City of Lincoln – Lancaster County

Public Safety Radio System Assessment Report

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Problem Statement

The City of Lincoln – Lancaster County retained Elert & Associates (E&A) to develop a complete assessment for an enhancement to the aging 800 MHz trunked radio system used by the city and county public safety personnel. The system supports law enforcement, fire, EMS, and other emergency and public service users.

The study includes the requirements for the Lincoln Emergency Communications Center, which dispatches for public safety agencies, and it has a focus on emergency communications facilities, system management, interoperability with adjacent county agencies, Lincoln Public Schools and the State of Nebraska. The study also contains best practices for communications and recommendations with budgetary estimates.

Executive Summary

Elert & Associates was asked to review the current radio system as well as the dispatch center. The following is a summary of our findings.

Radio System Overview

City of Lincoln – Lancaster County currently uses an EDACS 800 MHz radio system owned by the City of Lincoln and operated by the Lincoln Radio Shop. This system is old and outdated, and the platform is at end of life. Lincoln – Lancaster County wants to update its system to a standards-based P25 communications infrastructure and ensure interoperability with neighboring public safety agencies and the State of Nebraska.

This study is intended to present what E&A recommends as the best options for the City and County, as well as a path forward. The recommended system is the one deemed the most cost effective way to meet the requirements, as identified through interviews and through assessing terrain issues in the coverage area.

Upgrading a system as complex as this is challenging. Some of these challenges at Lincoln – Lancaster County are as follows:

- Cost – Although outdated, the current system is not very expensive when compared with any upgrade alternative. A new system will require significant expenditures of both capital and operating dollars.

- Technology – Multiple user groups share the current system. Although this single system approach can be maintained, it may be difficult to consider implementing certain technologies while some users are operating P25 equipment and others are using analog or a different non-public safety grade digital system.

- Coverage – Elert & Associates has identified several technical solutions, and a recommended approach is included in the technical summary.

- User Requirements – Public safety users find P25 has been standardized to focus on their requirements while other users of the system not requiring these features may find there are other alternatives that have a better fit.

Radio System Recommendation

E&A recommends that Lincoln – Lancaster County prepare an RFP for 800 MHz and VHF P25 systems for Public Safety and a Digital Mobile Radio (DMR) system for Public Service and Lincoln Public Schools (LPS)[1].

In addition, E&A recommends a more detailed study of the needs for LPS, as there are some specific technologies being developed for school communications that may be beneficial to LPS's operating environment. RFPs should define the technical requirements of the City-County, providing a baseline that all vendors/respondents would need to design their system to meet. Any considered options must meet the defined minimum criteria.

E&A has identified three options (described in an overview and the technical summary of this report on the next page), and our recommendation is to move forward with Option 3. Option 3 is a mix of P25, analog, and DMR and provides radio platforms that meet the radio communications needs of City and County users. We estimate that the capital costs for Option 3 will be $9,355,000 for the radio infrastructure and $11,128,000 for new field terminal units.

Public Safety users will have a tool that is designed for this level of service and provides the features that Public Safety uses on a continuous basis. The P25 system infrastructure will only service public safety communications providing multiple levels of priority with multiple advanced digital encryption platforms and data interfaces for options such as GPS location built into the field units.

Public Safety field units are ruggedized beyond that of other land mobile field radios and are designed to operate in hazardous atmospheres. A number of P25 features are realized only through capabilities of radio dispatch consoles. These items all contribute to the cost of the system and of the field terminal units. Any non-public safety users would be paying for but would not necessarily benefit from many of these P25 system features.

All Public Safety users including Sheriff and Rural Fire in this option would employ multiband radio units to enable interoperability with the City of Lincoln, Lancaster County, adjacent counties and with the State of Nebraska's communications system using VHF and 800 MHz. Rural Fire will continue to employ analog systems to provide the basic paging capability and could maintain interoperability with adjacent Fire departments with some multiband field radio units for leadership or for all officers over time.

Non-public safety users require a solid basic communications platform that a user can maximize the utility of the field units. The Digital Mobile Radio platform provides the latest communications system features needed for basic communications requirements at a lower cost per user. Interoperability can be easily provided via gateways or console patching to the public safety P25system when the need arises.

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[1] The agencies and department included in the major user groups are found in Appendix 6 – User Definitions.

Options Overview

Budgetary Costs for Radio System

Option	Description of Improvement	Estimated Cost	Outcome
1	**Single P25 Trunking System – All Users** • 800 MHz • 2 sites • 20 channels per site • Trunking controller • Simulcast controller per channel • Arbor 5-ch backup Microwave network Direct control of infrastructure Backup control station access Structural analysis on each tower Replace military equipment shelter Microwave network 809 P25 mobiles 428 analog mobiles 1802 P25 portables 468 analog portables 143 P25 control stations 20 analog control stations 12 P25 radio consoles	$22.19M	Two-site 800 MHz P25 simulcast trunking system New radio terminals for all users; no pagers Slight improvement in coverage due to digital for P25 users

Option	Description of Improvement	Estimated Cost	Outcome
2	**P25 Trunking - Public Safety/Service** • 800 MHz • 4 Sites • 14 channels per site • Trunking controller • Simulcast controller per channel • Arbor 5-ch backup **P25 Conventional - Sheriff** • 800 MHz • 6 sites • 2 channels per site • Trunking controller • Simulcast controller per channel **Analog Conventional – Rural Fire** • 800 MHz • 8 sites • 2 channels per site • Simulcast controller per channel **Paging – Rural Fire** • VHF • 2 separate 4-site systems • 1 channel per site • Simulcast controller per channel **Digital Mobile Radio (DMR) – LPS** • 800 MHz • 2 sites • 2 repeaters per site • 4 talk channels per site • DMR controller Direct control of P25 infrastructure Microwave network Backup control station access Structural analysis on each tower Replace military equipment shelter Equipment shelters on new sites 809 700/800 MHz P25 mobiles 225 DMR mobiles 203 analog mobiles 1665 700/800 MHz P25 portables 275 DMR portables 330 analog portables 172 700/800 MHz P25 control stations 18 analog control stations Over the air programming 20 P25 radio consoles	$30.25M	Four-site 800 MHz P25 simulcast trunking system for City Six-site 800 MHz simulcast P25 conventional system for Sheriff Eight-site 800 MHz analog conventional Eight-site VHF paging system for Rural Fire Two-site 800 MHz DMR system for LPS New radio terminals for all users, no pagers Improved coverage for all users

Option	Description of Improvement	Estimated Cost	Outcome
3	**P25 Trunking – City Public Safety** • 800 MHz • 4 sites • 12 channels per site • Trunking controller • Simulcast controller per channel **P25 Trunking – Sheriff & Rural Fire** • VHF (SRS) • 2 sites • SRS + 2 channels per site • Trunking controller • Simulcast controller per channel **Paging Infrastructure – Rural Fire** • VHF • 2 separate 4-site systems • 1 station per site • Simulcast controller per channel **DMR – Public Service & LPS** • 800 MHz • 2 sites • 7-8 talk channels per site • DMR controller Direct control of P25 infrastructure Microwave network Backup control station access Structural analysis on each tower Replace military equipment shelter Equipment shelters on new sites 400 multi-band P25 mobile 203 VHF P25 mobile 616 DMR mobile 1257 multi-band portable 240 VHF P25 portable 679 DMR portable 140 700/800 MHz P25 control station 44 VHF P25 control station 35 DMR control station Over the air programming 20 P25 radio consoles	$24.81M Note: Estimated cost would be reduced if fewer multiband radios were acquired	Four-site 800 MHz P25 simulcast trunking system for City Public Safety Two-site P25 SRS simulcast trunking system for Sheriff and Rural Fire Four-site paging system for Rural Fire Two-site DMR system for Public Service and Lincoln Public Schools New radio terminals for all users; no pagers Improved coverage for all users

City of Lincoln – Lancaster County Findings/Issues

Elert & Associates consultants completed site visits to the dispatch center, city/county towers, and radio shop facilities, and conducted interviews with 26 county and city public safety staff members. E&A distributed radio system user surveys to those interviewed and other system users through the Lincoln Radio Shop. The comments in the following sections provide a general review of what we believe was learned during this information gathering phase. After completing this portion of the study, we shared the findings with the leadership to gain further feedback.

Issues/Information Discovered through Interviews

The following is a summary of the comments related to the radio system.

- System users state that the overall coverage of the present EDACS system is relatively good, but coverage issues do exist on the county borders and in some municipalities, recreational areas, isolated areas across the County, and within some buildings in the City of Lincoln.

- Users have adopted alternative forms of communications (e.g., cell phones) in areas that they know have coverage issues. Some users have adopted cell phones as their primary form of communications, with the radio system as backup.

- Some users have issues trying to effectively operate the radios because they are unfamiliar with system use. For some users, radios are not simple to operate.

- System failure is very rare.

- EDACS ProVoice (digital mode) was noted to not always work well in some rural areas.

- The radio channel is very busy on game day. During these periods, over 50 to 100 users may be on a single channel. (E&A Note: This may be a procedural issue more than technical – recommend breaking into smaller groups.)

- All of law enforcement operates on the 11 East and 13 West talk groups (Law Main) countywide between 3:00 AM and 3:00 PM, and then splits between three talk groups from 3:00 PM to 3:00 AM.

  ○ Lancaster Sheriff Department and downtown officers move from the East talk group to the Expanded Dispatch talk group.

  ○ Lincoln PD SW division moves to the West talk group during the busy period.

- Outdoor portable coverage is relatively good in the City of Lincoln, but there are some coverage issues in various areas of the County.

- In-building coverage issues exist in some schools, the jail, hospitals (outside the ER), shopping malls, basements, and sub-basements.

- Lincoln high schools use EDACS units, while middle and elementary schools use conventional 800 channels.

Observations and Lincoln Radio Shop Interview Information

- Lincoln - Lancaster County currently uses an 800 MHz two-site simulcast EDACS 20-channel trunked radio system that is owned, operated, and serviced by the City of Lincoln. Coverage is provided by two towers in the northwest (Military) and southeast (Jensen Park) portion of the City of Lincoln.

- Originally the EDACS system was set up as two 10-channel sites[2]. In 1997 the system was expanded to a 20-channel simulcast system. In 2006 a five-channel backup system originally to be implemented on a trailer was actually constructed at Arbor Road as a fixed location.

- EDACS equipment is still working well.

- EDACS end of life is driving system replacement activity.

- The list of system components that cannot be replaced is growing.

- Components are failing more often.

- EDACS system site controller hardware is no longer available from the vendor.

- Portable coverage is good in the city. There are potential coverage issues in the north due to terrain.

- The EDACS system uses tower top amplifiers to improve talk-in coverage at the Military and Jensen Park repeater sites.

- About a dozen bi-directional amplifiers are installed in buildings around the City (LECC, jail, hospitals, etc.) to offer improved indoor radio system operation.

- The new jail and Lincoln Public Schools use 800 MHz EDACS channels on a regular basis.

- BDA systems were installed into the jails to enable EDACS operation.

- The City of Lincoln purchased the last EDACS site controller with the system upgrade in 2000/2001. The EDACS DEC master controller is no longer available.

- Other towers supporting conventional repeaters in the north and south portion of Lancaster County provide additional coverage for Rural Fire departments for voice and paging service.

- Rural Fire uses six 800 MHz conventional channels for voice and two VHF channels for paging.

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[2] The original EDACS system was installed in 1987. The main site was at 10th and Charleston, with a backup at the KOLN tower. In 1997 the KOLN site equipment was moved to the new Jensen Park tower site and simulcast with the 10th and Charleston site. In 2000, Military Road replaced the 10th and Charleston site.

- The City of Lincoln Radio Shop is responsible for all maintenance, support, and replacement of the infrastructure components. The City of Lincoln Radio Shop is funded through fees from the agencies that use the system.

- An Open Sky system was initially installed and used for mobile data. It was operational for a short period, but the system was never fully completed.

- Air cards used on a cellular network are now used for mobile data.

- All repeater sites are interconnected by microwave, and the control point is located at the Jensen Park tower site in southeast Lincoln.

- All sites are interconnected to the Lincoln Emergency Communications Center located in the basement of the Hall of Justice building in downtown Lincoln.

Information Reported through Surveys

Note: The following information is from 24 user surveys representing about 76% of the radio users on the City of Lincoln - Lancaster County EDACS 800 MHz radio system. The percentages found below reflect the total number of EDACS units each responder represents.

- 68% are not able to communicate via radio with other members of their department everywhere in their service area. City of Lincoln users have in-building coverage issues, while County users have trouble in some municipalities and along the border areas.

- 98% of the users find the system easy to use.

- 78% of responders have experienced problems reaching dispatch or their department's control station. This was mostly due to an increased level of dispatch activity and not the radio system. Animal Control appears to have a problem with their base equipment.

- 65% of responders report experiencing areas of no coverage.

- 11% of responders have reported a system busy. During interviews it was reported that oftentimes the system is busy with other unit traffic, not that the system is at capacity.

- 87% of responders indicate that they require in-building coverage.

- 86% of responders report having a backup communications plan of some sort in case of failure.

- 82% of responders report that their service area may go beyond the service area borders.

- 20% of responders communicate with adjacent counties or agencies on a normal basis.

- 59% of responders report occasional communication with adjacent counties or agencies.

- 80% of responders report that their talk group is shared with other departments allowing interoperability.

- 9% of responders report experiencing interference at some point when using the radio system.

- 47% of responders use or would like to use mobile data.

- 16% of responders use or would like to use automatic vehicle location.

Responders report use of the following mobile and portable operational system features.

Feature	Mobile	Portable
Scan	88%	86%
Priority Scan	53%	80%
Unit ID	85%	77%
Encryption	12%	13%
DTMF Pad	0%	0%
Noise Cancelling Microphone	16%	40%
Conventional Repeater Operation	8%	65%
Talk Around	73%	64%

Portable Accessories	
Speaker Microphone	85%
Noise Cancelling Microphone	60%
Ear Buds	61%
Headset	52%
Leather Case	30%
Belt Clip	87%
Display	36%

EDACS Radio Communications System

The primary voice communications for most City of Lincoln and Lancaster County Sheriff radio users is a two-site 800 MHz 20-channel simulcast Harris EDACS trunked radio system. The two main sites are located in the northwest quadrant of the City of Lincoln at 1901 North 14th Street (Military Road) and just outside the Lincoln boundary to the southeast at 9001 Yankee Hill Road (Jensen Park). A backup five-channel site (Arbor Road) is located just outside the Lincoln boundary to the northeast at 9600 North 70th Street. Sites are interconnected using 6 and 10 GHz microwave.

Lincoln Emergency Communications Center (LECC) is located at 575 South 10th Street in the lower level of the Hall of Justice building in downtown Lincoln. The LECC is set up with 14 operator stations. Ten of these positions are equipped with Harris Maestro radio consoles that interface directly to the EDACS trunking system.

All Harris Maestro® radio consoles are interfaced to the console interface equipment in the dispatch equipment room. The Maestro® console located at the Emergency Operation Center at 233 South 10th Street is connected via the City of Lincoln fiber-based I.S. network. Standalone EDACS control stations are installed at the 10 radio dispatch console positions for backup communications.

The console system is connected via 6 GHz microwave to the EDACS trunking system at the Jensen Park site. The console system is also interconnected to the conventional channel equipment at the south building (the Military Road site) via dedicated fiber. The Military Road site is also interfaced to the I.S. network to provide IP overhead via the 6GHz microwave ring.

In the case of simulcast failure, the system is programmed to evenly divide the available channels among the two main sites using channels 1 to 10 at Jensen Park and channels 11 to 20 at Military Road. Military Road was designated as bypass site 1, and Jensen Park became bypass site 2. The system would operate like a two-site communications system. If the infrastructure ever entered the bypass mode, field radio units would revert to site 1 (Military Road) by default thus the coverage would suffer some issues.

The Arbor Road location was chosen to cover I-80 going towards Omaha to serve as a backup repeater site. If needed for communications, the site must be activated manually. Originally, the trunking radio equipment used at the Arbor Road site was planned as a transportable repeater site made up of channels 1 to 5 of the 20-channel frequency set. At the time of E&A's visit, no call sign associated with this location could be found.

Portable coverage was noted as good in the City. Several indoor BDA systems at 911, hospitals, and jails assist with indoor coverage in these areas. Portable coverage in border areas is noted as lacking. Tower top amplifiers are used to improve portable talk-back into the system.

Portables are assigned to officers. Units use the badge number as their alias. Vehicles are assigned and used by the assigned personnel over multiple shifts. Sheriff vehicles are individually assigned.

The primary driver for the need to upgrade is the end of life on the EDACS system (per the manufacturer). The system continues to serve users well, but components are rapidly becoming hard to replace. Maintenance is ongoing, and if the controller were to fail, it could be a major problem, as parts are nearly impossible to obtain.

800 MHz EDACS Trunking System Sites

- Jensen Park (20-channel simulcast)
- Military Road (20-channel simulcast)
- Arbor Road (5-channel backup)

Radio Dispatch Consoles

Radio dispatch consoles are used to communicate with users of the EDACS radio system and other conventional radio channels used by public safety and public service users on City of Lincoln – Lancaster County radio systems. The Harris Maestro console system used by LECC and EMA provides a direct interface into the EDACS infrastructure, while other console models used by University of Nebraska Lincoln (UNL) and the Airport Authority operate control station radios to access the EDACS system. The console equipment provides operation on the other radio systems channels by remote control of base stations or control stations associated with those radio systems.

The number of radio dispatch console positions varies by agency. Each agency is equipped with the number of positions needed to provide the appropriate service.

- Lincoln Emergency Communications Center: 10
- Department of Emergency Management: 1
- University of Nebraska Lincoln: 3
- Lincoln Airport Authority: 2
- Fire Station 14 – backup: 6

The LECC has a total of 14 operator positions. Recently two Channel 50 Lincoln Police Department operators who were located at the Lincoln PD Service Desk were relocated to the LECC. One of these consoles was recently moved from the radio shop to one of the LECC positions to augment that operation. Positions are identified with position numbers 102 and 104 through 116 at the LECC. These positions are set up for call taking and/or radio dispatch per the table below.

	911 BU, Non-Emergency		Law Enforcement				911-Fire/EMS				911 BU, Non-Emergency			
	102	104	105	106	107	108	109	110	111	112	113	114	115	116
911	(X)	(X)	(X)	(X)	(X)	(X)	(X)	Primary Answer Point	Primary Answer Point	(X)	(X)	(X)	(X)	(X)
Admin	X	X									X	X		
Radios			X	X	X	X	X	X	X	X			X	X
	Call Take	Call Take	Expanded Dispatch	LE West	LE East	LE Spare/ Training	Supv	Call Take	Rural Fire	City Fire	Call Take	Call Take	INFO	Data Entry

The Department of Emergency Management operates one C3 Maestro® IP dispatch console from the Emergency Operations Center located at 233 South 10th Street and is connected to the console interface at the LECC via the Lincoln Information Services IP network. In normal operation, this position is primarily used to set off the Lancaster County warning sirens.

The University of Nebraska Lincoln Police Dispatch Services is located at 300 North 17th Street and utilizes three Zetron Integrator RD operator positions with Model 4217B audio panels. The

Zetron console system activates six control stations connected to a custom BDA system that provides EDACS service in and around the area of the dispatch room. RACOM is pressing the University of Nebraska Lincoln to update their Zetron Console computer OS, though they are not having any issues with their system. The position of the radio shop is to wait on any upgrades of this nature until the City makes decisions on a new system.

The Lincoln Airport Authority is located in the lower level of the Lincoln Airport terminal. The two-position Baker console system operates radios programmed for Airport Authority Police, ALERT, Operations, AIR ALL, Tower, and User Select talk groups. Connectivity is via control stations.

Backup for the LECC is in the lower level of Fire Station 14, where there is one Maestro IP console position linked via the City of Lincoln I.S. fiber network to the LECC and six Zetron console positions that operate via on-site control stations to access the various radios systems used by Lincoln – Lancaster County users.

Bi-Directional Amplifier BDA Equipment

Bi-Directional Amplifier (BDA) receives outdoor signals and retransmits on an indoor antenna network to provide enhanced indoor coverage. The BDA system also receives the talk back signals from the indoor antenna system and re-transmits outdoors. In each direction the signals are amplified to provide the appropriate signal level to the receiving device. System engineering is necessary for each BDA to determine the appropriate signal level and antenna placement.

The City of Lincoln EDACS system utilizes BDA systems to improve indoor coverage. Below are the locations where these systems are installed:

- Bryan LGH East Hospital, Emergency Room, 1600 S. 48th St.

- Bryan LGH West Hospital, Emergency Room, 2300 S. 16th St.

- St. Elizabeth Hospital, Emergency Room, 555 S. 70th St.

- Hall of Justice, Basement and 1st Floor, 575 S. 10th St.

- 911 and Lincoln Police occupy the basement.

- Lincoln Police and Lancaster County Sheriff occupy the first floor.

- Old Jail, Main floor, 605 S. 10th St.

- New Jail, Entire Building, 3801 W. O St.

- Youth Detention Center, Complete building, 1200 Radcliff St.

- Emergency Management, Basement, 233 S. 10th St.

- Backup 911 Center, Basement, 5435 N.W. 1st St.

- Health Department, Basement, 3140 "N" St.

- Lincoln High School, Entire Building, 2229 J St.

- Lincoln East High School, Entire Building, 1000 S. 70th St.

- Northeast High School, Entire Building, 2635 N. 63rd St.

- North Star High School, Entire Building, 5801 N. 33rd St.

- Southeast High School, Entire Building, 2930 S. 37th St.

- Southwest High School, Entire Building, 7001 S. 14th St.

- UNL Police Department-Dispatch

Primary Users of the EDACS Voice Radio System[3]

- Air National Guard Fire-Rescue

- City of Lincoln – Lancaster County Health

- City of Lincoln – Lancaster County Emergency Management

- City of Lincoln Airport Authority

- City of Lincoln Building and Safety

- City of Lincoln Fire – Rescue

- City of Lincoln Park and Rec

- City of Lincoln Police Department

- City of Lincoln Public Schools

- City of Lincoln Public Works

- Lancaster County Corrections Department (3801 W O St)

- Lancaster County Jail (605 S 10th St)

- Lancaster County Sheriff Department

- Lancaster County Youth Services Center

- Nebraska State Patrol

- University of Nebraska Lincoln

System Performance and Operation

The City of Lincoln controls the EDACS system infrastructure and is maintained by the City of Lincoln Radio Shop. Antennas have likely been changed since initial installation at Jensen Park and Military Road sites, but the transmission lines are probably original. The Radio Shop has a monitoring system to closely watch system performance. Alarms are monitored at some locations. The City of Lincoln Radio Shop does all of the IT work on radio communications systems.

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[3] A complete list of the EDACS system user groups can be found in Appendix 4.

The subscriber radio emergency button is used by Lincoln PD, the new LC jail, the old jail, Sheriff, State Patrol, UNL PD, and Youth Services. The selected talk group automatically becomes the emergency talk group if this button is energized. Dispatch consoles present an audible indicator until acknowledged by radio dispatch position when the emergency button is pressed. During an emergency, call operation moves to message trunking with hang time. A triple beep indicator appears due to message trunking at the end of hang time to announce this change to users.

The CAD network used to be independent but now is part of the City network. The majority of the other networks are part of the City network and are supported by the City of Lincoln Information Services. The Lincoln Police Department has its own IT personnel.

The Radio Shop uses Zetron SentriDial and CitectSCADA systems to deliver alarm information. They are also trying a Milestone product for video surveillance at the Jensen Park site. They would like to have something like this system at all sites with the new system.

The following are results of an analysis of system call statistics over one year from April 2012 to April 2013. There are 347 talk groups in the Lincoln – Lancaster County EDACS system.

- 84.21% of the total system airtime is logged by Public Safety.

- 9.26% of the total system airtime is logged by Public Service.

- 6.54% of the total system airtime is logged by Lincoln Public Schools.

- 53.38% of the total system airtime is logged by LPD.

- 5.80% of the total system airtime is logged by UNL Police.

- 7.54% of the total system airtime is logged by LFR.

- 5.46% of the total system airtime is logged by Youth Services.

- 2.30% of the total system airtime is logged by LCSO.

- 80% of the total system airtime is logged by 17 talk groups.

- 90% of the total system airtime is logged by 30 talk groups.

- 131 talk groups did not log any airtime over the period.

- 65 talk groups logged fewer than 100 calls over the period.

- 248 talk groups logged less than 60 minutes of total airtime over the period.

A Group Profiled Summary report tallies the call volume and airtime for each talk group in the system. They are sorted by the top 20 talk group by airtime usage. The top 20 talk groups represent over 82% of the air time used. "All Other" talk groups individually represent less than 1% of the total airtime used by system talk groups.
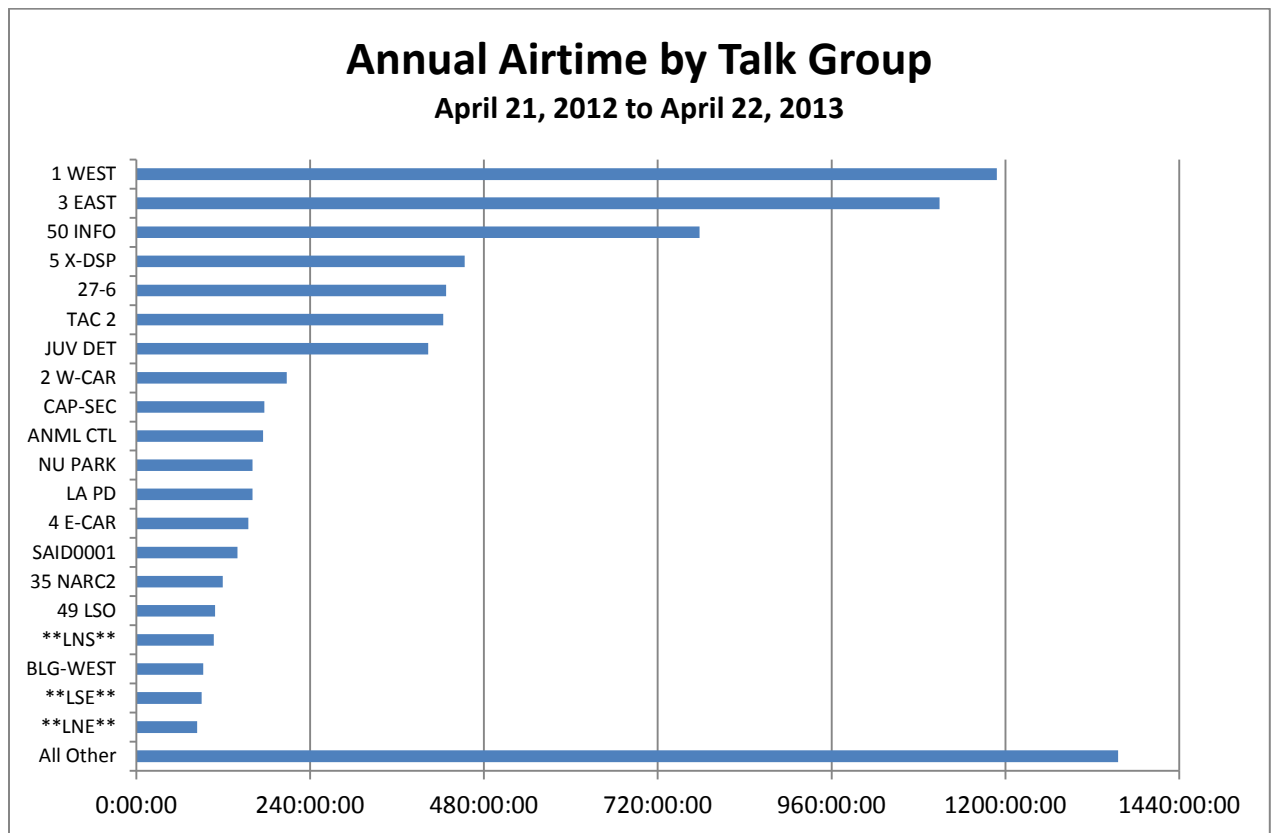
Figure 1: Annual Airtime Use by Talk Group
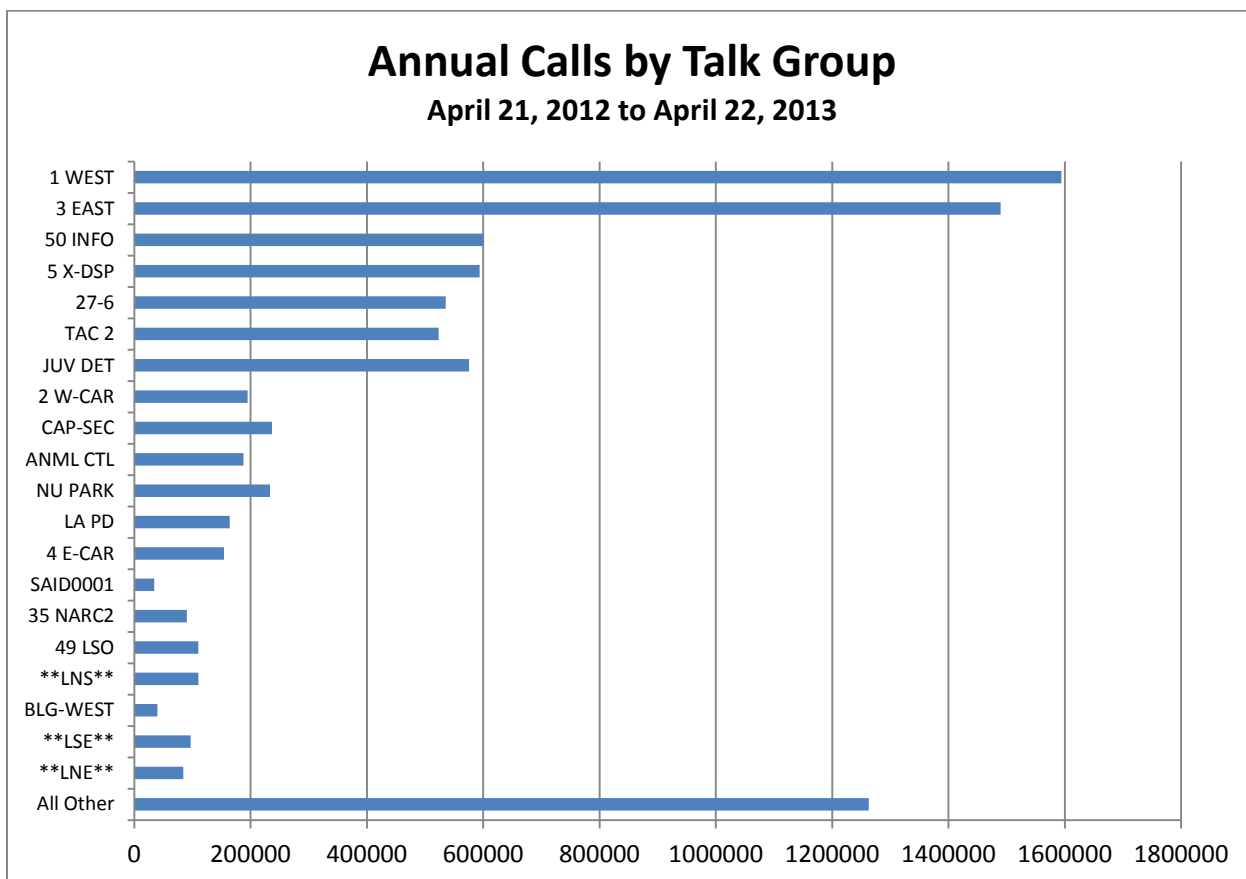
Figure 2: Annual Calls by Talk Group

The following graph represents total % talk time used by hour by day over one week from May 5 to May 11, 2013. The peak was 11.1% between 17:00:00 and 17:59:59 on Friday, May 10, 2013.
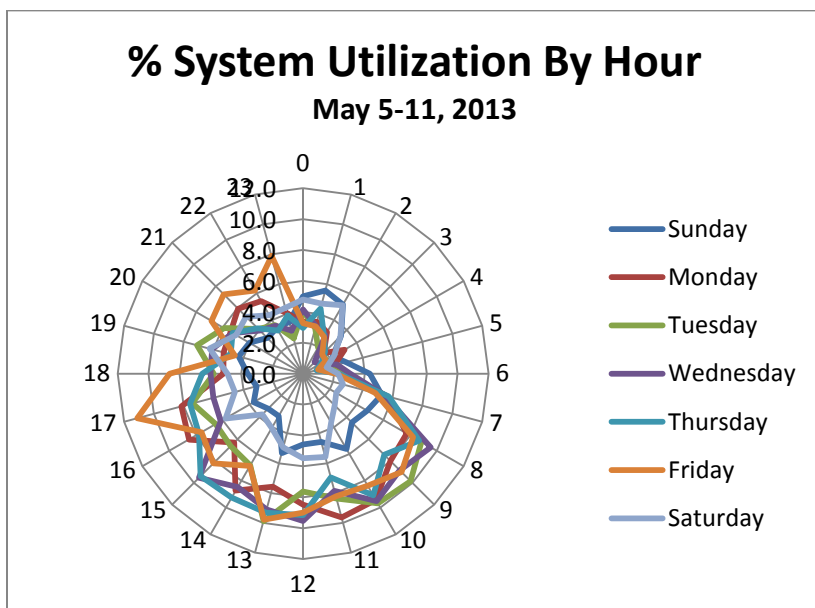
Figure 3: % System Utilization by Hour (May 5-11, 2013)

Game day weekends are expected to be the busiest time for the radio system. The following is a graph of the percentage loading by hour over a 48-hour period[4] on selected game weekends (home and away) in 2012. The highest loading is found to be 16%.
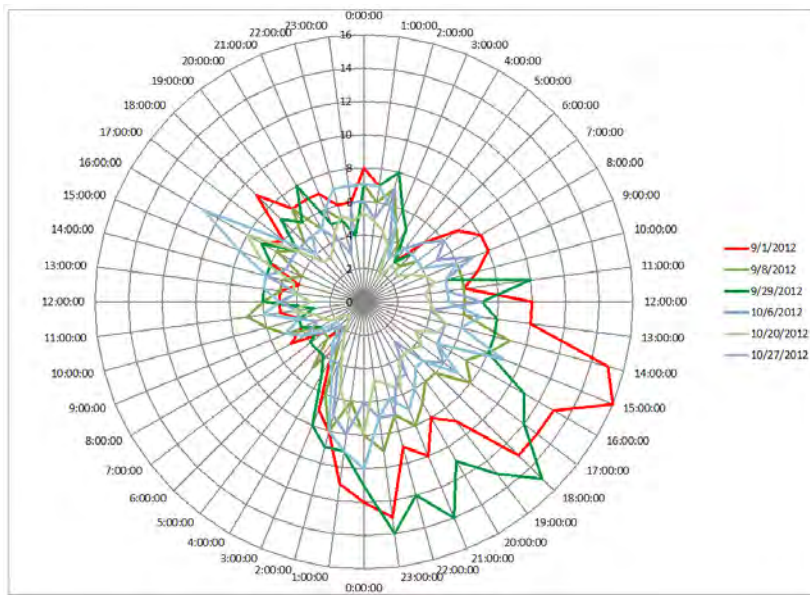
Figure 4: 2012 Game Weekend % System Usage by Hour

Technical Support

All departments are charged an annual fee per field unit (radio) for use, maintenance, etc. This fee funds the Radio Shop and all infrastructure and field unit hardware and support costs. The maintenance fee agencies pay includes any repairs, maintenance, programing or installs for the field units. The fees the agency pays is the only bill they receive from the Radio Shop unless it is an accessory or battery they want to purchase. There are about 3,000 radios in the system. 2,400 units are paid users. The cost per unit charged by the Radio Shop varies by radio type.

- Portable   ~$355/year

- Mobile   ~$370/year

- Control Station   ~$460/year

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[4] The 48 hour period is midnight Saturday morning through Sunday.

EDACS End of Life Concern

The manufacturer has announced that the EDACS system will no longer be supported after 2017. Thus, the City of Lincoln must find a solution, as they will be operating a system on borrowed time with no official support. From the time the decision is made to move forward with an upgraded system, the acquisition, build-out, and commissioning process typically requires 2.5 to 3 years. With the end of life assumed to be December 2017, the acquisition should begin no later than 2014.

Other Radio Communications Systems

The City of Lincoln – Lancaster County has several conventional radio communications systems in use. These systems provide radio communications for City and County systems for Rural Fire, Lincoln Public Schools, and jails. Other systems provide backup for the EDACS system, interoperability with adjacent counties, and common interoperability channels for special events.

Rural Fire

Until 2004/2005, rural fire departments operated on low-band VHF channels but received grant funds to update their voice radio communications systems. Lancaster County Rural Fire intended to move to UHF, but the Radio Shop advised that they should consider a transition to conventional 800 MHz for their voice radio system to allow interoperability with units operating on the City of Lincoln – Lancaster County 800 MHz EDACS network. They moved to 800 MHz when the system was funded by a grant and the Radio Shop agreed to pay for the ongoing support of the new repeaters.

Rural Fire uses geographically split systems—one in the north and the other in the south of the county. They operate identically but use different frequencies. Each geographical system has three 800 MHz conventional analog channels for voice and one VHF channel for paging. Each site has a primary 800 MHz conventional channel and an alternate channel for voice communications. The alternate channel is used if the primary channel does not provide appropriate service in the border areas. North Dispatch and South Dispatch repeaters are positioned at the Military and Jensen Park sites to provide primary radio communications. The 800 MHz portable coverage was lacking at the borders, so an additional repeater was added at Ceresco in the north and Firth in the south (Alt North and Alt South) to use if needed. Both North and South have a TAC repeater located at their respective border sites. The Lincoln Radio Shop is currently transitioning the Rural Fire equipment at the Firth tower to the Sneader tower near Hallam. A map of the fire districts can be found on page 77.

Paging

Paging was moved from low-band VHF to high-band VHF in 2004/2005. Rural Fire utilizes two VHF channels for two paging systems: north (154.35500 MHz) and south (154.29500 MHz). The north paging system uses the Military and Ceresco sites. The south paging system uses the Jensen Park and Firth sites. The equipment at Firth is being moved to the Sneader tower. The same two sites in each north and south zone also extend paging to the respective borders, utilizing two-site simulcast in each zone. Pages are multicast over the 800 MHz dispatch channel and received on 800 MHz receivers at both sites, which feed respective audio delay cards for simulcast transmission.

Using this configuration in addition to paging, the VHF channel retransmits all traffic on the respective dispatch channel. In addition, activity on the Alt Dispatch 800 MHz channel activates a mobile control station at the border sites, which transmits on the Dispatch 800 MHz channel, is received on an 800 MHz receiver on each interior site, and retransmits on the VHF paging channel. The VHF paging channel transmits all 800 MHz voice traffic in each zone, and the 800 MHz dispatch channel transmits alternate 800 MHz dispatch traffic in each zone.

Paging is initiated by LECC. When pages are initiated, the page is sent to the opposite zone of the event to alert responders of the incident, which may not be covered in the zone of the intended page. In this way, first responders carrying pagers can be alerted regardless of their location in the County. As these stations also carry the 800 MHz dispatch and 800 MHz alt traffic, to provide this operation the VHF transmitters must employ a 10-second hang time.

Pager users may have multiple channel pagers and change channels to monitor events in the opposite zone. If the channel is not returned to normal, the pages continue to be heard as long as the pager is in coverage of one of the paging systems.

The LECC Maestro® console system is not able to simul-select both paging channels when pages are sent out to the various departments, so they send them serially and then do the announcement using simul-select.

County Siren System

The Department of Emergency Management is charged with the operation of a public warning system and has 117 sirens throughout Lancaster County activated in five zones. Sirens are activated from the Emergency Operations Center at 233 South 10th Street using their Maestro® console. Sirens may also be activated at the LECC if they are not able to be activated at the EOC.

Sirens are activated over a VHF radio system operating on a frequency of 155.250 MHz. The primary transmitter is a VHF MASTR III located at south building of the Military Road site. A backup MASTR III station is located at the Hall of Justice building. A test of the siren system is performed on the first Wednesday of each month from the EOC. There is no regularly scheduled siren system test conducted from the LECC.

The siren system is one-way activate only. There is no response or acknowledge from any of the siren locations. The Emergency Director estimates that the cost to implement a two-way system would be about $500K.

Lincoln Public Schools

Lincoln Public Schools (LPS) have 63 facilities within the City of Lincoln. Several radio systems are used, employing about 500 subscriber radios. The six high schools use about 137 radios on the EDACS system. The remaining units used at elementary and middle schools are conventional 800 MHz. The 12 middle schools and 36 elementary schools use Kenwood radios working from three conventional repeaters designated as Blue, Green, and Orange. The Blue and Orange repeaters are located at the Military site, and the Green repeater is located at the Jensen Park site. The District office uses 6-8 EDACS units and 11-12 Kenwood conventional units. LPS transportation has its own 800 MHz channel, with the repeater located at Military and a control

station at the bus barn. District Facilities Maintenance uses a commercial UHF LTR system and employs 40 to 60 radios.

Network connectivity is provided by the school district between schools. Some schools have BDAs to enhance radio coverage. Schools have expressed the need to speak directly to the LECC or first responders. School Transportation stated that they would like to have automatic vehicle location (AVL).

Mobile Data Systems

- An 800 MHz Open Sky system was used for data on PD cruisers for a short period but was never truly implemented on the software side and is no longer being used. The Open Sky system equipment will be removed sometime in the future. The RF frequencies and associated RF components will be moved to other services for alternate or backup channels.

- Cellular air cards are currently used to provide connectivity.

Other 800 MHz Radio Systems (Site)

- Conventional
    - 800 Interop (Jensen Park)
    - Gage County Interop (Sneader)
    - Lancaster County Sheriff (Arbor Road)
    - Lincoln Fire – Rescue (Arbor Road)
    - Lincoln Public Works (Arbor Road)
    - Lincoln Police Department backup (St. Elizabeth Hospital)
    - North Rural Fire TAC (Ceresco)
    - Saunders County Interop (Ceresco)
    - Sheriff Conventional (Milford)
    - Sheriff Conventional (Seward)
    - Sheriff Conventional (Wilber)
    - South Rural Fire TAC (Sneader)
    - Water (Ashland)

- Jails
    - Lancaster County Jail (BDA indoor only)
    - Lancaster County Corrections Dept. (3801 West O Street)

Other VHF Radio Systems (Site)

- Low Band
    - 39.90 MHz (Military Road)
    - 39.98 MHz (Military Road)
    - 39.82 MHz (Military Road)

- Conventional/Backup
    - VHF Interop (Jensen Park)

- ○ VHF Interop (Arbor Road)

- P25

    - ○ State of Nebraska (Arbor Road)
    - ○ State Government (Military)

Other UHF Radio Systems (Site)

- Interop

    - ○ UHF Interop (Jensen Park)
    - ○ Old UHF Interop (Jensen Park)

900 MHz Radio Systems

- Water Department SCADA

FCC Licenses for Infrastructure

800 MHz Trunking System Channels

The channels used in the EDACS system are made up of City of Lincoln – Lancaster County licensed spectrum. The following repeater channels are licensed on call sign WNDX299 at the Military Road and Jensen Park sites.

WNDX299					
Frequency ID	Location	Frequency (MHz)	Antenna Height (ft)	Output Power	Max ERP
21	Military Rd	854.0125	341	100W	263W
22	Military Rd	854.1875	341	100W	263W
23	Military Rd	854.5875	341	100W	263W
24	Military Rd	854.6875	341	100W	263W
1	Military Rd	856.2125	341	100W	263W
2	Military Rd	856.4625	341	100W	263W
3	Military Rd	856.7125	341	100W	263W
4	Military Rd	856.9625	341	100W	263W
5	Military Rd	857.2125	341	100W	263W
6	Military Rd	857.4625	341	100W	263W
7	Military Rd	857.7125	341	100W	263W
8	Military Rd	857.9625	341	100W	263W
9	Military Rd	858.2125	341	100W	263W
10	Military Rd	858.4625	341	100W	263W
11	Military Rd	858.7125	341	100W	263W
12	Military Rd	858.9625	341	100W	263W
13	Military Rd	859.2125	341	100W	263W
14	Military Rd	859.4625	341	100W	263W
15	Military Rd	859.7125	341	100W	263W
16	Military Rd	859.9625	341	100W	263W
21	Jensen Park	854.0125	492	100W	226
22	Jensen Park	854.1875	492	100W	226
23	Jensen Park	854.5875	492	100W	226
24	Jensen Park	854.6875	492	100W	226
1	Jensen Park	856.2125	492	100W	226
2	Jensen Park	856.4625	492	100W	226
3	Jensen Park	856.7125	492	100W	226
4	Jensen Park	856.9625	492	100W	226
5	Jensen Park	857.2125	492	100W	226
6	Jensen Park	857.4625	492	100W	226
7	Jensen Park	857.7125	492	100W	226
8	Jensen Park	857.9625	492	100W	226
9	Jensen Park	858.2125	492	100W	226
10	Jensen Park	858.4625	492	100W	226
11	Jensen Park	858.7125	492	100W	226
12	Jensen Park	858.9625	492	100W	226
13	Jensen Park	859.2125	492	100W	226
14	Jensen Park	859.4625	492	100W	226
15	Jensen Park	859.7125	492	100W	226
16	Jensen Park	859.9625	492	100W	226

Note: Five EDACS stations using a subset of five primary system 800 MHz channels are implemented as backup at the Arbor Road location. E&A was not able to find these frequencies licensed at this site.

Conventional 800 Channels

WNDX303					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
1	Ashland	854.9625	FB2	70	120
1	St. Elizabeth	855.2375	FB2	100	462
3	Arbor Rd	855.4625	FB2	100	229
2	Arbor Rd	855.7375	FB2	100	229
1	Arbor Rd	855.9875	FB2	100	229

WQAS840 – Rural Fire-Rescue – North					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
2	Military Rd	851.7500	FB2	100	225

WQAY625 – Rural Fire-Rescue – North Alt					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
2	Ceresco	853.1875	FB2	100	275

WQAY622 – Rural Fire-Rescue – North TAC					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
2	Ceresco	852.2500	FB2	100	280

WQAU827 – Rural Fire-Rescue – South					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
2	Jensen Park	851.8125	FB2	100	220

WQAS235 – Rural Fire-Rescue – South Alt					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
2	7480 Olive Creek Road	853.1625	FB2	100	211
1	Sneader	853.1625	FB2	100	230

WQAU765 – Rural Fire-Rescue – South TAC					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
2	7480 Olive Creek Road	851.9750	FB2	100	211
1	Sneader	851.9750	FB2	100	230

WPYS986 – 8TAC5					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
2	Military Rd	851.3000	FB	100	334

WQAY624 – LPS					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
3	Military Rd	852.0625	FB2	100	250
4	Military Rd	852.3375	FB2	100	250
2	Jensen Park	852.3375	FB2	100	250

WQAZ575 – LPS					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
1	Military Rd	852.7750	FB2	100	166

WQAZ577 – Public Safety Data (OpenSky platform) - Unused					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
3	Jensen Park	852.0875	FB2C	75	150
3	Military Rd	853.1000	FB2C	75	150
4	Military Rd	853.4125	FB2C	75	150
5	Military Rd	8536875	FB2C	75	150

Conventional UHF Channels

KNAT464 – Lincoln Public Schools					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
1	Lincoln East HS	463.7000	FB	110	200

WPZN824 – UHF Interop					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
1	Jensen Park	460.2000	FB2	100	344

Conventional VHF Channels

KVN663 – Rural Fire-Rescue (unused)					
Frequency ID	**Location**	**Frequency**	**Station Class**	**Output Power**	**Max ERP**
1	Military Rd	39.82	FB	100	100
1	Bryan Medical Ctr East	39.82	FB	100	100
2	Military Rd	39.98	FB	100	83

KZE694 – School Buses

Frequency ID	Location	Frequency	Station Class	Output Power	Max ERP
1	Lincoln East HS	155.2200	FB	100	200

WNSI787 – Paging

Frequency ID	Location	Frequency	Station Class	Output Power	Max ERP
1	Military Rd	155.8200	FB	100	221

WPYG364 – Rural Fire Paging

Frequency ID	Location	Frequency	Station Class	Output Power	Max ERP
1	Fire Station 12[5]	154.1300	FB	100	201

WPZK789

Frequency ID	Location	Frequency	Station Class	Output Power	Max ERP
1	Hall of Justice	159.2100	FB2	110	234

WQAE795 (Rural Fire Paging)

Frequency ID	Location	Frequency	Station Class	Output Power	Max ERP
1	Ceresco	154.2950	FB	100	300
2	Ceresco	154.3550	FB	100	300

WQAF254 – Rural Fire Paging

Frequency ID	Location	Frequency	Station Class	Output Power	Max ERP
1	7480 Olive Creek Road	155.2950	FB	100	229
1	4500 West Pella Road	155.2950	FB	100	197
1	Sneader	155.2950	FB	100	218
2	7480 Olive Creek Road	154.3550	FB	100	229
2	Sneader	154.3550	FB	100	218

WQAG261 – Rural Fire Paging

Frequency ID	Location	Frequency	Station Class	Output Power	Max ERP
1	Military Rd	154.2950	FB	100	250
2	Military Rd	154.3550	FB	100	250

WQAG312 – Rural Fire Paging

Frequency ID	Location	Frequency	Station Class	Output Power	Max ERP
1	Jensen Park	154.2950	FB	100	250
2	Jensen Park	154.3550	FB	100	250

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[5] License is currently being moved to Sneader.

Microwave, Fiber and Network Connectivity

There are four microwave paths that interconnect the tower sites used in the radio communications system with the Lincoln Emergency Communications Center in the lower level of the Hall of Justice.

A microwave ring interconnects Military Road, Jensen Park, and the Arbor Road sites consisting of two 6 GHz paths and one 10 GHz path (Arbor – Military). The ring provides a redundant backhaul system to ensure reliability and performance. The path from Jensen Park to the Hall of Justice provides interconnect to the radio dispatch console system. Not shown is a 6 GHz link from the Arbor Road tower to Ashland Water.

Another 6 GHz microwave path is now operational from the Arbor Road tower to the Sneader tower.

A fiber link connects the south Military shelter to the LECC. Backup 911, the EOC, and the Radio Shop are linked to the LECC via the City of Lincoln I.S. fiber network to provide Maestro IP Console interface for each location.

Physical Facilities

Towers

The Jensen tower was built in 1997. It is a guyed tower with a height of 492.1 feet (150.0 m). It is one of the two primary 20-channel EDCAS sites and is equipped with stations for Rural Fire Paging, Lincoln Public Schools, and interoperability channels. The Jensen Park property was originally donated to the County for recreational use.

The Military tower was completed in late 2000. It is a self-supporting tower with a height of 359.9 feet (109.7 m). It is one of the two primary 20-channel EDCAS sites and is equipped with stations for Rural Fire Paging, Lincoln Public Schools, and interoperability channels. The Military site is in need of one new shelter. There are multiple cellular antennas at the Military site.

The Arbor Road tower was completed in mid-2006. It is a self-supporting tower with a height of 359.9 feet (109.7 m). This site has been equipped with station equipment to provide a five-channel backup for the EDACS system and conventional 800 MHz backup channels for EDACS system users.

The Sneader (Hallam) tower was completed in mid-2012. It is a self-supporting tower with a height of 359.9 feet (109.7 m). This site has been equipped with station equipment to provide Rural Fire coverage of the southern portion of the county.

Dispatch Center (LECC)

The dispatch center is equipped with 10 Maestro® consoles in custom furniture configuration in the lower level of the Hall of Justice. A VPI 96-channel logger records various talk groups plus selected channels at each position and 911 lines. An additional dispatcher comes on duty at 3:00 PM, thus splitting duties for law. Dispatch is CALEA certified. The dispatch space is 33'6" x 36'9" with almost 8' ceiling. The Dispatch Equipment Room is 13'9" x 25'.
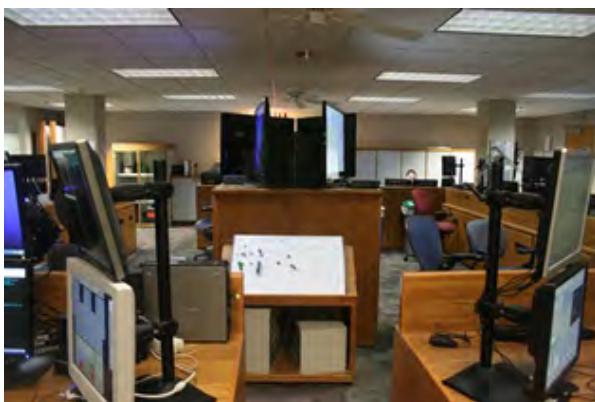
The Dispatch Equipment Room (DER) has unique common HVAC with Dispatch with return air flowing to the DER. Three Liebert HVAC units in the DER and one in dispatch are all using common under-floor distribution. This method of cooling continues to cause moisture problems in the DER and does not meet FEMA or NFPA guidelines for cooling of equipment rooms.

The equipment ground system does not seem to be bonded to the electrical building ground. Dispatch power is supplied by mains, single UPS, and dedicated generator with connection for external backup generator.

Dispatch console positions are equipped with backup control stations. Additional RF equipment is located in the penthouse. All antenna system transmission lines run to the roof. Antennas including the microwave antenna to Jenson Park are mounted on a small monopole and several roof skids.

Jensen Park Site

The Jensen Park site was constructed in 1997 and is located about one half mile south of Cheney and one half mile east of S. 84th Street just outside the City of Lincoln boundary. The nearly rectangular compound dimensions are about 95' x 40'. The compound contains one guyed tower and a single equipment shelter. Dimensions of the shelter are 31'4" x 16' with a 10' ceiling. The generator area is 8'3" x 16'. Two 500-gallon LP fuel tanks are located about 70 feet southeast of the shelter. Fuel runs underground to a regulator prior to entering the generator side of the shelter. Some rust was found on clamps used on the guy anchors.

The Jensen Park tower is 492 feet in height. The Jensen Park site is 278 feet higher than the Military Road site, and the tower is 151 feet higher. The antennas at Jensen Park are 429 feet higher than the Military Road site. The antennas at Military Road are at a height 68 feet above ground level at Jensen Park, and any signals reaching this area are blocked by trees in the area. Jensen Park signals will easily propagate beyond the Military Road site.
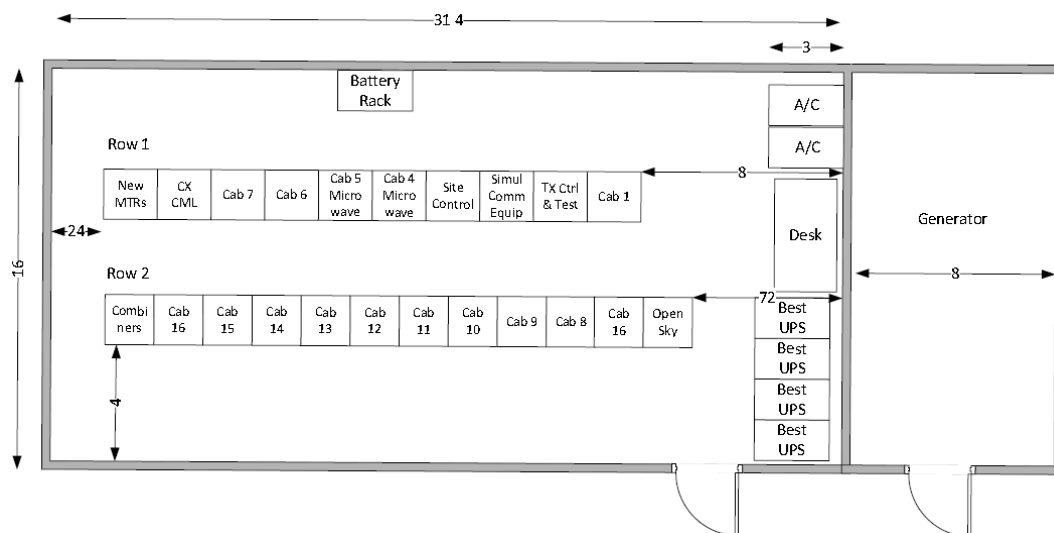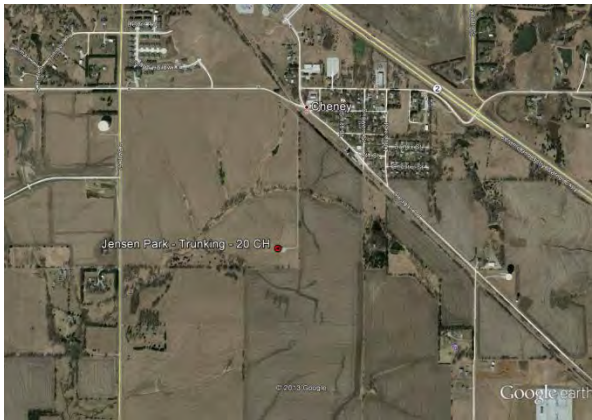
North ^

There are two rows of cabinets (22 total). Each row powered by its own UPS. Power and equipment ground have no visible bond which is required per the National Electrical Code.

Military Road

The Military Road site was constructed in 2000 and is located about .2 miles east of North 10th Street and .1 miles north of Military Road. The rectangular compound dimensions are about 110' x 80'. The compound contains one self-supporting tower and four equipment shelters. The two shelters closest to the tower belong to the City of Lincoln and house the City's system equipment. The other two shelters contain cellular equipment. Each of the City shelters houses its own backup generator.

The Military Road tower is 370 feet in height. The Military site is 278 feet lower than the Jensen Park site.

Military South
Building (Old)
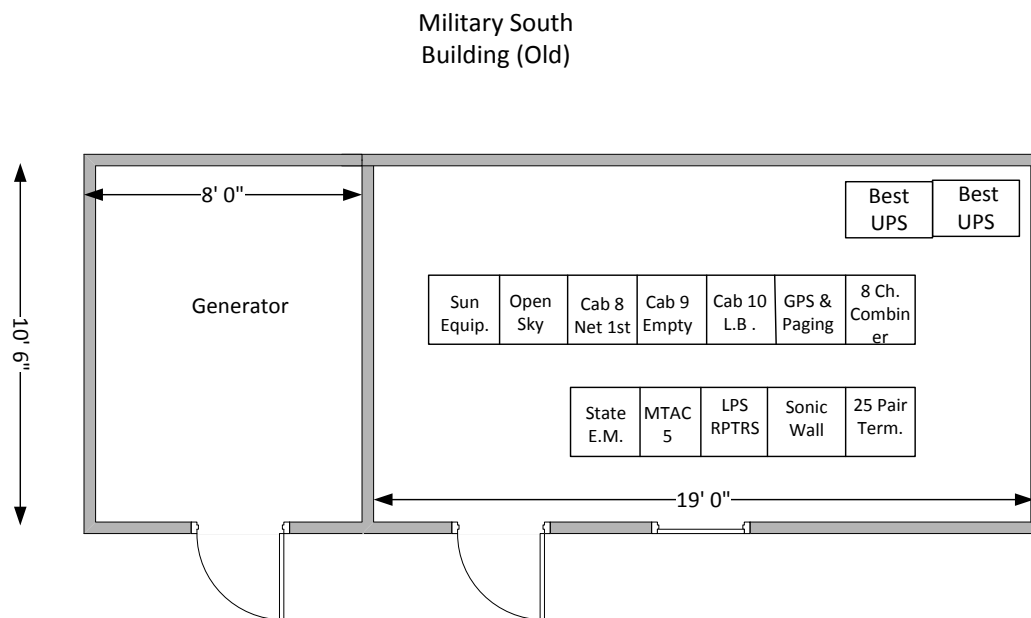
The south shelter is the older building and was moved to this location when the tower was constructed. The inside dimensions are 10'6" x 19' with a 10' ceiling. The building is the older of the two and is in poor shape. The west wall of the shelter is compromised. This shelter houses primarily paging, 800 MHz conventional, and Open Sky system equipment. One Best UPS system provides interim power in case of commercial power interruption.

Military North
Building (New)

27'-3 1/2" ▶

19' 7"

8' 0"

Bat. Rect.	Micro wave	Cab 7 Ch 13-16	Cab 6 Ch 17-20

Best UPS

Best UPS

11' 3"

10'-3 7/8"

10'-3 7/8"

Generator

10'-3 7/8"

Simul & MUX	Cab 2 Ch 1-4	Cab 3 Ch 5-8	Cab 4 Ch9-12	Celwave Comb.

Desk

27'-3 1/2" ▶

2'-6"

2'-6"
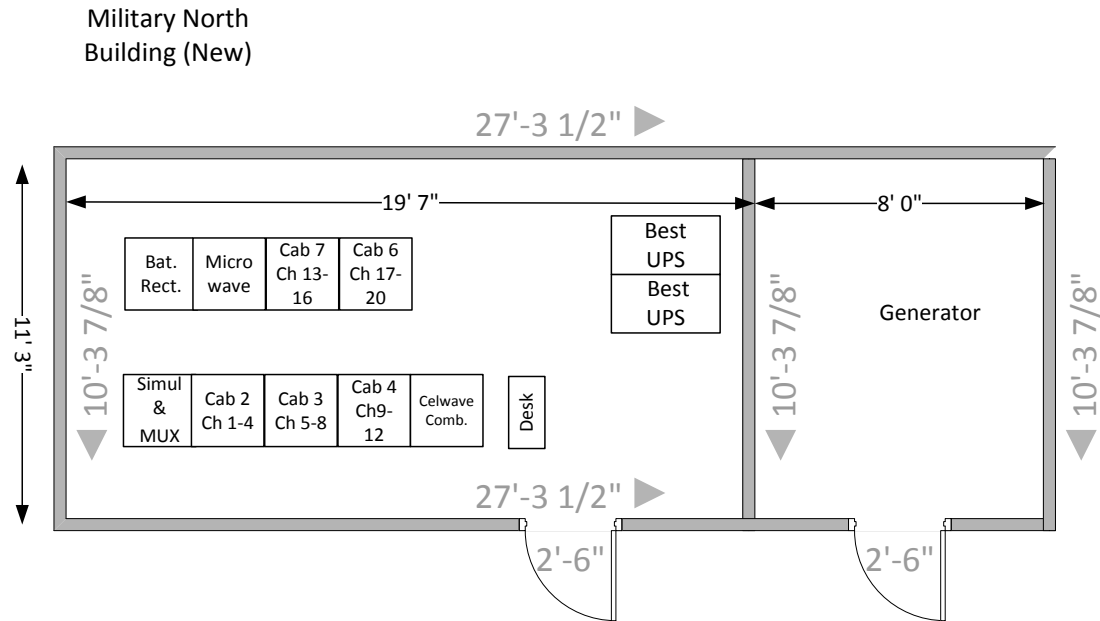
The north shelter was installed when the tower was constructed. The inside dimensions are 11'3" x 19'7" with a 10' ceiling. There are two rows of cabinets (nine total) that support the 20-channel EDCACS system. One Best UPS system provides interim power in case of commercial power interruption.

Fire Station 14 – Backup Dispatch

The current space used as backup is 25' x 39'9" with a 7' 8" ceiling. There is an expansion area of 26' x 39'9" in an adjacent space. There are nine positions, and six Zetron consoles are installed. Three Zetron consoles are set up for fire and three are set up for law. The remaining three positions are call-taker only positions. The fire station is built over a natural pond, so wet conditions persist.
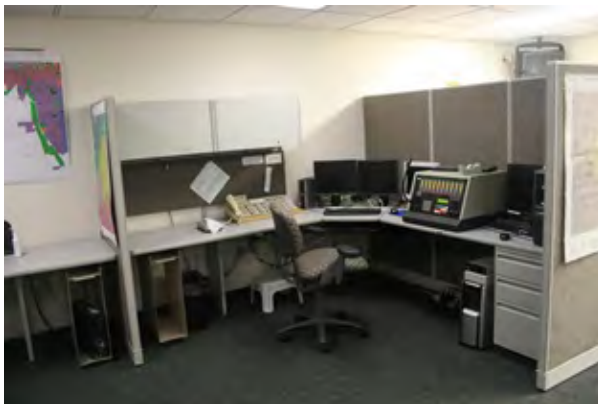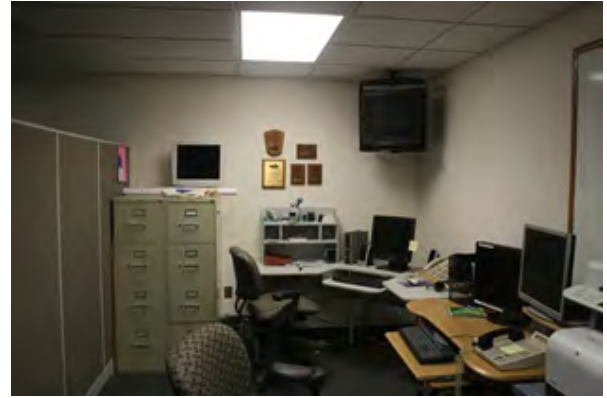
Arbor Road

The backup EDACS system uses the lowest five logical channels (channels 1-5) of the 20-channel EDACS system. 911 would access the backup system using the M7100 radios at their console positions. Originally the five-channel system was to be used on a trailer with a crank-up tower. The Arbor tower was to cover I80 toward Omaha. The Nebraska State system is on this site. The five-channel EDACS system must be enabled manually if needed, and only for long-term use. Field units are programmed with conventional channels for short-term use.

The Arbor Road tower is installed on power company property adjacent to a large substation with two wind generators to the south and a jet engine generating station a half mile to the ENE.

Bypass operation on the 20-channel system includes 10 channels from Jensen Park – site 2 (channels 1-10) and 10 channels from Military – site 1 (channels 11-20). The microwave from 911 goes to Jensen Park (site 2), but all field units are programmed for site 1, so in bypass mode the consoles are disabled and operators use the control station radios for communications. If the Military site were to go down, the majority of the field units would no longer work in the bypass mode. The Jensen Park site would need to be reprogrammed for site 1. The Sheriff radios are programmed to scan if they lose site 1.

Field Units

Agencies within City of Lincoln – Lancaster County are equipped with various models of mobile, portable, and control station radio units. The detailed inventory can be found on page 69. Some units are equipped with P25 capability. Although the majority of the field units operate on the EDACS radio system, Rural Fire and many of the Lincoln Public School units are Kenwood models, which are not sourced from or maintained by the Lincoln Radio Shop. These non-Harris radios are not capable of operation on the EDACS network.

Below is a summary of the user terminal inventory. The majority of the units in this inventory are radio units consisting of mobiles, portables, and control stations. The inventory also includes the LECC radio dispatch consoles and paging encoders used by Rural Fire.

User Terminal Inventory	
Building & Safety	9
Emergency Management	84
Health Department	51
Hospitals	24
Lancaster Co. Sheriff	156
Lincoln Fire & Rescue	231
Lincoln Police Department	896
Lincoln Public Schools	500
Park & Rec Department	40
Public Works	481
Radio Maintenance	49
Rural Fire	496
State Agencies	109
University of Nebraska	127
Youth Services Center	26
Others	95
Spare	272
Total	**3646**

The following graphs break down the field unit inventory by mobile, portable, and control station for agency and by model. The inventory consists of EDACS and conventional radio equipment as provided to Elert & Associates.

City of Lincoln - Lancaster County
Mobile Inventory by Agency

Agency	Count
911	1
Adult Detention Facility	4
Air National Guard	3
Engineering Services	7
Fleet Services	3
Lancaster County Emergency Management	15
Lancaster County Health Department	2
Lancaster County Sheriff	67
Landfill	29
Lincoln Airport Authority	13
Lincoln Fire & Rescue	68
Lincoln Police Department	194
Lincoln Public Schools	225
Nebraska Department of Roads	1
Nebraska State Health & Human Services	3
Nebraska State Patrol	3
Parks - Operations	15
Parks - Recreation	13
Radio Maintenance	31
Rural Fire	221
StarCare	2
StarTran	84
Street Maintenance	120
Traffic Engineering	14
University of Nebraska Parking	10
University of Nebraska Police	12
Waste Water	19
Water - Ashland	13
Water - Lincoln	41

City of Lincoln - Lancaster County
Mobile Inventory by Model

Orion Scan Mobile, 211; 500M Scan Mobile, 131; TK980 Kenwood Mobile, 428; M7100 Scan Mobile, 444; Other, 19; M5300 Scan Mobile, 7; M7300 Scan Mobile, 4; Orion System Mobile, 8

City of Lincoln - Lancaster County
Portable Inventory by Agency

Agency	Count
911 Backup	6
911	11
Adult Detention Facility	120
Air National Guard	12
Animal Control	11
Blood Bank	1
BNSF	3
Building and Safety - Fire Inspectors	9
Engineering Services	5
FBI	3
Lancaster County Emergency Management	67
Lancaster County Health Department	36
Lancaster County Sheriff	100
Lancaster County Youth Services Center	25
Landfill	11
Lincoln Airport Authority	65
Lincoln Fire & Rescue	156
Lincoln Hospital: Bryan/LGH East	3
Lincoln Hospital: Bryan/LGH West	3
Lincoln Hospital: St. Elizabeths Hospital	3
Lincoln Police Department	530
Lincoln Public Schools	275
Madonna	1
Midwest Medical	4
Nebraska Game and Parks	8
Nebraska Heart Hospital	1
Nebraska State Fire Marshal	5
Nebraska State Health & Human Services	12
Nebraska State Patrol - Capital Security	19
Nebraska State Patrol	44
Parks - Operations	12
Parks - Recreation	6
Radio Maintenance	234
Rural Fire	251
StarCare	4
StarTran	7
Street Maintenance	19
Traffic Engineering	3
University of Nebraska Parking	18
University of Nebraska Police	86
Waste Water	60
Water - Ashland	14
Water - Lincoln	14

City of Lincoln - Lancaster County
Portable Inventory by Model

- P5150 Scan Portable , 214
- LPE-200 Scan Portable , 146
- P7170 System Portable , 122
- Jaguar 700P Scan Portable , 105
- P5550 Scan Conventional Portable , 90
- MRK II Scan Portable , 48
- P5550 Scan EDACS Portable , 30
- P7130 Select Portable , 29
- MRK II System Portable , 15
- Kenwood TK-480, 385
- P7150 Scan Portable , 1061
- P7270 System Portable , 11
- Other, 21
- P7250 Scan Portable , 3
- Jaguar 700P System Portable , 1
- LPE-200 System Portable , 1
- P5500 Scan Portable , 3
- P7350 Scan Portable , 5
- P7370 System Portable , 7
- LPE-50 Select Portable , 1

City of Lincoln - Lancaster County
Control Station Inventory by Agency

City of Lincoln - Lancaster County
Control Station Inventory by Model

Propagation Prediction Simulations

City of Lincoln – Lancaster County Terrain

Figure 5: Lancaster County Terrain

Lancaster County terrain varies from a low point of 329 meters (1,080 feet) on Salt Creek in northeast Lancaster County to 463 meters (1,521 feet) in northwest Lancaster County. The lowest elevations in the county run southwest from the Cass County border in the northeast into the Lincoln area, with coulee type terrain extending perpendicular in both directions at various points along the way and several directions in the Lincoln area. Generally the terrain rises to the west, north, south, and southeast around the City of Lincoln.

Some terrain in Lancaster County and in the City of Lincoln impacts the ability for a field unit to reach a repeater site or a repeater site to reach a portable. As there are two sites in the current EDACS system, only one successful RF path to a field unit is necessary for communication, but the maximum number of paths is limited to the number of sites available. The variability of terrain increases the chance that there are no successful RF paths to a site. To increase the reliability due to terrain, additional sites need to be considered.

The ground elevation of the Jensen Park site is 278' higher than the Military Road site. Unlike other areas in Lancaster County, the change in elevation between sites is relatively gradual. Other areas in the County vary hundreds of feet over a range of a few miles, expanding the areas of unacceptable coverage performance.

City of Lincoln – Lancaster County Land Use

Figure 6 shows the land use (also known as clutter in propagation prediction) as defined in the propagation program for Lancaster County. The key to the right shows the land use employed by the prediction program to calculation coverage. Most of the City of Lincoln is identified as residential, mixed urban, commercial/industrial, and transportation. The majority of the county is identified mostly as agricultural and rangeland.

Color	Description
	Water
	Snow_Ice
	Wetland
	Open Land
	Rangeland
	Transportation
	Agricultural
	Residential
	Forest
	Mixed Urban/Buildings
	Commerial/Industrial
	High Density Urban
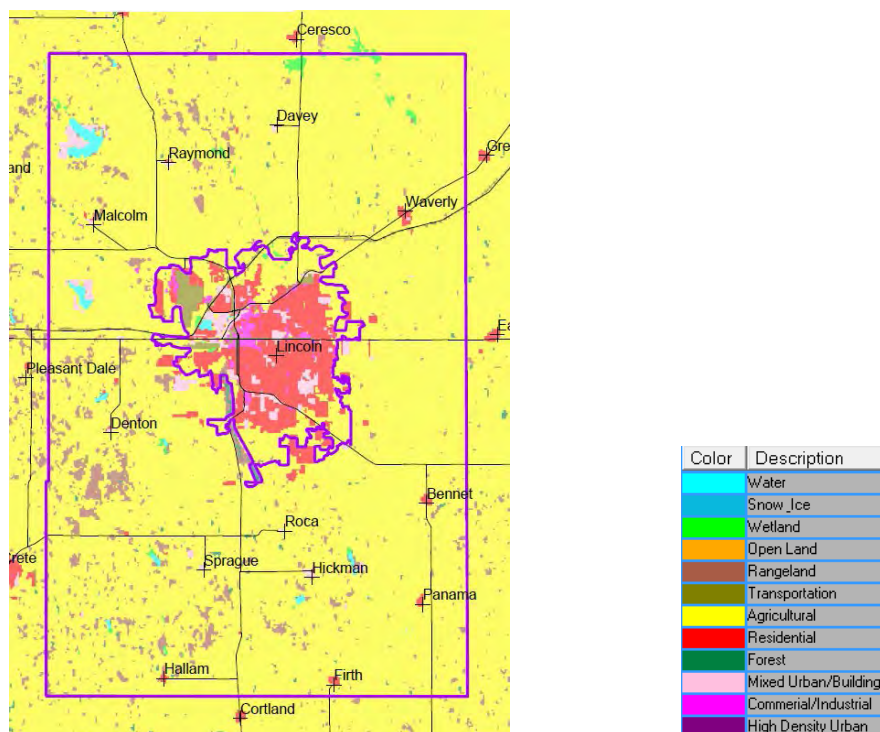
Figure 6: City of Lincoln – Lancaster County Clutter

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. Voice system calculations used TSB-88 testing guidelines to determine the minimum signal levels for predictions. Analog voice systems used attenuation factors that equate to a digital audio quality (DAQ) level of 3.4[6]. Reliability is also factored into the calculations to account for variability. The minimum level for reliable portable coverage is estimated to be -89 dBm. This figure includes a 95% reliability factor of 5.9dB. For new systems, the infrastructure is designed to provide this level of signal 95% of the time over 95% of the area.

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[6] The definition of all DAQ levels may be found in Appendix 5 – Delivered Audio Quality (DAQ) on page 76.

The prediction uses the clutter information (see Figure 6) in the calculations to estimate the signal level. The model does not know if a building is blocking or reflecting signals, so the performance could be quite different in actual operation.

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 may have loss factors that exceed 30dB or a factor of one-thousandth of the signal found on the outside of the building.

Prediction models use different criteria for calculating mobile and portable performance. Models can predict outbound to field unit (talk-out) and inbound to infrastructure (talk-back). For portables models can also predict outdoor and indoor performance. Indoor performance uses environment information associated with the clutter database that inserts an additional in-building loss into its calculations.

Portable outdoor talk-out model results are designated in the following predictions as portable talk-back outdoor (PTOO). Indoor predictions would be designated as PTOI. For a mobile talk-in it would designated as MTBO. Sometimes mobile prediction descriptions drop the 'O' and are designated as MTB as mobile predictions are always considered outdoors.

Below is a key for interpretation of the coverage predictions that follow. For portable operation, adequate coverage is usually achieved in yellow and green areas. The yellow represents outdoor coverage and the green is representative of operation from within a wood framed home with 8dB attenuation. As one moves away from the repeater antenna site, each color change reflects a reduction in received signal level. A portable may be able to work in the orange signal level are but the user may have make minor adjustments to their position or the direction they face to be able to communicate.

The marginal level below (orange) ranges from -89 dBm/-92 dBm (at the transition from yellow to orange) to -101dBm/-104 dBm (at the transition from orange to red) and represents the antenna / body loss factor. The orange to red transition represents the level of signal to provide an equivalent level for a DAQ of 3.4. The red area is marginal for mobile operation but provides only occasional performance for a portable. Areas in gray (< -114 dBm/-115 dBm) are below the receiver's effective sensitivity level. Mobiles may work in this area, but portables have little chance. The red and gray areas should not be depended upon for public safety service.

800 MHz Portable Performance levels per TSB-88 for DAQ Equivalent of 3.4				
Analog	-114 dBm	-101 dBm	-89 dBm	-81 dBm
Digital	-115 dBm	-104 dBm	-92 dBm	-84.dBm
	C_s/N	C_f/N (Loss for DAQ 3.4)	Antenna / Body Loss (-12dB)	In-Building Loss (-8dB)
Portable Environment	Out of Range	Hill Top	Outdoor	Light In-Building
Mobile Environment	Hill Top	Outdoor		
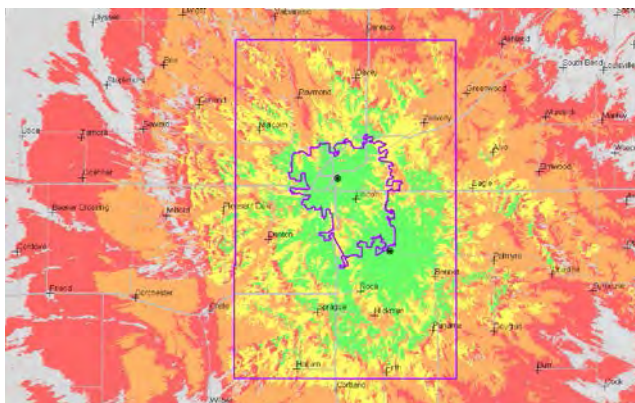
Figure 7: 800 EDACS 2-Site PTOO 61.1% County   *Figure 8: 800 EDACS 2-Site PTOI 77.2% City*
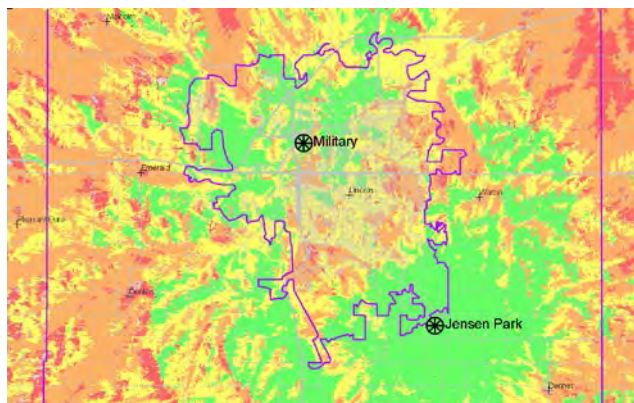
The above predictions are of the predicted portable outdoor (Figure 7) and portable indoor (Figure 8) system performance for the current 20-channel EDACS system using the Military Road and Jensen Park towers.

Talk-out performance (repeaters to portable) for a signal level from -89dBm or greater outdoors (yellow and green above) is predicted to cover 61.1% of Lancaster County and 92.4% the City of Lincoln (Figure 7). Residential indoor coverage (8dB) is predicted to be 77.2% of the City (Figure 8).

Portable Environment	Out of Range	Hill Top	Outdoor	Light In-Building
Mobile Environment	Hill Top	Outdoor		
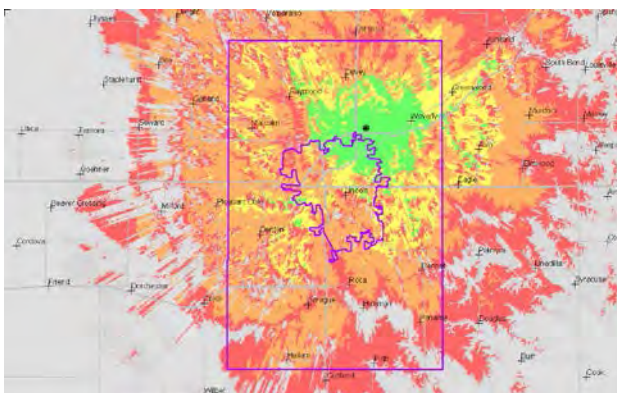
Figure 9: 800 EDACS BU PTOO 27.4% County   *Figure 10: 800 EDACS BU PTOO 38.0% City*
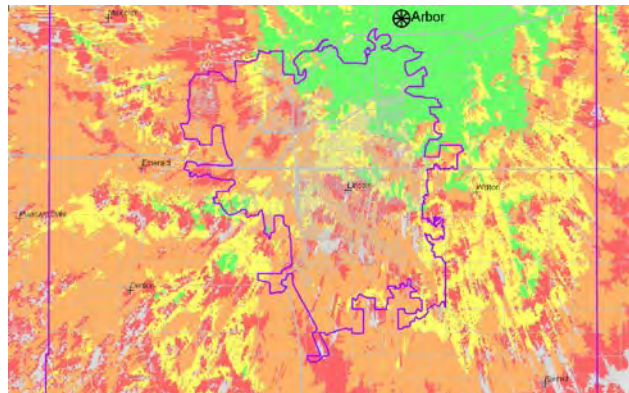
Arbor Road is the backup site for the current EDCAS trunking system. The above predictions estimate the portable talk-out performance at a level of -89dBm or greater from Arbor Road to be 38.0% of the City of Lincoln (Figure 10) and 27.4% of Lancaster County (Figure 9).

Below are predictions for Rural Fire 800 MHz voice and VHF paging systems. The sites used in the north and the south are bundled to represent the total coverage available to north and south Rural Fire areas.
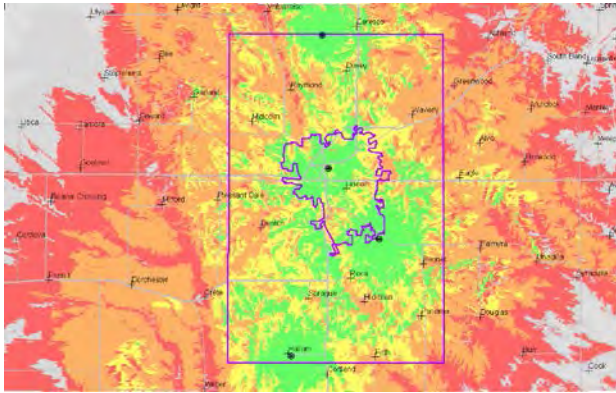
Figure 11: 800 Rural Fire PTOO 65.6% County
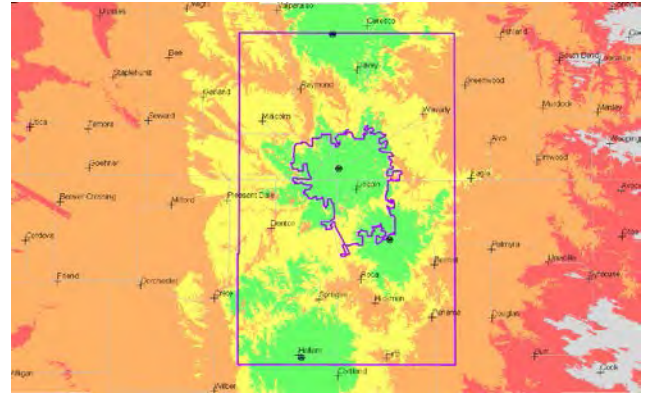
Figure 12: VHF Paging 75.7% County

The current area of coverage for north and south combined voice for portable talk-out outdoors at a level of -89dBm is 65.6% of the County (Figure 11). Paging at a predicted level of -78dBm (yellow and green) provides coverage to 75.7% of the County, and 8dB in-building coverage (green only) is predicted to be only 31.6% of the County.

System Users

Lincoln Public Safety Users

City of Lincoln public safety users include the following:

- Lancaster County Health Department
- Lancaster County Sheriff
- Lancaster County Youth Services
- Lincoln Airport Authority
- Lincoln Fire-Rescue
- Lincoln Hospitals
- Lincoln Police
- Lincoln - Lancaster County Building & Safety Department
- Lincoln - Lancaster County Emergency Management
- Nebraska State Patrol – Capitol Security
- University of Nebraska – Lincoln Police
- University of Nebraska – Parking

With over 2,000 field radios, public safety users in the City of Lincoln use 84.2% of the airtime of the current system. The service area of these users is generally within the City of Lincoln. Within this area, the current system typically provides adequate outdoor but limited indoor coverage for most public safety users.

Predictions indicate that outdoor on-the-hip portable coverage in the City of Lincoln is 90% of the area within the city limits. Indoor (light in-building) coverage is about 65% of this area. Many buildings surpass this level and bi-directional amplifier (BDA) systems[7] have been implemented to enhance indoor portable performance.

Lancaster County Sheriff

The Lancaster County Sheriff uses just over 150 EDACS trunked radios and requires radio coverage throughout Lancaster County. Due to the rugged terrain found in several locations outside the City of Lincoln, the current EDACS two-site system does not provide the portable coverage these public safety users need. Several county municipalities are located in lower elevation areas surrounded by ridges that block outgoing and incoming signals.

Users have found workarounds to establish and maintain communication, including use of conventional 800 MHz stations and cellular phones when required. The Sheriff Department has no direct UHF or VHF interoperability. Secure voice communications is important but the digital mode[8] of the current EDACS system does not function well in rural areas.

It is estimated from coverage predictions that 53% of the County has adequate outdoor on-the-hip portable coverage, with about 25% residential (8 dB) in-building penetration capability. It is suspected that much of this coverage occurs within the City of Lincoln. A vehicular repeater is used in the Sheriff's Command Post to offer locally enhanced coverage in the event that the EDACS system coverage is less than adequate at a location.

Rural Fire

Rural Fire uses several 800 MHz conventional repeater systems for communications in the County. North and south areas of the County each have three 800 MHz repeated channels to provide communications with dispatch and for tactical communications during an event. Rural Fire also employs talk-around if repeater coverage is not sufficient for portable operation. Although not reported as an issue, the use of scan and the appropriate selection of an assigned channel could create confusion among users.

Several adjacent county fire departments provide services within Lancaster County and use the Lancaster County Rural Fire repeater systems on a regular basis. Rural fire departments employ about 500 radio units, mostly consisting of Kenwood mobiles and portables. There was not an inventory of pagers, although it appears that pagers are used to monitor operations of dispatch and alternate dispatch repeater channels in the north and south areas of the county. Field units are maintained by multiple service firms, and Elert & Associates is not aware of any regular maintenance schedule for field units. This is a potential issue, as infrastructure and field units of the system are maintained by multiple radio shops thus not insuring all field units are set up to the same performance criteria. RF service monitors must be calibrated annually, repeaters should

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[7] A list of BDA locations can be found on page 13.

[8] ProVoice is digital audio, not encryption, using an IMBE vocoder like P25 although not compatible. This gives the Sheriff Department the impression of being secure as compared to analog.

be checked two to four times per year, and all field radios should be checked annually to validate that they meet specifications. To ensure operation, RF test equipment used for field radio maintenance should be checked against a local standard used to perform maintenance on repeaters. This would require that all service shops pay an annual visit to the Lincoln Radio Shop to document any differences in frequency calibration, FM deviation, SINAD, and RF level generation. Any differences that are not corrected will result in poor system performance. This issue is much more readily apparent with narrowband operation of VHF, UHF, and 700 MHz.

As rural fire departments are divided north and south, each area is equipped with three 800 MHz repeater stations at two sites. Both areas have a main dispatch channel using the Military and Jensen Park sites. Alternate dispatch channels are located near the north and south borders along with a TAC channel for each area. All operation on these channels is analog conventional. Dispatch channels are also patched into their respective VHF paging channels.

Coverage predictions indicate that mobile coverage is quite adequate, but portable on-the-hip performance is about 65.6% of the County. Predictions indicate that paging performance outdoors is about 72.6% of the County area at -78dBm. At these coverage levels, there are many locations in the County where voice communications and paging may be difficult. Pager performance can also be directly attributed to the pager itself, as well as its setup, tuning, and thus, its sensitivity.

Despite the coverage issues as indicated by the predictions users do not appear to have coverage problems. If they are unable to access a repeater they fallback to a simplex fire ground channel. This procedure would need to be used even if the current coverage could be enhanced as 100% coverage is not realistically attainable.

Public Service

City of Lincoln public service users include the following:

- Radio Maintenance
- Park and Rec
- Public Works
    - Engineering Services
    - Fleet Services
    - Landfill
    - StarTran
    - Street Maintenance
    - Waste Water
    - Water

Public service users operate over 550 radio units on the EDACS trunking system. The service area of most users is the City of Lincoln. Although these users operate on the current public safety system, they do not have the requirement for a public safety radio unit. They need to communicate just the same, however. Most of the public service users operate only in the city and require mostly outdoor coverage. Coverage that these radio users currently experience in the city is deemed acceptable.

Lincoln Public Schools

Lincoln Public Schools uses several radio systems to provide wireless communications. LPS has over 60 facilities. High schools currently use the EDACS system for communication, while the middle and elementary schools use conventional 800 MHz channels and lower cost radio units. There are also separate radio systems for transportation and facilities maintenance. LPS has an extensive fiber network that provides the data network to interconnect all of their facilities.

Several schools share the school's repeater conventional channel in today's system, and performance can be limited. Radio communication is via portable and mobile field units. The repeaters are located at the Military Road or Jensen Park sites. Ideally, each school facility could use an independent radio system for communications, and in the future LPS would like to be able to communicate directly to LECC dispatch if needed. There is a need for a mobile-based radio system that provides coverage between facilities.

System Improvement Options

General

The City of Lincoln and Lancaster County have several independent radio systems that provide primary and backup communications for some Lincoln – Lancaster County radio users. It is understood that the need for change for all other city-county radio systems is driven by the manufacturer's end of support on the EDACS platform. Although system failure is rare, some user groups have reverted to cell phones for their primary communications, and the ability to successfully use field radio units in times of need may be lacking. Any future system should be designed to meet the coverage and operational needs of the defined user community.

The systems considered for change include the primary EDACS 20-channel two-site simulcast system serving City of Lincoln and Lancaster County Sheriff, the Rural Fire conventional 800 MHz voice systems, and the radio system used for the Lincoln Public Schools. These systems provide radio communication service for nearly all Lincoln - Lancaster County radio users.

A single system has been used by most City of Lincoln radio users. A new digital P25 system is the likely choice for replacement, as it is the de facto public safety platform. Sharing a single system provides the highest level of interoperability, as all users are on the same platform. The transition from an analog to digital system platform will provide some system coverage performance improvement and a large audio quality improvement to system users. As the user community has different communication needs, however, one size may not be the best choice for all users from a technical or fiscal viewpoint.

From an RF point of view, City of Lincoln would be best served by the 800 MHz[9] band. The short wave lengths of the 800 MHz band allow for better in-building penetration than UHF or

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[9] This also includes the 700 MHz band. Nearly all field radio units today have both bands, as they are adjacent to each other and have similar RF characteristics.

VHF[10]. Most public safety portable users need at least residential in-building coverage. Another characteristic of the 800 MHz band is that the signals are not impacted by atmosphere conditions and behave more like light than the lower frequency bands (VHF and UHF). This is why they are most coveted by the cellular industry. If terrain is in a signal path, a shadow is formed that may prevent 800 MHz from working in the shadow area, but lower frequencies can still be used, as they tend to bend slightly. This is also true with clutter—the buildings, trees, and other objects that exist on land.

Sometimes atmosphere reflects lower frequency band signals, with one experience defined generally as "skip" on VHF and lower frequencies, while higher frequencies easily penetrate the atmosphere. This means with all other parameters equal (antenna height, power, etc.), 800 MHz will provide less coverage or less range per site than lower frequency bands like VHF, but lower frequency bands like VHF may exhibit adverse effects that may impact successful communications. Overall, VHF or 800 MHz could be considered for County users. Elert & Associates estimates the number of sites required for 800 MHz portable operation would be at least six, but only two sites would be needed using VHF.

Another huge difference that must be addressed is analog vs. digital and wideband vs. narrowband. The FCC has mandated narrowband operation of nearly all VHF and UHF channels, while 800 MHz remain wideband. The action to require narrowband means every component/device must be installed and tuned precisely to reduce the effects of atmospheric and manmade noise. Even after this is done, it has been found that the losses of narrowband are like reducing the power of the repeater and radios by half. Digital protocol, on the other hand, has increased the performance of radio channels (both low band and 800 MHz) to more than make up for the performance losses of narrowband. There are multiple protocols of digital, though only P25 has been generally accepted for public safety. No one currently makes a digital voice pager, however.

Predictions indicate that additional coverage is required for Rural Fire 800 voice and VHF paging systems to attain 95% of the area. As these systems are analog, a number of sites are required to enhance overall system coverage. When repeater operation is questionable, Rural Fire uses direct unit-to-unit communications. As there is no infrastructure, the ability for Fire Dispatch to monitor is not consistent and is completely driven by the location of an event and whether repeated communications is available. A vehicular repeater system could improve local communications and provide a mechanism for Fire Dispatch to remain connected.

A county system at 800 MHz would require several more sites. It is estimated that an additional six sites would be necessary to provide coverage to reach portable on-the-hip performance of about 95% of the County with P25. For analog operation, predictions indicate that the same portable coverage requires about eleven sites. If 800 MHz is used to provide coverage, eight sites would be used for Sheriff and Rural Fire, but the coverage for Rural Fire would fall short of the 95% portable performance desired for public safety.

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[10] The actual wave length is the key to successful building penetration. One wave at 851 MHz is almost 14 inches in length. At UHF (455 MHz), one wave is 25 inches, and at VHF (155 MHz), one wave is over 6 feet. The waves of VHF and UHF are easily distorted when entering doors and windows or even reflecting off objects, while those in the 800 MHz band can remain relatively intact.

As the Sheriff Department is normally assigned to the same talk groups as Lincoln Police, two P25 conventional channels should be able to carry their necessary traffic. Rural Fire would add another two channels. Interoperable communications between the Sheriff P25 conventional and Lincoln Police talk groups would be done at the system level. Sheriff units would scan for active talk groups when on the P25 conventional channels in the County. Talk groups would be assigned one of the two available channels. When entering the coverage of the City's P25 trunking system, the Sheriff radios would affiliate and operate on trunked mode.

At 800 MHz, Rural Fire would continue to operate in analog mode. Operationally, they would use one dispatch and TAC channel in each north and south zone. It is envisioned that each zone would have two simulcast analog channels operating on four sites each. This arrangement will improve current coverage, but will not provide countywide analog portable performance.

An alternative for Sheriff and Rural Fire at 800 MHz would be to use a five-channel 800 MHz simulcast trunking system. This would lower the total number of channels between them from six to five, and would provide P25 simulcast digital voice communications for Sheriff and Rural Fire throughout the County. With P25 trunking, Sheriff operation would be identical to the City. Rural Fire would have talk groups assigned to zones as they do today. Voice audio could also be retransmitted on the paging channel through a gateway. Rural Fire would be required to use P25 terminal equipment.

Gateways would provide an audio path from one system to another. This would be true for P25 to DMR and DMR to P25. A computer would enable a connection when the assigned talk groups become active. The user needs only to select the talk group assigned for this function.

Operation with P25 that use the same controller would be transparent to the user whether it is 800 MHz to 800 MHz as in the five-channel P25 County Sheriff – Rural Fire example above or the 800 MHz to VHF P25. Active talk groups appear on each of the individual systems as long as there is a unit affiliated with each of the system on the group that is active.

If Lincoln were to interface with SRS, there would need to be an ISSI interface provided. The interface would exchange system information between the Lincoln – Lancaster County P25 system and the SRS system. Each system will react to the activity as it is programmed.

The current EDACS system uses several bi-directional amplifier (BDA) systems to improve performance inside buildings. A list of these locations can be found on page 14. It is expected that structures in the core of the City of Lincoln, including the State Capitol complex, may experience communications issues. Many of these buildings will exhibit losses far above the level appropriate to address with radio infrastructure. A site in the core of the City (as on the roof of the Hall of Justice) may improve coverage within the Capitol complex, but would not assist the City-County facilities that are below the antenna site.

Improving in-building penetration in the City of Lincoln will require additional repeater sites. Radio sites dispersed around the City will increase the overall signal level and allow penetration of more buildings. It is possible that towers or City facilities would be candidates for antenna/repeater sites. Although towers have been chosen for the conceptual design, this does not prevent the City from considering other locations that may be more desirable. Other locations would need to provide the antenna height required for appropriate performance. Water towers, building structures, or City/County property where a tower could be built could be considered.

The State of Nebraska and several other states have built statewide systems using VHF. The choice of VHF is primarily due to the increased coverage and reduction of the number of sites required to build out the network statewide. Most statewide systems are designed for mobile coverage and quite often offer access to counties (or cities) for local communications. In order for a county to successfully provide portable coverage, additional sites will be required. In addition, the channel capacity would need to be addressed to ensure that the system is able to provide adequate service when it is needed. Lancaster County could consider this as a possible option to provide countywide P25 communications, but would need to address its channel capacity needs.

The Nebraska statewide system is named SRS. SRS is a VHF P25 Phase 1 system that is designed with four to five VHF channel pairs per site[11]. Although there may be sites still to build out to complete the design, there have been reports of issues with communications. E&A understands that these issues stem from the limited capacity of the system sites, as almost all sites are equipped with four VHF repeater channels. This results in only three simultaneous voice channels available per site. If more than three talk groups were active during an event, there are no other channels to use for communications.

Lincoln - Lancaster County would need to increase the number of sites and the number of available channels to use VHF across the County. As VHF frequencies are limited, it may be difficult to find frequencies that are compatible with existing SRS channels. Lincoln - Lancaster County would likely need to add at least two pairs to the existing SRS system at the Arbor Road site just to support Lancaster County Sheriff and Rural Fire. Arbor Road would need to be simulcast with Jensen Park to provide portable coverage. Converting to simulcast may require updating existing state-owned equipment at the Arbor Road site.

Backup repeaters that are currently in place for Lincoln Police, Sheriff, Fire, Public Works, etc., should remain in place for backup. Most of these stations are located in places other than the main site locations, providing geographic diversity in case one or both of the main sites is lost or are disabled.

Recommendation

As the City of Lincoln – Lancaster County system already uses 800 MHz, E&A recommends that the City continue using this band but consider increasing the number of sites in the City to improve portable in-building coverage. Predictions for the Military Road and Jensen Park sites estimate portable outdoor coverage at 95.1% and residential (8 dB) indoor coverage at 79.2% citywide. Two additional sites in the City bring indoor residential coverage to 92.7%.

800 MHz could also be employed in the County for improved interoperability, but the current system does not provide the Sheriff Department with adequate outdoor portable coverage across the County. 800 MHz coverage predictions indicate eight simulcast sites[12] could be required to provide 95% outdoor portable coverage with 95% reliability at a level of -92dBm. Using the

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[11] According to Radio Reference, the SRS system has 52 sites. All sites but the Giltner site are listed to have four frequencies.

[12] Predictions used existing towers and inserted new towers when needed.

TSB-88.1-C link budget formula, -92 dBm is the signal level that would provide consistent on-the-hip portable coverage. Predictions indicate that VHF P25 would provide portable coverage across the County with two sites[13]. Although SRS could be used a separate VHF P25 system for use by Sheriff and Rural Fire would provide enhanced radio communications service and replace all of the current 800 MHz conventional channels in service today. Paging would remain as designed today.

The primary public safety radio communications system should be based on P25, an industry standard protocol for that service. APCO P25 was designed for public safety use and is currently a standard. The protocol for public safety radio communications in the United States is APCO Project 25 (P25). The majority of public safety systems in the United States have adopted the Project 25 (P25) platform. P25 is a digital platform available in trunking and conventional formats.

One option is for public safety users to utilize P25, while public service and possibly other users could consider the use of a different infrastructure platform to reduce the cost of the field terminal units and potentially the infrastructure. Due to licensing for the P25 protocol and the ruggedness of the subscriber equipment for public safety, the costs are much higher than other digital systems. Gateways or console patching could be used to offer interoperability between two protocols.

The LECC and EOC should be equipped with new P25 radio consoles. Fire Station 14 should have an updated console system as well. The update could be P25 consoles equipped with a network connection to operate the infrastructure directly and through control stations. The UNL dispatch could also employ new P25 consoles (recommended), but a network connection would be required. The alternative would be to continue to operate via control stations. It is anticipated that the Airport Authority would continue to operate via control stations.

P25 consoles from the radio infrastructure manufacturers are usually the higher cost option, but other third party vendors demand a higher price as well. Alternatives to radio manufacturers such as AVTEK, C4I, and Zetron consoles using a CSSI interface could be considered, some of which will be lower in price though the CSSI interface would also have to be factored in thus possibly erasing savings.

The LECC and Fire Station 14 would be equipped with control stations. At the LECC, these stations would operate independent of the dispatch consoles. At both locations, a control station combining systems would be used to allow operation of these units.

The number of voice groups drives the need to employ trunking technology to share the existing 19 channels[14] among all users. The number of user voice channels for Lincoln - Lancaster County indicates that a trunking format is justified, although the number of channels required to

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[13] The Arbor Road and Jensen Park sites were used for predictions. If the County uses its own VHF channels they would need to be compatible with SRS to be used at Arbor Road.

[14] The current 20-channel system consists of one control channel and 19 voice channels. A control channel is transmitting 100% of the time to continuously update field terminal units. The remaining channels are assigned as needed for voice calls. A request for service is made on the control channel. Control channel frequencies change from time to time, so one repeater is not on the air continuously.

support the traffic load could be reduced without a reduction in service. Like the current EDACS system, P25 uses a control channel to communicate call traffic management to field units. Most P25 systems manage call traffic through a central controller with a backup controller. Public safety and public service user groups in Lancaster County and City of Lincoln have a sufficient number of user groups to justify the use of trunking.

Loading reports from the EDACS system indicate that the number of channels could be reduced without impacting the quality of service, as it seems to be only lightly loaded. Home football games are thought to be the heaviest use of the radio system. Usage reports from the 2012 football season indicate that the maximum loading on the system is about 16% or about three hours[15] of total traffic during the busiest hour. Based on the number of calls during this period, the average transmission time is 4.3 seconds. Erlang-C[16] calculations indicate that with the 19 channels available today and a 4.3-second transmit time, 99% of the callers wait .5 seconds or less, and the system will support over 8,500 calls per hour. The maximum reported calls in the busiest hour was 2,580. Erlang tables indicate that it will take 10 channels to support 25% more calls per hour (3,225) with all other parameters equal. The number of channels utilized by the system infrastructure could be reduced. Furthermore, user groups could use different radio infrastructure to maximize their utility and reduce overall cost. The current channels could be split up to support the different systems.

Improvements can be realized through multiple forms. A transition from analog to digital provides crystal clear audio over the entire coverage area. Once the system coverage ends, there is no audio. This has raised some concern with fire department users, as there are many circumstances where the coverage limit is unknown, such as entering a building into a basement where loss increases rapidly. Most manufacturers have incorporated visual and audible warnings that will alert a user when this condition exists.

There is a concern that Rural Fire does not have the funding required to purchase new VHF P25 trunking field equipment. Applications for Assistance to Firefighters Grants were accepted through December 6, 2013 which could assist in the funded if successful. If funding prevents Rural Fire from moving to a P25 platform the Sheriff department alone does not have the quantity of field units to justify a P25 trunking infrastructure. The Sheriff department may be able to employ two VHF P25 conventional channels that could be interfaced via gateway into the City of Lincoln dispatch and tactical voice groups. In this scenario the Sheriff would employ multi-band P25 field radios so they are able to employ any of the County systems if needed for interoperability. In order to provide improvement for Rural Fire additional sites and supporting microwave backhaul would be necessary. Decision will have to be made focused on the actual requirements in a future RFP.

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[15] Communication traffic is measured in Erlangs. Each Erlang represents one hour of radio, telephone, or circuit time. Three Erlangs represents three hours of continuous traffic in one hour of time.

[16] There are three Erlang models. The Erlang-A model assumes that any call attempts that are blocked are lost, and there is no retry. The Erlang-B model assumes that blocked call attempts will retry in a short time. Erlang-C is used when users are queued if no radio channels are available when a request for service is made. Erlang-C calculations will take into account a minimum percentage of users that are successful upon a wait of no more than a fixed time.

Alternative Recommendation for Non-Public Safety

The cost of P25 is higher than many other communications platforms. This is primarily due to the specifications required to provide a public safety grade system and hardened field terminals. Police, Sheriff, Fire, EMS, and other public safety users require such a system. Other users who currently use the EDACS system today may not require the hardened field units, but still use the same system to maintain interoperability. This comes with a cost that may be difficult to justify when moving to P25. As such, compromises can be made to gain an affordable system technology.

A number of public service entities may consider using an alternative digital protocol to P25 to reduce cost. If so, direct interoperability is lost, but there are alternative operating modes that could be implemented when interoperability is needed. Interoperability must be maintained if alternate technologies are employed. At a minimum, this could be accomplished through gateways that are activated by talk group selection. Public service users will certainly be able to communicate on a P25 system, but the cost of the field units as compared to other radio system technologies is usually much higher.

Fire Paging Recommendation

Fire paging is currently provided via two-site simulcast for north and south operations on separate channels. Initially, using one channel simulcast across the County was considered to simplify operations, but it was determined that this would create an issue with the north-south procedures in place today. Users monitor traffic over their paging units. Using one channel for paging would force changes to be made in the procedures for north and south, as all dispatch traffic would need to be simulcast as well to allow monitoring on a single paging channel. It is assumed that no changes in procedures are being considered within Rural Fire protocol, and it is preferred that procedures not change due to radio system limitations. Paging should be left as two channels simulcast north and south.

Predictions indicate that the Fire Paging system as a whole covers 76% of the county area. Additional sites would be required to improve the coverage of the current system. As there were no real complaints concerning paging performance, no changes appear to be necessary.

System Infrastructure Summary Recommendation

The following sections outline the potential infrastructure options that may be considered for Lincoln - Lancaster County radio system users.

After careful review of the information collected and considering the input from the user community, Elert & Associates envisions the need for up to five infrastructure platforms to support the user group radio communications needs for the City of Lincoln and Lancaster County. The choices to be made are interdependent on each other. Some selections limit the choices of others.

The needs of the following users groups drove the infrastructure options.

- City Public Safety (Law, Fire, EMS, Youth Services, Heath, Hospitals, EMS, Airport)

- County Sheriff

- Rural Fire

- Public Service (Public Works, Park and Rec., Radio Shop)

- Lincoln Public Schools[17]

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[17] There are too many variables to adequately address any changes to an LPS radio communications system. Although E&A has provided potential options for LPS to consider, additional study will be required before a complete assessment can be done and suitable recommendation formulated. E&A would be happy to provide a proposal for these services.

City of Lincoln – Lancaster County Infrastructure Options

OPTION 1

PUBLIC SAFETY
SHERIFF
PUBLIC SERVICE
SCHOOLS

Voice Infrastructure
- 800 MHz
- P25 Digital Voice
- Simulcast Trunking
- 20 Channels + 5 ch BU
- 3 Sites

RURAL FIRE

Voice Infrastructure
- 800 MHz
- Analog Voice
- Conventional
- 6 Channels
- 4 Sites

RURAL FIRE

Paging Infrastructure
- VHF
- Analog Paging
- Simulcast Conventional
- 2 Channels
- 4 Sites

SCHOOLS

Voice Infrastructure
- 800 MHz
- Analog Voice
- Conventional
- 3 Channels
- 2 Sites

OPTION 2

PUBLIC SAFETY
PUBLIC SERVICE

Voice Infrastructure
- 800 MHz
- P25 Digital Voice
- Simulcast Trunking
- 14 Channels + 5 ch BU
- 5 Sites

SHERIFF

Voice Infrastructure
- 800 MHz
- P25 Digital Voice
- Simulcast Conventional
- 2 Channels
- 6 Sites

RURAL FIRE

Voice Infrastructure
- 800 MHz
- Analog Voice
- Simulcast Conventional
- 4 Channels
- 8 Sites

RURAL FIRE

Paging Infrastructure
- VHF
- Analog Paging
- Conventional Paging
- 2 Channels
- 8 Sites

SCHOOLS

Voice Infrastructure
- 800 MHz
- Digital Mobile Radio (DMR)
- Trunking
- 4 Channels
- 2 Sites

OPTION 3

PUBLIC SAFETY

Voice Infrastructure
- 800 MHz
- P25 Digital Voice
- Simulcast Trunking
- 12 Channels
- 4 Sites

SHERIFF
RURAL FIRE

Voice Infrastructure
- VHF
- N-WIN P25 Digital Voice
- Simulcast Trunking
- 6 Channels
- 2 Sites

RURAL FIRE

Paging Infrastructure
- VHF
- Analog Paging
- Simulcast Conventional
- 1 Channel
- 4 Sites

PUBLIC SERVICE
SCHOOLS

Voice Infrastructure
- 800 MHz
- Digital Mobile Radio (DMR)
- Trunking
- 8 Channels
- 2 Sites

SCHOOLS

Voice Infrastructure
- In-building Only
- 2.4 or 5 GHz
- Digital
- Wi-Fi VoIP
- Requires additional Study

The following are descriptions of the various infrastructure options to meet the communications needs of Lincoln - Lancaster County. Each will have some choices or options to make prior to moving forward. More than one option may be used to meet the radio communications needs of the user community. Different options also may include a different set of sites. E&A suggests that these options be reviewed with a core group of representatives of Lincoln - Lancaster County to determine the choices for which to move forward in the final report.

The 20 channels in use today would be split up depending on how to move forward with the infrastructure. There are at least four other 800 MHz conventional repeater pairs used as backup today that could be added to the list. The quantity of channels listed above can be adjusted as necessary to support the anticipated traffic. Voice traffic on the current 20-channel system reached a maximum of 16% loading on September 1, 2012, with 2,580 calls in that hour. Even if traffic were 25% higher during some other event, this still reflects light load on the system.

Erlang-C calculations[18] for 4.25-second service time, 0.5-second average wait time, nine trunks, and a service level of 99% with no waiting resulted in 2,931 calls per hour. It appears that all current users could get by with 10 channels, but during a major public safety event, the demand for channels will increase. With 12 trunks, calls per hour could rise to 4,542 or 72% more than the highest reported call level. If other user groups chose to move onto a lower cost platform, this would further reduce the normal demand for service on the public safety system and potentially offer even more capacity for public safety.

Option for Public Services

An option for non-public safety users is Digital Mobile Radio (DMR). DMR systems place two digital channels on every RF channel using Time Division Multiple Access (TDMA). Two RF channels provide one control channel and three voice channels or, in the right configuration, four voice channels. One additional channel would provide five or six total voice channels. The DMR system for public service would use two sites and operate in a multi-site mode. In multi-site mode, the sites would not operate in simulcast (although some DMR solutions are capable), but would use different RF channels in each. If users on a common group were located at each site, a call would use both sites. The user does not need to be concerned about site selection when using the DMR solution, as they would not with P25 solution either.

The field units of a DMR system are significantly lower in cost than P25, but have the same basic feature set that users would want, as well as several other features that come standard, as the units are digital including GPS locations. DMR has not been deemed acceptable for public safety due to its lack of national interoperability and no standards-based simulcast capability.

For public service, a DMR system would be programmed to operate like the current radio system is today. DMR for LPS may be done quite differently, but may depend on the manufacturer. In LPS, each school would use one RF channel per facility. Each RF channel supports two voice channels. One manufacturer can set up the system to use one of these channels locally in the

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[18] Elert & Associates used an Erlang-C online calculator at http://www.math.vu.nl/~koole/ccmath/ErlangC/index.php to determine this value.

facility, while the other channel can be a common channel for a group or all facilities that are interconnected via the LPS fiber network.

Another alternative to explore for LPS is the use of the existing Wi-Fi systems that are in place at LPS facilities. There may be voice systems in the near future that could utilize the wireless access points that currently exist in the facilities. There is no way to know at this point if the current configuration can support such a system. Further investigation would be required.

Coverage Predictions

Portable Environment	Out of Range	Hill Top	Outdoor	Light In-Building
Mobile Environment	Hill Top	Outdoor		
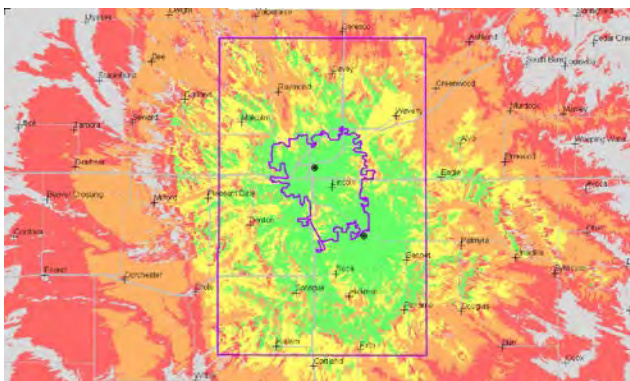
Figure 13: 800 P25 Two-Site PTOO 72.3% County
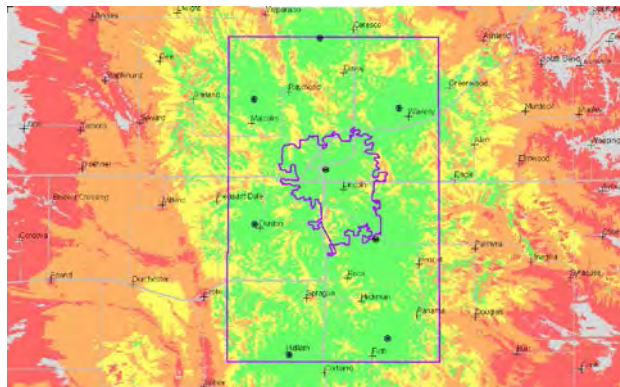
Figure 14: 800 P25 Eight-Site PTOO 94.0% County
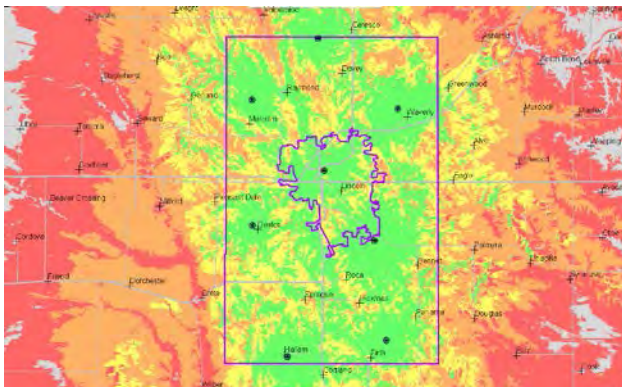
Figure 15: 800 MHz Eight-Site Analog PTOO 87.1% County
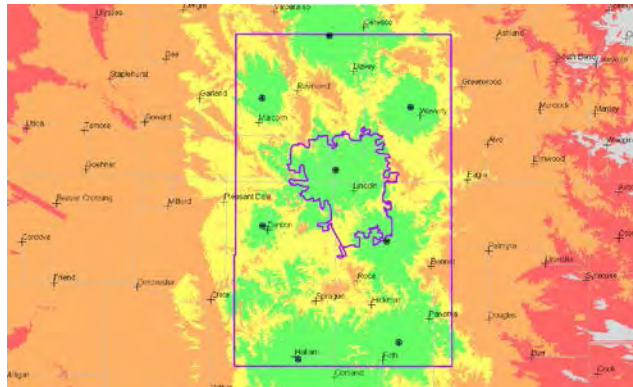
Figure 16: VHF Analog Four-Site Paging 88.4% County

Portable Environment	Out of Range	Hill Top	Outdoor	Light In-Building
Mobile Environment	Hill Top	Outdoor		
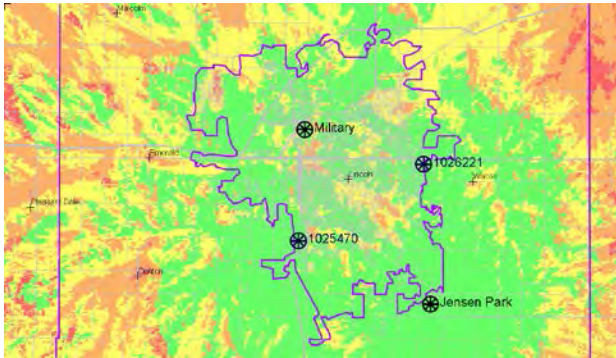
Figure 17: 800 Digital Four-Site PTOI 94.6% City
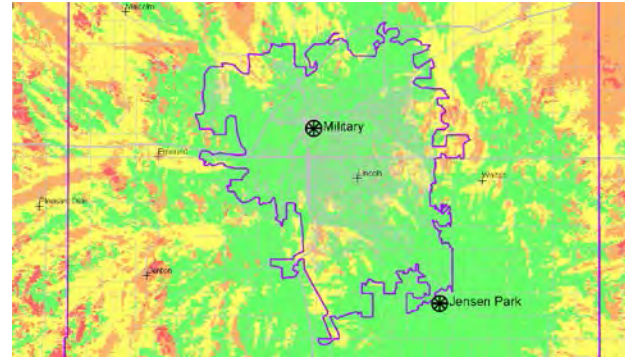
Figure 18: 800 DMR Two-Site PTOO 96.0% City
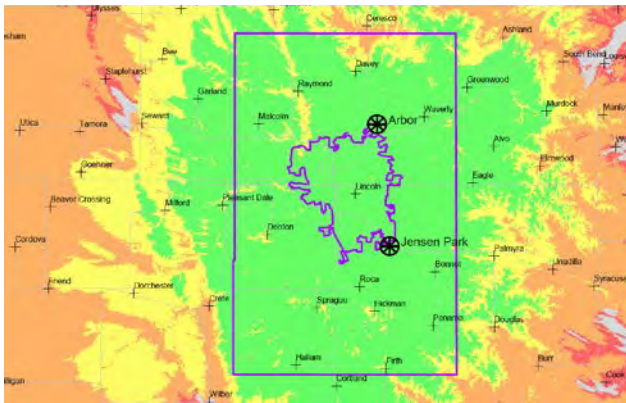
Figure 19: VHF P25 Two-Site PTOO 99.2% County
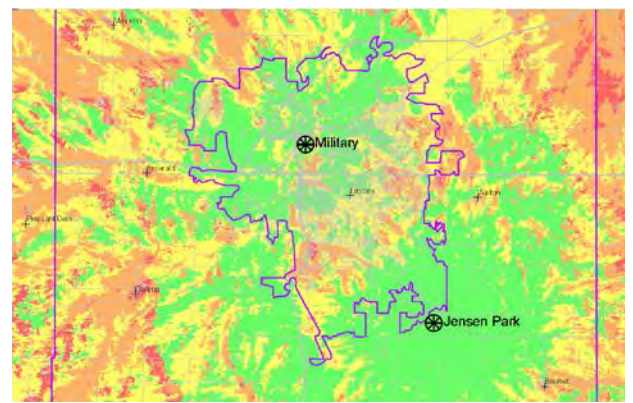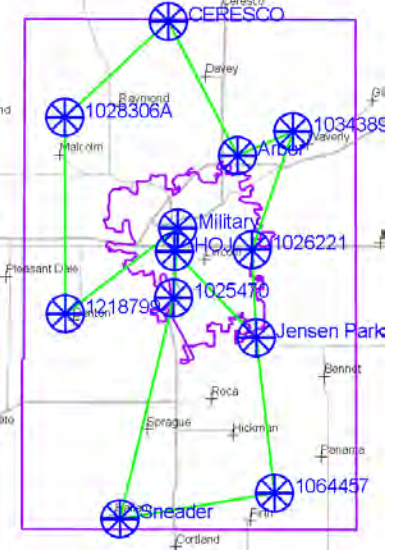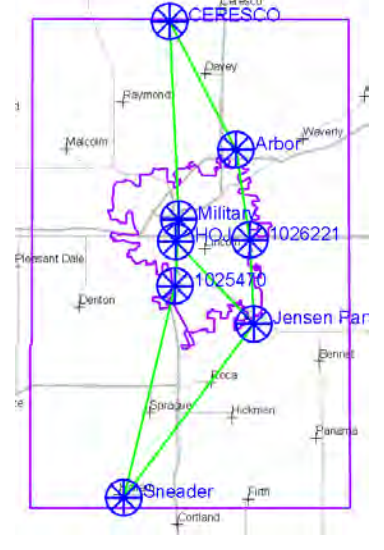
Figure 20: 800 MHz P25 Two-Site PTOI 85.4% City

Microwave

Option 1 Topology	Option 2 Topology	Option 3 Topology
Option 1 microwave is identical to the existing microwave network. There are other links in this network that are not shown.	Option 2 uses a ring topology that links all but the Hall of Justice on an 11-site continuous ring around the County using 6 GHz and 10 GHz microwave.	Option 3 uses fewer sites due to the use of VHF for coverage of the County thus fewer microwave links.

RFP Design Considerations

In a new system design, the level of coverage desired will be specified and the vendor will be required to meet these minimum coverage requirements through testing. For public safety, the common practice for the level of coverage is 95% of the area 95% of the time for a portable radio outdoors on the hip without a speaker microphone antenna. This requires that the system be able to provide a level of signal that would be received with a portable antenna worn on the hip. The system also must be able to receive a transmission from the portable while the unit is on the hip, but this is more difficult to measure, so one must ensure that the design is balanced for talk out vs. talk back. Unbalanced talk out or talk back may create confusion at fringe coverage locations.

Factors such as noise, interference, fading, antenna, body loss, building loss, and reliability must be considered when estimating coverage performance. When performance must be demonstrated, some of these factors must be included to ensure that measurements reflect actual performance. Performance testing involves drive tests where a vehicle with an outside antenna is used to measure signal level and BER performance. If the specification is for portable on-the-hip coverage, what factors need to be employed to compensate?

All cities have hardened structures that have even higher building penetration levels. The design will call for a specified building penetration level, but there are few automated ways to test these areas. Quite often, a subjective test is performed, where a team or teams representing all parties visit a list of buildings to determine the level of indoor performance. The number of buildings must be large enough to draw a conclusion on the validity of the testing. This test also documents the operation for all intended users of the system. Some buildings that fail will exceed the building penetration loss level in the design specification. After testing, any buildings that exceed the minimum penetration loss level but require coverage can be equipped at additional cost with a well-designed bi-directional amplifier (BDA) and distributed antenna system (DAS) to provide adequate in-building coverage.

Some users are unlikely candidates to move to digital trunking due to the use of over-the-air signaling systems. The vocoder used in P25 analyzes voice against a predefined set of voice codes that is used to reproduce the audio on the receiving unit. Most signaling systems use pure tones, which digital radio may not be able to reproduce properly. The street department snow plows may use DTMF signaling for associated applications over their radios. Although an alternative signaling scheme may be available, digital systems do not support DTMF signaling. Any application of this nature needs to be identified so the appropriate solutions can be chosen.

P25 system updates and upgrades will be available from manufacturers periodically. Lincoln Radio Shop personnel would need to complete an extensive technical training program from the vendor and would need to attend periodic updates to ensure technical competency on the system. Lincoln - Lancaster County would need to determine if the updates would be done by the manufacturer or by the Radio Shop. Although Radio Shop expertise may be sufficient, they may require the manufacturer's support for the first few years of operation. The level of this ongoing support from the manufacturer should be determined up front, as there will be a cost.

Users need to be properly trained to interoperate effectively, and appropriate procedures must be developed regardless of the methodology. If multiple technologies are employed, each user group would be trained on their system. Interoperability used for different technologies needs to be determined and made part of the acceptance test procedures. Depending on what technologies are ultimately chosen, there may be a need to work with multiple vendors to ensure operation.

Budgetary Costs for Possible Solutions

Below are budgetary estimates for an outright purchase of the conceptual design presented. All are P25. The number and cost of the field units are identical in each option. Each technical option offers alternatives to provide coverage for public safety radio systems as described above.

Option 1: Two Sites P25 Simulcast (Today's System – P25)

System Component	Description	Cost
Vendor Infrastructure	Repeaters, satellite receivers, voting, simulcast, antennas, microwave, power, shelter, grounding, towers, civil, dispatch equipment, and alarms	$6,273,000
Vendor Services	Engineering, installation, testing, commissioning, and training	$1,726,000
Field Terminal Equipment	Mobiles, portables, and associated accessories	$13,052,000
Contingency	Equipment, services, and site work	$883,000
Professional Services	Licensing, consulting, and project management	$251,000
	Total	$22,185,000

FIELD EQUIPMENT	3670
HIGH TIER SUBSCRIBER EQUIPMENT	
HIGH TIER MOBILES	
800 P25 Trunked Mobile	418
HIGH TIER PORTABLES	
800 Analog Conventional Portable	90
800 P25 Trunked Portable	1261
HIGH TIER CONTROL STATIONS	
VHF Analog Conventional Control Station	2
800 P25 Trunked Control Station	108
MID TIER SUBSCRIBER EQUIPMENT	
MID TIER MOBILES	
800 P25 Trunked Mobile	391
MID TIER PORTABLES	
800 P25 Trunked Portable	541
MID TIER CONTROL STATIONS	
800 P25 Trunked Control Station	35
LOW TIER SUBSCRIBER EQUIPMENT	
LOW TIER MOBILES	
800 Analog Mobile	428
LOW TIER PORTABLES	
800 Analog Portable	378
LOW TIER CONTROL STATIONS	
800 Analog Control Station	18

Option 1 is a virtual forklift replacement of the current EDACS trunking system with a 20-channel P25 system with five-channel backup at Arbor Road. This option replaces only the EDACS radio system infrastructure, microwave, antennas, and transmission lines. This also includes one new shelter for Military Road and ten P25 dispatch consoles at the LECC.

All other infrastructure supporting Rural Fire and conventional 800 MHz and VHF paging remains in place. All field radio units are also included for replacement, but non-trunking units used by Rural Fire and Lincoln Public Schools may not be considered end of life and could continue to be used.

AES single key digital encryption and over-the-air-rekeying (OTAR) is added to all public safety field units along with one KVL key loader. Over-the-air-reprogramming (OTAP) is included and priced into all P25 field units. Utilizing OTAR and OTAP makes for not requiring field units to be brought back in for reprogramming as this can be accomplished over the air remotely.

The transition from analog to P25 digital is expected to improve coverage about 11% in the county and 10% to the city. All other systems should expect about the same coverage, as the infrastructure will not change. New system monitoring and control hardware is anticipated to be positioned at Military Road or Jensen Park and LECC.

This option replaces system infrastructure, microwave, antennas, and transmission lines on all P25 system infrastructure with a figure for tower studies and possible strengthening included for contingency. This also includes one new shelter for Military Road and 10 P25 dispatch consoles at the LECC, 1 at the EOC and 1 at Fire Station 14. System monitoring and control hardware is anticipated to be positioned at Jensen Park and LECC.

Below is a listing of the major components used to build the cost estimate for the infrastructure.

P25 TRUNKED OPERATION	
P25 800 Trunked Repeater	5
P25 800 Trunked Repeater	40
P25 Encryption	45
VOTING	
P25 Comparator	20
CONTROLLERS	
Simulcast Controller	20
Trunking Controller	1
ANTENNA SYSTEM	
TX/RX Combining System	45
Antenna System	6
Tower Top Amplifier	3
LDF-5 7/8' Transmission Line	1666
LDF-7 1 5/8" Transmission Line	1184
LINKING & MICROWAVE	
Mid Range 6 GHz Link/mux /network	4

POWER	
1500W Dual Conversion UPS / DC Plant System	5
SHELTER & GROUNDING	
12' X 30' Shelter	1
TOWERS	
Tower Strengthening (Height of Structures)	1137
Alarm System	
Alarms	4
DISPATCH CONSOLES	
P25 Console	12
Console Furniture base on 4 postion Console config	10
OTHER	
Net Clock System	1
Audio Logging System	1
MPLS Core Router	1
MPLS Site Router	3
OTAP	1
OTAR	1

Option 2: 800 MHz P25 / 800 MHz Analog/DMR

System Component	Description	Cost
Vendor Infrastructure	Repeaters, satellite receivers, voting, simulcast, antennas, microwave, power, shelter, grounding, towers, civil, dispatch equipment, and alarms	$11,795,000
Vendor Services	Engineering, installation, testing, commissioning, and training	$3,244,000

Field Terminal Equipment	Mobiles, portables, and associated accessories	$12,897,000
Contingency	Equipment, services, and site work	$1,838,000
Professional Services	Licensing, consulting, and project management	$472,000
	Total	$30,246,000

FIELD EQUIPMENT	3681
HIGH TIER SUBSCRIBER EQUIPMENT	
HIGH TIER MOBILES	
800 P25 Trunked Mobile	418
HIGH TIER PORTABLES	
800 Analog Conventional Portable	90
800 P25 Trunked Portable	1261
HIGH TIER CONTROL STATIONS	
VHF Analog Conventional Control Station	2
800 P25 Trunked Control Station	137
MID TIER SUBSCRIBER EQUIPMENT	
MID TIER MOBILES	
800 P25 Trunked Mobile	391
MID TIER PORTABLES	
800 P25 Trunked Portable	404
MID TIER CONTROL STATIONS	
800 P25 Trunked Control Station	35
LOW TIER SUBSCRIBER EQUIPMENT	
LOW TIER MOBILES	
800 DMR Mobile	225
800 Analog Mobile	203
LOW TIER PORTABLES	
800 DMR Portable	275
800 Analog Portable	240
LOW TIER CONTROL STATIONS	
800 Analog Control Station	18

Option 2 shifts the Sheriff Department to their own two-channel 800 MHz P25 simulcast conventional system when operating outside city coverage. Six sites are positioned around the county to fill in the weakest areas. All but one site uses existing towers. The Verizon site south of the Branched Oak State Recreation Area needs additional tower height to be effective.

The sites used to provide Sheriff coverage will also expand the Rural Fire voice and paging systems to these sites, enhancing performance while maintaining identical modes of operation. Although improved, the Rural Fire analog systems will fall short of the 95% coverage of the county that public safety generally attempts to achieve. The cost to get to 95% coverage at a 95% reliability would be quite high.

Public safety and public service will be serviced by the City of Lincoln P25 800 MHz simulcast system. It will use 14 channels and be expanded to four sites to improve residential in-building performance. Two additional sites will encompass the city and increase the density of signal within the City.

Lincoln Public Schools are replaced by a four-channel 800 MHz Digital Mobile Radio (DMR) infrastructure providing a common digital platform for communications.

This option replaces system infrastructure, microwave, antennas, and transmission lines on all system infrastructure with a figure for tower studies and possible strengthening included for contingency. This option also includes one new shelter for Military Road and four other location. There are 10 P25 dispatch consoles at the LECC, 3 at UNL, 1 at the EOC and 6 at Fire Station 14. System monitoring and control hardware is anticipated to be positioned at Military Road, Jensen Park, and LECC.

Below is a listing of the major components uses to build the cost estimate for the infrastructure.

ANALOG - DIGITAL CONVENTIONAL	
Analog VHF Paging Repeater North	4
Analog VHF Paging Repeater South	4
Analog 800 Conventional Repeater North	8
DMR TRUNKED	
Analog 800 Conventional Repeater South	8
DMR 800 Trunked Repeater	4
P25 CONVENTIONAL OPERATION	
P25 800 Conventional Repeater	12
P25 TRUNKED OPERATION	
P25 800 Trunked Repeater BU Arbor RD	5
P25 800 Trunked Repeater Primary	56
P25 Encryption	61
VOTING	
Analog Voting Equipment	6
P25 Comparator	16
CONTROLLERS	
DMR Controller	1
Simulcast Controller	22
Trunking Controller	1
ANTENNA SYSTEM	
TX/RX Combining System	85
800 MHz Antenna System	22
Tower Top Amplifier	11
VHF Antenna System	6
LDF-5 7/8' Transmission Line	5714
LDF-7 1 5/8" Transmission Line	3467
LINKING & MICROWAVE	
6/10 GHz Link/mux /network	9
Mid Range 6 GHz Link/mux /network	3

POWER		
1500W Dual Conversion UPS / DC Plant System		13
15 kW Generator w/1X Belly Tank & Transfer Switch		7
SHELTER & GROUNDING		
Grounding System		7
Site Improvements		4
12' X 30' Shelter		1
12' X 16' Shelter		4
TOWERS		
Self Supporting (enter height in feet) per foot		300
Tower Strengthening (Hieght of Structures)		3016
CIVIL ENGINEERING		
Site Improvements (access road, etc.)		7
Alarm System		
Alarms		12
DISPATCH CONSOLES		
P25 Console		20
Console Furniture base on 4 postion Console config		10
OTHER		
Net Clock System		1
Audio Logging System		1
MPLS Core Router		1
MPLS Site Router		11
OTAP		1
OTAR		1

Option 3: 800 MHz P25 / VHF P25 / DMR

System Component	Description	Cost
Vendor Infrastructure	Repeaters, satellite receivers, voting, simulcast, antennas, microwave, power, shelter, grounding, towers, civil, dispatch equipment, and alarms	$9,355,000
Vendor Services	Engineering, installation, testing, commissioning, and training	$2,573,000
Field Terminal Equipment	Mobiles, portables, and associated accessories	$11,128,000

Contingency	Equipment, services, and site work	$1,374,000
Professional Services	Licensing, consulting, and project management	$375,000
	Total	$24,805,000

FIELD EQUIPMENT	3690
HIGH TIER SUBSCRIBER EQUIPMENT	
Multi-Band Multi-Mode Mobile	400
HIGH TIER PORTABLES	
Multi-Band Multi-Mode Portable	1257
800 Analog Conventional Portable	90
800 P25 Trunked Portable	4
HIGH TIER CONTROL STATIONS	
VHF P25 Trunked Control Station	26
800 P25 Trunked Control Station	122
MID TIER SUBSCRIBER EQUIPMENT	
MID TIER MOBILES	
VHF P25 Trunked Mobile	203
MID TIER PORTABLES	
VHF P25 Trunked Portable	240
MID TIER CONTROL STATIONS	
VHF P25 Trunked Control Station	18
LOW TIER SUBSCRIBER EQUIPMENT	
LOW TIER MOBILES	
800 DMR Mobile	616
LOW TIER PORTABLES	
800 DMR Portable	679
LOW TIER CONTROL STATIONS	
800 DMR Control Station	35

Option 3 shifts public service to an enhanced Digital Mobile Radio (DMR) system that is shared by LPS users. The DMR system is trunked and allows members of the same group on both sites to communicate seamlessly. The proposed system would have four trunked channels with all channels available for voice communications. The capabilities of different vendor products may offer other possible operating scenarios.

Public safety will be the primary users of the 12-channel, 4 site 800 MHz P25 simulcast system.

Sheriff and Rural Fire will use a six-channel VHF P25 simulcast trunking system that will utilize the State's SRS channel set along with two VHF channels[19] using two sites.

Public safety and Sheriff will utilize multi-band mobile and portable radios so that they are directly compatible with both P25 networks for backup purposes.

Rural Fire units are proposed to be VHF only. Backup communications would run over the north and south paging system channels.

This option replaces system infrastructure, microwave, antennas, and transmission lines on all system infrastructure with a figure for tower studies and possible strengthening included for contingency. This option also includes one new shelter for Military Road and two other locations. There are 10 P25 dispatch consoles at the LECC, 3 at UNL, 1 at the EOC and 6 at Fire Station 14. System monitoring and control hardware is anticipated to be positioned at Military Road, Jensen Park, and LECC.

Below is a listing of the major components uses to build the cost estimate for the infrastructure.

ANALOG - DIGITAL CONVENTIONAL	
Analog VHF Paging Repeater North	2
Analog VHF Paging Repeater South	2
DMR TRUNKED	
DMR 800 Trunked Repeater	8
P25 TRUNKED OPERATION	
P25 VHF Trunked Repeater County	12
P25 800 Trunked Repeater Lincoln	48
P25 Encryption	60
VOTING	
Analog Voting Equipment	2
P25 Comparator	18
CONTROLLERS	
DMR Trunking Controller	1
Simulcast Controller	20
Trunking Controller	1
ANTENNA SYSTEM	
800 MHz TX/RX Combining System	56
VHF TX/RX Combining System	14
800 MHz Antenna System	4
Tower Top Amplifier	2
VHF Antenna System	4
LDF-5 7/8' Transmission Line	3781
LDF-7 1 5/8" Transmission Line	1443
LINKING & MICROWAVE	
6/10 GHz Link/mux /network	5
Mid Range 6 GHz Link/mux /network	3

POWER	
1500W Dual Conversion UPS / DC Plant System	9
15 kW Generator w/1X Belly Tank & Transfer Switch	3
SHELTER & GROUNDING	
Grounding System	3
Site Improvements	2
12' X 30' Shelter	1
12' X 16' Shelter	2
TOWERS	
Tower Strengthening (Hieght of Structures)	2147
CIVIL ENGINEERING	
Site Improvements (access road, etc.)	3
Alarm System	
Alarms	7
DISPATCH CONSOLES	
P25 Console	20
Console Furniture base on 4 postion Console config	10
OTHER	
Net Clock System	1
Audio Logging System	1
MPLS Core Router	1
MPLS Site Router	4
OTAP	1
OTAR	1

Recommendation

In E&A's opinion, enhancements are needed in the public safety infrastructure for both the City of Lincoln and Lancaster County. Residential in-building level of coverage should be attained. For the City

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[19] It may be difficult to find two compatible channel pairs to use with the existing SRS channels at the Arbor Road site but without additional channel capacity Lancaster County users may find the system overloaded with local State traffic which would further complicate current system issues.

of Lincoln, two appropriately positioned sites would be added to the current sites. Sheriff operation beyond the City boundaries does not require several channels unless Rural Fire would be added. A digital VHF platform will provide service with a fraction of the sites required for similar 800 MHz performance. Joining the SRS system would require additional frequencies, but with narrowbanding behind us, additional pairs to increase the capacity should be attainable in the timeframe of the transition.

- All public safety users should operate on a P25 platform.

- Rural Fire should also transition to VHF P25, as this will provide the best perform in the rural areas of Lancaster County.

- Public service would be well served with an independent digital mobile radio system. Any interoperability requirements are easily attained via gateways.

- Lincoln Public Schools have both indoor and outdoor communications requirements. The DMR platform will serve LPS outdoor users well. Even though LPS indoor users may see a performance improvement with a DMR system as proposed, there may be other solutions to consider that will require additional study. E&A recommends that LPS take an additional step to explore other solutions for their indoor communications requirements that may be able to leverage their current Wi-Fi and/or fiber networks.

Elert & Associates recommends that the City of Lincoln - Lancaster County consider Option 3. This is not the only combination that could be implemented if there are other considerations. A new system could be implemented at any time and units taken off the current system over a period of time so cutover to new systems does not happen in a short time period. Also, if the reduction to 12 channels appears to be too much, current system channels could be taken off the air temporarily as a test of the actual number of channels required to provide adequate service. If the reduction in our recommendation needs to be raised, there are other 800 MHz pairs used for backup that could be tapped to attain the 800 MHz channels used for the DMR system for use by public service and LPS.

Once the City of Lincoln – Lancaster County have determined the course of action, each of the infrastructures that need to be pursued would be best handled by separate purchases, as some vendors will not handle all products. This, of course, is dependent upon the actions taken.

Transition Planning

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 on 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 not having 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.

Appendix 1 – User Terminal Inventory

Department	Qty	500M Scan Control Station	500M Scan Mobile	Jaguar 700P Scan Portable	Jaguar 700P System Portable	LPE-200 Scan Portable	LPE-200 System Portable	LPE-50 Select Portable	M5300 Scan Mobile	M7100 Scan Control Station	M7100 Scan Mobile	M7100 System Control Station	M7300 Scan Control Station	M7300 Scan Mobile	Maestro Console	MDX Scan Control Station	MRK II Scan Portable	MRK II System Portable	Orion Scan Control Station	Orion Scan Mobile	Orion System Mobile	P5150 Scan Portable	P5500 Scan Portable	P5550 Scan Conventional Portable	P5550 Scan EDACS Portable	P7130 Select Portable	P7150 Scan Portable	P7170 System Portable	P7250 Scan Portable	P7270 System Portable	P7350 Scan Portable	P7370 System Portable	TK-480 Portable	TK-980 Mobile
911	41									18	1				11												11							
911 Backup	22										1					15												6						
Adult Detention Facility	128								8															90	30									
Air National Guard	15		3	5																							2				5			
Animal Control	12										1																11							
Blood Bank	1																										1							
BNSF	3																										3							
Building and Safety - Fire Inspectors	9																											9						
Engineering Services	13									1	7											1					2	2						
FBI	3																										3							
Fleet Services	4									1	3																							
Lancaster County Emergency Management	85		1	1		13					13		3	1													44	9						
Lancaster County Health Department	39			12							1									2							24							
Lancaster County Sheriff	168		4	2						1	17			1						45							93	1	3			1		
Lancaster County Youth Services Center	26	1		6																							19							
Landfill	42		2			2				2	22											5	2				7							
Lincoln Airport Authority	85			1		7			3	7	10						11										46							
Lincoln Fire & Rescue	240		2	21						16	66																123	12						
Lincoln Hospital: Bryan/LGH East	4										1																3							
Lincoln Hospital: Bryan/LGH West	4										1																3							
Lincoln Hospital: St. Elizabeths Hospital	6										3																3							
Lincoln Police Department	735	10	9	18	1	58					33						31	1	1	152		2					418	1						
Lincoln Public Schools	500																					93					44						138	225
Madonna	1																										1							
Midwest Medical	4																			4														
Nebraska Department of Roads	2									1	1																							
Nebraska Game and Parks	8																										8							
Nebraska Heart Hospital	1																										1							
Nebraska State Fire Marshal	5																			5														
Nebraska State Health & Human Services	15					6					3																6							
Nebraska State Patrol	48					28				1	3																16							
Nebraska State Patrol - Capital Security	21	1									1											19												
Parks - Operations	27		1								14											4						8						
Parks - Recreation	19		3								10																	6						
Radio Maintenance	282		8	2		4	1	1		17	19						3	11	4			28				29	88	54		7		6		
Rural Fire	465										17			1				2									2						240	203
StarCare	6										2																			4				
StarTran	93									2	84																6	1						
Street Maintenance	144		87			3				3	33	2					1					10					5							
Traffic Engineering	19		3							2	11																3							
University of Nebraska Parking	30	1	4							1	6											16						2						
University of Nebraska Police	105			11		18				4	1						3		3	3	8						45	9						
Waste Water	80		26			3				1	19											24	3				3	1						
Water - Ashland	28					4				1	13											1					9							
Water - Lincoln	57		4							2	36			1								5					8	1						
Grand Total	3645	13	131	105	1	146	1	1	11	90	444	2	3	4	11	15	48	15	4	211	8	214	3	90	30	29	1061	122	3	11	5	7	378	428

Appendix 2 – FCC Trunked System Licensing

Federal Communications Commission
Public Safety and Homeland Security Bureau

RADIO STATION AUTHORIZATION

LICENSEE: LINCOLN, CITY OF

ATTN: CITY OF LINCOLN RADIO SHOP
LINCOLN, CITY OF
901 WEST BOND ST. SUITE 110
LINCOLN, NE 68521

Call Sign	File Number
WNDX299	0005479377

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

Regulatory Status
PMRS

Frequency Coordination Number

FCC Registration Number (FRN): 0002358307

Grant Date	Effective Date	Expiration Date	Print Date
02-03-2004	11-07-2012	04-19-2014	11-07-2012

STATION TECHNICAL SPECIFICATIONS

Fixed Location Address or Mobile Area of Operation

Loc. 1   Address: 1901 N 14th
          City: LINCOLN   County: LANCASTER   State: NE
          Lat (NAD83): 40-49-53.0 N   Long (NAD83): 096-42-13.0 W   ASR No.: 1213122   Ground Elev: 349.0

Loc. 2   Address: 9001 YANKEE HILL RD
          City: CHENEY   County: LANCASTER   State: NE
          Lat (NAD83): 40-43-12.0 N   Long (NAD83): 096-35-52.0 W   ASR No.: 1027527   Ground Elev: 434.0

Loc. 3   Area of operation
          Operating within a 32.0 km radius around 40-47-10.0 N, 096-41-16.1 W,
          Lincoln, LANCASTER county, NE

Loc. 4   Area of operation
          Land Mobile Control Station meeting the 6.1 Meter Rule: LANCASTER county, NE

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		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000856.46250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	

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.

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August 2007

Page 1 of 7

Licensee Name: LINCOLN, CITY OF

Call Sign: WNDX299   **File Number:** 0005479377   **Print Date:** 11-07-2012

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	000856.71250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000856.96250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000857.21250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000857.46250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000857.71250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000857.96250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000858.21250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000858.46250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000858.71250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000858.96250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000859.21250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000859.46250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000859.71250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000859.96250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	
1	1	000854.01250000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	03-18-2009
1	1	000854.18750000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	03-18-2009
1	1	000854.58750000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	03-18-2009
1	1	000854.68750000	FB2C	1		14K0F9W	100.000	263.000	104.0	78.0	03-18-2009
2	1	000856.21250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000856.46250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	

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August 2007

Licensee Name: LINCOLN, CITY OF

Call Sign: WNDX299   File Number: 0005479377   Print Date: 11-07-2012

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
2	1	000856.71250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000856.96250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000857.21250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000857.46250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000857.71250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000857.96250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000858.21250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000858.46250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000858.71250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000858.96250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000859.21250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000859.46250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000859.71250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000859.96250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	
2	1	000854.01250000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	03-18-2009
2	1	000854.18750000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	03-18-2009
2	1	000854.58750000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	03-18-2009
2	1	000854.68750000	FB2C	1		14K0F9W	100.000	226.000	150.0	191.0	03-18-2009
3	1	000811.21250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000811.46250000	MO	1965		14K0F9W	35.000	35.000			

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August 2007

Licensee Name: LINCOLN, CITY OF

Call Sign: WNDX299   File Number: 0005479377   Print Date: 11-07-2012

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	000811.71250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000811.96250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000812.21250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000812.46250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000812.71250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000812.96250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000813.21250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000813.46250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000813.71250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000813.96250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000814.21250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000814.46250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000814.71250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000814.96250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000856.21250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000856.46250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000856.71250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000856.96250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000857.21250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000857.46250000	MO	1965		14K0F9W	35.000	35.000			

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August 2007

Licensee Name: LINCOLN, CITY OF

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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	000857.71250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000857.96250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000858.21250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000858.46250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000858.71250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000858.96250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000859.21250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000859.46250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000859.71250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000859.96250000	MO	1965		14K0F9W	35.000	35.000			
3	1	000809.01250000	MO	1965		14K0F9W	35.000	35.000			03-18-2009
3	1	000809.18750000	MO	1965		14K0F9W	35.000	35.000			03-18-2009
3	1	000809.58750000	MO	1965		14K0F9W	35.000	35.000			03-18-2009
3	1	000809.68750000	MO	1965		14K0F9W	35.000	35.000			03-18-2009
3	1	000854.01250000	MO	1965		14K0F9W	35.000	35.000			03-18-2009
3	1	000854.18750000	MO	1965		14K0F9W	35.000	35.000			03-18-2009
3	1	000854.58750000	MO	1965		14K0F9W	35.000	35.000			03-18-2009
3	1	000854.68750000	MO	1965		14K0F9W	35.000	35.000			03-18-2009
4	1	000811.21250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000811.46250000	FX1	92		14K0F9W	30.000	30.000			

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August 2007

Licensee Name: LINCOLN, CITY OF

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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
4	1	000811.71250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000811.96250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000812.21250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000812.46250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000812.71250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000812.96250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000813.21250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000813.46250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000813.71250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000813.96250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000814.21250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000814.46250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000814.71250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000814.96250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000809.01250000	FX1	92		14K0F9W	30.000	30.000			
4	1	000809.18750000	FX1	92		14K0F9W	30.000	30.000			
4	1	000809.58750000	FX1	92		14K0F9W	30.000	30.000			
4	1	000809.68750000	FX1	92		14K0F9W	30.000	30.000			

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August 2007

Licensee Name: LINCOLN, CITY OF

Call Sign: WNDX299   **File Number:** 0005479377   **Print Date:** 11-07-2012

Control Points
Control Pt. No. 2
Address: 901 W. Bond St. Suite 110
City: Lincoln   **County:** LANCASTER   **State:** NE   **Telephone Number:** (402)441-8425

Associated Call Signs

Waivers/Conditions:

Grant of the request to update licensee name is conditioned on it not reflecting an assignment or transfer of control (see Rule 1.948); if an assignment or transfer occurred without proper notification or FCC approval, the grant is void and the station is licensed under the prior name.

Appendix 3 – Lancaster County Rural Fire Districts

Appendix 4 – EDACS User List

EDACS User List		
911		Nebraska State Patrol
911 Backup		Nebraska State Patrol - Capital Security
Air National Guard		Nebraska Surgery Center
Airport Authority		NRD
American Medical Response		Parks - Natural Resources
Animal Control		Parks - Operations
Blood Bank		Parks - Recreation
BNSF		Radio Maintenance
Bryan/LGH East		Red Cross
Bryan/LGH West		RF-Alvo
Building and Safety - Fire Inspectors		RF-Ashland
Daily Nebraskan		RF-Bennet
Engineering Services		RF-Ceresco
FBI		RF-Cortland
Fleet Services		RF-Crete
Health		RF-Eagle
Interop		RF-Firth
Journal Star		RF-Greenwood
KETV		RF-Hallam
KFOR		RF-Hickman
KLiN		RF-Malcom
KLKN-TV		RF-Pleasantdale
KOLN-TV		RF-Raymond
KRNU		RF-Southeast
Lancaster County Emergency Management		RF-Southwest
Lancaster County Sheriff		RF-Valparaiso
Landfill		RF-Waverly
Lincoln Fire & Rescue		Sales Stock
Lincoln Fire & Rescue - Ambulance Fund		St. Elizabeths Hospital
Lincoln Police Department		StarCare
Lincoln Public Schools		StarTran
Madonna		Street Maintenance
Media		Traffic Engineering
Midwest Medical		Unknown
Missing		UNL Parking
Missing		UNL Police
Nebraska Department of Roads		Waste Water
Nebraska Game and Parks		Water - Ashland
Nebraska Heart Hospital		Water - Lincoln
Nebraska State Fire Marshal		WOWT-TV
Nebraska State Health & Human Service		Youth Services Center

Appendix 5 – Delivered Audio Quality (DAQ)

DAQ Delivered Audio Quality	Subjective Performance Description
1	Unusable; speech present but unreadable.
2	Understandable with considerable effort. Frequent repetition due to noise/distortion.
3	Speech understandable with slight effort. Occasional repetition due to noise/distortion.
3.4	Speech understandable with repetition only rarely required. Some noise/distortion.
4	Speech easily understood. Occasional noise/distortion.
4.5	Speech easily understood. Infrequent noise/distortion.
5	Speech easily understood.

Appendix 6 – User Definitions

City Public Safety
City of Lincoln public service users include the following:

- Airport
- EMS
- Fire
- Heath
- Hospitals
- Police
- Youth Services

County Sheriff
- Lancaster County Sheriff Office

Rural Fire
In-County

- Bennet Fire and Rescue
- Firth Rural Fire District
- Hallam Volunteer Fire & Rescue
- Hickman Rural Fire Protection District
- Raymond Fire Department
- Southeast Rural Fire Department
- Southwest Rural Fire District
- Waverly Fire-Rescue

Out-of-County

- Ashland
- Ceresco
- Cortland
- Crete
- Eagle/Alvo
- Greenwood
- Malcolm
- Pleasant Dale
- Valparaiso

Public Service
City of Lincoln public service users include the following:

- Radio Maintenance
- Park and Rec
- Public Works

- ○ Engineering Services
- ○ Fleet Services
- ○ Landfill
- ○ StarTran
- ○ Street Maintenance
- ○ Waste Water
- ○ Water

Lincoln Public Schools

- Lincoln Public Elementary Schools
- Lincoln Public High Schools
- Lincoln Public Middle Schools
- Lincoln Public School District Office