Comments in Response to FirstNet Notice of Inquiry

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<th>TITLE</th>
<th>Rapid and Sustainable Deployment of FirstNet</th>
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(Note: On January 18, 2012, Telcordia Advanced Technology Solutions became an independently managed subsidiary of Telcordia Technologies, Inc., incorporated as TTGS doing business as Applied Communication Sciences) |
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I. Introduction

TT Government Solutions, Inc. ("TTGS") is pleased to provide its comments in response to the Notice of Inquiry (NOI), issued by the National Telecommunications and Information Administration (NTIA) on behalf of the First Responder Network Authority (FirstNet), regarding the conceptual network architecture presentation made at the FirstNet Board of Directors’ meeting held on September 25, 2012, as well as other considerations such as network design and its business plan, and fostering of an application ecosphere.

TTGS’ rich history of telecommunications expertise and innovation traces to our Bell Laboratories heritage. Historically, we played a significant role in design, deployment, and operation of telecommunications networks worldwide, including our role as the chief architect of the U.S. telecommunications system. This has included development of generic requirements, design guidelines, equipment certification, and development of operation support and network management systems for most of the major telecommunications carriers in the U.S. and as well as internationally. We have a proven track record of helping our customers overcome some of the most complex and technically demanding Information and Communication Technologies problems. We have also successfully brought to bear our expertise to help many U.S. government agencies including DARPA, IARPA, U.S. Army CERDEC, DISA, the Intelligence Community, and the DHS National Communications System. We currently are engaged on over 60 government-funded advanced research and development projects and have been awarded over 2000 patents in the areas of networking, software, information assurance, analytics, and operations. We are also prominent players in the global standard bodies and forums, including
ITU, IEEE, IETF, 3GPP, and 3GPP2. We draw upon this experience to document key issues facing FirstNet deployment and highlight potential approaches for addressing some of them.

Our comments are organized in two major areas. First we provide our feedback on the Network Design. We share the belief of most stakeholders that partnerships with commercial carriers are one of the central elements of FirstNet, and highlight the complexities in realizing such integration at the device, Radio Access Network (RAN), Enhanced Packer Core (EPC), and service layers. We also address the issue of extending coverage using rapidly deployable portable solutions such as Integrated Small Cells, Cellular on Wheels (COWs), and Wi-Fi extenders and mesh networks. We discuss the rapid rollout of FirstNet requiring quick deployment of Operations, Administration, Management, and Provisioning (OAM&P) capabilities. Finally, we cover the issue of integration of existing public safety services within FirstNet.

The second area covers FirstNet’s approach for applications and services. We contrast the Telecom Service Delivery Platform with the Apps Marketplace approach. In the presence of smart devices at the edge, we believe that Apps Marketplace is more appropriate for bringing together an eco-system of value-added providers to serve the first responder community. We do not believe a top-down standards-heavy approach is conducive to fostering an eco-system. Sustaining an eco-system requires minimizing entry barriers for new participants, consolidation of infrastructure and demand to realize scale, and equitable value distribution to encourage and reward innovation. We believe an Apps Marketplace model with lightweight governance is ideal for realizing these elements and provide some recommendations on how to implement such an approach.
II. Comments on Conceptual Network Design

A. Partnership with Commercial Carriers

To maximize coverage and performance and to minimize operations expenses (opex) and capital expenses (capex), FirstNet appropriately recognizes it is imperative to leverage existing Radio Access Network (RAN) and core network infrastructure installed by commercial mobile operators. Although accessing multiple operator connections increases the reliability, it is important to consider the implication on device complexity and network implementation costs. Given the limited budget, we believe that the number of operator networks and the types of radio access networks need to be carefully selected.

Multi-Band Device and RAN Complexity

While the Public Safety Broadband spectrum is in Long Term Evolution (LTE) Band 14, the three major terrestrial mobile operators in the U.S. primarily use LTE Band 13, Band 17, and Band 23 besides other re-farming options (e.g., Band 20). The six major mobile satellite operators are split among the L Band, S Band, and Big-LEO bands allocated by FCC. The Conceptual Architecture presentation to the FirstNet Board highlights the need to achieve reliability by simultaneously interoperating with several commercial carriers. However, even if we were to consider pair-wise arrangements based upon regional partnerships with carriers, as the table below indicates, the possible set of devices that FirstNet needs to support grows rapidly.

<table>
<thead>
<tr>
<th>Operator Name</th>
<th>RAN Frequency</th>
<th>Device FirstNet Needs to Support</th>
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<tbody>
<tr>
<td>Terrestrial Mobile A</td>
<td>LTE Band 13</td>
<td>Band 13, Band 14</td>
</tr>
<tr>
<td>Terrestrial Mobile B</td>
<td>LTE Band 17</td>
<td>Band 17, Band 14</td>
</tr>
<tr>
<td>Terrestrial Mobile C</td>
<td>LTE Band 23</td>
<td>Band 23, Band 14</td>
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</tbody>
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It is important to reaffirm that the FirstNet business case depends upon user subscription fees, and device and service costs will be a critical factor for attracting new subscribers. Considering that even in today’s commercial marketplace devices interoperate across at most one or two LTE bands, creating an eco-system of multi-band First Responder devices will pose a significant challenge for FirstNet Program Management. While FirstNet can foster or subsidize the initial development and licensing of LTE band 14 chipsets, FirstNet device suppliers would still need a solid business case to create multi-band devices. Besides the pure development costs for the devices, FirstNet also needs to consider the ongoing costs of certification and testing to support various combinations of devices and E-UTRANs.

There are several strategies to address the above challenges and a careful analysis of merits and drawbacks of each strategy would be required as part of FirstNet Program Management. For example, one strategy could be to avoid simultaneous rollout with several operators and instead interoperate with one large carrier. While this can reduce the cost of deployment and can potentially create scale for device suppliers, there are a number of reasons why reliance on just one carrier is unwise, and use of multiple carriers should be preferred. As the FirstNet Board recognizes, the use of multiple carriers allows FirstNet to sum their various coverage footprints and depths of capacity, while also achieving diversity to support QoS. On the business side, use of multiple carriers allows for competition among them in the negotiation of SLAs, benefiting costs and other terms of roaming, usage of commercial network elements, sharing/pooling of

<table>
<thead>
<tr>
<th>Mobile Satellite A</th>
<th>L Band</th>
<th>L Band, Band 14</th>
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<tbody>
<tr>
<td>Mobile Satellite B</td>
<td>S Band</td>
<td>S Band, Band 14</td>
</tr>
<tr>
<td>Mobile Satellite C</td>
<td>Big-LEO Band</td>
<td>Big-LEO Band, Band 14</td>
</tr>
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resources and other business arrangements. It is important that FirstNet Program Management understand these design flexibility requirements and options as they formulate their rollout strategy.

Another strategy that is very likely to succeed in the short term is the one that relies on COTS devices and their tethering with existing LMR/P25 units for accessing FirstNet. One does not have to say much about economies of scale and functionality of COTS devices – commercial mobile marketplace has already made a very strong statement. In fact, it is not unusual to see First Responders using COTS smart phones and tablets as part of incident management today. There are multiple benefits of this approach. First, it can successfully leverage existing investment in LMR/P25. Second, it provides form-fitting devices that users are already familiar and does not rely on suppliers to create new devices. Finally, they provide a seamless and independent mechanism for interoperability with various carriers and their existing Smart devices.

**Priority Access when Using Commercial Carriers**

Independent of the considerations of dual- or multi-mode devices is the issue of priority access for First Responders when using commercial carriers’ networks. It is impractical at a local level for each first responder agency to negotiate a service level agreement (SLA) with each commercial carrier, and this is where FirstNet adds significant value through its centralization of effort, expertise, and negotiating leverage with commercial wireless carriers and other vendors to leverage LTE network’s inherent capabilities to manage QoS. We anticipate the following typical scenarios for which priority access would be most important:
1. Commercial Operator A and FirstNet share E-UTRAN but each manages its own EPC. In this case, a FirstNet device authenticates to the visiting E-UTRAN of Operator A, and SLAs based upon LTE S1 interface would be needed to ensure appropriate latency and drop rates during congestion. In order to achieve this, FirstNet would need to specify metrics for S1 interface links that can be collected, cataloged and provided as a service for SLA verification.

2. Commercial Operator B and FirstNet have a roaming arrangement and FirstNet uses the EPC of Operator B. Operator B is responsible for the mobility and IP session management. Operator B needs to designate appropriate Service Data Flows (SDFs) and associate QoS Class Identifiers (QCIs) with those flows. The standard mechanism for doing this is based upon Access Point Names (APNs) for the services. FirstNet’s role here would be standardization of these names and their QCI mapping at the national level. Operator B would have to provision FirstNet users and their APN subscriptions in their subscriber databases. Operator B would have to establish acceptable standardized Traffic Flow Templates (TFTs) which eventually tie the SDFs and QCIs to their LTE scheduler. An important role for FirstNet would be to ensure the adequacy of these templates and to periodically stress-test the roaming partner system for compliance.

B. **Extending Network Access Using Rapidly Deployable Systems**

Since no commercial operator has sufficient nationwide coverage, extending network access in areas inadequately covered is a key requirement. Cost effective initial deployment using one carrier and the ability to extend coverage using rapidly deployable portable solutions Availability of Cellular on Wheels (COW), System on Wheels (SOW), and/or Cellular on Light Truck (COLT) resources
supporting LTE access to Band 14 and other relevant 700 MHz bands is important to meet public safety’s communication needs for large-scale emergency or other events in areas lacking LTE infrastructure capacity or adequate cell coverage.

To realize the COW/SOW/COLT strategy cost-effectively, FirstNet needs to: (1) select the technologies and products conforming to the emerging small cell and carrier Ethernet 2.0 standards; and (2) utilize a planning and provisioning tool to set up the backhaul connections for moving or parking the COW/SOW/COLT units.

Rapidly deployable solutions can also include direct communication as in today’s Land Mobile Radio (LMR)/Project 25 (P25) systems and mobile ad hoc networks using technologies such as Wi-Fi mesh. While FirstNet can leverage COTS Wi-Fi mesh approaches, seed research and development efforts are needed so that vendors of COW/SOW/COLT units can enhance their existing commercial offerings for Band 14 radios. To keep FirstNet device costs low, an option to tether LMR/P25 devices to cheaper LTE smart devices, leverage existing investment in LMR/P25 systems, is advisable.

To connect portably deployed solutions to the FirstNet network and the services/applications/database, a standardized broadband wireless backhaul needs to be planned for interoperability nationwide. Backhaul can be done most efficiently at the Ethernet level, instead of the IP level. The harmonized Carrier Ethernet 2.0 standard among the WiMAX Forum, IEEE 802.16, Metro Ethernet Forum, and Small Cell Forum is endorsed by 3GPP.

C. Rapidly Achieving Operational Capabilities

Operations, Administration, Maintenance, and Provisioning (OAM&P)
A properly defined and implemented OAM&P plan is critical to reaching operability capability quickly with sustainability and scalability. In the plan, it is important to consider designing the key OAM&P functions for networks, services, and devices in automated systems in the FirstNet system architecture as shown below. The key OAM&P functions include monitoring and managing: (a) the FirstNet distributed core networks, (b) the key service level metrics with operators which provides radio access, (c) the interface with existing public safety systems, (d) service and device configurations and policies across NPSBN and other networks, and (e) subscription, identification, and account management.

D. Interoperable Voice Services

PTT Interoperability

To address interoperability with existing public safety systems, the network architecture should include a cloud serving existing public safety systems connected to the FirstNet via interfaces like IP, SIP, HTTP, ISSI, CSSI, etc. as shown in the Figure below.

The Service Delivery Platform must support interoperability with the existing public safety systems at the service level, including key services like push-to-talk (PTT). It is important to begin the testing of interoperability and development of mission-critical PTT functionality at the first stage of RAN network deployment (when the Band 14 RAN is first implemented) with selected public safety and federal agencies, to meet the immediate interoperability needs of
FirstNet users and to support as early as appropriate the migration of existing legacy public safety system usage to FirstNet.

Interoperability or integration of new services with current legacy services will require: a) interworking software to run on a Band 14 LTE device in addition to the NPSBN core network; and b) multimode handsets that have the legacy LMR/P25 radio plus the Band 14 LTE radio as well as the commercial 4G/3G radio OR tethered or wireless dongles on legacy devices so that they co-exist with the new smart Band 14 devices.

**Cellular Voice Interoperability**

FirstNet cellular voice should be implemented in IP Multimedia Subsystem (IMS)-based voice-over-LTE (VoLTE), which includes emergency call handling. The voice call continuity feature between FirstNet and other commercial cellular networks (2.5G/3G/4G) requires a careful design and migration plan in concert with participating cellular network operators, each of which has its own seamless mobility solutions and evolution plans for voice services.
FirstNet EPC integration with 3G and 4G core networks of commercial operators could be expensive if the integration is based upon 3GPP or 3GPP2 handovers. Session continuity possibly can be traded for quicker deployment and cheaper solutions that do not require deep integration with operators’ cores. Instead, roaming arrangements (just like between operators today) with SLAs could be a more cost-effective and yet acceptable solution.

III. Comments on Conceptual FirstNet Apps Store

The primary purpose of a broadband network is to support mission-enabling applications that go beyond today’s voice applications. The present commercial environment of smart devices, apps marketplaces, and ever-improving wireless broadband network capacity is a world away from the current public safety network devices and their closely coupled software-based capabilities. A major imperative for the FirstNet organization should be to decouple devices from applications and to provide governance to support a healthy ecosystem of apps developers and device suppliers. Devices should be mere form-fitting containers that provide configuration and runtime support and a framework of security for Apps. FirstNet will have to address the following challenges to achieve this objective:

(1) Address the economies of scale issue. Building devices, services, and apps with addressable markets in hundreds of millions is fundamentally different than creating a marketplace for a few million users. The challenge calls for demand and infrastructure pooling and for leveraging off-the-shelf (OTS) capabilities to the fullest extent; and

Key to Realizing FirstNet App Store

- Devices as Apps Containers
- Consolidate Demand and Apps Infrastructure
- Address Local Control and Independence
(2) Address organizational level imperatives for local administrative controls. First responder user communities are fiercely independent at every organizational level of government. So a top-down model is unlikely to succeed. The challenge requires a design that standardizes infrastructure services but does so without assuming just a single, universal FirstNet administrative domain.

In fact, (1) and (2) can be conflicting in the absence of a well thought out implementation strategy. There is a need to provide pooling and adherence to lightweight standards, but not at the expense of imposing single administrative control. This balance has to be the driving principle for FirstNet deployment of an applications platform and governance model.

A. Service Delivery Platform (SDP) Versus Apps Marketplace Approach

A Service Delivery Platform, as it is widely understood, may not be the right approach for supporting an open ecosystem of devices and apps providers. Implementing a Service Delivery Platform can be expensive, and while there is a business case for such implementation by large Tier 1 commercial carriers, similar economies of scale do not exist for FirstNet operations. An apps marketplace model, on the other hand, is a true game-changer. It has enabled innovation at the edge, lowered the barriers of entry for suppliers, and created a business model for supporting long-tailed services. Long tails for services arise from the need to support service variants for adapting to the methods and procedures of local organizations. This is important as FirstNet considers the second challenge of supporting organizational specific user requirements.
SDP underpinnings are from the telecom domain, where services were centralized with no intelligence on the edge. Smart Devices and Cloud Services have fundamentally altered that paradigm. SDP focuses on abstraction of services for network control, billing, operations and maintenance so that these abstractions can be used by a service developer to create new services which execute on the telecom services platform of the carriers. Apps and apps composition frameworks (ability of one app to invoke another app) can be executed on the edges (devices and the clouds) and thus allow tremendous flexibility for the developers, while also creating a geometric explosion of available capability for reuse. Consider for example, Web 2.0 mashups and the richness that they provide to create today’s highly functional and media-rich native and web applications. Thus, we believe that instead of ideas from telecom Service Delivery Platforms, FirstNet should use more widely practiced and easy to use Web 2.0-based component and integration frameworks for bringing together communities of app developers.

B. First Responder Mobile Applications Platform

Considering the momentum being enjoyed by the leading mobile applications platforms, it would be counterproductive to propose something new or suggest platform-level changes that would result in platform fragmentation and prevent FirstNet users from fully benefitting from the future advances in these platforms.

FirstNet should have two principal obligations in the apps development domain. First and foremost is ensuring security and reliability of the developed apps. Second is the pooling of user requirements from various organizations so that developers can cost-
effectively develop apps that can meet most of these requirements, including configurations needed for local organizational adaptation. To achieve the first objective, we believe that consolidation and standardization of certain key services can have a high payoff. Some of these services include: location aggregation, device and user authentication, user profile and directory services, notification services, device and app management services, and data storage services. Standardization of these services would allow developers to cross-deploy apps across organizations with minimal changes. On behalf of its user base, FirstNet needs to identify the appropriate standards that apply for each service and maintain a roadmap for evolution so that apps developers and users don’t have to do so at the local level resulting in unnecessary fragmentation.

Cloud infrastructure for computing and storage and cloud services for reusable core functionalities indicated above should be the lynchpin for achieving reliability and security and for pooling resources so that both apps suppliers and app users can benefit from economies of scale. To address the independent nature of the local organizations, the platform needs to ensure that it can support different administrative domains. FirstNet also needs to ensure that the cloud infrastructure is delay and disruption tolerant so that users using non-infrastructure based access networks (such as a Wi-Fi mesh or a small cell deployment) can still reliably access the cloud services using proxy nodes that can be dynamically configured at the edges.

Data federation across different administrative domains would be another key challenge that FirstNet would have to address to avoid data silos. This is fundamentally not a technology issue but an issue of methods and procedures. For example, NIMS based incident management protocol specifies roles and access control rules for federating data across administrative domains. FirstNet should leverage the common user profile services and deploy policy-based
access control infrastructure that can be configured as per NIMS or other applicable standards by various domain administrators. Availability of a common infrastructure to federate access to several independently managed administrative domains would be a significant contribution of FirstNet and will most certainly enhance inter-agency collaboration during joint incident responses.

Lastly, the hosting platform needs to support collection of performance metrics to evaluate suppliers and to provide for a usage-based fees and licensing framework. Once again, this is a core infrastructure service for which FirstNet is in the best position to consolidate, so that all user organizations can benefit from omnibus arrangements with multiple development organizations, large and small.

C. Lightweight Approaches for Mobile Platform Governance

FirstNet would have to devote resources to develop guidelines for app certification, and while there may be a push for heavy top-down requirements, we believe FirstNet would be better served if it followed a “market driven” model, where incentives for wider adoption would naturally result in apps that are reliable, secure, interoperable, and composable. In general, we believe the following should be the focus of FirstNet Platform Governance:

(a) An Applications Platform Roadmap relying principally on the commercial world for the mobile OS developments and focusing much of its efforts on core services and core infrastructure evolution.
(b) Defining and managing the Apps Lifecycle Process. This includes: (1) certification of organizations and developers who can use the platform for developing apps; (2) certification of apps for compliance in their use of core services for making apps reliable and secure; and (3) certification of apps for compliance in their use of apps composition framework so that others apps can discover and invoke them to create hybrid apps mashups.

(c) Establishing and managing the apps usage licenses and fees. If FirstNet is to encourage apps that are reusable and interoperable, then it needs to establish a usage-based fees model that will encourage such behavior. Such omnibus arrangements with apps suppliers would not only allow the pooling of buyer purchasing power, but also reduce bids and proposals costs for the suppliers.

IV. Procuring and Standing Up FirstNet

We believe that the FirstNet Board can best establish FirstNet and its necessary procurements by establishing FirstNet in the following logical procurement and development phases:

(1) FirstNet should first put in place a Program Management Office (PMO) and technical support team to define the procurement and technical specifications for the system. It should procure any needed outside support for this through an open competitive procurement; and

(2) FirstNet should then proceed in steps to procure the core network, and flowing from that the RAN infrastructure and other elements.

In this manner, FirstNet Board can ensure a rapid, yet high quality and cost-efficient rollout of the FirstNet to all of its intended users.
V. About TT Government Solutions

TT Government Solutions (dba as Applied Communication Sciences) has a history of helping its clients with complex and large-scale Information and Communication Technology solutions. It has a rich history of innovation and thought leadership and has been instrumental in design and deployment of the next-generation converged communication networks. We have been awarded over 2000 patents and currently have over 60 government funded research and development efforts, as well as a proven track record of providing consulting, technical advisory and other high-value services to a number of U.S. government agencies. Nearly half of our staff members are patent inventors and nearly three-fourths hold government clearances. Some of our related efforts for broadband public safety efforts include:

(1) Leading a tactical effort for the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) to design and develop a Mobile Computing Applications Platform (MCAP) for DoD non-combat and civilian first responder users. The MCAP effort leverages COTS Smartphone platforms and a common middleware for core services to realize an Apps Marketplace for First Responders.

(2) Leading a U.S. ARMY CERDEC Multi-Access Cellular Extensions (MACE) R&D effort to develop and demonstrate a government off-the-shelf (GOTS) appliqué for commercial cellular equipment to allow operation in a tactical environment; interoperability of commercial cellular base stations with military networks for voice, data and network operations (NETOPS); and use of Smartphone applications on the battlefield.
(3) Leading efforts supporting NCS/DHS for more than eleven years in specification development and consulting services supporting nationwide deployment of Wireless Priority Service (WPS) and initial deployments of the NS/EP NGN Priority Services, through efforts such as Government Industry Requirements and Standards development, with particular recent focus on IMS Core Network and LTE Access Network specifications, in addition to other technologies such as WiMAX, satellite, HRPD and cable/fiber.

(4) Led the service requirements, system solution, and network architecture efforts for a 2011 DHS SBIR project on LTE-based mission critical voice solution.

(5) Involvement in the NSPSTC Broadband Working Group (BBWG) efforts and providing comments to its documents.

(6) Designing the next generation IP backbone for connecting the 27 PSAPs (Public Safety Answering Points) around the Minneapolis St. Paul metropolitan area for Minneapolis Metropolitan Emergency Services Board (MESB).

(7) Developing the AutoRF tool set for automatic network-wide load balancing in different types of cellular networks, such as CDMA, HSPA, etc. and interference management tool for LTE.

(8) Teaming with the Institute for Scientific Research to develop the Red Cell Concept of Operations for the Institute for Defense and Homeland Security. The Red Cell program uses the commercial cellular infrastructure to provide real-time alerts to users of wireless devices in emergency situations.

(9) Involvement in a large EU Framework 7 project-- E-SPONDER, which is developing a suite of real-time data-centric technologies which will provide actionable information and
communication support to first responders that act during abnormal events (crises) occurring in critical infrastructure.