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Mission-Critical Voice Over LTE:

What, When, and How?

The Public Safety community has been told by some within Congress that in order for the D Block to be reallocated to Public Safety and to receive federal funding for the network build-out, the Public Safety community will need to show good faith by returning the 14 MHz of 700-MHz spectrum that is presently being used for narrowband voice and slow-speed data. The assumption seems to be that the broadband assignment (the D Block and the existing Public Safety 10 MHz of spectrum) will soon be able to support mission-critical voice in addition to data and video services for Public Safety, therefore the 700-MHz narrowband spectrum should be returned so it can be auctioned for use by commercial network operators.

The end-goal of a single network that will provide voice, data, and video services across the nation is also a goal shared by the Public Safety community. However, this is a complex issue and a number of obstacles must be overcome in working toward that goal. In the meantime, those who believe the Public Safety LTE broadband network will soon be able to provide all of these services, making the 700-MHz narrowband spectrum obsolete, need to be aware of these issues and what needs to be done to overcome them.

This requirement that is contained in the bill presently in the House would, in reality, cripple the Public Safety community and negate all of the progress that has been made toward interoperable voice communications over the past ten years. The 700-MHz narrowband spectrum, which has only been available to Public Safety since the sunset of analog TV in June of 2009, has already seen a number of local, regional, and statewide systems built and put into operation. There are also many more agencies in the planning stages of making use of this spectrum for narrowband communications in order to further the ability to achieve voice interoperability, which has been lacking in Public Safety for more than thirty years and was brought to the public's attention during the attacks on 9/11 and the Katrina earthquake.

The assumption is that when the broadband spectrum supports mission-critical voice, Public Safety will be able to consolidate voice and data services on the broadband spectrum. While this is certainly the goal of the Public Safety community, it is premature to assume that mission-critical voice will be available on the LTE broadband network. The decision by Congress to include the 700-MHz narrowband spectrum as a "give back" in the House bill is, I believe, based on a lack of understanding of all of the implications this would have on existing and future Public Safety voice communications. While this is a goal that is sought after by both the federal government and the Public Safety community, there are

many other factors that must be taken into consideration before definitive dates can be placed on this giveback.

The definition of mission-critical voice services may not be fully understood by those involved in the decision-making process. Public Safety mission-critical voice is vastly different from voice services being offered over traditional commercial broadband networks. Verizon has stated, for example, that it is trialing voice over IP (VoLTE as it is called) and could be ready to deploy it on its LTE network starting in 2012. However, what Verizon will be offering when it is ready for commercial service is traditional voice for those who want to make and receive voice telephone calls. This type of voice service only provides one of many of the features and functions required within the Public Safety community.

Therefore it is important that those crafting legislation that includes the giveback of the 700-MHz narrowband spectrum (pers-7hrd5-2739852992@craigslist.org) fully and completely understand the differences between voice and mission-critical voice.

The National Public Safety Telecommunications Council (NPSTC) recently published what is becoming the standard definition for mission-critical voice not only over LTE but also over any wireless interface.[1] The Executive Summary states that the key elements for the definition of mission-critical voice include the following:

• ***Direct or Talk Around:*** *This mode of communications provides public safety with the ability to communicate unit-to-unit when out of range of a wireless network OR when working in a confined area where direct unit-to-unit communications is required.*

• ***Push-to-Talk (PTT):*** *This is the standard form of public safety voice communications today - the speaker pushes a button on the radio and transmits the voice message to other units. When they are done speaking they release the Push-to-Talk switch and return to the listen mode of operation.*

• ***Full Duplex Voice Systems:*** *This form of voice communications mimics that in use today on cellular or commercial wireless networks where the networks are interconnected to the Public Switched Telephone Network (PSTN).*

• ***Group Call:*** *This method of voice communications provides communications from one-to-many members of a group and is of vital importance to the public safety community.*

• ***Talker Identification:*** *This provides the ability for a user to identify who is speaking at any given time and could be equated to caller ID available on most commercial cellular systems today.*

• ***Emergency Alerting:*** *This indicates that a user has encountered a life-threatening condition and requires access to the system immediately and is, therefore, given the highest level or priority.*

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[1] The full NPSTC definition of Mission Critical voice may be found at: MCV Functional Description

• ***Audio Quality:*** *This is a vital ingredient for mission critical voice. The listener MUST be able to understand without repetition, and can identify the speaker, can detect stress in a speaker's voice, and be able to hear background sounds as well without interfering with the prime voice communications.*

A Comparison of these requirements and those available on today's 3G and 4G commercial networks is provided in the chart below:

Type of Voice Service	**Commercial LTE**	**Public Safety Narrowband**	**Public Safety Broadband**
Direct or Talk-Around	No not available	Standard feature	MUST be included
Push-to-Talk (PTT)	Will be Available in 2013-2014	Daily use on narrowband	Will start with non-mission critical PTT
Full Duplex Voice Systems	Yes-Commercial grade voice	Telephone interconnect is available	Commercial grade voice
Group Call	No-Must Set up Conference call	Yes in daily use	MUST be included in network
Talker Identification	Yes-Caller ID	Not in use	Not on LTE roadmap for inclusions in standards[2]
Emergency Alerting	No-Must dial 911	Yes	Not on LTE roadmap for inclusion in standards
Audio Quality	Yes	Yes	Required

As can be seen from the above comparison chart there are a number of key differences between commercial voice and mission-critical voice today, and the functions that are *NOT* a part of broadband commercial voice or cellular voice systems today are the most important aspects of mission-critical voice for Public Safety. While it is possible that these functions can be designed into the LTE broadband technology going forward, there remain several issues:

1) What is the timing for these functions to be incorporated into LTE?
    a. Would they have to be approved by the world standards bodies?
    b. Would there have to be on-off modifications to LTE for Public Safety only?

[2] Peer-to-peer or off-network data services could be of great value to Public Safety

2) Would one-to-many voice communications require the addition of what is known as eMMBS or enhanced Multi-Media Broadcast Services? If eMMBS is required, it will add substantially to the cost of the Public Safety LTE Network.[3]

3) Even if LTE can be modified to provide one-to-many push-to-talk, group call, emergency alerting, and off-network or peer-to-peer communications, can the Public Safety broadband LTE network support the number of voice paths that are needed?
    a. See details on voice paths below.

4) Today there is no definitive design document outlining and detailing all of the Public Safety requirements for mission-critical voice. Therefore, it is not possible to know for certain if all of these requirements can, in fact, be included in the LTE technology and if they can be, how long it will take before these changes could be made and devices become available.
    a. Will there be non-recurring engineering costs (NRE) associated with the development of these functions? Would these costs be paid by the federal government?

5) If LTE can be modified to meet all of the requirements for mission-critical voice at some point in the future, who will pay for the following?
    a. The move from 700-MHz narrowband systems to the Public Safety broadband system.
    b. The replacement of all existing LTE broadband devices in use by Public Safety on the broadband network until the time that mission-critical voice becomes available.
    c. These replacement costs will run into the multiple $millions. Will these costs be included in the relocation fees that the federal government will pay out from the proceeds of the 700-MHz narrowband spectrum auction?

It should be noted that most of the Public Safety requirements for voice services have little or no value to commercial operators. Thus, unlike the existing LTE standard, changes to the standards to permit mission-critical voice over LTE will have to be incorporated into the LTE standard for the Public Safety community only, or if the standards body elects not in include off-network voice and data communications into the standard, the standard will have to be modified for the Public Safety community, which is counter to the original purpose of making use of a commercial standard to reduce device costs.

There is also the issue of the qualifications of those promoting the use of mission-critical voice over LTE. Are they engineers with a complete understanding of mission-critical voice? Do they have any firsthand experience with Public Safety mission-critical communications? Many people assume that the requirements of commercial voice and mission-critical communications are the same. However, as

[3] It should be noted that today's 3G commercial technologies support MMBS or broadcast. However, this feature has not been installed within a single commercial 3G broadband network as of this date.

demonstrated above, there are a number of significant and important differences. When a cell phone is out of range of the network on which it operates or out of coverage, the device is useless to the person holding it. In the world of Public Safety that is not an option. Voice communication is and will continue to be the lifeline for our Public Safety professionals. They need to know that when they need help, they can make a simple push-to-talk voice call or push their emergency button and regardless of where they are within network coverage or outside of it, deep inside a building or simply out of range of the network, that their call for assistance will be heard and acted upon. Therefore, those who are making statements regarding voice over LTE must have a solid grounding in what the definition of mission-critical voice is and how it can be applied to the LTE technology. Unless and until all of the various forms of mission-critical voice communications can be provided by LTE, the need for narrowband spectrum and channels will remain.

There are two sets of issues that need to be considered when making a decision about when and if Public Safety narrowband spectrum can be reallocated. The first set of issues is to fully understand the requirements of the Public Safety community for mission-critical voice. The second is to look at what within the LTE technology will have to be changed, modified, or invented from scratch.

Understanding the requirements for mission-critical voice should be the first priority for anyone seeking to determine if and when voice over LTE will be able to provide all of the different types of voice services required. Again, Public Safety requirements go well beyond the simple use of voice for voice calls. It is, therefore, vitally important that those making statements about the use of mission-critical voice over LTE have a complete understanding of all of the requirements. Below is a list of suggested qualifications that should be used to determine whether those providing the information about voice over LTE are qualified to render their opinions.

1) They have read and understand the National Public Safety Telecommunications Council (NPSTC) document: Mission Critical Voice Communications Requirements for Public Safety (MCV Functional Description). This document is also being presented to ANSI to be certified as the standard definition for mission-critical voice.

2) They understand and can explain
    a. The use of both on and off-network voice communications.
    b. Why off-network voice even when within the coverage area of a network is important to Public Safety.

3) The range requirements (distance) of mission-critical off-network voice.
    a. How this will be accomplished when replacing traditional handheld and mobile narrowband voice devices that operate with a transmit power of from 5 to 100 Watts with LTE devices that are today transmitting at a peak power of ¼ watt.

4) The terms one-to-one, one-to-many, talk groups.

5) How many independent voice circuits or channels are required for any incident.
   a. Typically during an incident, each sub-group makes use of its own voice channel so it does not interfere with the others. The Incident Commander normally communicates with each sub-group leader and has a communications path between the incident and the command or dispatch center.

To my knowledge, beyond the NPSTC definition document referenced above, no group or individual has developed a set of specifications or a requirements document that could be provided to potential vendors to obtain feedback on the feasibility of adding all of the requirements of mission-critical voice to LTE before making a determination:

1) That LTE will be able to support mission-critical voice.
2) At what point in time these functions will be available for deployment within the Public Safety LTE network.
3) When devices will be available that will provide all of the functionality required for mission-critical voice over LTE and at what cost.

It is essential that a requirements document be drafted and that input from the chip vendors, device vendors, and software vendors be sought. Statements that are not based on specific requirements are not helpful to those who must make decisions that will impact the day-to-day operation of the Public Safety community.

That brings up the issues that must be understood and for which technical solutions must be found before there can be a determination of the "if and when" of mission-critical voice over LTE. Some of these are:

1) What are the range requirements for off-network voice communications?
   a. Today's narrowband voice devices range from 5-Watt handheld radios up to and including 100-Watt mobile radios. LTE devices today have a transmit power of ¼ Watt.
   b. Further, narrowband voice devices make use of more efficient external antennas while today's commercial broadband and voice devices have much less efficient internal antennas.
   c. What is the range of these devices for in-building communications when required?

2) How many simultaneous on and off-network voice channels are required?
   a. Many cities require multiple voice channels for dispatch. Today they normally have one to three citywide channels and then divide the city into districts with each having its own dispatch channel. They need additional voice channels on a district or multiple district basis for the units responding to an incident. The FCC's guideline for the number of vehicles that

can be managed on a single radio channel state that depending on the narrowband technology, between fifty and ninety vehicles can be dispatched and managed on a single voice channel. In many cities the number of vehicles in a fleet runs into the thousands.

b. In addition, each incident usually requires multiple off-network voice channels for the various types of responders. These channels are important since they enable the individual groups to work together while keeping voice traffic off the on-network voice channels.
c. The number of off-network voice channels will depend on the type of incident. In a major wild land fire as many as eighty or more of these channels are pressed into service as the incident grows in scale.

3) How the channel is changed on the voice device.
   a. On a typical LTE network, the network controls the channel assignment of the device. The device itself has no provisions for changing to a different channel.
   b. In today's narrowband voice systems, the channel assignments are given to those arriving at an incident and they manually switch their radios to the desired channel. Further, many field devices are set up to receive not only the assigned voice channel but also to monitor several other channels by using a scanning system with priority.
   c. Therefore when a device is making use of off-network voice some method of channel changing must be provided. Today's radios are usually multi-channel capable and many have several hundred voice channels pre-programmed into them for use during both local and mutual aid incidents.

4) Transmitter power output requirements.
   a. Today's handheld Public Safety devices have transmitter power output levels of 2 to 5 Watts and make use of an external antenna. Mobile devices have a transmitter power output of 20-100 Watts and also make use of an external antenna.
   b. Today's LTE devices have a transmitter power output of up to ¼ Watt and make use of internal antennas that are less efficient than externally mounted antennas. Further, the power level of the transmitter is controlled by the LTE network depending on the distance from the cell site to the device.
   c. The requirements for off-network voice communications call for these devices to be able to communicate with each other over a distance of several miles or between devices when one user is on the street and others are located within a building including in basements and other internal areas.

5) Audio output.
   a. Today's voice devices include device-mounted or external speakers and audio output is sufficient for users to be able to hear the voice traffic on the selected channel without having to hold the device in their hand.

b. Today's LTE devices are designed for handheld use or use with a Bluetooth device. Usual operational requirements are that the users hold the device.
c. Public Safety voice devices can be listened to without having to pick up the unit. Transmissions can be made by pushing the PTT switch on an external microphone or on the side of the radio. This is very different from today's commercial devices that require one and sometimes two-handed operation. Public Safety cannot *EVER* be required to use a device that takes two hands to operate. In many conditions they cannot afford to have a device that has to be held in order to hear the voice traffic on the channel.

Conclusions

The Public Safety community would like nothing better than to have a single, nationwide swath of spectrum that would enable true interoperability for all of its voice, data, and video needs. However, this must be balanced with the amount of spectrum required for day-to-day operations within large metro areas and the amount of voice, data, and video traffic that will ride on the wireless network. Overloading a commercial cellular network, as has happened on numerous occasions, results in blocked or dropped calls and dropped data sessions. This is not an option within the Public Safety community.

Going forward there must be a balance of existing voice spectrum and its usage with that of the new broadband spectrum. The 700-MHz narrowband spectrum is vital in this regard. As we move forward over the next five years and the Public Safety broadband network is built out, it will provide interoperable data and voice communications services. However, to expect it in the short term to also provide fully interoperable voice communications to replace that which is presently on the Public Safety narrowband channels is not realistic.

It is hoped that someday this can be accomplished. The issue is when that day will come, what must be done, and how much money must be invested before we get there. There are many questions and few answers, thus planning the obsolescence of the Public Safety 700-MHz narrowband voice channels is both premature and unwise. Today the best solution for providing as much voice interoperability as possible lies within the 700-MHz narrowband spectrum allocation. To plan now to reclaim it will stop, dead in its tracks, all further development of 700-MHz narrowband voice systems that are of vital importance. Public Safety does not have enough narrowband spectrum to operate on a day-to-day basis. Planning to reallocate the narrowband spectrum at some future time essentially stifles all future development of 700-MHz narrowband systems. Cities, counties, and states will not invest $millions building out new networks that could be taken from them in the next five or ten years. Public Safety systems are built to last for decades, not years, and local governments are struggling to find the resources they need to provide for all of the public services they normally must provide. Even for Public Safety, a vital community function, they won't invest in a network that will solve an interoperability problem today that will be shut down within a decade.

The optimists believe that mission-critical voice over LTE is just around the corner, the engineers and LTE system planners believe it will be at least a decade, and others are not convinced that LTE, as a broadband technology, will ever be able to replace narrowband mission-critical voice. From my perspective, we are better off revisiting this issue after a set of requirements has been vetted with the technical community and feedback has been provided by those responsible for the design and advancement of broadband technologies.

Further, it should not be up to anyone except the Public Safety community to decide if and when mission-critical voice over LTE will satisfy its requirements. Public Safety personnel are in the field every day to serve all of us, and they are in harm's way much of that time. They have the right to expect that when they call for help on their radio that call will be heard and help will be on the way. If they cannot trust their communications systems to work all of the time, every time, we have no right to ask them to put themselves in situations that endanger their own lives.

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