Mission Critical Voice Communications Requirements for Public Safety
National Public Safety Telecommunications Council
Broadband Working Group

Executive Summary

The term mission critical voice has been used within the public safety community for decades. However, until now there has been no one single complete definition of what, exactly, mission critical voice is. There are a number of definitions in use today but until the National Public Safety Telecommunications Council (NPTSC) Broadband Working Group took up the issue of providing a finite definition, mission critical voice has meant different things to different groups within the first responder community.

The effort to establish an accepted definition for mission critical voice was undertaken by NPSTC because, as public safety transitions to the Nationwide Public Safety Broadband Wireless Network, voice communications may transition from today's Land Mobile Radio (LMR) channelized narrowband voice systems to voice over the broadband network. If this transition is to be accomplished, it is imperative that those companies who will be developing the technology to provide voice over broadband fully understand all of the requirements that make up public safety mission critical voice.

This transition will take a number of years to accomplish and it is not clear that all of the features and functions required by public safety for mission critical voice can be accommodated using the commercial standards for wireless broadband. *This document is not designed to provide a road map for those who desire to build mission critical voice into wireless broadband technologies, but rather it has been written to provide a basis for a common understanding of the meaning of and the multiple requirements of mission critical voice.* Some of the features listed below contain descriptions of technology solutions and

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American Association of State Highway and Transportation Officials | American Radio Relay League | Association of Fish and Wildlife Agencies | Association of Public-Safety Communications Officials – International | Forestry Conservation Communications Association | International Association of Chiefs of Police | International Association of Emergency Managers | International Association of Fire Chiefs | International Municipal Signal Association | National Association of State Chief Information Officers | National Association of State Emergency Medical Services Officials | National Association of State Foresters | National Association of State Technology Directors | National Sheriffs' Association

functionality that are meant to provide an understanding of how these features have been addressed by today's technology, but are not meant to constrain future solutions. In order for the companies that are developing wireless broadband technologies desiring to add mission critical voice components to wireless broadband, other documents detailing actual voice requirements will be necessary. The definition herein, for example, does not provide details regarding the number of voice circuits or channels which are needed to meet the requirements of the public safety community during major incidents, nor does it detail the range requirements between devices that need to communicate with each other during these incidents. This document is intended to set the standard for the definition of mission critical voice as required by public safety in order to provide a starting point. Future revisions of this document will define the specifications and requirements that must be part of any broadband network which is to incorporate mission critical voice services.

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.
- **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.

Each of these components, which make up the requirements for mission critical voice, is essential. In order to be able to provide mission critical voice over any type of network the definition for each of these elements must be fully understood. The balance of the paper

discusses each of these areas in greater detail and provides a definition of each of the elements. It is, however, important to understand that for a network to fully support public safety mission critical voice communications each and every one of these elements must address part of the overall voice communications services supported by the network. A network cannot be a mission critical network without **all** of these elements.

Direct or Talk Around

Direct Mode is an ad hoc form of radio communications in which both the transmitter and the receiver operate without support from infrastructure. Users cannot talk and listen simultaneously, and only one user can talk at any one time, while multiple other users in the area listen. This mode is essential to public safety operations as it allows public safety users to communicate with each other outside the existing public safety communications network coverage area.

Public safety users typically choose this mode to support tactical operations within limited operational areas. As these communications do not rely on any existing network infrastructure, it is important that the range of usability for User Equipment (UE) in this mode be established and specific requirements developed. Public safety users will consider range of usability when evaluating the use of Direct/Talk Around mode.

A typical example of the Direct/Talk Around mode would be a Fire Department unit responding to a wildfire outside the network coverage area or at a structure. In the former example, the firefighters' radios would no longer have access to a network repeater or trunked radio base station, and therefore they would not be able to communicate on their network channel. The latter example of a structure fire would allow personnel to communicate within the structure to coordinate their actions when network access is poor or non-existent. By switching their radios to Direct/Talk Around mode, the firefighters would now be able to communicate in simplex mode, radio-to-radio; however, they would have no contact to other users on the network. Once they leave the scene or exit the building and return to network coverage, the firefighters would switch their radios from Direct/Talk Around mode back to the network channel and resume normal operation.

An example of an upgraded Direct/Talk Around capability would provide the ability, at the system level, to enable a radio to automatically switch to a predefined Direct/Talk Around channel when it detects that it no longer has a connection to the network. An audible or visual alert would let the user know that they are now out of the coverage area and on the Direct/Talk Around channel. When the radio returns to the network, it would then automatically switch back to the last channel or talkgroup it was on before leaving the network. This would be a feature that the network administrator could either enable or disable based upon the agency's policies.

Push-to-Talk (PTT) Voice Systems

Mission critical Push-to-Talk (PTT) voice systems utilized by public safety personnel allow them to selectively and sequentially transmit messages to one another, either on a one-to-

one or one-to-many basis.

The sequence of events for normal PTT operation is as follows: A user wishing to speak on a particular voice path listens to that voice path, and when no one else is speaking, the user presses a button either on the radio itself or on a remote control device. The user device may communicate channel grant or denial status to the user via visual and/or audio cues. When the user is finished speaking, he releases the PTT button, which places the radio in the listen mode. This action makes the voice path available so that another user on the same voice path may speak. Often, the system provides the identity of the speaker to listeners via a digital display.

Uses for mission critical voice include but are not limited to:
- Announcing incidents to responding agencies or individuals;
- Requesting and/or assigning resources to events;
- Declaring an emergency and requesting assistance by field units;
- Announcing or updating incident, unit, or agency status; and
- Coordinating responses and activities.

Full Duplex Voice Systems
Public safety personnel often switch between half duplex mission critical PTT systems and full duplex wireless voice systems (usually cellular), which are interconnected to the Public Switched Telephone Network (PSTN.)

When using a full duplex[1] voice system, once a conversation begins, the voice path remains open for all parties to communicate simultaneously, without regard to whether another user is currently speaking. Multiple users can talk and listen at the same time, meaning they can "talk over" one another. A voice call is ended when all users finish their conversation by terminating the call on their subscriber devices. Public safety users increasingly rely on cellular-style voice systems in mission critical situations to communicate with parties outside their own PTT systems, including citizens with emergencies, language translation services, and other outside agencies providing service to an incident or event. Even within an individual responder agency, full duplex conversations carry detailed or more fluid conversations than are easily achievable in half duplex PTT systems.

Many users assume full duplex cellular-style conversations cannot be monitored using scanners and are usually not recorded. In reality, although almost all full duplex commercial wireless networks employ digital modulation and may be difficult to monitor, they are not truly secure communications, since they are not encrypted.

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[1] Simplex (or half-duplex) communications means only communicating in one direction at a time between two or more participants, where full duplex means simultaneous bi-directional communications amongst two or more participants.

Ideally, both half duplex PTT systems and full duplex voice systems used by public safety agencies should provide a method for ensuring voice privacy if desired by system implementers. In such systems, voice privacy should be assigned to a voice path or user selectable voice path prior to the start of the conversation.

Group Call

Group call provides one-to-many communication between members of a talkgroup. The user may manually control his/her participation in a talkgroup by selecting a specific talkgroup of interest. Talkgroup membership may also be infrastructure driven where existing talkgroups are patched together to form a new group. In this case, the system may optionally provide the ability to delay the start of a call until all the relevant members of a talkgroup are idle. Talkgroups may consist of 10's or even 100's of users concentrated at a single location or distributed over a large geographic area.

Today, a group call employs half duplex voice, using an infrastructure component to limit voice conversations to one talker at a time. Conference calls with no floor arbitration and duplex voice calls are also possible but issues with intelligibility may arise when multiple simultaneous talkers are mixed together. In addition, many users employ encryption to protect their voice communications from being intercepted.

For mission critical applications, users have an expectation of "immediate" communication with their dispatch or command center and little to no end-to-end audio delays. In order to provide a predictable and consistent experience, spectrum and other resources must be acquired for all talkgroup members (or a critical subset) before permission to talk is granted by the system. If resources are not available at the start of a call, a call request may be granted, denied, or temporarily busied depending on resource availability and system policy. This may require that other active talkgroup calls be preempted to free up resources due to emergency conditions or other priorities. There is also the expectation that once a call is granted, the resources will continue to be available until the call is ended and a call back timer expires.

A scan feature provides the ability to monitor several conventional channels and/or trunked talkgroups, including talkgroups associated with other systems, without having to change modes on the subscriber unit. The scan feature typically supports primary and secondary priority modes.

Talkgroups may also have data features directed towards the group members. These may include identification of the current talker as well as alarms, status, messages, and alerts.

Mobile radios, portable radios, and wired consoles are used for talkgroup communications. Mobile and portable radios normally have specialized controls for PTT and group selection as well as a microphone and speaker. Portable radios often have external speaker microphones optimized for radio operation on the user's belt or in another location away from the user's head. Wired consoles typically support multiple simultaneous calls, as well as

the ability to patch and otherwise manage talkgroups. Consoles may also be configured to prioritize their transmit audio over talkgroup members in the field equipped with portable or mobile radios[2].

Talker Identification

Talker identification is considered a mission critical voice feature. Talker identification provides the ability for a user to identify who is speaking given information provided to the listener through the device. This information may be comprised of alphanumeric characters and/or may contain the UE ID and/or any customized character string designated by public safety users for a given UE.

Emergency Alerting

Emergency call alerting and activation indicates that a user has encountered a life-threatening condition and requires access to the system or a system's talkgroup immediately. This may require that another user or talkgroup member be instantly removed from the system or system talkgroup. This feature has the highest level of priority and is referred to as ruthless preemption. Activation of the emergency alert is typically achieved by momentarily depressing a button on the subscriber unit or devices attached to the subscriber unit such as a lapel microphone, wireless tether, or other device. The emergency function is typically deactivated either by resetting the activation button on the subscriber unit or by a console operator monitoring the talkgroup. Upon activation of the emergency feature, the subscriber unit transmits its location in standard coordinates (e.g., NAD83, NMEA 0183, etc.) to the console operator monitoring the talkgroup. In addition, the subscriber unit may transmit other data such as video or telemetry.

Once activated, today's emergency alerting function alerts members of a talkgroup (or multiple talkgroups) to the presence of a life-threatening emergency by the activation of audio and visual cues such as an emergency tone and text or other visual indicators. If the subscriber unit is set for vibrator alerting, the audio emergency alarm overrides the vibrating notification, alerting other users of the emergency condition.

The microphone of the subscriber unit declaring an emergency is capable of transmitting voice and/or data for a predetermined number of seconds without the user depressing a push-to-talk button. This feature is sometimes referred to as a "hot mike." In such cases, the dispatch console operator shall have the ability of overriding the open or hot microphone of the user declaring the emergency and communicate with members of the talkgroup(s) in which the emergency has been declared. The activation of an emergency, as well as all data related to the activated emergency, shall be recorded in the system's operating log of system events and conditions.

If a member of a talkgroup is transmitting voice and/or text during the time in which an

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[2] As indicated in the Executive Summary, the current day examples for group communications are not meant to be constraining for future needs, but simply included to provide additional context.

emergency (on that talkgroup) is declared, the microphone of the user not transmitting the emergency shall be instantly disabled and immediately returned to receive mode, making the user aware of the emergency in progress.

The emergency alert feature shall not require registration. This feature enables the system to accept an emergency alarm from a user in distress prior to registration and/or authentication with the target system. The UE then proceeds with the normal registration and/or authentication procedure. The system operator has the ability to disable this feature if emergency alerts by unregistered or unauthenticated subscriber units are not desired.

Audio Quality
The transmitter and receiver audio quality must be such that, in order of importance:
1. The listener can understand what is being said without repetition.
2. The listener can identify the speaker (assuming familiarity with the speaker's voice).
3. The listener can detect stress in the speaker's voice, if present.
4. The background environment audio shall be sufficiently clear to the listener that sounds such as sirens and babies crying can be determined.

Conclusion
As noted in the Executive Summary, each of these components, which make up the requirements for mission critical voice, is essential. In order to be able to provide mission critical voice over any type of network the definition for each of these elements must be fully understood. It is important to understand that for a network to fully support public safety mission critical voice communications each and every one of these elements must address part of the overall voice communications services supported by the network. A network cannot be a mission critical network without *all* of these elements.

NPSTC is a federation of organizations whose mission is to improve public safety communications and interoperability through collaborative leadership.

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