dispatch console for use in the P25 system. Harris produces the VIDA (Voice, Interoperability, Data, Access) IP gateway system to provide interoperability with other communications systems.

Harris is P25 Phase 1 (FDMA) compliant. Harris will have a P25 Phase 2 (TDMA) product in the future, and equipment today should be upgradeable to Phase 2 in the future when the P25 Phase 2 standard is released.

Simulcast operation is obtained via a control point located at one point in the system infrastructure. Failure of the control point will stop simulcast operation. The infrastructure is programmed to provide conventional operation at a pre-assigned channel if simulcast is disabled or a failure occurs.

Motorola

The Motorola P25 system is named the ASTRO 25 network. This system uses a central controller. In the Motorola system, the primary and secondary controllers must be located in the same physical location. In large systems, controllers from other regions could back up these controllers if desired and available. The Motorola system is designed to use the ASTRO 25 core. The core supports the radio access, command and control, and network interoperability. The core is available in multiple sizes to support a varying number of sites, channels, data, system features, interoperability elements, and number of users on the system. For the City of La Crosse, more than one core could be considered. Motorola has one core that would employ a system named SmartX to ease the transition to the P25 platform. This is a fully featured and more expensive core for which many of its capabilities would need to be investigated as they may not be utilized in the future.

Motorola has P25 Phase 1 and a Motorola version of P25 Phase 2 trunking available in the ASTRO25 system. As P25 Phase 2 utilizes the spectrum more efficiently, this system can provide the same voice communications with half the licensed voice channels and use the remaining portion of the license spectrum for other purposes like data transmission.

Motorola produces the MCC 7500 console, which would be used in most dispatch centers. They also have a MCC7100, which is designed for portability and as such really does not offer the feature of a full console operation.

Key items concerning the Motorola solution include the following:

- Additional equipment would be required to interface the County’s current Centracom Gold Elite console system to the system controller.

- Due to the age of the County's console equipment, Motorola suggests using control stations for the system interface. This would impact the ability to take control of a channel if this need ever surfaced. Although priority could be set higher, dispatch would not be able to take control of the transmitter.
- A partial or full console system replacement should be considered.
- As ISSI may be possible to provide interoperability with ARMER and/or WISCOM.

Tait Radio

The Tait P25 product is named TaitNet P25. Like all other manufactures, the Tait P25 system is designed to meet the P25 standards. Tait Radio is based in Christchurch, New Zealand, and the U.S. office is located in Houston, TX. The Tait design uses a central controller, and they employ IP to communicate to all elements of the system. Each site also has a site controller to process messages to and from field units. The TaitNet P25 simulcast system uses centralized voting but has the ability to use several sites for redundancy. The remaining functions and management features of the TaitNet P25 system are similar to other manufacturers. The system supports digital encryption and uses management systems where much of the updating can be done from virtually anywhere.

The Tait P25 platform is software-upgradeable to Phase 2. Tait announced its Phase 2 system at the 2012 APCO conference.

Key items concerning the Tait Radio solution include the following:

- Additional equipment (Tait gateways) would be required to interface the current Centracom Gold Elite console system to the system controller.
- As ISSI may be possible to provide interoperability with ARMER and/or WISCOM.
- Tait does have arrangements with at least two possible radio console manufacturers for direct interfacing and control of their trunking system.

La Crosse County 911

Dispatch Console System

The radio dispatch console system used at La Crosse County 911 is a Motorola Centracom Gold Elite. This system is no longer in production but has some

limited direct interface capabilities into the Motorola ASTRO 25 system. It also has limitations when operating with other manufacturer's P25 trunked radio systems although a MDC1200[1] interface can be used to somewhat get around limitations.

As referenced above Motorola would use control stations and any other P25 system would also use control stations to operate on their P25 system. In doing so some features will be lost or there will be a work around to get them to work. The biggest feature loss will be the inability to directly control the system infrastructure. Control stations at La Crosse County 911 may be assigned a higher priority for access but it cannot take over a channel and it cannot receive while transmitting.

Clearly the continued use of the Gold Elite will have some level of limitations whatever the trunked solution selected. Although an interface with the Motorola P25 system will have the fewest limitations interface to other P25 systems may be less than the feature set of the current system. Features like a simple P25 to P25 patch would be done at a control station level and use multiple P25 channels to complete. With an integrated dispatch console system patches between P25 groups establish a temporary talk group where only one channel is utilized.

Most manufacturers have engineered console systems that are integrated into their P25 infrastructure. The choice of infrastructure usually dictates the dispatch console system that is used. All P25 manufactures but Tait Radio offer an integrated dispatch console system. Tait utilizes a standards-based console interface thus supporting the likes of AVTEC and Zetron.

Other vendors of dispatch console systems do exist and attempt to sell their systems but it is very difficult to design a generic console that can be used with all of the P25 systems without a standard. AVTEC, ModUcom and Zetron are three vendors of consoles products not directly associated with P25 equipment manufacturers. The P25 Console Subsystem Interface (CSSI) and Fixed Station Interface (FSI) are specifications that would provide a standard interface to P25 fixed stations and console devices. As these standards are not complete no vendor of the console can assure an end user of operation and the selection of any one of these consoles may be subject to changes, likely limited to software, to allow them to meet the standards when finalized.

The selection of the P25 infrastructure will need to be a collaborative effort with La Crosse County. It is highly likely that the selection of the City of Lacrosse P25 infrastructure will drive the County to change at least a portion of their dispatch console system to attain the level of utility that is expected from the new P25 communications system that the City will utilize.

[1] MDC 1200 is a digital signaling interface that allows the received radio's unique identifier to be displayed at the console.

Propagation Predictions

City of La Crosse Terrain

Figure 4 shows the terrain of the City of La Crosse. There is an approximately 640-foot differential in elevation from the river valley on the west to the bluffs on the east. The city boundaries go around the bluffs on the northeast and the southeast. While the majority of the City is generally flat, there are variations in terrain that impact radio coverage in the northwest and southwest portions of the City of La Crosse. Each change in color represents about 66 feet in elevation change.

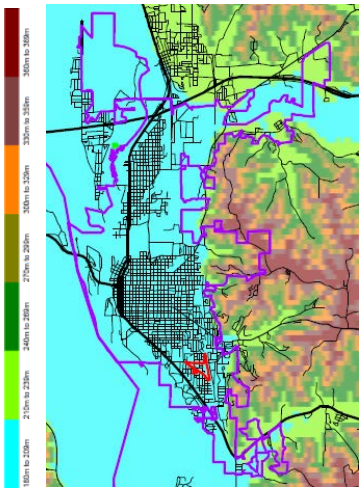


Figure 4: City of La Crosse Topography

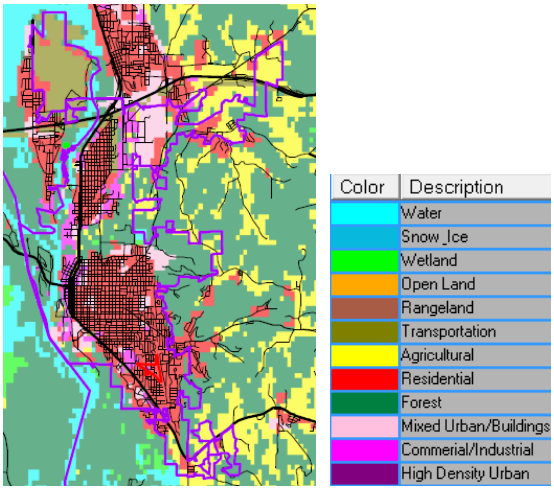


Figure 5: City of La Crosse Land Use

City of La Crosse Land Use

Figure 5 shows the land use (also known as clutter in propagation prediction) as defined in the propagation program for the City of La Crosse. The key to the right shows the land use employed by the prediction program to calculation coverage. Most of the City of La Crosse is marked residential, mixed urban, and forest.

Coverage Predictions

Coverage predictions are estimates of signal level using models based on actual field performance data. The variables include the antenna height, radio RF power, receiver sensitivity, terrain elevation, and clutter. Reliability is also factored into the calculations to account for variability. The minimum level for reliable portable coverage is estimated to be -95 dBm. For predictions that infrastructure is designed to provide this level of signal 95% of the time over 95% of the area.

Below is a key for interpretation of the coverage predictions that follow. Adequate coverage is usually achieved in yellow and green areas. As you move away from the antenna site, each color change reflects a 10X reduction in received signal level. The marginal level below (orange) ranges from -95dBm (at the transition to yellow) to -105dBm (at the transition to red).

Occasional	Minimum Mobile	Marginal	Good	Better	Best
		Portable Outdoor		Portable Indoor	

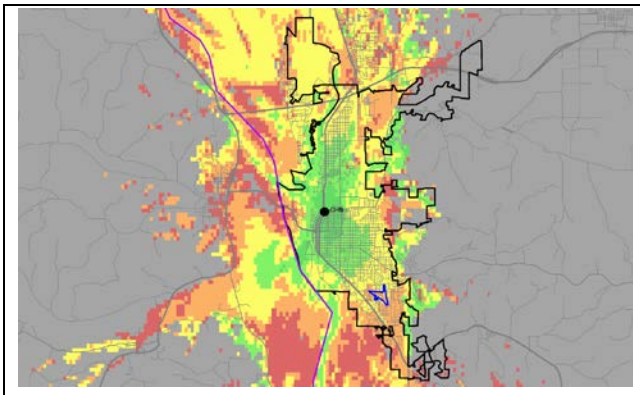


Figure 6: City Hall Portable Talk Out Outdoors

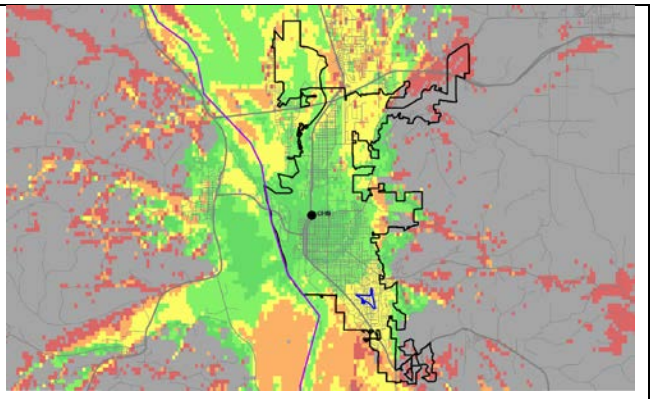


Figure 7: City Hall Portable Talk Back Outdoors

These above predictions are of the current portable outdoor system performance for the City Hall site based on information collected from the FCC licenses, equipment information, and on-site observations. The antenna selection to produce the prediction is an estimate based on the performance information from original antenna vendor. The differences in indoor and outdoor coverage is due to the amplification introduced in the model to make up for loss in the signal splitter used in the receive multicoupler. Commonly the system design will attempt to make the system balanced (identical talk-out and talk-in) with portables.

The prediction uses the clutter information (see Figure 5) in the calculations to estimate the signal level. The model does not know if a building is blocking or reflecting signals, so the actual performance could be quite different in actual operation.

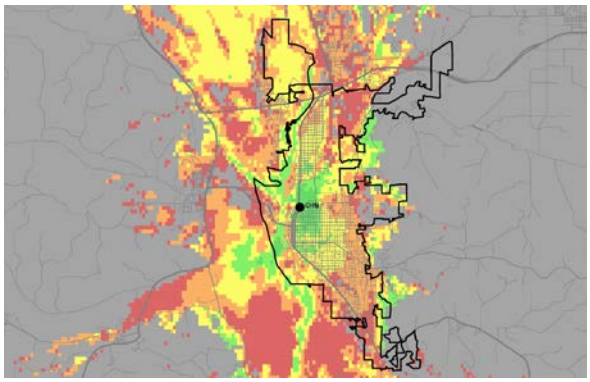


Figure 8: City Hall Portable Talk Out Indoor

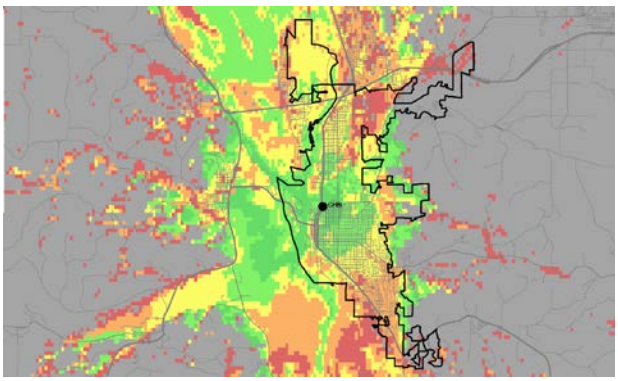


Figure 9: City Hall Portable Talk Back Indoor

The above predictions are also the City Hall site, predicting performance indoors. The amount of attenuation varies based on the indoor attenuation values embedded in the clutter model. A common attenuation value for residential areas is about 8dB, and for a commercial building, 15dB. Hardened structures and large structures such as a bank or La Crosse Center may have loss factors that exceed 30dB or a factor of one-thousandth of the signal found on the outside of the building.

The following are predictions of the other potential sites considered in a preliminary schematic design. All predictions are portable outdoor.

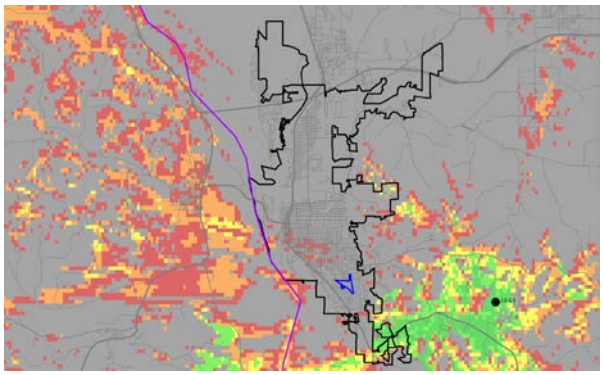


Figure 10: 14-61 Portable Talk Out

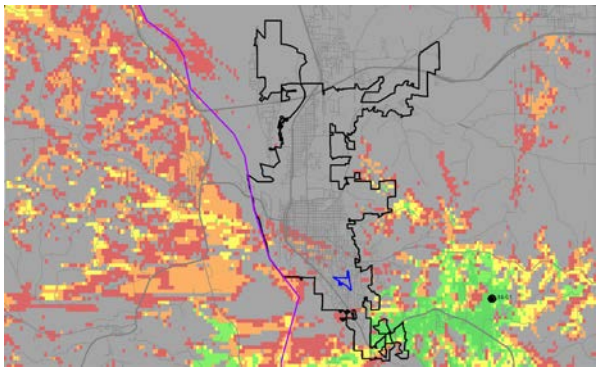


Figure 11: 14-61 Portable Talk Back

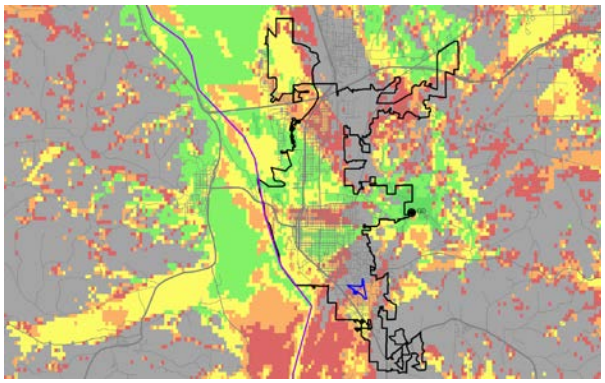


Figure 12: Grandad Portable Talk Out

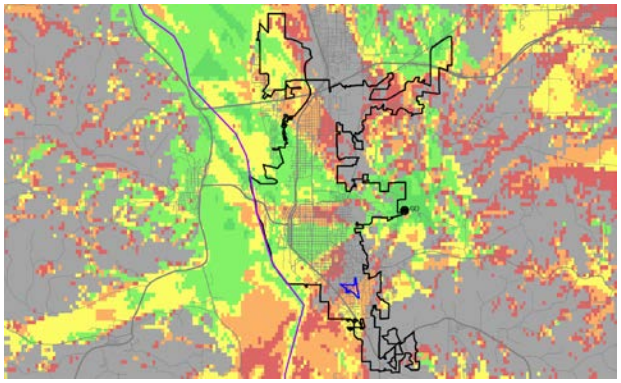


Figure 13: Grandad Portable Talk Back

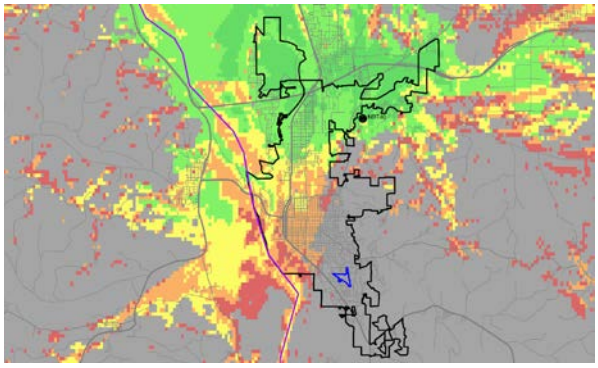


Figure 14: North Bluff 40m Portable Talk Out

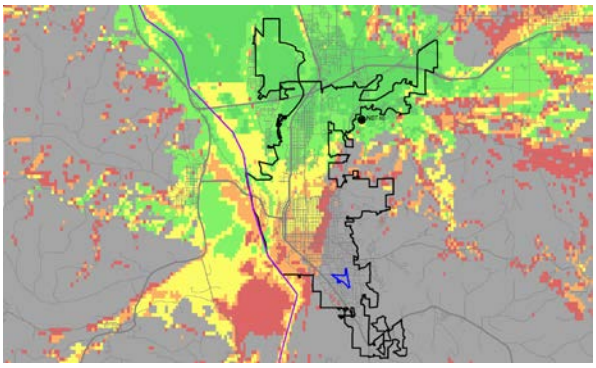


Figure 15: North Bluff 40m Portable Talk Back

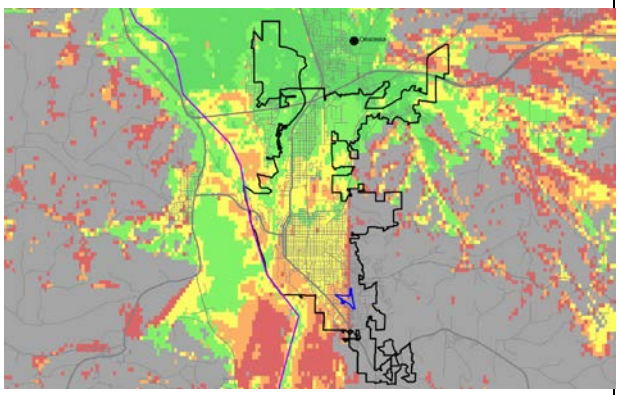


Figure 16: Onalaska Portable Talk Out

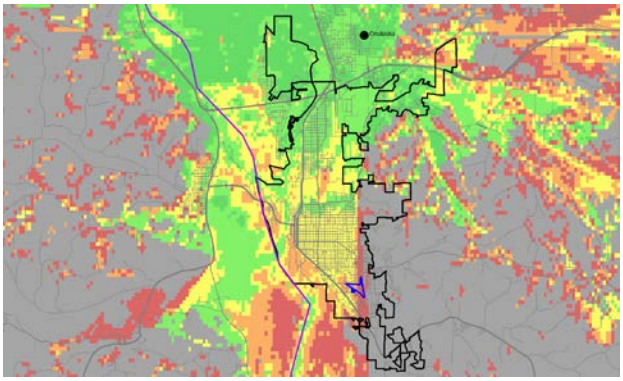


Figure 17: Onalaska Portable Talk Back

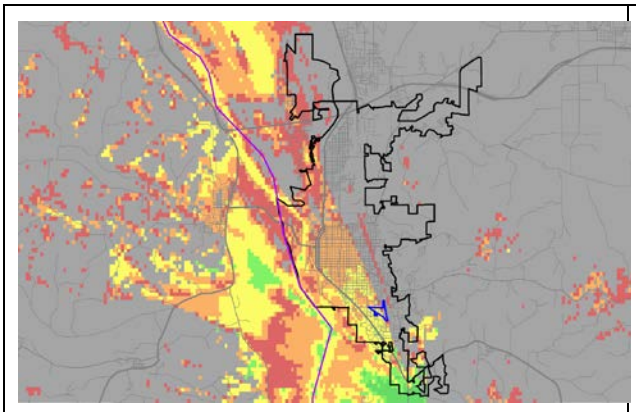


Figure 18: US Cellular Portable Talk Out

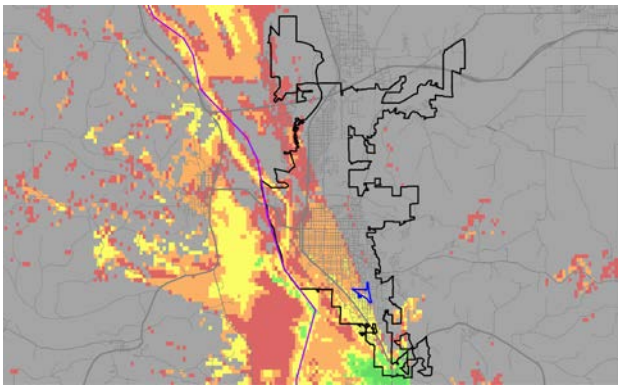


Figure 19: US Cellular Portable Talk Back

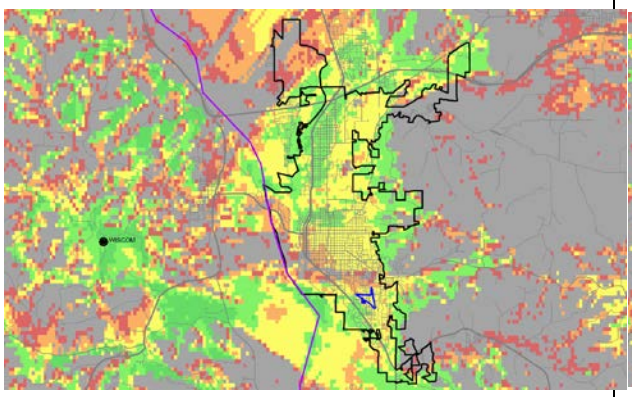


Figure 20: WISCOM Portable Talk Out

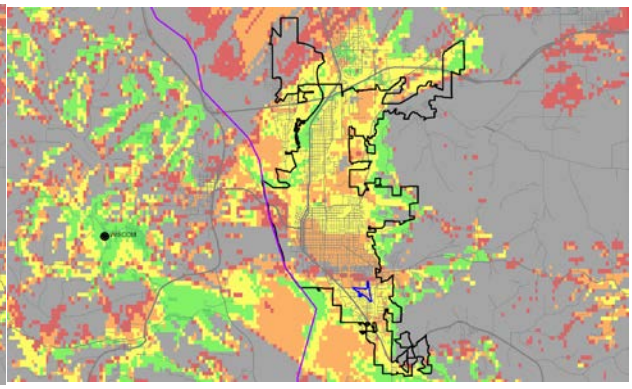


Figure 21: WISCOM Portable Talk Back

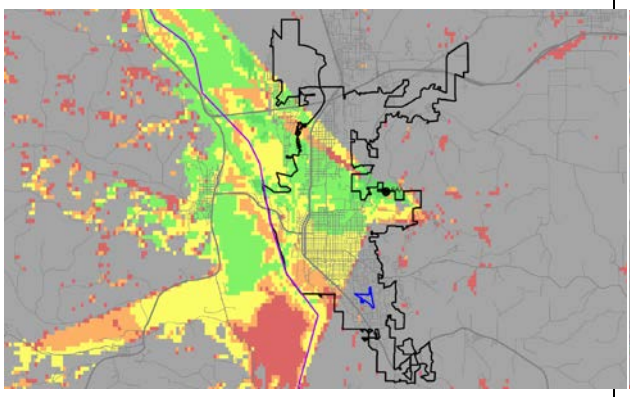


Figure 22: FAA Towers Portable Talk Out

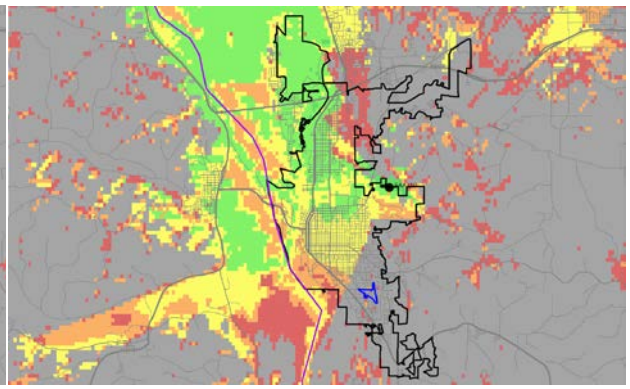


Figure 23: FAA Towers Portable Talk Back

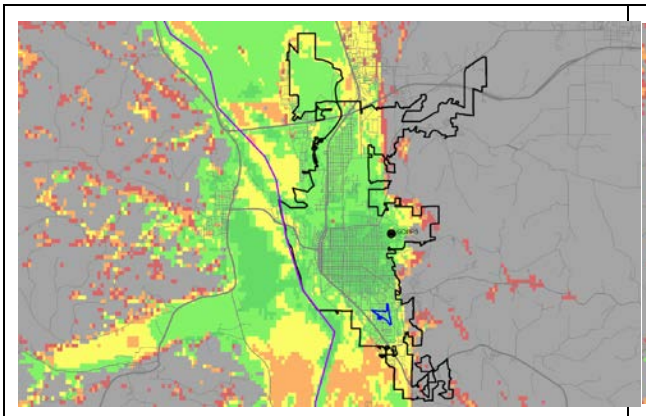


Figure 24: Grandad Park Portable Talk Out

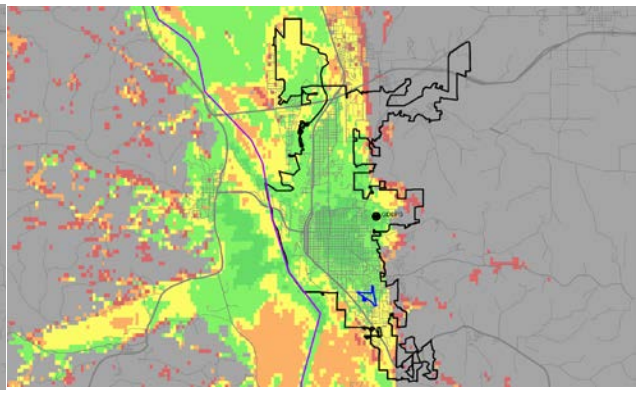


Figure 25: Grandad Park Portable Talk Back

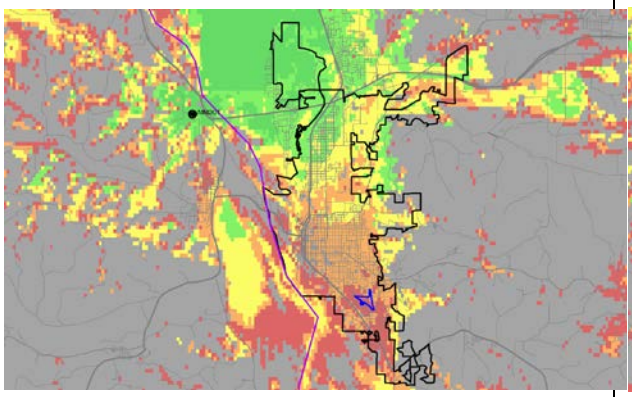


Figure 26: MDOT Portable Talk Out

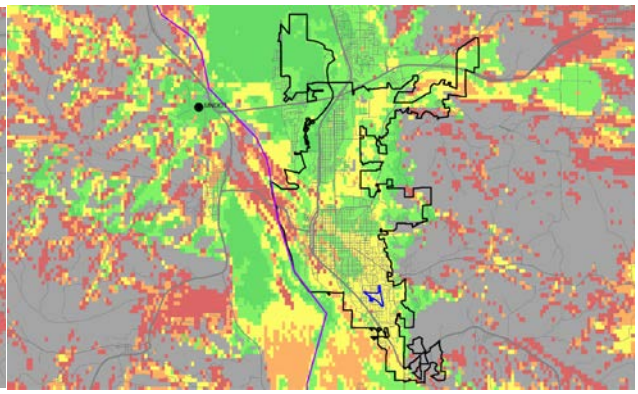


Figure 27: MDOT Portable Talk Back

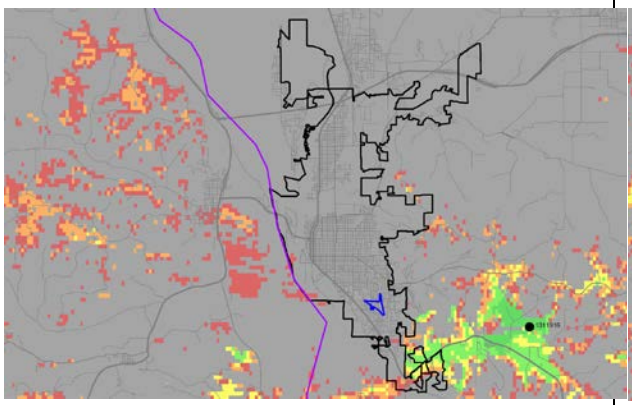


Figure 28: Verizon Portable Talk Out

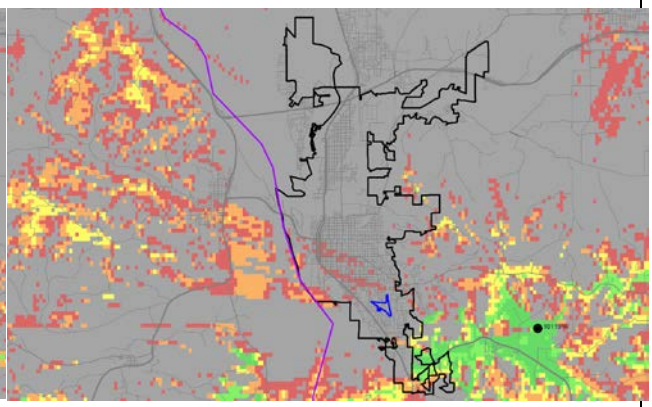


Figure 29: Verizon Portable Talk Back

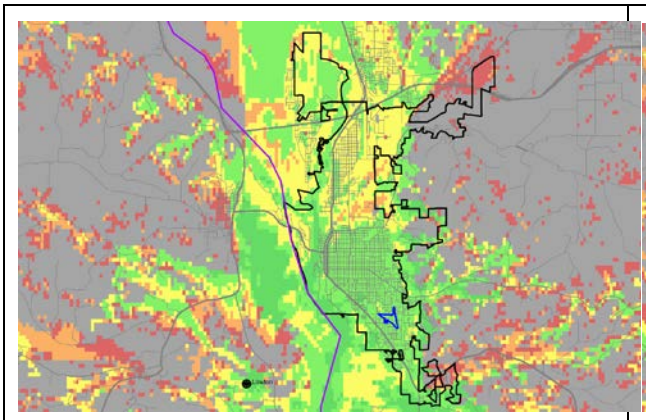


Figure 30: Lawton Portable Talk Out

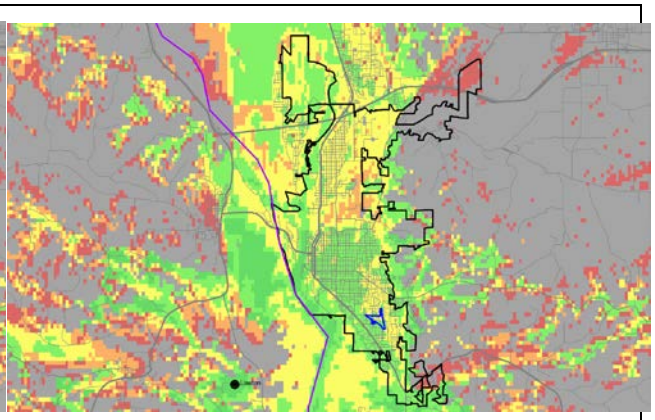


Figure 31: Lawton Portable Talk Back

Backhaul Path Predictions

La Crosse County provides the connectivity to the conventional channels used in the City of La Crosse system through the County of La Crosse microwave system that links La Crosse County 911 to the Grandad, Lawton and 14-61 sites. The current trunking system is a single site with no other receiver sites, so no back haul is required for operation.

Changes to the trunking system designed to provide enhanced coverage for the City will require backhaul. It is assumed that the City would be able to use excess capacity on the La Crosse County microwave system, provide any additional paths required, and improve the capacity or update any links required for operation.

The paths considered for operation for all potential P25 options are found in Figure 32. There are five paths. Three of these paths already exist in the County's microwave system. One of the proposed additions to this network adds a path from Grandad to a new site to the north. If Option 3B were to be the selected option then another link would be required to that site.

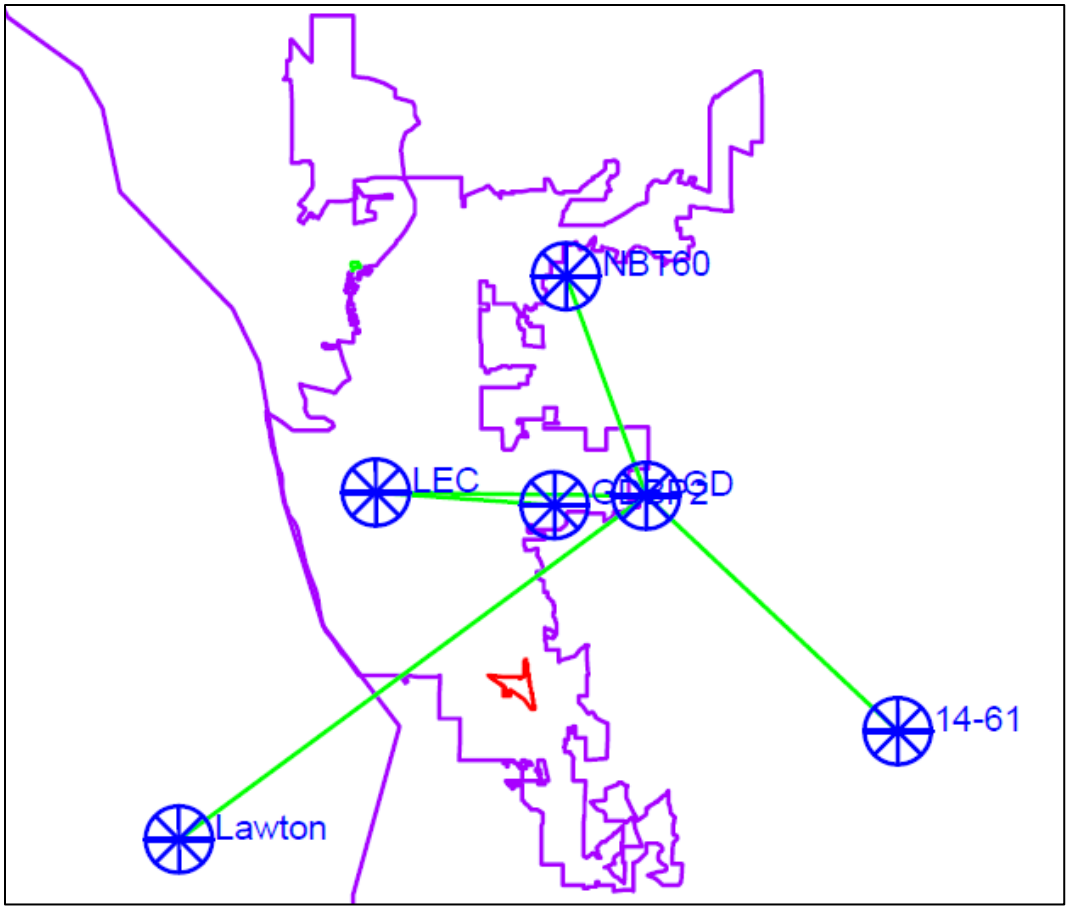


Figure 32: City of La Crosse – Proposed Microwave Topology

It is assumed that the County tower at the Grandad site is at capacity and needs to be strengthened to add any additional antennas. Assuming the Grandad tower can be strengthened, antennas would be added to provide the system performance required. A structural analysis will need to be done on all existing towers to determine what improvements, if necessary, would need to be made on the tower prior to installing additional antennas on the towers.

One of the antennas would be the dish antenna for the link from Grandad to a new proposed north site on the Mississippi Valley Conservancy property. This link is anticipated to use 10 GHz radios, which are smaller antennas in the 2-4 foot range.

The current link from Grandad to Lawton is used for a satellite receiver site for County communications systems. The bandwidth on this link is limited and it is anticipated that the bandwidth needs to increase. If so, it is assumed that this link would need to transition from a 960 MHz radio to a 10 GHz radio.

Paths required for the trunked system enhancement options include the following:

- Option 1
  - La Crosse County 911 – Grandad
  - Grandad – New North Site
  - Grandad – Lawton
- Option 2
  - La Crosse County 911 – Grandad
  - Grandad – New North Site
  - Grandad – Lawton
  - Grandad – 14-61
- Option 3A
  - La Crosse County 911 – Grandad
  - Grandad – New North Site
  - Grandad – Lawton
  - Grandad – 14-61
- Option 3B
  - La Crosse County 911 – Grandad
  - Grandad – New North Site
  - Grandad – Lawton
  - Grandad – 14-61
  - La Crosse County 911 – Grandad Bluff Park

The County currently has a redundant 10 GHz / 4.9 GHz link to the PSAP. All other links in the proposed design use 10 GHz radios. It is anticipated that the City can improve the current systems as necessary to use current 10 GHz system equipment. Below are path profiles for the new links that would be considered in the proposed microwave design. It would however be a requirement the present 960 MHz link to Lawton would be upgraded to a 10 GHz link.

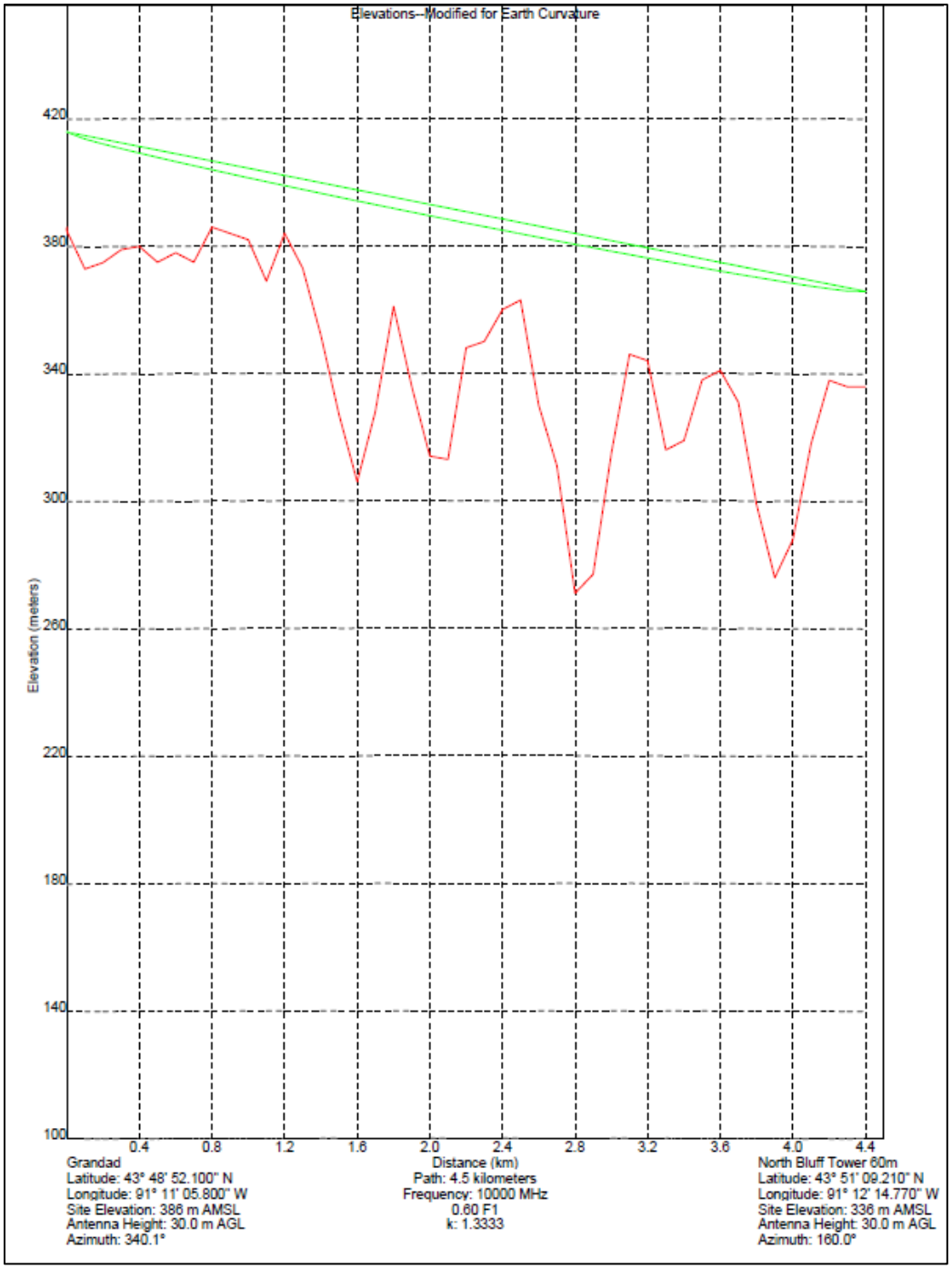


Figure 33: Grandad to North Bluff Tower Path

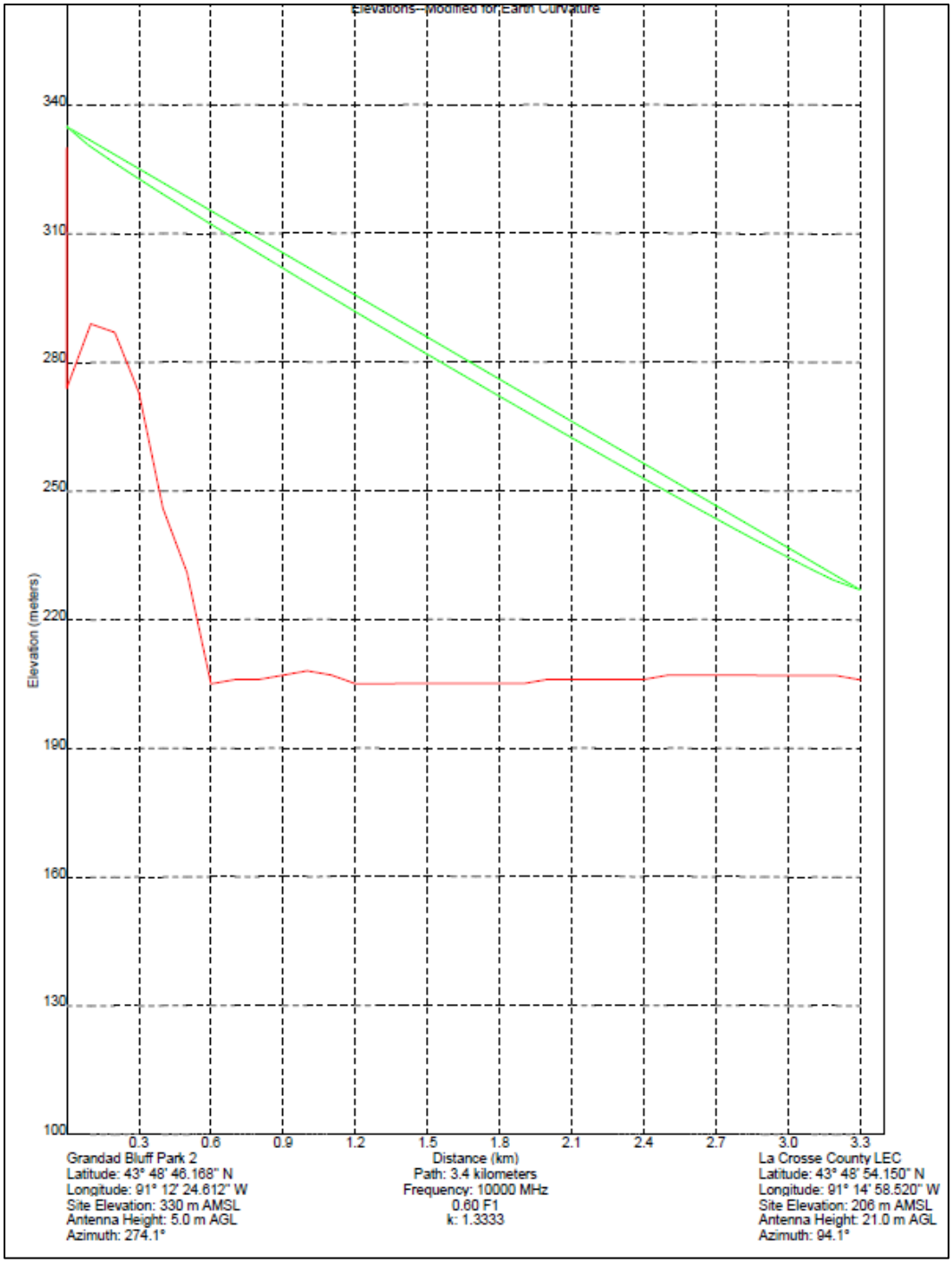


Figure 34: Grandad Bluff Park to La Crosse County 911 Path

Recommendations

The following are four potential options for the City to consider. Each option builds on the next and offers improved coverage for public safety radio systems. All options involve a transition to P25, and each option improves the level of coverage with the City.

Option 1 – Two Sites

- Secure property at the Mississippi Valley Conservancy (MVC) north of the City.
- Perform a structural analysis at the Grandad and Lawton towers and make any necessary improvements.
- Build a 160' self-supporting tower on the MVC property.
- Install new 10 GHz MW at MVC, Grandad, and Lawton sites.
- Install a six-channel P25 simulcast system at the MVC and Lawton sites.
- Install a P25 satellite receiver system at the City of La Crosse Police department.

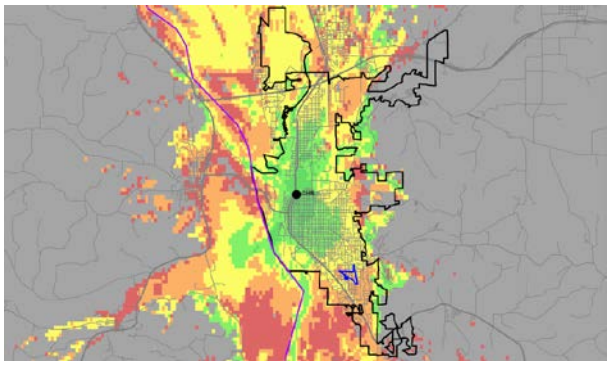


Figure 35: Current Portable Talk Out

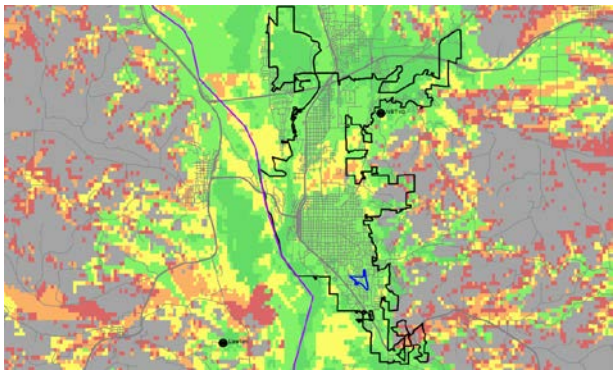


Figure 36: Option 1 Portable Talk Out

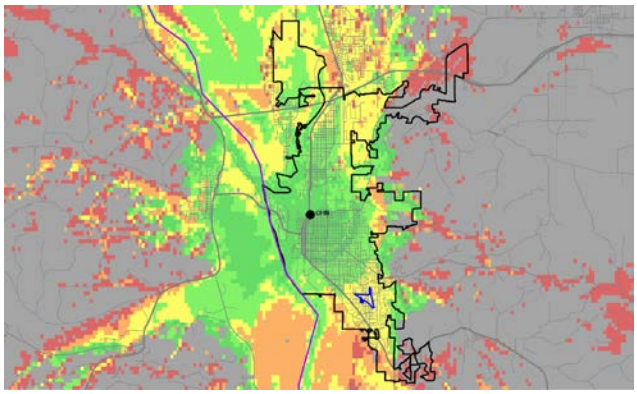


Figure 37: Current Portable Talk Back

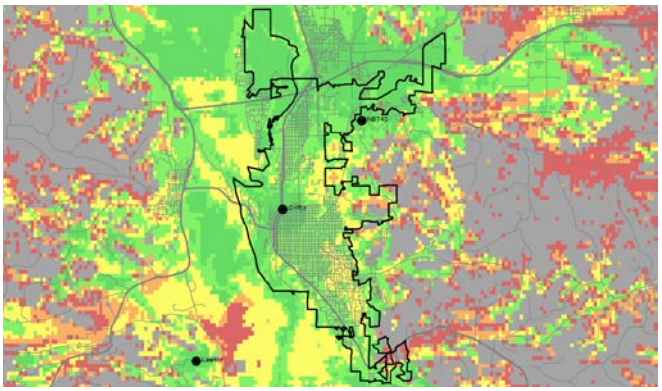


Figure 38: Option 1 Portable Talk Back

The yellow signal level (–95 dBm) of the Option 1 Portable Talk Out covers ~94.9% of the area of the City of La Crosse. Portable Talk Back is ~95.9% of the area.

Note: The extreme southeast portion of the City is not covered with this option.

Option 2 – Three Sites

This option includes all items in Option 1, with the following additions or changes:

- Update 10 GHz MW from Grandad to 14-61.
- Install a six-channel P25 simulcast system at the 14-61 site.

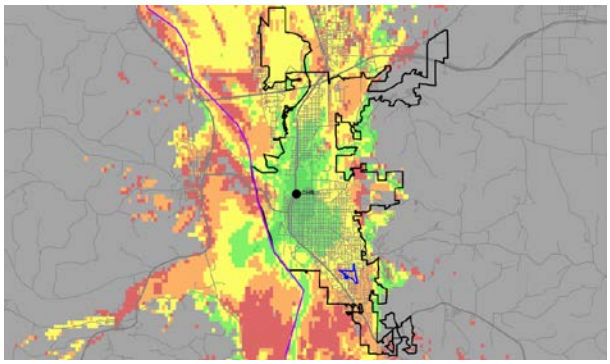


Figure 39: Current Portable Talk Out

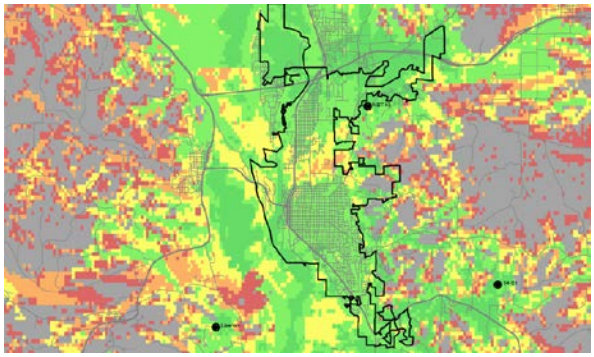


Figure 40: Option 2 Portable Talk Out

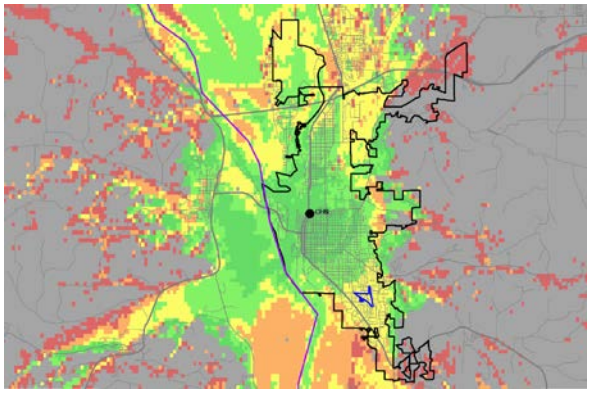


Figure 41: Current Portable Talk Back

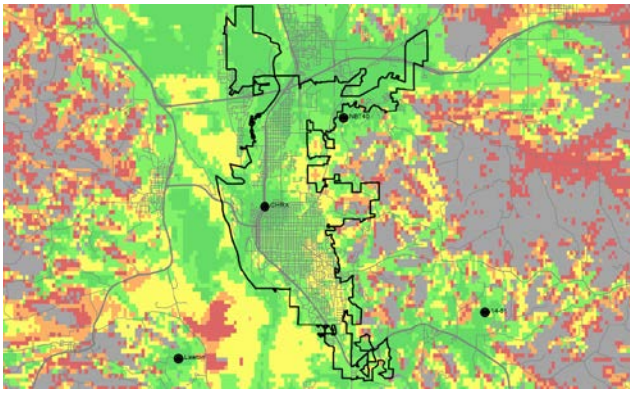


Figure 42: Option 2 Portable Talk Back

The yellow signal level (–95 dBm) of the Option 2 Portable Talk Out covers ~95.4% of the area of the City of La Crosse. Portable Talk Back is ~97.5% of the area.

Note: This solution provides basic coverage to critical areas of the City. The city center is covered by the Lawton site only.

Option 3A – Four Sites

This option includes all items in Option 1 and 2, with the following additions or changes:

- Perform a structural analysis at the Grandad for MW and P25 system antennas.
- Install a six-channel P25 simulcast system at the County's Grandad site.

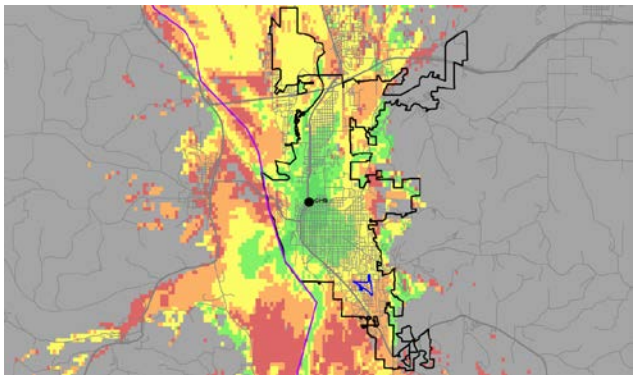


Figure 43: Current Portable Talk Out

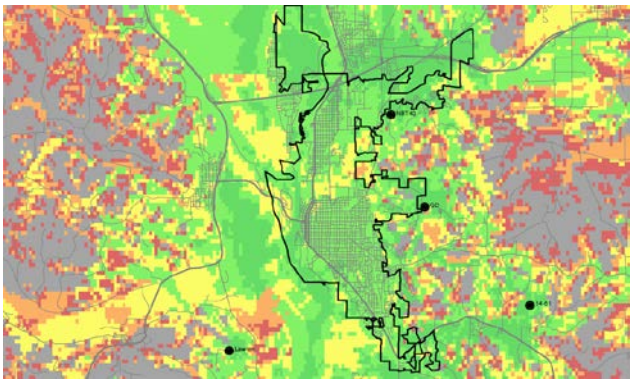


Figure 44: Option 3A Portable Talk Out

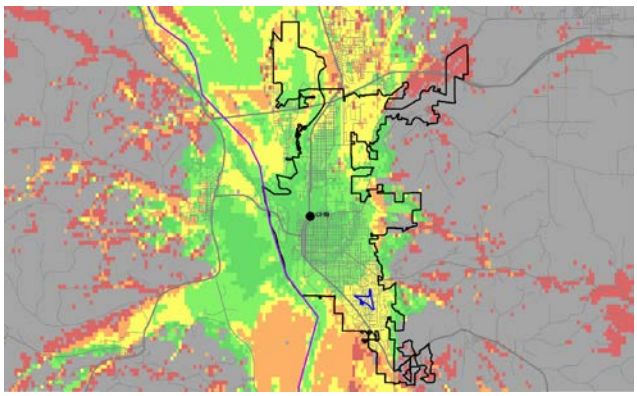


Figure 45: Current Portable Talk Back

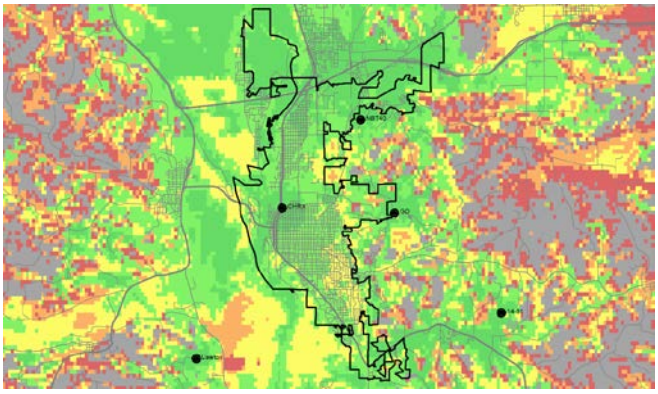


Figure 46: Option 3A Portable Talk Back

The yellow signal level (–95 dBm) of the Option 2 Portable Talk Out covers ~98.5% of the area of the City of La Crosse. Portable Talk Back is ~98.9% of the area.

Note: Although this option does provide a higher percentage of coverage, the bluff blocks a portion of the city due to the set back of the site on the bluff.

Option 3B – Four Sites

This option includes all items in Option 2, with the following additions or changes:

- Develop the Grandad Bluff Park site.
- Construct a disguised antenna structure for P25 antenna system.
- Install a six-channel P25 simulcast system at the Grandad Bluff Park site.

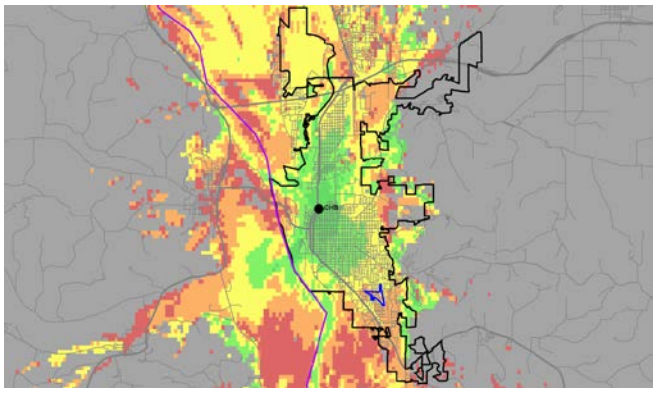


Figure 47: Current Portable Talk Out

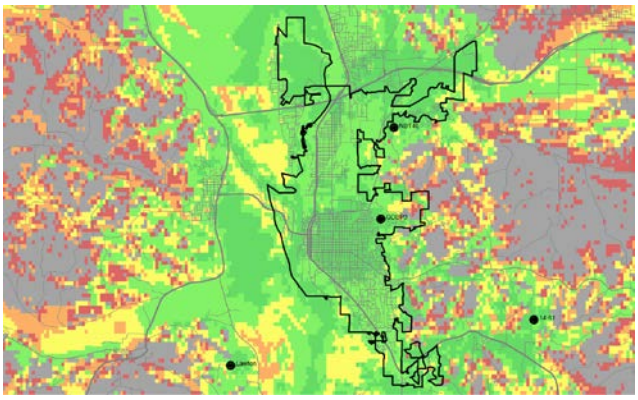


Figure 48: Option 3B Portable Talk Out

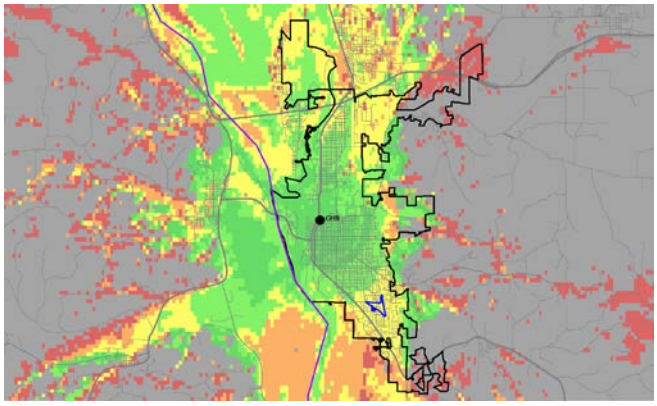


Figure 49: Current Portable Talk Back

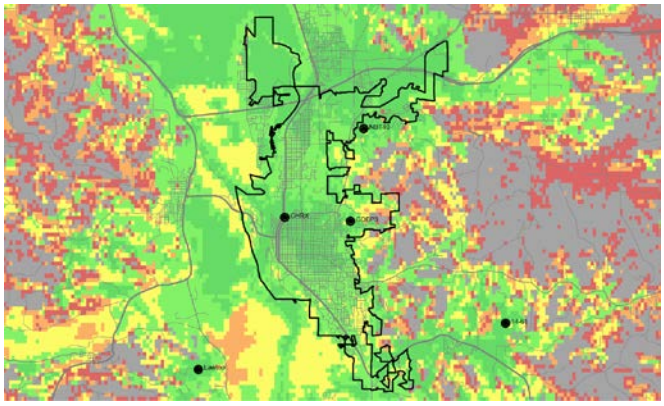


Figure 50: Option 3B Portable Talk Back

The yellow signal level (–95 dBm) of the Option 2 Portable Talk Out covers ~97.8% of the area of the City of La Crosse. Portable Talk Back is ~98.0% of the area.

Note: This option provides less overall City-area coverage but provides the best view into the City, because unlike the Grandad site, it is not blocked by the bluff.

The difficulty with the Granddad Bluff site would be to determine a method of providing for a tower/structure meeting visual demands. The use of a disguised flagpole is one option though a space for the equipment shelter and microwave could also be a huge issue.

Budgetary Costs for Possible Solutions

Option 1: Two-Site Simulcast P25

Lawton site and new MVC North Bluff Site.

System Component	Description	Cost
Vendor Infrastructure	Repeaters, satellite receivers, voting, simulcast, antennas, microwave, power, shelter, grounding, towers, civil, dispatch equipment, and alarms	$2,858,310
Vendor Services	Engineering, installation, testing, commissioning, and training	$786,035
Field Terminal Equipment	Mobiles, portables, and associated accessories	2,150,021
Contingency	Equipment, services and site work	$653,397
Professional Services	Licensing, consulting and project management	$222,000
	Total	$6,609,363

Option 2: Three-Site Simulcast P25

Lawton site, new MVC North Bluff Site, and 14-61 site.

System Component	Description	Cost
Vendor Infrastructure	Repeaters, satellite receivers, voting, simulcast, antennas, microwave, power, shelter, grounding, towers, civil, dispatch equipment, and alarms	$3,140,790
Vendor Services	Engineering, installation, testing, commissioning, and training	$863,717
Field Terminal Equipment	Mobiles, portables, and associated accessories	2,150,021
Contingency	Equipment, services and site work	$690,413
Professional Services	Licensing, consulting and project management	$244,000
	Total	$7,028,541

Option 3A: Four-Site Simulcast P25 (E&A RECOMMENDED)

Lawton site, new MVC North Bluff Site, 14-61 site, and County Grandad site at the eastern boundary of the City.

System Component	Description	Cost
Vendor Infrastructure	Repeaters, satellite receivers, voting, simulcast, antennas, microwave, power, shelter, grounding, towers, civil, dispatch equipment, and alarms	$3,383,710
Vendor Services	Engineering, installation, testing, commissioning, and training	$930,520
Field Terminal Equipment	Mobiles, portables, and associated accessories	2,150,021
Contingency	Equipment, services and site work	$727,385
Professional Services	Licensing, consulting and project management	$263,000
	Total	$7,394,236

Option 3B: Four-Site Simulcast P25

Lawton site, new MVC North Bluff site, 14-61 site, and new Grandad Bluff Park site at the western edge of the bluff.

System Component	Description	Cost
Vendor Infrastructure	Repeaters, satellite receivers, voting, simulcast, antennas, microwave, power, shelter, grounding, towers, civil, dispatch equipment, and alarms	$3,640,485
Vendor Services	Engineering, installation, testing, commissioning, and training	$1,001,133
Field Terminal Equipment	Mobiles, portables, and associated accessories	2,150,021
Contingency	Equipment and site work	$776,124
Professional Services	Licensing, consulting and project management	$283,000
	Total	$7,790,363

Public Safety Field Unit Options

Department	Description	Cost
Police	Replace 20 of 37 standard mobile units with multiband mobile units	$17,800
Police	Increase number of portable units to from 84 to 115 total radios of which 20 are multiband P25 portables units	$135,140
Police	Add one vehicular repeater station	$15,000
Police	Add AES Encryption	$38,400
Police	Add OTAP (over the air programming)	$6,750
Police	Add OTAR (over the air rekeying)	$16,800
Fire	Replace 21 of 21 standard mobile units with multiband mobile units	$18,690
Fire	Replace 42 of 42 standard portable units with multiband P25 portables units	$55,944
Fire	Add one vehicular repeater station	$15,000
	Total	$319,524

Recommendation

A P25 trunked system platform is essential to provide public safety features and operational needs of City of La Crosse Police and Fire. The level of overall system performance for these agencies has been decreasing as the City has been expanding. Police and Fire must be able to communicate throughout the City with a portable field unit. Areas of marginal or no coverage using portables must be addressed, and improvement for in-building performance is required. Although all of the options present improved overall coverage, much of the in-building performance requires sites with some degree of overlap to improve the chance of signal penetration. In areas where no overlap exists, the distance to a site needs to be minimal.

Option 2 provides coverage of the trouble spots reported, but Option 3 would provide the overlap necessary to improve in-building performance. There are two choices for Option 3, and one requires the construction of a green field site in a very visible location for most of the City. The view of the City from the Grandad Bluff Park from an RF point of view would provide a great site for the system, but would also require a disguised antenna structure, and the equipment shelter and backhaul antenna system would also need to be hidden from view or placed in an aesthetically compatible park facility. The

County's rim of the City (Grandad) tower is already in place, but is set back far enough that the bluff shades part of the City from the site. This position is a drawback, as part of the city is shaded, though this area is visible from a possible Mississippi Valley Conservancy (MVC) site on the north side of the bluff. The MVC site should provide the view from the opposite direction for most of the area to improve overall coverage in this area if the technical issues can be resolved to enable simulcast to function properly. Using existing sites when possible will lower the cost of implementation.

WISCOM and ARMER both support P25 Phase 1, and there are no plans to implement Phase 2 to date. Until P25 Phase 2 is more readily available and used by neighbors of La Crosse, the P25 Phase 1 system would use all of the available channels and thus provide the City five voice channels. Five channels have been deemed sufficient to handle the present number of users of the system.

Joining a statewide network will force the City to program the P25 system to be consistent with the network already in place. This will force the City to choose a single vendor of infrastructure product and will not allow the City to use competitive bidding practices. Many of the choices made to enable a network to be utilized statewide may not be the best for the City. An independent system that can be programmed with only the City's best interests will provide the maximum benefit and utility for the City. This is not to say that a proposer may not offer some hybrid of independent system and connectivity to one of the two state systems as an option for consideration.

Elert recommends the possibility of multiband radios for Police and Fire users to allow for instantaneous interoperability and a vehicular repeater system for Police and Fire to assist if either department requires a boost in on-scene coverage. Although the new system design will improve overall coverage there will be areas such as a large building complex that will perform better with a local repeater. Industrial buildings and hospitals may introduce more attenuation than the repeater infrastructure can overcome. A properly located vehicular repeater will provide additional building penetration.

NFPA 1 recommendations also provide guidance that the City could employ to improve in-building performance. The City should consider including these recommendations into a local building ordinance to ensure in-building communication capability. The extent to which these guidelines would be implemented would be up to the City but their use would assist in ensuring public safety communications. The wireless choices for mobile data are limited. To provide an RF infrastructure, additional channels and backhaul bandwidth are required. The ability to use one or two 800 channels and use P25 Phase 2 is limited by the availability of the Phase 2 standard systems. VHF or UHF bands would need to be narrowband and would limit the overall data rate. The FirstNet planned use of LTE (Long Term Evolution) would provide high speed data, but at best it is a year or more away depending on how the build-out will be done in Wisconsin.

E&A's recommendation is to pursue **Option 3A**, a four-site simulcast system, and to do the following:

- Develop a new radio tower site overlooking the County Highway B corridor at the Mississippi Valley Conservancy property.
- Choose to deploy an independent P25 Phase 1 system.
- Develop an RFP to choose a qualified vendor.
- Continue to use Verizon air cards for mobile data.
- Employ multi-control station back-ups at La Crosse County 911.
- Implement gateways to WISCOM, ARMER, and County public safety channels.
- Develop a plan to utilize consoles that can directly control the P25 infrastructure.
- Employ AES digital encryption for select Police and Fire talk groups.
- Develop procedures for the use of the emergency button.
- Evaluate the in-building performance of the La Crosse Center.
- Consider an AVL application for the bus transportation system.
- Limit use of cell phones for communications for any user expected to use a portable during an emergency.
- Develop and institute a user policy for individual calls.

The City should take the necessary steps to develop and approve a project budget for the desired system. Property that overlooks the County Highway B corridor should be secured and the appropriate approvals granted to allow construction of a tower on the property without significant delays. An FAA determination should be done as soon as possible. The County should be consulted on plans to utilize, enhance, and expand their current microwave network. A structural analysis to determine if the towers can be utilized for the recommended option or the option the City desires must also be considered to minimize future delays. A technical system specification for the desired system will also need to be developed and a procurement plan established to choose a vendor. Upon vendor selection, it would be best to have all projected sites firmly in hand, although the system performance and ultimately the site selections are up to the successful vendor.

The following items are not covered in the cost estimates:

- Property procurement
- Lease charges for sites and towers
- DAS for La Crosse Center
- AVL system for transportation
- Dispatch console system updates/upgrades
- Logging recorder updates/upgrades
- Additional field terminals
- ISSI for ARMER or WISCOM

Transition Planning

Developing a plan to transition from what has been disparate jurisdictional- and discipline-based systems to what should become a regional public safety and first responders communications system will require an alignment of new strategies and initiatives. The plan of action must continue to be driven by the organizations supporting it while focusing on the improvement of identified problems. Facilitating this change and managing the project of transitioning to a new technology will ultimately be a win–win solution and will overcome the identified barriers. The transformation will not only involve equipment and systems but is expected to address cultural, managerial, and financial impediments that unless addressed by the stakeholders, have the potential of killing the project.

The steps necessary to effect a successful transition include the following:

- Create a quality assurance program with focus on problem resolution.
- Evaluate the current technology, systems, and weak points.
- Evaluate the alternatives related to operations and coverage.
- Assess each jurisdiction's business rules and related operations.
- Facilitate meetings and groups to find common ground for the design.
- Understand and assist in the development of system expectations.
- Coordinate the implementation of the new communication system.
- Create/design all necessary project management materials, tools, and documentation to affect a positive outcome.
- Prepare required reports to jurisdictional policy/decision makers.

Training

With the implications of new and enhanced technology to meet the demands of today's public safety, first responder, and EMS personnel, the need for training in the use of the new capabilities has never been greater. With the advent of these new technologies, it is actually possible for the first time to enable users to program the radio technology just the way they want. Increasingly, this integration of voice and data is having a positive impact on productivity. This very positive change can happen only if users are trained in how to make use of the new technology and to gain access to its features.

The training plan must be a part of any transition plan, as to not have officers and other staff properly trained in the use will certainly doom the project or at least not allow the gains of expected productivity to be realized.

City of La Crosse Site Documentation

(March 2012)

City Hall	
43–48–59.5N, 091–14–53.8W – Elev 577’ Head House at City Hall  The antenna mast pipe is fastened to the east side of the elevator head house on top of the City Hall building. The antenna system is composed of separate transmit and receive antenna systems, each composed a two-antenna array.	The current City of La Crosse six-channel trunking is composed of MSF 5000 repeaters, combining system, and associated trunking control equipment packed into a closet on the top floor of City Hall. 

Site Location

The City of La Crosse system uses a single trunking site at the top of the City Hall building. Cellular carriers also rent space on the structure. The site coordinates on the City’s 800 license locate the site .4 mi from the City Hall at the intersection of Pearl and Highway 53.

Tower/Antenna Structure

The antenna mast pipe is fastened to the east side of the elevator head house on top of the City Hall building.

Antenna System

The antenna system is located on the penthouse roof. A separate antenna system is used for transmit and receive. The transmit and receive antennas are stacked vertically on the same mast pipe. Each antenna system is composed of two RFS 10099 13 dB gain panel antennas oriented nearly 180 degrees apart—one pointed to the north and the other to the south. The antennas have 17 degrees vertical beamwidth, 62 degrees horizontal beamwidth. They use a phasing harness to provide impedance matching. Transmission lines run down the staircase and are routed to the equipment closet on the top floor of City Hall. Transmission lines go directly into holes drilled into the wall. There is no cable entry port. Transmission lines terminate into the receive and transmit antenna ports of the combining system in the repeater system equipment closet.

Repeater System Equipment

Repeater stations are Motorola MSF5000 repeater stations. Each station is mounted in a cabinet with other associated hardware, and cabinets are stacked two high. The MSF5000 is discontinued, and support for these stations will be limited going into the future. The system controller hardware is also mounted in two stacked cabinets.

Other Equipment

There are controls stations and associated antenna systems located in lower floor equipment closets. Stations are equipped with signal attenuators to reduce the radiated power within the room. The control stations are interfaced to remote control units located in various areas of the building limiting the number of RF stations required.

Power

Each repeater appears to be powered by a separate circuit and on a UPS. It is assumed that the controller and critical system infrastructure elements are also on one or more UPS circuits. All power associated with the system is also on generator backup.

Grounding

All repeater stations and the combiner rack are grounded to a common bus bar that is connected to building ground.

Appendix 1 – City of La Crosse FCC License

REFERENCE COPY

This is not an official FCC license. It is a record of public information contained in the FCC's licensing database on the date that this reference copy was generated. In cases where FCC rules require the presentation, posting, or display of an FCC license, this document may not be used in place of an official FCC license.

Federal Communications Commission
Public Safety and Homeland Security Bureau

RADIO STATION AUTHORIZATION

LICENSEE: LA CROSSE, CITY OF

ATTN: CITY CLERK
LA CROSSE, CITY OF
400 LA CROSSE ST
LA CROSSE, WI 54601

Call Sign	File Number
WPCJ394	0004897488

Radio Service
YE - PubSafty/SpecEmer/PubSaftyNtlPlan,806-817/851-862MHz,Trunked

Regulatory Status
PMRS

Frequency Coordination Number

FCC Registration Number (FRN): 0004150421

Grant Date	Effective Date	Expiration Date	Print Date
02-09-2005	10-04-2011	04-05-2015	10-05-2011

STATION TECHNICAL SPECIFICATIONS

Fixed Location Address or Mobile Area of Operation

Loc. 1 **Address:** 400 LA CROSSE ST CITY HALL
City: LA CROSSE **County:** LA CROSSE **State:** WI
Lat (NAD83): 43-48-42.9 N **Long (NAD83):** 091-15-11.5 W **ASR No.:** N/A **Ground Elev:** 176.0

Loc. 2 **Area of operation**
Land Mobile Control Station meeting the 6.1 Meter Rule: WI

Loc. 3 **Area of operation**
Operating within a 32.0 km radius around fixed location 1

Antennas

Loc No.	Ant No.	Frequencies (MHz)	Sta. Cls.	No. Units	No. Pagers	Emission Designator	Output Power (watts)	ERP (watts)	Ant. Ht./Tp meters	Ant. AAT meters	Construct Deadline Date
1	1	000856.21250000	FB2C	1		20K0F1E 20K0F3E	150.000	193.000	37.0	-26.0	
1	1	000856.73750000	FB2	1		20K0F1E 20K0F3E	150.000	193.000	37.0	-26.0	
1	1	000857.21250000	FB2	1		20K0F1E 20K0F3E	150.000	193.000	37.0	-26.0	

Conditions:
Pursuant to §309(h) of the Communications Act of 1934, as amended, 47 U.S.C. §309(h), this license is subject to the following conditions: This license shall not vest in the licensee any right to operate the station nor any right in the use of the frequencies designated in the license beyond the term thereof nor in any other manner than authorized herein. Neither the license nor the right granted thereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934, as amended. See 47 U.S.C. § 310(d). This license is subject in terms to the right of use or control conferred by §706 of the Communications Act of 1934, as amended. See 47 U.S.C. §606.

FCC 601-ULSHS1
August 2007

Page 1 of 3

Licensee Name: LA CROSSE, CITY OF

Call Sign: WPCJ394 **File Number:** 0004897488 **Print Date:** 10-05-2011

Antennas

Loc No.	Ant No.	Frequencies (MHz)	Sta. Cls.	No. Units	No. Pagers	Emission Designator	Output Power (watts)	ERP (watts)	Ant. Ht./Tp meters	Ant. AAT meters	Construct Deadline Date
1	1	000858.21250000	FB2	1		20K0F1E 20K0F3E	150.000	193.000	37.0	-26.0	
1	1	000859.21250000	FB2	1		20K0F1E 20K0F3E	150.000	193.000	37.0	-26.0	
1	1	000854.21250000	FB2C	1		20K0F1E 20K0F3E	150.000	193.000	37.0	-26.0	08-14-2009
2	1	000811.21250000	FX1	20		20K0F1E 20K0F3E	15.000	10.000			
2	1	000811.73750000	FX1	20		20K0F1E 20K0F3E	15.000	10.000			
2	1	000812.21250000	FX1	20		20K0F1E 20K0F3E	15.000	10.000			
2	1	000813.21250000	FX1	20		20K0F1E 20K0F3E	15.000	10.000			
2	1	000814.21250000	FX1	20		20K0F1E 20K0F3E	15.000	10.000			
2	1	000809.21250000	FX1	20		20K0F1E 20K0F3E	15.000	10.000			
3	1	000811.21250000	MO	420		20K0F1E 20K0F3E	35.000				
3	1	000811.73750000	MO	420		20K0F1E 20K0F3E	35.000				
3	1	000812.21250000	MO	420		20K0F1E 20K0F3E	35.000				
3	1	000813.21250000	MO	420		20K0F1E 20K0F3E	35.000				
3	1	000814.21250000	MO	420		20K0F1E 20K0F3E	35.000				
3	1	000809.21250000	MO	420		20K0F1E 20K0F3E	35.000	35.000			08-14-2009

Licensee Name: LA CROSSE, CITY OF

Call Sign: WPCJ394 **File Number:** 0004897488 **Print Date:** 10-05-2011

Control Points

Control Pt. No. 1

Address: LA CROSSE EMERGENCY DISPATCH CTR 400 N 4TH ST RM B07

City: LA CROSSE **County:** LA CROSSE **State:** WI **Telephone Number:** (608)785-9634

Associated Call Signs

Waivers/Conditions:

NONE

Federal Communications Commission
Public Safety and Homeland Security Bureau

RADIO STATION AUTHORIZATION

LICENSEE: LA CROSSE, CITY OF

ATTN: CITY CLERK
LA CROSSE, CITY OF
400 LA CROSSE ST
LA CROSSE, WI 54601

Call Sign	File Number
WPCJ395	

Radio Service
GP - Public Safety/Spec Emerg, 806-821/851-866 MHz, Conv.

Regulatory Status
PMRS

Frequency Coordination Number

FCC Registration Number (FRN): 0004150421

Grant Date	Effective Date	Expiration Date	Print Date
06-06-2003	03-14-2007	06-07-2013	

STATION TECHNICAL SPECIFICATIONS

Fixed Location Address or Mobile Area of Operation

Loc. 1 **Area of operation**
Land Mobile Control Station meeting the 6.1 Meter Rule: WI

Loc. 2 **Address:** 1/2 MI E OF RES AREA ON GRANDADS BLUFF
City: LA CROSSE **County:** LA CROSSE **State:** WI
Lat (NAD83): 43-48-42.9 N **Long (NAD83):** 091-12-46.5 W **ASR No.:** N/A **Ground Elev:** 366.0

Loc. 3 **Area of operation**
Operating within a 32.0 km radius around fixed location 2

Loc. 4 **Address:** N1490 TOWER CT
City: LA CROSSE **County:** LA CROSSE **State:** WI
Lat (NAD83): 43-46-25.0 N **Long (NAD83):** 091-07-29.0 W **ASR No.:** **Ground Elev:** 348.4

Antennas

Loc No.	Ant No.	Frequencies (MHz)	Sta. Cls.	No. Units	No. Pagers	Emission Designator	Output Power (watts)	ERP (watts)	Ant. Ht./Tp meters	Ant. AAT meters	Construct Deadline Date
1	1	000810.21250000	FX1	18		20K0F3E	15.000	35.000			
2	1	000855.21250000	FB2C	1	45	16K0F3E 20K0F3E	150.000	310.000	37.0	145.0	

Conditions:
Pursuant to §309(h) of the Communications Act of 1934, as amended, 47 U.S.C. §309(h), this license is subject to the following conditions: This license shall not vest in the licensee any right to operate the station nor any right in the use of the frequencies designated in the license beyond the term thereof nor in any other manner than authorized herein. Neither the license nor the right granted thereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934, as amended. See 47 U.S.C. § 310(d). This license is subject in terms to the right of use or control conferred by §706 of the Communications Act of 1934, as amended. See 47 U.S.C. §606.

Licensee Name: LA CROSSE, CITY OF

Call Sign: WPCJ395 **File Number:** **Print Date:**

Antennas

Loc No.	Ant No.	Frequencies (MHz)	Sta. Cls.	No. Units	No. Pagers	Emission Designator	Output Power (watts)	ERP (watts)	Ant. Ht./Tp meters	Ant. AAT meters	Construct Deadline Date
3	1	000810.21250000	MO	385		20K0F3E	35.000	35.000			
3	1	000855.21250000	MO	385		20K0F3E	35.000	35.000			
3	1	000809.96250000	MO	420		20K0F3E	35.000	35.000			03-14-2008
3	1	000810.96250000	MO	420		20K0F3E	35.000	35.000			03-14-2008
3	1	000811.96250000	MO	420		20K0F3E	35.000	35.000			03-14-2008
4	1	000854.96250000	FB2	1		20K0F3E	75.000	163.000	45.9	114.3	03-14-2008
4	1	000855.96250000	FB2	1		20K0F3E	75.000	163.000	45.9	114.3	03-14-2008
4	1	000856.96250000	FB2	1		20K0F3E	75.000	163.000	45.9	114.3	03-14-2008

Control Points

Control Pt. No. 1

Address: EMERGENCY DISPATCH CTR 333 VINE ST

City: LA CROSSE **County:** LA CROSSE **State:** WI **Telephone Number:** (608)785-9634

Associated Call Signs

Waivers/Conditions:

NONE

Federal Communications Commission

Public Safety and Homeland Security Bureau

RADIO STATION AUTHORIZATION

LICENSEE: La Crosse, City of

ATTN: DIRECTOR OF INFORMATION SERVICES
LA CROSSE, CITY OF
400 LA CROSSE STREET
LA CROSSE, WI 54601

Call Sign	
WQJV364	
File Number	
Radio Service	
MW - Microwave Public Safety Pool	
SMSA	**Station Class**
	FXO

FCC Registration Number (FRN): 0004150421

Grant Date	Effective Date	Expiration Date	Print Date
01-12-2009	01-12-2009	01-12-2019	

LOCATION

Fixed Location Address or Area of Operation:
N1490 TOWER COURT
City: LA CROSSE **County:** LA CROSSE **State:** WI

Loc No.	Location Name	Latitude	Longitude	Elevation	Antenna Structure Registration No.
001	TOWER COURT	43-46-25.0 N	091-07-29.0 W	348.4	
002	GRANDAD BLUF	43-48-52.1 N	091-11-05.8 W	384.4	

FREQUENCY PATHS

Frequency (MHz)	Tol (%)	Emission Desig	EIRP (dBm)	Constr Date	Path No	Seg	Emit Loc No	Ant Hgt (m)	Gain (dBi)	Beam (deg) Reflector Ht(m)xWd(m)	POL	AZIM (deg)	Rec Loc No	Rec Call Sign
942.975	0.00015	200KD7W	46.200	07-12-2010	001	1	001	42.7	19.2	14.6	V	313.1	002	

Waivers/Conditions:

NONE

Conditions:
Pursuant to §309(h) of the Communications Act of 1934, as amended, 47 U.S.C. §309(h), this license is subject to the following conditions: This license shall not vest in the licensee any right to operate the station nor any right in the use of the frequencies designated in the license beyond the term thereof nor in any other manner than authorized herein. Neither the license nor the right granted thereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934, as amended. See 47 U.S.C. § 310(d). This license is subject in terms to the right of use or control conferred by §706 of the Communications Act of 1934, as amended. See 47 U.S.C. §606.

Federal Communications Commission

Public Safety and Homeland Security Bureau

RADIO STATION AUTHORIZATION

LICENSEE: La Crosse, City of

ATTN: DIRECTOR OF INFORMATION SERVICES
LA CROSSE, CITY OF
400 LA CROSSE STREET
LA CROSSE, WI 54601

Call Sign	
WQJV365	
File Number	
Radio Service	
MW - Microwave Public Safety Pool	
SMSA	**Station Class**
	FXO

FCC Registration Number (FRN): 0004150421

Grant Date	Effective Date	Expiration Date	Print Date
01-12-2009	01-12-2009	01-12-2019	

LOCATION

Fixed Location Address or Area of Operation:
HIGHWAY FA
City: LA CROSSE **County:** LA CROSSE **State:** WI

Loc No.	Location Name	Latitude	Longitude	Elevation	Antenna Structure Registration No.
001	GRANDAD BLUF	43-48-52.1 N	091-11-05.8 W	384.4	
002	TOWER COURT	43-46-25.0 N	091-07-29.0 W	348.4	

FREQUENCY PATHS

Frequency (MHz)	Tol (%)	Emission Desig	EIRP (dBm)	Constr Date	Path No	Seg	Emit Loc No	Ant Hgt (m)	Gain (dBi)	Beam (deg) Reflector Ht(m)xWd(m)	POL	AZIM (deg)	Rec Loc No	Rec Call Sign
933.975	0.00015	200KD7W	46.200	07-12-2010	001	1	001	42.7	19.2	14.6	V	133.1	002	

Waivers/Conditions:

NONE

Conditions:
Pursuant to §309(h) of the Communications Act of 1934, as amended, 47 U.S.C. §309(h), this license is subject to the following conditions: This license shall not vest in the licensee any right to operate the station nor any right in the use of the frequencies designated in the license beyond the term thereof nor in any other manner than authorized herein. Neither the license nor the right granted thereunder shall be assigned or otherwise transferred in violation of the Communications Act of 1934, as amended. See 47 U.S.C. § 310(d). This license is subject in terms to the right of use or control conferred by §706 of the Communications Act of 1934, as amended. See 47 U.S.C. §606.

Appendix 2 – City of La Crosse Inventory

DEPARTMENTS													#		
POLICE	FIRE	AIRPORT	LAX CTR	MTU	WWU	STREETS	PARKS	WATER	MTCE	DPW	ENG	HEADEND	UNITS	MODEL	RADIO TYPE
71	41	14	47	7	3	6	3	11		2	7	1	213	MTS2000	PORTABLE
					2	2							4	GTX	PORTABLE
13	1		22										36	XTS2500	PORTABLE
							3						3	MTX850	PORTABLE
2		2			1		4						9	MCS2000	MOBILE
35	21	4				3	1			2			66	XTL SERIES	MOBILE
				5	3	5	4	2			1		20	GTX MOBILE	MOBILE
		5		25	26	52	17	7	2		2		136	MAXTRAC	MOBILE
1	4	1	1	1	1	1	2	2	1	1	1	1	18	XTL CONSOLETTE	BASE
4	5	2		5	6	5	3	9	3	4	5	3	54	MC3000	REMOTE
1	4	1		1	1	1	1	2	1	1	1	1	16	ANY	RADIO INTERFACE BOX
														ANY	SYSTEM HEAD END EQUIPMENT
127	**76**	**29**	**70**	**44**	**43**	**75**	**38**	**33**	**7**	**10**	**17**	**6**	**575**		

Appendix 3 – Reported Areas of Communications Issues

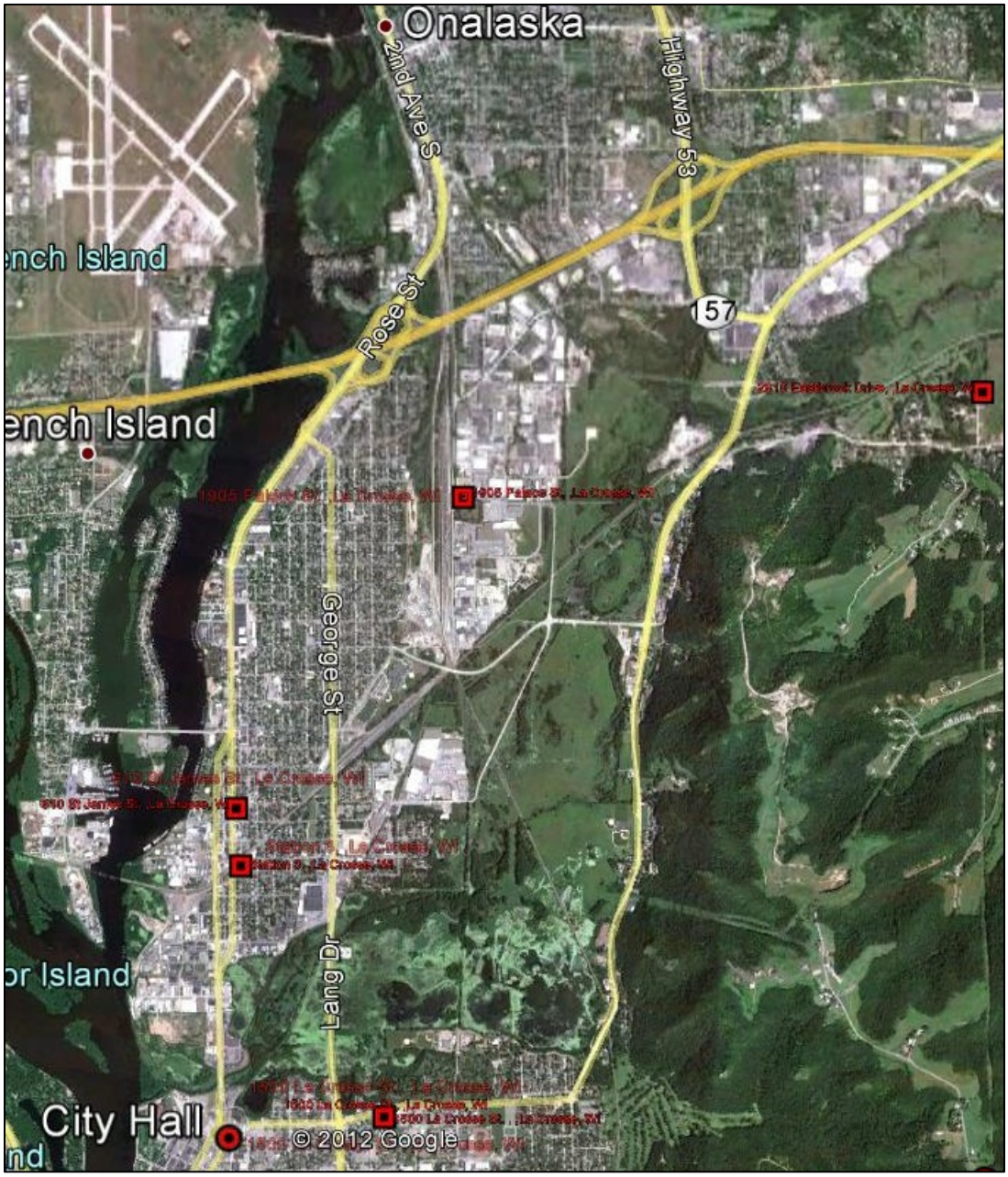


Figure 51: Problem Areas Reported North of City Hall

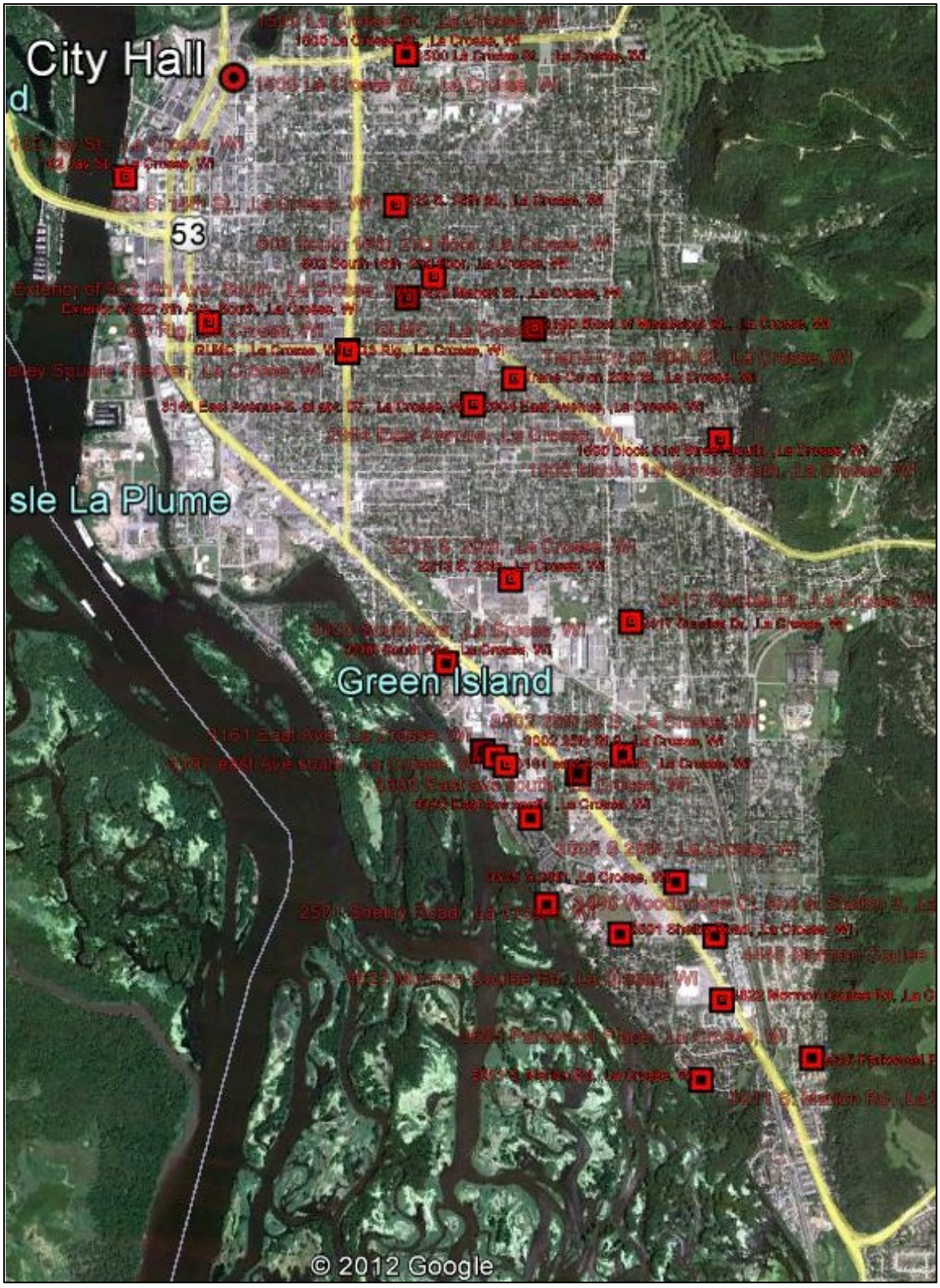
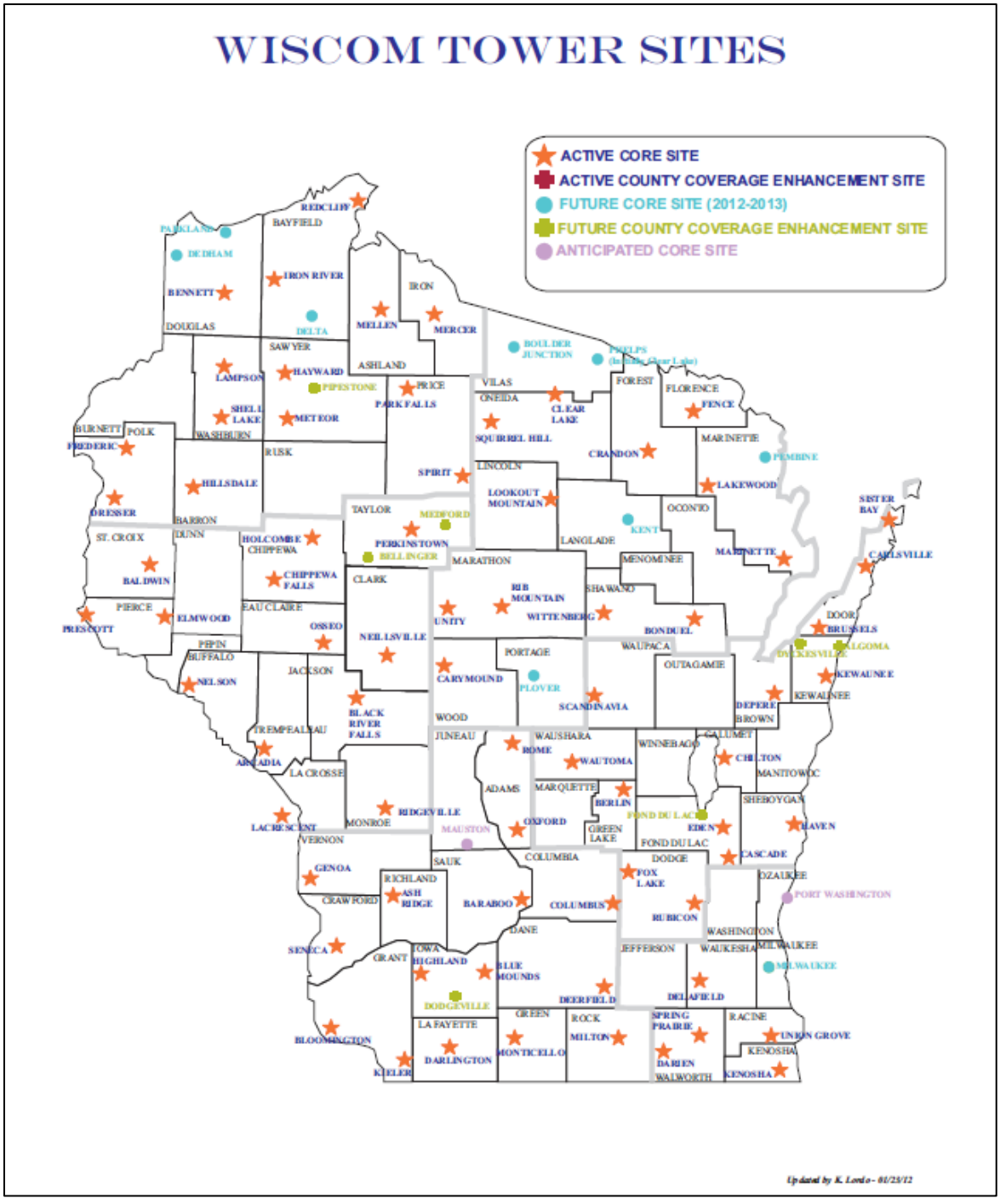
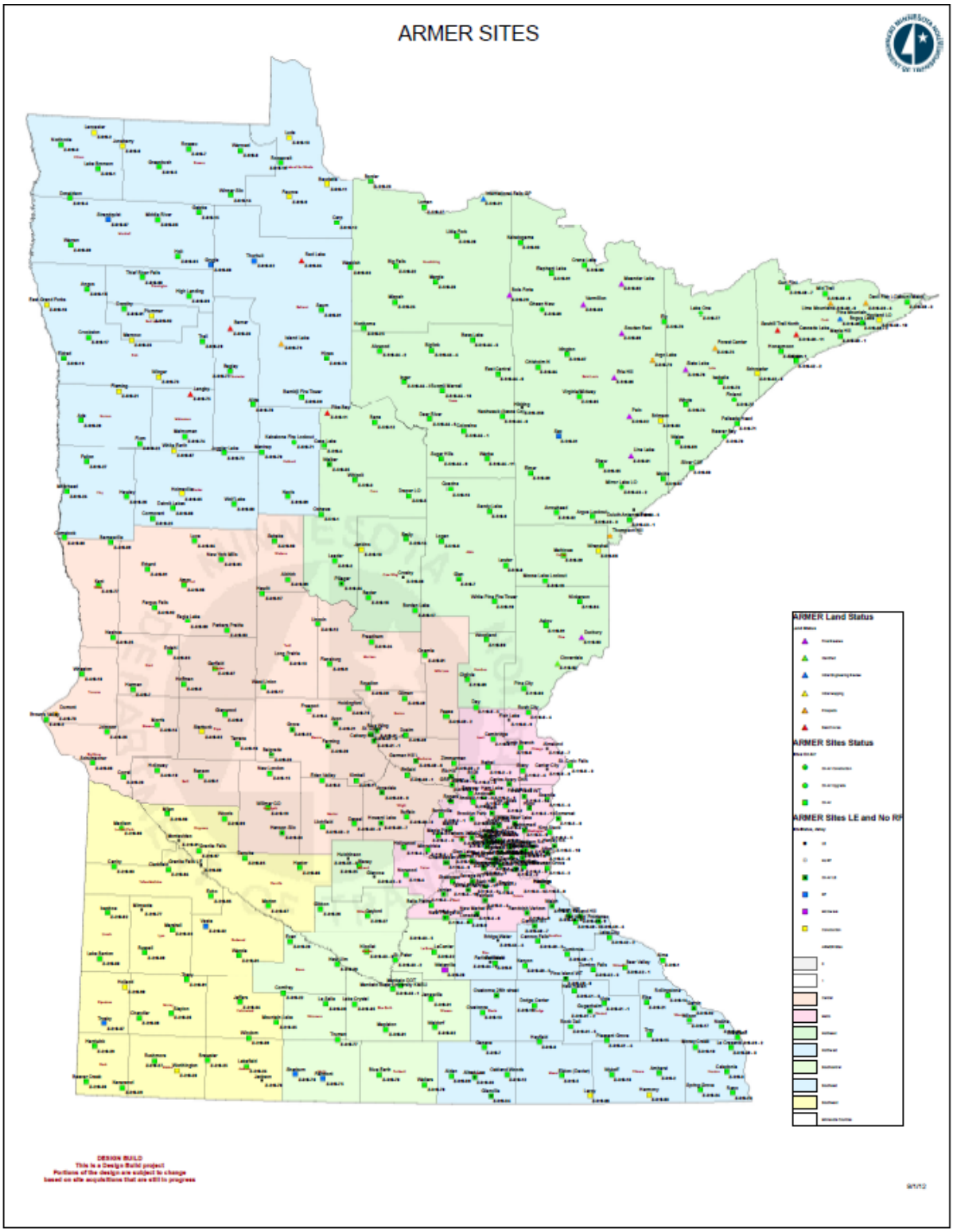


Figure 52: Problem Areas Reported South of City Hall

Appendix 4 – WISCOM



Appendix 5 – ARMER



Allied Radio Matrix for Emergency Response (ARMER)
Standards, Protocols, Procedures

Document Section:	**1 - Management**	**Status:** Complete
Sub-Section:	**State 1.10.0**	
Procedure Title:	**Requesting Participation & Participation Plan Changes**	
Date Established:		**SRB Approval:** 4/28/ 2011
Replaces Document Dated:	**n/a**	
Date Revised:	**02/01/2011**	

1. Purpose or Objective

The purpose of this standard is to establish the procedure for an eligible entity to apply for participation in the Allied Radio Matrix Emergency Response (ARMER) system and for a participant to request changes to their participation plan.

2. Technical Background

The following definitions apply to this standard:

- "Requesting entity" means an entity that wishes to gain access to the ARMER system for voice communication purposes. Entities that are not eligible ARMER participants may not apply for access.
- "Contracting entity" means the entity with which the requesting entity will contract, as defined in Standard 1.9.0.
- "Full participant" means an entity whose primary voice communications are fully integrated into the ARMER backbone.
- "Limited participant" means an entity whose primary voice communications are integrated with the ARMER system via patches, audio gateways, or other means.
- "Interoperability participant" means an entity who desires access to the ARMER system, via subscriber equipment, for purposes of interoperability and not as the entity's primary voice communication system. Interoperability participants may be authorized to maintain and operate subscriber equipment programmed to talk groups in accordance with the standards adopted by the SRB.
- "Regional and statewide plans" means any plans adopted by the contracting entity, the contracting entity's regional radio board, or the Statewide Radio Board (SRB).

3. Operational Context

Since changes to the ARMER system may affect other participants, the addition of new participants must be reviewed for possible performance or cost impacts to some or all users of the system prior to implementation. The participation plan provides the information needed to evaluate system impacts of taking on the new participant and assures that new users will have sufficient training and procedures to properly use the shared system and interoperate with other users.

Similarly, whenever existing participants change the nature of their use of the system, those changes need to be documented in a participation plan amendment and evaluated for system impacts prior to implementing those changes.

Only those issues that affect the operation of the system backbone are governed by this standard. Changes that affect only local resources may be managed at the local or regional level.

The system backbone is designed with a certain amount of capacity in anticipation of the addition of future participants joining the system. However, if a participation plan requires the addition of new backbone resources or triggers a major technical change, the technical change management procedures of ARMER Standard 1.8.0 may also apply.

4. Recommended Protocol/Standard

All participants accessing the ARMER system must have a current, approved participation plan or be included in the approved participation plan of another entity.

5. Recommended Procedure

A. Participation Plan Contents

When an entity elects to become a participant, it shall develop a design plan that is compatible with the plan of the contracting entity and with the plan adopted by the SRB. An entity requests participation by submitting the design plan and a letter requesting participation to the contracting entity. Prior to submitting the plan to the contracting entity, the requesting entity and their engineer are encouraged to consult with Mn/DOT staff to facilitate later plan approval.

Full or Limited Participation

The plan should include all the necessary information required for Mn/DOT to determine the impact that the planned participation will have on the ARMER backbone. Typical items that should be in the plan include:

- Site additions
- Channel additions
- Equipment additions
- Frequency plan
- Subscriber radios
- Talk groups
- Prelim Fleet Map
- PSAP consoles
- PSAP logging
- ATIA data requirements
- Contingency plans
- Backup equipment
- Connectivity
- System administration
- Alarm & monitoring
- Training plan
- Cut over plan
- Schedule
- Interop plan
- Maintenance
- Other local elements

Interoperability Participation

When an entity elects to become an interoperability participant Interoperability plans should contain the following information:

- The type and quantity of equipment;
- Whether the agency has PSAP equipment capable of accessing the ARMER system;
- A narrative description of the entity's intended use; and
- A list of public safety agencies that the entity would anticipate communicating with over the ARMER system.

The requesting entity may be granted access to these talk groups:

- I-CALL and I-TAC channels from the NPS PAC plan
- Statewide Interoperability talk groups
- Statewide system patches to legacy communication systems
- Other talk groups whose owners have granted permission to the requesting entity

B. Plan Review

The contracting entity shall determine whether the requesting entity's plan is consistent with regional and statewide plans. The contracting entity may resolve inconsistencies by amending its plan, suggesting changes to regional or statewide plans, or seeking adjustments to the requesting entity's proposal. The contracting entity shall not approve plans where there is an inconsistency between regional and statewide plans and the requesting entity's plan. Once the requesting entity's plan is found to be consistent with regional and statewide plans, the contracting entity shall approve it and submit it to Mn/DOT for review.

Mn/DOT will review the requesting entity's plan to ensure that these requirements are met:

1. The plan accurately reflects any impacts on the ARMER system that would result from its implementation.
2. The plan is consistent with the capacity and operational constraints of the ARMER system.

3. The plan is consistent with the currently adopted plan and standards of the SRB.

If Mn/DOT determines that the requirements are met, Mn/DOT shall notify the requesting entity who may then submit their participation plan to the Operations and Technical Committee for approval by the SRB.

If Mn/DOT determines that the requesting entity's plan does not meet these requirements, Mn/DOT shall communicate its objection to the plan to the requesting entity. The requesting entity may then revise and resubmit their plan or submit the plan and with Mn/DOT's assessment to the Operations and Technical Committee. The Operations and Technical Committee shall review the plan and assessment, and make a recommendation to the SRB, who shall have final authority over acceptance of the plan.

The requesting entity gains access to the system when their request for participation is approved and the entity has executed a subscriber agreement.

C. Participation Plan Amendments

If a participant desires to make changes to their approved plan, the plan amendment shall be submitted for approval following the same procedure as for the initial approval of a plan. If Mn/DOT determines that the plan amendment does not impact the backbone, Mn/DOT may approve the amendment without further action by the Operations and Technical Committee or the SRB.

6. Management

The Operations and Technical Committee is responsible for the management of this standard. Mn/DOT and DECN staff shall maintain a record of approved and amended local participation plans.

Appendix 6 – Primer on Best Practices

Public Safety Communications

Technology has changed the concept of communications for public safety communications officers just as it has changed nearly every occupation's day-to-day operations. The importance of readily available information cannot be understated as an objective of communications system designs. In addition to readily available information, officers also need a tool whereby they can communicate with whomever necessary in a secure means. Interoperability across jurisdictions and across the multiple disciplines that serve the public is an absolute requirement.

Historical Technology Perspective

Many jurisdictions began the upgrade to high band VHF FM radio technology in the 1980s as an upgrade from low band VHF. A single (or in some cases multiple) repeater(s) in support of an area offered a means of dispatch-to-car and car-to-car communications within the served area. Everyone shared the frequency in a specified area, and adjacent counties may have added neighboring counties' frequencies to their mobiles. Over time, additional repeaters were added for fire, EMS, and other needs to increase capacity and congestion. As mobile radios were replaced, these radios provided the capacity to be programmed with more frequencies, and thus, interoperability for a localized region was improved if everyone was on the same band. At the same time, some states or regions coordinated mutual aid frequencies that further enhanced interoperability at a critical incident scene. The fire departments also made dual use of their main frequency by the addition of paging to call off duty fireman. In some cases, paging was also incorporated by other disciplines.

The problem with this expanded sharing and multiple frequencies then became how to monitor all of the activities at the same time and then how to interconnect when the need occurred. The solution was that dispatchers were provided the means of interconnecting various frequencies with a "tie" or bridging device on the console, sometimes called a patch. The result allows everyone to talk to everyone if their channels were on the dispatch console. This solution has worked, and even today this capability is included in most dispatch consoles. Channel overloading has created traffic blockage, however.

Radio Systems Technology Today

As the need increased with more and more use of radio communications, adding more frequencies became the norm. Eventually, however, there were no more additional frequencies to use. Thus, the only solution at hand was to use narrower channels and thus to create new channels between the previous wider channels in the VHF and UHF bands. In some cases, narrowbanding requires an upgrade of

equipment. Beyond VHF, the FCC started allocating in the higher bands of UHF and then later 800 MHz. The 700 MHz frequencies for land mobile radio use are already narrowband only. By the end of 2012, all UHF and VHF channels are to be narrowband operation.

During the 1990s, a number of public safety jurisdictions turned to the newly allocated frequencies in the UHF and the 800 MHz band, though this move also required a change to a new technology, called trunking radio. Trunking radio allows multiple users to share a group of frequencies while establishing specific talk groups defined for each group of users. Police, fire, EMS, and public works could share the system infrastructure while each in effect had their own channel. Overall frequency loading increased with trunking, though more simultaneous paths of communications can occur as each channel is shared. Think of the checkout counter at a store, where lines form for each row, as compared to the airport, where one line of waiting customers waits for multiple representatives. The line at the airport may be longer, but it does move faster. This is the same with trunking. The users may not have to wait for their turn, as every frequency is available to every user. The hidden control frequency is used to steer the user to the unused frequency. The FCC does require enough users to make use of trunking before channels are approved.

On the positive side, interoperability was enhanced by trunking because these different disciplines could also share a common talk group where they could all communicate among each other when needed. On the negative side, however, the adjacent jurisdiction that was still on VHF could not easily communicate, thus reducing interoperability. Another positive outcome was that the higher frequency (UHF and 800 MHz) offered enhanced in-building coverage, due to the physics of radio frequency energy in these bands and the development of a frequency plan that allows for grouping of all send and receive frequencies. By this grouping of frequencies, in-building equipment can be placed to allow better coverage and also to include cellular and paging.

High band VHF (150-159 MHz) offers some amount of expanded range as compared to UHF (450 – 512 MHz) and the newer 800 MHz bands. There was never a band plan for VHF, however, as the need was primarily to create non-interfering frequency pairs having the highest priority. This requirement was further enhanced when portables began to appear on the scene. The frequencies in use had to have enough physical separation that portables operating in close proximity to one another did not interfere with each other. Radios in the 70s and 80s were not capable of operating with frequencies assigned with close adjacency.

Narrowbanding has created its own set of challenges, as to accomplish the use of less bandwidth means the radios have to overcome the ever increasing noise in the atmosphere, and with VHF this can mean a smaller communications range. To overcome the noise issue, digital transmission was developed. APCO set out to establish a new digital standard. The outcome was Project 25, which will be discussed in further detail later in this section. For now, it should be noted that the

use of P25 has shown that the combination of narrowband and this technology has actually extended the reach of what wideband used to offer.

Conventional Radio Repeater Technology

Land mobile radio (LMR) in its simplest form consists of two radios that make use of the same frequency and the same modulation scheme, located close enough to allow communications. In public safety, this is defined as simplex (or talk around) operation and tends to be used for close-in needs at the scene over a distance of a mile or two at best. As soon as more distance or more users are expected to share the system, communications infrastructure is needed. Namely, a repeater is generally installed at a central higher point in the geography of the area. This repeater listens to the mobile/portable units and retransmits what is heard to all other mobiles units. With either scheme, the limitation is how many channels the radio has as compared to the number of talk paths and how to share these channels of communication.

Over time, repeaters were installed throughout a jurisdictional area, but this resulted in a new problem. Both the subscriber and dispatch had to know which repeater site to use, and across the coverage area this created more interoperability issues.

Whether the system is simplex-based or a repeater system, the issue of too many users ultimately causes overload of the frequency. The answer has been to increase the number of frequencies, though the number of frequencies is limited and hundreds of miles have to separate the various users to avoid causing interference. Once users began running out of one band of frequencies, they moved to another and then another. Today, some public safety users operate in the VHF band, some in the UHF, and still others on 800 MHz and in the near term also narrowband 700 MHz. Due to the various bands in use, public safety organizations even within the same community may be unable to talk to each other.

Trunking Radio Technology

As the need increased for more channels than a simple repeater system could supply, a better way had to be found to make more spectrum efficiencies possible and to increase interoperability. This need has resulted in a technology defined as trunking, where subscribers to the system share the available channels via time division. Though with different technology, not everyone elects to make use of the system for various financial, political, and management reasons.

With trunking radio technology, many differing types of users can share a number of frequencies simultaneously. To keep these users separate, talk groups are assigned, and a special control system manages the assigned frequencies or channels and what their priority of use is. Trunking, as compared to individual

repeaters per user group, shows a marked improvement in spectrum efficiency while also enhancing interoperability. There is a cost to this improvement, however, in that the subscriber radios are more expensive than conventional repeater radios, and the system is much more complex to maintain and operate.

The idea of a talk group is foreign to many users of conventional repeater system technology, though once trained in its simple limitations and numerous benefits, users tend to not want to go back to the simpler life of simplex and repeaters. From the user perspective, a channel selector is used to obtain access to a talk group, just as in the past one would select a frequency to use. Once the talk group is selected, pressing the PPT button sends a request to use and the sender must wait 50-100 ms for a response to begin talking. The 50-100 ms is the time for the control system to connect all talk group users to the same group and allow them to hear the sender's statements.

The real power of trunked radio is the fact that all users of the system can become part of a talk group if needed and that priority messages can be sent to all system users quickly and easily. APCO Project 25 is one specialized use of trunking technology that goes to a higher level of interoperability than with the old Project 16 capability of the 1979 vintage of trunking.

VHF trunking has its own unique issues in that a frequency plan was never really developed that enables multiple frequencies to be used for trunking, as was the case for UHF and 800 MHz. With the intended move to narrowband assignment and the states of Wisconsin, Wyoming, and South Dakota using VHF trunking, interoperability means the use of radios that also offer trunking.

With the advent of public safety trunking operating in the VHF, UHF, 700 MHz, and 800 MHz bands, special devices called Inter-Sub-System Interface (ISSI) will allow users of these systems to bridge their system communications across operational borders and bands of operation.

Fire Paging and EMS Paging

As stated earlier, paging of part-time fire fighters and EMS in most parts of the country has been and remains a utilization of the main fire/EMS repeater or base station system, as commercial paging focuses on offering coverage only in inhabited areas. With the FCC's plan to require narrowband deployment of radio systems using the VHF, UHF, and 800 MHz frequencies, this results in a problem. In addition, the paging industry is somewhat being replaced by cell phones and two-way paging/messaging devices. Paging as an industry is suffering a lowered demand. As a result, there is a lack of pager equipment availability, as the various manufacturers decide to drop their product lines. As also stated, coverage continues to be an issue in rural areas.

The solution may be to equip all part-time staff with two-way radios that have paging alert capability or to utilize an emergency notification system capable of

sending short messages to multiple devices such as an office telephone, a cellular phone, an e-mail address, etc., when the need arises. One way or another, paging must be addressed as an issue. The VHF and UHF systems continue to be the choice for radio paging systems.

APCO Project 25

In the mid-1990s, the Association of Public Safety Communications Officers (APCO), in conjunction with the manufacturers of land mobile radio, created a new standard for interoperable radio communications called APCO Project 25. As had been accomplished in the 1980s with Project 16, the trunking standard, this new digital standard is hoped to be the solution for many years to come. Most federal and state agencies have adopted Project 25 as a minimum for any grant funding.

Definition

APCO Project 25 is a digital FDMA (frequency division multiple access[1]) trunked radio specification with backward compatibility to traditional analog FM technology. The ideal was to create a standard whereby users would be able to integrate equipment from multiple manufacturers while maintaining interoperability. Through the proposed integration of various levels of equipment and manufacturers, the customer would be given the opportunity to acquire equipment at various budgetary levels to meet their specific goals. Within the specification, the proposed benefits include the use of digital architecture for enhanced reliability, data services, improved spectrum efficiency, and some amount of backward compatibility.

Phases

Three phases are defined within the specification. Phase 0 (zero) refers to the radio's ability to be backward compatible with wideband analog FM radios, while Phase 1 allows the doubling of available channels (through the use of narrowbanding) and operation over trunking technology with digital services. Phase 2 is an enhancement, whereby it will be possible to support up to two or four talk or data paths over the same bandwidth channel. When the Phase 2 specification results in product, then digital TDMA[2] will be the method of choice for some agencies.

Phase 2 is also expected to offer the integration of voice and some limited data over the same air interface channel. This will allow for short text

[1] FDMA refers to the use of different frequencies to carry different conversations as compared to TDMA (time) where each channel is a different timeslot.

[2] As stated, TDMA (time division multiple access) makes use of different time slot multiplexing to carry multiple paths of information, be it voice or data.

messages to be sent to and from a subscriber's radio. The connection speed is not very fast as compared to dedicated circuits today, but the fact that a message can be sent and responded to by an officer is a vast improvement over today's technology. (Note: This is not broadband data.)

One element of Project 25 that does not yet have even a working draft is that of interoperability between the core infrastructure elements of the trunking systems of the various manufacturers. In simpler words, a Project 25-compliant radio from one manufacturer can talk over the trunking system of another manufacturer, but one manufacturer's repeater cannot interconnect with another manufacturer's at the system level.

The ultimate goal of Project 25 is to allow the greatest choice and operational flexibility for the user. There are a total of 33 separate documents that make up Phase 1, with at least six such documents related to Phase 2. One of the most important outcomes of Project 25 to date was the establishment of a common air interface, allowing one manufacturer's radio to talk to another manufacturer's repeater. The task now is for the other standards to be completed, including inter-subsystem and an open console interface. These are being completed as a part of Phase 2, and product is becoming available in the market. Phase 2 is not yet a fully functioning standard, however.

So, What Does Project 25 Standard Offer?

- Mobiles and portables are able to scan at least eight conventional channels sequentially and at least eight trunked talk groups using unsecure or secure voice. (This is considered dual-mode though not simultaneous operation for all subscriber equipment and optional for fixed equipment.)
- Direct communications between mobiles and portables shall be allowed at any time without degrading normal system performance, irrespective of encryption use.
- Interfacing in support of data or voice to the commercial interconnect of the telephone industry shall be possible with quality equal to or better than conventional analog.
- Up to four levels of encryption shall be supported, thus meeting national government needs for classified and unclassified use plus commercial requirements. DES (Digital Encryption Standard) has been adopted by Project 25, though some users may have incorporated AES (Advanced Encryption Standard) which must be used by federal government agencies.
- Over-the-air rekeying of encryption keys shall be enabled to allow updating radio systems on the fly.

- Radios supporting Project 25 shall support roaming from one repeater system to another through the use of inter-subsystem interfaces. This capability extends to conventional analog also using the 9.6 Kbps transmission rate, thus allowing for future ISSI between manufacturers.
- As Phase 2 becomes operational, equipment shall continue to operate in conventional narrowband analog mode as long as FCC rules permit. The equipment shall be backwards compatible, thus supporting Phase 1 digital while allowing migration to Phase 2.
- The intent of Project 25 products as replacement for conventional repeaters of the same frequency band shall not require more tower sites. If simulcast, then this could be an issue in some situations.
- When compared to analog narrowband coverage, P25 Phase 1 systems exceed the past coverage of wideband in almost every aspect.

Primary Features

The primary features that ultimately have public safety excited about Project 25 technology and its merits include the following:

Voice Features	Data Features
• Talk groups (preset & on the fly)	• Continuous caller ID
• Digital priority scan	• Circuit and packet data
• Private call	• Encryption
• Telephone interconnect	• Over-the-air-rekeying
• Alert calls/paging	• Radio check
• Emergency alarm	• Selective radio inhibit
• Direct radio-to-radio	• Direct radio-to-radio
• ISSI roaming	• Silent emergency via ISSI

Is Project 25 Technology Being Deployed?

The answer is yes, as this is the direction suggested by nearly every national and statewide agency, due primarily to the goals and agreement to build an interoperable format supported by over 40 manufacturers.

Not everyone agrees that P25 is the best solution, however. Small public safety organizations and first responders see the estimated costs for subscriber equipment to be more expensive than conventional hardware.

Common Air Interface

The common air interface (CAI) is suggested to be the most important single element of Project 25 Phase 1, because it is the means by which multiple manufacturers' radios can interoperate on different infrastructures. The CAI defines the following specifically:

- Channel access: FDMA (Frequency Division Multiple Access)
- Modulation: C4FM (Compatible 4-Level Frequency Modulation) for Phase I
- Channel spacing: 12.5 KHz
- Frame format: 128-bit header followed by 528-bit error correction inclusive of 3,456 bit superframe
- Bit transmission rate: 9,600 bps
- Voice encoder: IMBE (improved multi-band excitation) operating at 4,400 bps speech coding

Mutual Aid Channels

Across the country, a number of VHF, UHF, and 700/800 MHz frequencies have been identified as mutual aid frequencies. It is recommended that these channels or frequencies be installed in every subscriber radio and in many dispatch centers to allow for interoperability at the scene of an incident. Generally, these frequencies are simplex, where talk and listen are the same, though in some cases conventional repeaters have been established. In the 700/800 MHz bands, there are also repeater channels that have been established.

Mobile Data

Typically, the drivers for mobile data are the need to make information available to public safety officers more quickly and the need to transfer this information from the voice channel to an out-of-band method. As the need for mobile data has increased, so also has the need for faster delivery of requested information and for more types of information. The new 700 MHz broadband spectrum has become the most desirable.

Limitations do exist as compared to fixed data connections when mobility is expected and required. As most forms of computing today have increased the need for bandwidth, so also have these services for public safety grown in size. To make the system work, it's important to be smart about how information is sent over the air interface. Matching the needs to the available bandwidth becomes the key to success. Another issue that sometimes needs to be addressed is the quality of service as related to voice and video. Special software on the mobile data

computer can sort out the connectivity bandwidth to ensure that critical information gets though.

Broadband Technologies – Long Term Evolution (LTE)

The newest technology to promise broadband data networking is the 700 MHz band using LTE. As of late February 2012, the government (through the FCC) has authorized sufficient bandwidth, and National Institute of Standards and Technology (NIST) is defining a plan for the rollout of technology for the use of this band. LTE is expected to offer public safety an opportunity to have its own broadband interconnect for on-scene use in support of an incident command situation without the potential overloading that can occur with cell phone carrier 4G services.

When fully developed, this new 4G (LTE) technology is expected to provide upwards of 50-100 mbps downlinks, though today it is in its infancy, where link offerings are measured in the 1-3 mbps range. In addition, the LTE technology is also expected to provide PTT voice operation with future enhancements.

It should be noted that two major impediments are holding back voice over LTE. One is the need for infrastructure (base stations) to operate, and the other is what technology to use. Voice developments will occur over the next few years, and it is believed that solutions will be found, including a method of talk-around.

For now, public safety waits for the recently formed FirstNet board to establish a plan of action for the rollout of the technology. Most organizations expect 2013 to be the year this technology really takes roots.

Infrastructure

Behind the scenes, connectivity of various radio base station sites, dispatch centers, and other segments of the system must have sufficient bandwidth and reliability to maintain system operations. The conventional technology of single and even multiple channel repeaters has been interconnected with microwave and/or leased phone lines using typically 64 kbps (DS-0) connections. In many locations, the connectivity made use of 960 MHz or 2 GHz microwave that provides up to 12 or 96 analog voice channels. Where geography allowed, a single repeater may have made use of multiple receivers and a voting system to select the best receiver.

Today, the interconnecting infrastructure of choice has become IP (Internet Protocol) over Ethernet. With the demands of Quality of Service to carry these voice channels and in the future video, this IP transport may actually be carried over a synchronous connectivity such as DS-3 circuits or even better, direct IP. In some places, fiber optics is also being used to connect various points of the network.

As mobile data becomes more a requirement, this need for even higher bandwidth in the backbone will be even more important. Bandwidths of 150 Mbps or more will not be uncommon.

Other Elements

Beyond electronics and communications circuits, other issues also need attention. Certain questions must be answered. For example, are the buildings acceptable to house the new technology? Are the existing towers mechanically sound enough to hold the new systems while the old ones are still mounted to them? Are towers and buildings in the right locations? Does sufficient power and grounding exist at the sites?

Assuming microwave is utilized in support of the infrastructure requirements and assuming 2 GHz had been the link, the only option may be to move to 6 or 11 GHz systems. While the older 2 GHz distances supported 25 miles, the 6 GHz distance is only 18-19 miles, and 11 GHz supports less than 8-9 miles. The potential that a relay tower and associated equipment may be necessary is very real for many users.

With the move to narrowband operation, it is absolutely necessary to improve the power surge suppression and facility grounding to ensure the lowest possible noise at the site. This generally requires a total rework of the site infrastructure.

Appendix 7 – Commercial Service Options – 3G and 4G

The commercial cellular/PCS voice wireless services are used by many jurisdictions as an adjunct to their own private radio systems. In addition, some public safety organizations are either using or contemplating the use of commercial wireless data services. The connectivity is via air cards in the public safety vehicle computer. One must understand that currently voice and data share the same air interface. Only AT&T is able to maintain both a voice and data channel simultaneously.

One of the most popular data services available is 3G (third generation) CDMA2000 1X EV-DO (Evolution Data Only), offering peak rates of 2.4 Mb/s within a 1.25 kHz bandwidth channel. Another carrier offers CDMA/1XRTT at 144 Kb/s, though actually providing 50-60 Kb/s, while another offers GPRS/GSM at 115 Kb/s with throughputs of 20-50 Kb/s. Roaming between these various technologies is not possible. Even if the same technology is used, the flavor of the technology is generally different.

The newest option, currently available only in some very dense areas of the country, is what is termed 4G (Fourth Generation) wireless for data only. This option, if available, can easily exceed the throughput of the previous 3G plans, though it still suffers the largest single issues: coverage and reliability. During an emergency, the load on commercial networks typically causes a loss of ability to establish a connection or to pass data with any level of priority. These networks currently don't have a system of priorities, though this is an option being considered.

Appendix 8 – Government Issues, Rules, and Grants

Interoperability

In 1995, the Public Safety Wireless Advisory Committee (PSWAC) was formed and charged with delivering a report within three years of its charter. In 1996, a series of technical, spectral, and planning recommendations were made for federal, state, and local public safety agencies. The basis of the report was to move from a group of "independent" stovepipe systems to a single "shared" utility to be used and shared by all public safety entities in a region. Three key elements were specifically addressed:

1. The lack of radio frequencies for public safety, especially in urban areas, has reached the situation where agencies are no longer able to meet communications needs.

2. Interoperability is hampered by the use of multiple frequency bands, incompatible equipment, and a lack of standardization in repeater spacing and transmission formats. The committee's recommendation was for a minimum baseline standard, interfaces/gateways, and a fair/open method of systems acquisition. Non-technical issues must also be addressed, such as funding sources, human factors, and spectrum availability.

3. Public safety agencies have not been able to implement advanced features such as broadband data and video into their systems.

Federal Communications Commission

The FCC assigns frequencies via a license to operate over a defined property area, thus ensuring that frequency assignments are distant enough to reduce the potential for interference among users (i.e., the Property Model). With the demand for additional frequencies, the FCC has adopted a rule-making action whereby channel bandwidth must be reduced to half of what is the 25 KHz per channel norm that has been in place since VHF and UHF channels have been offered. Under the FCC rules, effective January 1, 2013, all VHF and UHF channels will be reduced to 12.5 KHz. This is known as narrowbanding. The expected outcome is the doubling of available channels.

This issue of narrowbanding has resulted in another problem, however. Just making the change means the user community may well suffer a retraction of the distance a radio system covers. The single biggest issue is that noise with wide band was less of an issue than with narrowband. To overcome this issue, the choice is either to use P25 or to rebuild the plant to tighter specifications.