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Before the
National Telecommunications and Information Administration
Washington, DC 20230

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In the Matter of Development of the Nationwide Interoperable Public Safety Broadband Network	Docket No. 120928505–2505–01

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COMMENTS OF QUALCOMM INCORPORATED

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QUALCOMM Incorporated ("Qualcomm") hereby submits these comments to the

National Telecommunications and Information Administration ("NTIA") in response to its *NOI*

seeking input on the Conceptual Presentation on Network Architecture that was made at the First

Responder Network Authority ("FirstNet") Board of Directors' September 2012 meeting.[1]

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INTRODUCTION & SUMMARY

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Qualcomm appreciates the critically important steps that NTIA and the FirstNet Board of

Directors are taking towards the rapid realization of an interoperable nationwide wireless

broadband public safety network. It is essential that our nation's first responders have access to

a state-of-the-art mobile broadband network as soon as possible so they can use the most

advanced technologies to communicate with one another, especially during emergencies.

Qualcomm completely agrees that the FirstNet Nationwide Network ("FNN") can and should

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[1]   *See* Department of Commerce, National Telecommunications and Information
Administration, Development of the Nationwide Interoperable Public Safety Broadband
Network, Docket No. 120928505–2505–01, *Notice of Inquiry*, 77 Fed. Reg. 60680 (Oct. 4, 2012)
("*NOI*"). *See also* Craig Farrill, Conceptual Presentation on Network Architecture, First
Responders Network Authority, Presentation to the Board (Sept. 25, 2012) ("Conceptual
Presentation") *available at*
http://www.ntia.doc.gov/files/ntia/publications/firstnet_fnn_presentation_09-25-2012_final.pdf

successfully "leverage the significant investments and combined efforts of the public sector and the commercial wireless industry to achieve the major elements of the nationwide wireless network … , including ubiquitous coverage, reliable, redundant, and interoperable service, at reduced costs and with accelerated availability."[2] Qualcomm's wireless technologies can help achieve this goal, and for this reason, Qualcomm is interested in seeing detailed requirements for FirstNet devices, along with FirstNet's timetable.

Qualcomm, through its Qualcomm Mobile & Computing division, is the world's largest manufacturer of chipsets for wireless devices, including smartphones, tablets, and other devices that can provide ubiquitous high speed wireless connectivity for first responders over the FNN. All of Qualcomm's chipsets are multi-mode (meaning that the chipsets that support 4G also support 3G and 2G technologies) and multi-band (meaning that the chipsets provide connectivity on multiple frequency bands, such as cellular, PCS, AWS-1, etc., subject to a numerical limit based on the physical limitation of the RF chip used with the chipset).[3] This capability provides first responders equipped with Qualcomm-powered devices the widest possible interoperability and roaming, consistent with the approach laid out in the Conceptual Presentation.

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[2] *NOI,* 77 Fed. Reg. at 60681.

[3] Qualcomm chipsets consist of MSMs (Mobile Station Modems), MDMs (Mobile Data Modems), and APQs (Application Processors). Both MSMs and MDMs are designed to work seamlessly with a Qualcomm RF chip. Qualcomm RF chips, when built into devices in conjunction with other parts, enable the devices to send and receive on various frequency bands. A Qualcomm MSM includes an integrated Qualcomm modem, which supports various wireless technologies (such as LTE, CDMA2000, HSPA, UMTS, etc.), and an integrated Qualcomm applications processor, which includes a central processing unit (CPU). A Qualcomm MSM can enable voice and data connectivity. A Qualcomm MDM includes an integrated Qualcomm modem, but does not include a Qualcomm application processor. An MDM only supports data connectivity on its own. But a Qualcomm MDM can support voice as well if it is used in conjunction with a Qualcomm MSM. A Qualcomm APQ, which consists only of an application processor, must be used with an MSM or MDM to provide voice or data connectivity.

In particular, Qualcomm is working on adding LTE data connectivity on Band 14, the FirstNet spectrum, in addition to the many frequency bands that Qualcomm supports in its next-generation RF chip, the WTR1605L. To do so, Qualcomm will use an external GPS RF solution to limit interference within a device on GPS operation from the Band 14 harmonics.

It is highly challenging for Qualcomm and its many partners in the wireless industry to support all the various frequency bands on which 4G, 3G, or 2G service is, or will be, provided. Adding bands and band combinations in a rapid manner to keep up with burgeoning consumer demand and in a hyper-competitive atmosphere multiplies the challenges. Worldwide, LTE has already been standardized for deployment on at least 36 frequency bands.[4] Here in the U.S., LTE is or will be deployed on the following bands:

- 700 MHz 3GPP Bands (Bands 12, 13, 14, & 17)

- 850 MHz cellular band (Band 5);

- Original PCS band (Band 2);

- PCS Block G (Band 25);

- AWS-1 band (Band 4);

- Potential AWS-4 band (Band 23);

- Original 800 MHz iDEN band (Band 26); and

- BRS band (Band 41).

And, the above list does not include the new 600 MHz band that the FCC proposes to create as the result of its voluntary incentive auction of TV spectrum and other bands on the FCC's road map.

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[4]   *See* Radio-Electronics.com, LTE Frequency Bands & Spectrum Allocations, *available at* http://www.radio-electronics.com/info/cellulartelecomms/lte-long-term-evolution/lte-frequency-spectrum.php.

Qualcomm is working as hard as possible to meet these challenges and has made great progress. For example, Qualcomm's new WTR1605L RF chip, which can be used in conjunction with Qualcomm's most advanced multi-mode, multi-band chipsets, such as the MSM8960 and the MDM 9x15, can support a total of seven frequency bands—three below 1 GHz, three higher bands, and one very high band (such as 2.5 GHz). For this purpose, each 3GPP band is considered a separate band. As a result, the WTR1605L could, for example, support two 700 MHz bands and the cellular band.[5] Moreover, Qualcomm has developed satellite-based technology that can be included in the MSM8960 to reach remote areas that are unduly expensive to cover with terrestrial mobile broadband.[6]

Thus, Qualcomm is working on developing chips will advance the vision laid out in the Conceptual Presentation by providing support for Band 14 and for frequency bands used by commercial mobile networks and by at least one mobile satellite network. However, given the complexity of the tasks for Qualcomm and other equipment manufacturers, there are many important details and requirements that need to be specified for FirstNet and the devices to operate on its network, particularly given the limited number of bands that Qualcomm can support in its chips. Moreover, FirstNet's network and device timetables will be important to Qualcomm and other equipment vendors.

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[5]   In some cases, support for an additional frequency band can be enabled via so-called band stitching, which requires device manufacturers to add the necessary software provided by Qualcomm and to perform integration work.

[6]   *See* DISH Press Release, "DISH Invests in Broadband Satellite Chipsets for Mobile Devices," (June 11, 2012) ("Qualcomm to enable support of satellite-based communications in Qualcomm's Snapdragon S4 MSM8960 platform, … with an integrated multi-mode 3G/LTE modem, for use in future DISH wireless devices. The new satellite air interface technology developed by Qualcomm is a 3G-based standard referred to as Enhanced Geostationary Air Link") *available at* http://press.dishnetwork.com/press-releases/dish-invests-in-broadband-satellite-chipset-for-mo-nasdaq-dish-0897618.

For example, Qualcomm cannot provide support in one chipset for Band 14 and every

other frequency band used by every U.S. mobile network and every mobile satellite band. To

provide support for Band 14 plus some of the bands used by four US mobile networks is not

impossible in theory, but will depend upon the particular bands in question and a host of other

important implementation details and requirements. Moreover, since there are differing

implementations of voice-over-LTE among the operators, Qualcomm is limiting these

Comments to the provision of 4G/3G/2G data connectivity. Finally, Qualcomm has not

determined whether it can support special, ultra-high power devices, which some have proposed

for public safety; its Comments are limited to support of the same types of wireless devices,

smartphones, tablets, data dongles, etc., that are sold commercially. We note that the Conceptual

Presentation did not mention any special devices. Qualcomm looks forward to working with

FirstNet to ensure that FirstNet's requirements can be met on an appropriate timetable.

In addition, Qualcomm is working on technologies that, although not mentioned in the

Conceptual Presentation, may well be of interest to FirstNet. In the last 12 months, on a GAAP

basis, Qualcomm spent over $3.5 billion on wireless research and development. Qualcomm's

R&D teams are working on many technologies to increase the capacity and capability of wireless

networks to provide mobile broadband. One such technology will enable device-to-device or

peer-to-peer LTE-based communications. This technology is called LTE-Direct. It is one of the

enhancements being proposed in 3GPP by many companies for inclusion in LTE Release 12 and

includes use cases for both commercial and public-safety use. LTE-Direct provides secure, low-

latency, broadband connectivity among hundreds of users within the same geographic area

(discovery range of up to one kilometer); it allows users to discover one another and directly

communicate, as needed. Particularly in emergencies, LTE-Direct could potentially allow public

safety personnel to discover and communicate with one another on an interoperable basis and even if there is no cellular infrastructure at the location of the emergency.

Qualcomm also is working on enabling hetereogenous networks (also known as hetnets). Hetnets will use a dense network topology, comprised of macro cells and small cells seamlessly working together to support exponentially increasing mobile broadband network data demands. In addition, hetnets will rely on adaptive interference management and advanced interference cancellation techniques to provide increased capacity.

DISCUSSION

I. Qualcomm Is Actively Developing A Broad Range Of Wireless Technologies That Can Be Used In Support Of The FirstNet Nationwide Network

Qualcomm is a world leader in developing innovative wireless technologies, including Code Division Multiple Access ("CDMA") -based and Orthogonal Frequency Division Multiple Access ("OFDMA") -based cellular technologies, which are used throughout the world for voice and broadband communications and countless mobile products and services. Qualcomm's semiconductor business, QMC, is the world's largest provider of wireless chipset technology that is used in mobile phones, tablets, and other consumer electronics devices. QMC's multi-mode, multi-band chipsets support the full gamut of standardized, globally harmonized 2G, 3G and 4G wide area mobile broadband and cellular technologies, Bluetooth, Wi-Fi, and all of the leading operating systems. QMC's highly integrated chips, and the technologies they support, will enable next generation public safety communications and advance the critically important work performed by America's fire, police, emergency medical, and other critical public safety personnel.

A. Qualcomm's Multi-Mode, Multi-Band Chipsets Support Many Frequency Bands & Technologies

As explained above, because Qualcomm's chipsets are multi-mode and multi-band, all chipsets that support 4G also support 3G and 2G technologies. As the Conceptual Presentation appears to recognize, it will take years for the nationwide LTE-based FNN to achieve the coverage of today's 3G and 2G commercial mobile networks. To ensure the widest coverage for public safety personnel as quickly as possible and in a cost effective manner, Qualcomm agrees with FirstNet that public safety devices should be multi-mode and, therefore, support 4G/3G/2G technologies to enable roaming on the existing commercial networks, thereby taking advantage of the billions of dollars in investment already spent by commercial carriers to achieve near-universal coverage.[7]

For the same reason, Qualcomm agrees with the vision of the Conceptual Presentation that FirstNet's devices must work on multiple frequency bands in order to enable roaming on commercial mobile networks. As Qualcomm explained earlier this year, its next-generation RF chip, the WTR1605L, supports more ports than Qualcomm's prior model RF chip, the RTR8600.[8] The new WTR1605L RF chip, which can be used in conjunction with Qualcomm's most advanced multi-mode, multi-band chipsets, such as the MSM8960 and the MDM9x15, can support a total of seven frequency bands — three below 1 GHz, three higher bands, and one very high band (such as 2.5 GHz). For this purpose, each 3GPP band is considered a separate band —

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[7]   *See* Conceptual Presentation at 10-12.

[8]   *See* Comments of Qualcomm Incorporated, Promoting Interoperability in the 700 MHz Commercial Spectrum, WT Docket No. 12-69 (June 1, 2012) at 61.

so, for example, the WTR1605L can support two 700 MHz bands and the cellular band.[9]

Qualcomm is working on adding LTE data connectivity for Band 14 to the many frequency

bands that Qualcomm supports.

Another aspect of Qualcomm's technology work that is consistent with the Conceptual

Presentation concerns the use of a mobile satellite network to potentially augment FirstNet's

network coverage. Qualcomm has developed a satellite-based technology that can be included in

a wireless smartphone chipset, the MSM8960, which also supports terrestrial broadband in order

to reach remote areas that are unduly expensive to cover with terrestrial mobile broadband.[10]

Hybrid satellite-terrestrial user devices incorporating these chipsets can be used to fill coverage

holes in terrestrial mobile broadband networks and support ubiquitous high speed wireless

broadband coverage. Once again, the Conceptual Presentation did not spell out any requirements

for this capability, and Qualcomm looks forward to working with FirstNet as those requirements

are developed.

B.   **LTE-Direct Technology Can Enable Public Safety Personnel To Establish Direct Peer-to-Peer Connections On An As-Needed Basis**

LTE-Direct technology, which is one of the enhancements that Qualcomm and other

companies are proposing in 3GPP for LTE Release 12, can be extremely useful for public

safety.[11] This spectrally-efficient technology allows thousands of wireless devices within a

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[9]   In some cases, support for an additional frequency band can be enabled via so-called band stitching, which requires device manufacturers to add the necessary software provided by Qualcomm and to perform integration work.

[10]   *See* DISH Press Release, n.6, *supra*.

[11]   Qualcomm is seeking to incorporate many of the capabilities underlying its FlashLinq technology, which has been in development for many years, into the LTE-Direct standard. *See Qualcomm to Demonstrate New Peer-to-Peer Technology at Mobile World Congress* (Feb. 8,

several block radius to discover one another automatically. They can then communicate either

directly at broadband speeds or via direct peer-to-peer ("P2P") and device-to-device ("D2D")

communications.[12]

One of the key value propositions of LTE-Direct is introducing low power, autonomous

discovery not only of devices within proximity of each other, but also of the applications and

services running on those devices. Upon discovery, direct communication would represent an

optimization of the current alternatives for sending and receiving data/media within the current

3GPP framework.[13] This discovery tool will enable countless innovative services and

applications within the overall LTE eco-system. It not only offers interesting commercial

opportunities, but it also introduces a number of practical possibilities for public safety services

and applications.

By mitigating current limitations of scalability, high power consumption, and resource

utilization, LTE-Direct technology adds new levels of utility for proximity based applications.

In this context, LTE-Direct, which is expected to be standardized in 3GPP for worldwide

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2011) *available at* http://www.qualcomm.com/news/releases/2011/02/08/qualcomm-demonstrate-new-peer-peer-technology-mobile-world-congress.

[12]   LTE-Direct creates a form of "Proximal Communications" using OFDMA, whereby nearby devices "discover" each other, "estimate" their mutual link quality/path loss as a function of this discovery signal, "sense" their RF proximity and available interference-free communication channels, "infer" the quality of these channels based on their estimated path loss, "exchange" their RF proximity information and communication capabilities (*e.g*., 3G/4G WAN connectivity, Wi-Fi variants, Bluetooth), "negotiate and agree" on the best means to communicate within that proximity, and subsequently "communicate" on those terms, on a P2P/D2D basis, without burdening the cellular networks.

[13]   3GPP SA WG1, a specification group within 3GPP, has already worked on the Feasibility Study for Proximity Services (ProSe) in Release 11, studying use cases and identifying potential requirements for an operator network-controlled discovery and communications between proximal devices. Use cases include public safety, commercial/social use, and network offloading. The requirements for Proximity Services are being captured in 3GPP TR 22.803.

implementation, can become the platform of choice to enable proximity-based discovery and communication between devices, and promote a vast array of future and more advanced proximity-based applications, including public safety applications that can leverage the economies of scale from the commercial deployments.

C. **Qualcomm Is Working To Enhance Mobile Broadband Performance Via Small Cell Deployments And Other Network Topology Enhancements**

In conjunction with its wireless industry partners, Qualcomm also is developing a new, denser network topology that would rely upon heterogeneous networks or hetnets, comprised potentially of macro cells working in conjunction with small cells, all operating within the same coverage area but in a highly optimized manner to achieve greater capacity. Small cells may be deployed in an operator's external plant or within an end-user's premises and be connected to a DSL, fiber, or cable broadband connection. Hetnets comprised of macro cells and small cells achieve enhanced coverage, greater spatial reuse, and increased cellular network capacity by enabling cells of different sizes to operate in concert with one another.

These next generation networks use adaptive interference management and interference cancellation in the user equipment to achieve a substantial increase in network capacity as opposed to a network consisting just of macrocells. Indeed, this design could act as a layer of network redundancy in areas of high risk to further "harden" the FirstNet network. Interference management techniques can optimize these arrangements to achieve the greatest possible coverage and capacity and control interference within a network or adjacent frequency blocks.

D. **Qualcomm Has Provided Public Safety With Innovative Wireless Technologies And Emergency Communications Tools For Decades**

Qualcomm has been serving public safety needs since its founding more than 27 years ago. Qualcomm's Government Technologies division ("QGOV") has been at the forefront of

advising government agencies and developing wireless communication solutions for public safety personnel, pioneering efforts in cellular standards, microelectronics design, mobile broadband data, encryption, and value-added end-user applications for wireless phones. QGOV works with government personnel to help them use wireless technologies to meet their specialized needs. Through leveraging the company's wireless expertise, innovative technologies, and industry reach, Qualcomm offers product engineering and advisory services to meet government needs.

CONCLUSION

Qualcomm is eager to work with FirstNet and other industry participants as the plans for FirstNet are developed further over the coming months to ensure that a fully interoperable and robust 700 MHz public safety wireless broadband network is timely and successfully deployed, consistent with the high-level Conceptual Presentation. Qualcomm's intensive R&D efforts are in line with the Conceptual Presentation, and our company looks forward to closely working with all stakeholders on this effort.

Respectfully submitted,

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