



FirstNet Innovations

Revolutionizing Public Safety Communications

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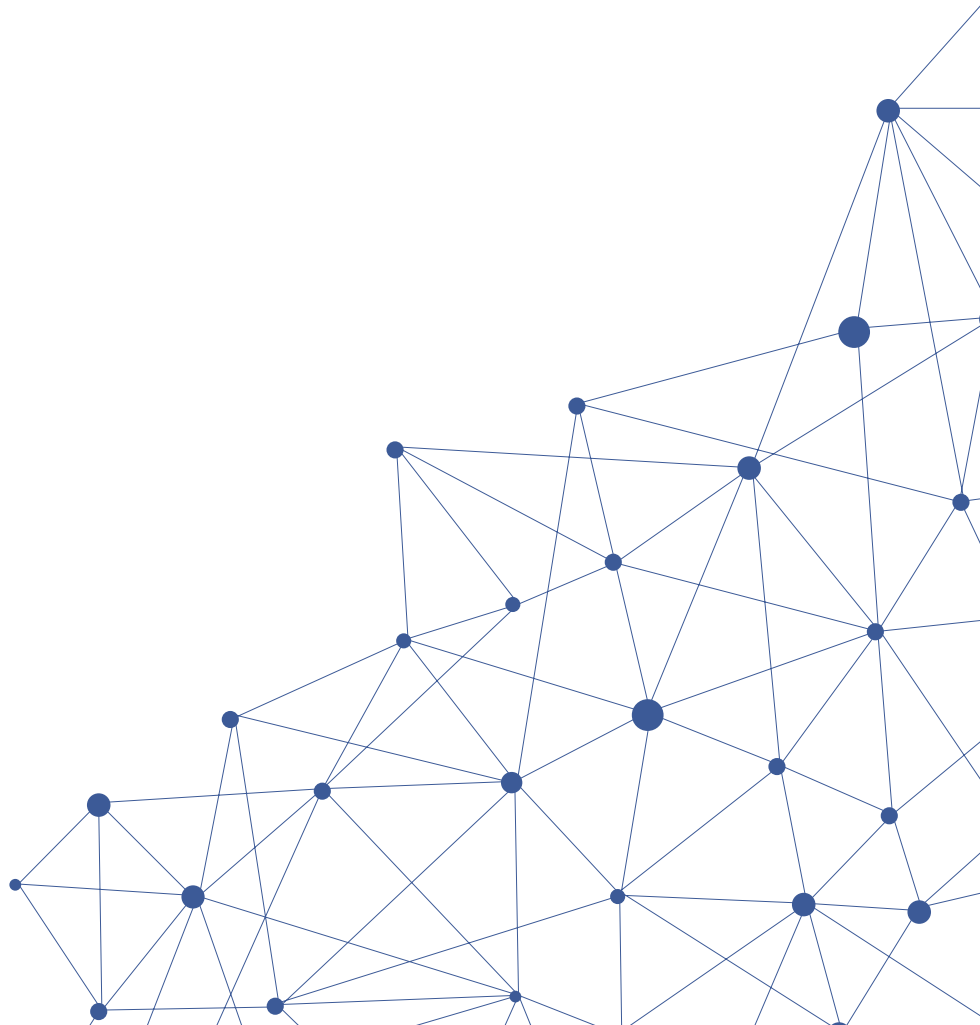
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It goes without saying that communications are absolutely critical for Public Safety. The very nature of Public Safety services requires highly reliable systems, while with many new technologies, reliability tends to follow sometime after introduction. This creates a challenge to the implementation of the National Public Safety Broadband Network (NPSBN) and the application of 4G LTE services to the unique needs of Public Safety.

AT&T through their FirstNet contract has embraced this challenge with innovations targeting Public Safety's functionality and reliability requirements. Embodied in this challenge is an understanding of Public Safety's long history using Land Mobile Radio (LMR) systems to meet their communications requirements. This history has built a level of trust that FirstNet must meet in providing Mission Critical voice communications as well as with their new and innovative services.

The application of what many understand as a well-known solution, 4G Cellular, to the long-standing and critical communications requirements of Public Safety may seem trivial, however; it is not. The hurdles that must be overcome are many and include the perception and the 'trust' that LMR completely satisfies their needs. This 'trust' increases the challenge, as the solution must address not only the actual service delivery requirements, but also this perception.

To meet this challenge, FirstNet has implemented their network on a stable foundation of standards and technologies, while implementing innovations targeting the critical needs of Public Safety and other Mission Critical communications users. All of the functional innovations being provided, as well as those on the roadmap for future release, build on this foundation. Through this purposeful implementation, FirstNet brings each feature into a reliable and trusted ecosystem for Public Safety.

Meeting Public Safety's Unique Requirements

Public safety has unique communications requirements driven by a demand for Mission Critical reliability and the need for the capabilities of their systems to integrate with their operational procedures.

Public Safety's use of LMR evolved hand-in-hand with the development of LMR's technical capabilities. This symbiotic evolution of systems and processes makes the substitution of new technologies challenging. This is often seen as the need that a new system not just "do the same thing" but also do it "the same way". Even technologies with more capabilities, such as LTE, can stumble meeting this requirement. In addition, sometimes striving to do things the "same way" can lead to Public Safety not leveraging new technologies as fully as they otherwise could. Public Safety's requirements for reliability and resiliency also set a high bar, even for their existing LMR systems. However, even when objective analysis shows it is not earned, the confidence derived through their experience with these systems satisfies the

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need. Sometimes that confidence goes well beyond the actual level of reliability and resiliency delivered. This dichotomy between the perceived and actual reliability requirements can create an impediment to acceptance of a new technology.

FirstNet, by engaging Public Safety directly, is working to address the reality of these requirements and build the confidence needed.

Working within a highly standardized industry.

FirstNet Built with AT&T operates within the cellular 3G/4G (Becoming 5G) industry which is highly standardized. These standards target the requirements for wireless Internet/datacom and telephony services delivered to the many consumer and commercial users. This is significantly different than the LMR systems traditionally used by Public Safety, where it is common to first implement new features and functionality in a proprietary manner and then, once proven, develop a standardized approach.

To meet the Public Safety challenge, these cellular services require many changes to the standards, and to the processes they use to verify compliance. The FirstNet Authority and FirstNet Built with AT&T are working within the standards bodies to develop the standards for the features and functions Public Safety requires. FirstNet Built with AT&T is then able to implement these standards within their systems, services, and greater FirstNet ecosystem to meet the needs of Public Safety.



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Driving Innovation for Public Safety.

The rate that new features and technology evolution occurs in the 4G/5G solutions standardized by 3GPP tends to far exceed that which occurs in the LMR industry. FirstNet, working internal to 3GPP provides input and feedback on these standards-based solutions and how they can be enhanced for Public Safety. FirstNet's application of individuals with Public Safety experience and background is critical to the success of this standards process. To continue driving innovation in this manner, policy makers and technology providers must obtain Public Safety's feedback in a timeframe that allows the input to be included in the global standards making process. FirstNet has established focus groups and forums to generate the dialogue and valuable feedback required to meet this critical need.

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FirstNet Technology Innovations

The solution to meeting Public Safety's requirements is the development of the National Public Safety Broadband Network (NPSBN) with the integration of the many Public Safety unique features and functions into the LTE standards. The realization of the NPSBN is FirstNet Built with AT&T.

FirstNet, being the first and only cellular network designed and implemented specifically for Public Safety and Mission Critical users, is developing and implementing the standards required to deploy the many technology innovations addressing the challenge. These innovations include refinements of cellular system technology and its operating parameters, as well as leveraging additions to the standards targeting Public Safety and Mission Critical users' needs. Additionally, FirstNet is continuing to research and develop yet to be standardized services, as additional needs are uncovered, thereby always innovating and evolving forward.

Priority and Preemption

A primary issue for all communications systems is ensuring adequate capacity when needed. However, with Public Safety and Mission Critical networks it is essential that even during overload the available capacity serves critical needs first and foremost. Most Public Safety LMR systems are privately operated and therefore under full control of the user agency. This control allows them to assign resources as needed to best accomplish their mission, even if doing so requires delaying or blocking low priority traffic to ensure high priority communications are completed.

Cellular systems have developed, similar to public utilities, attempting to distribute resources to all users, with little to no preference to any. Because of this, changes are required to the standards and the 4G architecture to enable and manage the assignment of priorities and to provide the ability to "preempt" an ongoing session. Additionally, changes are also required to the implementation of control and management operation of the network for these features to be utilized in a timely and effective manner.

To accomplish the required network availability, FirstNet uses a system of priority and preemption enabled by both enhancements to the LTE standards and careful optimization of their radio and network systems. This effort provides the priority and preemption features that replicate the operation of modern Public Safety trunked radio systems. FirstNet also provides the tools to Public Safety to manage their service through "uplifting" users, while not using bandwidth caps and other limitations for their own benefit or to encourage buying higher service levels.

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Mission Critical Push to Talk (MCPTT)

The primary mode of radio communications for Public Safety is Push-to-Talk (PTT) voice. Mission Critical Push to Talk (MCPTT) is an extension to the 3GPP (4G) standards enabling Push-to-Talk (PTT) functionality on an LTE system in a manner that effectively replicates the operation of PTT on a state-of-the-art LMR digital trunked radio system. FirstNet is championing the technology innovation and deployment of MCPTT to fill this vital requirement. MCPTT is closely paired with the previously mentioned, priority and preemption, in meeting the immediate needs of Public Safety.

While various systems and technologies have provided PTT operation on cellular networks, most fall short in terms of setup speed, voice latency and reliability. Additionally, most PTT over Cellular (PoC) systems rely on proprietary technology from a limited set of vendors.

MCPTT answers this challenge with standardized functionality designed specifically to address the needs of PTT users for Mission Critical communications. The development of this standard was driven by the people and organizations responsible for the creation of the NPSBN embodied in FirstNet. An important distinction is that MCPTT includes both standardized processes and minimum performance metrics (Key Performance Indicators or KPIs). While we are seeing some non-standardized PTTtoC systems meeting the KPIs, only when a system also adheres to the standard is it truly MCPTT. MCPTT on a network without priority, preemption, and the other FirstNet differentiators may fall short when Public Safety needs it most.

Other Mission Critical Functions

As with MCPTT, FirstNet has targeted the delivery of each of the other modes of communications in a standardized form designed specifically to address the needs of Mission Critical users. This includes both data and video services. Like MCPTT, Mission Critical Data (MC-Data) and Mission Critical Video (MC-Video) are built as standardized services relying on the priority and preemption functionality of FirstNet.

While these services have not been fully defined, what is being standardized includes appropriate KPIs to assure that it is a high speed, low latency, highly reliable operation that can be maintained even when network congestion would slow or cripple standard data and video services.

An important distinction from other carrier offerings is that FirstNet MC-Data and MC-Video are not simply stricter Service Level Agreements (SLAs) or simply commitments not to 'throttle' access, but rather fundamental technical differences built into the standard and into the FirstNet system.

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LMR to LTE Interoperability

As Public Safety applies FirstNet to their communications requirements, it is critical that users on FirstNet seamlessly interoperate with users on their existing LMR systems. Today, this is principally an issue for PTT voice services, but as we move forward all primary and supporting services need to be included.

MCPTT and other PTTtoC functionality needs to connect as seamlessly as LMR systems do today. Whether that connection is with a digital trunked system, a conventional channel, or even another PTTtoC service, it is critical that the interoperability comes first. The LMR to LTE Interoperability that FirstNet is developing does exactly that. With FirstNet supporting their Network Integrated PTT, FirstNet-PTT, as well as several Over-the-Top PTT solutions; the application of their innovative interoperability approach allows communications to continue without the barriers we have seen between proprietary technologies.

Dual Mode (LMR-LTE) Subscriber Equipment

FirstNet, in providing a viable LTE communications system for Mission Critical Public Safety communications, and including LMR interoperability, has enabled the practical use of dual-mode LMR- LTE equipment. FirstNet, by fostering an environment for Dual-Mode LMR-LTE subscriber equipment, has enabled a market segment that minimally existed prior to now.

As a network operator, FirstNet encourages the development of Dual-Mode LMR-LTE equipment, even though the task resides with the many manufacturers providing Public Safety radio equipment. FirstNet and Public Safety's move to the NPSBN has increased the scale of this enabling environment. In the few years since FirstNet was created, there has been everincreasing activity in this segment, with many products brought to market by various manufacturers. FirstNet further assists this market through their certification program, helping assure that as products are released, users can be confident in receiving the features and functionality they require.

High Power User Equipment

A significant difference between Public Safety LMR and current LTE systems resides in the power output of the field equipment (subscriber units). LMR systems rely on a higher-powered field equipment to help assure acceptable coverage in fringe areas. This is vastly different from cellular, especially LTE, where the equipment operates at lower power level for a multitude of reasons. The low power of LTE equipment helps extend battery life, helps manage the high numbers of subscribers, and maintains a level of safety for units used close to the body for extended periods of time.

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High Power User Equipment (HPUE) is a technology innovation unique to FirstNet that allows for power levels significantly higher than typical subscriber units. The application of this concept requires changes to both the standards and the system. FirstNet is implementing these changes to assure HPUE is effective in increasing the reliable range and coverage of the system, without compromising the efficiency of the LTE network.

This innovation was conceived early in the work on the NPSBN, when Public Safety first adopted LTE as their system standard, long before FirstNet was created. However, it only came into operation with FirstNet's support of the HPUE standard and HPUE equipment. Currently HPUE only applies to data services. However, by doing so, it addresses the current versions of



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FirstNet PTT and other FirstNet supported PTT, data, and video solutions, providing reliable communications beyond the areas served by most cellular networks.

Deployable and other coverage enhancements

Emergencies do not always happen where you have coverage. This is true for most all systems, LMR and Cellular. Public Safety has addressed these requirements with stop-gap measures such as besteffort use of fringe coverage, simplex (direct unit to unit) communications, and transportable equipment.

Cellular providers often deploy temporary equipment in response to an outage; however, their process is often centered around temporarily covering an area where a cell has failed or providing additional capacity for preplanned events that overburden the existing infrastructure.

FirstNet addresses this need with equipment and systems designed specifically for emergency deployment. Whether it is a remote area lacking coverage, high traffic area lacking capacity, or for restoration in the event of a failure, FirstNet has a solution. Rather than relying on a one-size fits all method, FirstNet has innovated these deployable resources across a wide range of system sizes, from single fill-in sites to entire stand-alone subsystems. Experimentation and innovation continue with vehicle, terrestrial, and even tethered aloft systems, to handle as many different situations as may occur.

In addition to the technology innovations, FirstNet has worked to ensure innovative operational and procedural systems are in place to quickly deploy the appropriate resources to areas of

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need as quickly and smoothly as possible. The FirstNet Network Disaster Response (NDR) team is a critical part of bringing technical solutions when operationally required.

Network Encryption RAN>CORE>RAN

Public Safety has always had a requirement for a level of security in their communications. This has evolved over time with concerns for operational safety of the responders as well as the privacy of sensitive and personal information transmitted. While most commercial cellular systems provide security on the over-the-air links, FirstNet is the only network that has extended the level of encryption so that it also addresses the network backhaul transport and core systems. Using these innovations in security, FirstNet automatically and completely protects communications as they are transported between the sites and throughout the core. Through this system enhancement, FirstNet applies a rigorous level of security well above that required by industry standards or that assured by other carriers.

Z-Axis Location

For some needs, technology and effective standards have lagged Public Safety's requirements. One of these is the enhancement of location services to include an accurate and usable height measurement.

Accurate information, such as height, is required to quickly locate people needing assistance and other events requiring a Public Safety response in multi-story buildings. While GPS and other location technologies have greatly enhanced the accuracy in finding a map location, called the X-Y plane, the technology to determine elevation, the so called "Z-Axis" has remained a challenge. Determining accurate "Z-Axis" data becomes especially difficult within buildings, where it is most needed. Additionally for this information to be actionable it must be reported at the "floor" level and not just a height measurement.

FirstNet has been able to apply its market power as the defined provider of the NPSBN to drive an initial solution ahead of standards. Over time Z-Axis capabilities will likely be met by multiple vendors with disparate technologies, and one or more of these may eventually be standardized. However, until that is possible, FirstNet will continue to use its position to bring innovative capabilities to Public Safety quickly and efficiently.

In this manner, FirstNet is not only driving innovation within their system, but also across the industry and in adjacent technologies to the benefit of Public Safety.

FirstNet Operational Innovations

Innovations are often thought of primarily in the technical domain, however operational innovations are just as important. FirstNet's unique position as the provider of the NPSBN, and the strict requirements placed on them, are therefore also driven by many operational

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innovations. Some of these innovations are based on the technical differences between FirstNet and other commercial cellular providers. Other operational innovations are based on the needs of their users, Public Safety. Several examples are highlighted below, and over time we will see many more be put into place.


Use of a Dedicated Physical Core

A significant differentiator between FirstNet and other carriers' is its use of a dedicated physical core. Even where FirstNet shares sites and carriers with the commercial AT&T system, all communications and all services are provided by this separate, dedicated FirstNet core. As the information technology (IT) world moves towards virtualization of hardware and services, this difference may seem mostly transparent during normal operation, however, when delivering Mission Critical services, it becomes vital.

The criticality of a dedicated core is essential during events outside the norm, such as extreme loading, unanticipated disruptions, and deployment of extended coverage and capacity equipment. It is also central to providing Mission Critical levels of service (meeting KPIs) for services such as MCPTT, MC-Data, and MC-Video. It is this higher level of service during normal and adverse conditions that makes FirstNet appropriate for Public Safety's greatest needs.

Dedicated Spectrum

The very concept of the NPSBN, and hence what became FirstNet, started by asking the question; "what could be accomplished if Public Safety had access to the dedicated spectrum required to implement their own LTE network?" With this concept of having dedicated spectrum at its core, FirstNet has been able to drive both technical and operational innovations in the use of this indispensable resource. At a fundamental level, this dedicated spectrum allows

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for enhanced priority and preemption, as competition for bandwidth between Public Safety and other users can be controlled and limited. Additionally, dedicated spectrum provides a significant advantage in the use of deployable resources and the application of technologies such as HPUE.

For deployable solutions providing coverage and/or capacity enhancement, dedicated spectrum resolves the frequency conflict issues typical with cellular system configuration. Furthermore, since this spectrum is dedicated to Public Safety, it opens the door to agency owned and

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operated coverage and capacity enhancements, whether they are transportable or fixed. This dedicated spectrum, in the 700 MHz band, enables FirstNet's support of agency owned and operated deployable systems, addressing the specific needs of Public Safety without the limitations of relying solely on carrier equipment and systems.

Response Operations Group

In a similar manner to the establishment of the dedicated physical core and the FirstNet NDR team, FirstNet has developed a Response Operations Group (ROG) dedicated to FirstNet users. This innovation helps assure Public Safety receives the response to support requests they require, and that response is timely and appropriate. The ROG spans the activities typical to a cellular operations call center, expanded to address the range of response scenarios such as deploying physical resources such as COWS, COLTS, and other deployable network resources. The FirstNet ROG even includes the recently announced "ROG the Dog" program to bring therapy dogs to first responders during crisis situations.

Device and Application Ecosystem

In the support of FirstNet, AT&T has built an ecosystem specifically addressing the needs of Public Safety. It includes an ever-increasing range of standard and specialty products, and a multitude of certified applications for Public Safety and other Mission Critical uses. It is this focus on Public Safety that drives the development and expansion of this ecosystem of devices and applications, all tailored to address the unique functional, security, and interoperability requirements.

Most carriers and some system manufacturers have built "ecosystems" around the products and services they offer. This is to fulfill the basic requirement that their products and services not interfere with each other, other users, or system operation. These ecosystems typically target the broad consumer market and are extremely limited in specialty equipment. The difference with the FirstNet ecosystem is that in addition to supporting these minimum needs, it supports Public Safety's critical requirements, especially where they differ from that of the mass consumer and commercial markets, and in this manner is indispensable.

In Conclusion – Your involvement is critical

Only FirstNet Built with AT&T provides Public Safety with access to a truly standards-based LTE system which encompasses the innovations required to meet their requirements for day-to-day and emergency communications. As a member driven organization, your agency and their needs will drive the future innovations integrated into FirstNet for the benefit of all. These innovations include today's features, a roadmap of functionality for tomorrow, and a yet to be enumerated list to continue to meet the needs of Public Safety and other Mission Critical users into the future.

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Neil Horden has 38+ years of experience in wireless communications working with users and manufacturers in the wireless communications markets. As a leading consultant in the industry, he has aided many organizations in the selection and application of wireless technology to their communications needs. He is an active member of the PSBTA, APCO, NENA, PTIG, NPSTC, and iCERT, and has written for MissionCritical Communications magazine and Public Safety Communications magazine. He is well known for presentations at regional and national conferences.

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