



# The Compelling Case for Standards Compliant Interworking

From Catalyst Communications Technologies, Inc.

TOOLS TO MIGRATE GRACEFULLY TO FIRSTNET™

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## Introduction

FirstNet™ promises improved capabilities for First Responders, offering the larger coverage footprint and increased data carrying capacity of Long-Term Evolution (LTE), which greatly exceeds that of current Land Mobile Radio (LMR) systems. The migration from LMR to LTE will be gradual, however, and Push-to-Talk voice communications between the two different systems is going to be required for the foreseeable future. This concept—called ‘interworking’—will require new technology to enable LMR and LTE to communicate with each other.

Critical for First Responders is that interworking occurs between existing LMR systems and **standards compliant** Mission Critical Push to Talk (MCPTT) applications on LTE and other broadband networks. Pre-MCPTT systems deployed today are proprietary, not mission critical and create incompatible islands of communications that subvert the universal interoperability goals of FirstNet™.

This paper describes why interworking between LMR and LTE networks must be based on standards developed for this purpose. A standards compliant interworking solution developed by Catalyst Communications Technologies is proposed, based upon research and development funded through a contract with the Department of Homeland Security (DHS) Science and Technology Directorate (S&T), that will help users migrate their current LMR systems to FirstNet™.

MCPTT over LTE cellular networks is here. The First Responder community has been experimenting with various products that offer push to talk over cellular (PoC) technologies for many years, however, most acknowledge that these solutions do not match the stringent requirements for robustness and reliability that are necessary for emergency operations. Nevertheless, these products have demonstrated that LTE, and other broadband networks, including Wi-Fi and 5G, provide some advantages over LMR systems and can augment the LMR networks used by First Responders today.

*Critical for First Responders is that interworking occurs between existing LMR systems and standards compliant MCPTT applications on LTE and other broadband networks.*

A clear requirement for any LTE-based solution targeted to the First Responder community is communications between existing LMR subscribers and users of new push to talk (PTT) solutions on LTE networks, including FirstNet™. Adoption of LTE based PTT applications will be gradual, and communications between these different network technologies will be vital both during the transition and even in the decades ahead since some agencies may never move to LTE. PoC has struggled with acceptable solutions for integrating communications with LMR subscribers. Previous implementations have exposed issues that introduce complexity when attempting to solve this technical challenge:

- Previous efforts have not gained sufficient traction to drive the cost of solutions down as would occur through a coordinated, standards-based adoption as contemplated by FirstNet™.
- Previous efforts did not account for the integration with complementary tools that will leverage MCX (3GPP's MCPTT, MCVideo, and MCDData collectively) messaging that will be valuable for situational awareness (video, alarms from sensors – gas detection, flood water levels, motion detection, etc.).
- As the PoC vendors each promote their own proprietary solution, these solutions create islands of communications that are incompatible with other proprietary and/or standards compliant PoC solutions. This is the case both with Enhanced Push to Talk (EPTT) offered by wireless carriers and with Over the Top Push to Talk (OTT) solutions that provide carrier agnostic proprietary PTT products.
- Some PoC vendors propose a rudimentary interface to LMR networks. This level of communications does not include any meta data currently available with LMR networks and needed by the First Responder community for mission critical applications but merely passes the voice as baseband analog audio. LMR meta data can include subscriber identification,

Acronyms useful to understand while reading this White Paper

- **LMR** – Land Mobile Radio
- **LTE** – Long Term Evolution
- **3GPP** – Third Generation Partnership Project
- **P25** – Project 25
- **IWF** – The Interworking Function
- **MCPTT** – 3GPP's Mission Critical Push to Talk
- **MCVideo** – 3GPP's Mission Critical Video
- **MCDData** - 3GPP's Mission Critical Data
- **MCX** - 3GPP's MCPTT, MCVideo, and MCDData collectively
- **PoC** – Push to Talk over Cellular
- **ISSI** – Inter Sub-System Interface
- **EPTT** – Enhanced Push to Talk
- **OTT** – Over the Top Push to Talk

group identification, emergency status, subscriber location, and other critical attributes of the individual or group making the call. Analog to digital conversions degrade the audio quality; when possible, the audio should be kept in a digital format end-to-end.

- Some PoC vendors have chosen to require that customers use the Project 25 (P25) Inter Sub-System Interface (ISSI) to interface to their LMR radio systems. While this interface overcomes many of the shortcomings above and provides additional high-level features for LMR to LTE communications, only a minority of organizations have implemented a P25 network and of these, only a handful have implemented the expensive ISSI interface. Of those with ISSI, often licensing limits the allowed capacity. As a result, the ISSI is not a viable interface for many users interested in LMR LTE communications.

### **Use Cases for Standards Compliant Interworking**

The requirement for standards compliant MCPTT can be best appreciated when considering mutual aid or when other cross-organizational communications is required for an event. A First Responder from an adjacent organization responding to a call for assistance and with an MCPTT LTE device can be added to the conversation and benefit from mission critical level communications with peers. Contrast that scenario with the alternative – a First Responder from an adjacent organization responding to a call for assistance and with a non-standard PoC device can only be added to the communications environment if they coincidentally happen to have the same proprietary PoC product as the requesting organization. This example subverts the intent of a nationwide First Responder network—the premise of FirstNet™—and introduces more confusion and chaos into an already tense event.

When standards compliant MCPTT PoC is in use, interworking between PoC users and First Responders arriving on scene with LMR subscriber units is also less

compromised. Provided these LMR users are communicating on the same frequencies as the requesting organization, their communications are automatically heard by LMR users on that frequency and the MCPTT LTE users who have their talk group mapped via their Interworking solution to the LMR talk group.

The biggest issue with both EPTT and OTT is that once a vendor is selected for the application, everyone needs to have that vendor's application. For instance, a Harris BeOn PTT system cannot directly communicate with a Motorola Wave PTT system and neither can it communicate with an ESChat OTT system. This quickly destroys interoperability and becomes an untenable management problem.

Therefore, MCPTT that adheres to Third Generation Partnership Project (3GPP) standards should be implemented. Also, none of the PTT over cellular products currently on the market are designed to be used to deliver the mission-critical voice communications traditionally transmitted via LMR systems. The conclusion is that, prior to 2020, an acceptable standards compliant Interworking solution for LMR LTE communications does not yet exist.

Other compelling use cases include maintaining communications with an organization's command staff and other executives, off-loading public service traffic, and back-up for the LMR system. Public Safety executives already carry smart phones, tablets, and other modern devices and should not need to also carry an LMR radio, especially since they are often outside the LMR coverage area. Traditionally, municipal maintenance personnel and other public service users have used LMR radios. Many of these employees would be better served with LTE devices that support the applications they need and at a lower cost. By moving these individuals off the LMR system, a municipality can reduce the loading on the LMR system, eliminating bottle necks and contention during critical events, and providing bandwidth for data applications to LMR devices. Natural and human-made disasters can disable even the most robust LMR systems. Cellular networks have demonstrated that in

many cases, these alternative wireless communications platforms are valuable backups. All of these use cases are best implemented with a standards compliant PoC solution that allows each department to choose the tools that best meet its operational needs. When disaster strikes, seconds count. Governmental organizations need solutions that are well understood and universally implemented, not one-off approaches.

### Efforts to identify Standards Compliant Interworking

Aware of these limitations, DHS S&T solicited proposals from vendors to research a standards compliant Interworking solution. Interworking is the term that describes interoperability between LMR and LTE networks. Catalyst Communications Technologies (or simply Catalyst) was one of two vendors selected for this research. (A companion white paper published in August 2019 from Catalyst describes the results of this research and this paper can be downloaded at

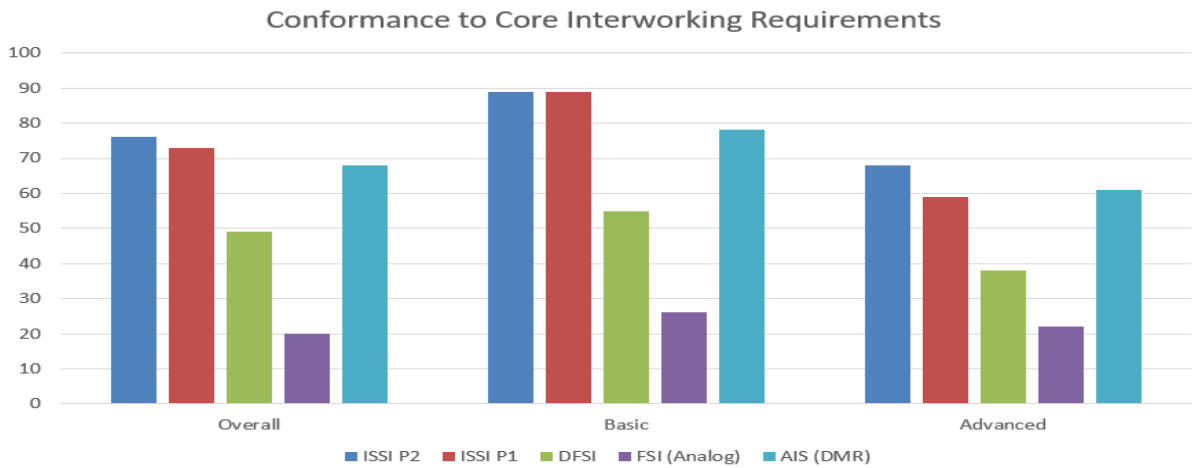
<https://www.catcomtec.com/download-interworking-white-paper/>). For anyone interested in a deeper dive than that provided by this summary, please write to [info@Catcomtec.com](mailto:info@Catcomtec.com).)

Our research concluded that a standards compliant Interworking solution was possible, and that the highest level of conformance to a series of Interworking requirements published by the National Public Safety Telecommunications Council (NPSTC) in a report titled *“Public Safety Land Mobile Radio (LMR) Interoperability with LTE Mission Critical Push to Talk,”* was through the Phase 2 P25 ISSI implementation to the LTE 3GPP MCX Interworking standard. The research analyzed conformance with other radio systems in use by First Responders and found that the type of radio system (P25 vs. Digital Mobile Radio (DMR) vs. Legacy Trunked vs. analog, etc.) and the interface to that system dramatically impacted the conformance. The graph below shows the conformance for



five scenarios. Basic functionality includes group calls, Emergency, user ID, the resolution of different audio codecs, late entry to a communication, and console support. Advanced functionality includes private calls, text messages, pre-emption, and location.

## Your LMR System's Interworking Capabilities Will Differ From Others



Our research also concluded that since the ISSI interface was so sparsely deployed and expensive, and due to the large number of public safety organizations with different LMR systems, alternatives to the ISSI interface that maintained compliance with standards was needed. We identified such a standards compliant solution and described how an “LTE client” interface could deliver basic functionality between the two network systems sufficient for mission-critical first responder use. From that conclusion, Catalyst was awarded a second contract from S&T to develop an Interworking prototype based upon these recommendations.

This paper describes the reasons why a standards compliant solution to Interworking is preferred over the proprietary products that have been deployed over the past few years.

We conclude nonstandard interworking solutions do not serve the interests of public safety organizations or the country. In this paper we also describe a product architecture and design that offers standards compliant Interworking between MCPTT on broadband networks with P25 LMR networks and also the vast majority of other public safety radio networks that are not P25.

### **Broadband Networks for Public Safety, and the FirstNet™ Initiative**

Mobile PTT networks have been around for quite some time, and many readers will remember Nextel in the 90s and early 2000's. For this paper, it is useful to reference FirstNet™ when considering mission-critical PTT and Interworking with existing LMR networks. FirstNet™ is a nationwide wireless broadband network for First Responders being built and deployed through a partnership between the federal government and AT&T. FirstNet™ and other broadband networks are attractive to Public Safety because of the much higher data carrying capacities of LTE compared with LMR. A wide variety of applications, including video, data, location, presence, and others, are possible on LTE networks and are not feasible or are highly constrained on LMR. Despite these advantages, interest in PTT over LTE from public safety was not well received prior to FirstNet™, because the shared cellular network did not give priority to First Responders over non-public safety users, and these First Responders were confident in their existing LMR networks. In moving to FirstNet™, or other broadband networks, the existing advantages of LMR must be maintained.

In the initial roadmap of FirstNet™, AT&T promoted its data transport features. First Responders quickly indicated that voice communications were a high priority. Unlike previous carrier-based PoC offerings and OTT products, AT&T is

*AT&T is contractually obligated to provide MCPTT to First Responders. The U.S. Department of Commerce oversees the FirstNet™ contract and has identified Interworking as a key essential capability for the voice communications domain of the Roadmap.*



contractually obligated to provide MCPTT to First Responders. All indications are that AT&T will invest the resources to make it successful. By focusing on voice, the need for Interworking with LMR became prominent and a key component to the success of FirstNet™. The U.S. Department of Commerce oversees the FirstNet™ contract through the FirstNet Authority, and it has identified Interworking as a key essential capability for the voice communications domain of the Roadmap.

### **Initial First Responder trials with PoC and the corresponding rise of MCPTT**

After FirstNet awarded their contract to AT&T, vendors with PoC technologies began to expand their products and marketing efforts to focus on early adopters in the public safety sector. The carriers offered “enhanced” PTT, most often using technology from Kodiak Networks (since acquired by Motorola) and later differentiated by carrier grade Quality of Service (QoS), as traffic of PTT apps could be prioritized. Another technology, OTT, offered by L3Harris, Motorola, ESChat and other PoC vendors, are PTT solutions that are a layer over the general mobile phone provider network, which directly describes its main advantage over the carrier-grade solution. EPTT solutions are neither interoperable between different carrier networks, nor with OTT solutions; and neither technology includes the robust requirements of MCPTT being standardized by 3GPP. As these systems were not “mission critical”, MCPTT became a defined project of the international mobile communications standards community. Features and capabilities for MCPTT were added to the docket of the 3GPP committees responsible for defining LTE and other mobile communications standards such as 5G.

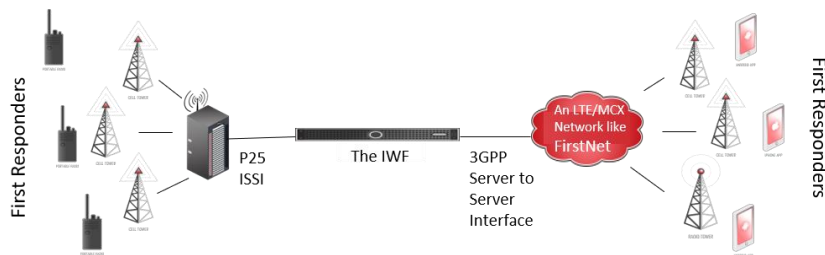
In parallel, standards-oriented organizations including 3GPP internationally and, in the U.S., Telecommunications Industry Association (TIA), National Institute of Standards and Technology, NPSTC, The Alliance for Telecommunications Industry Standards (ATIS) and others looked for a standards compliant solution to Interworking.

The award to Catalyst referenced above was one effort towards solving this challenge.

**The Interworking Function (IWF)**

The 3GPP MCX standards include IWF, a comprehensive system-to-system interface between LMR and LTE. TIA and ATIS began work on the North American LMR side of the IWF in 2012 through a Joint Project Committee known as “JLMRLTE”. This committee plans to accommodate P25 Conventional, P25 Trunking and TIA-603 based Conventional Analog FM (Frequency Modulation) service. In 2014, the JLMRLTE agreed to “postpone further work in JLMRLTE until the LTE part of MCPTT work in 3GPP is more developed”. In December 2017, JLMRLTE work resumed, and initial 3GPP MCX standard documents are planned for Release 15 and 16. We believe the implementation of this capability in FirstNet™ is years away, and as previously indicated, expensive.

For North America, this approach envisions a P25 ISSI interface to the radio system and a 3GPP MCX server-to-server interface to the LTE system. TIA-102 concerns the functionality and performance necessary to enable interoperable (i.e., multi-manufacturer) implementation of open interfaces, services, and features for digital LMR equipment. TIA-102 is being modified by addendum to accommodate an interface to an IWF Gateway, although no date for its publication has been offered and there is much work to be done.



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During the research that Catalyst completed through our first S&T contract, we determined that the highest level of conformance to the Interworking requirements defined by NPSTC was through these interfaces.

This solution, while technically robust, has serious constraints on where it can be practically applied. There are over 70,000 police, fire, EMS and government organizations in the U.S. that may need Interworking between their LMR networks and broadband networks like FirstNet™. The Project 25 Technology Interest Group estimates that approximately 2,500 of these organizations have implemented P25, and of those, very few ISSI interfaces have been installed (and primarily for LMR to LMR interoperability and primarily for trunked systems). The leading vendors of these systems, Motorola and L3 Harris, charge many thousands of dollars for the ISSI feature. ISSI is not an alternative for public safety organizations that do not have a P25 radio system, or who cannot afford the high price of the ISSI feature.

### **If not IWF, then what?**

Another option for Interworking is to implement technology, at the LTE interface, that mimics a MCPTT mobile phone. In contrast to the “server to server” interface contemplated by the IWF, this LTE “Client” interface is a defined, mature standard today, can be more easily implemented and managed than the IWF, is much less expensive than the IWF, and provides most of the capabilities needed by First Responders. The Client interface was introduced in 2016 in 3GPP MCX Release 13 and has been used in LTE systems, including those in South Korea, for many years.

With an LTE Client interface, Interworking with a wide variety of LMR systems is attractive. Catalyst evaluated many radio systems against the core Interworking requirements of the report published by NPSTC, “Public Safety Land Mobile Radio (LMR) Interoperability with LTE Mission Critical Push to Talk,” and concluded that public

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safety grade—“Mission Critical Interworking”—had high levels of conformance to the core requirements of the report, excepting conventional analog radio systems. For radio systems with some level of digital protocol control, public safety grade Interworking is highly effective. Even conventional analog channels can be Interworked with MCPTT, though the features will be severely limited as the capabilities on the LMR side to meet many of Public Safety’s requirements are missing.

Radio interface technology is a technology strength of Catalyst, and our IntelliLink™ Interworking solution enables standards compliant Interworking for many of these radio interfaces, not just P25 ISSI. Catalyst’s IntelliLink™ Interworking product can support the following radio interfaces: P25 Digital Fixed Station Interface (DFS), P25 Common Air Interface, DMR Application Interface Specification (AIS), Analog, and vendor proprietary interfaces, including L3Harris EDACS™ and Kenwood Nexedge™, LTR and Fleetsync™.

Catalyst identified 10 different Interworking interface options, described below:

1.	<u>P25 LMR ISSI to 3GPP MCX Server-to-Server Interface</u>	This is the IWF model. As discussed above, the 3GPP organization is completing the initial definition of the LTE side of this capability in their Release 16. As of the date of this paper, 3GPP has published the specifications for the high-level portions of Release 16 but not all of the detailed documents. We believe the implementation of this capability in FirstNet is years away and, as previously indicated, expensive. TIA is working to define how the ISSI would be used for North American IWF implementations, however, no date to publish this
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		<p>approach has been set. Even with the standard fully complete, it is unclear if and how a server-to-server interface will be enabled in the network such as AT&amp;T FirstNet, as currently no external MCPTT servers can connect into the AT&amp;T FirstNet network.</p>
2.	<p>P25 LMR ISSI to 3GPP Client Interface</p>	<p>Catalyst developed the ISSI/CSSI (Console Subsystem Interface) interface as part of our suite of radio interface technologies in 2016, so this is one version of our IntelliLink™ Interworking product. We do not expect high demand for this model, as there are few radio side implementations of ISSI, and ISSI is complicated to configure and maintain. While some functionality will be lost when ISSI is translated to the client interface, compared to the ISSI IWF server-to-server implementation, some agencies will appreciate its value.</p>
3.	<p>P25 LMR DFSI to 3GPP MCX Server-to-Server Interface</p>	<p>While technically possible, this configuration depends upon the IWF being implemented in the LTE system, currently scheduled for Release 16, years away, and, as previously indicated, expensive. TIA has announced plans to define this portion of the North American IWF but only after it completes its initial work using ISSI. Even with the standard fully complete, it is unclear if and how the server-to-server interface will be enabled in the network such as AT&amp;T FirstNet, as currently no external MCPTT servers can</p>

		connect into the AT&T FirstNet network.
4.	P25 LMR DFSI to Client Interface	Catalyst has developed the DFSI interface as part of our suite of radio interface technologies, so this is one version of our IntelliLink™ Interworking product. We expect this configuration to be popular and the primary means for conventional P25 radio systems to interwork with 3GPP MCPTT. As a standard, DFSI offers public safety agencies a wide choice of suppliers and supports analog as well as P25 conventional.
5.	DMR/Terrestrial Trunked Radio (TETRA) LMR to 3GPP IWF ISSI	While technically possible, this configuration depends upon the ISSI interface on the LTE side, currently scheduled for Release 16, years away, and, as previously indicated, expensive. We can envision that a DMR radio manufacturer could build an interface to ISSI, although we are unaware if any manufacturer has done so. Even with the standard fully complete, it is unclear if and how server-to-server interface will be enabled in the network such as AT&T FirstNet, as currently no external MCPTT servers can connect into the AT&T FirstNet network.
6.	DMR/TETRA LMR to Client Interface	Catalyst has developed the DMR AIS interface as part of our suite of radio interface technologies, so this is one version of our IntelliLink™ Interworking product. We expect this configuration to be the primary

		<p>means for DMR radio systems to interwork with 3GPP MCPTT. Similarly, Catalyst has developed a DMR Tier II (conventional) solution using a control station that supports the DMR Air Interface standard, and its integration with the MCPTT client interface provides a powerful tool. A TETRA interface is possible with this configuration.</p>
7.	Conventional Analog LMR to 3GPP IWF ISSI	<p>While technically possible, this configuration depends upon the ISSI interface on the LTE side, currently scheduled for Release 16, years away, and, as previously indicated, expensive. Other than audio, this configuration would provide little advantage to end users due to the limited capability of analog radio systems to meet the requirements for mission critical communications expected by First Responders. Even with the standard fully complete, it is unclear if and how server-to-server interface will be enabled in the network such as AT&amp;T FirstNet, as currently no external MCPTT servers can connect into the AT&amp;T FirstNet network.</p>
8.	Conventional Analog LMR to Client Interface	<p>Catalyst has developed analog radio interfaces, including the Fixed Station Interface (FSI), EIA Tone Control, and dc (direct current) control, as well as signaling such as MDC-1200, as part of our suite of radio interface technologies, so there are a variety of versions of our</p>

		<p>IntelliLink™ Interworking product supporting conventional analog. We expect a high demand for these interfaces and have laid out an approach to provide basic Interworking with 3GPP MCPTT. When combined with a dispatch console, simple analog conventional channels can be patched to MCPTT talk groups, and the Interworking can be managed by the dispatcher. Using FSI or Tone Control or a set of single channel base stations, the dispatcher can select the appropriate LMR channel and patch it to the appropriate MCPTT group. When signaling like MDC-1200 is available, the dispatcher can collect information like Caller ID and Emergency on both systems and manage communications as he would between two conventional LMR channels. The MCPTT client interface provides a cost-effective, feature-appropriate complement to conventional LMR systems.</p>
9.	Proprietary LMR to 3GPP IWF ISSI	<p>While technically possible, this configuration depends upon the IWF on the LTE side, currently scheduled for Release 16, years away, and, as previously indicated, expensive. We envision that the radio infrastructure manufacturers will provide a migration path for their proprietary systems but anticipate that it will perpetuate their single source relationship, add additional costs, and limit</p>



		<p>access to many of the innovative new tools that LTE will unleash. Even with the standard fully complete, it is unclear if and how server to server interface will be enabled in the network such as AT&amp;T FirstNet, as currently no external MCPTT servers can connect into the AT&amp;T FirstNet network.</p>
10.	Proprietary LMR to Client Interface	<p>Catalyst has developed serial and other advanced control interfaces to various radio systems, including L3Harris EDACS™ and Kenwood NexEdge™, LTR and Fleetsync™ protocols, as part of our suite of radio interface technologies, so there are a variety of versions of our IntelliLink™ Interworking product in this category. We expect these configurations to be popular and the primary means for the many proprietary radio systems currently in use to interwork with 3GPP MCPTT. They provide cost-effective solutions that can be efficiently adapted as the agency evolves its LMR and MCPTT usage and are available now.</p>

### **Mission Critical Interworking**

In addition to compliance with standards, there are several additional requirements for communications between LMR and LTE users to be “mission critical”. PTT solutions meeting the 3GPP standard for MCPTT are designed to meet or exceed the performance of public-safety LMR standards like P25 and TETRA when the user device is connected to an LTE network. LMR users expect audio from an LTE MCPTT

subscriber to be equal to or better than the audio from another LMR subscriber. Minimal delay, protection against lost syllables and words, the provision of meta data to dispatchers (and eventually between subscribers), and priority access to network facilities all must be maintained.

FirstNet™ is contractually and legally obligated to provide standards-based technology for both LMR and LTE networks to enable communications between MCPTT devices on these networks.

The Catalyst approach best meets the needs of Public Safety:

- Catalyst’s technology protects against dropped syllables and hung channels. Especially for standards compliant radio networks, including P25 and DMR, and certain proprietary radio systems with digital protocol control, including L3Harris and Kenwood, our technology is “aware” of the radio status and can, for example, buffer the audio when the radio is busy and transmit only after a channel becomes available, preserving the entire communications.
- Catalyst’s radio interface technology supports a wide array of LMR radio systems, not just P25 trunked systems with sufficient ISSI capacity.
- For Dispatchers, Catalyst’s Dispatch Console (pictured below) provides a high level of symmetry with what First Responders are currently expecting, including Unit ID, Alias, and Emergency Indication, from users on both networks. Creating Interworking between LMR and LTE talk groups is consistent with how Dispatchers currently create LMR – LMR interoperability.



- The Catalyst solution does not require a Catalyst Dispatch Console. Catalyst provides an intuitive User Interface for managing Interworking for organizations with other Dispatch Console products.

### The Compelling Case for Standards Compliant Interworking

This paper has shown that proprietary PoC solutions available in the marketplace have been effective in demonstrating the use cases for LTE and other broadband-based networks for First Responders. However, these products create islands of communications that are not responsive to First Responder requirements and can't be easily interconnected in case of an unexpected emergency. These PoC products do not have the reliability and robustness of LMR networks used by First Responders today. They do not always include meta data, including unit ID, Alias, Emergency Indication, and priority that are available to First Responders on LMR networks today. And they cannot interwork with LMR systems with a level of capability expected by First Responders today.

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In contrast, MCPTT on public safety grade networks such as FirstNet™ are provisioned on networks that do provide the reliability and robustness – perhaps even greater – of today's First Responder LMR networks. MCPTT provides meta data to subscribers and Dispatchers consistent with today's

capabilities, including Unit ID, Alias, and Emergency indication, and can enhance these capabilities with new features, including location, presence, video, data, and other to be developed capabilities. MCPTT is a standard, and Interworking with LMR networks can be provided, which promotes communications between LMR and LTE subscribers in line with the goals of FirstNet™ and other LTE networks offered in support of mission critical communications.

For support with your unique Interworking, Dispatch, and Interoperability needs, please contact Catalyst at 434-582-6146 or [info@catcomtec.com](mailto:info@catcomtec.com).

