

Public Safety Communications Interoperability In the MARC Region (Kansas City Metro Area) *Status Report & Options Analysis*

Section 1 – Executive Summary

GeoComm was commissioned in September, 2003 to conduct an assessment of and provide an analysis of the options for improvements to the Public Safety/Emergency Communications Interoperability capabilities in the MARC region. The principle underlying intent was to examine existing and proposed voice and data radio communications systems to determine where opportunities exist to improve and broaden the scope of interoperable public safety communications within the 8 county MARC region.

Ultimately the goal of the combined public safety agencies within the Kansas City Metropolitan (area as represented by the MARC Regional Interoperability Committee) is to implement communications interoperability solutions that;

1. Enhance day-to-day public safety mutual aid communications for minor emergency situations
2. Enhance major disaster public safety communications focused in a particular geographic area and;
3. Enhance Public safety communications during major region-wide situations.

Project Methodology

The project was initiated via a project kick-off meeting during which members of the GeoComm research team met with the MARC Regional Interoperability Committee to establish the precise parameters of the study and to provide a general understanding of the technical issues to be explored. This initial meeting gave way to a comprehensive on-site analysis of the region's public safety communications facilities to acquire a detailed understanding of the existing technical capabilities as well as to establish the financial, operational and political environment within which they currently exist and function.



The preliminary data acquired via this comprehensive process, along with responses from a data collection survey instrument returned by 55 communications entities was then analyzed by the project team and incompatibilities and commonalities and were noted. The incompatibilities were thereby established as the underlying existing impediments to interoperability between the public safety communications systems in the greater Kansas City Area. To achieve the goals as established by the Regional Interoperability Committee as alluded to above, these incompatibilities would have to be eliminated or overcome. The commonalities which remained were, by extension, then established as a baseline foundation upon which all subsequent technical options would be developed.

Simultaneous to this winnowing process, the GeoComm researchers examined other metropolitan regions wherein similar public safety communications challenges have been identified and, in some fashion, addressed. These other systems would then be compared to the common foundation identified with the MARC region to determine what, if any, of the myriad solutions implemented by these other communities might serve in part to address the ultimate goal of the MARC Regional Interoperability Committee to enhance and improve public safety radio interoperability within the MARC region.

Finally, GeoComm met with local professional radio system service and equipment providers involved in the day-to-day management and servicing of public safety radio infrastructures identified during our research. The purpose of these meetings was to avail ourselves of their years of technical experience concerning the progressive technical evolution of public safety radio systems within the MARC region and to discuss the practical aspects of the preliminary options identified to this point in the study. These meetings lent a much-needed practical aspect to the various technical options required if our final recommendations were to be offered in a manner consistent with their potential implementation.

Recommendations

1. **STEP 1: Regional Multi Band Interoperability System:** As a first step, and a part of an overall migration plan, GeoComm recommends the establishment of a conventional (non trunked), analog, multi-band (700/800 MHz, 150 MHz VHF and 450 MHz UHF) region-wide interoperable radio system/network. The system infrastructure we envision for such a system/network would include 9 radio repeater sites strategically located with approximately 14-mile separation

throughout the MARC region. These 9 sites would be linked via microwave and operate in a simulcast mode. Each of these sites would have 11 radio repeaters, five of which would operate at 800 MHz, three operating on VHF and three operating on UHF. At each site, three sets of the 800, VHF and UHF repeaters would be linked together so as to act as cross band repeaters. This linkage would, in effect, create interoperability between all three radio frequency bands, thereby creating the interoperable platform sought by the MARC Interoperable Committee. The establishment of this system would require the designation of two control centers (could be existing communications centers) capable of some small measure of technical control as well as generally passive monitoring of the network infrastructure.

To a large (and potentially total) degree, this system would enable all existing and planned public safety subscriber mobile radios in the entire region to:

- Talk to any other same band radio from anywhere in the region to anywhere in the region.
- Concurrently talk to any other dissimilar band radio from anywhere in the region, to anywhere in the region

We estimate that the establishment of the above radio system would have an estimated maximum cost of approximately 5 million dollars. This cost estimate should be considered our estimated ceiling as the total system costs area subject to some mitigation based upon site selection

2. **STEP 2: Wide Area Shared Mobile Data Backbone:** As a second step in this plan, we would recommend considering a “wide area public safety data RF backbone system”. This would be accomplished by installing several 700 MHz data repeaters at each of the nine sites referenced above, and inviting all public safety mobile data users in the region to move their “data transport” over to the wide area 700 MHz system. This would also mean the end mobile data using agency would have to install compatible 700 MHz data radios. Such a system would create a wide area RF coverage footprint for mobile data, as well as a transmission backbone that would carry the end user’s mobile data back to their home system. It would mean that a mobile data terminal in a vehicle from an agency in one of the far corners of the region would continue to work even if they were miles away in the other corner of the region. It could also mean that mobile data could become available to agencies that do not now have it by providing for them a “mobile data highway and infrastructure” to which they could subscribe end user

devices and not have to put in and license their own backbone infrastructure.

While 700 MHz may be the only band in which adequate frequencies would be available for such a system, the 700 MHz band also offers the operational advantage of permitting “channel aggregation” (tying several channels together to make for a “wider” channel capable of carrying more data faster ---- similar to the difference between dial-up and broadband internet access).

It is premature to estimate these costs since they would be totally dependent on the number of repeaters needed at each site, and that would be dependent on the number of subscriber devices that would be accessing the system. But, having the site, the shelters, the power, and the microwave already in place via Step 1 would mean that these costs could be kept relatively minimal.

3. **STEP 3: Implementation of all purpose, wide area, shared voice system.** Having taken the above two steps, the region would then be well positioned to incrementally implement a region wide 700 MHz, Project 25 compliant trunked radio system, perhaps using the trunking system controller that will be at the heart of the to-be-installed City of Independence 700 MHz P25 trunked radio system.

Providing anywhere near a finite estimate on what it would cost to implement a wide area, all purpose, 700 MHz P25 compliant, digital, trunked radio system for the entire MARC region will require an engineering and planning effort far beyond the scope of this project. These costs, which could certainly run into the 10’s of millions of dollars, would be driven by several variables to include:

- a. The number sites required to support the required level of voice signal coverage.
- b. The number of repeaters (channels) required at each site.
- c. The number of subscriber radios, their type and feature sets.
- d. The number of dispatch centers and workstations that will be interconnected to the system, and the level of control they require.

Section 2 – Analysis of Existing Systems

It can be firmly stated that today’s public safety communications environment in most to all major metro areas of the USA is a disjointed, uncoordinated, patchwork quilt of often incompatible radio systems operating on different frequency bands, using different technologies, and sometimes even speaking in different coded “languages”. In this regard, the Kansas City Metropolitan Area is no exception.

By our count there are at least 41 separate and distinct local and state government police and fire two way radio systems in the MARC region. Some of these systems have good “interoperability”, some do not, but none present any insurmountable challenges to effecting good interoperability. (For detailed agency specific data see Appendix A of this report).

The only question is how, and in what way(s)?

Current Situation:

- 19 of the agencies operate primarily VHF radio systems in the 150 MHz range. (We consider the Ft. Leavenworth MP’s radio system which operates in the “federal VHF” spectrum at 160 MHz to be VHF.)

#	Agency	VHF
1	Jackson Co Sheriff	X
2	North Kansas City	X
3	American Med	X
4	Blue Springs MO	X
5	Cass Co. Sheriff	X
6	Clay Co. MO	X
7	Claycomo Police	X
8	Excelsior Springs	X
9	Harrisonville Police	X
10	Johnson Co. KS	X
11	Liberty Police	X
12	Platte County	X
13	Pleasant Hill Police	X
14	Pleasant Valley	X
15	Ray County	X
16	Riverside Public	X
17	Sugar Creek	X
18	Raymore Police	X
19	Ft. Leavenworth	X

Primary VHF Agencies

- 8 of the agencies operate primarily UHF radio systems in the 450-460 MHz range. (We consider the Ft. Leavenworth planned “federal UHF” trunking system, which will operate between 380 MHz and 400 MHz to be UHF).

#	Agency	UHF
1	Belton Police	X
2	Lees Summit Fire	X
3	Lees Summit Police	X
4	Lenexa KS Police	X
5	M.A.S.T.	X
6	Olathe KS Police	X
7	Shawnee KS Police	X
8	Leavenworth City KS	X

Primary UHF Agencies

- 12 of the agencies operate primarily 800 MHz systems
 - o 4 of these are “conventional” (non-trunked) 800 MHz systems.
 - o 5 of these are Ma/Com EDACS® 800 trunked systems
 - o 3 of these are Motorola Smartnet® 800 trunked systems.

#	Agency	800
1	Grandview Police	X
2	Johnson Co. KS Sheriff	X
3	KC MO Fire	X
4	KC MO Police	X
5	Leawood KS Police	X
6	Overland Park KS	X
7	Prairie Village KS	X
8	Raytown Police	X
9	Wyandotte Co KS	X
10	Gladstone Public Safety	X (PD)
11	Leavenworth County	X Law
12	North Kansas City	X PD

Primary 800 Agencies

In addition many of the above agencies operate across frequency lines with operations that rely on a mix of communications technologies for day-to-day operations.

#	Agency	VHF	UHF	800
1	Jackson Co Sheriff	X	PacRT	
2	Ft. Leavenworth KS	X	X Soon	
3	North Kansas City	X-FD		X PD
4	Independence Police	X (FD)	X (PD)	
5	Gladstone Pub Saf	X (FD)		X (PD)
6	Leavenworth County	X (FDs)		X Law

Mixed Frequency Operations

As our research has indicated, we have clearly established that there is significant diversity in the architecture and personality of public safety communications systems in the MARC region. Whereas this was not unexpected, in the business of public safety communications, ***such diversity (while common) is not necessarily a desirable goal!*** This is particularly true when interoperability is considered.

To date, many of the public safety agencies in the MARC region have attempted to accomplish some modicum of interoperability between themselves and other operationally aligned neighboring agencies. There are any number of technical and operational mechanisms that have been employed by individual agencies in the region to facilitate joint communications interoperability. Here are just some of them:

1. Direct Interoperability

In many cases, an agency has the conventional radio channel(s) of their “frequency compatible” neighbors (VHF if they are VHF, for example) right in their regular vehicle and/or portable radios and they can talk on the neighbor’s channel(s) and vice-versa, almost at will, provided the neighbor has authorized such operations on their licensed frequency. While we did not do an inventory of all of these installations, they are prevalent, and with today’s frequency synthesized radios, adding a frequency compatible neighbor’s channel can be very inexpensive, as it is a quick programming job by the local technician.

We are particularly in favor of these implementations as one of the better ways of implementing routine, day to day interoperability and intercommunications between neighboring agencies.

2. Frequency Scanning

In some cases, agencies have implemented either receive only scanners, or receive only channels in main radios in vehicles to

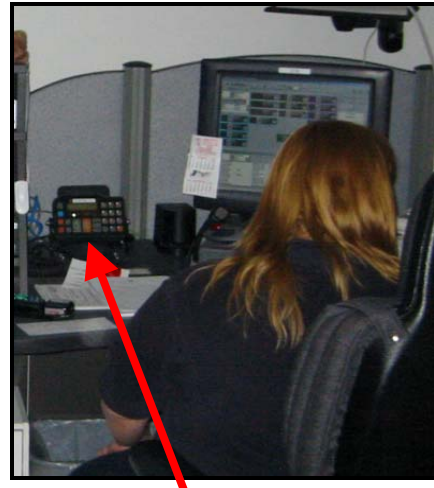
facilitate listening to their neighbors. If the neighbor is on the same band as the scanning agency, this “listen only” capability can be right in the main radio. If the neighbor is on a different frequency band, a stand alone receive-only scanner is required. We’re aware of many instances where neighboring “frequency incompatible” agencies actually communicate back and forth “scanner to scanner”. We did not catalogue the numerous instances of scanning main radios (most are) or stand-alone scanners in vehicles, but suffice it to say that most main radios have scan capability, and whether or not a given neighbor is in a radio’s “scan list” is a function of how that radio is programmed, and re-programming a radio is very inexpensive.

3. “RF Control Station” Access

In some cases there are “RF control stations” (often as simple as a mobile two way radio “hard mounted” in a dispatch center or console and connected to an AC power supply and an external antenna) in place to permit the dispatchers from Agency A to talk to the dispatchers and field units at Agency B.



**Factory Made RF Control Station
(North KC PD’s KCMO EDACS unit)**



**Mobile Radio as PSAP
an RF Control station**

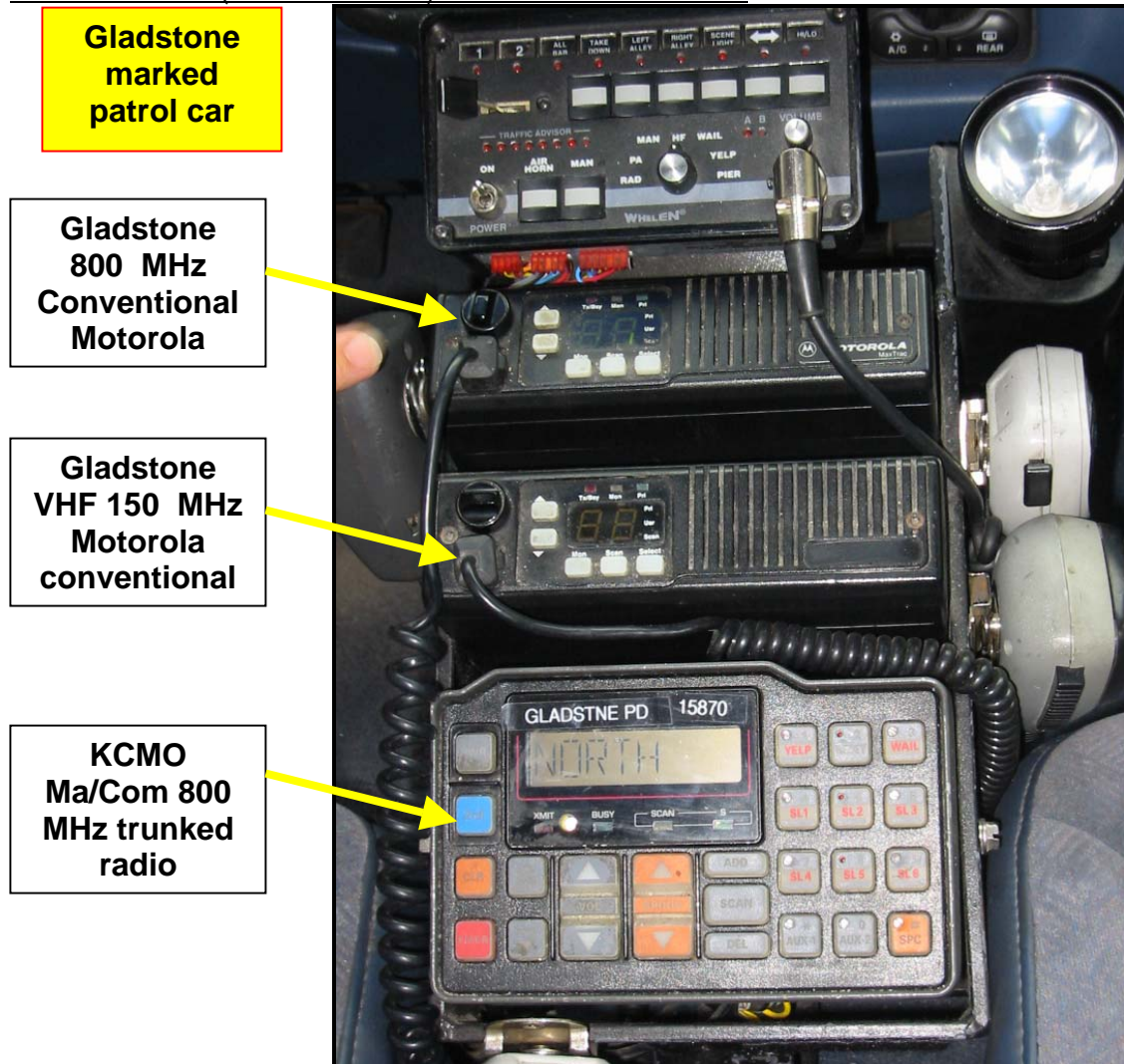
4. Receive Only Monitors

In some cases there are rack mounted, professional quality “receive only monitors” installed in radio rooms and feeding this “audio of interest” on some neighbor’s radio system to that dispatch center. (But they can’t talk on that channel) Often one sees these monitoring the “Weather Radio” channel.

5. Multiple Mobile Radio Installations

In some cases there are 2nd (and even some 3rd) radios mounted in vehicles on which the “frequency/system incompatible” neighbors can be reached.

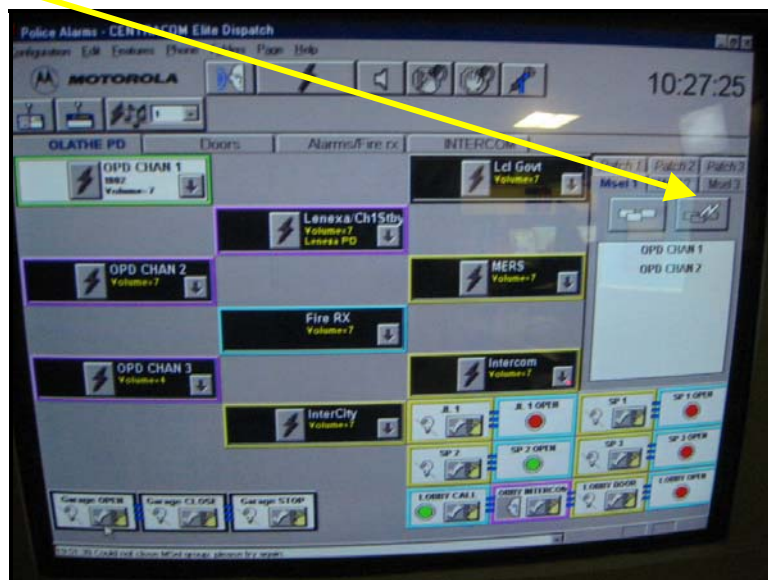
For example, the Gladstone Police squad cars have a Motorola, conventional 800 MHz radio as their primary radio. Said radio is not capable of talking to the surrounding KCMO Police cars on their Ma/Com EDACS trunked radio system. So, they have a second 800 MHz radio in their car, which is a Ma/Com EDACS trunked radio provided by the KCMO PD radio shop. To take this a step further (and to indicate the degree to which interoperability is important) on the Gladstone PD patrol motorcycles, it would not be practical or safe to try and fit two mobile radios. So, for their one mobile radio, they actually have a KCMO PD Ma/Com EDACS 800 MHz trunked motorcycle radio, into which they have programmed the several Gladstone PD conventional (non-trunked) 800 MHz channels.

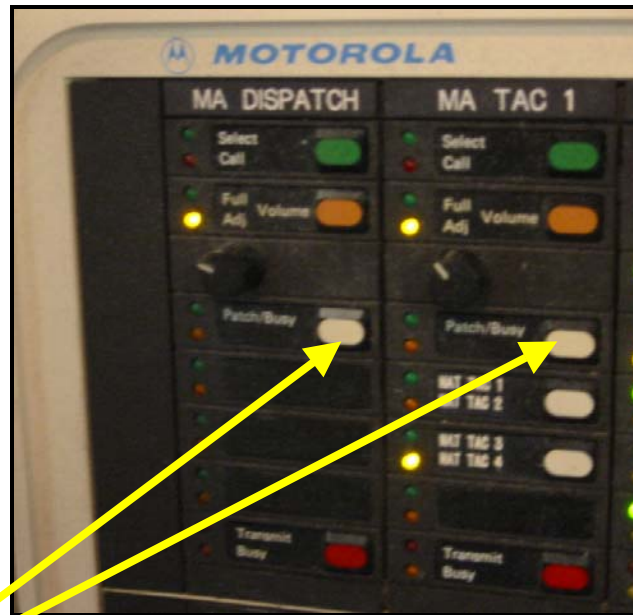


6. Console Patches

Most public safety agency's dispatch consoles or terminals (*most radio control consoles are now CRT based computer systems*) have the ability to “patch” one or more radio channels that appear on that console to another radio channel that appears on that console. The concept of “console patches” has been around for a couple of decades, and they definitely have a role to play. Simply put, the way console patches work is they take audio that is being presented to the console (or its backroom electronics) from some audio source like another radio channel, a phone caller's voice, the National Weather Service, or some other audio source and feed that audio over on to the “transmit wires” of a different radio channel. Consequently, what is “heard” from the audio source is then transmitted out on whatever channel that audio source is patched to, and vice versa. When they are managed, supervised, installed, and optimized properly, they can work quite well. However, they have the inherent disadvantage of tying up at least two radio channels whenever two radio channels are patched together.

Below is an example of a typical CRT Radio Control console (Olathe PD). Each “black box” (plus the one white box in the upper left corner) with a lightning bolt through it is a radio channel accessible to the dispatcher. Note the “patch” button near the upper right corner. Via this, either pre-programmed patches can be accessed, or a new “ad-hoc” patch can be set up.





The patch capability in an older “button and light” console is shown in an extreme close-up below (the white button). If these two white buttons were both selected, then these two separate radio channels would be “patched together”.

As the above indicates, we have established that many (almost all) of the dispatch center agencies in the MARC region, and many of the field response vehicles have gone to varying lengths to add modest to significant communications interoperability capabilities, at their own expense, and without significant guidance or a “master regional plan” to follow.

Section 3 - Available Regional Interoperability Resources

Regarding the generally available “interoperability radio channels” there are actually quite a few that have either been formally set aside by the FCC, or have developed along more informal lines as a regionally agreed upon interoperability channel in the VHF, UHF, 800 and 700 MHz bands. A table showing these is on the next page.

NAME	BAND	FREQUENCY	USAGE
“Point to Point”	VHF	155.370 MHz	<u>Law enforcement</u> dispatch center to other law enforcement dispatch center within range of this simplex channel. Informal – not officially established under FCC rules for this purpose. May be base or mobile, could be a repeater output channel as well.
“Law Mutual Aid”	VHF	155.475 MHz	The official name for this channel is NLEEC (Nat'l Law Enforcement Emergency Channel) as applied by the FCC when they set it aside for national usage. Each state is free to set their own rules on it and give it their own name. It's restricted to law enforcement, but we know of authorizations granted to EMS also. According to FCC Rules (Part 90) it is also supposed to always be simplex.
“MO Sheriff's Net”	VHF	155.730 MHz	By agreement of Missouri Sheriff's, a law enforcement agency to law enforcement agency mutual aid channel.
“MTAC”	VHF	154.680	State of MO statewide base and mobile, but base on temporary basis only.
“Fire Mutual Aid”	VHF	154.280 MHz	One of three nationally designated (by FCC) base and mobile channels for fire mutual aid purposes. The other two are 154.295 and 154.265. Unknown if they are available in the MARC region, although Johnson Co. seems to be licensed on 154.295 (F5?)
“NPSPAC” Interoperability Channels (see below)	800 MHz	821/866.0125 821/866.5125 822/867.0125 822/867.5125 823/868.5125	“I-CALL” is calling channel FCC official name. MARC has re-named it to be “MA DISP” for Mutual Aid Dispatch. 4 “tactical channels” are officially called ITAC1, 2, 3 and 4. All repeated.
FCC Narrow Band VHF InterOp Channels	150 MHz	151.1375 154.4525 155.7525 158.7375 159.4725	V-CALL V-TAC 1 V-TAC 2 V-TAC 3 V-TAC 4 <i>Narrow band – requires newer narrow band capable radios. <u>MOBILE ONLY ex.</u> For temporary bases</i>
FCC Narrow Band UHF InterOp Channels	UHF	453/458.2125 453/458.4625 453.458.7125 453/458.8625	U-CALL U-TAC 1 U TAC 2 U TAC 3 <i>Narrow band – requires newer narrow band capable radios.</i>
New 700 MHz Channels	700 MHz	32 pairs of repeated channels	List and channel specific assignments developed by MO State 700 MHz Regional Planning Committee as a part of the State 700 MHz planning process. KS has not yet developed their plan.

As detailed above, it is our collective opinion that sufficient communications resources are available today to create the necessary networks to accomplish the region's interoperability goals. The challenge is to integrate these resources in a manner consistent with both the current perceived operational requirements (day-to-day small events), and the future anticipated larger scale events either geographically focused or affecting the regions public safety resources as a whole.

Under an earlier initiative, MARC took some actions to implement a regional interoperability capability within the NPSPAC 821 MHz radio channels. This effort consisted of the following actions:

- Purchasing and providing a Motorola mobile radio equipped for use as an RF control station (AC power supply) to each of the Primary dispatch centers (and others) listed on the Appendix A table. This radio has all 5 NPSPAC (821 MHz) FCC designated National Interoperability channels programmed in it. MARC has chosen to re-name them to be called:
 - MA DISP (**M**utual **A**id Dispatch channel)
 - MA TAC 1 (**TAC**tical Channel) for Missouri agencies North of the river
 - MA TAC 2 for Kansas agencies
 - MA TAC 3 for Missouri agencies South of the river
 - MA TAC 4 for use as a spare when other channel is occupied

- The PSAP funded installation of an external antenna for said RF control station.

- MARC permitted the installation of hard wired connection between either these mobile radios as RF control stations, or more complete rack mounted RF control stations and the PSAP's dispatch console. Such a connection permits patching between the NPSPAC channel selected on the NPSPAC radio and any other "patchable" channel on that console.

- MARC permitted programming of the TAC channels into any agency's 800 MHz radio (mobile or portable) so they could use the TAC channels from the field.

- MARC prepared training manuals, offered classes and distributed operational procedures for use of these channels.

Our site visits and discussions with local dispatch operators and PSAP managers have convinced us that the above program is almost universally technically misunderstood, at least at the PSAP operator level. As such, it is not being well integrated into the current public safety operations and for this reason, as well as others, it is unlikely to significantly remedy the

issues of lack of functional interoperability in the future. In addition, the underlying premise of this implementation (one centralized repeater site located atop the City Hall Building in KCMO) has created a network that is technically unable to provide the requisite radio coverage required of a regional interoperable communications network.

In appendix B to this document, the reader will find a set of computer based radio signal propagation models relating to this NPSPAC Interoperability System as deployed in the MARC region. Using terrain data for the region (topographical information), using the known coordinates of the KCMO City Hall, using the known elevation at the top of the KCMO City Hall, and then inserting some reasonable projections regarding the antenna heights and effective radiated power (ERP) for the field mobile radios and dispatch center RF control stations, we can arrive at the conclusions that the radio coverage for this system is likely to be inadequate, particularly at the fringes of the region. In fact, during our site visits, we were advised at several PSAPs that they were not going to install the MARC provided radio due to their perception that it would not work for them from their location.

Perhaps the only way this system could provide solid talk-in and talk-out coverage to all of the PSAP locations (so it could then be well received and console patched to whatever channel resources might exist in that PSAP or their field fleet) would be to employ higher power RF control stations, with significantly higher and greater gain antennas at the remote PSAPs. Then, while the PSAP could probably talk in and out to the KCMO City Hall repeater site on MA-DISP or one of the MA-TAC channels, and subsequently patch what it heard out on a local channel, the problem would still remain with the remote PSAP's ability to hear (and subsequently patch) what a NPSPAC using mobile or portable radio is saying while in or near the remote PSAP's jurisdiction. That mobile or portable talking on one of the NPSPAC interoperability channels operating in one of the farther out communities would have a very hard time hitting the repeater at KCMO City Hall to get their message out to be picked up by the RF control station at that remote community PSAP.

Simply put, relying on a single central repeater site, with no remote (satellite receivers) for such a system in an area this size will not work well. One could add satellite receivers to add in picking up weak, distant or portable signals, but that would require 5 such receivers at several sites, and the attendant one time or recurring costs of either implementing microwave or low-power RF relay systems from those receiver sites to the

central repeater site, or the monthly recurring costs of leased phone lines for the same purpose.

Or, one could implement multiple repeater sites, with all 5 NPSPAC repeaters at each site (necessary to provide more than one channel with equivalent performance at any given location), but with these multiple repeater sites operating independent of each other (meaning no expensive “transmitter steering” or simulcast operation), the troublesome prospect of having a variety of dispatchers having to figure out which repeater site to enable and which to disable based on where an incident is happening (or moving to), and providing them a pathway via which to perform that repeater enable/disable function rears its head.

Based on all of the above, we have issues with the manner in which the NPSPAC Mutual Aid Interoperability system has been or practically could be implemented in the MARC region. While well intentioned, we see current and on-going problems with the coverage for PSAP RF control stations; the coverage (or lack thereof) for mobile and portable users who may not have been made aware of its coverage limitations; the resulting reliable system availability; and a relative lack of real-time communication to the user community about the system’s availability and operational status.

This should not be taken as a targeted criticism, per se. It is a reiteration of the exact same set of pitfalls we have seen in similar, well intentioned (but under funded) attempts at interoperability elsewhere. All too often, the implementations are feasible, they can work, and they have attractive features and capabilities, but more often than not, they are plagued with usage and application problems that are not well understood by the “lowest common denominator”, day-to-day field and PSAP user. And if they don’t understand the capabilities and limitations of the system, not only can they not figure out the various “workarounds” that may be required (like using a “talk-around” channel), they can make continued usage of the system problematic.

We believe MARC needs to strive for a solution that will work for almost everyone, almost every time, in almost every situation, with a minimum of technical awareness. Some would call this the “lowest common denominator” approach. This implies a system that “when all else fails”, it will still be accessible, reliable and provide service to any type of qualified user.

Section 4: Alternative Solutions

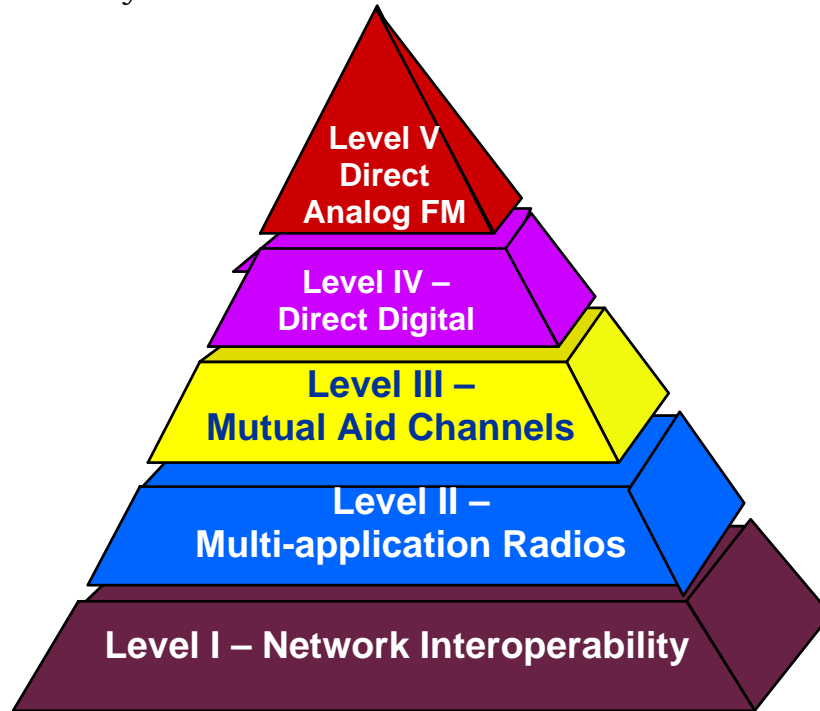
As the reader probably already appreciates, there is any number of varying options available to MARC relative to the progressive incorporation of improved interoperability into the prevailing public safety communications systems operating within the region.

Before we provide a general outline of the conceptual options currently available to the region, we should articulate the fundamental objectives and principles the MARC region users established and adopted via their participation in two Regional Interoperability Workshops that were held as a part of this project. These represent the principles the users would like to see any interoperable system adhere to. They are:

1. An interoperability system ought to be easily accessible to and operable by the least experienced of qualified field first responders and dispatchers.
2. An interoperability system ought not require the purchase of lots of additional, field level radio devices. First responders carry enough already.
3. An interoperability system ought to be as close to ubiquitous as possible – should provide its benefits across as wide an area to as many users as possible.
4. An interoperability system should not only support large, multi-agency incidents, it should also support smaller, more common events and, (perhaps under a “priority of usage” protocol) even itinerant and routine interagency communications. Such usage can generate competence and confidence in the system and ensure its better performance when really needed.
5. An interoperability system should not be “throw-away” technologies that will “band-aid” the region for a few years, only to be replaced by something else.
6. An interoperability system should provide a base line capability for any radio equipped first responder to speak with any other radio equipped first responder or dispatcher, within the parameters of the Incident Command System and common sense practices regarding not too many people talking not too much of the time.
7. An interoperability system should also promote the implementation of wide area public safety data communications. Not necessarily interoperability between data systems (at this stage), but at least a wider coverage foot print for today’s data systems.

Within the general range of these options, we see five conceptual categories or phases as represented by the graphic below. Due to the seminal nature of these concepts we will spend some amount of time

further describing each concept as these conceptual categories represent identifiable transitional phases that should form the framework for future interoperable improvements to the existing regional public safety communications systems.



The Pyramid of Interoperability¹

Using the above hierarchy, let's define the terms and the presumed concept here.

LEVEL V: “DIRECT ANALOG FM”. The highest and purest form of interoperable communications is when one FM two-way radio (all public safety two way radios are FM radios) can talk directly to another FM two way radio in an analog (non digital) mode. Taking that a step further, it would be when all two-way radios can talk in a direct analog mode to all other two way radios. This level of interoperability can be interpreted to be either “repeated” or “simplex”, with simplex being the simplest and least complicated and the form that will work everywhere. It is also important to note and emphasize the underlying “fabric” of this level of interoperability is analog, as opposed to its digital equivalent as fully illustrated in Level 4 below, thereby sidestepping any issues related to the ability of one digital scheme to interoperate with a different digital scheme. (One of the major elements of the decades long APCO Project 25 debate).

¹ Borrowed from a presentation done by Ma/Com explaining their “Network First[®]” solution

Within the context of this concept, everybody has a radio on which they can talk directly to everybody else. Everybody shares or has equal access to a big radio network on one common frequency band and all share common analog, direct channels.

Today there are at least 41 separate communications networks within the MARC region that have internally achieved Level 5 Interoperability. They all share a common frequency range and a common communications backbone allowing them to directly communicate radio-to-radio to all other users of their “system”, assuming they have decided to program some common channels into that system. Therefore, at their department or jurisdictional level they have achieved Level 5 Interoperability.

To deliver true Level 5 Interoperability region-wide one would have to deploy a vastly expanded common backbone (receivers, transmitters, etc.) operating in a common frequency band that would serve all public safety users within the region, and all of those users would have to be equipped with radios on the same common band (700, 800, VHF or UHF) as the expanded backbone, in order to access it.

If one is considering such a large radio system (even a trunked system) at VHF or UHF, it’s not likely to happen in a major urban area. There are not enough licensable and interference free VHF or UHF channels available, and such a system --- if it was to also be everyone’s day to day usage radio system (even trunked) would likely require 100+ such channels.

If one is considering a large conventional 800 MHz trunked system, even one using 821 MHz NPSPAC channels, the challenge of getting adequate numbers of frequencies in the KC metro area would be daunting, unless a number of the current 800 MHz trunked and conventional users were willing to give their licenses up and pool those resources. Even if the licensing issues could be overcome, this type of regional trunked radio system would require the expenditure of an estimated dozens of millions of dollars to build the required backbone infrastructure not to mention the replacement of several thousand end user radios.

Finally, there is the new option for a 700 MHz system. 700 MHz is the only band in which one can find adequate, local, unlicensed clean channels to build a trunked system of this magnitude, but a design premise of 700 MHz is that it will be all digital, and all P25 compliant, except for some very lower power (2 watt) service specific “scene of action” channels which may be analog.

In summary, achieving Level 5 Direct Analog FM as a goal of the MARC Interoperability Committee would most certainly require the development of an analog 700 MHz system for use throughout the 8-county region. Whereas this is technically an option, it could not be APCO Project 25 Compliant by virtue of its underlying analog framework. As it is the expressed intent of the MARC Regional Interoperability Committee to research only options that are Project 25 compliant this approach seems non-compliant.

LEVEL IV: DIRECT DIGITAL:

Currently there are no agencies within the MARC region operating a digital radio system. The City of Independence 700 MHz P25 compliant system will presumably be the first in the region.

As previously stated, implementing a wide area digital two way radio system would almost certainly have to be done at 700 MHz, due to channel availability there. If done at 700 MHz it would certainly have to be trunked for a system of this size. If done at 700 MHz, it would have to be digital. If digital, the MARC group has said (and the FCC and State of MO in their 700 MHz plan agree) that it should be Project 25 (P25) compliant. Having established this, it is a fact that the City of Independence ICE Grant Application and the resulting USDHS award did allude to the availability of the expensive and centrally important trunking controller for the Independence system as being available as a central trunking controller for any wider area P25 implementations in the MARC region.

Assuming that said controller would be available, and would be configured/configurable to be capable of managing a system large enough to serve the entire MARC region, this would be a technically viable approach to follow. In its simplest sense, all one would have to do is to properly position several dozen additional repeater sites (at \$1 million++ per site) throughout the region, license several dozen additional 700 MHz channels for installation at those sites, install sophisticated console control positions at several dozen PSAPs in the region and then tie them all back to the trunking controller in Independence via an integrated microwave network between all the sites and PSAPs, and then go out and buy several thousand “subscriber” portable and mobile radios for the end users, at between \$1,200 and \$5,000 each.

Once all of the above was done, one would have one large, integrated, digital trunked radio system over which all subscribed radios could talk

directly to any or all other subscribed radios on that system either through the trunking controller, or via non-trunked, stand-alone repeated channels, or via direct, simplex, radio to radio “scene of action” channels which could be either analog or digital.

Such a system would achieve Level 4 Interoperability.

LEVEL III – MUTUAL AID CHANNELS:

This is the level where most of the Kansas City metro area agencies find themselves today, in varying degrees.

As can be seen from the tables in Appendix A, we list the following as today’s widely existing and available Mutual Aid Channels:

- MA-DISP (Technically called the NPSPAC Calling Channel)
- MA-TAC 1 (NPSPAC Tactical Channel 1)
- MA-TAC-2 (NPSPAC Tactical Channel 2)
- MA-TAC-3 (NPSPAC Tactical Channel 3)
- MA-TAC-4 (NPSPAC Tactical Channel 4)
- 155.475 (Missouri Mutual Aid, but technically NLEEC)
- 155.370 (Point to Point)
- 155.730 (MO Sheriff’s Channel)
- 154.280 (Fire Mutual Aid)
- 154.340 (Statewide Hospital/EMS Channel)
- MERS (Metro Emergency Radio System for primarily weather events)

Generally speaking, most agencies are eligible for licensing on and installation of either fixed base or mobile/portable radios on the above frequencies. If an agency has VHF field radios, they can have 155.475 (for example) programmed into those radios at little expense. Similarly, if an agency has 800 MHz radios, they can program all the NPSPAC channels into those radios, regardless of whether they are on a Motorola Smartnet or Astro trunked system, or a Ma/Com EDACS system, an EF Johnson LTR system or are 800 MHz conventional. Furthermore, any agency implementing any 700 MHz system is strongly encouraged to require that any end user subscriber radios they purchase also be capable of operating at 800 MHz so as to be able to access the NPSPAC mutual aid channels.

Mutual aid channels as implemented in the MARC region are the norm around the USA, and can be very effective. But the primary problem they present is that they are frequency band specific. In other words, on a given channel, you can interoperate with and provide mutual aid to any other radio on that same band and that same channel. If you want to

cross over to and interoperate with a radio from a different band, other intermediary technologies are required.

LEVEL II – MULTI-APPLICATION RADIOS:

We interpret this to mean one radio that can operate in multiple application modes, such as both EDACS and ASTRO (Ma/Com and Motorola trunking) or over multiple bands (800, 700, 450 and 155, for example). We do not see this as a technologically practical or likely alternative in the near term. As a result we will also discount this approach out-of-hand.

LEVEL I: NETWORK INTEROPERABILITY:

We interpret this category to represent the concept of inter-connecting a number of otherwise incompatible two way radio networks. This type of capability is sometimes now being referred to as “Voice-Over Internet Protocol or VoIP.) It can happen in one of several modes, from elegantly simple to simply elegant, as follows:

- **Console patches are a form of network interoperability.** If an agency had a Motorola Astro 25 700 MHz trunked radio in their back “radio room” that, as an RF control station, was registered on the planned new Independence, MO 700 MHz system, and one also had a Ma/Com EDACS trunked radio registered to the KCMO system in the same back room, and one had a UHF RF control station on the Tri-City UHF system serving Lenexa, Shawnee and Olathe, Kansas, one could patch these three separate and totally incompatible networks together, and users on each could talk, real time, to each other, provided each of those field users could get a signal back to their “home system”.
 - o **CON:** Patched channels tie up and busy-out as many different channels as are patched together. For example, if 4 channels are patched together, and party A on System A wants to talk to Party B on System B, they must activate and occupy A’s channel, B’s channel, but also C’s channel and D’s channel, meaning that nobody on C’s channel and D’s channel can talk while A and B are talking.
 - o **CON:** Not all console patches work well. Fairly precise level setting and some “attack time” and “hang time” settings are required to make these work properly. If not done, or not done properly, it can cause significant confusion for end users.

- **CON:** Patching requires that the dispatcher at the “patching agency” be competent in patching and pay some attention to the patched conversations, even if that dispatcher is not directly involved in the patch.
 - **CON:** Patching runs the risk of having dispatchers at several PSAPs patching the same channels to each other. For example, at PSAP A they patch 155.475 to MA-DISP. At PSAP B they do the same thing. Then a field unit talks on 155.475. It is received at both PSAP A and PSAP B, where both of them automatically (because the buttons are pushed) patch it out to MA-DISP, which means there are two MA-DISP RF control stations keying up at about the same time trying to access the one MA-DISP repeater, which is a recipe for disaster.
 - **PRO:** Patches are pretty much in place today with console patch capability in most dispatch centers already.
- **Field deployable or fixed cross band/cross system repeaters or audio switches represent a form of network interoperability.**

Vendors now sell a “tactical field cross band repeater box”. These can be had for as little as \$7,500. They can contain several otherwise incompatible mobile radios, complete with fused 12V DC or 120V AC power supplies. Via electronic circuitry in the box, it can take whatever is heard on radio 1 (*the operator turns on and selects radio one to whatever conventional channel or trunked talk group is desired*) and cause for it to be transmitted out on radios 2, 3 and 4 simultaneously, through external antenna connectors that could even be connected to a mast antenna on a building, or the box could be carried to the top of a building. The above can be extended to radios 2, 3, and 4 also. The box does not care what frequency band the radios are, or whose trunking protocol they are on, or even whether they are digital or analog.

Presumably, the box could even be hard wired somewhere, locked in a room and be kept in place as a fixed “cross band repeater”. Other, higher tech versions of this capability are available for hard mount “back room” installations or hard-wired installations in more sophisticated custom made vehicles like Suburbans or Explorers or mobile command vehicles, and they

often use higher tier radios, electronic switch panels, higher tech audio switching matrices, built in telescoping antennas and so forth. (Example: The JPS ACU-1000)

All of the above, when field deployed, are trying to accomplish the same general objective: To take radio audio from different bands on different systems at the scene of an incident and cause for it to “get married” within a device and be rebroadcast out on radio bands and system protocols that can be heard by other radios at that scene.

- **CON:** As was the case with console patches, if these devices are trying to take audio generated from a radio talking on or through a trunked or repeated radio system, and that on scene radio can’t effectively get its signal back to its home trunked or repeated radio system to be switched (in a trunked system) or repeated back out, then the expensive black box or special truck on the scene can’t inter-connect its audio to anybody else, because it never got to the special black box or truck. It doesn’t matter if this special box or truck is connected to even a 200 foot telescoping antenna at the scene, even if that antenna is directional back to the transmitting antennas of the talking radio’s home head end. The issue is that the scene radio can’t get back home, not that the black box or command vehicle can’t pick up that distant home system.

Clearly, to the extent that those who deploy these systems employ non repeated or non trunked “scene of action” channels by the on scene personnel, these problems can be mitigated. But, of course, that means that somebody on scene must be aware of these potential problems, recognize them when they occur, be able to communicate them to the field radio users, cause for them to take corrective action (go to the proper on-scene channel) and then implement the corrections.

- **PRO:** These devices are relatively affordable, can be small and easy to transport, and can be easy to operate.
- **CON:** Who/which agencies have these devices. Who gets them to the scene? Who maintains them? Who operates them? Who gets priority for their use? Who pays the cost of the person who brings it to the scene and operates for a

“foreign agency”, and their home agency has no involvement in the incident? Who buys/owns the component radios that go into such a box or vehicle?

- **Otherwise incompatible networks can be interconnected and switched at a higher, more sophisticated level (VoIP).**

In this age of digitization, it is possible to do all sorts of things. For example, using a PC one could surf over to a web site and pick up the audio for the dispatch channel of the California Highway Patrol’s San Francisco District. It would come in as an audio packet over the internet. One could then take that CHP audio that is being fed to the PC’s loud speakers and present it to a Motorola CentraCom Gold Elite console electronics bank one could have in the back room. Those console electronics could then support patching that CHP audio out to the City of Gladstone’s water department channel and water department trucks in Gladstone could listen to the CHP dispatcher in San Francisco. This “interoperability” would be one-way in this example. And, while one may be able to reach out via the internet to pick up the received audio for CHP dispatch in San Francisco, one can’t take what a Gladstone water department truck says and feed it back out to the CHP San Francisco outbound dispatch channel. But somebody with authorization and the proper equipment certainly could. And certainly an agency operating a legitimate VoIP audio matrix switch for legitimate interoperability purposes could do so.

That is the general concept behind what is commonly thought of as network based interoperability. (Example: Ma/Com’s NetworkFirst® system) Imagine, for example, that at every main police, fire and EMS radio system head end in the KC metro area there was an “Analog to Digital” converter that took analog audio and turned it into a digital packet. It then took all the desired audio from those emergency service radio systems and sent them as digital audio packets over a secure digital wide area network and the audio packets all arrived someplace where a master audio switch was in place.

At that master audio switch there could be a big screen computer monitor displaying an icon for every public safety radio system from which it is receiving these digital audio packets throughout the whole MARC region. For example, assume that the an officer of the Harrisonville Police (far South Cass County) needs to talk directly, and right now, to the Ft. Leavenworth MPs, many miles away. A person sitting at this big screen PC would merely use the touch-screen to tap

the “HPD” icon, drag it over to the FLMP icon, let the icons touch, and they’d be electronically interconnected.

This is not science fiction. It is readily doable today and such systems are being sold today. But is it what is needed in the MARC region?

It is our view that such systems, while marvels of technology, operate from several underlying premises that we believe merit serious challenge. These are:

1. That independent units of local government, and even agencies within the same unit of local government (police dept. vs. fire dept., for example) have tended to implement incompatible two way radio systems.
2. That such actions, while perhaps not always wise, are a part of the fabric of independent action and decision making available to local government in the USA that nobody is likely to tamper with or succeed at tampering with.
3. Therefore, that undoing such actions with “grander plans for coordinated actions and system implementations” (read implementing wide area coordinated, integrated radio systems) will not take place too many times or places around the USA.
4. Therefore, since such “grand scheme” plans are doomed to fail, any time or money spent pursuing them is time and money wasted.
5. Therefore, accept as a fact that there are lots of incompatible radio systems today, there will be lots of them tomorrow and there will be lots of them forever.

If this final premise is acceptable (and this is the part we think demands a strong challenge), let’s get about the business of interconnecting these invariably, inevitably and perpetually incompatible radio systems.

- **PRO:** Such a system can be implemented today. And Implementation takes a relatively short time. Cost would be much lower than any solutions that require purchasing lots of end user radios or new network elements.

- **CON:** Depending on how the audio packets are carried from place to place, there may be significant recurring costs for data lines or microwave systems.
- **CON:** Just like the above discussions about console patches, etc. this one is even more dependent on participating radios in this audio switched interconnection system getting their signals back to their home system's "head end", as it is there where their audio is retrieved, digitized and sent on to the master switch for switching out to the desired end destination system. What about a radio using a non-repeated (or not received back at the head end) tactical channel? Where does their audio get picked up in order to be digitized and sent on to the master switch for further redistribution?
- **CON:** Who runs this system? Just who is it that sits at our (albeit probably mythical) big screen terminal moving icons around and connecting and interconnecting them? Who tells this person when to move this icon there and that icon here? Dispatchers from the local PSAPs? Field commanders on some command channel from the field? Or is the system "hardwired" whereby all the audio from channel/talk group A is always inter-switched to talk group/channel B? Can this "master operator" be aware of and/or manage the quality of the switched output product that is being broadcast out over the end destination's radio system?
- **CON:** What if several entities bought and operated independent capabilities such as this "network inter-connection" or the earlier discussed electronic audio switch/patch panel or the tactical black box field deployable devices? Is there the possibility of "too many devices spoiling the stew?" Yes, that possibility always exists. And the more complicated and involved their set up and tear down becomes, the greater the possibility of unintended consequences (such as too many channels patched or switched or repeated to the same channels at several places) occurring. We have seen this happen in even simpler systems all too often to rule it out.

RECOMMENDED ALTERNATIVES:

Having evaluated the five levels of interoperability, we are now at the point of recommending the best alternatives for the MARC region. Considering the earlier established objectives for such a system, and the factors identified in the candidate technologies above, we have narrowed the field to two candidate systems. One represents a very ambitious, holistic, and

long term solution that would require considerable planning, cooperation, legislation and design engineering work, not to mention funding. The other represents a first, but very practical and effective step that would meet most, if not all, of today's demonstrated needs.

Specifically, we are going to refer to these two alternatives as:

1. Region Wide Single Band Trunked Radio System
2. Regional Area Multi Band Integrated System (RAMBIS)

1. Regional Wide Single Band Trunked Radio

Such single band trunked system capabilities (#1 above) are now being implemented in a number of very large, fully integrated, wide area digital trunked radio systems that are now in use, under construction or under planning in several places around the USA. An example of a regional system of this type is to be found in the Twin Cities of Minneapolis and St Paul. This system, which has been under planning and development for the past 13 years and is now supporting 8,000+ subscriber radios in a wide variety of state and local government agencies, is now beginning to deliver on its interoperability promises as identified in the early 1990's.

Whereas such a system is most certainly a noble goal for the MARC region, it should be noted and stressed that this level of shared infrastructure and interoperability requires literally years of technical, political, and financial commitments as a precursor to the ultimate operational benefits of full fledged interoperability.

There are also somewhat similar developments in Illinois (statewide with voluntary local participation), Michigan (statewide, with voluntary local participation), South Dakota (statewide with free participation by locals) Colorado; Ohio; Pennsylvania and others. And in Missouri, the St. Louis County Board has been granted authority by the legislature to go to their voters in early 2004 for a bond issue of up to \$100 million to fund the beginning of such a system in their metro area.

The question is: Can and should the Kansas City metro area build such a system? From strictly a technical perspective, almost certainly, the MARC region could build such a system. However, it would likely have to be built using 700 MHz channels, as most to all of the 806 MHz and 821 MHz channels are already licensed in the area. As stated earlier, there may have already been some movement forward relative to this approach. One of the explicit premises of the ICE grant application submitted by and

approved for the City of Independence, MO (one of the participating emergency agencies within the MARC region) is that the main control computers they will be installing for their multi site, 700 MHz, P25 compliant, digital trunked system will be sized for and capable of serving as the main controller for a build out serving other areas. If this were to be viewed as the beginnings of a region wide single band system it could represent a several million dollar savings. In addition, any additions to their system's controlling role need not be contiguous to Independence.

Could such a system be accomplished politically? Again most certainly, although this is best answered specifically by the Regional Interoperability Committee and by the MARC Board from a general policy standpoint. However, this level of political commitment is not without precedence and could most certainly bear significant fruit. Particularly if it was viewed and structured as a "logical migration process" over the next 10-15 years, it could likely be made palatable and economically attractive. It is difficult to envision that many local jurisdictions within the region, which have made recent major investments in new communications infrastructure, are prepared to reinvest in different and new systems quite yet. But as systems age, technology becomes obsolete and operational requirements evolve, many local agencies would most likely avail themselves of a regional program if there was a ready-made, planned migration and development option for these agencies. The chances would likely be even greater if one factor in the added potential was engendered by some "funding incentives" or viable local "funding vehicles" at the State or Regional level.

Systems Costing:. As discussed earlier, such systems are not cheap. From a very loose "order of magnitude" perspective, costs approaching \$100,000,000 for such a wide area system would not be out of the question. Recently we have seen such systems in the ranges of:

- \$20,000,000 for one county, 7 sites and 2,500 subscriber radios
- \$ 8,000,000 for one county, 10 sites and 16,600 subscriber radios.
- \$ 7,000,000 for one city, 6 sites and 1,000 subscriber radios.

Clearly, a system serving 8 counties, nearly 4,000 square miles (requiring dozens of sites) and multiple thousands of radios would cost several dozens of millions of dollars. There are also very significant recurring costs for system maintenance.

Finally, it needs to be remembered that over the next 10-20 years, millions of federal, state and local dollars will be spent in the MARC region on

public safety and local governmental radio equipment. Much of the radio equipment in place today in the region (in the VHF and UHF band) has been “obsoleted” by recent actions of the FCC in their “narrow banding” rulings. This means that many entities will have to buy many new radios, many of which will cost nearly as much as radios that could be subscribed to a region wide trunked radio system would cost.

Therefore, the real question should not be:

Does the MARC region want to spend several dozens of millions of dollars over the next couple of decades on a new radio system(s)?

Rather it should be:

Since several dozens of millions of dollars will be spent on new radio systems, one way or the other, is it better to spend those dollars in a coordinated and planned manner that will result in a fully interoperable, wide area, shared infrastructure system, or should they be spent on stand-alone, incompatible systems that will have to be externally interconnected?

Multi Band Network Backbone Interoperability

For the past few pages we have been discussing ways in which system backbone elements can be implemented to take otherwise incompatible network outputs and interconnect them to each other. There is another angle from which this can also be approached.

Specifically, one could deploy an array of “within band” mutual aid channels, properly deployed with multiple receivers and receiver “voting” and properly interconnected so as to provide simultaneous broadcast from multiple sites on that channel within that band (simulcast). Then, one could implement relatively straightforward “cross connects” at each of these several repeater sites so as to take what is said on (for example) one of the NPSPAC mutual aid channels, and have it rebroadcast out over new and “parallel” VHF and UHF mutual aid channels, and vice versa.

Simply put, with such a system, an end user would only have to select whichever channel is designated on their radio as their “MAIN HELP” channel (regardless of brand or frequency band) and initiate a call for help. That call would then be received at one or more of several satellite receiver sites listening to that specific channel. The best of those received signals would be “voted” and then repeated out simultaneously

throughout the entire region, on the HELP CHANNEL for the band the user called in on, as well as the HELP CHANNELS on the two bands with which that user's radio is incompatible.

It is our view that such a system can be implemented today, could be implemented in a relatively short time frame, could be done so relatively cost effectively, and could form the foundation onto which greater shared infrastructure and more interoperability capabilities could be provided in the future.

A Regional Area Multi Band Integrated System (RAMBIS)

As we researched and prepared this report, we met with numerous persons in the area, many of whom were quite knowledgeable about the needs, the various alternatives and related issues. We also had lengthy talks with other industry experts and with State of Missouri radio and regulatory staff. After all that, we kept returning to an idea which was presented to us by one of the professional radio service shops in the area. It is important to stress that the idea they presented is absolutely not technology that only they can sell. In fact, it is of such a design that there are numerous radio shops and hardware vendors that could sell, install and service such a system.

The detail on the development and deployment of this system is as follows;

- At strategic locations throughout the Kansas City metro area, one would implement 9 repeater sites. These sites could be existing towers or building tops that could be obtained cost effectively, and (in most cases) should not require the erecting of tower structures.
- Interconnect these 9 repeater sites via microwave. This could be lower cost unlicensed microwave, or more secure and less interference prone licensed microwave.
- At each of the nine repeater sites, install eleven repeaters, as indicated on the following page:

1. Repeater on NPSPAC Calling channel (MA-DISP) change name to **8-CALL**
 2. Repeater on NPSPAC TAC 1, change the name to **8-TAC1**
 3. Repeater on NPSPAC TAC 2, change the name to **8-TAC2**
 4. Repeater on NPSPAC TAC 3, change the name to **8-TAC3**
 5. Repeater on NPSPAC TAC 4, change the name to **8-TAC4**
 6. A repeater on a new VHF Interoperability CALLING channel ² called **V-CALL**.
 7. A repeater on a new VHF Interoperability tactical channel (*) called **V-TAC1**, same caveats as above.
 8. A repeater on a new VHF Interoperability channel (*) called **V-TAC2** with the same caveats as above.
 9. A repeater on a new UHF interoperability CALLING channel (this may be able to be one of the new Federally assigned UHF interoperability channels, as they permit repeaters on those channels) called **U-CALL**.
 10. A repeater on a new UHF interoperability channel called **U-TAC1** (same caveat as above).
 11. A repeater on a new UHF interoperability channel called **U-TAC2** (same caveat as above).
- Implement a simulcast system so that any transmission coming out of any one repeater would instantly come out of all like repeaters metro wide³.
 - Integrate the 9 sets of site receivers for each channel into a voting comparator system which would select the best received audio from all over the metro area and use that to send out for simulcast rebroadcast from all repeater sites on that and any channel it is connected to.
 - Link the 8-CALL, V-CALL and U-CALL repeaters to each other at each site. Any inbound transmission to any one of them would result in a repeated broadcast over all of them.
 - Assume that VHF and UHF CALL and TAC channels are likely to have to be narrowband the radios into which these channels are programmed must be narrow band capable.

² Not one of the national VHF interoperability channels mentioned in the page 11 chart, as they do not permit base stations)

³ Via this plan, no channel changing driven by where you are or where you want to talk would have to be done.

- Establish two “metro emergency communication coordination centers” (MECCC) designated for this system, one in the East metro and one in the West metro.
- These MECCC centers would be able to do the following:
 1. Disable a receiver from the voting system if it was causing an interference problem.
 2. Disconnect and reconnect the connection between the CALL repeaters and the TAC1 and TAC 2 repeaters on all three bands, with the default setting being that they are always interconnected.
 3. Monitor system for problems, provide guidance when needed, be the prime audio recording site (others can also record), etc.
- The only new end user radios that would be required would be replacements for any older VHF or UHF radios that are not narrow channel capable.
- All end user VHF radios should also be programmed with all of the new 5 federally assigned narrow band interoperability channels for “scene of action” work in confined areas.

How much would such a system cost?

System Cost elements:

1. **Infrastructure:** The infrastructure for such a system would be divided into two components, one “Prime Site” and eight Remote Sites. The prime site would house voting comparators, simulcast controllers and the like. The prime site would be co-located with one of the 9 “remote sites”. At the remote sites there would be the nine repeaters, microwave connectivity, cabinets, antennas and combiners, emergency power, etc.
2. **Hardware:** All of the hardware in this plan is off-the-shelf, standard public safety grade radio equipment, similar in grade and construction to the infrastructure equipment in place today in the region’s radio systems. None of it is proprietary in any respect.

Importantly, none of this equipment is or needs to be Project 25 compliant, per se. The reason for this is simple. P25 is a standard that relates to the implementation of digital communications systems, and the communications elements of this proposed system are all analog. The reason they are all analog is to permit any and all radios currently in any/all agencies in the MARC region to access these 11 repeaters at these 9 sites. Remember, nobody has digital

radios today, and those that will be getting them should/will have analog capability in those radios so that they can access the NPSPAC 821 MHz analog interoperability channels. For these reasons, there is no applicability of the P25 standard to this system.

3. **Software:** Other than software needed by the installing/servicing technicians to program the repeaters and optimize the simulcast and voting receiver operations, this is, quite frankly, an “elegantly low-tech” system not requiring the expensive software driven radios and periodic and expensive software upgrades.
4. **Recurring costs** for the system: Assuming that microwave is chosen as the medium to interconnect these 9 sites, there would be no recurring costs, per se, in phone bills, etc. Assuming this equipment can be located at existing governmental sites where no monthly site rental would be charged, that too could limit or eliminate monthly recurring costs. Perhaps the only significant recurring cost should be a maintenance agreement with a competent radio shop (private or governmental) for system repairs and periodic performance checks.
5. **Total costs:** We have pored over detailed cost spreadsheets developed by the local service shop who devised this system for all of the necessary equipment elements, and we are satisfied that they represent a good overview of all that would be required to implement this system. Depending on a variety of factors, we accept the service shops “order of magnitude” estimate that this system would cost between \$4.1 and \$5.1 million. The million dollar spread is accounted for in the decision required between “spread-spectrum”, unlicensed microwave, and licensed microwave. However, we would remind the region that such a system would almost certainly have to be competitively bid, and given the significant potential of this system for replication elsewhere in the USA, it is conceivable that some significant competition could impact these prices. And, the fact that all of the equipment in question is made by a wide range of manufacturers would indicate that numerous bids could be expected.

As to what the system could look like, a conceptual diagram, assuming approximately 14 mile separation for simulcast is shown on the following page.

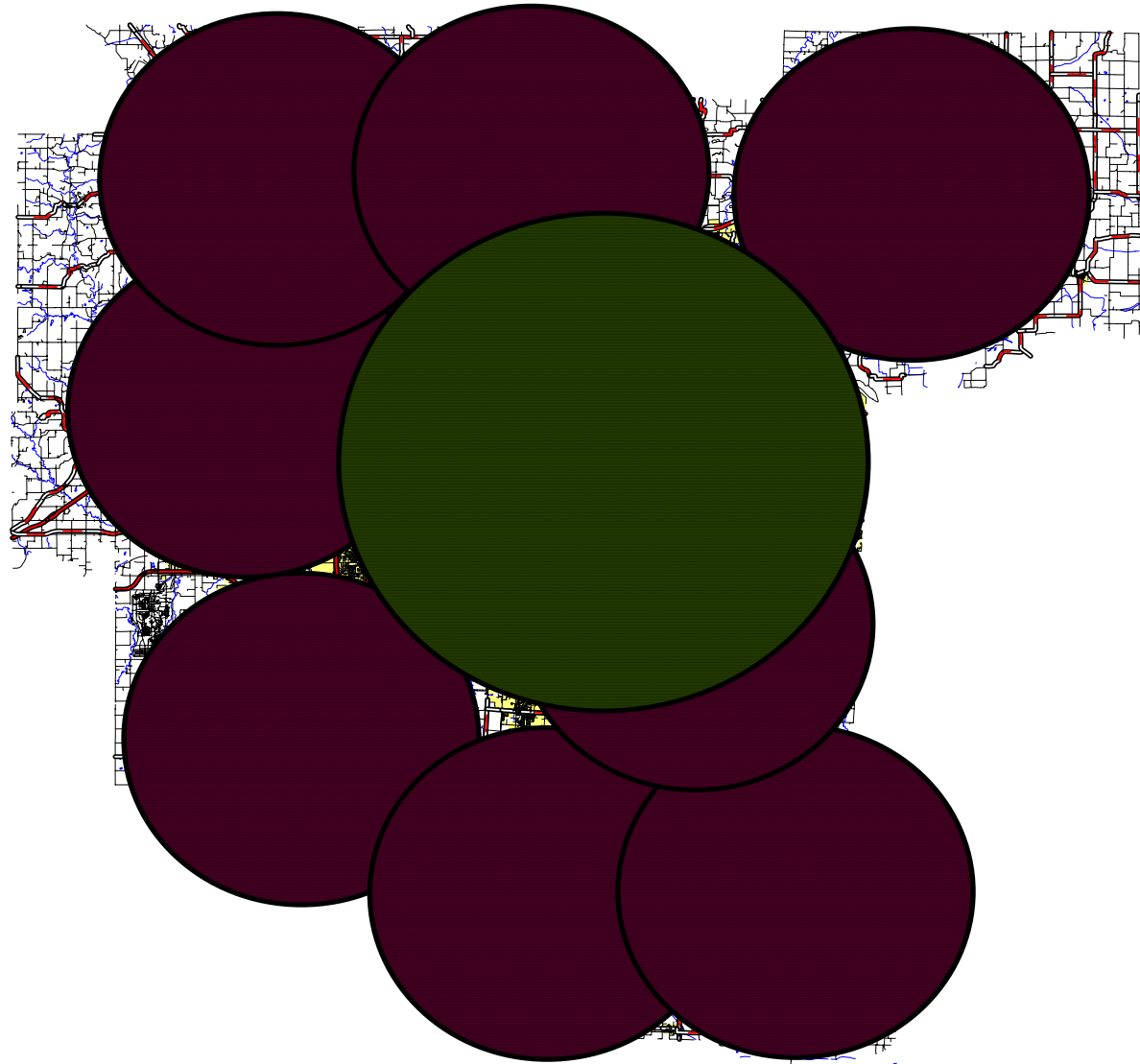
**CONCEPTUAL
SITE
PLACEMENT
RAMBIS
9 sites**

**8 on Existing
Sites**

**(Shown in red
shading)**

**1 on KC City Hall
in
Downtown KC
MO**

**(Shown in light
green/ yellow
shading)**



We see this Multi-Band System (RAMBIS) as being able to contribute directly to the future implementation goal of the single band system as follows:

By establishing a microwave system interlinking the 9 sites for RAMBIS, the framework is in place for installing a set of radio repeaters on 700 MHz (perhaps aggregated “fat” channels for massive data movement ---- color mug shots, maps, etc.) in a cooperative venture, to which any/all of the local MDT systems could be “subscribed” for data transport. Since the 9 towers would be placed strategically to achieve (at least) mobile coverage throughout most of the area for voice interoperability, they would, by definition, also be placed to provide coverage to 700 MHz data radios for MDTs. Once agencies subscribe their MDTs to the new data backbone, they would have MDT data access to their home system (and to any other MDT system to which they have access permission and protocols) from anywhere throughout the entire metro area.

Regardless of whether or not such a data backbone system is eligible for federal “ICE” money, installing a few such bases at each of nine sites (and perhaps doing their trunking control through the new, federally funded and intended-to-be-interoperability-facilitating City of Independence, MO controller would be a highly cost efficient move, compared to any or many individual agencies trying to achieve the same objective.

Having installed the above data repeaters at all nine sites, and trunking them through one controller (all sharing the RAMBIS microwave backbone), it now becomes a relatively minor task to start adding 700 MHz voice repeaters at these nine sites to provide appropriate capacity for a wide area, mobile coverage (almost everywhere), portable coverage (in many places), 700 MHz, digital, P25 compliant, trunked radio system.

Then, as radio systems operated by individual entities become obsolete, they could plan migration to this system. If they are satisfied with the now observable on street mobile and some portable coverage provided by the initial 9 sites, no sites would have to be added for that agency’s usage. If, however, they wanted better coverage, added sites could be installed. If that local entity needed more capacity (ability to support multiple conversations at one time) than the standard region wide voice system could offer, added channels could be installed at the repeater sites in that local zone, as warranted.

Conclusion:

In conclusion our work has established that:

- There is significant public safety radio system incompatibility in the MARC region.
- This incompatibility has negatively affected the ability of public safety agencies to interoperate as effectively as would be desirable.
- Significant money has been spent in the past decade or so on individual local public safety radio system upgrades or expansions.
- Significant money will be spent in the next decade or so to upgrade and/or bring existing systems into FCC “narrow band” compliance.
- Strong consideration should be given to having these future expenditures be done in compliance with coordinated plans for an integrated, wide area radio system.
- A fair amount of local effort has been expended by individual agencies to try and develop a variety of “work-arounds” to the interoperability hurdles in their local area.
- A MARC region initiative has been implemented to attempt to provide wide area interoperability via the NPSPAC Interoperability Channels and their potential patching to local UHF and VHF systems, but with less than stellar results.
- It would be possible to implement a wide area, single band (700 MHz), integrated and shared trunked radio system in the MARC region, and that such a system would inherently provide an extraordinarily high interoperability capability.
- It would be possible and appropriate for such a system to be Project 25 compliant.
- Such a system would cost, at a minimum, dozens of millions of dollars.
- Such a system could use as its central controller, the trunking controller that will be a part of the planned City of Independence 700 MHz system

- That immediate relief to interoperability concerns, without requiring any change out of any end user equipment (PSAP or field) is possible via the implementation of a Region wide multi-band interoperability radio system.
- That the implementation of such a system would not preclude consideration of or migration to a phased approach to a wide area integrated trunked radio system. In fact, it would provide a necessary vehicle that could facilitate such a migration in the form of a microwave backbone linking multiple sites.
- That the addition of data radio capabilities to the above microwave linked sites would be feasible and would provide wide area public safety data coverage and such capabilities could be controlled by the Independence trunking controller.
- That the phased addition of wide area, integrated trunked voice capabilities to this backbone system would be feasible, practical and facilitated by the above, as well as permitting local enhancements for coverage or capacity improvements.





GeoComm is confident that the MARC region is now poised to better understand the existing status of public safety communications interoperability, and the options that exist to improve these capabilities.

Should MARC choose to move forward to implement any of the recommendations contained in this report, we stand ready to assist in any appropriate way. A logical first step would be the development of a detailed system design, site access/acquisition plan and RFB specifications for the recommended RAMBIS system. This initial phase would be followed closely by publication of the RFB, the review and evaluation of the resulting bid proposals, and the determination of the ultimate affordability of and funding opportunities for such a system.

Appendix A – Summary of Regional Radio Usage



The following data represents the results of recent site visits to 38 of the 39 “Primary & Secondary Public Safety Dispatch Centers” (PSAPs) in the MARC region and the tabulation of survey data received from a number of these agencies as well. (67% or 26 of the 39 PSAPs returned our surveys plus another 29 surveys turned in by “allied agencies” which do not operate PSAPs but which would be in the general “public safety community”, including organizations such as City and County Public Health agencies, Fire Departments dispatched by others, Police Departments dispatched by others, County Emergency Management Agencies, State agencies (DNR, colleges), hospitals, the Red Cross and the Department of U.S. Energy (total surveys returned = 55).

We have attempted to color code the table to give a snapshot of the communications interoperability situation. The colors and their full meanings are as follows:


-  = Primary ⁴ radio system(s) is/are VHF (150 MHz)
-  = Primary radio system(s) is/are UHF (450-460 MHz)
-  = Primary radio system is mixed
-  = Primary radio system is 800 MHz.

Where appropriate, the vertical columns on the table are also color coded in the above scheme to reflect what system is in what band in the “mixed” system agencies.

Finally, there are two other sets of colors on the chart. The first set are:

-  = Operates a Ma/Com EDACs 800 MHz trunked system
-  = Operates a Motorola Smartnet 800 trunked MHz system

And lastly, there are two vertical columns which highlight the two **VHF interoperability radio channels operated by most agencies**, specifically, the National Law Enforcement Emergency Channel at 155.475 MHz and Statewide at 154.280 MHz, also operating CSQ.

-  = Common mutual aid channel operators (155.475 & 154.280)

⁴ The determinant defining **PRIMARY** is the type of portable radio carried by the individual.

MARC REGION PUBLIC SAFETY INTEROPERABILITY SNAPSHOT

Colors: **VHF**; **UHF**; **800**; **EDACS trunked**, **Motorola trunked**
Mixed PSAP (PD/FD)

AGENCY NAME	VHF (150 MHz) Primary	UHF (450 MHz) Primary	800 MHz Primary	Trunked?	Ma/Com EDACS Primary	Motorola Analog Primary	NPSPAC MA-DISP in PSAP	155.475 In PSAP	155.370 in PSAP	155.730 n PSAP	154.280 in PSAP	154.340 in PSAP	MERS in PSAP	Special Interop Interfaces	Comments
1. American Med Resp (AMR)	X			NO			X					X		KCPD EDACS in KC rigs	
2. Belton Police		X		NO			X	X	X	X					
3. Blue Springs MO Police	X			NO			X	X	X	X	X		X		
4. Clay Co. MO Sheriff	X			NO			X	X	X	X			X		
5. Claycomo Police	X			NO			X	X						KCPD EDACS radios in squads	
6. Cass Co. Sheriff	X			NO			NO	X	X	X	X				Chose not to install NPSPAC in consoles
7. Excelsior Springs Police	X			NO			X (*)	X	X	X	X		X		MA-DISP won't work --- too far & too low
8. Ft. Leavenworth KS MPs	X 162-174 Mhz	Soon 390-400 MHz		Soon			X								Implementing UHF trunked (390-400 MHz) soon
9. Gladstone Public Safety	X (FD)		X (PD)	NO		X	X	X	X		X		X	KCPD EDACS radios in squads	All NPSPAC Interop channels via full control station
10. Grandview Police			X	YES		X	X								
11. Harrisonville Police	X			NO			X	X	X	X	X		X	Has all 6 VHF MO-FCC Interop Ch in console & mobiles	
12. Independence Police	X (FD)	X (PD)		NO			NO	X					X		Getting new 700 MHz P25 trunked system soon
13. Jackson Co Sheriff	X	PacRT		NO			X	X	X						
14. Johnson Co. KS ECC	X			NO			X				X	X	X		Access to most I-O capabilities
15. Johnson Co. KS Sheriff			X	YES		X	X	X			X	X	X	Interface to KS, OP and other EDACS as well	
16. KC MO Fire			X	YES	X		X				X		X	VHF In Chief Officer vehicles for Fire Mutual Aid	
17. KC MO Police			X	YES	X		X	X					X		
18. Leavenworth City KS		X (PD/FD)		NO			X				X			PSAP facility is shared between City and County w/ separate radio systems	

AGENCY NAME	VHF (150 MHz) Primary	UHF (450 MHz) Primary	800 MHz Primary	Trunked?	Ma/Com EDACS Primary	Motorola Analog Primary	NPSAC MA-DISP in PSAP	155.475 In PSAP	155.370 in PSAP	155.730 n PSAP	154.280 in PSAP	154.340 in PSAP	MERS in PSAP	Special Interop Interfaces	Comments
19. Leavenworth County KS	X (FDs)		X Law	NO		X	X				X			PSAP facility is shared between City and County w/ separate radio systems	
20. Leawood KS Police			X	YES	X		X						X	Full access to Overland Park, and KCMO EDACS systems	
21. Lees Summit Fire		X		NO							X			UHF & VHF portables in rigs	VHF port in rig for Fire l Aid
22. Lees Summit Police		X		NO			X	X	X					Comm Van with lots of inter-op capabilities	
23. Lenexa KS Police		X		NO							X		X	Shared UHF system with Olathe, Lenexa and Shawnee	Transmit/receive sites all over the metro area for their users
24. Liberty Police	X		Note	NO			X	X	X		X				Lots of NPSAC channels licensed (9) – unclear what they are used for, if anything yet. (Maybe data?)
25. Metropolitan Ambulance Services Trust (MAST)		X		Note			X					X		Tied in with Wyandotte Motorola Smartnet as well as KC EDACS in addition to their normal UHF system and Med Channels	
26. North Kansas City PD/FD	X FD		X PD	NO		X	X	X	X				X	Has KC PD EDACS system control station in PSAP – Has NPSAC inter-op channels in all PD radios	
27. Olathe KS Police		X		NO									X	Participant in “Tri City” UHF system with Lenexa and Shawnee	Has not installed NPSAC MA
28. Overland Park KS Police			X	YES	X		X						X	Good inter-op with “Tri City” system, good with KC PD, Leawood and Prairie Village on separate EDACS , also RF control into JoCo SO Smartnet	
29. Platte County Sheriff	X			NO				X	X	X	X		X		Hasn't yet installed NPSAC MA – fear it won't work from that far out
30. Pleasant Hill Police	X			NO			X	X	X		X				
31. Pleasant Valley Police	X			NO			X	X			X		X		
32. Prairie Village KS Police			X	YES	X		X						X	Good inter-op with “Tri City” system, good with KC PD, Leawood and Overland Park on separate EDACS , also RF control into JoCo SO Smartnet	

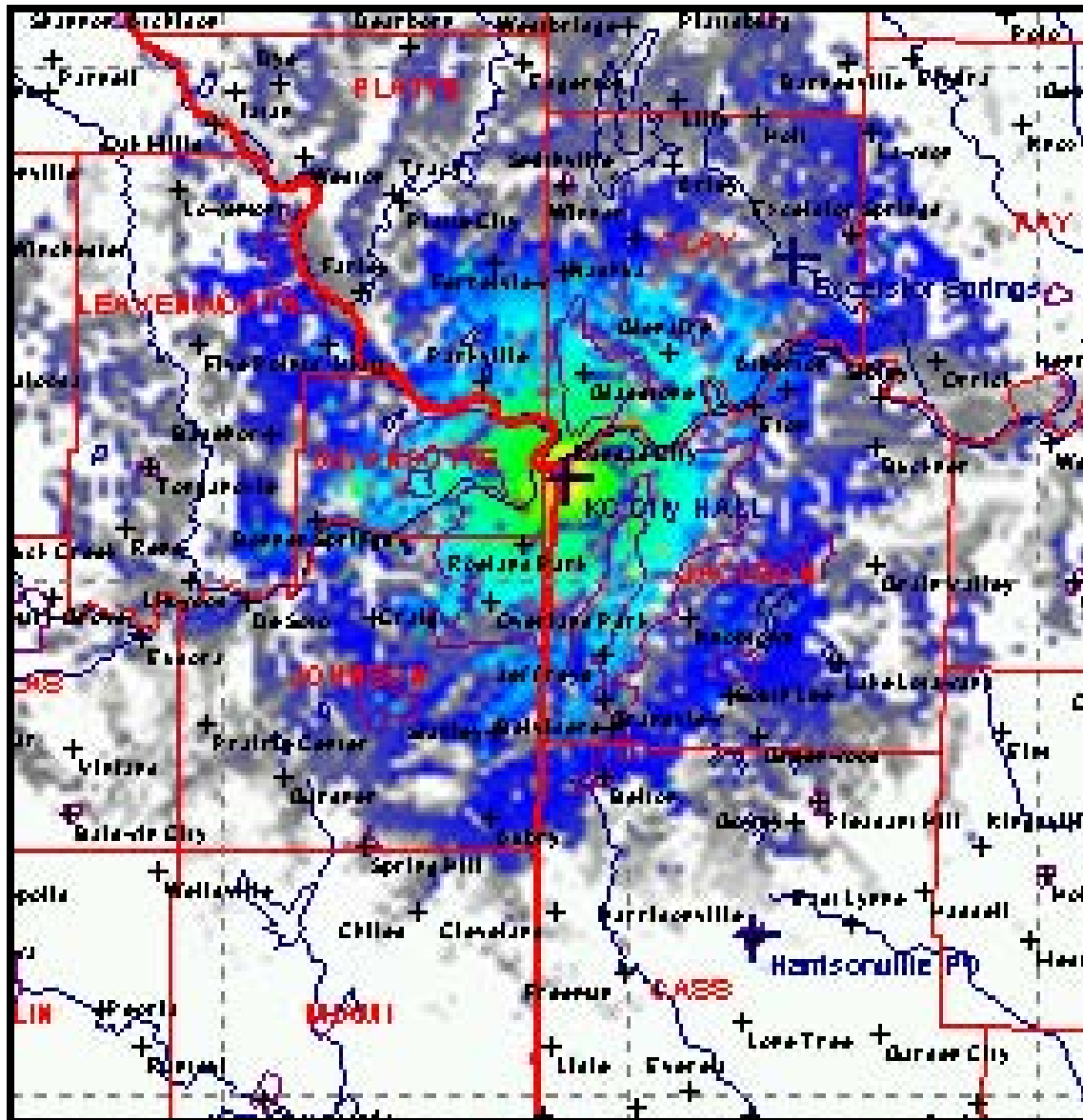
APPENDIX A: SYSTEM STATUS DATA

AGENCY NAME	VHF (150 MHz) Primary	UHF (450 MHz) Primary	800 MHz Primary	Trunked?	Ma/Com EDACS Primary	Motorola Analog Primary	NPSAC MA-DISP in PSAP	155.475 In PSAP	155.370 in PSAP	155.730 n PSAP	154.280 in PSAP	154.340 in PSAP	MERS in PSAP	Special Interop Interfaces	Comments
33. Ray County MO/Richmond PD	X			NO			X	X	X	X	X				NPSAC RF control not likely to work due to distance from repeater
34. Raymore Police	X			NO				X			X		X		
35. Raytown Police			X	YES		X	X	X			X		X		
36. Riverside Public Safety	X			NO			X	X		X	X	X	X		
37. Shawnee KS Police		X		NO			X						X	Part of the "TriCity" system with Lenexa and Olathe on shared UHF infrastructure	
38. Sugar Creek PD/FD	X			NO			X	X		X	X		X		
39. Wyandotte Co KS (KCK)			X	YES		X	X			X	X		X		

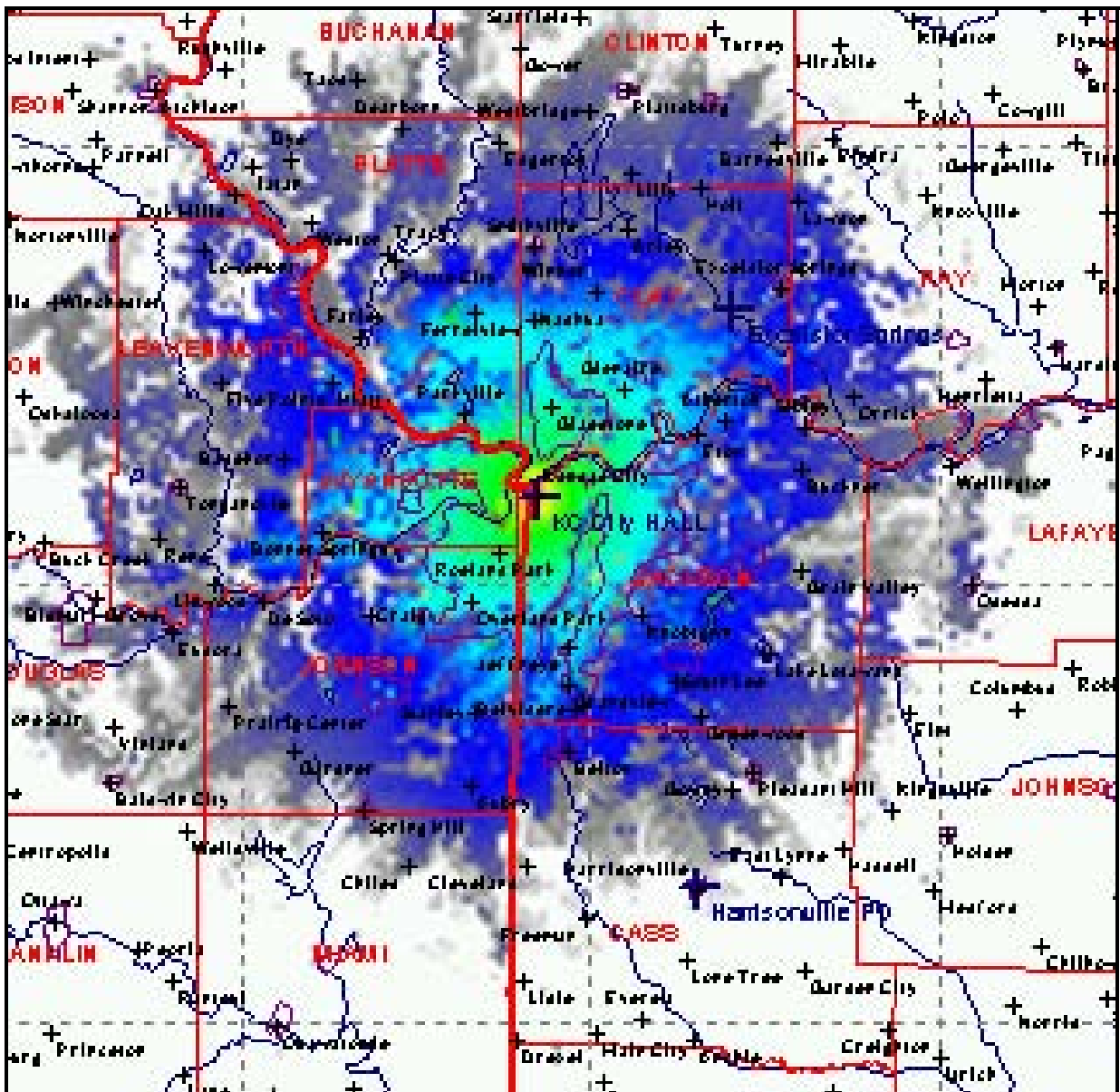
APPENDIX A: SYSTEM STATUS DATA

Appendix B – Radio Propagation Models

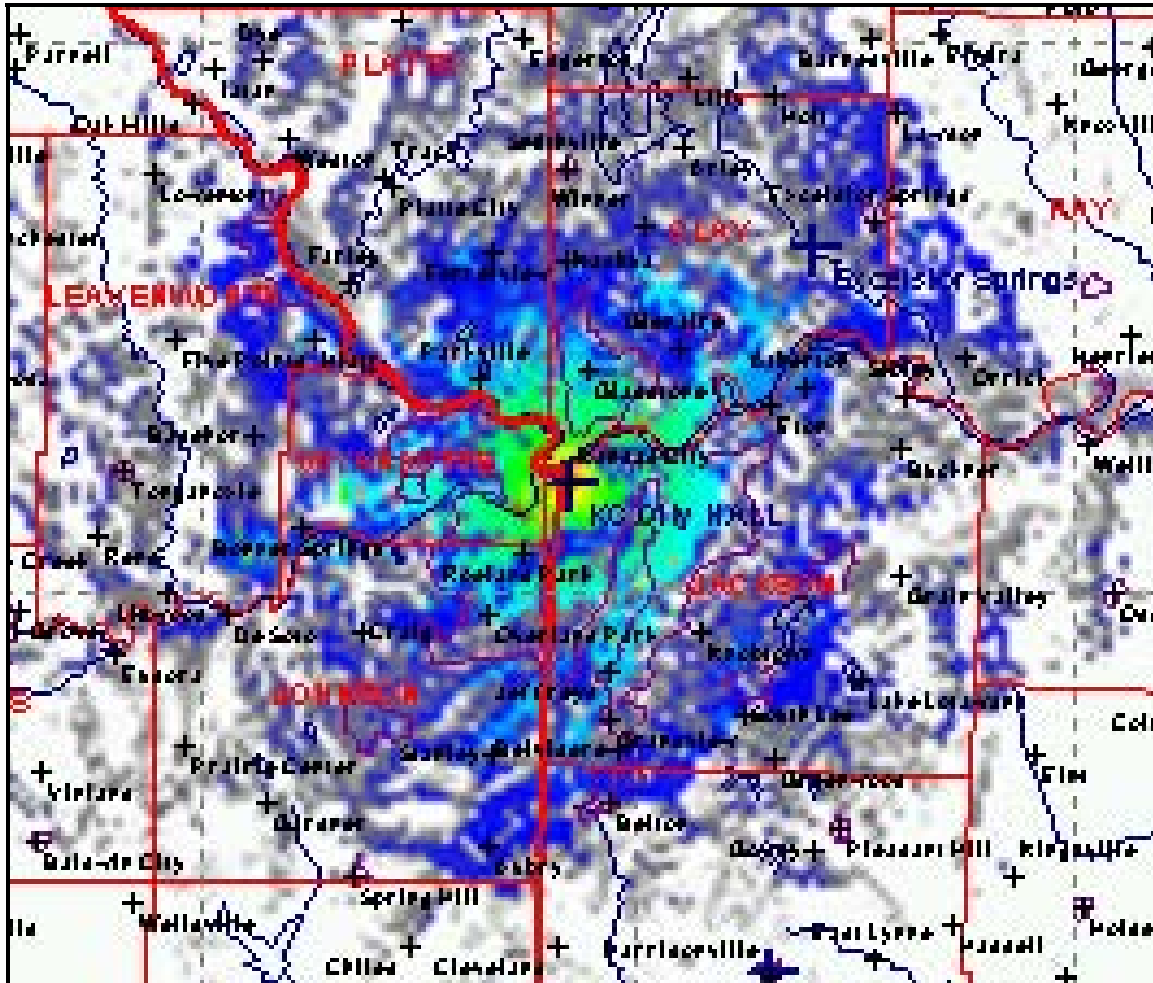
NPSPAC Repeater talking out from KC City Hall to receivers with antennas at 6 meters AGL (assumes RF control @ PSAP)



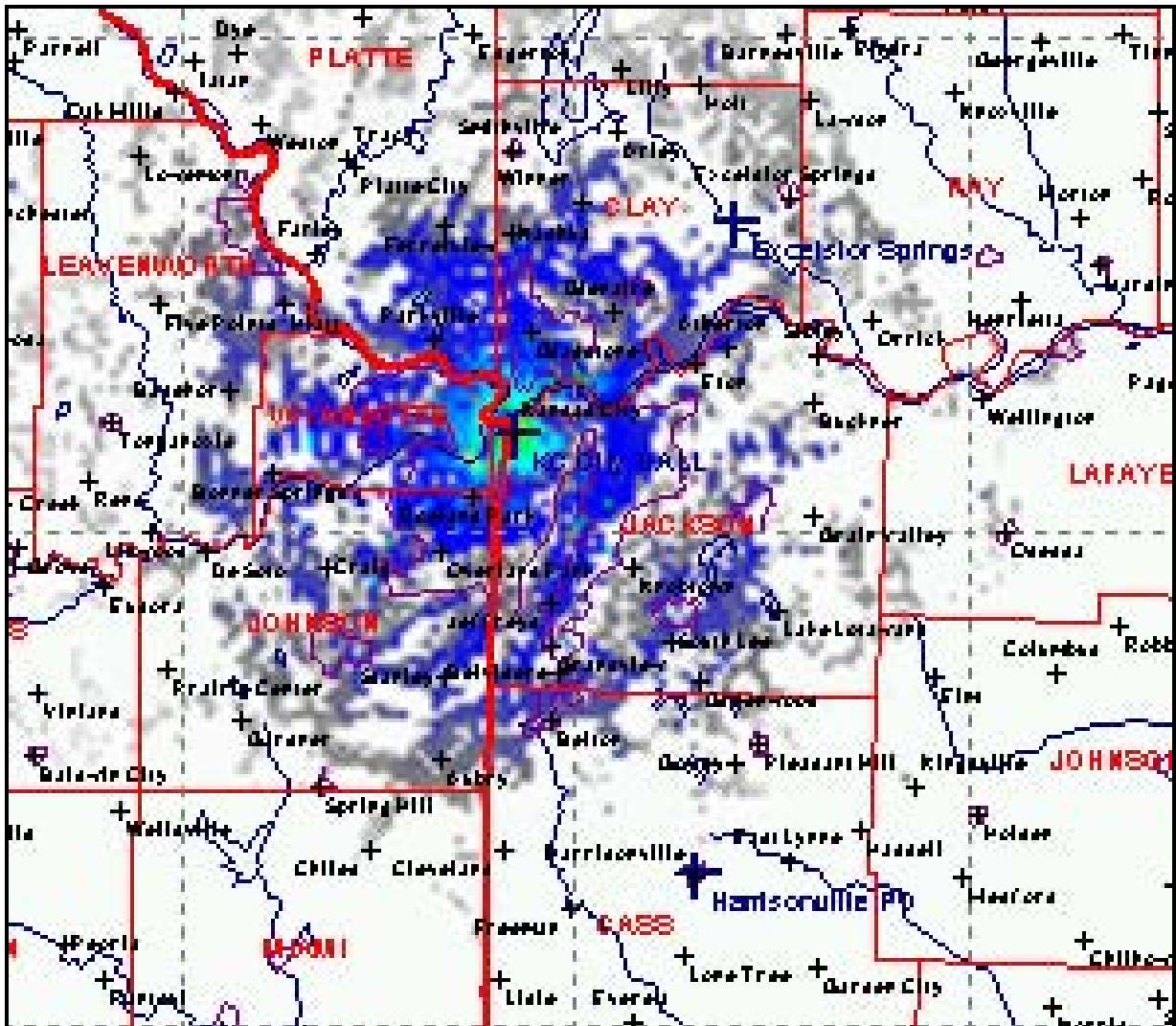
NPSPAC Repeater on KC City Hall talking OUT to RF control stations with antenna at 65 feet



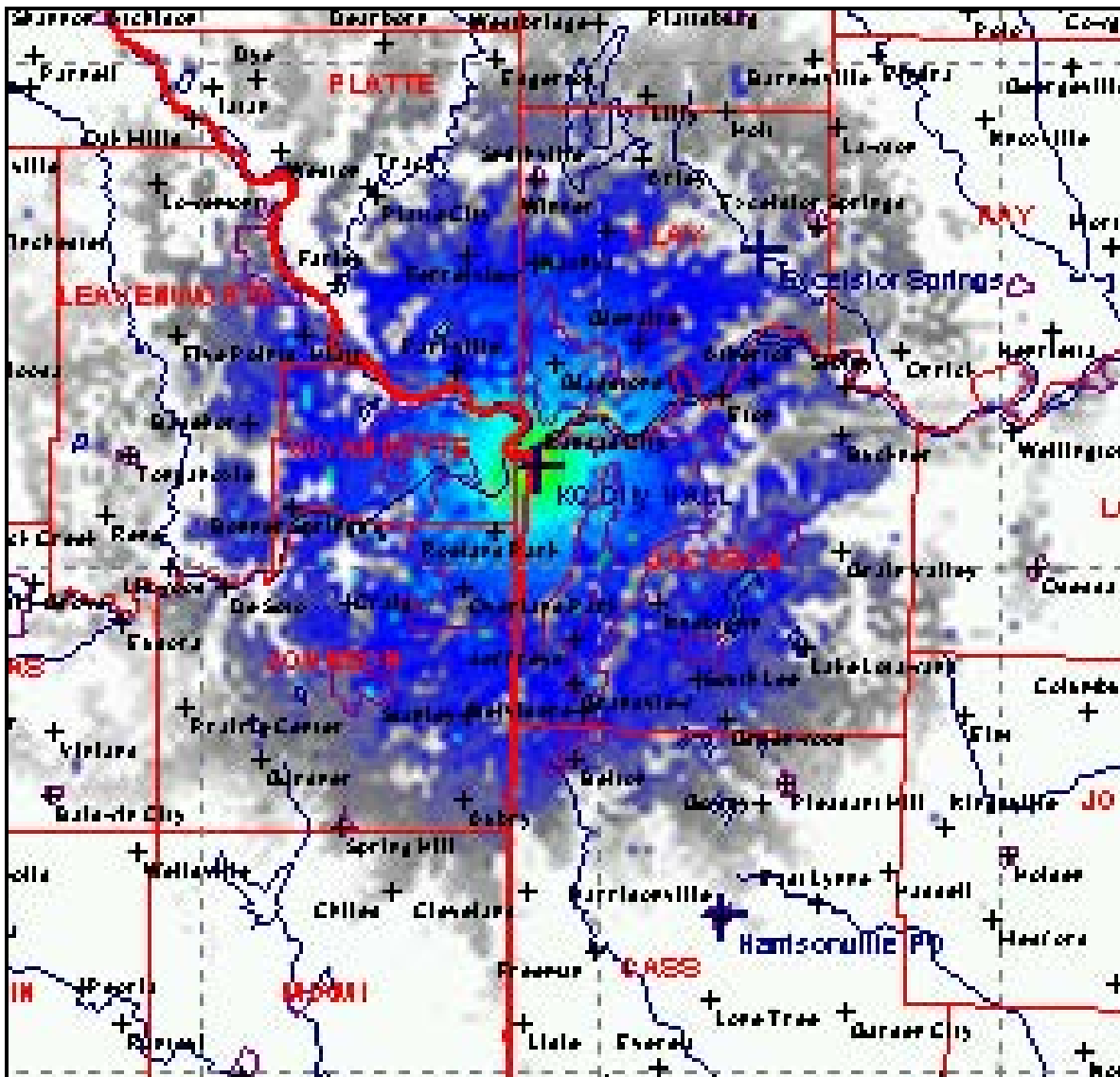
NPSPAC Repeater on KC City Hall Talk-out to on street mobiles



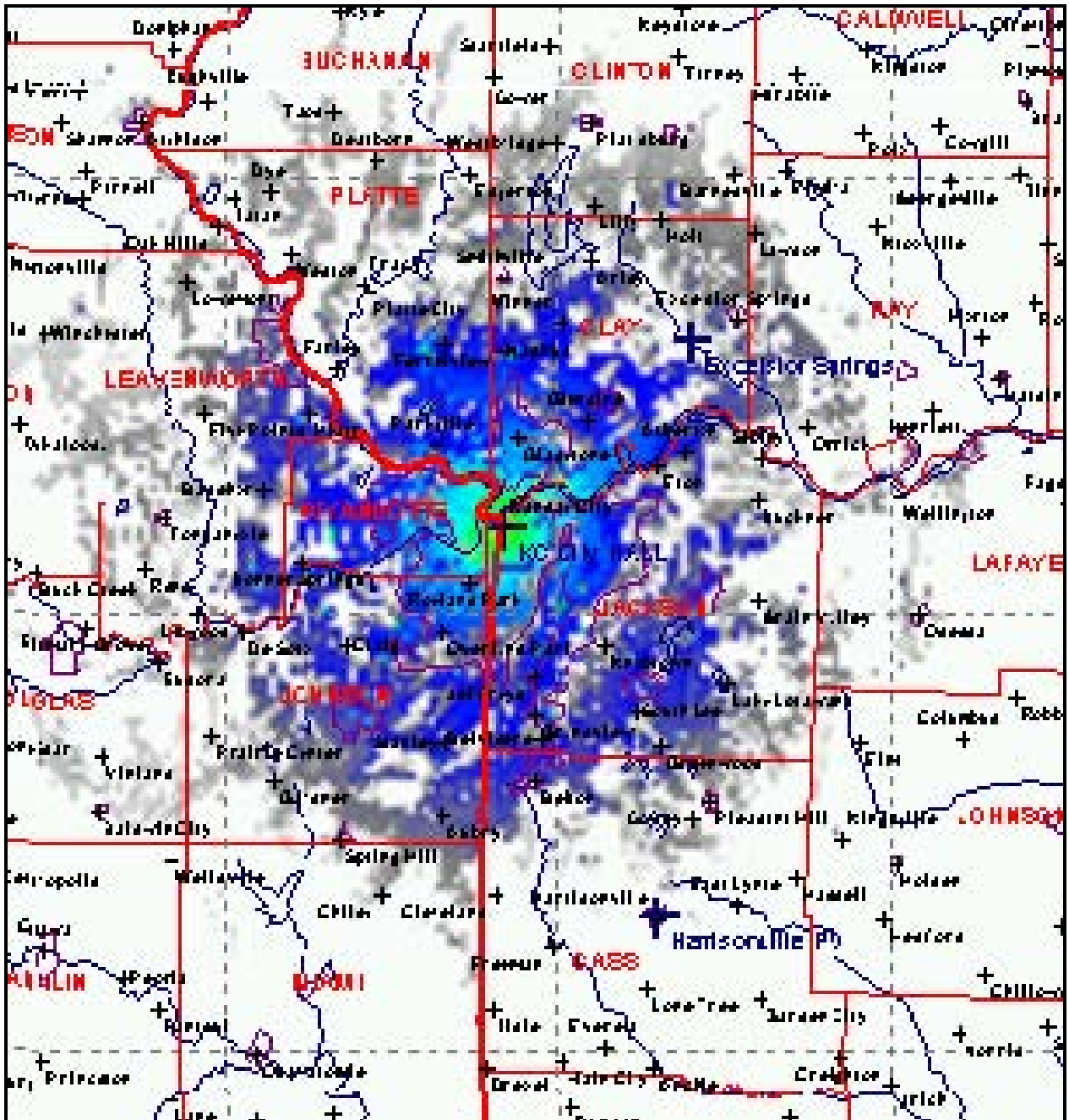
NPSPAC Mobile On Street TALK-IN to repeater on KC City Hall



RF Control stations **talking IN to repeater** on KC City Hall
Assuming 65 foot high external antenna (phone pole height)



NPSPAC Repeater “talk-in” to top of KC City Hall
from 35 watt RF control stations, connected to a 9 db gain
external antenna, mounted at 6 meters AGL at 95% reliability



Appendix C Definition of Terms

- **VHF**: A radio, radio system or channel that operates in the Very High Frequency band around 150 Megahertz (MHz). If your FCC license says something like 155.250 MHz that's a VHF channel.
- **UHF**: A radio, system or channel in the Ultra High Frequency range around 450-460 MHz.
- **LOW BAND**: A radio channel that operates in the 39-45 MHz band.
- **"T-BAND"**: A radio channel that operates in the 470-512 MHz band.
- **800 MHz**: A radio, system or channel that operates in the 806 and 851 MHz bands. These systems may or may not be trunked radio systems.
- **TRUNKED**: A computer managed radio system with multiple radio channels. For each transmission, the computer assigns a channel to the participants for the duration of that transaction.
- **TALKGROUP**: A selection on a trunked radio's "channel selector" switch which defines a grouping of persons, users, agencies or radios as a place for them to "meet and talk" via radio.
- **"NPSPAC"**: A radio, system or channel that operates in the 821 & 866 MHz bands. (National Public Safety Planning Advisory Committee)
- **CONSOLE PATCH**: Buttons or icons in the dispatcher's radio console that (when properly selected) permit the ability to "patch" or connect two dissimilar regular radio channels or "trunked radio talkgroup" together for a specific conversation.
- **HARD PATCH**: A system whereby a dedicated radio is installed to take what it hears and always patch it over to a another radio system channel or talk group, and (sometimes) vice-versa.
- **CROSS BAND REPEATER**: A single device which receives inbound radio traffic on one channel in one band (say VHF 155.475 MHz) and rebroadcasts it out on another channel in another band (say NPSPAC InterOp Channel 1 at 866.0125 MHz) and vice-versa
- **"CHANNEL INTEGRATOR"** (Our term): A fairly new and sophisticated, process/device or system which takes several inbound radio signals from a variety of bands and electronically interconnects them on the "outbound side"

to one or more other otherwise incompatible radio channels. Examples: JPS ACU-1000 switch and Ma/Com's "Network First" switch

- **RADIO EXTENDER/VEHICULAR REPEATER:** *The use of a hand-held portable radio to talk to the vehicle which the operator is associated with, and then the vehicle radio re-broadcasts the communication into the main radio system, and vice-versa. The portable is usually on a different radio band than the main vehicle radio to which it is connected back in the vehicle. AKA Pac R/T, "Pack Rat" or Vehicular Repeater.*
- **REPEATER:** *A base transmitter/receiver that exists for the purpose of receiving inbound radio traffic on one channel in a band and re-broadcasting it out at base station power on a companion channel in that same band. Example: A VHF repeated channel has field radios talking in on a channel like 156.015 MHz and the base repeater re-broadcasting the signal back out on 155.79 MHz, to which all radios on that channel are selected for hearing the repeater output.*
- **SATELLITE (OR VOTING) RECEIVER SYSTEM:** *A set (more than one) of receive only devices placed out in the field at various locations to pick up weaker inbound radio signals and bring them into the "head end" via phone lines, microwave or other means to present them to the dispatcher and/or to the repeater to be re-broadcast out.*
- **MICROWAVE:** *A "point to point" radio system that transmits signals (often data) from one fixed point (microwave dish) direct, in a line of sight mode, to another fixed point. Often microwave is implemented to "bypass" expensive, monthly recurring costs for "data lines" leased from the phone company.*
- **SIMULCAST:** *The process of having a radio signal transmitted simultaneously from multiple transmitters in different locations so as to increase the area over which that radio signal can be heard, as well as the chances of that radio signal effectively penetrating dense buildings.*
- **DIGITAL & ANALOG:** *The method of modulating a radio signal as it travels through the air. Example: Digital signals are the speaker's words turned into a series of 1's and 0's, which are then transmitted through the air, received at the other end and then reconstituted back into the audio sounds of the speaker's words. Analog signals are the speaker's words formed into wave forms and the wave forms are then sent through the air and can be output through a loudspeaker at the receiving end. Generally, analog wave forms require a wider radio channel bandwidth than a digital transmission carrying the same sound but digitally.*