

Waukesha County



And

Milwaukee County



Phase 1 Study for Trunked Radio Consulting Project

Prepared and Submitted by:



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Scope and Purpose

This Phase 1 Study is the first of two pre-procurement deliverables for the Waukesha and Milwaukee Public Safety Trunked Radio Communications Consulting Services Project. It serves to document the needs of users (public safety and public service agencies in Waukesha and Milwaukee Counties) for a replacement radio system (or systems), to describe alternative design and implementation concepts that could meet those needs, to calculate budgets (both capital and on-going) for those alternatives that may be pursued in

future activities. Those future activities include the second and final pre-procurement deliverable for this project, the technical specifications for the selected alternative that will be included in a request for proposals (RFP) to solicit and select a public safety radio system communications design and vendor. Key findings and recommendations are included at the end of each section of this Report.

Current Situation

Waukesha County's Current Radio System

Waukesha County currently operates a Motorola Smartnet II+ 7-site 13 800MHz-NPSPAC-channel analog (Project 16) simulcast countywide trunked radio system. The Waukesha County trunked system serves the agencies that provide Law Enforcement, Fire, EMS, Public Works, Highway, Parks/Land Use, and Government Administration services in the County. System site backhaul is currently via private, licensed microwave lines.

The County also is licensed for three 800 MHz mobile-only simplex channels for at-scene and other non-trunked intensive communications.

Existing subscriber equipment is from both Motorola and E.F. Johnson.

Waukesha County operates 15 Motorola Centracom Gold Elite wireline console positions at its countywide dispatch center, the Waukesha County Communications center. Backhaul to the Public Safety Answering Point (PSAP) is on privately-operated fiber which has T1 backup lines. Seven other independent PSAPs (City of Waukesha, New Berlin, Muskego, City of Oconomowoc, Elm Grove, Menomonee Falls and Mukwonago) operate on

the Waukesha County trunked system, all of which use wireless (control base) and not wireline connections into the system.

Maintenance is mainly provided by the Waukesha County Radio Services Department, however, some agencies obtain service for their subscriber radios from a private radio shop.

Milwaukee County's Current Radio System

Milwaukee County currently operates a Motorola Smartnet II+ 9-site 14 800MHz-NPSPAC-channel analog (Project 16) simulcast countywide trunked radio system. (Note: Two of the 9 sites in the system operate as receive-only sites.) The Milwaukee County trunked system serves Law Enforcement, Fire, EMS, Public Works, Public Health, and Transit, plus other special applications such as Zoo and Airport operations. System site backhaul is currently via leased T1 circuits, though the County is in the planning stages of converting to private licensed digital microwave.

Existing subscriber equipment is from both Motorola and E.F. Johnson.

Milwaukee County operates a 12-position Centracom Gold Elite console at the Sheriff's



Department. Eleven other dispatch centers (Bayside, Cudahy, Franklin, General Mitchell Airport, Greendale, Medical Center, Northshore, Oak Creek, South Milwaukee, St. Francis, and Wauwatosa) operate Motorola consoles on the trunked system and are linked via leased T1 lines through an existing Motorola Embassy switch. Two others (Hales Corners and West Allis) operate via control stations.

Maintenance is currently via a combination of contract personnel and a private radio shop.

It is important to note that although the Waukesha and Milwaukee County systems are of the same technology and general vintage; the two systems use different radio channels and are separate and distinct from each other.

Analysis of User Needs

Methods to Collect Input

To gather information regarding needs for system (or systems) to replace those currently in use in Waukesha and Milwaukee Counties, three groups of individuals were contacted: users (those who use the system on a daily basis), management (those who manage the individuals that use the system on a daily basis), and dispatchers (those who operate dispatch centers that connect to the systems). Contact was accomplished via two methods: i) an on-line survey and ii) interviews that were conducted either face-to-face or via phone conference. Both methods sought to gather answers to the same questions about how well the systems, in their current configurations, meet user needs regarding the system performance attributes of coverage (the ability to make or receive calls in all areas of operation), capacity (the ability of the system to carry calls without overloading the available equipment or channels), reliability (service without outages), capabilities (the availability

Motivation for Change

Through their age and outdated designs, the Waukesha and Milwaukee County radio systems have both become difficult and expensive to maintain. They also do not provide the necessary levels of service required by users. Users of the two system systems have noted areas of problematic coverage and the staffs that maintain the systems have described insufficient control and security over system operation and subscriber provisioning. Additionally, the technologies of the two systems do not allow them to interconnect to each other nor to other, important external systems such as the State of Wisconsin WISCOM system and the OpenSky® radio system used by the City of Milwaukee for its Police and Fire Departments.

of user features), interoperability (the ability to communicate between agencies or jurisdictions), security (defense from physical or electronic threats), maintenance (upkeep and repairs of failures), monitoring/reporting (tracking performance and providing reports), and training and exercises (regarding usage of the system). For the on—line survey, participants were asked to address the degree to which the system they use (either the current Waukesha County system or the current Milwaukee County system) meets their operational needs on a scale from 1 (“Needs not met”) to 5 (“Needs very well met”). Copies of the on-line surveys are included in Appendix B of this report. While both methods used the same questions, interviews were based on more open-ended questions than were the surveys and thus the interviews allowed the collection of additional information.

As noted, the individuals that were contacted were the users, managers, and dispatchers of the current Waukesha and Milwaukee County



radio systems. They included representatives from County-level and local law enforcement, fire, emergency medical, highway/transportation, public works, health/hospital, and parks/land use agencies. The surveys were open for a period of 6 weeks in July, August, and September of 2012 and notice of need for participation was undertaken by the Radio Administrators for Waukesha and Milwaukee Counties. Individuals were selected for interviews based on two criteria: i) members of the Waukesha and Milwaukee County Radio Advisory Committees were contacted for interview and ii) those respondents to the survey that specifically noted that they wanted further involvement were also contracted for interview. Interviews were conducted during August and September of 2012.

meet user needs are summarized in the following table.

The participation levels for the surveys is as follows: there were 115 total responses to the User Survey (71 from users within Waukesha County, 44 from users within Milwaukee County), 39 total responses to the Management Survey (33 from managers within Waukesha County, 6 from managers within Milwaukee County), and 7 responses to the Dispatch Survey (all from dispatchers within Milwaukee County)¹. A total of 15 interviews were completed and while another 12 individuals were contacted for surveys that were not completed for reasons of scheduling.

A listing of the agencies that participated in the surveys and interviews is included in Appendix A of this report.

User Survey Quantitative Results

The quantitative responses to the User Surveys regarding the ability of the current Waukesha County and Milwaukee County Radio System to

¹ Note: Although no dispatchers from Waukesha County participated in the Dispatcher Survey, input was collected from them during tours of the Waukesha County Communications facility.



Distribution of User Survey respondents answers regarding ability of their current system to meet their needs.			Degree to Which Needs are Currently Met				
			Needs Very Well Met	Needs Well Met	Needs Adequately Met	Needs Only Somewhat Met	Needs Not Met
			(5/5)	(4/5)	(3/5)	(2/5)	(1/5)
Performance Attribute	Coverage	Waukesha County	14.1%	35.2%	39.4%	7.1%	4.2%
		Milwaukee County	16.3%	46.5%	25.6%	4.6%	7.0%
	Capacity	Waukesha County	15.5%	31.0%	40.8%	12.7%	0.0%
		Milwaukee County	32.6%	39.5%	25.6%	2.3%	0.0%
	Capabilities	Waukesha County	18.3%	31.0%	36.6%	11.3%	2.8%
		Milwaukee County	32.6%	44.2%	18.5%	4.7%	0.0%
	Interoperability	Waukesha County	18.3%	28.2%	36.6%	12.7%	4.2%
		Milwaukee County	20.9%	44.2%	23.3%	9.3%	2.3%
	Reliability	Waukesha County	25.4%	40.8%	29.6%	4.2%	0.0%
		Milwaukee County	41.9%	37.2%	20.9%	0.0%	0.0%
	Security	Waukesha County	26.8%	35.2%	36.6%	1.4%	0.0%
		Milwaukee County	25.6%	39.5%	27.9%	4.7%	2.3%
	Maintenance	Waukesha County	23.9%	33.8%	40.9%	1.4%	0.0%
		Milwaukee County	20.9%	41.9%	30.2%	4.7%	2.3%
	Monitoring/Reporting	Waukesha County	22.5%	22.5%	46.6%	5.6%	2.8%
		Milwaukee County	20.9%	39.5%	37.3%	2.3%	0.0%



It was expected that the topic of coverage would be of special concern to users so the survey included specific questions about that attribute. In response to specific questions regarding coverage, users reported the following levels of audio quality from their portable radios and mobile radios:

% of Users Reporting About Audio Quality	Waukesha County		Milwaukee County	
	Portable Radio	Mobile Radio	Portable Radio	Mobile Radio
Very Good Audio	16.9%	21.1%	25.6%	32.2%
Good Audio	43.7%	38%	48.8%	46.5%
Acceptable Audio	33.8%	25.4%	20.9%	11.6%
Bad Audio	5.6%	0.0%	4.7%	0.0%
Very Bad Audio	0.0%	15.5%	0.0%	11.6%

Additionally, users were asked about the location of their portable radio's antenna when the unit is keyed for transmission and they reported the following:

% of Users Reporting Portable Radio Antenna Location	Waukesha County	Milwaukee County
At the head	50.7%	41.9%
At the hip	42.3%	44.2%
No answer	7.0%	14.0%

It was also expected that the topic of interoperability would be of special concern to users and the user survey therefore also contained specific questions about that performance attribute. Users were asked if they would use the following interoperability features if they were available in a future system: i) the ability to talk between agencies in both counties (inter-county interoperability) on authorized talkgroups, ii) the ability to roam on all talkgroups between the two counties, and iii) the ability to scan the talkgroups (as authorized) of agencies in both counties. Their responses were as follows:

% of Users Reporting Interest in Use of Future Interoperability Capabilities	Waukesha County			Waukesha County		
	Cross County Talk-groups (i)	Inter-County Roaming (ii)	Cross – County Scanning (iii)	Cross County Talk-groups (i)	Inter-County Roaming (ii)	Cross – County Scanning (iii)
Would Use Often	7.0%	12.7%	19.7%	16.3%	9.3%	18.6%
Would Use Sometimes	39.4%	26.8%	36.6%	25.6%	32.6%	30.2%
Might or Might Not Use	31.0%	29.6%	18.3%	37.2%	30.2%	23.3%
Would Probably Not Use	16.9%	25.4%	22.5%	16.3%	23.3%	20.9%
Would Never Use	5.6%	5.6%	2.8%	4.7%	4.7%	7.0%

[Note: Because users were not required to respond to survey questions about training and exercises, the inputs from those that did provide answers is included in the following section regarding Survey Qualitative Results.]

User Survey Qualitative Results

Users were also offered the opportunity to provide qualitative (open or free-text) input regarding the same performance attributes of their current systems as were included in the quantitative survey questions. The responses to the qualitative questions are included in the following table; they are separated by performance attribute and the columns include the number of respondents that reported the specific comment, concern, problem, or issue with the current radio systems.



# of Users Reporting Specific Comments, Concerns, Problems, or Issues with Existing Systems (by Performance Attribute)	Waukesha County	Milwaukee County
Regarding Coverage		
There are coverage problems in specific larger or older buildings	24	15
There are coverage problems in specific outdoor areas ²	9	6
The coverage from the current system is insufficient to support on-network communications for fireground operations	2	0
Regarding Capacity		
Busies occur during major events	7	2
There is congestion (too much talking for me to participate) on our main/dispatch talkgroup	2	2
Regarding Features		
Better over-the-air encryption with clearer audio is needed	5	3
The emergency key on our radios needs to operate better	0	1
The radios need to support user-programmable scan lists	1	1
The system needs to support the recording of fireground channels	2	0
The system needs to support data (notably Automatic Vehicle Location (AVL))	2	0
Regarding Interoperability		
Better interoperability between Waukesha and Milwaukee Counties is needed	2	2
Better interoperability with the City of Milwaukee Police and/or Fire Departments is needed	0	5
Better interoperability with neighboring counties is needed ³	2	2

² The problem areas reported (and the number of respondents reporting the problem areas) were: Lake Michigan Lakefront (6), Vernon (3), Big Bend, (2), SE Waukesha County (1), SW Waukesha County(1), Merton/Monches (1), Coldwater Creek/Rockridge (1))

# of Users Reporting Specific Comments, Concerns, Problems, or Issues with Existing Systems (by Performance Attribute)	Waukesha County	Milwaukee County
Interoperability is required with the WISCOM (State) system	2	1
Better/easier patches to mutual aid channels (MABAS, SMART, IFERN, etc.) are needed	4	5
Regarding Reliability		
Coverage in our area will go away if one specific site fails	2	0
There is no 'backup system' – all radio will be lost if the entire system fails ⁴	0	2
Regarding Security		
Better over-the-air encryption with clearer audio is needed	7	4
The radio sites need better physical security	1	0
Regarding Maintenance & Reporting⁵		
There needs to be a standard process for requesting service	0	2
There needs to be a recommended 'service plan' for portable and mobile radios	1	1
There should be more options for authorized programming/ maintenance shops (including the option for agencies to program their own radios	2	2
Regarding Training and Exercises⁶		
There should be new training with a new system and/or new portable or mobile radios	21	
The new training should be provided by outside 'professionals'	11	

³ The neighboring counties that were identified (and the number of respondents reporting neighboring county) were: Ozaukee (3) and Jefferson (1).

⁴ The systems of both Waukesha and Milwaukee County do have "failsoft" features that provide continuous, but limited, functionality during most failure scenarios.

⁵ The responses regarding "Maintenance" and "Monitoring/Reporting" were so nearly identical so there were combined into one attribute for this table.

⁶ The responses from both Counties for Training and Exercises were tabulated together.



# of Users Reporting Specific Comments, Concerns, Problems, or Issues with Existing Systems (by Performance Attribute)	Waukesha County	Milwaukee County
The training should address both daily-use and special-event (interoperability) situations	12	
The training should be provided in both 'in-person' and 'recorded' formats	9	
The training should include the distribution of laminated or pocket guides to radio programming and use	5	
The training should include exercises	4	
Any exercises should include multiple jurisdictions	5	
Any exercises should include interoperability methods such as patching or mutual aid channels	3	
Any exercises should be carried out in compliance with the Incident Command System (ICS)	2	
Any exercises should include failure modes of the radio system	1	

Management Survey Results

Individuals identified as 'managers' (those who oversee departments or groups that use radios) were invited to participate in a separate Management Survey. The Management Survey was constructed to be shorter in length than the User Survey, to include more qualitative questions, and to focus more on the issues of cost and value (fit to an agency's strategic goals) than the User Survey. Questions regarding the performance attributes listed above were also included.

The responses to the Management Survey included very little variation between the participants from Waukesha and Milwaukee Counties. A summary that combines the

responses from both Counties is included in the following table.

Summarized Responses to Management Survey Questions	Combined "Typical" Response from Waukesha and Milwaukee County Management
How well does the current radio system help you meet your operational goals?	The systems generally meet operational needs but there are concerns for on-going reliability and the lack of interoperability.
What role(s) should your organization hold in the operation, management, and use of a new system?	Most organizations view their role as a user but some would also like to participate in advisory committees.
How much does your organization pay for use of your current system?	Most Waukesha County users recognize their maintenance costs and most Milwaukee County users know their cost of \$0.
How much should your organization pay for the use of your current system?	Most agencies would like a funding/sustainability plan so that the ongoing usage cost to their organization is \$0 but others recognize the need for a fair/equitable usage cost (based on amount of system resources used and/or population served). ⁷
How much would your organization be willing to pay for use of a future system?	
What comments, concerns, problems, or issues does your organization have regarding coverage?	There are general concerns over in-building coverage. In Waukesha County, there is a need for improvements in Southeast and Southwest areas. In Milwaukee County improvements are needed at the lakeshore.
What comments, concerns, problems, or issues does your organization have regarding capacity?	The systems have been busy during storms. There is also too much congestion on some dispatch talkgroups.
What comments, concerns, problems, or issues does your organization have	The systems are general reliable but there are concerns over the age of the existing equipment (and its ability to be

⁷ The answers to questions of desired current and future costs were so similar that they are summarized together in this table.



Summarized Responses to Management Survey Questions	Combined "Typical" Response from Waukesha and Milwaukee County Management
regarding reliability?	served) and the performance of the entire system in large events.
What comments, concerns, problems, or issues does your organization have regarding capabilities/features?	There is a need for encryption that provides useable audio quality. The new system should also allow for alert tones to be broadcast on talkgroups to signal an emergency condition. AVL would be used by public service agencies.
What comments, concerns, problems, or issues does your organization have regarding interoperability?	There is a need to improve interoperability with surrounding counties (Ozaukee), with the City of Milwaukee's Police and Fire Departments, with conventional mutual aid and interoperability channels, and with WISCOM.
What comments, concerns, problems, or issues does your organization have regarding maintenance?	The maintenance of the system has been acceptable or excellent but there should be more options for authorized organizations to program subscriber radios (including support for some agencies to program selected features in their own radios)

As can be seen from the above table, the responses to the Management Survey in the areas of the performance attributes of the current (and future) system strongly reflect (and support) the responses to the User Survey.

Interview Results

The format of the interviews that were conducted as follow-ups to the User and Management Surveys were open discussions in which the interviewee was encouraged to make any statements they felt needed to be made 'above and beyond' their survey responses. Through the 15 interviews that were

completed, the input that was collected that is not already contained in the survey summaries included above are: i) some agencies in Waukesha County expressed physical discomfort with the non-coiled cord used with shoulder-mounted "public safety" speaker-microphone-antenna equipment (however, they did recognize the improvement to coverage and sound quality that such equipment provides, ii) EMS agencies in Milwaukee County would like to use a new trunked radio system as a backup transport mechanism for the EMS data that is transmitted from paramedics to hospitals but such functionality is not an absolute requirement (they plan to continue to use their existing conventional UHF channels as the primary system for this operation), iii) almost all interviewees would like to continue their involvement in the process of identifying needs and reviewing specifications for a replacement system.

In addition to interviewing individuals from agencies that use the existing system, an interview was held with the radio system administrators of the City of Milwaukee Police Department. The main concerns expressed by individuals from that agency were: i) improved interoperability with users of the Milwaukee County system is needed and should be accomplished via the Project 25 (P25) Inter-RF Subsystem Interface (ISSI) standard (this interoperability method was discussed because it was viewed as the best way to connect the City of Milwaukee's OpenSky® system, which can support ISSI but not other portions of the P25 standard, with a future, P25-based County system), ii) wide-scale, direct use of a future, P25-based County system by City of Milwaukee OpenSky® subscriber radios may be technically feasible but it is not financially or operationally viable (upgrades to support P25 would be approximately \$1,000 per radio and, even after such an upgrade, City of Milwaukee radios would have to be powered off-and-on to switch from OpenSky® to P25



operations), iii) limited-scale direct operation by City of Milwaukee radios on a future, P25-based County system should be considered but only for specifically-identified users that have operational requirements for such interoperability (e.g., command operations), and iv) Milwaukee County and the City of Milwaukee should continue to discuss the shared use of radio sites to house the equipment of their separate radio systems (as doing so could lower capital and ongoing site costs).

Dispatch Survey Results

The final component of outreach was a survey to collect the specific requirements of dispatchers and dispatch centers. Specific questions were asked about the layouts, interfaces (including Push-to-Talk methods), and functionalities required to support dispatch operations.

Summarized Responses to Dispatch Survey Questions	Responses from Dispatch Survey Participants
Layout and Interfaces	
What is the number of modules per "page" on your console?	Maximum: 36 Minimum: 13 Average: 24
What is the number of "pages" of modules on your console?	Maximum: 6 Minimum: 1 Average: 3
Does your console include the display and/or control of Knox Boxes?	Yes: 2 No: 6
Does your console include the display and/or control of radio system alarms?	Yes: 3 No: 4 (No answer: 1)
Does your console include an interface to the 9-1-1 phone system?	Yes: 3 No: 4
Does your console include an interface to a dispatch "status bar" (on-phone, on-radio, etc.) system?	Yes: 3 No: 3 (No answer: 1)
Does your console include an interface to a logging recorder system?	Yes: 5 No: 2
Does your console include an interface to an instant recall recorder system?	Yes: 4 No: 3

Summarized Responses to Dispatch Survey Questions	Responses from Dispatch Survey Participants	
Push-to-Talk Methods		
Do you currently have and use (or would you like to have and use) the following method to activate a Push-to-Talk on the radio system: Button on Wired Headset	Have & Use:	4
	Have & Don't Use:	1
	Don't Have but Would Use:	1
	Don't Have and Wouldn't Use:	1
Do you currently have and use (or would you like to have and use) the following method to activate a Push-to-Talk on the radio system: Button on Wireless Headset	Have and Use:	5
	Have & Don't Use:	0
	Don't Have but Would Use:	2
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following method to activate a Push-to-Talk on the radio system: Button on Desk Microphone	Have & Use:	3
	Have & Don't Use:	4
	Don't Have but Would Use:	0
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following method to activate a Push-to-Talk on the radio system: Touch Screen on Console Display	Have & Use:	5
	Have & Don't Use:	2
	Don't Have but Would Use:	0
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following method to activate a Push-to-Talk on the radio system: Foot Pedal	Have & Use:	5
	Have & Don't Use:	2
	Don't Have but Would Use:	0
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following method to activate a Push-to-Talk on the radio system: Mouse Button	Have & Use:	4
	Have & Don't Use:	2
	Don't Have but Would Use:	1
	Don't Have and Wouldn't Use:	0
Console Features		
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Announcement Group(s)	Have & Use:	1
	Have & Don't Use:	0
	Don't Have but Would Use:	4
	Don't Have and Wouldn't Use:	1



Summarized Responses to Dispatch Survey Questions	Responses from Dispatch Survey Participants	
Do you currently have and use (or would you like to have and use) the following dispatch console feature: All Call (System Wide Call)	Have & Use:	1
	Have & Don't Use:	0
	Don't Have but Would Use:	2
	Don't Have and Wouldn't Use:	3
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Unit ID Display	Have & Use:	3
	Have & Don't Use:	0
	Don't Have but Would Use:	4
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Dispatch Priority (Transmit Over Subscribers)	Have & Use:	1
	Have & Don't Use:	0
	Don't Have but Would Use:	6
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Patches	Have & Use:	4
	Have & Don't Use:	2
	Don't Have but Would Use:	0
	Don't Have and Wouldn't Use:	1
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Simulselect (transmit on multiple modules at the same time)	Have & Use:	5
	Have & Don't Use:	1
	Don't Have but Would Use:	1
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Radio Unit Monitoring (Remotely key and listen to a subscriber radio)	Have & Use:	3
	Have & Don't Use:	0
	Don't Have but Would Use:	3
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Emergency Alarm & Emergency Call	Have & Use:	4
	Have & Don't Use:	1
	Don't Have but Would Use:	2
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Display Loss of Network Connection	Have & Use:	0
	Have & Don't Use:	2
	Don't Have but Would Use:	3
	Don't Have and Wouldn't Use:	1

Summarized Responses to Dispatch Survey Questions	Responses from Dispatch Survey Participants	
Do you currently have and use (or would you like to have and use) the following dispatch console feature: RF Control Station Backup Connection	Have & Use:	2
	Have & Don't Use:	0
	Don't Have but Would Use:	3
	Don't Have and Wouldn't Use:	1
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Call Playback / Instant Playback on Console	Have & Use:	4
	Have & Don't Use:	0
	Don't Have but Would Use:	3
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Alert Tones (One time tones)	Have & Use:	6
	Have & Don't Use:	0
	Don't Have but Would Use:	1
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Channel Marker Tones (Continuous Tones)	Have & Use:	0
	Have & Don't Use:	0
	Don't Have but Would Use:	3
	Don't Have and Wouldn't Use:	3
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Individual Call (to one specific subscriber)	Have & Use:	1
	Have & Don't Use:	0
	Don't Have but Would Use:	3
	Don't Have and Wouldn't Use:	1
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Intercom (with other local dispatch consoles)	Have & Use:	0
	Have & Don't Use:	0
	Don't Have but Would Use:	4
	Don't Have and Wouldn't Use:	2
Do you currently have and use (or would you like to have and use) the following dispatch console feature: More than One Unselect Speaker	Have & Use:	6
	Have & Don't Use:	0
	Don't Have but Would Use:	1
	Don't Have and Wouldn't Use:	0
Do you currently have and use (or would you like to have and use) the following dispatch console feature: Radio Status Messages	Have & Use:	0
	Have & Don't Use:	5
	Don't Have but Would Use:	0
	Don't Have and Wouldn't Use:	1



Because all dispatch survey responses were received from dispatch centers in Milwaukee County, a tour of the Waukesha County Communications Center, which provides consolidated dispatch for many agencies in Waukesha County, was conducted. This tour showed that the Center has a total of 15 dispatch positions (1 of which is a supervisory position), all of which use 19" non-touch screens, have wireline (direct connection to radio infrastructure) radio dispatch capabilities, and have a separate radio control station nearby for backup operations. (The supervisor position also has control over a remote Raytheon ACU1000, which can conduct patches between various mutual aid and interoperability channels) and connection to a radio on the State of Wisconsin WISCOM system. Each position has two, 6-wire headphone jacks which operate in parallel (no supervisory cutoff) and the methods for Push-to-Talk are: i) wired handset, ii) foot pedal, iii) mouse button, and iv) general transmit on the dispatch "CPU" box. All dispatch console positions have the ability to access four pages of modules for Law Enforcement, Fire/EMS, County, and Interoperability channels and talkgroups (which also includes the ability to initiate/control an alert tone on a regional MABAS channel). The features of patching, emergency message, and simulselect are often used but others (such as radio unit monitoring, status messaging, alert tones, channel marker messages) are not used and were not viewed as mandatory requirements.

Implications of Other, Non-Trunked Radio Systems

In addition to identifying the needs that are currently met and unmet by the existing trunked radios systems, discussions with the Radio Service Division of Waukesha County and the Radio System Administrator of Milwaukee County to inventory the non-trunked radio systems that are used

throughout the Counties and to identify any important relationships and interfaces.

In order to improve the in-building coverage performance of the Waukesha County trunked system, there are a total of approximately 42 800MHz bi-directional amplifiers deployed in larger or older buildings (such as schools, municipal buildings, hospitals, etc.) across Waukesha County. There are approximately 31 such 800MHz bi-directional amplifiers deployed in similar locations across Milwaukee County.

Waukesha County operates a Siren Control radio system on a VHF simplex channel. The Waukesha County Communications Center houses a DTMF-based Zetron controller that generates tones on the VHF channel and that are carried to American Signal Corporation or Federal Signal Corporation siren controllers throughout the County. Some municipalities (such as the City of Brookfield) use their own radio systems to relay the signal controls to their own signal controllers. As an important exception, the municipality of the City of Muskego uses a talkgroup on the existing Waukesha County 800MHz trunked radio system to carry siren control and telemetry information. Waukesha County also uses a VHF channel to carry Knox Box signaling from a Knox Box encoder (housed at the Waukesha County Communications Center) to Knox Boxes throughout the County (but mainly on fire apparatus). These Knox Box signals are also carried on an separate talkgroup ("Fire Alert") the existing Waukesha County 800MHz trunked radio system via a permanent, 1-way patch that is established on the dispatch consoles. Most fire departments access the Knox Box signals via this trunked talkgroup and not via the VHF channel.

[Note: EMS telemetry is not carried on the existing Waukesha County 800MHz trunked radio system – the City of Brookfield once used the radio system for such communications to



local hospitals but it has since switched to using cellular technologies for wireless telemetry transfers.]

Waukesha County also operates, and has licenses for, three 800MHz simplex channels to provide for on-scene communications for any discipline.

Other systems operated within Waukesha County are: i) a UHF radio system operated in the Waukesha County Correctional facility, ii) separate radio systems for transit operations, iii) a separate and standalone 800MHz mobile data system (using IPMobileNet technology on 5 800MHz channels in a reuse pattern at 6 sites) and iv) 800MHz conventional mutual aid base stations for interoperability channels such as 8CALL90 and 8TAC93.

Likewise, discussions were held with representatives of Milwaukee County to identify other systems that have operational or technical interfaces to the existing Milwaukee County 800MHz trunked radio system. A separate, one-site, 800MHz Project 25 trunked system exists and operates at the Channel 58 site in Northeast Milwaukee County. It was deployed as a “test-bed” system and, although it was never expanded, it is used by agencies that are dispatched by the Bayside Communications Center (who use console patches to connect selected talkgroups from the single-site P25 radio system to the existing Milwaukee County 800MHz trunked radio system.)

In Milwaukee County, EMS telemetry is conducted via separate, repeated, UHF radio channels. There are no over-the-air transmissions of Knox Box signals on the existing Milwaukee County 800MHz trunked radio system and siren control signaling is carried on UHF channels that are separate from

the existing Milwaukee County 800MHz trunked radio system.

The North Shore fire department, which is dispatched from the Bayside Communications Center, uses Mobex Digital Vehicular Repeater System (DVRS) units to relay conversations from 800MHz talkgroups to VHF simplex, conventional channels (such as Fireground Red), and vice-versa, to allow direct/simplex radio communications in fireground operations to occur with dispatch involvement and logging.

User Needs: Summary/Key Findings

The following summary includes the key findings from this Report section on User Needs:

Key Findings: User Needs	
	Users identified areas that require coverage improvements including in-buildings and in outside areas of Waukesha and Milwaukee Counties.
	Users stated that both “internal” (between the two Counties) and “external” (with outside agencies) interoperability requires improvement.
	New radio system features are required, most notably high-audio-quality encryption.
	System maintenance has been very good but users requested the ability to make some ‘simple’ programming changes (such as reordering talkgroups).
	Most existing dispatch console features should be continued but some new features area also required, most notably announcement groups, announcement tones (channel markers), and wireline features (such as priority and ID display).
	Several key interfaces to non-trunking systems exist and must be considered.



Implications of User Needs – Criteria for a Replacement System

Technical/Performance Criteria for a New System

The input gathered from the surveys, interviews, visits, and discussions described above provides the basis to develop criteria that must be met by the new system that will replace the existing Waukesha County and Milwaukee County 800MHz trunked radio systems.

The same performance attributes that were used to identify needs can be used as the categories for criteria for a replacement system. The table below shows, by performance attribute, the performance levels of the current Waukesha County and Milwaukee County trunked radio systems as well as the suggested performance criteria for a system that will replace them.

The contents of the following table describe the performance of one system or multiple systems that must meet the needs of the individual Counties (i.e., the table presumes that the Counties may have different, albeit similar, requirements for some performance attributes). Subsequent sections of this Report will describe alternative system design concepts and will weigh the ability of single-system and combined-system alternatives to meet these criteria.

These criteria for performance are not the only criteria that will be used in selecting an alternative system design concept: other, non-technical factors are included after the following table.



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
Coverage		
Waukesha County has identified that their existing coverage specification is that coverage must exceed “95% reliability at the head in 12 dB density buildings in 95% of Waukesha County.” <i>[NOTE: Waukesha County has stated that coverage testing, performed during system deployment, showed that the system performed better than this specification.]</i>	A replacement trunked radio system should be designed with a coverage specification of: “95% talk-in and talk-out service area coverage reliability at a delivered audio quality (DAQ) level of 3.4 for a portable radio with a public safety microphone (SMA) used at shoulder level in 15 dB density buildings across Waukesha County.” To promote high levels of audio quality, subscriber equipment should be capable of both IMBE and AMBE +2 vocoders.	The change from buildings of 12dB to 15dB is made based on: i) the input collected from users that noted coverage problems in specific large or older buildings and ii) the specification by TSB-88-C⁸ that “medium buildings” produce a loss of 14.4dB at 800MHz. The addition of a DAQ specification is required to confirm an audio quality specification that is recommended by TSB-88-C for public safety operations. The other additions provide clarifications. The continued inclusion of the public safety microphone is based on the assumption that agencies in the County have, and will continue to use, such equipment. The inclusion of both vocoders is based on the requirement for audio quality that is as clear as possible. (The AMBE +2 vocoder is an enhanced full-rate vocoder that has been shown to produce superior audio quality to the IMBE vocoder.)
Milwaukee County has identified that their existing coverage specification is that coverage must be: “i) 99% mobile on street coverage with a DAQ of 3.4 and ii) 95% in building coverage with up to 15Db density portable coverage at the hip with DAQ of 3.0.”	A replacement trunked radio system should be designed with a coverage specification of: “i) 95% talk-in and talk-out service area coverage reliability at a delivered audio quality (DAQ) level of 3.4 for a portable radio transmitting from hip level in a swivel case in 15 dB density buildings across Milwaukee County and ii) 99% talk-in and talk-out service area coverage reliability at a delivered audio quality (DAQ) level of 3.0 for a mobile radio transmitting with an antenna on the roof of a standard passenger car in outdoor/street-level	The change in the specification for audio quality for in-building portable use is based on the recommendation by TSB-88-C that DAQ 3.4 is the audio quality specification for public safety operations. The continued change in the specification for audio quality for on-street mobile use is based on the recommendation by TSB-88-C that DAQ 3.0 is the audio quality specification for public service operations (which are typically mobile-radio based).

⁸ TSB-88-C is the Telecommunications Industry's Association's publication Telecommunications System Bulletin number 88-C (TSB-88-C) and it defines “Wireless Communications Systems Performance in Noise and Interference Limited Situations.” It is used as a standard for modeling and measuring the coverage performance of land mobile radio communications systems like the 800MHz public safety systems in use by (and being considered by) Waukesha and Milwaukee Counties.



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
	locations across Milwaukee County.” To promote high levels of audio quality, subscriber equipment should be capable of both IMBE and AMBE +2 vocoders.	(The AMBE +2 vocoder is an enhanced full-rate vocoder that has been shown to produce superior audio quality to the IMBE vocoder.)
Capacity		
Waukesha County’s current radio system consists of 13 channels, one of which is dedicated to trunking control and the other 12 of which are used to process voice calls. There are approximately 4,560 radio units from 135 agencies registered in the database of the current Waukesha County radio system. Waukesha County had prepared reports showing the usage of the Waukesha County trunked radio system during a significant recent event; a shooting involving three fatalities in the retail area near Brookfield Square in Brookfield, Wisconsin, on Sunday October 21st, 2012. This report showed that in the 12 hours from the beginning of the event (the first 9-1-1 call was received at approximately 11:00am), a total of over 19,000 calls were processed by the system and that no radio busies were incurred. During the first 30 minutes of the event, the system channels incurred the following loads: the 7 non-encrypted talk channels were loaded between 39% and 54% and the 5 encrypted talk channels were loaded between 0% and 5% (the 13th channel was the control channel which was not available for voice traffic.) Waukesha County also prepared radio traffic reports from 2010, 2011, and parts of 2012 and they showed that in February 2012, the most recent month for which a report was provided, a total of 3072 active	A replacement trunked radio system should be designed with a capacity specification of: “The number of channels included in the system should provide a peak-hour Grade of Service of 0.05 (5%) in which any talk request that is queued is considered ‘busied or blocked’ and that no busied call be held in queue for longer than 5 seconds (on average).”	The term “Grade of Service” is defined as the probability that any call request is blocked or busied and a Grade of Service of 0.05 means that, on average, 5 of every 100 call requests will be queued (this value of a Grade of Service of 0.05 is a typical value for public safety trunked radio communications systems. Based on the report from the incident of October 21st 2012, the current 13-channel radio system produced a Grade of Service of 0.00 (0 calls out of 100 were busied). While 7 of the 12 available talk channels were at or nearing the maximum recommended load of 50%, the other 5 (non-encrypted) voice channels were only very slightly used. Based on the traffic reports of 2010 to early 2012, the County can assume that a replacement radio system with 15 channels (14 voice and one control) is sufficient to accommodate growth and peak traffic. This recommendation is based on the assumption that the County experiences a 20% growth in the number of active units and, that at a peak hour (a serious event), each unit utilizes 150% more airtime minutes than typical (i.e., 2.5 times the load of typical). In this scenario, the new system should be sized to accommodate approximately 3700 units, each utilizing and average of 7.0 airtime minutes per hour. In order to maintain an average loading of 50% on the entire



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
units from 126 agencies/organizations utilized a total of 51,432 active airtime minutes (or an average of 16.74 minutes per unit per month). The report that showed the heaviest usage was July 2010 which showed 2102 units utilizing a total of 68,886 active airtime minutes (or an average of 34.24 minutes per unit per month).		trunked system, a replacement system should be sized at approximately 14 voice channels. (Note: the figure of 50% is commonly used as the threshold below which trunked radio systems operate normally and without excessive busies.)
Milwaukee County's current radio system consists of 14 channels, one of which is dedicated to trunking control and the other 13 of which are used to process voice calls. In September, 2012, Milwaukee County's radio system carried traffic from 4,150 active radio units (from a total of 46 different agencies). Milwaukee County had prepared reports showing the usage of the Milwaukee County trunked radio system during a significant recent event; a shooting involving seven fatalities at the Sikh Temple in Oak Creek, Wisconsin, on August 5th, 2012. This report showed that in the 12 hours from the beginning of the event (the first 9-1-1 call was received at 10:26am), a total of over 41,000 calls were processed by the system and that only 5 radio busies, with an average of less than 2 seconds per busy, were incurred. Milwaukee County also prepared reports from a significant weather-related event, a snowfall of 9.1" on February 2nd, 2010 (which occurred one day after a snowfall of 8.5"). The voice traffic from this day showed that the system (then only 13 channels total) carried a total of 91,895 calls and produced a total of 1,268 busies (with an average duration of approximately 4 seconds per busy).	A replacement trunked radio system should be designed with a capacity specification of: "The number of channels included in the system should provide a peak-hour Grade of Service of 0.05 (5%) in which any talk request that is queued is considered 'busied or blocked' and that no busied call be held in queue for longer than 5 seconds (on average)."	Based on the report from the incident of August 5th, 2012, the current 14-channel radio system produced a Grade of Service of 0.00012 (0.012 calls out of 100 were busied). Based on the report from the incident of February 2nd, 2010, the then 13-channel radio system produced a Grade of Service of 0.000138 (0.0138 calls out of 100 were busied) over the entire 24-hour period, however, the Grade of Service varied significantly over the day. Unless an alternate definition of peak-hour is developed (alternate to the data from the incident of August 5th, 2012), the County can assume that a replacement radio system with 14 channels (13 voice and one control) is sufficient to accommodate current loading. In order to determine the number of channels required in the replacement radio system, Milwaukee County will also have to produce estimates of growth (in terms of number of units active on the system). <i>[NOTE: For planning and budgetary purposes, Milwaukee County has requested that this report use a capacity value of 18 channels for a zone that serves only Milwaukee County.]</i>



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
Capabilities		
Both Waukesha County's and Milwaukee County's current radio systems provide the trunking features of Motorola's Project 16 (analog trunking) SMARTNET II+ systems. Both systems have also been enhanced to include DES-XL (analog-based) encryption.	A replacement trunked radio system for both counties should be based on the Association of Public Safety Communications Officials International's (ACPOs') Project 25 (P25) standards for public safety radio communications. This will provide a high degree of signaling compatibility between products of multiple vendors. The P25 standard for the Common Air Interface (CAI) provides for a number of mandatory, standard-option, and standard-option-required features. These classifications are defined as follows: • Mandatory (M) – The user shall minimally receive all mandatory features when procuring P25 compliant equipment. • Standard Option (SO) – The user has the option to choose this feature. If a vendor chooses to offer the feature, it shall be implemented in compliance with the P25 standards. • Standard Option Required (SO-R) – If a Standard Option is implemented by a vendor, all respective sub-options specified as SO-R shall be implemented as well. A replacement trunked radio system for both counties should include the following P25 CAI features (listed with their designed classification): • Unaddressed Voice Calls (M) • Group Voice Calls (SO) • Broadcast Call (SO) • Emergency Group Voice Call (SO) • Individual Voice Call (SO) • All Call / System Call (SO) • Discrete Listening (SO) • Pre-emptive Priority Call (M)	The features/capabilities listed to the left are suggested because they are: i) significantly similar in user functionality to those currently provided by the existing Motorola Project 16 SMARTNET II+ systems, ii) typically deployed in most public safety radio communications systems, and/or iii) specifically noted as requirements/needs by participants in the User or Management Surveys described above. The features/capabilities that were excluded from the list to the left were done so because they are not deployed in the existing Motorola Project 16 SMARTNET II+ systems or because they were not noted as requirements by participants in the Surveys. It is important to note that the detailed technical specifications for Project 25 CAI features describe the format for the signals and data streams that are exchanged between system components but they do not specify details regarding user functionality. For example, two subscriber radios from different vendors could both comply to the P25 CAI specifications for Emergency Message by generating and accepting the correct/compliant over-the-air signals but they could each provide very different interfaces and experience to the human user (i.e., one could require a button to be pressed for a short length of time and the other could require a completely different method of activation). Therefore, it is suggested that the Counties specify both the P25 technical specification and a required user functionality (description of inputs and outputs with the human user) for the features listed to the left.



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
	• Supplementary Voice Calling Features • Call Alert (SO) • Emergency Alarm/Call (SO) • Radio Check (SO) • Radio Unit Inhibit / Uninhibit [Disable/Enable] (SO) • Radio Unit Monitoring (SO) • Short Message (SO) • Status Query (SO) • Status Update (SO) • Radio Inhibit/Uninhibit (SO) • Transport of Talking Party ID (SO) • Selectable Squelch (Normal (M), Monitor (M), Selective (SO)) • Busy Channel Lockout (SO) • AES Encryption (SO) • Registration (Static, Dynamic, Mobility) (M) • Affiliation (M) • Intersystem/Intrasystem Roaming (Manual (M), Automatic (SO)) • Data Bearer Services (SO) • Terminal Services; Radio Control & Simple Network Management Protocols (SO) • Encryption Key Management (load, erase, view keys, etc.) (SO) • Over-The-Air-Rekeying (OTAR) (change keys, rekey, key assignment, warm-start, responses, etc.) (SO) <i>[Note that the following P25 CAI features are not included in the above list:</i> • <i>Telephone Interconnect (landline-to-group, landline-to-unit, unit-to-landline, signaling, overdial, etc.) (SO)</i> • <i>GPS Services; NEMA 0183 Sentences (lat, long,</i>	



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
	<i>fix data, # satellites, etc.) (SO)</i> • <i>Location Services; LRRP Services (immediate, unsolicited and triggered location reports, etc.) (SO)</i> • <i>DES Encryption (SO-R)]</i>	
Interoperability		
<u>Waukesha County's and Milwaukee County's</u> current radio systems each deliver radio service only to users that are programmed to operate on one network or the other. Users of the systems <u>cannot</u> roam from one system to the other, directly communicate across the systems on shared talkgroups, or directly scan a talkgroup that 'belongs' to the other system. Interoperability between the two systems is provided through patches that are established on a permanent or temporary basis via wireline dispatch consoles or gateways. These same methods are used to provide interoperability with external systems such as those of neighboring counties, departments of the City of Milwaukee, and mutual aid and interoperability channels. These methods can be problematic to implement (requiring human intervention) and inefficient to operate (requiring channel resources on multiple systems for all transmissions that occur on one system).	A replacement trunked radio system for both counties should allow for "internal interoperability" between agencies in Waukesha and Milwaukee Counties by natively providing the abilities to: i) talk between agencies in both counties on authorized talkgroups, ii) roam on all talkgroups between the two Counties, and iii) scan the talkgroups (as authorized) of agencies in both counties. A replacement trunked radio system for both counties should allow for "external interoperability" between the agencies of Waukesha and Milwaukee Counties and the users of the City of Milwaukee's OpenSky ® system and the State of Wisconsin's WISCOM system via the P25 Inter RF-Subsystem Interface (ISSI) standard. It should also support connectivity to mutual aid and interoperability channels via gateways and through console patches. The other external systems that should be supported by these methods are those of Ozaukee County and Jefferson County.	The methods of "internal interoperability" listed were specifically noted as requirements by participants of the User Survey. The requirements for "external interoperability" with the listed systems and agencies were also specifically noted in Survey responses. <i>[NOTE: Although not specifically called for by any participant in the Surveys, it is also assumed that the external system used by the City of Greenfield in Milwaukee County.]</i>
Reliability		
<u>Waukesha County</u> does not have a specifically-identified requirement for system reliability, however, the Request for Proposals that was used to procure the existing trunked radio system specified a "99.5% operational level" (which was further defined	A replacement trunked radio system should be designed to include no single point of failure in either the trunking control or audio selection/distribution paths that would cause complete loss of operations of the system. Additionally, a replacement trunked radio	The suggested criteria are based on standard design specifications for public safety trunked radio communications systems.



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
as "a percentage determined by dividing the total productive operational use time by the total productive operational use plus equipment failure time"). Milwaukee County has identified a system reliability requirement of "99.9% system availability including towers and simulcast system."	system should be designed such that the failure at one P25 trunked radio site shall not diminish the ability of other sites to communicate as they would normally. The main trunking control components (including trunking controllers and audio selection/voting and distribution equipment) shall have a product reliability of 99.999% (five nines) meaning that their hardware and software shall be inoperable or unavailable for no more than 5.25 minutes per 365 days.	
Security		
Waukesha County's and Milwaukee County's current radio systems each use DES-XL encryption technology on a limited set of channels. Additionally, the links used to provide the interconnections between trunking control and audio components are circuit-based and on closed networks. Radio sites are generally at secured locations (county or local municipality land with locked shelters or leased facilities with controlled/restricted access).	A replacement trunked radio system should provide for AES-based digital encryption that is carried across the entire trunked radio system (i.e., encrypted and decrypted only at subscriber radios, dispatch consoles, and logging recorders). Methods for encryption and key management should comply with P25 standards. Additionally, a replacement trunked radio system should utilize a P25-compliant authentication (compliant to TIA-102.AACE standards). The network(s) used to interconnect the trunking controllers, radio sites, and dispatch centers should continue to be closed and virtual private networks should be used whenever transport across public or otherwise external networks is required. Firewalls should be used for any external connections for the sake of monitoring or maintenance. Radio subscriber units should comply with Federal Information Processing Standards (FIPS) 140-2 Level 3 specifications for encryption management.	Responses to the User and Management Surveys noted the need for encryption and the suggested specifications provide such functionality while enhancing it over current capabilities by: i) designating the need for full end-to-end encryption and ii) specifying standards-based methods for encryption and key management. The inclusion of authentication, specifically P25-compliant authentication, will provide for a method to ensure that only authorized radios (defined by a securely- applied authentication key, not a programmable identifier (or Unit ID)) are allowed access to the system.



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
	Radio sites should continue to be located at secured locations with preference placed on buildings and towers located on county or local lands. The systems should establish a secure method for remote access for off-site monitoring and maintenance. For example, a secure/encrypted ISDN line and/or application firewall could be established.	
Maintenance, Monitoring, and Reporting		
<u>Waukesha County's and Milwaukee County's</u> current radio systems are separately maintained by the Waukesha County Radio Services Division and the Milwaukee County Information Management Services Department (IMSD), respectively. These organizations hold primary responsibility for monitoring the systems' performance, performing any necessary repairs, and compiling and disseminating any internal or external reports. The primary tool used by both organizations for monitoring and reporting is Genesis GenWatch™. The programming of subscriber radios is provided by a limited number of organizations including Waukesha County Radio Services and some local, vendor-authorized service shops.	Managing, monitoring, and reporting on a P25-based interoperable replacement trunked radio system (or systems) will be more complex than performing these same tasks on the current systems. The same organizations that currently hold the primary responsibilities for these tasks can and should remain as lead organizations for a replacement trunked radio system (or systems), however, the tools and processes should comply with the "FCAPS" model for Fault, Configuration, Accounting, Performance, and Security (FCAPS) management. a replacement trunked radio system (or systems) should provide the following FCAPS functionalities: <u>Fault Management</u> • View system, component, link, or other faults with identification of the failed item, the time of the failure, and the location of the failure • View, sort, and clear fault alarms (including historical alarms) • Configure alarms (severity levels) and alarm	Responses to the User and Management Surveys noted general satisfaction with the management, monitoring, and reporting of the current systems. The application of the FCAPS model (with the specific functionalities listed) provides further details on the capabilities required to manage typical wide-area, interoperable/shared P25-based trunked radio systems. The suggestion for a hardware-based advanced system key is based on the need to balance security in programming user/subscriber radios with the requirement identified in the User and Management Surveys for more local-access to routine programming operations such as reordering talkgroups.



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
	processing routines (send pages, emails, etc.) <u>Configuration Management</u> • Add a new subscriber to the system (including addition of the subscriber ID and association of IP address) • Define an 'alias' for a new subscriber • Create a new talkgroup and assign subscribers to that talkgroup • Assign priorities to both individual subscribers and talkgroups • Define and change 'feature profiles' for subscribers (including abilities/inabilities for private calls, encryption, etc.) • Define radio consoles and assign talkgroups and conventional channels as resources to those consoles • Define permissions for subscriber radios that establish the sites on which they are allowed and not allowed to access <u>Accounting Management</u> • View and print or export data on usage (number of transmissions and combined length of airtime) for individual units or ranges of units <u>Performance Management</u> • View all subscribers enabled on the system including their status and their system configuration parameters • Define the operational parameters for emergency call modes (preemption vs 'top of queue') • Develop reports on the utilization levels of network control subsystems and individual radio systems (sites) in order to determine the need for additional resources (additional channels, sites, etc.) • Allow initiation of P25 functions such as Radio	



Performance of Current System (by Performance Attribute)	Suggested Performance Criteria of Replacement System	Justification
	Check • Dynamically regroup subscribers into new talkgroups including the ability to create, store, activate, and deactivate storm plans that affect many subscribers. <u>Security Management</u> • Inhibit subscriber radios from operation on the entire system (all sites) and in such a way that the subscriber radio remains entirely inoperable until/unless it receives a “uninhibit” (allow operation) command from the system • Set authentication keys and other provisioning details regarding authentication and encryption Additionally, the provisioning and programming of subscriber radios should include the use of a software program and a hardware-based advanced system key. Users that attempt to program a subscriber radio without the hardware-based advanced system will be allowed limited and controlled access to the portions of the radio’s configuration that they can view and change.	



Non-Technical Criteria for a New System

In addition to the performance-related criteria listed above, a replacement trunked radio system (or systems) must also meet non-technical criteria to demonstrate that it can be financially-viable, able to be implemented, and governed in a sustainable way. The following criteria also apply to the evaluation of a replacement system (or systems) for Waukesha and Milwaukee County:

Non-Technical Criteria	Requirement for Replacement System
Cost (Capital Amount)	Must meet technical requirements at lowest possible capital cost (total and per County)
Cost (Capital Flexibility)	Must meet requirements for funding availability (Waukesha vs Milwaukee County)
Cost (Operational Amount)	Must meet technical requirements at lowest possible ongoing cost (total and per County)
Licensing	Must be able to be licensed under the rules and processes of the Federal Communications Commission
Governance	Must be able to have clear delineation of rights, roles, responsibilities for shared and individually-owned assets

Replacement System Criteria: Summary/Key Findings

The following summary includes the key findings from this Report section on Replacement System Criteria:

Key Findings: Replacement System Criteria

	Waukesha County should consider using 15 dB, not 12dB, buildings in its coverage specifications
	Both Waukesha and Milwaukee Counties should consider using DAQ 3.4 as a coverage specification for public safety use
	The current systems appear to be appropriately sized for peak-hour traffic but additional analysis is needed to plan for growth and to confirm the definition of "peak-hour"
	The P25 Common Air Interface feature set is consistent with user needs but both signaling (P25 compliance) and functionality (human interface) requirements need to be defined
	Encryption and authentication should be implemented per P25 standards to improve security of communications and system access
	Requirements for maintenance and monitoring based on the "FCAPS" model will improve the tools used by system administrators
	Non-performance-related criteria are also required to evaluate various system alternatives.



Conceptual Design Alternatives

High-Level Design Architecture

As is noted above, the current radio systems used by both Waukesha and Milwaukee Counties employ 800MHz, trunked, simulcast architectures. It is recommended that the replacement system (or systems) continue this same general use of 800MHz trunked, simulcast architecture but that they employ APCO Project 25 (P25) technology (instead of analog Project 16 technology).

High Level Architecture Element	Rationale
The replacement system should use Trunking technology:	The large number of users and the relative scarcity of licensable, dedicated public-safety channels requires the efficiencies provided by trunking systems. Additionally, trunking systems (with their use of a dedicated control channel) inherently provide the feature sets required by public safety (features such as emergency message and radio inhibit).
The replacement system should use Simulcast technology:	The large service area of the individual (or combined) Counties and the relative scarcity of licensable, dedicated public-safety channels requires the efficient "reuse" pattern of simulcast in which all system channels are located at all sites and all sites simultaneously broadcast the same conversations. Additionally, because multiple sites can contribute signal to any given location in the service area, the

High Level Architecture Element	Rationale
	coverage provided by simulcast systems typically exceeds the coverage reliability delivered by the same sites if they were operating individually.
The replacement system should use 800MHz channels:	Channels in the VHF and UHF bands are difficult to acquire in sufficient quantities and are prone to interference. The Counties already hold 800MHz licenses the existing subscriber equipment is already capable of operating on this allocation of spectrum. Channels in the 700MHz public safety narrowband allocation of spectrum might be considered but: i) 700MHz requires more stringent loading requirements than 800MHz, ii) 700MHz is currently undergoing a narrowbanding process (similar to that in progress in the VHF and UHF bands) that is to be completed by 2017 and the deployments of systems using 700MHz narrowbanded (12.5 KHz) channels are only just beginning, iii) the coverage from narrowbanded 700MHz systems is expected to be less than that of 800MHz systems, and iv) there is no anticipated plans for a narrowbanding effort for 800MHz. (Note: the use of 700MHz frequencies in



High Level Architecture Element	Rationale
	<i>the replacement system/systems should still be considered for specific applications which will be described below.)</i>
The replacement system should use Project 25 technology:	Project 25 (or P25) is the standard for voice radio communications that is embraced by the Association of Public Safety Communications Officials International (ACPO). Deploying a system based on it helps provide a high degree of signaling compatibility between products of multiple vendors. Additionally, Project 25 provides the feature set required by the users of the Waukesha and Milwaukee trunked radio systems.

Subsequent sections of this Report provide further analysis on lower-level alternatives (such as the number of sites to be deployed; the “Phase” or version of Project 25 to be deployed; and the options for incorporating non-trunked systems) however, the balance of this Report is based on the assumption that the replacement system (or systems) will utilize an 800MHz, Project 25, trunked, simulcast architecture.

Main Alternatives: One Simulcast System or Two?

The recommendation for the general architecture described above does allow for the analysis of variations and alternatives, most notably the deployment of one simulcast that would cover both Counties with the same number of channels, each delivering the same talkgroup conversations over the entire combined service area, or two separate

simulcast ‘zones’, each of which would cover one of the two Counties but which would be directly interconnected by one common/shared master site controller. These two alternatives have been called in recent discussions the “One Massive Simulcast” and “Two Connected Zones” alternatives, respectively, and while they have their differences, they have the following in common: i) both use a shared Master Site controller, ii) both are based on P25 simulcast technology, iii) both could use 700 or 800 MHz frequencies, and iv) both could allow legacy migration. Among their main differences are: i) their different approaches to architecture to radio network (the “One Massive Simulcast” concept is more homogenous vs while the “Two Connected Zones” concept is more differentiated), ii) their different approaches to the delivery of interoperability performance (both are capable of delivering the necessary “internal” interoperability described above but they would do so in different ways), iii) their different cost models, and iv) their slightly different governance models.

Diagrams of the two design concepts are included after the following descriptions.

As noted, the “One Massive Simulcast” system involves deploying one, homogeneous system across both Counties. All sites in both Counties would have the same channels (same number of channels and same channel pairs) and they would all be treated as part of one system by shared/common trunking control equipment known as the Master Site Controller (or Zone Controller). The Master Site Controller would interface to all of the radio sites by one shared/common Prime Site Controller. The number of radio sites and their locations can be adjusted to meet the specific coverage requirements of the two Counties (i.e., the two Counties can maintain different coverage specifications). All wireline dispatch consoles would need to be upgraded to versions that supports an IP-based technology in order to



interface to the new Master Site Controller. Options may be available, depending on the vendor that is selected to deploy the replacement system, to deploy a legacy console interface that could be used to connect any existing, non-IP-based consoles to the Master Site Controller in an interim period. Likewise, options may be available, depending on the vendor that is selected to deploy the replacement system, to interface the existing Project 16 trunked radio systems into the new Master Site Controller in order to allow subscriber radios that are not capable of operating on P25 networks to interconnect into the new system. Network management terminals would be available locally (in the same location as the Master Site Controller) and remotely (at other locations) to provide the necessary maintenance and management functions. Interoperability with "external" systems would be conducted through Project 25 ISSI-based links (to systems capable of also operating ISSI interconnections such as the City of Milwaukee and the State of Wisconsin's WISCOM system) and through the same type of gateways or console patches used in current systems, however, such gateways and patches could be established in a more consistent manner such that only one connection is required to serve the entire combined system.

The "One Massive Simulcast" system does require that all of its radio sites be equipped with the same number of radio channels and that the number of radio channels deployed be sufficient to carry all conversations from all possible users. For Waukesha and Milwaukee Counties, this means that each site in the system would need the number of channels (and associated repeater and antenna/network equipment) required to carry the capacity of approximately 7,000 to 7,500 users (the combined load of both Waukesha and Milwaukee Counties). As noted above, if deployed separately, Waukesha County and Milwaukee County would need approximately

14 to 15 channels per system to carry the radio traffic from their respective user bases, however, if "One Massive Simulcast" system were deployed, approximately 22 channels (the actual number would be determined by more detailed loading analyses) would need to be located at each and every site in both Counties. The technologies used by vendors of P25 radio systems do not allow the same option for "variable density simulcast" (in which sites could be populated with different number of channels) as was available with Project 16 technologies. As will be described below, this requirement for homogeneity has an impact on cost, cost flexibility, and the ability to license channels from the FCC.

The "One Massive Simulcast" system does, however, have significant benefits for user operations, most notably in the areas of "internal interoperability". Because the system would operate as one unified system, the ability converse and scan on the same talkgroups across both Counties, and to roam between them, would be seamless.

The configuration of a system with "Two Connected Zones" would differ from that of the "One Massive Simulcast" concept in that each County would operate their own simulcast system, each with different channels and possibly with different numbers of channels. The two simulcast systems would, however, operate as connected zones, interfacing to each other through the shared/common Master Site Controller but first through individual Prime Site Controllers. The same methods and interfaces as were described for the "One Massive Simulcast" system could be used in this "Two Connected Zones" concept for dispatch consoles, legacy systems, management and maintenance terminals, and "external" interoperability.

This separation of zones would allow each of the two simulcast systems to be 'sized' to meet the capacity requirements of the individual



Counties. The number of channels deployed in each County's simulcast zone would need to take into account the impact of conversations that would occur between the two zones (i.e., a conversation on a shared talkgroup that spans both simulcast zones would consume channels from both Counties). This is because conversations between users in the different simulcast zones could occur on the same talkgroup as the Master Site Controller is connected to both and it would facilitate the necessary user-and-talkgroup tracking and call-setup processes. This means that a "Two Connected Zone" concept can, if configured as such, facilitate the same general capabilities for cross-county conversations and for roaming, however, it has implications to talkgroup scanning. For a user of simulcast zone "A" to scan a talkgroups in use in zone "B", there must be some mechanism that forces the desired talkgroup to occur in zone "A". This will naturally occur if a user of the desired talkgroup is already in zone "A" or it could occur, depending on the implementation of the system vendor, by forcing the talkgroup to occur on zone "A" because it is configured as a critical zone for that talkgroup. The mechanics of cross-county scanning in a "Two Connected Zone" concept are more complex but they can be configured to produce approximately the same results as the "One Massive Simulcast" concept.

The impact of the "Two Connected Zone" concept's ability to allow different number of channels per zone affects cost, cost flexibility, and the ability to license channels from the FCC.

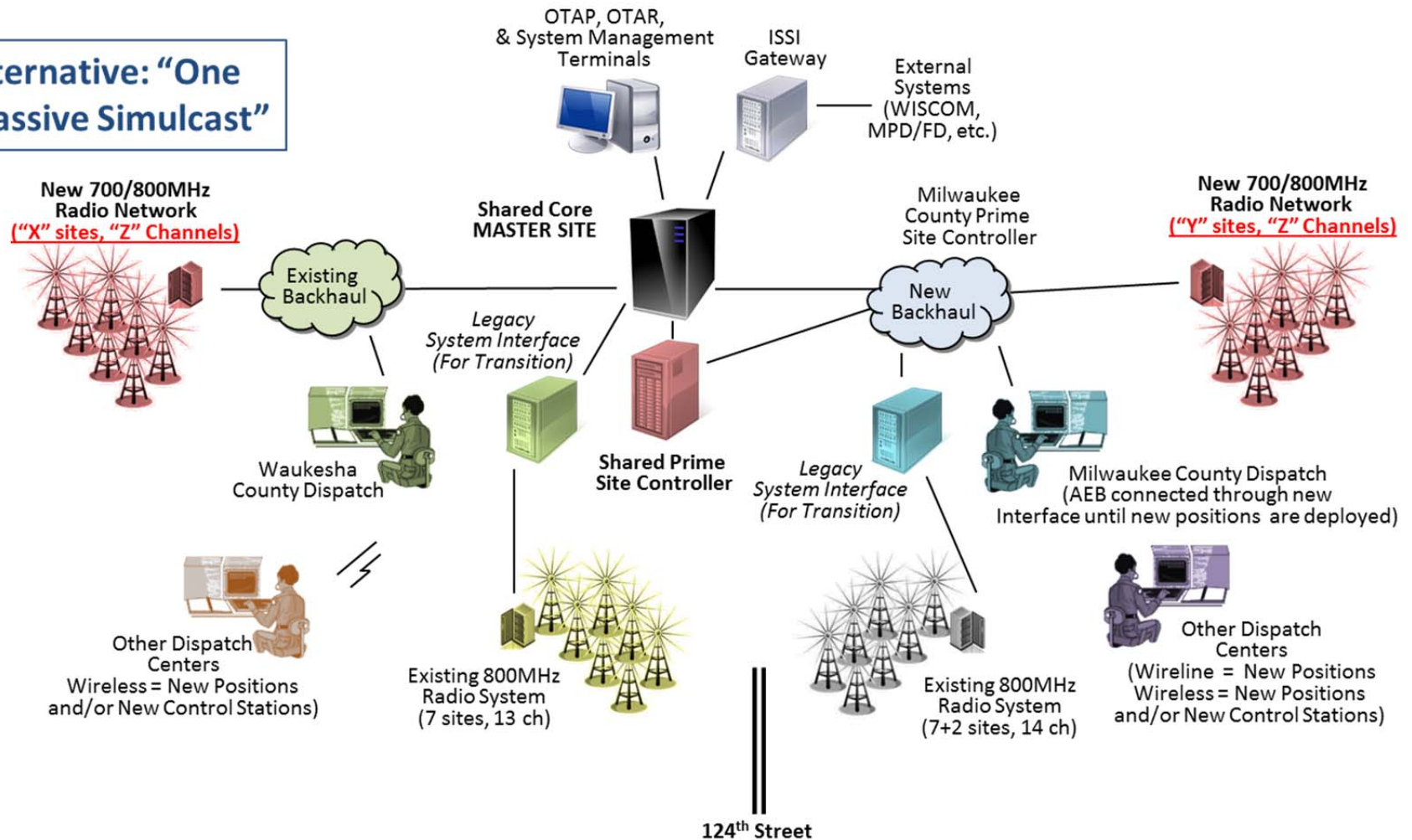
The following diagrams⁹ illustrate the basic design concepts of "One Massive Simulcast" and "Two Connected Zones".

⁹ Notes regarding Design Concept diagrams: 1) the use of "legacy interfaces" to connect existing trunked systems and/or dispatch consoles is optional and

may vary depending on vendor, 2) not all backhaul in Waukesha County will be "Existing" and not all backhaul in Milwaukee County will be "New", however, it is expected that Waukesha County will be able to reuse a significant amount of its digital microwave system (depending on final site selections) and that Milwaukee County will replace most or all of its existing leased T1's with new digital microwave, and 3) "124th Street" is shown to illustrate the border between the two Counties and their current, and potentially future, systems.

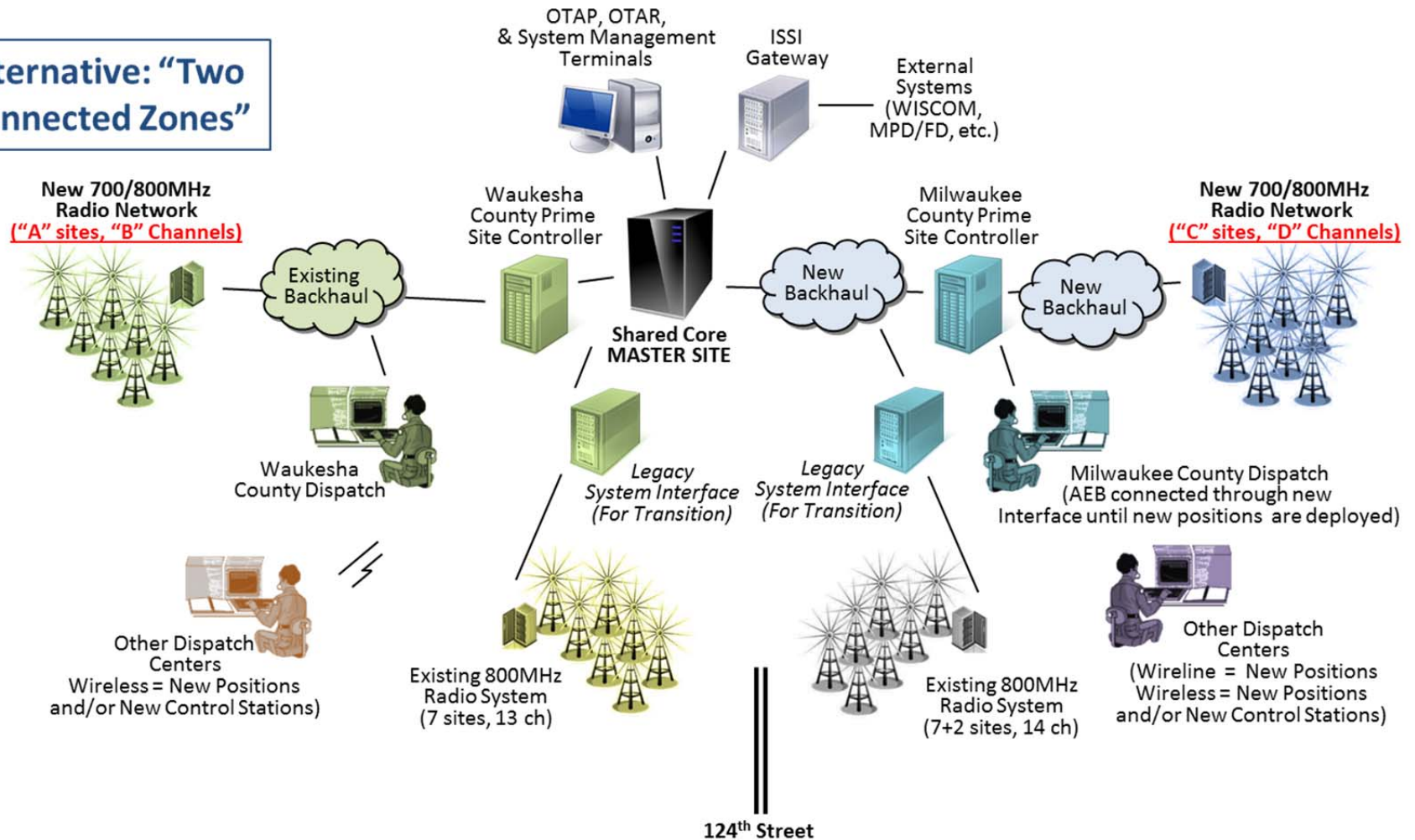


Alternative: "One Massive Simulcast"





Alternative: "Two Connected Zones"





Coverage Variations on Main Alternatives

There are a number of variations on the two main design concept described above that could affect their resulting coverage performance. These variations include: i) the number and locations of sites, ii) the impact of transitions from the current analog modulation scheme (Project 16) to current digital modulation schemes (Project 25 Phase I), iii) subsequent transitions to emerging digital modulation schemes (Project 25 Phase II), iv) the location of the portable subscriber radio's antenna (at the head using a "public safety microphone" vs at the hip in a swivel case), and v) the factor used for in-building losses.

Appendix C includes a series of coverage predictions to model these variations. Three sets of maps are provided. The first set depicts a baseline of the current Waukesha County trunked radio system and variations from that baseline to represent variations of the Waukesha County portion of the "Two Connected Zones" concept. The second set provides the same analysis for Milwaukee County, namely depicting a baseline of the Milwaukee County trunked radio system and then progressing through variations from that baseline to represent variations of the Milwaukee County portion of the "Two Connected Zones" concept. Finally, the third set shows the alternative, with variations, of the "One Massive Simulcast" concept.

All maps are developed for portable radios in the presence of different building losses. It is expected that the performance for mobile radios would exceed that of portable radios. All maps were developed for a Delivered Audio Quality of 3.4.

All maps were developed using 800MHz-NPSPAC channels of 25KHz bandwidth with the exception of the maps that depict P25 Phase II technologies which were developed using parameters for 800MHz channels of 12.5KHz

bandwidth. In determining these applicable parameters for these and other factors, the maps were developed in compliance with the standards of TSB-88-C.

Each map is a composite of both "talk-out" (from system to portable) and "talk-in" (from portable radio to system) coverage. On all maps, the presence of a light red color designates 95% (or better) talk-out coverage reliability, the presence of a light blue color designates 95% (or better) talk-in coverage reliability, and the presence of light purple designates the both (balanced 95% (or better) talk-out and talk-in coverage reliability).

Information about the radio sites (both current and variations) was obtained from the Radio System Administrators of Waukesha and Milwaukee Counties.

The following table is a guide to the maps included in Appendix C.



Map Index	Counties Analyzed	Radio Modulation	Sites Included	Portable Antenna Location	Building Loss	Notes / Purpose
Map W.1	Waukesha County	Analog	Current Sites	Head Level	12 dB	Develops a baseline of the current, analog system using current sites at Waukesha City, Nashotah, Delafield, New Berlin, Eagle, Brookfield, and Menomonee Falls (the last two utilize directional antennas)
Map W.2	Waukesha County	P25 Phase I	Current Sites	Head Level	12 dB	Depicts the impact of transitioning to P25 Phase I digital modulation
Map W.3	Waukesha County	P25 Phase I	Current Sites	Head Level	15 dB	Depicts the impact of 15dB (not 12dB) building loss in a P25 Phase I system
Map W.4	Waukesha County	P25 Phase I	Current Sites	Hip Level	15 dB	Depicts the impact of locating the portable radio antenna at the hip (in a swivel case) and not at the head/shoulder (with a 'public safety' microphone) in a P25 Phase I system with 15 dB building loss
Map W.5	Waukesha County	P25 Phase I	Current Sites Plus Vernon Town Hall	Head Level	15 dB	Depicts the impact of adding a site at the Vernon Town Hall (42.883 N, -88.248 W, with a 85 meter tower and bi-directional antennas)
Map W.6	Waukesha County	P25 Phase I	Current Sites But Menomonee Falls Site Moved	Head Level	15 dB	Depicts the impact of relocating the site in Menomonee Falls to an alternate location ("Tower Hill" at 43.134 N, -88.158 W with a 40 meter tower) in a P25 Phase I system
Map W.7	Waukesha County	P25 Phase I	Current Sites Plus Vernon Town Hall	Head Level	15 dB	Depicts the impact of adding a site at the Vernon Town Hall (42.883 N, -88.248 W, with a 85 meter tower) <u>and</u> a site at the Merton Fire Department (43.140N, -88.310 W, with a 64 meter tower and bi-directional antennas)
Map W.8	Waukesha County	P25 Phase II	Current Sites	Head Level	15 dB	Depicts the impact of transitioning to P25 Phase II digital modulation
Map M.1	Milwaukee County	Analog	Current Sites (2 RX-only)	Hip Level	15 dB	Develops a baseline of the current, analog system using current sites at US Bank, Muirdale, Greenfield, Channel 58, Channel 49, Brown Deer Park, County House of Corrections, E38/Donna Drive, and Lakeshore Tower (the last two operate as receive-only sites and Brown Deer Park utilizes a directional antenna)
Map M.2	Milwaukee County	P25 Phase I	Current Sites (all TX/RX)	Hip Level	15 dB	Depicts the impact of transitioning to P25 Phase I digital modulation and of configuring all sites to operate as full transmit/receive sites
Map M.3	Milwaukee County	P25 Phase I	Current Sites (all TX/RX)	Hip Level	20 dB	Depicts the impact of 20dB (not 15dB) building loss in a P25 Phase I system
Map M.4	Milwaukee County	P25 Phase I	Current Sites (all TX/RX) but Lakeshore moved to 440th	Hip Level	15 dB	Depicts the impact of relocating the site at Lakeshore Towers to an alternate location ("the 440 th " at 42.932 N, -87.902 W with a 33 meter tower)



Map Index	Counties Analyzed	Radio Modulation	Sites Included	Portable Antenna Location	Building Loss	Notes / Purpose
Map M.5	Milwaukee County	P25 Phase I	Current Sites (all TX/RX) but Brown Deer moved to Bayside	Hip Level	15 dB	Depicts the impact of relocating the site at Brown Deer Park to an alternate location ("Bayside PD" at 43.181 N, -87.905 W with a 50 meter tower and a directional antenna)
Map M.6	Milwaukee County	P25 Phase II	Current Sites (all TX/RX)	Hip Level	15 dB	Depicts the impact of transitioning to P25 Phase II digital modulation
Map C.1	Combined Counties	P25 Phase I	Current Sites (all TX/RX)	Hip Level	15 dB	Depicts the coverage of "One Massive Simulcast System" using all current sites (all in a full transmit-receive configuration) and with Milwaukee County's coverage concerns (portable antenna at hip level in a swivel case and with 15dB building loss)
Map C.2	Combined Counties	P25 Phase I	Current Sites (all TX/RX) but Brookfield moved to Vernon Hall	Hip Level	15 dB	Depicts the coverage of "One Massive Simulcast System" using all current sites (all in a full transmit-receive configuration) but replacing the Waukesha County sites at Brookfield with one at Vernon City Hall and with Milwaukee County's coverage concerns (portable antenna at hip level in a swivel case and with 15dB building loss)



Analysis of Coverage Variations

The following analysis is based on a review of the coverage maps included in Appendix C:

For Waukesha County

- The transition from analog to Project 25 Phase I technologies in the Waukesha County portion of a "Two Connected Zones" concept would improve countywide coverage
- The impact of changing Waukesha County's coverage specification to include 15dB, not 12dB buildings, does not significantly affect delivered coverage
- The impact of some users in Waukesha County transmitting with their portable radio at their hip (not head) does not significantly affect delivered coverage (this is likely due to the fact that the coverage gains due to the increased elevations of "public safety microphones" (which place the antenna at the shoulder/head level) can be nearly entirely offset by the loss associated with the cable used to connect the "public safety microphone" to the portable radio)
- The addition of a site at Vernon Town Hall does significantly improve coverage in the area around Mukwonago and in the southeast corner of the County
- The addition of the site at Merton Fire Department does significantly improve coverage in the area around Merton and Sussex and along the north edge of the County
- The relocation of the site from its current location in Menomonee Falls to Tower Hill has little positive or negative affect

For Milwaukee County

- The transition from analog to Project 25 Phase I technologies in the Milwaukee County portion of a "Two Connected Zones" concept would have little impact on countywide coverage

- The impact of changing Milwaukee County's coverage specification to include 20dB, not 15dB buildings, does not significantly affect delivered coverage, however, such a change is not recommended
- The relocation of the site at Lakeshore Towers to the 440th would likely cause further problems in talk-out coverage along southern portions of Milwaukee County's lakeshore
- The relocation of the site at Brown Deer Park to the Bayside Police Department would improve coverage along the northern portions of Milwaukee County's lakeshore but it would cause problems with talk-out coverage in areas North of Greater Milwaukee International Airport (GMIA)

For Both Counties

- The transition from analog to Project 25 Phase II technologies would cause significant coverage problems in both Waukesha and Milwaukee Counties (Note: the maps included in Appendix C do not include diversity receivers and antennas at infrastructure sites, a practice that is recommended by some vendors)
- The coverage of the "One Massive Simulcast" system concept, using existing sites, provides good coverage across both Counties, however, the relocation of the site at Brookfield to the site at Vernon Town Hall improved coverage near Mukwonago but introduced coverage problems West of Menomonee Falls

Performance/Technical Comparison of Main Alternatives

As was described immediately above, the two design concepts ("One Massive Simulcast" and



“Two Connected Zones”) produce viable coverage performance for users in Waukesha and Milwaukee Counties.

The following table uses coverage and the other performance/technical criteria developed in previous sections of this Report to further describe the ability of each alternative to meet user and project needs. The first column of the table shows the previously-developed performance criteria; the second describes which, if either, design concept has an advantage regarding the performance criteria, and the justification for the advantage. The non-technical criteria of cost (capital amount), cost (capital flexibility), cost (operational amount), and governance are reviewed in subsequent sections of this Report.

It should be noted that the licensing of radio channels the “One Massive Simulcast” concept would be more difficult than for the “Two Connected Zones” concept. This is due to manner in which both 700MHz and 800MHz channels are allocated for use in public safety communications systems. The bodies that plan, coordinate, and license channels assume that a channel allocated to one county can be reused several counties away. A channel that is used in two neighboring counties (such as Waukesha and Milwaukee Counties) would increase the distance required to reuse that channel from either county (i.e., a channel used only in Milwaukee County could, perhaps, be reused in Columbia County, however, that reuse may not be possible if the channel were used in both Milwaukee and Waukesha Counties because its use in Waukesha County brings it closer to possible interference with Columbia County).

In preliminary discussions with the body that plans the use of 700MHz and 800MHz radio channels for use in public safety radio systems in the southeast portion of Wisconsin (Region 54 of the FCC’s Regional Planning Committees), it was learned that the licensing

of channels for the “One Massive Simulcast” concept could be accomplished, however, it would require significant coordination with and cooperation by other Counties in Southeast Wisconsin and Northeast Illinois.



Suggested Performance Criteria of Replacement System	Advantage Held by Either Design Concept?	Justification
Coverage		
Waukesha County: A replacement trunked radio system should be designed with a coverage specification of: “95% talk-in and talk-out service area coverage reliability at a delivered audio quality (DAQ) level of 3.4 for a portable radio with a public safety microphone (SMA) used at shoulder level in 15 dB density buildings across Waukesha County.” To promote high levels of audio quality, subscriber equipment should be capable of both IMBE and AMBE +2 vocoders.	Neither design concept has an advantage regarding coverage.	Although the use of all sites in both counties on the same channels (in the “One Massive Simulcast” concept) would deliver stronger signals throughout the entire service area, the possibility for destructive simulcast interference (due to signals from different sites arriving at specific locations in ways that cancel, not amplify, each other) increases with both the number of sites and the different site separations used in Waukesha County (typical site separation of 14 to 18 miles) and Milwaukee County (typical site separation of 9 to 13 miles).
Milwaukee County: A replacement trunked radio system should be designed with a coverage specification of: “i) 95% talk-in and talk-out service area coverage reliability at a delivered audio quality (DAQ) level of 3.4 for a portable radio transmitting from hip level in a swivel case in 15 dB density buildings across Milwaukee County and ii) 99% talk-in and talk-out service area coverage reliability at a delivered audio quality (DAQ) level of 3.0 for a mobile radio transmitting with an antenna on the roof of a standard passenger car in outdoor/street-level locations across Milwaukee County.” To promote high levels of audio quality, subscriber equipment should be capable of both IMBE and AMBE +2 vocoders.		
Waukesha County: A replacement trunked radio system should be designed with a capacity specification of: “The number of channels included in the system should provide a peak-hour Grade of Service of 0.05 (5%) in which any talk request that is queued is considered ‘busied or blocked’ and that no busied call be held in queue for longer than 5 seconds (on average).” In the absence of peak-loading data, the County can assume that a replacement radio system with 15 channels (14 voice and one control) is sufficient to accommodate growth and peak traffic.	The design concept of “Two Connected Zones” system has an advantage regarding capacity.	The deployment of separate zones would allow a different number of channels to be located in each zone. This would prevent the need for the relatively large number of channels associated with
Milwaukee County: A replacement trunked radio system should be designed with a capacity specification of: “The number of channels included in the system should provide a peak-hour Grade of Service of 0.05 (5%) in which any		



Suggested Performance Criteria of Replacement System	Advantage Held by Either Design Concept?	Justification
talk request that is queued is considered ‘busied or blocked’ and that no busied call be held in queue for longer than 5 seconds (on average).” Unless an alternate definition of peak-hour is developed (alternate to the data from the incident of August 5th, 2012), the County can assume that a replacement radio system with 14 channels (13 voice and one control) is sufficient to accommodate current loading. In order to determine the number of channels required in the replacement radio system, Milwaukee County will also have to produce estimates of growth (in terms of number of units active on the system).		the combined traffic load of both Counties to be located at all sites.
Capabilities		
<u>Waukesha County and Milwaukee County:</u> A replacement trunked radio system for both counties should include the following P25 CAI features (listed with their designed classification of “M” for Mandatory and “SO” for Standard Option): • Unaddressed Voice Calls (M) • Group Voice Calls (SO) • Broadcast Call (SO) • Emergency Group Voice Call (SO) • Individual Voice Call (SO) • All Call / System Call (SO) • Discrete Listening (SO) • Pre-emptive Priority Call (M) • Supplementary Voice Calling Features • Call Alert (SO) • Emergency Alarm/Call (SO) • Radio Check (SO) • Radio Unit Inhibit / Uninhibit [Disable/Enable] (SO) • Radio Unit Monitoring (SO) • Short Message (SO) • Status Query (SO) • Status Update (SO) • Radio Inhibit/Uninhibit (SO) • Transport of Talking Party ID (SO) • Selectable Squelch (Normal (M), Monitor (M), Selective (SO)) • Busy Channel Lockout (SO) • AES Encryption (SO)	<u>Neither</u> design concept has an advantage regarding capabilities/features.	The set of features listed as a suggested specification are part of the P25 standards and they can be deployed in either a single zone (“One Massive Simulcast”) or multi-zone (“Two Connected Zones”) design.



Suggested Performance Criteria of Replacement System	Advantage Held by Either Design Concept?	Justification
• Registration (Static, Dynamic, Mobility) (M) • Affiliation (M) • Intersystem/Intrasystem Roaming (Manual (M), Automatic (SO)) • Data Bearer Services (SO) • Terminal Services; Radio Control & Simple Network Management Protocols (SO) • Encryption Key Management (load, erase, view keys, etc.) (SO) • Over-The-Air-Rekeying (OTAR) (change keys, rekey, key assignment, warm-start, responses, etc.) (SO)		
Interoperability		
<u>Waukesha County and Milwaukee County:</u> A replacement trunked radio system for both counties should allow for “internal interoperability” between agencies in Waukesha and Milwaukee Counties by natively providing the abilities to: i) talk between agencies in both counties on authorized talkgroups, ii) roam on all talkgroups between the two Counties, and iii) scan the talkgroups (as authorized) of agencies in both counties. A replacement trunked radio system for both counties should allow for “external interoperability” between the agencies of Waukesha and Milwaukee Counties and the users of the City of Milwaukee’s OpenSky ® system and the State of Wisconsin’s WISCOM system via the P25 Inter RF-Subsystem Interface (ISSI) standard. It should also support connectivity to mutual aid and interoperability channels via gateways and through console patches. The other external systems that should be supported by these methods are those of Ozaukee County and Jefferson County.	The design concept of <u>“One Massive Simulcast”</u> system has an advantage regarding “internal interoperability” (i.e., communications between agencies that use the replacement Waukesha and Milwaukee County radio system/systems). <u>Neither</u> design concept has an advantage regarding “external interoperability” (i.e., communications with agencies that are ‘outside of’ the replacement Waukesha and Milwaukee County radio system/systems).	Because “One Massive Simulcast” system would operate as one unified system, the abilities converse and scan on the same talkgroups across both Counties, and to roam between them, would be seamless. The “Two Connected Zone” concept can, if configured as such, facilitate the same general capabilities for cross-county conversations and for roaming. Cross-county scanning in a “Two Connected Zone” concept is, however, more complex but the zones can be configured to produce approximately the same results as the “One Massive Simulcast” concept



Suggested Performance Criteria of Replacement System	Advantage Held by Either Design Concept?	Justification
		The same methods for “external interoperability”; namely ISSI, gateways, and console patches; would be used in either design concept.
Reliability		
<u>Waukesha County and Milwaukee County:</u> A replacement trunked radio system for both counties should be designed to include no single point of failure in either the trunking control or audio selection/distribution paths that would cause complete loss of operations of the system. Additionally, a replacement trunked radio system should be designed such that the failure at one P25 trunked radio site shall not diminish the ability of other sites to communicate as they would normally. The main trunking control components (including trunking controllers and audio selection/voting and distribution equipment) shall have a product reliability of 99.999% (five nines) meaning that their hardware and software shall be inoperable or unavailable for no more than 5.25 minutes per 365 days.	The design concept of “ <u>Two Connected Zones</u> ” system has a slight advantage regarding reliability.	Either concept can be designed to minimize single points of failure but the separate Prime Site Controllers used in “Two Separate Zones” would divide effect of their failure. Also, failsoft (a non-trunking method of communications used when a trunking controller fails) would be more flexible in “Two Separate Zones.” Finally, coverage redundancy along the border of the two zones in a “Two Separate Zones” concept could exist such that the an agency on the border could use either zone.



Suggested Performance Criteria of Replacement System	Advantage Held by Either Design Concept?	Justification
Security		
Waukesha County and Milwaukee County: A replacement trunked radio system should provide for AES-based digital encryption that is carried across the entire trunked radio system (i.e., encrypted and decrypted only at subscriber radios, dispatch consoles, and logging recorders). Methods for encryption and key management should comply with P25 standards. Additionally, a replacement trunked radio system should utilize a P25-compliant authentication (compliant to TIA-102.AACE standards). The network(s) used to interconnect the trunking controllers, radio sites, and dispatch centers should continue to be closed and virtual private networks should be used whenever transport across public or otherwise external networks is required. Firewalls should be used for any external connections for the sake of monitoring or maintenance. Radio sites should continue to be located at secured locations with preference placed on buildings and towers located on county or local lands. Radio subscriber units should comply with Federal Information Processing Standards (FIPS) 140-2 Level 3 specifications for encryption management.	Neither design concept has an advantage regarding security.	The features of encryption and authentication can be supported independent of the use of one or two simulcast zones as can the hardening of radio sites and interconnection networks. The provision of FIPS 104-2 Level 3 is a function only of subscriber radios (not infrastructure).
Maintenance, Monitoring, and Reporting		
Waukesha County and Milwaukee County: A replacement trunked radio system should provide and/or support tools and processes that comply with the "FCAPS" model for Fault, Configuration, Accounting, Performance, and Security (FCAPS) management. A replacement trunked radio system (or systems) should provide the following FCAPS functionalities: Fault Management • View system, component, link, or other faults with identification of the failed item, the time of the failure, and the location of the failure • View, sort, and clear fault alarms (including historical alarms) • Configure alarms (severity levels) and alarm processing routines (send pages, emails, etc.) Configuration Management • Add a new subscriber to the system (including addition of the subscriber ID and association of IP address) • Define an 'alias' for a new subscriber • Create a new talkgroup and assign subscribers to that talkgroup • Assign priorities to both individual subscribers and talkgroups • Define and change 'feature profiles' for subscribers (including abilities/inabilities for private calls, encryption, etc.)	The design concept of "One Massive Simulcast" system has an advantage regarding maintenance, monitoring, and reporting.	Because "One Massive Simulcast" system would operate as one unified system, there would be less to configure and monitor (including the absence of a second Zone Controller).



Suggested Performance Criteria of Replacement System	Advantage Held by Either Design Concept?	Justification
• Define radio consoles and assign talkgroups and conventional channels as resources to those consoles • Define permissions for subscriber radios that establish the sites on which they are allowed and not allowed to access • Support typical subscriber radio programming features including centralized management of radio programming files <u>Accounting Management</u> • View and print or export data on usage (number of transmissions and combined length of airtime) for individual units or ranges of units <u>Performance Management</u> • View all subscribers enabled on the system including their status and their system configuration parameters • Define the operational parameters for emergency call modes (preemption vs 'top of queue') • Develop reports on the utilization levels of network control subsystems and individual radio systems (sites) in order to determine the need for additional resources (additional channels, sites, etc.) • Allow initiation of P25 functions such as Radio Check • Dynamically regroup subscribers into new talkgroups including the ability to create, store, activate, and deactivate storm plans that affect many subscribers. <u>Security Management</u> • Inhibit subscriber radios from operation on the entire system (all sites) and in such a way that the subscriber radio remains entirely inoperable until/unless it receives a "uninhibit" (allow operation) command from the system • Set authentication keys and other provisioning details regarding authentication and encryption Additionally, the provisioning and programming of subscriber radios should include the use of a software program and a hardware-based advanced system key. Users that attempt to program a subscriber radio without the hardware-based advanced system will be allowed limited and controlled access to the portions of the radio's configuration that they can view and change.		
Licensing		
<u>Waukesha County and Milwaukee County:</u> A replacement trunked radio system will require the licensure of sufficient number of channels across the entire service area of Waukesha and Milwaukee Counties.	The design concept of " <u>Two Separate Zones</u> " has an advantage regarding licensing.	Region 54's allocations of 700MHz and 800MHz spectrum



Alternatives for Other, Non-Trunked Radio Systems

As is noted above, there are several non-trunked radio systems that provide critical functionality and that must be analyzed when evaluating replacement trunked radio systems for Waukesha and Milwaukee County systems. Whereas the existing Waukesha County trunked radio system carries the City of Muskego's siren control/telemetry information and the Knox Box signaling used by fire departments across Waukesha County on dedicated analog talkgroups, such signals are incompatible with P25, digital trunked systems. This is because P25 digital trunked radios sample and digitize audio inputs (before transmission) in ways that would not produce acceptable receiver outputs for siren and Knox Box tones. To date, there are no solutions available to carry either the siren alerting or Knox Box signaling on P25 trunked talkgroups. Therefore, some analog-based solution must be continued or established in order to carry signals of these systems across Waukesha County.

One alternative would be to deploy one or more new VHF analog channels, in a conventional simulcast configuration, to support siren and Knox Box operations, however, VHF channels are more prone to interference than 800MHz channels and, if VHF channels were used, the existing 800MHz analog-capable radios could not be reused.

Another alternative would be to deploy a similar conventional simulcast system using 700MHz channels, however, while such an approach would reduce the possibility of the interference associated with VHF channels, it would not still require replacement of the existing 800MHz analog-capable radios used in the applications of siren and Knox Box operations.

A viable solution exists to deploy a conventional simulcast system using one or

more 800MHz channels to carry the City of Muskego's siren alerting and countywide Knox Box signaling. Doing so would allow reuse of the existing 800MHz analog-capable radios. [Note: This approach of deploying a dedicated, analog, 800MHz, conventional, simulcast system for siren alerting and Knox Box is used by Calumet and Winnebago Counties (who recently transition to an 800MHz P25 trunked simulcast system). Those Counties also use the 800MHz analog conventional system as a backup in the event of the total failure of their P25 trunked simulcast system.]

The deployment of a new digital, P25 trunked radio system should not affect the North Shore fire department's use of its Mobex Digital Vehicular Repeater System (DVRS) as those devices are currently operating on the single-site Project 25 radio system that is located at Channel 58 and that is tied into Milwaukee County's larger, existing analog, trunked simulcast radio system.

Conceptual Design Alternatives: Summary/Key Findings

The following summary includes the key findings from this Report section on Conceptual Design Alternatives:

Key Findings: Conceptual Design Alternatives

	A replacement system (or systems) should continue to use a 800MHz, trunked, simulcast architecture
	Two main alternative design concepts exist: "One Massive Simulcast" and "Two Separate Zones" and either alternative can be used to meet coverage criteria
	The transition to P25 Phase I should not introduce new problems to coverage and alternate sites can be used to resolve existing coverage problems but they will need further analysis in order to prevent the creation of new problems



Key Findings: Conceptual Design Alternatives

	The "One Massive Simulcast" system concept has advantages regarding internal interoperability and maintenance, monitoring, and reporting while the "Two Connected Zones" concept has advantages regarding capacity, reliability, and licensing (but neither concept has a distinct advantage regarding coverage, capabilities, external interoperability, or security)
	The transition to P25 Phase II may introduce coverage problems and will require the analysis of new/additional

Key Findings: Conceptual Design Alternatives

	sites and/or the use of diversity receive antennas at existing sites
	Analog conventional 800MHz channels will be required in Waukesha County to provide radio transport for non-voice applications

Replacement System Deployment Issues

Backhaul Analysis

As is noted above, the current radio systems used by both Waukesha and Milwaukee Counties utilize different technologies for site-to-site backhaul links.

Waukesha County currently utilizes digital microwave links in a star configuration radiating from the prime site at the Waukesha County Radio Services location and with hot-standby equipment for each path. The microwave links are in the 6 and 11 GHz range with equipment from Ceragon Networks, Inc. All paths have a total available bandwidth of 45 Mbps and, although they are not currently configured for such operation, they can be subdivided into two separate networks. Each path can carry up to 8 T1 circuits however only one or two of the T1's are used to each site. One T1 is used to sites that have only 800MHz equipment (Delafield and Menomonee Falls) and two T1's are used to sites that have both 800MHz and VHF (siren alerting, etc.) equipment (Brookfield, New Berlin, Eagle, and Nashota). Private fiber, backed by leased T1 lines with auto hot standby switching, are used

to connect to the Waukesha County Communications dispatch center.

Waukesha County's existing backhaul has sufficient bandwidth to accommodate the migration to a replacement Project 25 trunked simulcast radio system. New links would need to be deployed to connect any new sites and the existing channel banks (Motorola TENSr) would need to be retained in order to support the VHF systems.¹⁰

Milwaukee County currently utilizes leased T1 circuits to interconnect its radio sites to the prime site at Muirdale. Leased T1 circuits are also used to connect the Muirdale site to the wireline dispatch center at Milwaukee County Sheriff which houses a Motorola Embassy Switch to allow interconnection of multiple dispatch positions and locations. Leased T1 circuit then connects the wireline dispatch center at the Milwaukee County Transit System

¹⁰ Waukesha County has noted that new time standards would need to be deployed for the existing channel banks due to continued failures of the existing Efratom equipment which currently supply the time standard.



headquarters location (and other wireline dispatch operations such as Milwaukee County EMS Coordinators and local municipality dispatch centers) to the Embassy Switch at the Milwaukee County Sheriff's facility.

Milwaukee County is in the planning stages of implementing new, digital microwave that will replace its existing leased T1's. Different topologies are being considered including multiple rings that all interconnect at the prime site at Muirdale (i.e., a "north ring", an "east ring", and a "south ring") and that use a mix of 6GHz and 11GHz spectrum. The bandwidth of this new microwave network has yet to be determined but it is expected that it would have bandwidth capabilities that are at least equivalent to that of Waukesha County (i.e. at least 45 Mbps).

In planning for a new digital microwave backhaul system to support a P25 trunked simulcast radio system, it is important to note that most radio vendors now support, and even prefer, IP/Ethernet-based backhaul links over those that are T1-based. Research in the requirements that radio vendors have on such IP/Ethernet-based links shows that the following specifications should be met: i) radio vendors typically require less than 30 mS of round-trip latency between a prime site and a remote radio site (however most vendors can accommodate latency values of up to 80 to 100 mS), ii) radio vendors typically require packet loss of less than 1% in order to ensure acceptable audio quality, and iii) the following bandwidths are required for various types of connections:

Connection Type	Bandwidth Required
Master Site to Master Site	Approximately 4.5 Mbps
Master Site to Simulcast Prime Site (for a 15 channel simulcast zone)	Approximately 900Kbps
Simulcast Prime Site to Simulcast Remote Site	Approximately 900Kbps
Master Site to Dispatch Center (9 active positions)	Approximately 1.5Mbps

Options for Legacy System and Console Reuse

The diagrams shown above include optional 'legacy interfaces' to connect the existing Waukesha County and Milwaukee County trunked radio systems into a replacement P25 trunked simulcast system. This legacy radio system interface is available from Motorola Solutions Incorporated under the SmartX brand name and it can be used to connect a legacy SmartZone™ radio system to a Motorola P25-based ASTRO25® system. The SmartX interface allows interoperability between Motorola P25 ASTRO25® and SmartZone™ systems by allowing the SmartZone™ system (which is not P25-based) to interface to the ASTRO25® Master Site and to operate with that Master Site just as a true P25 zone would.

The SmartX interface will not interconnect a legacy Motorola SmartZone™ system to a replacement P25 trunked simulcast system provided by a vendor other than Motorola. The existing Waukesha County and/or Milwaukee County SmartNet II+ trunked radio systems would need to be first upgraded to SmartZone™ before the SmartX interface could be used to interconnect either of them to a new P25-based ASTRO25® Master Site.

The benefit to using SmartX is that, if a Motorola P25-based ASTRO25® system were



deployed as the replacement P25 trunked radio system, one of both of the exiting radio systems could be interconnected to it. This would allow for a transition period in which both the legacy and the replacement systems are operational and interconnected. User agencies that do not have P25-based subscriber radios could continue to use their existing SmartNet II+ radios until they can afford to purchase new radios while remaining in contact with those user agencies that have fully transitioned to P25.

The detriments to such an approach are: i) the extra costs required for both SmartX and the initial upgrade of the existing systems to SmartZone and ii) the extra planning, coordination, and maintenance required to operate both the existing and replacement systems which can be more challenging if the replacement system is to use the same frequencies as the existing system.

Additionally, the diagrams shown above also include an optional interface to interconnect the Milwaukee County Embassy Switch into a replacement P25 trunked simulcast system. This legacy Embassy Switch interface is available from Motorola Solutions Incorporated under the "Motorola Gold Elite Gateway" (or "MGEG") brand name and, like SmartX, it will only operate with a replacement P25 trunked system that is procured from Motorola. Also like the SmartX interface, the MGEG can be used to allow the existing dispatch consoles to interface to a Motorola ASTRO25® Master Site. This would allow the legacy consoles to operate with a new P25 trunked radio system (albeit only one from Motorola) until new, IP-based consoles are procured.

As with SmartX, the MGEG has the detriments of involving additional cost and requiring additional planning, configuration, and maintenance.

Possible Reuse of Other Existing Assets

Each of the two Counties' trunked radio systems includes numerous components and subsystems that interact to provide the users with radio communications services. Much of that equipment will need to be directly replaced as those systems are replaced. This is due to the fact that the existing equipment is both obsolete and incapable of providing solutions to the unmet needs of users as identified throughout this Report. Two subsystems of each radio system may be considered for reuse in the deployment of future radio systems at adult institutions and they are: i) the antenna subsystems (including transmit and receive antennas, antenna line, multicouplers, combiners, and lightening suppression equipment) and ii) the radio power subsystems including backup batteries/universal power supplies.

As is described above, a dedicated, analog, 800MHz, conventional, simulcast system should be considered to carry siren alerting and Knox Box signaling in Waukesha County. Such a system could reuse existing repeaters and voting/distribution equipment.

Although the existing antenna subsystems may be entirely compatible with any new 800MHz trunked radio systems to be deployed at adult institutions, it is recommended that no such equipment be reused. The existing antenna subsystems are likely to be of the same age as the existing systems (over 15 years old) and they may suffer from degradation in performance due to such causes as corrosion and general wear. Additionally, the vendor of any new 800MHz P25 trunked radio systems may not provide a full coverage guarantee for their new system if the existing antenna subsystems are reused.

The power subsystems at radio sites could be considered as viable candidates for reuse with replacement 800MHz trunked radio systems,



however, only after inspection of each can verify that such equipment is both in good working order and of the size (power rating) required by the new equipment.

The assets of the non-trunked radio systems (800MHz and UHF analog conventional radio systems) should likewise be considered as viable candidates for reuse but only after inspection can verify that such equipment is in good working order and can be maintained in a cost effective manner.

Implementation Approaches: Non-Phased vs Phased

It is understood that Waukesha and Milwaukee Counties have different funding situations: that Waukesha County has availability to all funds required to implement their 'portion' of either the "One Massive Simulcast" or "Two Connected Zones" concepts in one deployment phase in 2013 but that Milwaukee County will receive funds on an annual, partial basis between the years of 2013 and 2017, thus requiring a multi-year, multi-phase approach to deploy either alternative design concept.

The deployment of the Waukesha County portion of the system would occur in one overall phase in which the new shared Master Site would be readied, the new radio sites deployed and interconnected to the Master Site, the dispatch consoles replaced/upgraded to IP-based technology and interconnected to the Master Site, and all user radios are upgraded or replaced to operate on a P25 digital trunking system. Transition would occur by operating both the existing system and the replacement system in parallel, transferring users one agency at a time from existing to replacement system, steadily increasing the number of channels used in the replacement system while simultaneously decreasing the number of channels used in the existing system. These activities would take place if either the "One Massive Simulcast" or "Two Connected Zone" concept is selected. (In the

former, the radio sites would connect to the one Prime Site controller that is shared by both Counties and, in the later, the radio sites would connect to a Prime Site controller that is used only by Waukesha County's radio sites.)

The phased deployment of the Milwaukee County portion of the replacement system is more complex. It must account for the need to match Waukesha County's non-phased deployment plan (i.e., it must not impede that plan) while making sure that expenses are made in increments that meet the anticipated funding stream and maximizing the benefit to Milwaukee County users in each phase. Details on the costs of each of the following phases are contained in subsequent sections of this report, however, the following table lists a suggested 5-phase (5-year) deployment plan for Milwaukee County's portion of the shared replacement trunked radio system.

Milwaukee County Project Phase & Main Activities	Rationale
Year 0 – Deploy New Microwave	This is a committed project for 2012 that will eliminate the on-going costs of the leased T1 backhaul circuits.
Year 1 – Purchase Milwaukee County's Share of Master Site and Begin Replacing Subscriber Radios (Included in this Phase is the optional deployment of a legacy system interface and a legacy console interface)	This is required to support Waukesha County's deployment that will utilize the same Master Site. (The optional legacy system interface would allow users of the Milwaukee County radio system to interoperate with Waukesha County users while the legacy console interface would support connection of the existing consoles to the new Master Site.) The ongoing replacement of subscriber radios will: i) address user requirements for new



Milwaukee County Project Phase & Main Activities	Rationale
	radios and ii) prepare users for the upcoming conversion to the P25 trunked system.
Year 2 – Upgrade Dispatch Consoles (to IP technology), Remediate Radio Sites, Begin Purchases/ Deployments of Radio Site Equipment, and Continue Replacing Subscriber Radios	The console upgrades are required to replace the aging dispatch consoles with those that support IP interconnections to the Master Site. The remediation of radio sites would address any site or tower construction work that is needed to properly house the new equipment. If the “Two Connected Zone” concept is selected, the initial purchases of radio site equipment could be deployed in a way that provides full coverage from a limited-capacity system (e.g., a 9 site, 4 channel system to be used by selected user agencies). If the “One Massive Simulcast” concept is selected, the initial purchases of radio site equipment could be held for future deployment when sufficient equipment to provide uniform capacity across both Counties is procured.
Year 3 – Complete Purchasing/ Deploying Radio Site Equipment and Continue Replacing Subscriber Radios	This phase would involve completion of the full set of radio sites (full coverage, full capacity) required to deploy either the “One Massive Simulcast” or “Two Connected Zones” concepts

Milwaukee County Project Phase & Main Activities	Rationale
Year 4 – Finalize Replacements of Subscriber Radios	This phase will complete the transition of all users to the new trunked radio system and would include the decommissioning of the legacy system interface, if it were deployed.

Implementation Impact to Dispatch Consoles

Many of the dispatch consoles in use in Waukesha County and Milwaukee County; including at the Waukesha County Communications center, the Milwaukee County Sheriff's Department Dispatch Center, and the Milwaukee County Transit System's Dispatch Center; are Motorola CentraCom Gold Elite. This model of dispatch centers are no longer in production and Motorola has announced that they will no longer sell many of the replacement parts required to provide service to these products. Therefore, both Counties should plan on replacing their dispatch consoles soon and as an initial step in the deployment of a replacement system (or systems).

For Waukesha County, this will mean that dispatchers would need to operate both existing and replacement consoles during a transition period and that dispatch console patches would be used to provide the necessary connectivity between users of the existing and replacement radio systems.

As is noted in the phased deployment plan for Milwaukee County described above, the upgrade of the dispatch consoles would occur in Year 2, after the deployment of the Master Site but before the implementation of replacement P25 trunked simulcast radio sites. In order to interface the existing consoles (which interconnect via a Motorola Embassy Switch) to the P25 Master Site, a legacy console interface (MGE) would be required



until all CentraCom Gold Elite consoles are replaced by IP-based dispatch consoles

In addition to these CentraCom Gold Elite wireline consoles, many local dispatch centers use wireless (control-station) links to connect to the radio system. In deploying a new P25 trunked simulcast system, the control stations that provide the links for these dispatch centers would need to be replaced with P25-capable radios.

Implementation Impact to Subscriber Radios

The deployment of a P25 Phase I trunked simulcast radio system would have a significant impact on the subscriber radio fleets in use by Waukesha County and Milwaukee County.

Records of Waukesha County's existing fleet of approximately 4,500 user radios show that approximately 2,700 can be reconfigured by software ("flashed") to support P25 capabilities. Similarly, Milwaukee County records show that of the approximately 4,150 total subscriber radios currently in use on the system, an estimated 1,000 could be reconfigured by software ("flashed") to support P25 capabilities. For both Counties, those radios that cannot be reconfigured by software to support P25 would need to be replaced.

Frequency Licensing Considerations

This Report includes the recommendation that Waukesha and Milwaukee County continue to use 800MHz spectrum for the replacement P25 trunked simulcast system. This recommendation is made because: i) the Counties currently hold licenses in this spectrum, ii) the users of the Counties' systems currently own subscriber radios that are capable of 800MHz operation, iii) there are at least 42 800MHz-based bidirectional amplifiers in Waukesha County and approximately 31 such devices in Milwaukee County that could continue service with little or

no impact, and iv) beyond the recently completed rebanding initiative, there are no announced requirements for reconfigurations (such as narrowbanding) for this band of channels. (Regarding the later concern: the 700MHz public safety voice band, in contrast, must be narrowbanded to transition from use of 25KHz to 12.5KHz channels by 2017. Such a transition to narrowbanded channels in the 700MHz band would require deployment of P25 Phase II technology. Issues with such a transition are described below.)

Waukesha County currently holds licenses for 13 pairs of 800MHz channels (and licensees for an additional 3 simplex 800MHz frequencies) while Milwaukee County holds licenses for 14 such pairs. The total number of channels required for the replacement system will be determined once peak-hour load analyses determine the total capacity requirement and once a determination is made to deploy either the "One Massive Simulcast" or "Two Connected Zones" concept. It is not, however, expected that a significant number of additional channels will be required by either County.

Initial, informal discussions with Region 54 of the FCC's Regional Planning Committee has identified that a limited number of 800MHz channels could be available to Waukesha and Milwaukee Counties, provided they meet the Regions' and the FCC's rules for loading and other technical and project-related factors.

Region 54 of the FCC's Regional Planning Committee has also stated that both Waukesha and Milwaukee Counties have an initial allocation of 18 pairs of 700MHz public safety voice frequencies but that 4 of Milwaukee County's pairs have been allocated to the City of Milwaukee for use in their OpenSky® radio system (specifically for use with Digital Vehicle Repeater Systems, or DVRSSs, that provide a "bridge" between the OpenSky® radio system



radio system and channels used for on-scene, tactical operations).

Waukesha and Milwaukee Counties should consider channels from their allocation of 700MHz public safety voice channels for use in special applications or for future expansions. Examples of the special applications could include use as backhaul channels to connect DVRTS units used with the replacement P25 trunked simulcast system or as analog, conventional channels for use with siren-alerting, telemetry, or other similar technologies.

Future (P25 Phase II) Migration Concerns

Migration beyond the initial deployment of a 800MHz P25 Phase I trunked simulcast system that is designed per either the "One Massive Simulcast" or "Two Connected Zones" concepts is possible but requires technical analysis and planning.

A likely migration would be to Project 25 Phase II which uses Time Division Multiple Access technologies to support two talkpaths in one channel (including in one 12.5 KHz narrowbanded channel). Such a migration would bring the benefit of essentially doubling the capacity of the system (by doubling the number of talkpaths per channel).

As in shown in Maps W.7 and M.6 in Appendix C, a transition to P25 Phase II would cause degradation in coverage (as compared to P25 Phase I performance), especially in Waukesha County which uses greater separation between sites than does Milwaukee County. The maps do not represent the coverage that would be produced if diversity receivers and antennas were used at radio sites, a practice recommended by some vendors. Should a migration to P25 Phase II be considered, it would likely require the addition of diversity receivers and antennas at radio sites and/or the addition of approximately 3 to 4 additional

sites in Waukesha County and the possible addition of 1 site in Milwaukee County.

Additionally, as noted above, some of the subscriber radios in Waukesha and Milwaukee Counties can be upgraded to P25 Phase I operations, however, only a very small number are capable of operations on a P25 Phase II system. In both Waukesha County, less than 100 of the existing fleet are capable of operating on a Phase II system and it is expected that fewer than 200 radio currently operating on Milwaukee County's radio system have the same, P25-Phase-II capability.

Impact to Shared-Asset Governance

In both design concepts, the replacement public safety radio communications system will utilize some shared assets (including a shared Master Site Controller and, possibly, a shared Prime Site Controller) which shall be jointly owned and operated by both Counties. Therefore, a governance model is required to define how the share assets will be funded, owned, used, operated, and maintained by Waukesha and Milwaukee Counties.

It is also assumed that each County will individually fund, own, operate, maintain, and be generally responsible for its own set of radio sites, one or more dispatch centers, and a network of backhaul links (including those that directly or indirectly interconnect connect sites-to-sites, sites-to-shared-core, and dispatch-centers-to-core). The shared-asset governance model will not address those assets owned and operated by only one County.

The selection of the "One Massive Simulcast" or "Two Connected Zones" concept will have a limited effect on shared-asset governance. Because both concepts include some shared assets, the general structures of the governance model for each will have common components and tenants. The "Two Connected Zones" concept, would, however



have a slight advantage regarding governance as such a system would be easier to 'dismantle' in case of separation.

Replacement System Deployment Issues: Summary/Key Findings

The following summary includes the key findings from this Report section on Replacement System Deployment Issues:

Key Findings: Replacement System Deployment Issues	
	Waukesha County's existing digital microwave system should be sufficient to meet the backhaul requirements of its portion of the replacement P25 trunked simulcast system. Likewise, the digital microwave system being planned by Milwaukee County should be sufficient to meet the backhaul requirements of its portion of the replacement P25 trunked simulcast system. Modifications would be required if alternate sites are used.
	Legacy interfaces are available to interconnect the existing Motorola trunked radio systems and dispatch consoles to the replacement P25 trunked radio system but only if the system is also provided by Motorola.

Key Findings: Replacement System Deployment Issues

	Milwaukee County can prepare a phased implementation plan that meets the availability of its funding for a replacement P25 trunked system and that does not greatly impact Waukesha County's plans for an "all-at-once" implementation.
	Because of their age and lack of manufacturer support, the existing CentraCom Gold Elite dispatch consoles should be among the first items replaced by both Counties.
	Some of the subscriber radios in use on both the existing Waukesha and Milwaukee County systems can be software "flashed" to support Project 25 Phase I operations but most will need to be replaced. (Very few will be able to support Project 25 Phase II operations.)
	A future migration to Project 25 Phase II will have a negative impact on coverage (and will require the addition of equipment and/or sites), however, the timing of a future migration to Project 25 Phase II can be controlled by continued use of 800MHz spectrum.



Capital and Operational Budget Analysis

Budget Analysis Methodology

In order to complete the analysis of the two main alternative design concepts ("One Massive Simulcast" and "Two Connected Zones"), their costs, and the costs of variations from them, must be developed. To this, this section of this Report assembles budgetary cost estimates in the following categories:

Category	Values
Cost Owner	Waukesha County, Milwaukee County, or Shared
Cost Type	Capital Cost (a.k.a., "one time" or "project" costs) or Operational Cost (a.k.a., "on-going" or "operations-and-maintenance" costs)
Expense Type	Master Site Controller, Prime Site Controller, Dispatch Consoles, Dispatch Center Equipment (logging recorders, control stations, etc.), Radio Site Remediation (civil repairs, etc.), Radio Site Equipment, Backhaul/Networking Equipment, Subscriber Equipment, and Miscellaneous (contingencies, permits, studies, temporary help, etc.)
Cost Year	Year 0 (current year), Year 1 (deployment year), Year 2 (first operational year), etc.

The cost data used to populate the budgetary cost estimates is derived from a number of

sources including: i) proposed pricing that vendors have recently submitted to other public safety radio communications project of similar scope and ii) cost information provided by vendors to Waukesha and Milwaukee Counties.

All cost figures include the equipment's hardware and software costs as well as typical service costs for programming, installation, optimization, and testing.

It is expected that the amounts shown are budgetary in nature and in the range of -10%/+20% from the actual cost values required to deploy the system (i.e., the budgetary estimates are between 10% lower to 20% higher than actual vendor amounts).

Additionally the amounts included for subscriber costs include the total amounts estimated to either replace or "flash" upgrade all subscriber radios that will be used on the system (not just those owned by the County-level agencies). The total number of radio subscriber units to be replaced and "flash" upgraded by Waukesha County and Milwaukee Counties are: 1,800 replaced, 2,700 flashed for Waukesha County and 2,070 replaced and 1,000 flashed for Milwaukee County.

Capital and Operational Budgetary Cost Estimates for the "One Massive Simulcast" Concept

The end result of the "One Massive Simulcast" concept will be a system that includes the following configurations for the various types of equipment:



Equipment Type	"One Massive Simulcast" Configuration
Master Site Controller	One shared Master Site Controller with ISSI, OTAR, network management capabilities
Prime Site Controller	One shared Prime Site Controller
Dispatch Consoles	New dispatch consoles at the Waukesha County Communications center (16), the Milwaukee County Sheriff's Department (12), the Milwaukee County Transit System (5), and the Milwaukee County EMS facility (4)
Dispatch Center	One logging recorder (for Milwaukee County) with control stations to be provided to local agencies in Milwaukee County (not Waukesha County) for wireless dispatch connectivity
Site Remediation	Typical site improvements at 17 total sites (8 in Waukesha County, 9 in Milwaukee County) with development of two new at a sites (Vernon Town Hall and Merton Fire Department) and significant improvements to towers and/or shelters at Donna Drive, Brown Deer, Lakeshore Tower
Radio Site Equipment	A radio network with 22 channels (including new site networking, backup battery, and antenna systems) at each of 18 sites. The sites to be used are the existing 7 sites in Waukesha County plus two new sites (at Vernon Town Hall and Merton Fire Department) (9 total Waukesha County sites) and the existing 9 Milwaukee County sites (all operating as full TX/RX sites). Additionally, a single-channel, analog conventional simulcast subsystem is included for Waukesha County (for siren-alerting, etc.) <u>NOTE: Because all sites must have the same number of channels in this design concept, no site can be operationally deployed until it is equipped with all 22 channels. Therefore, the Radio Site Equipment purchases made in Year 2 will likely not be deployed until the balance of the Radio Site Equipment Purchases are made in Year 3.</u>
Backhaul	Two new digital microwave hops for Waukesha County (to link the new sites at Vernon Town Hall and Merton Fire Department) and an new 11-hop microwave backhaul system for Milwaukee County (which includes a hop from Milwaukee County to the shared Master Site equipment to be housed in Waukesha County)
Subscribers	1,800 replaced, 2,700 flashed radio subscriber units (plus 35 control stations for wireless dispatch centers) for Waukesha County and 2,070 replaced and 1,000 flashed radio subscriber units for Milwaukee County – all capable of Project 25 Phase I operation with encryption, authentication, and accessories.
<i>The expense type of Miscellaneous (or "Misc") includes Spectrum Licensing, Permits & Studies, Temp Help, and Contingencies.</i>	

The following tables show the capital and operational budgetary cost estimates for the "One Massive Simulcast" design concept. These estimates are based on the assumptions that Waukesha County will implement its portion of the entire system in one year (in one deployment phase) and that Milwaukee County will implement its portion of the system in the 5-year, phased approach described above.

Operational costs take into account the fact that "Year 1" will be the 'implementation year' so there will not be maintenance costs for the radio system equipment (but there will be for microwave system equipment). "Year 1" will include costs for site leases and any continued charges for leased backhaul. (It is understood that Milwaukee County will continue to use leased backhaul as a backup method for



selected links in the newly-deployed microwave system.) The operational costs also take into account the fact that "Year 2" will be the 'warranty year' for the radio system equipment so there will not yet be costs for system software or hardware maintenance. In "Year 3" and beyond, full costs are incurred for radio system software upgrades and hardware maintenance. Additionally, operational costs are included for "Year 3" and beyond for regular upgrades to equipment not provided by the radio system vendor (such as IT/networking equipment or 3rd party reporting products) and for regular replacements for programming software and other maintenance tools.



"One Massive Simulcast" Concept - Capital Costs																				
Owner: Waukehsa County											Owner: Milwaukee County									
Expense Types										Cost Year	Expense Types									
Master Site	Prime Site	Dispatch Consoles	Dispatch Center	Site Remediation	Radio Site Expt	Backhaul	Subscribers	Misc	TOTAL		Master Site	Prime Site	Dispatch Consoles	Dispatch Center	Site Remediation	Radio Site Expt	Backhaul	Subscribers	Misc	TOTAL
										Year 0	Milwaukee County deploys a new 11 hop microwave backhaul network									
\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0									\$1,782,000		\$1,782,000
All equipment deployed in single implementation phase										Year 1:	Milwaukee County deploys its share of the shared "core" controllers (with ISSI, OTAR, legacy interfaces, & network management) & approx 25 subscribers									
\$879,000	\$402,900	\$1,699,000	\$0	\$1,075,000	\$5,841,200	\$297,000	\$12,395,000	\$947,700	\$23,536,800		\$879,000	\$636,900						\$100,000	\$233,900	\$1,849,800
										Year 2:	Milwaukee County deploys new dispatch consoles (9 positions for MCSO, 5 for MCTS, and 4 for MC-EMS), remediates sites (Lakeshore Towers & Brown Deer extensively) , purchases radio equipment for 4 channels at 9 sites, purchaes approx 40 subscribers									
													\$1,975,400	\$605,000	\$950,000	\$2,221,275		\$150,000	\$233,900	\$6,135,575
										Year 3:	Milwaukee County purchases radio equipment for 18 more channels at 9 sites, purchaes approximately 1,200 subscribers and "flashes" approximately 500 more									
																\$3,702,125		\$5,550,000	\$233,900	\$9,486,025
										Year 4:	Milwaukee County purchases approximately 1800 subscribers and "flashes" approximately 500 more									
																		\$7,950,000	\$233,900	\$8,183,900
Totals by Expense Type										<< Expense Totals >>					Totals by Expense Type					
\$879,000	\$402,900	\$1,699,000	\$0	\$1,075,000	\$5,841,200	\$297,000	\$12,395,000	\$947,700	\$23,536,800		\$879,000	\$636,900	\$1,975,400	\$605,000	\$950,000	\$5,923,400	\$1,782,000	\$13,750,000	\$935,600	\$27,437,300
Total for Waukesha County										<< Owner Totals >>					Total for Milwaukee County					
\$23,536,800											\$27,437,300									
Combined Project Total																				
\$50,974,100																				



"One Massive Simulcast" Concept - Operational Costs																		
Owner: Waukehsa County									Owner: Milwaukee County									
Expense Types									Expense Types									
Core Platform SW	System HW Maint	Site Leases	Site Utilities	Site Upkeep	Leased Backhaul	Non-Vendor Upgrades	Tools, Mgt SW	TOTAL	Cost Year	Core Platform SW	System HW Maint	Site Leases	Site Utilities	Site Upkeep	Leased Backhaul	Non-Vendor Upgrades	Tools, Mgt SW	TOTAL
System Implementation Period - Year 1 - System Implementation Period																		
\$0	\$18,000	\$0	\$7,200	\$4,500	\$7,200	\$0	\$0	\$36,900		\$0	\$31,000	\$125,000	\$8,100	\$4,500	\$12,000	\$0	\$8,000	\$188,600
System Warranty Period - Year 2 - System Warranty Period																		
\$0	\$18,000	\$0	\$7,560	\$4,500	\$7,200	\$0	\$0	\$37,260		\$0	\$139,300	\$125,000	\$8,505	\$4,500	\$12,000	\$0	\$8,000	\$297,305
Year 3																		
\$310,000	\$194,500	\$0	\$7,938	\$12,000	\$7,200	\$12,000	\$12,000	\$555,638		\$310,000	\$151,300	\$125,000	\$8,930	\$15,000	\$12,000	\$15,000	\$8,000	\$645,230
Year 4																		
\$316,200	\$198,390	\$0	\$8,335	\$4,500	\$7,200	\$15,000	\$12,000	\$561,625		\$316,200	\$261,300	\$125,000	\$9,377	\$4,500	\$14,000	\$15,000	\$8,000	\$753,377
Year 5																		
\$322,524	\$202,358	\$0	\$8,752	\$4,500	\$7,200	\$12,000	\$12,000	\$569,333		\$322,524	\$266,526	\$125,000	\$9,846	\$4,500	\$14,000	\$15,000	\$8,000	\$765,396
Year 6																		
\$328,974	\$206,405	\$0	\$9,189	\$12,000	\$7,200	\$12,000	\$12,000	\$587,769		\$310,000	\$151,300	\$140,000	\$10,338	\$15,000	\$14,000	\$15,000	\$8,000	\$663,638
Year 7																		
\$335,554	\$210,533	\$0	\$9,649	\$4,500	\$7,200	\$15,000	\$14,000	\$596,436		\$316,200	\$261,300	\$140,000	\$10,855	\$4,500	\$14,000	\$17,500	\$10,000	\$774,355
Year 8																		
\$342,265	\$214,744	\$0	\$10,131	\$4,500	\$7,200	\$12,000	\$14,000	\$604,840		\$322,524	\$266,526	\$140,000	\$11,398	\$4,500	\$14,000	\$17,500	\$10,000	\$786,448
Year 9																		
\$349,110	\$219,039	\$0	\$10,638	\$12,000	\$7,200	\$12,000	\$14,000	\$623,987		\$310,000	\$151,300	\$140,000	\$11,967	\$15,000	\$14,000	\$17,500	\$10,000	\$669,767
Year 10																		
\$356,093	\$223,419	\$0	\$11,170	\$4,500	\$7,200	\$12,000	\$14,000	\$628,381		\$316,200	\$261,300	\$140,000	\$12,566	\$4,500	\$14,000	\$17,500	\$10,000	\$776,066



Capital and Operational Budgetary Cost Estimates for the "Two Connected Zones" Concept

The end result of the "Two Connected Zones" concept will be a system that includes the

following configurations for the various types of equipment (note that differences between this concept and that of "One Massive Simulcast" concept are shown in bold font):

Equipment Type	"Two Connected Zones" Configuration
Master Site Controller	One shared Master Site Controller with ISSI, OTAR, network management capabilities
Prime Site Controller	Two, separately owned and operated prime site controllers
Dispatch Consoles	New dispatch consoles at the Waukesha County Communications center (16), the Milwaukee County Sheriff's Department (12), the Milwaukee County Transit System (5), and the Milwaukee County EMS facility (4)
Dispatch Center	One logging recorder (for Milwaukee County) with control stations to be provided to local agencies in Milwaukee County (not Waukesha County) for wireless dispatch connectivity
Site Remediation	Typical site improvements at 17 total sites (8 in Waukesha County, 9 in Milwaukee County) with development of two new sites (at Vernon Town Hall and Merton Fire Department) and significant improvements to towers and/or shelters at Donna Drive, Brown Deer, Lakeshore Tower
Radio Site Equipment	Two connected radio networks: i) a Waukesha County radio network with 15 channels (including new site networking, backup battery, and antenna systems) at each of 9 sites and ii) a Milwaukee County radio network with 18 channels (including the same items) at each of 9 sites. The sites to be used are the existing 7 sites in Waukesha County plus two new sites (Vernon Town Hall and Merton Fire Department) (9 total Waukesha County sites) and the existing 9 Milwaukee County sites (all operating as full TX/RX sites). Additionally, a single-channel, analog conventional simulcast subsystem is included for Waukesha County (for siren-alerting, etc.) <u>NOTE: Unlike the "One Massive Simulcast" concept, this concept can support differing number of channels in the two simulcast zones. Therefore, the Radio Site Equipment purchases made in Year 2 can be deployed immediately.</u>
Backhaul	Two new digital microwave hops for Waukesha County (to link the new sites at Vernon Town Hall and Merton Fire Department) and an new 11-hop microwave backhaul system for Milwaukee County (which includes a hop from Milwaukee County to the shared Master Site equipment to be housed in Waukesha County)
Subscribers	1,800 replaced, 2,700 flashed radio subscriber units (plus 35 control stations for wireless dispatch centers) for Waukesha County and 2,070 replaced and 1,000 flashed radio subscriber units for Milwaukee County – all capable of Project 25 Phase I operation with encryption, authentication, and accessories.
<i>The expense type of Miscellaneous (or "Misc") includes Spectrum Licensing, Permits & Studies, Temp Help, and Contingencies.</i>	



The following tables show the capital and operational budgetary cost estimates for the "Two Separate Zones" design concept. These estimates are based on the same assumptions regarding non-phased and phased deployments for Waukesha and Milwaukee Counties, respectively. Likewise the same assumptions are made regarding the operational costs that will and will not occur in Years 1 and 2 of the operational period as well as the costs that will begin to incur in the following years.



"Two Connected Zones" Concept - Capital Costs

Owner: Waukesha County											Owner: Milwaukee County																		
Expense Types											Expense Types																		
Master Site	Prime Site	Dispatch Consoles	Dispatch Center	Site Remediation	Radio Site Eqpt	Backhaul	Subscribers	Misc	TOTAL	Cost Year	Master Site	Prime Site	Dispatch Consoles	Dispatch Center	Site Remediation	Radio Site Eqpt	Backhaul	Subscribers	Misc	TOTAL									
Year 0											Milwaukee County deploys a new 11 hop microwave backhaul network																		
\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0								\$1,782,000			\$1,782,000									
All equipment deployed in single implementation phase											Year 1: Milwaukee County deploys its share of the shared Master Site controller (with ISSI, OTAR, legacy interfaces, & network management), its own full Prime Site Controller, & approx 25 subscribers																		
\$879,000	\$765,800	\$1,699,000	\$0	\$1,075,000	\$4,417,000	\$297,000	\$12,395,000	\$947,700	\$22,475,500		\$879,000	\$999,800					\$100,000	\$233,900		\$2,212,700									
											Year 2: Milwaukee County deploys new dispatch consoles (9 positions for MCSO, 5 for MCTS, and 4 for MC-EMS), remediates sites (Lakeshore Towers & Brown Deer extensively) , purchases radio equipment for 4 channels at 9 sites, purchaes approx 40 subscribers																		
													\$1,975,400	\$605,000	\$950,000	\$1,135,911		\$150,000	\$233,900	\$5,050,211									
										Year 3: Milwaukee County purchases radio equipment for 14 more channels at 9 sites, purchaes approximately 1,200 subscribers and "flashes" approximately 500 more																			
																\$3,975,689		\$5,550,000	\$233,900	\$9,759,589									
										Year 4: Milwaukee County purchases approximately 1800 subscribers and "flashes" approximately 500 more																			
																		\$7,950,000	\$233,900	\$8,183,900									
Totals by Expense Type										<< Expense Totals >>										Totals by Expense Type									
\$879,000	\$765,800	\$1,699,000	\$0	\$1,075,000	\$4,417,000	\$297,000	\$12,395,000	\$947,700	\$22,475,500		\$879,000	\$999,800	\$1,975,400	\$605,000	\$950,000	\$5,111,600	\$1,782,000	\$13,750,000	\$935,600	\$26,988,400									
Total for Waukesha County										<< Owner Totals >>										Total for Milwaukee County									
\$22,475,500											\$26,988,400																		
Combined Project Total																													
\$49,463,900																													



"Two Connected Zones" Concept - Operational Costs

Owner: Waukehsa County									Owner: Milwaukee County								
Expense Types									Expense Types								
Core Platform SW	System HW Maint	Site Leases	Site Utilities	Site Upkeep	Leased Backhaul	Non-Vendor Upgrades	Tools, Mgt SW	TOTAL	Core Platform SW	System HW Maint	Site Leases	Site Utilities	Site Upkeep	Leased Backhaul	Non-Vendor Upgrades	Tools, Mgt SW	TOTAL
System Implementation Period - Year 1 - System Implementation Period									System Implementation Period - Year 1 - System Implementation Period								
\$0	\$18,000	\$0	\$7,200	\$4,000	\$7,200	\$0	\$0	\$36,400	\$0	\$31,000	\$125,000	\$8,100	\$4,500	\$12,000	\$0	\$8,000	\$188,600
System Warranty Period - Year 2 - System Warranty Period									System Warranty Period - Year 2 - System Warranty Period								
\$0	\$18,000	\$0	\$7,560	\$4,000	\$7,200	\$0	\$0	\$36,760	\$0	\$139,300	\$125,000	\$8,505	\$4,500	\$12,000	\$0	\$8,000	\$297,305
Year 3									Year 3								
\$370,000	\$184,500	\$0	\$7,938	\$12,000	\$7,200	\$12,000	\$12,000	\$605,638	\$370,000	\$151,300	\$125,000	\$8,930	\$15,000	\$12,000	\$15,000	\$8,000	\$705,230
Year 4									Year 4								
\$377,400	\$188,190	\$0	\$8,335	\$4,000	\$7,200	\$15,000	\$12,000	\$612,125	\$377,400	\$261,300	\$125,000	\$9,377	\$4,500	\$14,000	\$15,000	\$8,000	\$814,577
Year 5									Year 5								
\$384,948	\$191,954	\$0	\$8,752	\$4,000	\$7,200	\$12,000	\$12,000	\$620,853	\$384,948	\$266,526	\$125,000	\$9,846	\$4,500	\$14,000	\$15,000	\$8,000	\$827,820
Year 6									Year 6								
\$370,000	\$191,000	\$0	\$9,189	\$12,000	\$7,200	\$12,000	\$12,000	\$613,389	\$392,647	\$271,857	\$140,000	\$10,338	\$15,000	\$14,000	\$15,000	\$8,000	\$866,841
Year 7									Year 7								
\$377,400	\$194,820	\$0	\$9,649	\$4,000	\$7,200	\$15,000	\$14,000	\$622,069	\$400,500	\$277,294	\$140,000	\$10,855	\$4,500	\$14,000	\$17,500	\$10,000	\$874,648
Year 8									Year 8								
\$384,948	\$198,716	\$0	\$10,131	\$4,000	\$7,200	\$12,000	\$14,000	\$630,996	\$408,510	\$282,840	\$140,000	\$11,398	\$4,500	\$14,000	\$17,500	\$10,000	\$888,747
Year 9									Year 9								
\$392,647	\$202,691	\$0	\$10,638	\$12,000	\$7,200	\$12,000	\$14,000	\$651,175	\$416,680	\$288,496	\$140,000	\$11,967	\$15,000	\$14,000	\$17,500	\$10,000	\$913,644
Year 10									Year 10								
\$400,500	\$206,745	\$0	\$11,170	\$4,000	\$7,200	\$12,000	\$14,000	\$655,614	\$425,014	\$294,266	\$140,000	\$12,566	\$4,500	\$14,000	\$17,500	\$10,000	\$917,846



Capital Budgetary Cost Estimates for Additional Channels and Sites

The following matrixes show the capital costs associated with adding a new radio site and a new radio channel to the system as described above. The figures are based on the

assumption that the additions would be made to the "Two Connected Zones" concept and the tables include descriptions of the scope of the additions (in terms of the expense types described above):

Capital Costs For Additional Radio Site (based on "Two Connected Zones" concept)		
Equipment Type	Equipment/Services Included	Associated Costs
Master Site Controller	None	n/a
Prime Site Controller	Simulcast voter expansion, software upgrade to support additional site	\$125,000
Dispatch Consoles	None	n/a
Dispatch Center	None	n/a
Site Remediation	Construction of new shelter and new tower (assume 12x12 shelter with 150 to 170 ft tower)	\$475,000 total (includes \$100,000 for shelter, \$350,000 for tower, and \$25,000 for permits and studies; land acquisition costs excluded)
Radio Site Equipment	For Waukesha County, one radio site with 15 channels including 15 repeaters, 1 receive antenna and 2 transmit antennas, multicoupler and combiner systems, UPS, site networking equipment For Milwaukee County, same but with 18 channels and 18 repeaters	For Waukesha County: \$395,000 For Milwaukee County: \$452,000
Backhaul	One new digital microwave hop for to connect new site to Prime Site Controller	\$162,000
Subscribers	None	n/a
Miscellaneous	Spectrum licensing fees and contingencies	\$55,000
TOTALS		\$1,212,000 for Waukesha County \$1,269,000 for Milwaukee County



Capital Costs For Additional Radio Channel (based on "Two Connected Zones" concept)		
Equipment Type	Equipment/Services Included	Associated Costs
Master Site Controller	None	n/a
Prime Site Controller	Additional voter, software upgrade to support additional channel	\$225,000
Dispatch Consoles	None	n/a
Dispatch Center	None	n/a
Site Remediation	None (sites exist)	n/a
Radio Site Equipment	For Waukesha County, one repeater to be located at each of 9 sites and to use existing racks, antennas, multicoupler and combiner systems, UPS, and site networking equipment For Milwaukee County, same as above (one repeater to be located at each of 9 sites)	For Waukesha County: \$207,000 For Milwaukee County: \$207,000
Backhaul	None (use of existing capacity on existing backhaul)	n/a
Subscribers	None	n/a
Miscellaneous	Spectrum licensing fees and contingencies	\$35,000
TOTALS		\$467,000 for Waukesha County \$467,000 for Milwaukee County

Capital and Operational Budget Analysis: Summary/Key Findings

The following summary includes the key findings from this Report section on Capital and Operational Budget Analysis:

Key Findings: Capital and Operational Budget Analysis

☞	The capital costs for the "One Massive Simulcast" concept <u>are more</u> (approximately \$1.4M more in total) than those of the "Two Connected Zones" concept. This is due to the fact that the One Massive Simulcast" concept must include a significantly larger number of repeater stations and their cost more than offsets the cost of the two separate Prime Site Controllers that are included in the "Two Connected Zones" concept.
☞	The operational costs for the "One Massive Simulcast" concept <u>are less</u>

Key Findings: Capital and Operational Budget Analysis

	(approximately \$1.3M less in total over a 10 year period) than those of the "Two Connected Zones" concept. This is because of the cost savings associated with the platform software and hardware maintenance associated with the Prime Site Controller that is shared in the "One Massive Simulcast" concept.
☞	In considering the cost impacts of the two concepts, the Counties should consider the possible variability in the funding available from Milwaukee County. Because the "Two Connected Zones" concept does not mandate a uniform number of channels at all sites, it is more accommodating to variances in available funding.



Summary of Next Steps

The next steps for the "Consulting Services: Trunked Radio" project for Waukesha and Milwaukee Counties is to prepare a conceptual Infrastructure Design and an Implementation Roadmap. These two documents are to be based on the findings of this Phase 1 Study and are will lead to the Specifications of the Request for Proposal for a new trunked radio system for the Counties.

Based on the findings of this report, CDX Wireless recommends that the conceptual Infrastructure Design and Implementation Roadmap be based on the "Two Connected Zones" approach. While the "One Massive Simulcast" approach holds many technical and operational advantages, its higher cost, its lack of cost flexibility (the fact that all sites must be equipped with the same number of channels), and the potential for issues with licensing all make it less viable for non-technical reasons.



Appendix A – Agencies/Departments that Participated in Surveys & Interviews

- Agencies/Departments that Responded to the User Survey
 - o City of Bayside Police Department
 - o City of Brookfield Fire Department
 - o City of Brookfield Highway Department
 - o City of Brookfield Police Department
 - o City of Brookfield Water Utility
 - o City of Cudahy Fire Department
 - o City of Cudahy Police Department
 - o City of Delafield Police Department
 - o City of Franklin Police Department
 - o City of Glendale Police Department
 - o City of Greenfield Emergency Management
 - o City of Greenfield Health Department
 - o City of Greenfield Police Department
 - o City of Lisbon Fire Department
 - o City of Menomonee Falls Police Department
 - o City of Muskego Police Department
 - o City of Oconomowoc Parks, Recreation, and Forestry Department
 - o City of Pewaukee Police Department
 - o City of Pewaukee Water & Sewer Department
 - o City of South Milwaukee Fire Department
 - o City of South Milwaukee Fire Department Police Department
 - o City of St Francis Police Department
 - o City of Waukesha Engineering Division
 - o City of Waukesha Police Department
 - o City of Waukesha Water Utility
 - o City of Wauwatosa Police Department
 - o City of Wauwatosa Fire Department
 - o City of Wauwatosa Health Department
 - o City of West Allis Fire Department
 - o City of West Allis Police Department
 - o City of West Milwaukee Police Department
 - o Flight For Life
 - o Milwaukee County Behavioral Health Division
 - o Milwaukee County Department of Parks, Recreation, and Culture
 - o Milwaukee County Department of Transportation - Airport Division (GMIA & Timmerman)
 - o Milwaukee County District Attorney's Office
 - o Milwaukee County Fire Department
 - o Milwaukee County Sheriff's Office Emergency Management
 - o North Shore Fire Department



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- o Southridge Mall Public Safety Department
 - o State of Wisconsin ARES/RACES
 - o Town of Brookfield Buildings Inspection Department
 - o Town of Brookfield Police Department
 - o Town of Delafield Fire Department
 - o Town of Vernon Fire Department
 - o Village of Brown Deer Police Department
 - o Village of Chenequa Police Department
 - o Village of Elm Grove Police Department
 - o Village of Greendale Fire Department
 - o Village of Greendale Police Department
 - o Village of Hales Corners Fire Department
 - o Village of Hales Corners Health Department
 - o Village of Hales Corners Police Department
 - o Village of Hartland Police Department
 - o Village of Nashotah Police Department
 - o Village of Pewaukee Police Department
 - o Village of Shorewood Police Department
 - o Village of Sussex Police Department
 - o Village of Whitefish Bay Police Department
 - o Wales Genesee Fire Department
 - o Waukesha County Communications
 - o Waukesha County Department of Public Works
 - o Waukesha County Department of Public Works/Highway Operations
 - o Waukesha County Emergency Management
 - o Waukesha County Park System
 - o Waukesha County Sheriff Department
 - Agencies/Departments that Responded to the Management Survey
 - o Big Bend Police Department
 - o City of Brookfield Fox River Water Pollution Control Center
 - o City of Brookfield-Sewer Department
 - o City of Franklin Police Department
 - o City of Muskego
 - o Dousman Fire District
 - o Hartland Fire Department
 - o Lake Country Fire
 - o Lake Country Fire and Rescue
 - o Menomonee Falls Fire Department
 - o Menomonee Falls Police Department
 - o Mukwonago Fire Department
 - o Pewaukee Police Department
 - o Sussex Fire Department
 - o Town of Merton
 - o Vernon Fire Department
 - o Village of Big Bend
 - o Village of Lannon Fire Department
 - o Village of Mukwonago Police



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- o Village of Sussex WPCF
 - o Village of Wales
 - o Wales Genesee Fire Department
 - o Waukesha County Central Fleet
 - o Waukesha County Department of Health and Human Services
 - o Waukesha County Department of Public Works
 - o Waukesha County Department of Public Works - Highway Operations Division
 - o Waukesha County Emergency Management
 - o Waukesha County Park System
 - o Waukesha County Sheriff's Department
 - o Waukesha Water Utility
 - Agencies/Departments that Responded to the Dispatch Survey
 - o City of Bayside Police Department (Communications)
 - o City of West Allis Police Department
 - o Milwaukee County Emergency Medical Services
 - Agencies/Departments that Participated in an Interview
 - o City of Bayside Police Department
 - o City of Brookfield Fire Department
 - o City of Milwaukee Fire Department
 - o City of Milwaukee Police Department
 - o City of West Allis Police Department
 - o Lake Country Fire Department
 - o Milwaukee County Sheriff Department
 - o Milwaukee County Emergency Medical Services
 - o Milwaukee County Transit System
 - o North Shore Fire Department
 - o Waukesha County Sheriff Department
 - o Waukesha County Highway Operations
 - o Waukesha County Parks / Land Use Department



Additional Appendices (B and C)

Appendix B, which contains copies of the User, Management, and Dispatch Surveys, and Appendix C, which contains the coverage prediction maps, are included as separate files.