

Kenton County, KY

Public Safety Radio Systems Analysis and Recommendations Report



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**Kenton County, Kentucky
Public Safety Radio Systems
Analysis and Recommendations Report**

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Kenton County, Kentucky Public Safety Radio Systems Analysis and Recommendations Report

1.0 EXECUTIVE SUMMARY

Trott Communications Group, Inc. was retained by Kenton County, Kentucky to assess its current public safety radio communications systems and provide recommendations for future upgrades. The investigation process included:

- Assessment of the current radio systems
- Interviews with system stakeholders
- Analysis of coverage performance
- Development of possible short-term improvements
- Development of long-term system upgrade options
- Preparation of budgetary cost estimates for system upgrade options

The investigation process found that public safety communications within the County are performed using six separate conventional radio systems consisting of the following:

- Kenton County Fire
- Kenton County Police
- Covington Fire
- Covington Police
- Erlanger Fire
- Erlanger Police

All fire protection frequencies are in the VHF band and all law enforcement frequencies are in the UHF band. Kenton County operates a consolidated dispatch center for Kenton County Fire, Kenton County Police, Covington Fire, and Covington Police dispatch functions. Erlanger operates a separate and independent public safety dispatch center.

A majority of the two-way radio infrastructure utilizes the Motorola Quantar repeater platform. Quantar equipment and associated devices have been discontinued and support will end after 2018. Support has already ended for some critical devices such as GPS receivers and analog voter/comparators. The existing Kenton County console system has

also been discontinued, with overall support ending after 2018. Some console components, which are necessary to add new positions, are unavailable from the manufacturer and can only be acquired through secondary markets.

Reliability of the existing equipment is a major concern for the system users. In addition to the infrastructure hardware itself, critical backhaul circuits have been prone to failure. Leased telephone circuits have historically suffered from weather-related outages.

Based upon the age, lack of long-term manufacturer support, and overall reliability of the existing radio systems, it is apparent that the existing public safety communications systems must be replaced in the coming years.

Two long-term solutions have been presented herein.

1. Replace systems with a redesigned countywide VHF/UHF conventional solution
2. Replace systems with a 700/800 MHz P25 trunking solution

A conventional solution will utilize similar technology as the current systems but will deploy current generation equipment with long-term manufacturer support. The system will be redesigned to address coverage and capacity issues to the extent feasible. In order for a consolidated countywide system to meet the current operational and capacity requirements, it is estimated that five VHF fire channels and six UHF police channels will be needed. It should be noted that conventional systems are not spectrally efficient and not generally recommended to support large numbers of users and operational groups. Trunking technology is often deployed for systems with more than 5 - 6 channels.

A countywide P25 trunked radio system will provide the most feature-rich solution and will best address the needs and requirements of the system users. Due to the efficiency of trunking, more users and operational groups can be supported with fewer radio channels. Therefore, the overall cost of system infrastructure for a trunking solution is not

significantly higher than that of a conventional system. However, the cost of user equipment is dramatically more expensive for P25 trunked systems.

A conventional system will allow existing user radios to be retained. The radio fleet can be managed and maintained as it is today with little cost impact to user agencies. None of the existing radio fleet is capable of migration to a 700/800 MHz P25 trunking system. All user radios that will operate on a P25 system day-to-day must be replaced. The price point for P25 trunking radios is 2 - 4 times more costly than typical conventional radios. The replacement user equipment cost is similar to the overall infrastructure cost. The P25 trunking option does assume that fireground operations will continue on VHF simplex frequencies, which helps to reduce the number of units that must be replaced. Cost estimates for the various system upgrade options are presented in §12.

It is understood that it will take time to review system upgrade options, select an upgrade path, secure funding, and implement the upgrade. Therefore, short-term solutions have been prepared to address immediate reliability concerns. The short-term actions, if executed, will help extend the life of the existing system until a replacement system can be deployed.

2.0 INTRODUCTION

Trott Communications Group, Inc. (hereafter, "Trott") was retained by Kenton County, Kentucky (hereafter "Kenton County" or the "County") to assess its current public safety radio communications systems, investigate the needs and requirements of system users, and make recommendations for future system upgrades. The investigation process included a full assessment of the current radio system, interviews with system stakeholders, analysis of coverage performance (current and future requirements), analysis of system capacity (current and future requirements), evaluation of interoperability requirements, assessment of available technology, and preparation of budgetary cost estimates for potential system upgrades.

This Report is intended to present the findings to the County and equip officials with the information necessary to develop plans for future system upgrades.

3.0 TERMINOLOGY

This Report refers to various technologies and definitions relevant to two way radio and communications systems.

"Simulcast" refers to the utilization of the same transmit frequencies at multiple site locations. Specialized equipment is utilized to synchronize transmissions for all sites. The result is a larger coverage footprint, comprised of the combined coverage of all sites.

Simulcast systems use a device known as a *"voter"* or *"comparator"* to evaluate received signals and select the best source for rebroadcast. Received audio from all base station receivers in the system is forwarded to the comparator. The comparator evaluates the quality of each source; the best source is redistributed to the simulcast transmitters for broadcast.

Some radio systems, both simulcast and non-simulcast include "*receive-only*" sites. These sites have base station receivers but no transmitters. The receivers are part of the overall network and are tied back to the voter/comparator. Receive-only sites are implemented in cases where low power portable radios are unable to reliably communicate with the repeater sites. They provide fill-in coverage to enhance the inbound radio path.

Two way radio systems fall into two categories of channel switching technology, "*conventional*" and "*trunked*". In a conventional system, each radio channel is a stand-alone resource, typically with a dedicated function (i.e. PD dispatch, fire operations, etc). Users must manually change channels to gain access to the desired frequency. All radio systems in Kenton County utilize conventional technology.

"*Trunked*" radio systems include an intelligent controller that assigns frequencies dynamically on an as-needed basis. "*Talkgroups*" function as virtual channels to group users together for a specific function. Instead of having a PD Dispatch channel there is a PD Dispatch talkgroup. The control mechanism tracks users that are currently registered on the PD Dispatch talkgroup. Each time a member initiates a conversation, the controller assigns an available channel and instructs the radios of all talkgroup members to tune to the assigned frequency. Trunked systems are efficient and support substantially more users and talkgroups than equivalently sized conventional systems.

Radio system modulation also falls into two broad categories, "*analog*" and "*digital*". Analog systems utilize simple FM modulation. Virtually all two way radios available commercially are compatible with analog FM modulation. Digital systems utilize a variety of transmission protocols. User equipment must be compatible with the specific digital protocol in order to function. A majority of public safety digital systems use P25 digital modulation. P25 was specifically designed for public safety applications and is supported by all major manufactures of public safety radio equipment. P25 equipment is available in both trunked and conventional formats.

P25 is further subdivided into P25 Phase 1 and P25 Phase 2. "P25" generally implies Phase 1 unless "Phase 2" is specifically referenced. P25 Phase 1 is a mature technology and supports one talkpath or conversation on each radio channel. P25 Phase 2 utilizes TDMA technology to provide two talkpaths for each radio channel. P25 Phase 2 equipment is only recently available with relatively few system deployments nationwide. However, as demand for spectrum increases, P25 Phase 2 deployments will increase due to the additional capacity provided.

4.0 CURRENT SYSTEM OVERVIEW

Public safety communications within the County are performed using six separate conventional radio systems consisting of the following:

- Kenton County Fire
- Kenton County Police
- Covington Fire
- Covington Police
- Erlanger Fire
- Erlanger Police

Each of the Kenton County and Covington radio systems are further subdivided into multiple channels.

Kenton County operates a consolidated dispatch center for Kenton County Fire, Kenton County Police, Covington Fire, and Covington Police dispatch functions. Erlanger operates a separate and independent public safety dispatch center.

4.1 Kenton County Fire

The Kenton County Fire radio system utilizes two analog simulcast channels in the VHF band. The "Fire 1" channel operates transmit-only from six site locations. This channel transmits tones and dispatch information to pagers, fire stations, and radios. The tones are Quick Call II format and determine which pagers and fire station receivers are activated

(alerted) and which devices hear the dispatch communications. Tones and dispatch audio are also audible to any two-way radio tuned to the Fire 1 channel.

"Fire 2" is used for all County Fire two-way communications, excluding fireground communications. The simulcast channel utilizes five sites for full transmit and receive functions. The transmit sites are collocated with Fire 1 transmitters, excluding the Erlanger site. Three additional sites are receive-only to enhance communications for portable radios. Table 1 provides a listing of the Kenton County Fire sites.

Name	City	Type	Height (ft)	Latitude	Longitude	Function
Devou Park	Covington	Tower	300	39-05-05.6	084-32-25.6	Simulcast
St. Elizabeth	Edgewood	Building	129	39-00-49.3	084-33-47.1	Simulcast
Dispatch	Independence	Tower	275	38-54-36	084-32-42	Simulcast
Piner	Morning View	Tower	250	38-49-49	084-32-11	Simulcast
Ryland	Ryland Heights	Tower	282	38-57-15	084-27-53	Simulcast
Graves Rd	Erlanger	Tower	199	39-01-22	084-36-36	TX FD 1
Mt. Echo	Cincinnati	Tower	187	39-05-30	084-33-59	Receive-Only
Kenton Lands	Erlanger	Water Tank	145	39-01-27.1	084-35-34.0	Receive-Only
Taylor Mill	Taylor Mill	Tower	480	39-01-49	084-30-22	Receive-Only

Table 1

Trott's investigations of the FCC licenses revealed that neither Fire 1 nor Fire 2 are licensed for operations at the St. Elizabeth Hospital Edgewood location. This license discrepancy should be rectified.

Both Kenton County Fire channels utilize Motorola Quantar series base stations. The Fire 2 two-way channel utilizes a Motorola DIGITAC voter/comparator. Backhaul for receiver voting and simulcast distribution is comprised of a combination of microwave paths and leased T1 telephone circuits. The County backhaul systems are described in more detail in §5.0.

The Kenton County Fire communications system supports the following fire departments and fire companies:

- Bromley
- Crescent-Villa
- Edgewood
- Fort Mitchell
- Fort Wright
- Independence
- Kenton
- Ludlow
- Park Hills
- Piner
- Ryland
- Taylor Mill
- Villa Hills

4.2 Kenton County Police

The Kenton County Police radio system is comprised of two analog simulcast channels in the UHF band. All dispatching traffic and primary communications occur on the "PD 1" channel. "PD 2" is utilized as a query channel for records requests and secondary communications. Both police channels utilize five transmit/receive sites and two receive-only sites. The sites are collocated with the Kenton County Fire sites listed in Table 1 with the exclusion of Taylor Mill.

Both Kenton County Police channels utilize Motorola Quantar series base stations and Motorola DIGITAC voter/comparators. The police channels share backhaul equipment with the County Fire system.

The Kenton County police communications system supports the following police departments and law enforcement agencies:

- Edgewood
- Fort Mitchell
- Fort Wright
- Independence

- Kenton County Police
- Kenton County Sherriff
- Lakeside Park / Crestview Hills
- Ludlow
- Park Hills
- Taylor Mill
- Villa Hills
- Kenton County Animal Control
- Kenton County Probation & Parole

4.3 Covington Fire Department

Kenton County has assumed maintenance and dispatching responsibility for the City of Covington Fire channels. The system remains the primary radio communications resource for the Covington Fire Department as it provides superior in-building coverage within the Covington jurisdiction. The Covington Fire radio system is comprised of two VHF analog channels. Each channel utilizes one full transmit/receive site and multiple receive-only sites. Channel 1 serves as the primary channel for all dispatching, paging, and station alerting. Channel 2 is a secondary frequency and incorporates channel steering technology to switch transmissions between a north and south site. Table 2 provides a listing of the Covington Fire sites.

Name	City	Type	Height (ft)	Latitude	Longitude	Function
Taylor Mill	Taylor Mill	Tower	480	39-01-49	084-30-22	Main Ch 2 / Receive Ch 1
Ida Spence	Covington	Water Tank	165	39-03-21.6	084-30-57.3	Main Ch 1 / Receive Ch 2
Court House	Covington	Building	110	39-05-15.7	084-30-27.9	Receive-Only / Backup Ch2
Barrington Woods	Ft Wright	Water Tank	165	39-03-35.1	084-32-29.9	Receive-Only / Backup Ch1
Devou Park	Covington	Tower	300	39-05-05.6	084-32-25.6	Receive-Only
Hands Pike	Covington	Tower	150	38-58-57.0	084-31-05.2	Receive-Only

Table 2

The transmit site for Channel 1 uses a Motorola GTR8000 base station. The receive-only sites utilize Motorola Quantar receivers. The voter/comparator is a Motorola DIGITAC, which is located at the Covington Police Department Headquarters. Channel 2 utilizes

Motorola Quantar stations at all sites and a Motorola DIGITAC voter/comparator. Receiver voter backhaul utilizes a combination of telephone circuits, T1, and microwave.

4.4 Covington Police Department

Along with the Covington Fire system, Kenton County has assumed maintenance and dispatching responsibility for the City of Covington Police channels. The Covington Police radio system is comprised of three UHF conventional channels capable of operating both analog and P25 digital modes (i.e. "mixed mode"). Users and dispatchers can select between analog and P25 modes on-the-fly.

"PD 1" is the primary channel of operation, supporting all dispatching functions and a majority of other query and informational calls. "PD 3" is also used as a secondary channel during heavy traffic times. PD 1 and PD 3 are typically operated in analog mode. Conversations are switched to P25 when privacy is desired. However, P25 scanners are readily available to the general public. Therefore, P25 conversations only prevent eavesdropping by older analog-only scanners and radios.

"PD 2" is primarily operated in P25 mode. Approximately ten radio units are equipped with DES-XL encryption. Narcotics/VICE and SWAT officers utilize encryption as needed for secure communications.

The Taylor Mill site hosts the primary transmitters for all three Covington PD channels. Backup transmitters for the PD channels are located at Ida Spence. The associated base station receivers at Taylor Mill and Ida Spence are active regardless of which transmitter (primary or backup) is currently supporting traffic. Other receive-only sites are collocated with the Covington Fire receivers shown in Table 2.

Both the main and backup sites utilize a mixture of Motorola Quantar and Motorola Quantro base stations as detailed in Table 3. All receive-only sites use Quantar receivers. The voter/comparators are Motorola AstroTAC 3000, which supports both analog and P25 operations. Leased telephone lines are used for receiver voter backhaul. Motorola

DIU's ("Digital Interface Units") are used to interface with the Kenton County console system. The DIU for each channel serves as the interface to allow console devices to operate in both analog and P25 digital modes.

Name	Function	Ch 1	Ch2	Ch 3
Taylor Mill	Main	Quantro	Quantro	Quantar
Ida Spence	Backup	Quantar	Quantar	Quantro
Court House	Receive-Only	Quantar	Quantar	Quantar
Barrington Woods	Receive-Only	N/A	Quantar	N/A
Devou Park	Receive-Only	Quantar	Quantar	Quantar
Hands Pike	Receive-Only	Quantar	Quantar	Quantar

Table 3

4.5 Kenton County Emergency Communications Center

The Kenton County Emergency Communications Center (KCECC) is a multiagency dispatch center operated by Kenton County. The dispatch center services all agencies utilizing the Kenton County Fire, Kenton County Police, Covington Fire, and Covington Police radio systems. The center is equipped with six Motorola Gold Elite radio consoles. The consoles can communicate on all Kenton County and Covington radio channels. The console system is also connected to various interoperability stations.

Tones for fire paging and fire station alerting are generated from the computer aided dispatch (CAD) system. The console provides a backup method of generating paging/alerting tones. KCECC is equipped with a MOTOBRIDGE system, which is a computer interface for the setup and management of interoperability patches. The MOTOBRIDGE system is not integrated with the console system and requires separate training and configuration. Therefore, the MOTOBRIDGE is primarily utilized for preplanned and prolonged multiagency events. It is not well suited for on-the-fly interoperability functions.

4.6 City of Erlanger

The City of Erlanger operates an independent radio system and dispatch center. Although Erlanger is not part of Kenton County's communications responsibilities, the Erlanger radio system and dispatch center were documented as part of this project.

Erlanger shares the Kenton County Fire 1 frequency and infrastructure for the transmission of paging tones and dispatching of fire calls. The Erlanger dispatch center has a parallel connection to the Kenton County Fire 1 transmission system and is responsible for the generation of tones for its firefighters and fire stations. Both Kenton County and Erlanger monitor the channel before initiating dispatch calls to minimize the potential for channel contention. Erlanger maintains a separate backup transmitter (Motorola model MTR2000) for the Fire 1 channel. The backup transmitter is connected to the Erlanger console system and is available to Erlanger dispatchers in the event of a failure with the Kenton County Fire 1 simulcast channel.

All two-way communications for the Erlanger Fire Department utilize the VHF analog simulcast system referred to as "Fire 5". The channel formerly used three simulcast sites but has been reduced to two sites, Graves Road and St. Elizabeth Hospital. The site equipment is comprised of Quantar stations and a DIGITAC voter/comparator.

All primary police communications occur on Erlanger PD 1. This channel is an analog UHF simulcast system with two transmitter sites, Graves Road and St. Elizabeth Hospital. Receive-only sites are located at Pleasure Isle and Kenton Lands. PD 1 also features a low power repeater on a separate relay channel, which is used to extend coverage into the Richardson Road Valley and Narrows Road area. Officers must manually switch to the relay channel when in the service area. The low power repeater is used to relay audio to and from PD 1, serving as a two way coverage extender.

Erlanger PD 2 is a secondary channel used as back-up and for tactical operations. Erlanger PD 1 and PD 2 are constructed with the Motorola Quantar stations and DIGITAC voter/comparator units.

The Erlanger dispatch center is equipped with four Motorola MCC5500 radio console positions. The center is responsible for all dispatching, paging, and station alerting for the Erlanger FD and Erlanger PD radio channels.

5.0 BACKHAUL

Reliable backhaul circuits are essential for simulcast systems. The simulcast sites on the Kenton County radio systems utilize a combination of microwave and leased T1 circuits. The microwave links were installed in 2007 as part of the Northern Kentucky Interoperability Microwave Expansion Project or subsequent additions to that system. The microwave circuits primarily serve as backhaul for the MOTOBRIDGE interoperability network. Excess capacity on the microwave system is available for use by the hosting agencies. The following site locations are connected to the Northern Kentucky microwave loop:

- KCECC
- Erlanger PSCC / Graves Road
- Covington PD
- Mt Echo

Leased T1's provide backhaul for the following sites:

- Kenton Lands
- Devou Park
- St. Elizabeth Hospital
- Ryland Heights
- 303 Court Street

T1 circuits are susceptible to telephone company outages resulting from rain and other weather events. Although reliability is better than 4-wire audio circuits, T1 outages are not uncommon.

Receive-only sites require less bandwidth and are not critically timed. In some cases, 4-wire audio circuits are leased to provide backhaul for receive-only sites. It should be

noted that the reliability of 4-wire audio circuits in the area is historically poor. Rain events frequently disable backhaul circuits to various receive-only sites. The only Kenton County site serviced with a 4-wire telephone circuit is Taylor Mill. A majority of the Covington receive-only sites utilize 4-wire circuits for receiver backhaul. These include:

- Taylor Mill
- Ida Spence
- Hands Pike
- Barrington Woods

The Erlanger radio systems share microwave and T1 backhaul with Kenton County at collocated sites. Pleasure Isle is the only Erlanger site that utilizes 4-wire audio circuits.

6.0 END-OF-LIFE

6.1 Infrastructure

A majority of the Kenton County, Covington, and Erlanger radio system infrastructure equipment has been discontinued by the manufacturer. End-of-life notices have been issued on all major components. Support has ended for some equipment and will be ending for remaining items in the coming years. Major components include:

- Motorola Quantar base station
- Motorola Quantro Base Station
- Motorola DIGITAC comparator
- Motorola AstroTAC 3000 comparator
- Motorola DIU
- Motorola Gold Elite console system

The Motorola Quantar is utilized as the primary base station throughout Kenton County, Covington, and Erlanger. Approximately 32 Quantar repeaters (full transmit and receive units) and 27 Quantar receive-only stations are in service. The Quantar has been discontinued by the manufacturer; support and parts are available through 12/31/2018. The Motorola GTR8000 replaces the Quantar and can be substituted if a Quantar is not repairable. However, for simulcast channels, all transmitters must be matched. Therefore,

the substitution of one Quantar transmitter on a given channel will require the substitution of all Quantar transmitters on that channel.

The Covington PD channels include three Quantro base stations; see Table 3. The Quantro predates the Quantar, is no longer supported, and parts are generally unavailable. Quantar or GTR8000 stations can be used as replacement stations if needed.

Support has already ended for DIGITAC comparators and parts are scarce. If a DIGITAC is not repairable, a Motorola MLC8000 comparator may be substituted. Other third-party comparator units are also available.

The three P25 channels used by Covington PD utilize Motorola AstroTAC 3000 comparators and Digital Interface Units. Support for both the AstroTAC 3000 and DIU ends 12/31/2018. The Motorola GCM8000 digital comparator can be used as a substitute for the AstroTAC 3000 and also performs DIU functions, eliminating the need for a separate interface unit.

Support for the Motorola Gold Elite console system utilized by KCECC ends 12/31/2018. There is no substitute for individual console positions or components. Failure of critical parts will require replacement of the complete console system.

Synchronization and frequency stability is critical for reliable simulcast operations. Each simulcast site in the Kenton County networks relies on an Efratom GPS time standard. The device is no longer supported and is not repairable. Any failures will require replacement with a compatible unit, such as a Spectracom SecureSync; however the site will remain inoperable until a replacement unit is acquired and installed. GPS devices can be replaced on a site-by-site basis.

The Covington Fire 1 transmitter is a Motorola GTR8000. This is a current production model with full manufacturer support. Full manufacturer support is also available for the

City of Erlanger Motorola MCC5500 console system. MCC5500 consoles are not compatible with the Gold Elite consoles used by the County.

Table 4 provides a summary of the end-of-support dates for the major infrastructure components.

Model	Function	End of Support	System
Quantro	Base Station	Unsupported	Covington PD
Quantar	Base Station	12/31/2018	All Systems
GTR8000	Base Station	Fully Supported	Covington FD
DIGITAC	Comparator	Unsupported	Kenton County, Covington FD, & Erlanger
AstroTAC 3000	Comparator	12/31/2018	Covington PD
DIU	Console Interface	12/31/2018	Covington PD
Gold Elite	Console	12/31/2018	Kenton County
Efratom GPS	Time Standard & Master Oscillator	Unsupported	Kenton County
MCC550	Console	Fully Supported	Erlanger

Table 4

6.2 Backhaul

The Northern Kentucky microwave system, which provides backhaul to critical site locations, primarily utilizes Harris 5200 series microwave radios. These units have been discontinued. Factory service and parts remain available with no announcements related to end-of-support. There is no immediate concern with maintaining the system, but the long-term sustainability of the equipment is unknown.

The Motorola TeNSr channel banks are utilized to interface to microwave T1 and leased T1 circuits. The channel banks also provide critical time synchronization for simulcast distribution. Although the TeNSr product is obsolete with newer IP platforms, there have been no end-of-life or end-of-support announcements.

6.3 User Equipment

The primary voice pager device utilized throughout Kenton County is the Motorola Minitor V or the newer Minitor VI. Both pagers are fully supported by the manufacturer.

There is a wide variety of user radios utilized with the various public safety radio systems in the County. There are significant quantities of Motorola HT750, HT12500, CDM1250, XTS1500, and XTS2500 radios deployed. Support is available for these units for the foreseeable future. Older models such as the HT1000 are also in service. The HT1000 has been discontinued and manufacturer support has ended; replacement parts and repairs are available on a "best effort" basis. However, since there are no immediate plans to change technology (i.e. trunking or digital upgrades), manufacturer support for the various user radios is mostly irrelevant. Any malfunctioning device that is not repairable is simply replaced on a case-by-case basis. It should be noted that all agencies purchase and maintain their own user equipment.

7.0 STAKEHOLDER INTERVIEWS

7.1 Interview Process

To fully encapsulate the status of the existing radio systems and to define the requirements for potential radio system upgrades, Trott interviewed departmental users and stakeholders of the existing radio systems including representatives from Kenton County Emergency Communications, county fire departments/companies, county police departments, Covington PD, Covington FD, Erlanger Emergency Communications, and Erlanger PD. Interviews occurred throughout the week of September 8, 2014. Each department/agency was invited to participate in the interview process. The stated goals of the stakeholder interviews were to:

- Discuss the capabilities, deficiencies, and reliability of the existing radio systems
- Document radio system utilization and unique operational requirements
- Develop preliminary needs and requirements for an upgraded system

Meetings were also conducted with Mobilcomm, the service and maintenance provider for the existing systems. The Mobilcomm meeting was focused on maintenance history and support options.

7.2 General Findings

As noted in §4.0, there are six separate radio systems that serve the various public safety agencies in Kenton County. These systems utilize a mixture of analog and digital modulation and operate in two different frequency bands. Therefore, it is impossible to globally address all issues and requirements. However, the interview process did reveal common themes that are applicable to all users.

7.2.1 Reliability

Mobilcomm provides installation, repairs, and service for all public safety radio systems in the area. Mobilcomm has a knowledgeable team and an excellent local service record. However, due to the age of the infrastructure equipment, failures are becoming more frequent. As such, all user groups expressed concerns about system down-time and the overall reliability of the infrastructure. It was further noted that various sites and channels experience weather-related issues, presumably due to backhaul outages.

It was noted during Trott's investigations that the fault detection and reporting system, known as MOSCAD, does not extend to all equipment and all backhaul circuits. MOSCAD has been discontinued and cannot be expanded. Therefore, some critical components and critical backhaul circuits are not monitored. Routine checks by Mobilcomm or trouble reports from users are the only means of detecting faults in unmonitored equipment. There have been circumstances where equipment was offline or inoperable for extended periods before routine checks or user reports identified an issue. It was noted by several fire companies that system monitoring is an important component of the Insurance Service Office's (ISO's) Public Protection Classification evaluation and rating system.

7.2.3 Intraoperability

All police agencies within the county operate in the UHF band and all fire agencies operate in the VHF band. All but a handful of the user radios in the County are single-band units. Therefore, there is little or no radio communications between police and fire agencies countywide. Any communications required is accomplished via telephone, dispatcher relay, or verbal communications while on-scene. County fire and County police agencies expressed a need for intraoperable communications to the extent feasible. The Covington and Erlanger users were less concerned with communications between police and fire, but noted multiple instances when direct radio communications would have been beneficial.

7.2.4 Interoperability

Kenton County along with Boone and Campbell counties operate analog conventional radio systems. In each case fire protection utilizes the VHF band while law enforcement uses the UHF band. User radios are programmed so that law enforcement agencies can interoperate with each other as needed. Officers that travel into the coverage area of Boone or Campbell counties simply tune to the respective channels on their UHF radios. Likewise, users from Boone or Campbell can travel into Kenton County and tune to Kenton County frequencies. Similarly, firefighters from all three counties are programmed for VHF interoperability.

Users report that programmed interoperability is simple, effective, and utilized often. Future system upgrades should maintain a high level of interoperability between Kenton, Boone, and Campbell counties.

There is no direct interoperability with agencies on the Hamilton County trunked radio system, including the City of Cincinnati and the Cincinnati/Northern Kentucky Airport trunked radio systems. A number of agencies expressed a

strong need for limited interoperability with select talkgroups on the Hamilton County and Airport systems.

The MOTOBRIDGE system was intended to provide a mechanism for regional interoperability. In theory, audio patches can be activated between most any public safety radio system in the region. Users and dispatch operators indicate that the system is cumbersome and impractical for establishing short-term or on-the-fly patches. It is only suitable for preplanned or protracted events that warrant interoperable communications.

7.3 System-Specific Findings

7.3.1 *Kenton County Fire*

Multiple agencies reported significant coverage issues with the Kenton County Fire VHF system. Noted areas of deficiency include:

- Hands Pike, Madison Pike corridors – particularly in-building
- I-275 down the hill from the Turkey Foot Rd exit
- Taylor Mill Rd east to the Licking River valley
- In-building coverage
 - Schools
 - emergency department at St. Elizabeth Edgewood Hospital
 - Lookout Corporate Center – 1717 Dixie Hwy, Ft Wright
 - Walmart – Madison Pike

Mobile coverage (with vehicular-mounted radios) is generally acceptable in these areas. However, handheld portable radios are frequently unable to function properly. Pagers in these areas may generate an alert tone but the voice dispatch traffic is often unreliable.

Firefighters also report that coverage inside of medium and dense building structures throughout the county is unreliable. Various simplex (radio-to-radio)

frequencies are used as fireground channels. These fireground channels are not reliant upon system coverage to function. However, once communications has moved to a fireground channel, contact with dispatchers is lost and radio traffic is no longer recorded. Ideally users could remain on a system channel to allow for wide area communications and recording. The problem could also be mitigated if there was a method of relaying fireground traffic back to a recorded channel that is accessible to dispatchers.

The Edgewood FD reported that even simplex traffic is often unreliable inside of various building structures include St. Elizabeth Hospital. It is believed that these issues are isolated to maintenance and/or programming of the impacted units. The Ft. Mitchell FD cannot communicate with Air Care on portables (Intercounty Channel 4 – simplex) to set up landing zones for incidents on I-275 near the Turkey Foot Rd intersection.

All dispatch and alerting traffic occurs on County Fire 1 and all two-way traffic occurs on County Fire 2. It was noted that the channels can be congested during times of high activity. It was further noted that although additional channels would be beneficial, better training and more efficient system utilization would likely address a majority of the congestion issues.

7.3.2 Kenton County Police

Multiple law enforcement agencies report coverage issues with portable radios operating inside of building structures. School buildings throughout the County are problematic as are Walmarts and similarly sized retail locations. Areas with outdoor portable radio coverage issues include:

- Madison Pike
- Fowler Creek
- Richardson Road
- Cody Road
- Decoursey Pike

- Licking River valley
- In-building coverage
 - Schools
 - St. Elizabeth Edgewood Hospital
 - Apartment Complexes

There are also reports of intermittent coverage problems, which indicate reliability issues with infrastructure equipment and/or backhaul circuits.

All dispatching and primary communications are performed on County PD 1. System users report frequent channel congestion on PD 1. Second Shift (12 pm - 10 pm) is particularly problematic. Wait times of 60 seconds or longer are not uncommon in the 5 pm - 7 pm time frame. Extended events are moved to PD 2, which is also utilized as a query channel. Although PD 2 is often busy, its capacity is generally adequate. PD 1, however, is overloaded and additional capacity for dispatching and primary communications is needed.

Interoperability was requested for the following agencies:

- Kentucky State Police
- City of Cincinnati
- Fish and Wildlife
- Cincinnati / Northern Kentucky International Airport (CVG)
- Pendleton & Grant County PDs (southern border) on VHF

7.3.3 Covington Fire

Covington Fire reported that backhaul for receive-only sites has been an ongoing challenge to system reliability. Outages are common during rain events. Furthermore, the lack of adequate system alarms and monitor features greatly increases the duration of outages. The primary method of fault detection is user complaints.

All dispatching, station alerting, and primary two-way communications occur on the same channel, Covington Fire 1. The channel is often busy and it has been

recommended by Fire command staff to move tones to a different channel. Moving Covington pagers and station alerting to County Fire 1 has been considered. This action is generally supported by the Covington Fire Department. It was also reported that a high percentage of calls on Covington Fire 1 are EMS related. Statistics from the County's CAD system show that Covington EMS accounts for a high percentage of all emergency calls countywide. Covington Fire 2 is not routinely utilized and is available for special events and non-critical communications. Congestion could also be improved by relocating status calls to an alternate system such as MDC.

Fireground operations are performed using two simplex channels. There is a strong desire to record and monitor fireground communications.

7.3.4 Covington Police

Although Covington PD channels are P25 capable, 75% or more of communications occur in analog mode. Users report that analog audio quality is better. P25 mode is primarily utilized when increased privacy is desired. However, it should be noted that off-the-shelf P25 scanners are readily available. Encryption is required for secure communications. Approximately 10 units in the Covington radio fleet utilize encryption. Most encrypted conversations occur on PD 2. It was noted that coverage performance on PD 2 is weaker than on PD 1 and PD 3.

There have been ongoing issues with missed transmissions from dispatchers. Investigations show that some dispatch calls fail to broadcast. Mobilcomm, the maintenance contractor, believes that there are issues with the Digital Interface Units (DIUs), which are used as the audio interface between the dispatch console system and the Covington PD infrastructure. Motorola has performed upgrades to the units, which has improved but not eliminated the problem.

Coverage in western portions of Covington is weak. Mobile units function well but portables can be unreliable. Users also report interference from other agencies from time-to-time. It is believed that all agencies in the region utilize the same CTCSS (squelch tones). Therefore, distant users on the same frequencies can be heard by Covington units at the end of transmissions or when conditions allow. Noted areas of deficiency include:

- Western Covington - Bond St & Altamont Rd
- In-building coverage
 - Majority of structures
 - Large Apartments – Golden Towers, The Panorama Senior Center
 - St. Elizabeth Covington

Covington officers request interoperability with Cincinnati District 1. There are frequent joint response events and the only existing form of interoperability is dispatcher relay or telephone communications.

7.3.5 Erlanger

Erlanger reports that coverage performance on their channels is generally good excluding the areas served by the low power extender repeater (Richardson Road) and the Stevenson / Turkey Foot area. The extender repeater seems to perform as intended but is not ideal, since it requires user intervention. Under some circumstances, users must switch back and forth in order to remain in contact with the dispatch center.

Sharing of Kenton County Fire 1 is much better now that both dispatch centers monitor the channel before initiating broadcasts.

8.0 SITE LOCATIONS

The various radio systems in Kenton County utilize a combined 14 site locations. Table 5 provides basic information for all sites.

Name	Type	Height (ft)	Latitude	Longitude	Owner	Class
Barrington Woods	Water Tank	165	39-03-35.1	084-32-29.9	Water District	1
Court House	Building	110	39-05-15.7	084-30-27.9	County	3
Devou Park	Tower	300	39-05-05.6	084-32-25.6	County	3
Dispatch	Tower	275	38-54-36	084-32-42	County	1
Graves Rd	Tower	199	39-01-22	084-36-36	Erlanger	1
Hands Pike	Tower	150	38-58-57.0	084-31-05.2	Covington	1
Ida Spence	Water Tank	165	39-03-21.6	084-30-57.3	Water District	2
Kenton Lands	Water Tank	145	39-01-27.1	084-35-34	Water District	2
Mt. Echo	Tower	187	39-05-30	084-33-59	Cincinnati	1
Piner	Tower	250	38-49-49	084-32-11	Leased	2
Pleasure Isle	Tower	280	38-58-54	084-32-44	Leased	2
Ryland	Tower	282	38-57-15	084-27-53	Leased	2
St. Elizabeth	Building	129	39-00-49.3	084-33-47.1	St Elizabeth	1
Taylor Mill	Tower	480	39-01-49	084-30-22	Mobilcomm	1

Table 5

Of the sites in Table 5, five are owned and maintained by one of the public safety agencies; three others are owned and maintained by the Northern Kentucky Water District. The remaining sites are leased. Table 5 includes a site condition score with three number classifications.

- Class 1 sites are in good condition or require only minor improvements to support future system upgrades.
- Class 2 sites are in acceptable condition overall but require improvements to provide adequate equipment and/or facilities to support future system upgrades.
- Class 3 sites require significant improvements and/or full replacement to result in a suitable facility for future system upgrades.

Kenton Lands and Pleasure Isle are receive-only sites and utilize outdoor enclosures to house equipment. These sites lack equipment shelters and adequate backup generators, which are recommended for a full communications site. If these locations are utilized in a system upgrade, it may be necessary to add equipment shelters and backup power. Existing generators at Piner and Ryland are unreliable and in need of replacement.

The equipment shelter at Ida Spence will need improvements to function as a suitable facility. The building is poorly sealed, dirty, and uses a retro-fitted consumer grade HVAC system. These issues will need to be corrected going forward.

The Court House site in Covington utilizes equipment space in the abandoned jail on the top floor of the building. The equipment space is not climate controlled and requires considerable improvements to function as a suitable communications site for a system upgrade.

The Devou Park tower is in poor physical condition. There are obvious structural issues with guyed wires, foundation, and tower steel. It is unlikely that the existing structure complies with TIA 222 standards or could be brought into compliance. If the location is deemed critical for future use, the tower structure must be replaced. The equipment shelter is in reasonable condition but also needs improvements regarding cleaning, sealing, and HVAC.

9.0 SYSTEM COVERAGE

As noted in §7, portable radio coverage was reported as less than ideal by multiple fire protection and law enforcement departments. Improvement in coverage performance is one of the critical goals of the radio system upgrade project. Coverage requirements must be clearly defined for the system procurement process. Trott performed coverage analyses of the existing systems and utilized those results to predict the potential coverage performance of the various system upgrade options presented in §10.

9.1 Coverage Analysis Methodology

The following is a summary of the coverage analysis methodology. A detailed description of the propagation modeling process and performance threshold calculations is provided in the Appendix.

SIGNAL™ propagation software package from EDX Wireless, Inc. was used by Trott to perform propagation studies and to generate the propagation (i.e. coverage) maps of the existing radio system and various potential site configurations for a system upgrade. SIGNAL™ provides a comprehensive suite of terrain-based propagation models and design tools. United States Geological Survey (USGS) 1 arc-second terrain data was acquired for the area and utilized in the modeling process to increase accuracy.

Equipment and configuration data for the existing sites was collected by Trott through site surveys and consultations with the existing maintenance contractor. Relevant modeling data for candidate site locations was derived from public site databases and typical equipment configurations.

Performance thresholds to represent reliable radio coverage were developed utilizing performance standards and methods published in TIA/EIA TSB-88-D. All thresholds are based upon the recommended public safety performance of DAQ 3.4 audio quality and 95% signal level reliability. All coverage maps include thresholds for mobile radios, outdoor portable radios, and portables inside of medium density buildings. The indoor coverage is modeled using a building attenuation margin of 10 dB to represent medium density buildings. This margin is presented globally and does not identify where buildings actually exist. Locations with light density buildings such as residential structures will perform better than indicated. Likewise, high density buildings may perform worse than indicated.

It should be noted that VHF and UHF systems are typically limited by the inbound signal path. Portable radios have less range "talking back" to the sites due to lower output

power. In higher frequency bands, such as 700/800 MHz, it is often possible to balance inbound and outbound paths through amplification at the sites. However, higher levels of ambient noise and interference in lower frequency bands tend to limit the ability to provide equivalent inbound and outbound performance. Therefore, receive-only sites are often added to VHF and UHF systems to help balance performance. Site noise and interference vary considerably from site-to-site. For coverage mapping purposes, typical site noise was assumed.

9.2 Existing VHF Coverage

As noted in §4.1, the Kenton County Fire system includes one two-way VHF channel (County Fire 2) and one outbound-only channel (County Fire 1) for fire paging and station alerting. Each is intended to provide countywide service. Specific areas of coverage deficiency were noted by system users. Propagation maps generated by Trott generally correlate with user reports. Appendix Figure 1 shows the County Fire 1 outbound performance, which is a transmit-only system with six sites. Figure 2 shows the County Fire 2 outbound performance and Figure 3 shows County Fire 2 inbound performance. The geographic percentage of the County coverage for each channel is presented in Table 6.

Channel	10dB Building	Portable	Mobile
VHF Fire 1 Outbound	67.8%	92.2%	99.8%
VHF Fire 2 Outbound	65.3%	91.5%	99.8%
VHF Fire 2 Inbound	36.4%	73.9%	99.8%

Table 6

As seen, County Fire 1 provides outdoor service to pagers throughout approximately 92% of the County. Approximately 65% of the County is predicted to have service indoors. Based upon inbound performance of County Fire 2, portable radios are served in approximately 74% of locations. In-building for County Fire 2 is only provided in 36% of the geographic area. As noted above, the in-building coverage percentages are based upon the required signal margin countywide, regardless if buildings are actually present. The coverage maps show that a majority of the in-building coverage obtained is concentrated in areas where buildings are more prevalent.

9.3 Existing UHF Coverage

The Kenton County PD 1 and PD 2 systems described in §4.2 share sites and antenna equipment and therefore should provide identical coverage performance. The outbound and inbound coverage predications are provided as Figures 4 & 5 respectively. The associated geographic coverage percentages are seen in Table 7.

Channel	10dB Building	Portable	Mobile
UHF PD Outbound	56.7%	74.1%	92.4%
UHF PD Inbound	41.7%	60.5%	93.2%

Table 7

9.4 Coverage Enhancement Options

9.4.1 Site Selection

Coverage enhancement options generally involve the addition of tower sites and/or relocation of sites. It should be noted that sites are seldom positioned in the ideal location for maximum coverage and efficiency. Therefore, site selection typically involves a compromise in performance, location, availability, and cost.

Existing site locations were presented in §8. Coverage enhancement options are based upon various combinations of these existing sites. Potential site layouts were developed from the coverage predictions performed by Trott and only represent potential solutions. These layouts should be considered preliminary and theoretical. Any long-term solution will involve a Request For Proposals (RFP) process. Potential system suppliers will be responsible for developing a valid system design, which could utilize different site combinations.

9.4.2 Existing Kenton County Fire System

It is not possible to address all documented coverage issues of the existing system without additional transmit sites. As noted in §4.1, end-of-life issues make it impractical to add simulcast sites to the current system platform. However,

improvement in key areas could be achieved through the addition of one or more receive-only sites; receivers may be mixed and matched independent of system platform. Adding a County Fire 2 receiver to the Pleasure Isle site provides the most significant improvement by enhancing performance along the Madison Pike corridor. The Ida Spence water tower site is strategically located and could serve as a fill-in location in southern Covington and Taylor Mill areas. Figure 6 shows the coverage achieved by the addition of these two receive-only sites.

9.4.3 Existing Kenton County Police System

Figure 7 shows predicted UHF coverage with the addition of receive-only sites at Pleasure Isle, Taylor Mill, and Ida Spence. Pleasure Isle provides the most significant improvement in the area of highest user complaints.

9.4.4 Redesigned VHF & UHF Systems

The VHF and UHF systems must be redesigned to obtain substantial coverage improvement countywide. Trott examined candidate sites and prepared a theoretical system layout. Antenna systems were reconfigured to maximize gain and minimize losses. Antenna heights were also adjusted in some cases. Figure 8 shows the predicted outbound performance of a seven-site VHF (Fire) layout. Figure 9 shows the corresponding inbound performance with three additional receive-only sites. These layouts are duplicated for the UHF band (Police) in Figures 10 & 11.

The VHF and UHF outbound maps utilize Ida Spence as a simulcast site. It is debatable as to whether Ida Spence or Taylor Mill is the better simulcast site location. Ida Spence provides superior in-building coverage in southern Covington and Taylor Mill areas while the Taylor Mill site provides better coverage along Decoursey Pike. Both sites are used in the inbound layouts.

It should be noted that even with seven simulcast and three receive-only sites, areas with less than ideal performance remain. The availability of sites and terrain challenges make it almost impossible to provide complete countywide coverage without constructing new towers and further increasing the site count. However, the preliminary layout does result in significant coverage improvements. Table 8 shows the static performance of the conventional configurations.

Channel	10 dB Building	Portable	Mobile
VHF Redesigned Outbound	79.0%	95.9%	99.9%
VHF Redesigned Inbound	54.4%	84.0%	99.9%
UHF Redesigned Outbound	68.8%	84.6%	97.5%
UHF Redesigned Inbound	58.6%	74.5%	97.5%

Table 8

External coverage enhancement solutions such as vehicular repeaters and bi-directional amplifiers (BDA) are technically possible for UHF channels. The VHF band does not separate transmit and receive channels, making it nearly impossible to deploy BDA systems that support more than one repeater pair. It is also challenging to license vehicular repeater frequencies with sufficient separation from system channels to avoid local interference.

9.5 Predicted 700/800 MHz Coverage

One of the upgrade options presented in §10 is migration to a 700/800 MHz P25 trunking platform. The various sites in the County were analyzed to develop a possible site configuration and site count for budgetary planning. Due to the lower noise environment and use of receiver tower-top amplifiers, inbound and outbound performance is typically balanced in the 700/800 MHz band. Therefore, all coverage maps are based upon outbound propagation calculations with no need for receive-only sites. Figure 12 shows the predicted 800 MHz coverage utilizing seven existing site locations. With this configuration, 94% of the County is predicted to have service for outdoor portable radios and 83% of the County has sufficient margin for 10 dB in-building coverage. Mobile coverage is better than 98%.

10.0 UPGRADE OPTIONS

10.1 General

The fundamental decision facing Kenton County is whether to continue with a conventional radio system or to transition to a trunked radio environment. Coverage and reliability issues can be solved with either configuration. Differences arise when comparing capacity, interoperability, features, and cost.

This section will examine the differences between trunked and conventional systems and present the pros and cons of the following potential solutions:

- Short-term improvements and a plan to extend the life of the existing conventional systems (i.e. buy more time)
- Replacement of the existing systems with similar conventional configurations (using updated, current-production equipment)
- Replacement of the existing systems with a county-wide trunked radio solution to service all public safety and mission critical users

10.2 Conventional vs. Trunked

The long-term critical path for Kenton County is selecting between a conventional or trunked solution. Based upon the existing radio system issues and the stated needs and requirements of the various users, a trunked radio solution presents several important advantages but at higher cost.

As established in §4.0, there are six separate conventional radio systems serving the public safety agencies in Kenton County. These systems collectively broadcast on 12 frequency pairs and support 29 public safety agencies/departments. There are approximately 600 fire protection radio units and 850 law enforcement radio units in service. The total user radio count of 1450 assumes that all units are in good working order and routinely access the systems. However, with a significant number of volunteer

firefighters, it is likely that a sizable portion of the 600 fire protection radios are less frequent users.

Trunking solutions are often deployed for systems consisting of the number of channels, user groups, and radio units in Kenton County. As a general rule, when five or more radio channels are in use, trunking technology is recommended. Further, a typical five channel trunking system can support many more than five talkgroups (i.e. virtual channels). It would be possible to setup various police tactical talkgroups and fire operations talkgroups to offload traffic from the primary dispatch channels. With police and fire units on a common system, a trunking solution would also establish the intraoperability requested by the users. Depending upon the number of channels (i.e. talkpaths) deployed, there could be sufficient capacity to add other governmental users to the system. Talkgroups would be established as needed to support all system users. Trunking systems also include many advanced features including user authentication, tracking of airtime usage, call priority, unit enable/disable, etc.

The only notable issues with trunking solutions are complexity and cost. Trunked systems are complicated and require significant maintenance efforts. Administration of trunked systems is also more challenging than that of simple conventional solutions. However, cost is the most notable concern associated with deploying trunked radio systems. Trunked systems require robust controller equipment, which is expensive to purchase and maintain. Compatible user equipment for P25 trunked systems is several times more costly than basic analog-only user radios.

10.3 County Fire 1 VHF

Regardless of the long-term path selected by the County (conventional or trunked), it is likely that County Fire 1 will be needed. Even if two-way communications are migrated to trunking technology, it is anticipated that analog VHF tone and voice paging will be utilized to alert firefighters and fire houses/stations. Therefore, it should be assumed that all communications solutions will include replacement of the County Fire 1 VHF

simulcast infrastructure. Existing VHF pagers and station receivers can be utilized and replaced as needed due to age and wear.

10.4 Short-Term Improvements

The Short-Term Improvements option is intended to resolve ongoing reliability issues and extend the service life of the existing systems, allowing more time for long-term planning. Although support ends in 2019 for a large portion of the existing infrastructure equipment, careful planning now can potentially extend system life beyond the end-of-support dates. The short-term improvement recommendations are divided into two priority levels. Priority One items should be performed ASAP (2015 - 2016 timeframe); other recommended improvements should follow as time and budget permit.

10.4.1 Priority One (ASAP)

As noted in §4.4 there are three Motorola Quantro base stations in the Covington PD radio system. These stations should be replaced. The new base stations should be used for the primary PD transmitters in Covington while rotating existing Quantar stations to a backup role. Furthermore, as noted in §7.3.4, the Covington PD DIU's have experienced intermittent performance issues with no apparent solution. The AstroTAC 3000 comparators and DIUs could be replaced with the GCM8000 comparator system for channels that remain mixed mode. There has been discussion of converting one or more Covington PD channels to analog-only operations. Analog-only channels utilize the MLC8000 analog comparator at substantially lower cost. As stated in §4.4, P25 scanners are now common off-the-shelf items. As such, there is little privacy resulting from P25 operations. Covington PD may wish to maintain only one channel with mix-mode P25 capability.

It was noted in §7.2.1 that the MOSCAD alarm and reporting system is at maximum capacity. As a result, not all equipment and critical circuits are monitored. Other software solutions are available to augment MOSCAD and

provide alarm and reporting features. An existing MCN system from CTI Products is currently in use to monitor some components and provide remote control for the comparators. It will be necessary to upgrade the MCN (a.k.a CTI) to provide remote control and monitoring of the Covington PD replacement comparators. The upgraded MCN may also be expanded to incorporate unmonitored components and circuits.

Priority One short-term improvements should include a full "maintenance sweep" at all sites. The process would incorporate the following items:

- preventive maintenance procedure on all base stations and retune as needed
- verify optimum tuning of all combiners, duplexers, and filters and make any necessary repairs/replacements
- sweep all transmission lines and antennas and make necessary repairs/replacements
- verify optimum routing of cables and jumpers and correct as needed
- verify grounding and lightning protection

10.4.2 Other Improvements

Telephone circuits with known reliability issues should be replaced or upgraded. Circuits that support the Ida Spence and Taylor Mill sites are historically problematic and should be prioritized for replacement. Barrington Woods has also experienced reliability issues but to a lesser degree. Long-term, these circuits should be replaced with microwave or fiber. However, until long-term sites and bandwidth requirements are known, leased T1's provide a reasonable short-term method of improving reliability for critical locations. Other sites are also prone to backhaul failure but rank lower in priority and will be addressed with long-term solutions.

Backup generators at Piner, Ryland, and Kenton Lands are past their useful life and historically unreliable. These generators should be replaced.

As noted in §7.3.3, there is potential benefit to moving Covington Fire Department pagers and station altering to the Kenton County Fire 1 channel. Once the operational impact of this proposed change is fully understood and accounted for, it is recommended that the plan move forward.

10.4.3 Spares and Enhancements

As noted in §6.1, the Efratom GPS time standard in use at four of the County simulcast sites is no longer supported. However, there is at least one spare unit in stock. Furthermore, the GPS units at each site function independently and can be replaced individually without the need to perform a costly upgrade at all sites simultaneously. As Efratom GPS equipment is removed throughout the county, it may also be possible to acquire spare units at minimal cost. Therefore, it is recommended that short-term improvements exclude GPS upgrades even though the existing equipment is at end-of-life and end-of-support.

The County has sufficient spare parts for a majority of the Gold Elite console components with the exception of the Console Interface Electronics (CIE) unit, which serves as the audio interface for each console position. The Gold Elite CIE unit is no longer available for purchase. It will be necessary to acquire spare CIE units through a secondary market. Three spare units are recommended.

The coverage analysis (see §9.0) confirms that outbound performance for all systems is generally acceptable, with a few noted exceptions. The most cost-effective form of coverage enhancement is to add one or more receive-only sites to boost inbound performance for portable radios. New GTR platform receivers can be mixed with existing Quantar receivers for additional receive-only sites or to replace failed units.

New GTR platform transmitters at simulcast sites cannot be mixed with existing Quantar transmitters. All transmit sites for a given simulcast channel must utilize the same make and model equipment. The County has several Quantar spares in stock. The maintenance contractor believes that it can maintain the existing Quantar equipment for the next several years. It may also be possible to acquire additional Quantar spares through secondary markets as other agencies perform upgrades.

As noted in §10.3, all long-term solutions will include replacement of the County Fire 1 infrastructure. This replacement could be accelerated if VHF Quantar equipment and/or maintenance parts become unavailable sooner than anticipated. If County Fire 1 infrastructure is replaced, any functioning Quantar equipment from that channel can be converted to the spares inventory.

The short-term improvements option assumes that all existing user equipment and fire station alerting equipment will be retained. Any unreliable user equipment should be addressed by the corresponding agency.

The short-term solutions do not address additional system capacity, intraoperability, or interoperability. Existing VHF and UHF interoperability with surrounding counties will be maintained. The Short-Term Improvement option will provide more time for Kenton County agencies to evaluate long-term communications plans and establish potential funding sources.

10.5 Conventional System Upgrade

The Conventional System Upgrade option assumes that the County will ultimately replace the existing radio systems with a new, consolidated conventional radio system. Fire agencies and fire companies will remain in the VHF band while law enforcement agencies will remain in the UHF band. The plan would eliminate separate radio systems for Covington and Erlanger, if Erlanger chooses to participate, and provide sufficient channel resources to service all fire protection and law enforcement agencies in the

County. A new coverage design and site configuration will be established to ensure that all system users are provided with adequate coverage. The reuse of any existing sites will include replacement antenna systems. Coverage predictions for possible VHF and UHF site layouts were presented in §9.4.4. As noted, coverage can be substantially improved through a system redesign. However, limitations of the VHF/UHF band and terrain challenges make it impossible to address all coverage deficiencies with a reasonable site count.

The Conventional System option assumes that all existing user equipment and fire station alerting equipment will be retained. Any unreliable user equipment will be replaced by the corresponding agency. Selection of this option is a commitment to a conventional radio configuration for the foreseeable future.

If desired, the conventional upgrade plan can be divided into multiple phases rather than replacing and building out all channels at once.

10.5.1 Phase 1 - County Fire 1 & County PD 1

Phase 1 of a multiphase approach could accelerate the replacement of Kenton County Fire 1 and Kenton County PD 1. This action will improve reliability for the two primary channels and create a spares pool for the maintenance of Quantar stations and DIGITAC comparators. If existing sites are utilized, Phase 1 can be implemented quickly to improve system reliability and maintenance plans. Simultaneous to Phase 1 activities, the County will be planning for the Phase 2 redesign and build-out. All equipment replaced under Phase 1 will be reusable in Phase 2.

10.5.2 Phase 2 - Redesign & Build-Out

Based upon Trott's initial findings, at least four VHF fire channels and five UHF law enforcement channels will be required to support all users and functions. Based upon the existing operational models the ideal configuration will increase

the channel count to five VHF and six UHF channels. All channels will utilize simulcast technology and provide countywide coverage. Available site locations will be evaluated to determine optimum site placement. It is assumed that channels will operate primarily in analog mode with mixed-mode P25 available on at least two UHF channels to support encryption for select law enforcement users. In a phased approach, Phase 2 will modify County Fire 1 and County PD 1 from Phase 1 as necessary. Otherwise, the deployment of all channels will occur simultaneously.

The option will replace the existing dispatch console system, replace the alarm and reporting system, and upgrade backhaul circuits as needed. The existing logging recorder and CAD system will remain in service.

The Conventional System Upgrade solution will not address intraoperability between police users in the UHF band and fire users in the VHF band. It will not establish direct interoperability with agencies on the Hamilton County trunked radio system or other non-VHF/UHF systems requested by users in §7. Existing VHF and UHF interoperability with surrounding counties will be maintained.

10.6 P25 Trunked System Upgrade

The most comprehensive and feature-rich solution is a countywide P25 trunked radio system. All infrastructure, dispatch console equipment, and logging recorder system will be replaced. The solution will also require a reliable IP network at all sites for backhaul. It may be possible to continue utilization of the Northern Kentucky Interoperability Microwave System at connected sites. However, as noted in §6.2, the existing microwave system is at end-of-life and does not provide native IP connectivity. Therefore, it is assumed that existing microwave equipment at P25 sites will be replaced or separate IP-based microwave paths will be added. New microwave paths will also be added at site locations that are not part of the Northern Kentucky Interoperability Microwave System.

Spectrum to support the network must be acquired. Existing 800 MHz frequencies from the unused mobile data system can be repurposed. However, these frequencies are currently licensed at single-site locations. It is unknown if the license footprints can be expanded for countywide coverage. Additional 800 MHz and 700 MHz frequencies may be available in the area. It will be necessary to determine the scope of the system in order to project the number of channels/talkpath required. Existing public safety users are likely supported with a basic five channel (four talkpath) system. However, the addition of other departments, allocation of interoperable talkgroups, and future growth must be considered. Analysis of required capacity is beyond the scope of this project. For planning purposes, cost estimates will be based on a six channel system.

Coverage predictions for an 800 MHz P25 solution are presented in §9.5. As indicated, seven sites provide good performance throughout the County. All cost estimates as based upon a seven-site layout.

It should be noted that fire paging and fire station alerting (FSA) currently occurs as an analog service in the VHF band. It is possible to convert FSA to a P25 and/or IP environment. However, no P25 trunked pagers are currently on the market. Therefore, it will be necessary to assess the voice paging and FSA requirements going forward and plan for appropriate replacements. Options include:

- move paging to commercial text and alpha numeric services
- move FSA to P25 and/or IP
- deploy an overlay VHF transmit frequency for paging and FSA

Per §10.3, it is assumed that a trunking solution will include replacement of the existing County Fire 1 analog VHF infrastructure, which could be utilized for paging and alerting functions.

None of the existing two-way radios in the County fleet are capable of migration to a 700/800 MHz P25 trunked environment. All user radios that will operate on the trunked system must be replaced. For planning and budgetary purposes it assumed that all law enforcement mobiles and portables will be replaced. Likewise all fire apparatus and fire

vehicle mobiles will be replaced. Fire protection portables will consist of a mixture of 700/800 MHz trunking units and existing VHF analog portables.

It is generally preferred that fireground operations occur in analog simplex mode. This is the simplest, most reliable form of communications and does not rely on system coverage, trunking controllers, or digital vocoders for functionality. Based upon the sizeable fleet of existing VHF units, it is recommended that fireground operations continue on existing VHF fireground simplex channels. Cross-band vehicular repeaters can be used to relay fireground traffic into the trunked system for centralized monitoring and recording purposes. Firefighters will continue to utilize existing VHF portable radios for fireground purposes. Each fire station/fire house will be equipped with a number of 700/800 MHz P25 trunked portables for general use. Budgetary pricing assumes that 200 trunked portables will be distributed for fire purposes. All fire apparatus will be equipped with vehicular repeaters.

A move to P25 trunking in the 700/800 MHz band will gain direct interoperability with other P25-equipped agencies in that band. Hamilton County and CVG are both migrating to P25 trunking in the 800 MHz band.

Direct interoperability with surrounding counties in the VHF and UHF bands will be lost (excluding fireground VHF portables that will be retained). Boone and Campbell counties have expressed interest in a move to P25 trunking but no immediate plans are in place. It is possible to expand a Kenton County P25 trunking system to include Boone and Campbell counties, forming a regional communications network. However, such an expanded scope may result in an extended implementation schedule with multiple phases. It will be necessary to develop interim interoperability strategies. These could include:

- Deployment of multiband radios with VHF and/or UHF capabilities
- Maintaining a portion of the existing VHF and UHF fleet (mobiles & portables) for interoperability purposes
- Implementation of new VHF and UHF interoperability console patches

Since firefighters will retain VHF portables for fireground purposes it also recommended that they maintain VHF mobiles in fire vehicles. This action will allow for continued interoperability with VHF users.

11.0 SPECTRUM

The existing radios systems in the Kenton County utilize a combination of VHF and UHF spectrum. These include five VHF channels and seven UHF channels. The VHF channels consist of one transmit-only (Kenton County Fire 1) and four repeater pairs. All seven UHF channels are authorized as repeater pairs. The existing spectrum is adequate if the County agencies choose to remain in the existing bands with conventional systems. License discrepancies for Kenton County Fire 1 and Fire 2 are noted in §4.1. Other minor license discrepancies may also exist. These minor discrepancies and necessary license modifications can be addressed as part of either conventional system upgrade option.

A decision to migrate to a 700 MHz or 800 MHz trunked solution will require spectrum acquisition. The County and Covington are collectively licensed for seven 800 MHz frequency pairs per the following FCC callsigns;

- WQAF238
- WPMN476
- WRG666

These 800 MHz channels are licensed at individual sites. It is not know if the authorized services areas can be expanded to support countywide simulcast operations. A preliminary frequency analysis indicates that four of the frequencies are likely available for countywide service areas. A fifth frequency is potentially available if properly coordinated. The remaining two frequencies are licensed to other nearby agencies and likely blocked from countywide operations. It is possible that additional 700 MHz and 800 MHz frequencies are available to Kenton County. It will be necessary to consult the NPSPAC regional planning committee and a public safety frequency coordinator to determine availability of additional 700/800 MHz spectrum.

12.0 BUDGETARY PRICING

12.1 General

Budgetary pricing has been prepared for each of the upgrade options presented in §10. Pricing is based upon comparable system procurements and various equipment quotations received within the past 12 months. It should be noted that vendor pricing will adjust based upon current market trends and regional business incentives. The actual price offered to Kenton County could differ significantly based on these and other factors. However, the pricing included herein is believed to be reasonable for planning purposes.

12.2 Short-Term Improvement

Trott worked with the existing maintenance contractor to develop a general scope of work and budgetary pricing for the Priority One short-term improvements described in §10.4.1.

Labor for preventive maintenance and general equipment evaluation is included in the existing maintenance contract. The pricing herein addresses recommended hardware replacements and other items outside of the scope of the current maintenance agreement including:

- Replacement of Covington PD 1 & PD 3 repeaters & comparators with analog-only configuration
- Replacement of Covington PD 2 repeater & comparator with mixed-mode (analog/P25) configuration
- Repurpose existing Covington PD Quantar repeaters for backup
- Upgrade MCN remote monitoring and control to MCN8000
- New VHF combiner at St. Elizabeth's Hospital

The estimated cost including hardware, software, installation, and services is \$275,000,

Additional short-term improvements are described in §10.4.2 and include:

- Replace Taylor Mill, Ida Spence, & Barrington Woods telephone circuits with leased T1 circuits
- Reprogramming Covington FD pagers and FSA receivers
- Additional alert receivers
- Replace generators at Piner, Ryland, and Kenton Lands

The estimated cost including hardware, software, installation, and services for 10.4.2 activities is \$180,000.

Pricing does not include acquisition of additional spare parts or unanticipated repairs.

12.3 Conventional System Replacement

The conventional system replacement option described in §10.5 effectively replaces all existing infrastructure equipment. The system will continue to utilize conventional technology, with fire companies in the VHF band and law enforcement in the UHF band.

Pricing assumes the following

- Five VHF analog channels
- Four UHF analog channels
- Two UHF mixed-mode analog/P25 channels
- Seven simulcast sites per channel
- Three receive-only sites per channel
- Four new microwave paths
- Replacement console system with seven positions
- Alarm monitoring and reporting system

The 11-channel Conventional System Replacement option is estimated at \$5 million as detailed in Table 9.

DESCRIPTION	COST	QTY	EXT COST
Conventional Console System	\$175,000	1	\$175,000
Console Positions	\$29,000	7	\$203,000
County Fire VHF analog simulcast repeaters (7 sites)	\$171,462	5	\$857,308
County Fire analog voter system - MLC8000	\$27,000	5	\$135,000
County Police UHF Analog simulcast repeaters (7 sites)	\$171,462	4	\$685,846
County Police analog voter system - MLC8000	\$27,000	4	\$108,000
County Police UHF Digital simulcast repeaters (7 sites)	\$183,808	2	\$367,615
County Police mixed mode voter system - GCM8000	\$49,385	2	\$98,769
Spectracom Secure Sync GPS reference	\$54,323	7	\$380,261
VHF combiner and antenna system	\$38,000	7	\$266,000
UHF combiner and antenna system	\$35,000	7	\$245,000
Receive-only VHF sites (3 sites)	\$54,000	5	\$270,000
Receive-only UHF sites (3 sites)	\$56,500	6	\$339,000
Additional alert receivers	\$32,923	1	\$32,923
Microwave Path (IP connectivity)	\$100,000	5	\$500,000
MCN remote control and monitoring system	\$65,000	1	\$65,000
Services	\$270,000	1	\$270,000
Conventional System Total			\$4,998,723

Table 9

As noted, the cost estimated is based upon 11 total radio channels to support all fire protection and law enforcement agencies in the County. If operating procedures are altered to more efficiently utilize channel resources, it may be possible to reduce the number of channels deployed.

12.4 P25 Trunked Solution

Budgetary pricing was also developed for the P25 trunked system option described in §10.6. The solution assumes that all public safety agencies in the County will be migrated to a common P25 trunked platform operating in the 700 and/or 800 MHz frequency band. The efficiencies of a trunked solution will allow additional governmental departments to be added to the system over time if desired. Unlike the other solutions presented, migration to P25 trunking will require replacement of all user equipment for those that will utilize the radio system for routine communications. As noted in §10.6, this option assumes that firefighters will continue to utilize existing VHF radios for fireground

operations. Therefore, only 200 portable radios will be initially purchased for firefighter use. Approximately 120 of these units will be assigned to specific locations/functions and 80 units will be designated for key staff. All fire vehicles will be equipped with new trunked radios and all fire apparatus will include a cross-band vehicular repeater to relay fireground traffic to a designated talkgroups on the system. All law enforcement mobile and portable radios will be replaced.

Infrastructure cost and user equipment costs have been separated for discussion purposes. The infrastructure cost estimate includes replacement of County Fire 1 VHF equipment, which will continue to service existing VHF pagers and station alerting receivers. A complete microwave backhaul system is also included. Infrastructure pricing includes the following items:

- seven simulcast sites
- six P25 channels
- seven console positions
- County Fire 1 VHF equipment at all seven sites
- seven microwave paths
- replacement logging recorder

The total infrastructure cost is estimated at \$5.7 million as detailed in Table 10.

DESCRIPTION	QTY	COST	EXT COST
P25 Core	1	\$750,000	\$750,000
Console System	1	\$500,000	\$500,000
P25 Site Equipment	7	\$400,000	\$2,800,000
Microwave Paths	7	\$100,000	\$700,000
Logging Recorder	1	\$160,000	\$160,000
VHF Fire Paging	1	\$125,000	\$125,000
Services	1	\$600,000	\$600,000
P25 System Total			\$5,635,000

Table 10

The P25 cost estimate does not include site improvements or backup generators if needed at certain site locations. As seen, the infrastructure cost of a trunking solution is not significantly more than the conventional solution presented in §12.3. However, user equipment costs based upon preliminary quantities and lower tier (yet fully capable) units is approaching \$4 million; see Table 11.

Description	Cost	Units	Extended Cost
APX4000 Portable (Law Enforcement)	\$2,832	350	\$991,200
APX4000 Portable (Encrypted)	\$3,382	75	\$253,650
APX4000 Portable (Intrinsically Safe Fire)	\$2,882	200	\$576,400
APX4500 Mobile (Fire)	\$3,386	120	\$406,320
APX4500 Mobile (Police)	\$3,386	425	\$1,439,050
Cross-Band Vehicular Repeater	\$3,000	100	\$300,000
Low Tier User Equipment Total			\$3,966,620

Table 11

Moving up to higher tier single band radios increases to cost as follows:

Description	Cost	Units	Extended Cost
Cross-Band Vehicular Repeater	\$3,000	100	\$300,000
APX6000 Portable	\$3,800	550	\$2,090,000
APX6000 Secure Portable	\$4,350	75	\$326,250
APX6500 Remote Mount Mobile	\$4,588	545	\$2,500,460
High Tier Single Band Equipment Total			\$5,216,710

Table 12

Deployment of dual-band portable radios for interoperability purposes further increases projected costs as seen in Table 13. The dual-band estimate continues to utilize single-band mobiles. It is generally preferred to utilize separate radios for each band in mobile applications.

Description	Cost	Units	Extended Cost
Cross-Band Vehicular Repeater	\$3,000	100	\$300,000
APX7000 Dual-Band Portable	\$5,832	550	\$3,207,600
APX7000 Dual-Band Secure Portable	\$6,382	75	\$478,650
APX6500 Single-Band Remote Mount Mobile	\$4,588	545	\$2,500,460
Dual-Band Equipment Total			\$6,486,710

Table 13

A comparison of budgetary estimates presented in §12 show that the cost of both the conventional and trunked solutions are similar (within 13%). However, a trunking solution provides significantly superior features and functions as described in §10.2 and better overall coverage performance as described in §9. It is the cost of user equipment that dramatically raises the overall cost of system ownership. The replacement cost of

user equipment is typically in the same range as the infrastructure. Furthermore, ongoing cost of user radio acquisition and routine replacements over time is more than the current price point for the typical conventional radios used by the various agencies in the County.

13.0 DECISION POINTS

13.1 Short-Term Improvements

The Priority One short-term improvements presented in §10.4.1 address the most critical reliability issues and should be performed regardless of the long-term solution selected. It is recommended that actions to address these items be incorporated into plans and budgets as soon as possible.

13.2 Project Timeline

Other strategies to extend the useful life of the existing systems are presented in §10.4. The importance of these strategies is largely dictated by the overall project timeline. If the County expects to make long-term decisions and begin execution of those decisions within the next 24 - 36 months, it is possible minimize the investment in the existing systems. However, if it is believed that the existing system must realistically survive for the next 4 - 6 years, steps should be taken to ensure that the existing system platform can remain operational through implementation of the long-term solutions.

13.3 Conventional vs. P25 Trunked

All long-term planning and budgeting is based upon the selected technology for the future communications system. Kenton County must decide if it will continue with VHF/UHF conventional technology or migrate to P25 trunking. Selection of a VHF/UHF conventional solution could lead to an accelerated timeline and potentially a phased implementation approach. A move to P25 trunking will require more planning before implementation can begin. The sooner a decision can be reached; the sooner communications resources can become more focused and more efficient.