



A NPSTC Public Safety Communications Report

The National Public Safety Telecommunications Council is a federation of organizations whose mission is to improve public safety communications and interoperability through collaborative leadership.

Public Safety Broadband Push-to-Talk over Long Term Evolution Requirements

7/18/2013

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Document Notices

The following section contains publication information for this document.

Abstract

This document contains public safety requirements for push-to-talk (PTT) capability over a Long Term Evolution (LTE) broadband communications network.

The National Public Safety Telecommunications Council (NPSTC) is a federation of organizations whose mission is to improve public safety communications and interoperability through collaborative leadership.

Acknowledgements

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Executive Summary

Public safety agencies require real-time applications in addition to public safety grade push-to-talk (PTT) voice communications. Some of these applications, such as digital dispatch, can be implemented using existing narrowband land mobile radio (LMR) channels, while other applications, such as video, require broadband spectrum allocations. Public safety grade PTT voice remains the most critical means of communications for first responders in emergency situations and cannot be compromised. Although the focus of this document is public safety grade PTT voice communications, it is not intended to exclude other forms of voice communications currently routinely used by many public safety agencies such as public switched telephone network (PSTN) voice, and commercial grade PTT voice, from the network.

We believe that Long Term Evolution (LTE) public safety grade voice PTT communications requirements are universal, and these requirements should be adopted globally. These requirements stem from a collaboration of users, and the implementation of Best Practices within the mission critical public safety community. This document defines those requirements.

Objectives

Our goal in identifying PTT and direct mode communications requirements is that these requirements will be adopted in their entirety by the First Responder Network Authority (FirstNet) and the Third Generation Partnership Project (3GPP) community for incorporation into future LTE releases.

Scope

Recent advances in wireless broadband technology have driven public safety to explore broadband technology as a means to improve radio communications. The allocation of 20 MHz of spectrum in the 700 MHz band, the adoption of LTE as the technology platform for the Nationwide Public Safety Broadband Network (NPSBN), and the establishment of the FirstNet provides public safety with an opportunity to break from the past by deploying a nationwide public safety broadband network on a common frequency band, based on global wireless standards.

Public Safety Grade PTT Communications

Mission critical PTT communications utilizing LMR technologies evolved over several decades to present day capabilities. For many years the only application was PTT voice communications. Later, low bandwidth data applications were developed and deployed on LMR channels. These systems have been deployed on disparate frequency bands and often incorporate vendor-specific proprietary features. This situation has been an impediment to interoperability, which can often only be achieved by patching systems or channels together using special purpose devices.

LMR Interface to LTE

For an extended time after LTE is capable of supporting PTT requirements for mission critical voice, there will continue to be legacy LMR systems in operation. As the NPSBN and existing LMR systems evolve, there is a need to interface from the NPSBN LTE system to these legacy LMR systems to promote interoperable communications. This interface will be required to preserve interoperability as some agencies may transition their voice operations onto the NPSBN, while adjoining agencies may be slower in their transition planning. During this transition, a standard specification for LMR system

interconnection to the NPSBN system needs to be established. This specification would be similar to what is known in computer programming as an Application Program Interface (API).

Off-Network Communications

Direct mode voice communications are a necessary subset of off-network communications capabilities. Direct mode offers public safety users immediate access to necessary communications during mission critical incidents. Today, public safety users rely on direct mode voice communications in situations where network access is unavailable and the need to communicate is immediate. Direct voice communications allows the public safety user to quickly harness communications as soon as a network outage or unavailability is detected.

While the public safety community recognizes the benefits that the deployment of the NPSBN will provide, we also believe that the ability to communicate directly, from device to device, will continue to be an essential component of public safety wireless communications in the future. Today, public safety utilizes LMR systems designed with multiple hardened sites and equipped with emergency power (backup batteries and generators) to provide uninterrupted electrical power in the event of commercial power failure. In addition, public safety networks require redundant backhaul connectivity to ensure that first responder communications networks remain viable under the most severe circumstances. However, even if the infrastructure implemented in the NPSBN is hardened to the same standards as today's public safety communications systems, the need to communicate via direct mode will remain essential for public safety in cases where the network is not available.

Even as the NPSBN becomes more fully integrated into public safety wireless communications, public safety users will always need the ability to communicate by voice directly with each other in the absence of an operable network.

Audience

While we share the vision of an integrated nationwide public safety broadband network supporting voice, video, and data as outlined in the National Broadband Plan, it is imperative that we preserve existing public safety grade voice PTT features essential to public safety operations. We must educate and encourage international wireless standards bodies to include public safety requirements in the LTE standards. This will allow public safety to realize the benefits of global standardization, while enhancing interoperability, and to benefit from a reduction of wireless costs.

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1 Introduction

This section introduces basic concepts about the document while reading the Push-to-Talk (PTT) requirements it identifies. Appendix A defines many terms that appear in this document.

1.1 Purpose of this Document

The principal purpose of this document is to define, from the perspective of the National Public Safety Telecommunications Council (NPSTC), broadband public safety PTT requirements for consideration by FirstNet as it embarks on its mission to deploy the nation's first Nationwide Public Safety Broadband Network (NPSBN) and the 3rd Generation Partnership Project (3GPP), along with other international standards bodies.

1.2 Scope of this Document

The scope of this document is limited to the preliminary definition of PTT requirements for FirstNet's consideration in the deployment of the NPSBN.

1.3 Public Safety Grade Communications

The concept of "Public Safety Grade" (PSG) drives those design choices that result in a greater overall network reliability than found in commercial networks and provides for resiliency against network disruptions due to natural and manmade events. PSG is the result of implementation techniques typically used by public safety to achieve PSG systems.

Qualitatively, we define PSG communications simply as the effect of reliability and resilient characteristics of a communications system. The system should be designed to minimize the impact of, or eliminate entirely, equipment or component failures that result in a loss of data throughput or coverage, and be designed in a manner that promotes the system's quick return to optimal performance.

A PSG communications system should be designed to resist failures due to man-made or natural events as much as practical. This definition includes: descriptions of coverage criteria for public safety systems that must be considered as a component of system reliability and elements of resiliency that ensure a return to optimal performance. PSG communications systems are systems that are used by public safety responders and that have been evaluated by public safety officials to provide sufficient reliability to ensure resilient operation in the event of natural or man-made disasters or events.

In defining Public Safety Grade requirements, no intent lays herein to impose these specific methods on the NPSBN network. We seek to assist in educating manufacturers and vendors as to the requirements of the public safety community. The intent is for the NPSBN services to be equivalent in reliability and resiliency to public safety LMR communications systems that are currently in use to support law enforcement, fire, and EMS operations, commonly referred to as mission critical systems.

1.3.1 Reliability

Reliability is the ability of a component or system to function satisfactorily for an extended period of time. It is the ability of a system to perform and maintain its functions, in routine, hostile, or unexpected circumstances. In public safety communications systems, reliability is achieved through equipment redundancy and by identifying and eliminating single points of failure.

Reliability is enhanced when system operators stock spare parts on-site and, in some cases, use transportable backup systems to restore communications to normal operation quickly when failures do occur. Reliability is further enhanced by agencies understanding their resource capabilities and recognizing their limitations. Careful component selection must be considered at all stages of system design.

1.3.2 Resiliency

Resiliency is the ability of a component or system to: continue to function satisfactorily under adverse circumstances, to quickly recover from a failure, and/or return to its original form. In public safety communications systems, resiliency is achieved through careful evaluation and consideration of local environmental conditions in the immediate area, and by analyzing how natural disasters such as earthquakes, wildland fires, hurricanes, floods, lightning, ice, tornadoes, and even vermin, can disrupt or damage the NPSBN. Consideration must also be given to common atmospheric conditions such as extreme temperature shifts, high/low humidity, or the effects of salt air on infrastructure equipment and how these factors affects resiliency.

During natural disaster events, a common failure is the loss of commercial power service. Public safety communications systems incorporate both battery and generator backup at their radio sites to ensure reliable power for operation of their communications infrastructure equipment. The capacity and type of batteries and generators vary from region to region depending on a number of factors.

Each disaster type requires a different strategy regarding what is required to ensure network resiliency. These requirements may differ from site to site within a public safety communications system. Resiliency is factored into the network at the earliest stages of system design.

The resiliency of a public safety communications site also includes the ability of the site to restrict access to only authenticated users who are authorized to access the site with appropriate security measures in place.

1.4 LTE Interface to Land Mobile Radio

As the NPSBN and existing land mobile radio (LMR) systems evolve, there is a need to interface the NPSBN LTE system to the LMR system to promote interoperable communications. This interface will be required as some agencies may transition their voice operations onto the NPSBN while adjoining agencies may transition on a different timeline or not at all. A standard specification, similar to what is known in computer programming as an Application Program Interface (API), needs to be established for all types of LMR systems to connect to the NPSBN.

1.5 Direct Mode Off-Network Communications

Direct mode allows peer-to-peer communication when network infrastructure is inoperable or unavailable or not desirable. Direct mode voice communication enables first responders to maintain communications in hostile environments. It is used routinely in a variety of rural and urban operating environments, from firefighters responding to wildfires, to undercover police officers covertly monitoring criminal activity in the Nation's most densely populated areas.

It is anticipated that applications may be using direct mode communications to allow off-network voice communication subscriber units to act as a "bridge" between other off-network devices and on-network devices. Having this ad hoc (peer-to-peer) mode available will allow NPSBN subscriber units to interface with each other to share and extend the bandwidth between units while also enhancing the range of off-network subscriber units, as necessary.

1.6 Document Organization

This document is organized as follows.

The Executive Summary highlights the key information contained in the document, including the document's principal conclusions and recommendations.

Section 1 provides an overview, including identification of the scope and purpose of the document.

Section 2 defines PTT call requirements.

Section 3 defines PTT service requirements.

Section 4 defines PTT call priority requirements.

Section 5 defines PTT identity and security requirements.

Section 6 defines PTT between LTE and LMR requirements.

Section 7 defines PTT off-network requirements.

Section 8 identifies the references cited in this document.

Appendix A provides list of glossary terms and abbreviations used in this document.

Appendix B provides a list of contributors who provided input to developing this document.

1.7 Contextual Terms in this Document

This document uses the following terms according to the context described here. Appendix A provides a more general glossary of terms, including the key terms used in this document.

Active Push-to-Talk Group	A current conversation utilizing the NPSBN with PTT Group participants.
Affiliated Users	UE's that can participate in a PTT Group.
Alias ID	Identifies user of the UE or a PTT Group by a name that describes the user or PTT Group. Examples – "Engine 24" "Tac 1" "Loma Linda Hosp."
Announcement Group Call	A preplanned or pre-designated aggregation of talkgroups. This function currently can also "push" a subscriber from its current talkgroup to a designated talkgroup for a period of time by a user with higher authority.
Availability Check	A UE/User initiated query to determine if a particular User/UE is capable of participating in a PTT group, private, or announcement call.
Callback Request	Indicates the desire for the PTT UE/User to have the receiving party call back the initiating PTT UE/User at the earliest convenience.
Codec	Coder/Decoder used to convert between analog audio and coded digital audio.
Concurrent Receive	Allows the UE/User to receive multiple voice paths, with priority, concurrently on a single device.
Emergency Call	The ability of the first responder UE to signal an imminent threat via Group Call with preemptive priority due to the association of the responder's life-threatening condition.
Immediate Peril	A call prioritized in the event of immediate threat to human life. Immediate peril is an urgent call and highlights the potential of death or serious injury.
Initial Lost Audio	The portion of the talker's utterance that is lost at the beginning of the voice transmission after the user is granted permission to speak by the PTT Service. The service should recover and relay as much of this audio as possible in support of its users.
Late Call Entry	An event where one or more users, who were not participants at the beginning of the call, may join the call in progress.
Live Time In Queue	The time that, upon expiration, a UE call-attempt seeking access to the network is terminated by the network. A "time out" function will be needed for a UE in queue.
Location	The current physical location of the UE/User that can be cross-referenced to a map

Information	for display and 2 Dimensional (X,Y) or 3 Dimensional (X,Y,Z) views.
Monitoring	Listening to a PTT Group, private group, or announcement transmission while not transmitting.
Near Real Time	A short period of time that appears to be instantaneous to the user.
NPSBN	Nationwide Public Safety Broadband Network. The wireless broadband network that FirstNet is deploying to support public safety operations nationwide.
Off Network PTT Communications	Communications between UE devices that do not rely on the normal NPSBN infrastructure.
Override	The ability of an authorized user to interrupt and take control of an Active PTT Group conversation.
Participate	Transmitting or listening to PTT Group, private group, or announcement group transmissions.
Public Safety Audio Operating Conditions	Conditions derived from public safety field testing with ambient noise measured up to 100 dBA and routine noise bursts measuring up to 120dBA. An interval of noise is considered “ambient” when the measurement extends over a period of 60 seconds or greater. An interval of noise is considered a “noise burst” when noise exceeds a specified level for no more than 60 seconds. Examples of ambient noise include loud engines, distant emergency sirens, crowds, and firefighter safety alarms. Examples of noise bursts include nearby emergency sirens, fire apparatus, and cheering crowds.
Public Safety Grade Audio Quality	Ability of a listener to understand an utterance without repetition, identify the speaker, detect stress in the speaker’s voice, and be able to hear background sounds (as required) as separate and distinct from human voice when operating equipment in Public Safety Audio Operating Conditions.
PSE	Public Safety Entity. PSE is synonymous with a public safety agency who may be responsible for operations and maintenance (O&M) of a public safety network. For example, procedures may be negotiated to permit NPSBN users (NPSBN-Us) to roam onto commercial networks so they receive consistent treatment of their assigned priority classifications, such as through admission control (AC), allocation and retention priority (ARP), and/or quality of service class identifier (QCI), commensurate with their PSE identity.
PSEN	Public Safety Enterprise Network. A PSEN is a communications network that serves one or more public safety agencies. A PSEN can serve an entire state or a single

agency.

Public Safety Entity Administrator	An employee of a Public Safety Entity with authoritative responsibilities over the jurisdiction. The Administrator has the responsibility to manage user's capabilities, permissions, and authorizations as they relate to the NPSBN.
PTT	Push-to-Talk. A radio communications protocol used in group, private, or announcement calls, requiring a user to push a button to switch from receive to transmit mode, and to release the button to return to receive mode.
PTT Device	An electronic component capable of accessing the NPSBN using PTT protocol through either wired or wireless connectivity.
PTT Group	Utilizing Push-to-Talk communications to communicate to one user or a group of users simultaneously.
PTT Group Member	All UE/User(s) that are affiliated with a PTT Group.
PTT Group Patching	The ability for a properly authorized user to merge two or more PTT Groups temporarily.
Push-to-Talk Group (PTT) Transmission	A Push-to-Talk call that allows the user initiating the call to communicate with one or more PTT Group members simultaneously.
PTT Private Call	A one-to-one PTT call that cannot be monitored by others, absent approval.
Recording Interface	A physical or virtual location where PTT audio and / or data can be recorded by a device for future retrieval by authorized personnel.
Ruthless Preemption	The act of dropping transmissions of a UE(s) in order to free up resources for a higher priority UE(s). This act is carried out automatically by the system using a predetermined set of rules.
Scan Mode	The sequential presentation of audio from two or more selected PTT Groups to a UE/User. (Note: Scan mode refers specifically to the sequential presentation of multiple audio streams to the user rather than the simultaneous presentation of multiple audio streams, which is referred to as concurrent receive in this document.)
Talker	A public safety user currently transmitting on the NPSBN in a group, private, or announcement call.

Talker ID	A unique Identifier assigned to a UE/User by the PTT Service. This identifier is typically an alphanumeric string not intended to be recognized by PTT Group members.
Top of Queue	In times of congestion, call requests for groups with “top of queue” priority are queued and are allocated system resources prior to any lower priority call requests. Queuing is managed by a Public Safety Entity Administrator.
User	An individual or PTT device granted certain permission levels to operate a UE in PTT mode.
User Density	The number of devices supported in a specified geographical area. The geographical area is defined as X devices per cell(s) or cell sector(s), depending on the nature of the location.
UE	User Equipment. A network access device utilized by an end user to communicate on the NPSBN network.

2 PTT Call Requirements

The ability for a PTT subscriber to accommodate multiple voice paths within LTE simultaneously may remove some of the prioritization schemes required today in LMR trunked networks. Public safety should not limit its abilities within PTT over LTE due to legacy architecture limitations of LMR networks.

2.1 Group Call

Following are requirements for PTT Group calls.

Table 1. PTT Group Call Requirements

#	Requirement
1	The PTT Service SHALL provide a mechanism by which a UE can make a 1-to-many PTT transmission to any PTT Group for which it is authorized.
2	The PTT Service SHALL provide a mechanism by which PTT UEs can determine the currently active PTT Groups for which it is authorized.
3	The PTT Service SHALL provide a mechanism by which PTT UEs can determine what PTT Groups are being monitored by some other UE, as authorized.
4	The PTT Service SHALL provide a mechanism by which a Public Safety Entity Administrator, from any location, may define the membership of a PTT Group.
5	Public Safety Entity Administrators SHALL have the capability to create a hierarchy for what users, user types, and/or devices can override an active PTT Group transmission.
6	When an authorized user overrides a PTT Group transmission, authorized users SHALL be able to listen to both the overriding and overridden PTT Group transmissions.
7	When an authorized user overrides a PTT Group transmission, a Public Safety Entity Administrator SHALL be able to configure which PTT Group transmission a user receives, overriding and/or overridden.
8	When an authorized user overrides a PTT Group transmission, the PTT Service SHALL provide a means of notifying the overridden talker that the transmission has been overridden.
9	The PTT Service SHALL allow the Public Safety Entity Administrator to designate specific PTT Groups to be inaccessible to other users, including dispatchers or supervisors.

#	Requirement
10	PTT Groups SHALL support up to the number (N) of PTT Group members selected by the Public Safety Entity Administrator.
11	The PTT Service SHALL allow a UE to actively participate in 1 PTT Group transmission while simultaneously monitoring additional PTT Group transmissions. ¹
12	The PTT Service SHALL present users with alias or alphanumeric group identifiers ² for PTT Groups. ³
13	The PTT Service SHALL provide a notification, for example audio and/or visual, to a user that there are no members on a PTT Group being used/monitored by the user and that the user is the only user affiliated to that talkgroup.
14	The PTT Service SHALL, upon request of a User, make available the list of affiliated members on a PTT Group.
15	The PTT Service SHALL provide, upon request, the complete list of members of a PTT Group to an authorized UE.
16	The PTT Service SHALL provide a mechanism to prioritize, dynamically and in real-time, PTT Groups.
17	The PTT Service SHALL provide a mechanism to organize PTT Groups into a hierarchy for prioritization.

2.2 Private Call

Following are requirements for PTT private calls.

Table 2. PTT Private Call Requirements

#	Requirement
1	The PTT Service SHALL provide a means by which a UE can make a 1-to-1 PTT transmission to any user for which it is authorized.
2	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator/Supervisor to configure which users, within their authority, can place a PTT Private Call.

¹ This ability is important to an environment where an emergency message needs to be distributed to those in the field who are monitoring other resources such as an emergency message to immediately evacuate a building. Monitoring multiple talk paths may be beneficial in the distribution of important, real-time information, as needed.

² Further studies are needed to quantify field length.

³ Users need to have the ability to consistently implement their own talkgroup aliases in a manner consistent with other agencies within their community.

#	Requirement
3	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator to configure which UEs, within their authority, can place a PTT Private Call to other UEs within the same authority.
4	The PTT Service SHOULD provide an availability check for PTT Private Calls.
5	The PTT Service SHALL provide a mechanism for a PTT Private Call callback request.
6	The PTT Service SHALL provide a UE receiving a PTT Private Call callback request with an indication of which user called and when.

2.3 Announcement Group Call

Following are requirements for announcement PTT Group calls.

Table 3. PTT Announcement Group Call Requirements

#	Requirement
1	The PTT Service SHALL support Announcement Group Calls in accordance with agency policy ⁴ as determined by the Public Safety Entity Administrator.
2	The PTT Service SHALL support Announcement Group Calls to a defined geographic area.
3	The PTT Service SHALL allow real-time, dynamic creation and management of Announcement Group Calls by an authorized Public Safety Entity Administrator.

⁴ Policy could include geographic area,site, agency based, discipline based, and role.

3 PTT Service Requirements

The subsections that follow list PTT service requirements.

3.1 General Audio PTT Call Performance

Following are general audio performance requirements for PTT calls.

Table 4. PTT Call General Requirements

#	Requirement
1	The PTT Service SHALL provide a mechanism to accommodate ongoing Encoder/Decoder (codec) improvements within LTE. ⁵
2	The PTT Service SHALL provide public safety grade service to all members of a PTT Group transmission regardless of group size and/or user density.
3	The PTT Service SHALL provide public safety grade call setup times ⁶ between any two UEs within coverage of the NPSBN.
4	The PTT Service SHALL provide public safety grade mouth-to-ear latency ⁶ between any two UEs within coverage of the NPSBN.
5	The PTT Service SHALL provide public safety grade initial lost audio on the NPSBN.
6	The PTT Service SHALL provide public safety grade audio quality or better under public safety operating conditions.

3.2 PTT Late Call Entry

Following are late call entry requirements for PTT calls.

Table 5. PTT Late Call Entry Requirements

#	Requirement
1	The PTT Service SHALL support late call entry.
2	The PTT Service SHALL provide Talker IDs to UEs that enter a call late.
3	The PTT Service SHALL provide location information to UEs that are late entering a call in progress.

⁵ This will ensure improvements will be available to users while retaining backwards compatibility to previous versions of the LTE standard.

⁶ May be multiple values at different levels of government and geography.

3.3 Dynamic Group Management

Following are requirements for dynamic group management.

Table 6. PTT Dynamic Group Management Requirements

#	Requirement
1	The PTT Service SHALL provide a mechanism for dynamic creation and termination for PTT Group “patching” by Public Safety Entity Administrators and/or authorized users.
2	The PTT service SHALL provide a mechanism to notify patch PTT Group members of initiation and termination of their PTT Group patch.
3	The PTT service SHALL provide a mechanism to encrypt patched PTT Group transmissions.

3.4 Call Monitoring

Following are requirements for PTT call monitoring.

Table 7. PTT Call Monitoring Requirements

#	Requirement
1	The PTT Service SHALL allow a UE to actively participate in one PTT Group while simultaneously monitoring additional PTT Groups.
2	The PTT Service SHALL provide a mechanism for an authorized UE to prioritize the order in which multiple PTT Groups are monitored by the UE.
3	The PTT Service SHALL, provide multiple Talker IDs for display on UEs when multiple PTT Groups are monitored.
4	The PTT Service SHOULD provide a mechanism for a Public Safety Entity Administrator and/or authorized user to order the PTT Groups being monitored by the UE.
5	The PTT Service SHALL provide a mechanism for a number (N) of calls to be simultaneously received by a UE, authorized by a Public Safety Entity Administrator and/or authorized user.
6	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator to limit the total number of PTT Group transmission that a UE can simultaneously receive.
7	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator to monitor calls to and from PTT Group members within their authority without noticeable impact or knowledge of the user. ⁷
8	The PTT Service SHALL provide a mechanism for a PTT Private Call callback request. ⁸

⁷ These capabilities need to be defined at the local agency level.

⁸ The requirement is the same as requirement #5 in Table 2.

#	Requirement
9	The PTT Service SHALL provide a UE receiving a PTT Private Call callback request with an indication of which user called and when. ⁹
10	The PTT Service SHALL provide a mechanism for an Public Safety Entity Administrator and/or authorized user to initiate unit monitoring (UE) for UEs within their authority.
11	The PTT Service SHALL provide a mechanism for a Public Safety Entity to record all PTT Group transmissions (including call audio, talker ID, talkpath ID, location of initiating party, and potentially other META data) by their organization.
12	The PTT Service SHALL provide a mechanism to deliver encrypted PTT Group transmissions to a recording interface.

⁹ The requirement is the same as requirementst #6 in Table 2.

4 PTT Priority Requirements

Prioritization within public safety communications has always been an important requirement. The introduction of public safety interconnected Project 25 trunked radios networks into the public safety community has allowed Unit and Talkgroup Identifiers for each device and talkgroup used within the network to be prioritized within the network. When contention for a channel exists at a common location between multiple users, either the talkgroup used or the Unit Identifier in question can be a parameter to determine which user should have priority over access to network resources.

Public safety will continue to require PTT services in the NPSBN that allow resource prioritization at specific locations in near real time.

4.1 PTT Call Priority

Following are requirements for PTT call priority.

Table 8. PTT Call Priority Requirements

#	Requirement
1	The PTT Service SHALL support ruthless pre-emption.
2	The PTT Service SHALL support top of queue priority.
3	The PTT Service SHALL support a number (N) of users at the top of the priority queue, within an agency's priority levels.
4	The PTT Service SHALL ensure that immediate peril cannot pre-empt emergency calls.
5	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator to establish the priority and characteristics of PTT Group transmissions within their jurisdictional authority.
6	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator to configure a live time in queue for "top of queue" capability.
7	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator to create, under his authority, a pre-emption hierarchy for PTT Group transmissions and their associated users within their jurisdictional authority to promote local management of the service and its resources.

4.2 Emergency/Imminent Peril Call

Following are requirements for emergency/imminent peril calls.

Table 9. PTT Emergency/Imminent Peril Call Requirements

#	Requirement
1	The PTT Service SHALL support emergency calls.
2	The PTT Service SHALL support immediate peril calls.
3	The PTT Service SHALL ensure that emergency and immediate peril calls have the highest priority over all other PTT Group transmissions.
4	The PTT Service SHALL provide a mechanism to ensure that emergency and immediate peril calls, including their content and signaling, have pre-emptive priority over all other types of PTT Group transmissions.
5	The PTT Service SHALL support emergency calls that persist until being acknowledged and terminated based on criteria created by a Public Safety Entity Administrator.

5 PTT Identity and Security Requirements

Push-to-Talk voice capabilities on the NPSBN will require the same degree of security and user identity of today's LMR systems. The ability for the service to authenticate a subscriber device for valid operation on the network is critical to the security of the network and its users. The ability for a subscriber device to have its identity displayed to other network users is a benefit public safety radio systems offer today at the device level. It would be beneficial for the PTT service and devices that operate on it to also allow for the identify of the *user* to be displayed to other users of the network, as necessary.

5.1 Talker ID

Following are requirements for PTT talker ID.

Table 10. PTT Talker ID Requirements

#	Requirement
1	The PTT Service SHALL provide a mechanism such that each PTT Group member has a unique Talker ID.
2	The PTT Service SHALL ensure that each Talker ID has an Alias ID assigned by a Public Safety Entity Administrator and/or authorized user.
3	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator to configure Alias IDs.
4	All UEs SHALL provide a configurable capability to display the Talker ID, PTT Group, Alias ID, and Public Safety Entity name.
5	The PTT Service SHALL provide talker ID.
6	The PTT Service SHALL provide a mechanism for the Talker ID of a user to be associated with that user's authentication and use of the NPSBN. ¹⁰

5.2 Personality Management

Following are requirements for PTT personality management.

Table 11. PTT Personality Management Requirements

#	Requirement
1	The PTT Service SHALL provide a mechanism for near real-time UE PTT configuration by a Public Safety Entity Administrator and/or authorized user of PTT Group members.

¹⁰ For example, if a user UE was used on first shift by User A, the Talker ID should be that of the user per their authentication sign on. Another user that utilizes that same device on second shift would have their Talker ID displayed per their authentication sign on.

#	Requirement
2	The PTT Service SHALL provide a mechanism for a Public Safety Entity Administrator and/or authorized user to perform personality programming within their authority.

5.3 Security

Following are requirements for PTT security.

Table 12. PTT Security Requirements

#	Requirement
1	The PTT Service SHALL employ compliant open standards for encryption and authentication, subject to applicable national policy.
2	The PTT Service SHALL provide a mechanism to encrypt all PTT Group transmissions, both user and control plane data (for example, audio, Talker ID, etc.).
3	A UE SHALL provide a mechanism for an authorized user to select what services are available on the UE PRIOR TO full authentication on the UE (for example, 911 calls on commercial UEs).
4	The PTT Service SHALL provide a mechanism to accommodate ongoing security algorithm improvements, which could include over the air key management.

5.4 PTT Location Requirements

Following are requirements for PTT location.

Table 13. PTT Location Requirements

#	Requirement
1	The PTT Service SHALL provide a mechanism for Public Safety Entity Administrators to manage the privacy of location information for users within their authority.
2	The PTT Service SHALL provide a mechanism for an authorized user to prevent location information (for its own UE or another UE) from being conveyed by the PTT Service.
3	The PTT service SHALL provide Talker Location.

6 PTT Between LTE and LMR Requirements

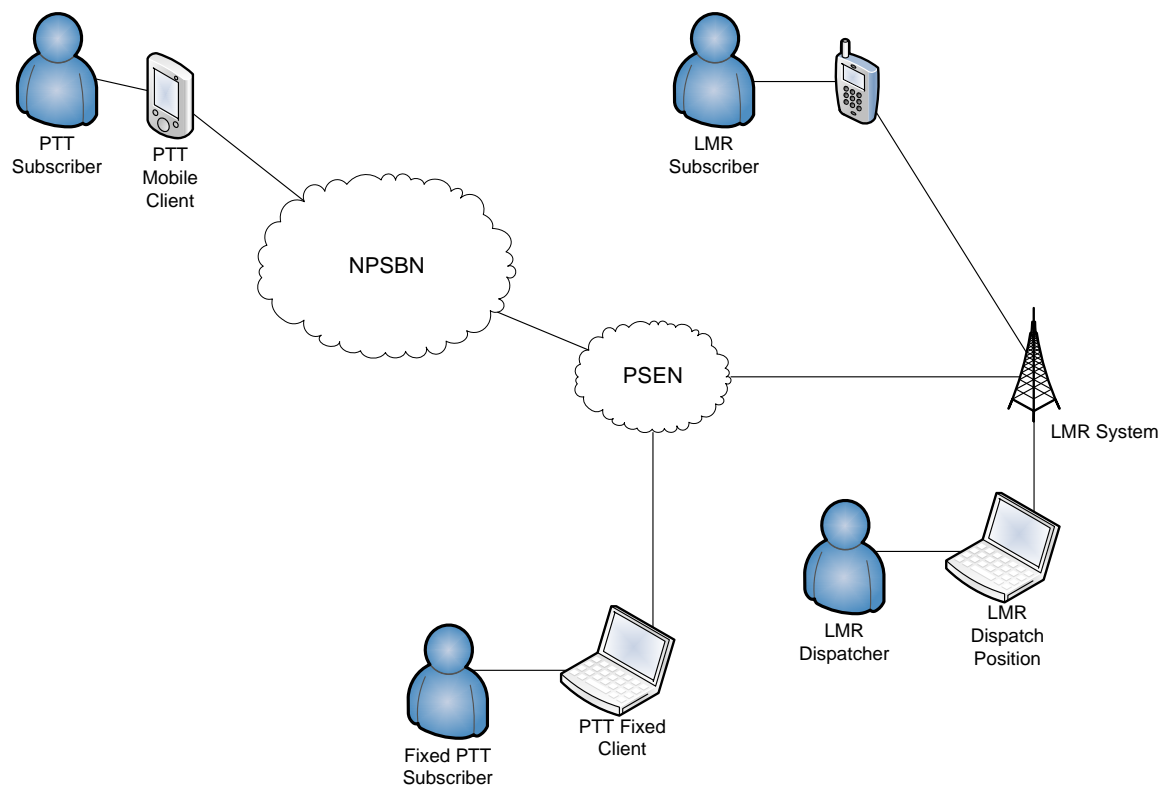
The goal of PTT communications between LTE and LMR subscribers is that, insofar as it is technically possible, LMR subscribers and dispatchers experience no essential differences in their communications with each other, and with PTT subscribers using an NPSBN-compliant PTT service. Likewise, insofar as a particular feature is interoperable, PTT subscribers experience no essential difference in the communications with LMR subscribers versus those using an NPSBN-compliant PTT service.

A standard specification, similar to what is known in computer programming known as an Application Program Interface (API), needs to be established for all types of LMR systems to connect to the NPSBN. The interface would define a standard method for radio manufactures to interface to a particular LMR technology. The LMR manufacturers or commercial developer would be responsible to build a gateway that allows interface between their products to the standard LTE interface.

The LTE-to-LMR interface SHALL maximize the functionality between the LMR system and the LTE NPSBN system. The interface would be similar to the Project 25 (P25) [Section 8: 1] Inter-Sub-System-Interface (ISSI) and should have similar functionality to the P25 ISSI but across LMR technologies.

Figure 1 shows a model for LMR interoperability. In this model, LMR subscribers and dispatchers are able to communicate with PTT subscribers and dispatchers by virtue of transport and services provided by the Public Safety Entity Network (PSEN) and Nationwide Public Safety Broadband Network (NPSBN).

Figure 1. PTT LTE and LMR Interoperability Model



New and extended requirements (i.e., requirements for features that do not exist in existing LMR systems) on NPSBN PTT may not necessarily be interoperable with LMR systems. For instance, the

“group address” space of the PTT service may be a superset of that in LMR systems. This is acceptable so long as interoperable groups are truly interoperable.

One important example of this kind of technology incompatibility is the interoperation of the dispatch and supervisor override in the PTT service with the corresponding feature in Project 25 [Section 8: 2]. As specified above, in PTT service, dispatch and supervisor override pre-empt and terminate overridden talk-bursts. Most, if not all, Project 25 radios are half-duplex at the air interface. As a result, when a dispatcher or supervisor overrides an ongoing talk spurt, the overridden talker is not aware of having been overridden. In these systems, the audio of the overridden talker is not dismissed, but is instead routed as “losing audio” to suitable dispatch positions. Likewise, in many P25 systems, when two subscribers collide on different sites in the same system, it can occur that both are granted access, with the system determining one “winner” and one or more “losers” after the fact. Again, in these cases, the “losing” audio is routed to dispatch. Because of these facts about LMR systems, LMR system interoperability requires that the PTT service provide for “uninterruptable” and “losing” audio cases.

Finally, it should be noted that, in addition to P25 systems, it is critically important that the PTT service be interoperable with conventional FM systems, including those employing CTCSS tones for grouping (such as, for example, mutual aid systems). The specific interoperable feature requirements for such systems are identified separately in Table .

6.1 LTE to Project 25 Interoperability

Following are requirements for establishing PTT LTE to P25 interoperability.

Table 14. PTT LTE to P25 Interoperability Requirements

#	Requirement
1	The PTT Service SHALL support fully featured interoperable 1:1 calls between P25 LMR (Trunked and Conventional) subscribers and dispatchers and NPSBN fixed and mobile PTT subscribers and dispatchers.
2	The PTT Service SHALL support fully featured interoperable group calls between P25 LMR (Trunked and Conventional) subscribers and dispatchers and NPSBN fixed and mobile PTT subscribers and dispatchers.
3	The PTT Service SHALL support losing audio and unstopable transmissions from P25 LMR (Trunked and Conventional) subscribers and dispatchers.

6.2 LTE to Legacy LMR Interoperability

Following are requirements for establishing PTT LTE to Legacy LMR systems interoperability, including existing analog interfaces.

Table 15. PTT LTE to Legacy LMR Interoperability Requirements

#	Requirement
1	The PTT Service SHALL support PTT Private Calls between Legacy LMR subscribers and dispatchers and NPSBN authorized users and dispatchers
2	The PTT Service SHALL support PTT Group transmissions between Legacy LMR subscribers and dispatchers and NPSBN authorized users and dispatchers
3	The PTT Service SHALL provide a mechanism to reconcile different codecs between Legacy LMR and NPSBN PTT codecs.

6.3 LTE to any future Trunked/Conventional LMR Interface

Following are interoperability requirements for PTT LTE to users operating (Conventional and Trunked) LMR systems utilizing any future LMR interface.

Table 16. PTT LTE to any future LMR Interface Interoperability Requirements

#	Requirement
1	The PTT Service SHALL support PTT Group transmissions between LMR systems and dispatchers and PTT NPSBN authorized users and dispatchers, regardless of the protocol or mode of operation utilized by the interfacing LMR technology.
2	The PTT Service SHALL provide a mechanism to reconcile codec's utilized by any LMR system interface and NPSBN PTT over LTE.

7 PTT Off-Network Communications Requirements

Public safety communications systems are designed and built to enable first responders to communicate in the direst of circumstances. This includes instances where the public safety radio system they are operating on has had its infrastructure damaged or has completely lost the ability to function. In such circumstances, it is paramount that first responders retain voice communications capability directly, from radio to radio, without depending upon any infrastructure. This capability is possible due to a commonality that is planned for and included (common agency-based channels, common interoperability channels, etc.) in each public safety radio.

While the NPSBN will be a primary, reliable transport of public safety voice and data, there are many situations where voice and data communications will be required in areas where the NPSBN is not available. NPSBN Users (NPSBN-U) may be outside of the range of the fixed network, such as first responders in a rural area assisting in a response to a plane crash or police officers inside a residence responding to a domestic issue. Off-network voice communications must be immediately accessible to users in the absence of the NPSBN. This includes areas and locations where the ability to access non-terrestrial communications can be impaired such as within building and other enclosed areas where non-terrestrial communications may not be available. Additionally, there may be times when users may wish to communicate off-network. Today, firefighters often join a local communications network, which does not leverage the fixed network, but rather, relies on either direct communications between the user devices or communications via a local repeater on-scene. Firefighters can voluntarily leave the fixed network either due to the unpredictable coverage of the fixed network, or if the coverage of direct communications or the local repeater is well known, based on experience.

There will be occasions where a user may be within network coverage and will need to communicate with users who are on the network and off-network, such as an Incident Commander (IC) supporting fire response activities. These users must be able to communicate to users on the fixed network, such as dispatch, as well as the local users who are off-network or when it is desirable to provide voice, data and video connections between users without connection to the network even if within network coverage.

A relay function is critical for off-network communications when NPSBN coverage is not sufficient to support the public safety mission. In the case of firefighters who are responding to a wildfire while outside of the coverage of the fixed network, if one user becomes encircled by the wildfire and is beyond the range of the IC, but within the range of another device that can act as a relay, the endangered firefighter can still update his status to the IC.

A UE device operating on the NPSBN SHALL be capable of relaying PTT traffic between a UE device operating off the network and a UE Device operating on the network.

7.1 Off-Network Operational Communications

In today's public safety environment, direct voice capability utilizes either mobile or portable radios with varying transmit values that operate in multiple frequency bands, providing a variety of range capabilities for users operating in the direct mode. Different frequency bands, by their nature, have varying range capabilities and that applies to operations in the direct mode. The transmit power, use of mobile or portable radios and the frequency band in use are all major factors in determining the distance over which two users can communicate in the direct mode.

The ability for NPSBN subscribers to operate in a peer-to-peer mode will enhance range possibilities between units and offer bandwidth extension between devices within urban areas. Direct mode communications could also offer the ability to enhance in-building coverage in the nations cities.

Non-terrestrial communications should not be considered an alternative to off-network (direct mode) voice capabilities. Non-terrestrial communications may not offer public safety users the same capability or accessibility as off-network, direct mode capabilities.

The following are requirements for off-network operations.

Table 17. PTT Off-Network Communications Operational Requirements

#	Requirement
1	Off-network PTT Communications SHALL not cause interference to on-network operations and on-network operations SHALL not cause interference to off-network operations.
2	On-network operations SHOULD not cause interference to off-network PTT Communications.
3	Off-network PTT Communications SHALL minimize interference to other off-network devices.
4	Public Safety Users SHALL have off-network PTT Communications, as necessary and authorized, in the complete absence of any fixed infrastructure.
5	Off-network PTT Communications SHALL allow a minimum number of (N) simultaneous fff-network PTT Communication transmissions.
6	Off-network PTT Communications SHALL only be available for authorized users.
7	The PTT Service SHALL provide a notification to a user when approaching the edge of the network. ¹¹

7.2 Off-Network PTT Communications Status

Following are requirements for the off-network communications status of users.

Table 18. PTT Status Requirements of NPSBN User Off-Network Communications

#	Requirement
1	A UE SHALL be capable of switching to an off-network PTT Communications mode when detecting an off-network condition.
2	The PTT Service SHALL allow an authorized user to move PTT Groups off network for use with off-network PTT Communications.
3	An authorized user SHALL be capable of switching to an off-network PTT Communications mode.

¹¹ Could include audible, visual, or vibration notification.

#	Requirement
4	Off-network PTT Communications SHALL provide a range similar to what is offered by current LMR solutions at an outdoor incident scene. ¹²
5	Off-network PTT Communications SHALL provide a range similar to what is offered by current LMR solutions between users within a building and users outside of the building. ¹³
6	Off-network PTT Communications SHALL support a number of (N) PTT Groups as authorized by the agencies System Administrator. ¹⁴

7.3 Off-Network UE Functionality

On-network communications is usually the preferred communications path. However, because fixed network coverage cannot be provided everywhere, it is beneficial for devices to be able to relay communications from off-network devices to the fixed network, when possible. An example of the benefit of this case, is when a user who enters an emergency condition is out of the fixed network coverage, but is within the coverage of another device that is in network coverage. By relaying the emergency state of the off-network user, critical information is passed to the network to protect the life of the user. The capability of NPSBN users to be able to communicate simultaneously with the NPSBN on-network and users who are off-network may also be required during mission critical incidents.

Typically, users operating off-network will want to discover other users, and be discovered by other users on the scene. Sometimes, users will not want to be discovered, such as undercover agents in the area. Other times, users may not want to participate in off-network communications at all. Because of this, the ability to configure a device to discover other users, to be discoverable by other users, and to permit or restrict off-network communications, must be supported.

Following are UE requirements for off-network communications.

Table 19. Off-Network Communications UE Functionality Requirements

#	Requirement
1	A UE SHALL be capable of off-network PTT Communications and on-network PTT at the same time.
2	Off-network PTT Communications SHALL provide a mechanism to dynamically create PTT Groups.
3	Off-network PTT Communications SHALL provide a mechanism for a UE to monitor what PTT Groups are active.

¹² There are many ways to provide this capability, including but not limited to higher power UEs or portable infrastructure.

¹³ The users within the building may be on different levels/floor and at varying distances within the building.

¹⁴ Breaking with the qualitative nature of this document, the minimum number of PTT Groups that must be supported is a minimum of 20.

#	Requirement
4	Off-network PTT Communications SHALL provide a mechanism for a UE to relay off-network PTT Group transmissions from an on-network UE to an off-network UE.
5	Off-network PTT Communications SHALL provide a mechanism for a UE to relay off-network PTT Group transmissions between off-network UEs.
6	A UE SHALL be capable of transmitting its location, if known, to other UEs when operating off-network.
7	A UE SHALL be capable of utilizing off-network PTT communications while still connected to the NPSBN and access required services.
8	A UE SHALL be capable of being connected to the NPSBN and utilizing required network services while operating off-network PTT communications.

8 References

[1] APCO International, Project 25. Information available: <http://apointl.org/spectrum-management/resources/interoperability/p25.html>. Cited March 2013.

[2] APCO Project 25, "Statement of Requirements (P25 SoR)," March 2010. Available: <http://ftp.tiaonline.org/TR-8/APIC/P25%20UNS/PUBLIC/Current%20Approved%20Project%2025%20Statement%20of%20Requirements/>. Cited March 2013.

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Appendix A Glossary of Terms

1:1 PTT Call	Also 1 to 1. A private push-to-talk call between only two devices that are actively affiliated.
1:N (1 to Many) PTT Call	A one-to-many push-to-talk call. Also known as a group call. “N” is identified as the number of users required in that particular group call and/or the number of UE’s authorized for that group call by the agency’s System Administrator.
Announcement Call	<p>A special type of group call wherein the group is composed of the users who have selected a group that is part of the announcement group.</p> <p>An Announcement Call is a call sent to user devices based on either:</p> <p>A.) The selected user device personality is slaved to a particular announcement voice resource.</p> <p>B.) The user device has selected a voice resource that belongs to a multi voice resource group.</p>
Availability check	Request sent to a subscriber polling the device to see if it is actively registered on the network.
Call	A series of one or more push-to-talk transmissions.
Caller	A user of a fixed or mobile device placing a call on the network.
Call-Setup or Access Time	The time that the talker presses his PTT control, and the time that he is able to speak. These values include elements associated with some of the following characteristics: The amount of time required from PTT to voice resource grant, mouth-to-ear latency, public safety grade audio fidelity, trailing lost audio, initial lost audio, among other values.
Emergency Call	Group calls with preemptive priority due to their association with a life-threatening condition being experienced by a responder and automatically routed to the related/appropriate administrative authority for immediate response or action.
Encoder/Decoder (CODEC)	A codec is a device or computer program capable of encoding or decoding a digital data stream or signal.

Encryption	Client-server encryption Client initiates a connection request and establishes a connection to a server. The client stores a list of known hosts locally and uses this list to authenticate the server each time a connection is made.
	Pre-positioned “shared” key(s) A common key(s), called a Pre-Shared Key (PSK), must be pre-loaded into the subscribers.
	Key distribution Remotely transfer key management messages to radios to update a radio’s keys, poll the radio, inhibit the radio, and erase the radio’s keys. Radios can also send key management messages to the Server to acknowledge events or to request a key update.
	Key negotiation Authenticates the device(s) before establishing a connection to the network.
Full Duplex	Two or more one parties can talk simultaneously.
Group Call	A one-to-many (1:N) push-to-talk call made to N devices that have selected a particular resource.
Half Duplex	Only one party can talk at a time.
Imminent Peril Call	A call, which is automatically routed to the related/appropriate administrative authority and surrounding associated users for immediate response or action.
	A type of group call with elevated priority of an urgent nature impacting human life safety and/or incident operation.
Initial Lost Audio or Late Call Entry	Powering up the device or selecting voice resource while a call is in progress.
Live Time in Queue	Active time a PTT transmission is being processed by the PTT service.
Monitor	The act of observing something (and sometimes keeping a record of it).
Personality Programming	The ability to implement into a subscriber unit characteristics indicative of a specific agency’s user(s) with particular access to talkgroups associated with that agency.
PTT Service	Push-to-talk voice service using user equipment (UE).

PTT Transmission	A single continuous push-to-talk communication from a talker to zero or more listeners.
PTT User	Someone that uses a push-to-talk subscriber.
PTT Subscriber	A device that has a subscription to the push-to-talk service, or an “Application User” that has such a subscription. Herein, the term is used generally when a requirement applies to both Fixed and Mobile PTT Subscribers.
PTT Fixed Subscriber or Fixed PTT Subscriber	A wireline push-to-talk subscriber (e.g., a console) that accesses the PTT service from a PSEN. PTT Fixed Subscribers include dispatchers and dispatch supervisors. Console devices are typically connected to the network via XXXXX. However, in mobile command posts, the network connection could be over the air.
PTT Mobile Subscriber or Mobile PTT Subscriber	A wireless push-to-talk subscriber (e.g., a handheld device) that accesses the PTT service over the air. PTT Mobile Subscribers include responders in the field.
Prioritization	A scale of urgency of need for an active talk path. Subscriber and talkgroup each have their own respective level of priority.
Private Call	Push-to-talk call only heard by two specific users.
PSE	Public Safety Entity. PSE is synonymous with a public safety agency responsible for operations and maintenance (O&M). For example, procedures may be negotiated to permit NPSBN users (NPSBN-Us) needing to roam onto commercial networks so they receive consistent treatment of their assigned priority classifications, such as through admission control (AC), allocation and retention priority (ARP), and/or quality of service class identifier (QCI), commensurate with their PSE identity.
PSEN	Public Safety Enterprise Network. A PSEN is a communications network that serves one or more public safety agencies. A PSEN can serve an entire state or a single agency.
Public Safety Grade	Refers to components such as, coverage calculations, tower construction, equipment installation, environmental controls, and many other requirements.
LMR Subscriber	A land mobile radio subscriber is a user communicating from an LMR system.
Reliability	The ability of a system to perform and maintain its functions in both routine and

	hostile or unexpected circumstances.
Resiliency	The ability of a component or system to continue to function satisfactorily under adverse circumstances and to quickly recover from a failure and/or return to its original form.
Ruthless Preemption	The lowest priority user is forced off a call to provide resources for an emergency call.
Scanning	Monitoring multiple voice resources simultaneously.
Services	Common network applications authorized users can use.
System Call	A dispatch-originated high-priority call that is received by all units in a designated geographic area without regard for jurisdictional boundaries.
Talk Group	Subscribers organized by agency and/or functionality to conduct PSE operations/business.
Talker ID	Identification of calling subscriber.
Top of Queue	Call is routed to top of waiting call list.
UE	User Equipment
User	The user is the person that is utilizing the NPSBN Subscriber device.

Appendix B Contributors

NPSTC wishes to recognize the significant involvement of the PTT Task Group members and thank them for their tireless dedication to this project. Special thanks to Steve Devine, Task Group Chair.

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