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4G Broadband: Bridging to Public Safety Land Mobile Networks

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1) Introduction

The public safety community is finally in a position to begin making use of wireless broadband services on spectrum the FCC has set aside exclusively for its use. Today, and in fact, since the 1930s, public safety has relied primarily on mission-critical voice radio systems (land mobile radio or LMR) to be able to communicate. Recently, the FCC approved some broadband spectrum that is adjacent to the new spectrum that will be used by AT&T, Verizon Wireless, and others to provide next-generation or 4G wireless broadband services.

This does not mean the public safety community will be giving up its voice networks. In fact, voice will continue to be the method of choice for daily and emergency operations well into the future. However, it does mean that it will be able to incorporate data, multimedia, and video services that will enable first responders to serve us better, obtain information they need in the field in a more timely manner, and provide for additional first responder safety capabilities.

It is important to understand that public safety agencies have unique needs that cannot, for the most part, be satisfied by using commercial voice and broadband networks. This new spectrum enables the addition of broadband services that, if the networks are designed correctly, can be integrated into local, regional, and state networks to provide the best of both voice and broadband services using an interconnected network back-end design. If the new public safety broadband networks are designed and built as separate networks, they will provide some of the capabilities that have been missing from public safety for years, but they won't provide the integration between voice and broadband networks that can add a whole new level of capabilities.

These capabilities include better incident management, quicker response of the proper resources for the incident, and additional data-heavy capabilities to ensure the safety of the personnel in the field who risk their lives daily on our behalf. It may be difficult for those of us who have been using voice, text messaging, and broadband services for several years to understand that the public safety community has been without many of these capabilities until now. It is vitally important that its new networks be designed from the ground up to not only provide these new services, but to incorporate its existing voice networks to provide the full capabilities wanted and needed in the field.

Many people question why public safety needs its own mission-critical networks and cannot simply use existing commercial networks. The answers are many and include the fact that each local jurisdiction needs full control over its networks, including the types of devices, the applications, and management of the network. Public safety needs mission-critical communications that are not available on commercial networks, and it needs to be able to provide both voice and data on a one-to-many basis. Further, its networks need to provide coverage deep inside buildings, subways, and other subterranean structures, and field personnel must be able to communicate even when they are out of range of a tower.

There is certainly a need for cooperation and sharing with commercial networks for non-emergency communications and services, and public safety and commercial network operators are working together to provide this integration. More importantly, public safety needs its own hardened, mission-critical networks and devices that can withstand harsh environments.

The public safety community has all of these capabilities when it comes to voice networks, but it cannot readily interoperate with other first responders in other jurisdictions. In addition to providing the

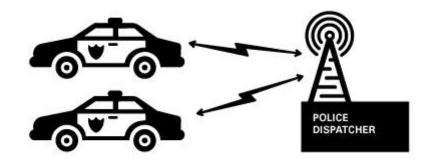
needed data, multimedia, and video services, if designed properly, these new broadband networks will also provide a higher level of voice integration. The same network infrastructure can also provide voice interoperability if the broadband networks are thought of as intelligent extensions of the existing voice networks and not as standalone networks. This is one case where combining networks and serving both voice and data will have an additive effect in the types of services that can be delivered to public safety resources in the field, and public safety will finally have the same capabilities that consumers have had for a few years.

2) Land Mobile Radio Is Different from Commercial Cellular

For anyone not directly involved with public safety communications, it is difficult to understand why public safety cannot use today's commercial wireless networks. Commercial network coverage has improved over the last few years, and text, data, multimedia, and video capabilities have been added to provide consumers and business customers alike with both voice and data capabilities. But the fact is that public safety has many mission-critical requirements that cannot be satisfied by commercial networks or devices. That is not to say there is no place for commercial networks in administrative and non-emergency communications.

There are a number of differences between commercial wireless (cellular) and public safety communications. The distinction between the two can be confusing to those accustomed to using cellular phones in their everyday activities, and understanding this distinction is critical to the successful deployment of 4G broadband networks for public safety. Since the 1930s, the public safety community has been employing specialized wireless communications networks called Land Mobile Radio (LMR) networks. Some of the services and capabilities public safety relies on today include one-to-many voice dispatch, instant voice communications, the ability to talk unit-to-unit without having to rely on a cell site, and low-speed data. Each department has full control of its own network management, devices, and applications it uses and does not have to share the network with commercial users. Unlike cellular networks that are designed to cover large areas and provide many different types of services to their customers, public safety voice networks have been designed to provide local areas with mission-critical voice communications services. They are usually built to be able to communicate from deep inside buildings, in subways, and parking garages. Each local jurisdiction or group of local jurisdictions has built and refined its LMR networks over many years, and they are hardened to withstand most, if not all, of the adverse conditions that can affect their operation.

In the following description, we have chosen to use police officers as an example of public safety professionals, but the same applies to firefighters, paramedics, and so on. Typically, when police officers make calls on their radios, they talk directly to a dispatcher. There is no need to dial any number, because the dispatcher's job is to listen to the radio channel, monitor all of the traffic, and respond when called from the field. In turn, when the dispatcher speaks, all of the other police officers on the network hear the conversation. This is the wireless equivalent of a conference call. When dispatchers want to speak to a particular officer, they must address that officer verbally. Since everyone can hear the call, all officers in the field receive an advance indication of an impending incident and are aware of exactly what is happening in their area.

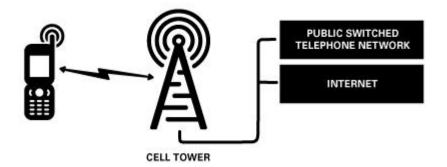


At other times, it is important that the dispatcher be able to talk to multiple officers at once. It is a movie cliché for the dispatcher to announce, "All units, be on the lookout for..." but it is based on standard practice. Public safety radios have another property. They are not dependent on a base station or cell tower. If two or more police cars are in a remote location, they can communicate with each other even if they cannot reach the dispatcher. This is an important capability in rural areas when responding to accidents or natural disasters.



Also, in emergency situations, the responding officers can quickly switch to a local channel and talk among themselves without flooding the larger network. This local mode enables coordination from the scene.

In contrast to the police officer's radio, your cell phone communicates with a nearby cell tower. When you place a phone call, the tower routes the call onto the Public Switched Telephone Network (PSTN), which enables you to call any phone on the planet. Likewise, any phone can call your mobile phone. But to place a call, you must "dial" a number and it can take tens of seconds for the voice circuit between the two parties to be set up.



This is quite different from the public safety network where you can talk immediately. Some cellular networks feature a "push-to-talk" mode of operation that approximates the experience of the public safety network, but it is not possible to dynamically set up a local group to communicate separately from the main network. Cellular networks are designed for one-to-one voice calls and are not equipped to handle the broadcast operations described above.

Also unlike public safety radios described above, cell phones are completely dependent on the cell tower infrastructure. If your phone cannot communicate with a cell tower, it is useless. It cannot call another cell phone in the immediate vicinity unless both phones can connect to a tower. Just as you can dial any phone number in the world from your cell phone, if you open a web browser on your phone, the data requests are routed onto the Internet and the responses from the website you visited are returned to your phone. Note that all of this happens automatically without human intervention. Not shown in the above diagram are the numerous switches, computers, and other components that make all of this work, and it works well.

In summary, the key differences between commercial and public safety networks today are that

- Commercial networks have back-end systems that connect to the PSTN for voice and the Internet for data.
- Commercial networks rely on the cell tower infrastructure for all communications. Where there are no cell towers there is no communication.
- Commercial networks are designed for one-to-one communications, not for broadcast (one-tomany).
- Public safety networks provide a constant line of communication between the user and the dispatcher.
- Public safety networks are not dependent on base stations or cell towers, thus users can communicate between each other if they are in range.
- Public safety networks support broadcast communications (one-to-many).

3) Understanding Public Safety Communications and Use of Commercial Cellular Networks

Today, many public safety agencies employ commercial third-generation networks for voice telephony, text and multimedia messaging, and Internet access, but this use is generally limited to non-missioncritical communications and/or secondary usage. Their experience with these 3G networks has been positive and they continue to be used as supplemental systems. When there is an emergency, the demand for both public safety communications and consumer use of commercial networks increases dramatically, making it difficult for these networks to adequately provide services to all who need them. The public safety community cannot be put into a position of having to compete with consumer and business wireless traffic.

It is important to understand the gap between the public safety community's requirements and what is available with commercial wireless networks and devices, and that cellular networks are not designed to withstand the adverse conditions under which public safety must operate. In summary, public safety requires it own dedicated communications capabilities.

4) Public Safety Now Has Access to Broadband Spectrum

Until recently, public safety did not even have enough spectrum to be able to use many of the non-voice services more than 287 million people in the United States use daily. None of public safety's spectrum was capable of being converted from the existing voice systems to broadband systems because its allocations are so spread out and, in many cases, intermingled with business Land Mobile Radio (LMR) users. The FCC recently allocated additional spectrum for public safety to be able to build broadband networks that can be interconnected to provide interoperability between agencies, something that has been lacking for more than thirty years. A recent FCC ruling will permit a number of city, regional, and state agencies to begin constructing these networks.

While some of this spectrum is reserved for channelized mission-critical voice communications, some has been allocated for a broadband network to provide data, multimedia, and video capabilities for the first responder community; the same types of capabilities commercial customers take for granted today. While this new spectrum will only partially solve the interoperability issues faced by public safety, it is a very good start. During the same time, the public safety community has been addressing voice interoperability and has begun to find ways to tie voice networks together during major incidents to help alleviate the interoperability problems.

5) Broadband Will Be Supplemental (It Cannot Replace LMR)

While these broadband networks will enable new high-speed data and multimedia services such as the transmission of video and mug shots, they must remain as an adjunct to public safety's existing voice-optimized LMR networks. There are a number of key mission-critical criteria that simply cannot be duplicated on the new broadband networks designed for consumers, such as instant one-to-many communications and the ability to communicate in areas where there is no network coverage (for example, when fighting a fire deep inside a commercial building). Some agencies have subscribed to commercial broadband services, but commercial networks don't have the same tailored coverage and hardening as their own voice networks. The new broadband networks will be able to carry voice as a service in the future, but only non-mission-critical voice. The LMR networks are critical to public safety's everyday success and must co-exist with the new broadband networks as they are deployed and evolve.

6) Public Safety Broadband Networks Should Be Extensions to Public Safety LMR Networks

a.) Blending Mission-Critical Voice and Data Networks

In order to provide the first responder community with the tools it needs on both a day-to-day basis and for major incidents, it is necessary to combine the best of the existing public safety networks with the best of the commercial networks and technologies. This will help bring the public safety community into the 21st Century and will result in having the tools it needs to serve all of the citizens of the United States.

The vendor community is already at work designing the specialized broadband equipment that will be needed to meet the needs of the public safety community. Many within both the commercial and public safety industries are viewing these new broadband networks as standalone networks that will be deployed as second networks for the agencies. We believe there is a better way to accomplish the goal of bringing the communications capabilities of the first responders into the 21st Century. To get the most value for public safety from these broadband networks, they must be implemented as an extension of both the public safety LMR (voice-oriented) networks and the public safety wired IT networks.

b.) Public Safety Agency Level Control

One key to success for any public safety agency is a tailored, clearly understood set of operational policies and procedures. Today, each public safety agency chooses its own devices and applications, and sets its own LMR network policies and priorities to support its specific operations. (This is sometimes referred to as "open access.") During an incident, seconds matter and delays can occur as requests to use the system outnumber capacity. Each agency carefully controls access to its LMR network — to be able to assign priority for incidents that are deemed more severe, for individual roles at an incident that are more critical, and for any responder in a state of emergency. A broadband network will have the same demands and each agency must be able to control who has access to the network within its jurisdiction, dynamically adapting to changing incidents and roles.

It is vitally import that each jurisdiction be able to control the network(s) that serve its own communities while providing for interoperability when more resources from out of the area are necessary. On a daily basis, local public safety networks operate in a standalone mode with coordination between agencies, access to databases, and other information being funneled to the dispatch center. With this method, the system can be managed efficiently, making sure that all who need access to voice services have that access. The broadband networks will need to be built with this same concept in mind, but if these networks are designed to help blend voice and data into a central system, the one interconnected infrastructure will provide a higher degree of interaction between the standalone voice and data networks. The result will be more efficient than if these networks remain separate.

c.) Coordinate Complementary Services Across Broadband and LMR

The broadband network can also act as an extension of the LMR network by coordinating complementary services across the networks. For example, the two networks should be able to coordinate LMR push-to-talk calls with push-to-send image services over the broadband network. That way, the voice communications about, for example, a suspect in a robbery, will be followed quickly with

a picture of a suspect, or a live camera feed at the crime scene. Also, since the broadband network will support non-mission-critical voice in the future, the reach of an LMR push-to-talk call should be able to be extended to include second responders or government officials operating on the broadband network. This would enable first responders at an incident who are challenged with a broken or contaminated water main to coordinate with a public works employee on the broadband network. It would also enable a mayor on the broadband network to listen to the LMR voice traffic during a large incident. Integrating the broadband and LMR services has the potential to be a powerful and natural extension of what public safety can do today.

Another example of this type of network interaction might be the case of an officer in distress. Today, if officers find themselves in a situation where they need assistance, they use their voice radio to call for help. If this is not possible, they push an emergency button on their radio and a message is sent to the dispatch center. This message contains the officer's unit number and location, but it does not include any information about the incident or its severity. The dispatcher sends additional units to offer assistance, but these officers are responding to an unknown condition and there is no way of knowing whether other resources are needed until they arrive at the scene.

If the voice and broadband networks are built as we are describing, then this scenario, which plays out all too often in real life, would include the ability for the data network to automatically locate cameras nearest the incident, turn them toward the incident, and perhaps zoom in so the exact nature of the emergency could be assessed. This video would not only be viewed by the dispatcher, it would also be transmitted over the broadband network to the responding units. On their notebook computers that are permanently installed in their vehicles, they would be able to view the incident as well receive the alarm from the dispatcher. They could then plan their approach to maximize their assistance to the officer in trouble while making sure they were not putting themselves in harm's way as well.

Building the new broadband networks so they are complementary to the existing mission-critical voice networks is key to providing new tools for public safety in the form of direct data, multimedia, and video access, and to adding value to that information. Being able to send a suspect's picture to both the dispatch center and all of the surrounding units, and to simultaneously add information via the voice networks, gives those in the field valuable new tools that will assist in the apprehension of a suspect more quickly and will provide an increased level of safety for the officers in the field.

d.) The Mobile Office: Extending the IT Network

At present, both the FCC and the public safety community are focused on the issues surrounding the funding and construction of a nationwide broadband network. In reality, this network will be made up of a number of different networks built out to common fourth-generation standards — some will be built by cities, some by counties, some by consortiums of cities and counties on a larger scale, and still others by states. Each of these networks will be incorporated into the national public safety broadband network that will tie all of these together into a master network with the capabilities needed by the public safety community.

These networks will take advantage of the latest fourth-generation broadband technology (LTE) and will be designed using commercial network technologies. Some will be standalone, some will be built in cooperation with commercial network operators, and some will use commercial networks' back-end systems and high-speed backhaul. However, in all cases, the focus is on the broadband side of interoperability, which could lead to a fully interoperable, but separate, nationwide broadband network.

A properly designed intelligent back-end system, implemented first on a local level and then tied into the nationwide intelligent backbone, could provide for much better control for all forms of public safety communications and connectivity, yet each voice network would continue to function as a standalone voice network for routine public safety communications. In times of major incidents, all of the networks would be able to cross-communicate, tying the various jurisdictions together. The result of this type of system architecture would be to provide a total communications solution for the public safety community.

The broadband network should also be able to operate as an extension of public safety's existing IT network. Public safety agencies operate much like any other enterprise, but with a very special mission. They host email servers on their IT networks along with many specialized applications including 911 Call Taking and Computer Aided Dispatch (CAD) applications used to respond to emergency calls, and unique message switches that provide access to various state and national public safety databases to determine if an individual is wanted for a crime or to run a vehicle's license plate number. They are also ramping up on video applications as surveillance cameras are deployed throughout cities. The capacity and speed of these new wireless broadband networks is approaching that of wired IT networks in most offices and with a secure broadband network, first responders can potentially use these departmental applications while connected to the IT network, effectively creating the tailored mobile office for each public safety agency. Wireless access to agency applications, chosen and controlled by the agency, further empowers each agency to equip its first responders with the solutions that best support its specific operations.

The agency's wireless broadband devices must also accommodate these IT applications and operations. Today, most departments employ voice radios both in their vehicles (mobile radios) and on their officers (handheld radios), but their data capabilities are currently limited primarily to in-vehicle laptop computers. As the broadband networks are completed, the next generation of devices will include another device for broadband services in the field. When used in conjunction with existing voice radios, and integrated on the back-end, new these services will provide for faster access to data from the field and the ability to send and receive data, multimedia, and video feeds coupled with existing voice communications systems. It is important that each agency maintain the ability to choose its devices and this type of network architecture would be valuable as broadband capabilities move from the vehicle onto the officer.

7) "Enterprise Mobile" Not a "Consumer "Mobile"

Public safety organizations are more like a collection of local enterprises, each with their own networks, than consumers with a cellular network operator and multiple subscribing users. In the "consumer model," one central entity makes the policy, application, and device decisions for all. This cannot work for public safety. In the "enterprise model," these broadband networks would be deployed as extensions of each agency's current networks, both LMR and IT. The strength of the "enterprise model" is that it adapts the technology to extend and enhance current public safety operations — it does not require public safety to adapt to the technology. At this point, it appears that only Motorola and ALU, partnered with EADS, have realized this and are proposing this type of solution.

8) Interoperability with the "Enterprise Model"

It is also important to understand what public safety interoperability really means. It does not mean that a police officer in Dallas needs to communicate directly with a police officer in Boston, but it does mean

that when there is a major incident, such as a hurricane or a wildfire, those responding from out of the area can be assured that when they arrive on the scene they will be able to communicate with others from different areas who are already on the scene. During both 9/11 and Katrina, emergency personnel were sent from every state in the Union, and when they arrived with their own radios, they were not able to communicate with those already on the scene.

The public safety communications world needs to be one in which any first responders can be sent to any area of their state, their region, or the nation, and upon arrival have the same communications capabilities available to them as they had in their own primary service area. This not only means building a nationwide public safety-specific broadband network, it means designing the infrastructure to be able to integrate the many different voice systems that make up today's public safety networks and to provide gateways and interfaces to the commercial networks. While the public safety community needs its own dedicated spectrum, it can also benefit from being able to integrate its systems with commercial networks. The commercial networks provide a nationwide system that can today, and more effectively in the future, provide communications capabilities for non-emergency or non-priority traffic. This will, in turn, lessen the demand on public safety networks and help reduce congestion.

Inter-agency communications can be achieved much more efficiently using the "enterprise model" than the network-centric "consumer model." This new generation of networks has key differences from earlier networks. For starters, they are designed with standards-based IP-based technology and will be deployed in spectrum common to all public safety agencies. Nationwide interoperability is enabled by a common set of applications and services and inter-network interfaces, and the effort to identify and standardize these is already underway. Thus local and regional agencies will retain control of their own networks, applications, and types of devices while being able to intercommunicate with the other networks nationwide and use multi-agency applications when needed for major incidents.

9) The Role of Commercial Network Operators

This is not to say that today's and tomorrow's commercial networks do not have a role to play in public safety communications. Commercial networks can provide additional coverage or capacity on an asneeded basis. They can also reduce the cost of the public safety networks by sharing their cell sites and backhaul, where most of the cost lies. A new generation of 911 services is on the horizon, and citizens and businesses will be able to submit pictures, video, and text messages. Commercial networks will be the key in delivering this content to the 911 center. Commercial network operators want to continue to support the public safety communications and will play an important role in its total communications capabilities on a secondary basis, while local, regional, and statewide voice and broadband public safety networks will be reserved for emergency and mission-critical response activities.

10) Conclusions

We believe that it is imperative that these new public safety broadband networks become part of an overall solution for public safety and not merely another standalone network. Public safety will gain new levels of officer safety and effectiveness in the field, making better use of scarce resources, by ensuring that these LTE networks work as seamless extensions of their existing communications networks and current operational procedures, while providing new capabilities and levels of interoperability that have long eluded our nation's first responders.