GLOBALSTAR LICENSE MODIFICATION APPLICATION

PUBLIC INTEREST STATEMENT

I. Introduction

Globalstar Licensee LLC, GUSA Licensee LLC, and GCL Licensee LLC (collectively, "Globalstar") are filing companion applications with the International Bureau for minor modification of their licenses, in order to implement Globalstar's planned terrestrial wireless broadband operations.[1] Globalstar's terrestrial systems will use its licensed Big LEO Mobile Satellite Service ("MSS") spectrum at 2483.5-2495 MHz.

Globalstar Licensee LLC is requesting a minor modification of Globalstar's first-generation satellite constellation license (call sign S2115). GUSA Licensee LLC is requesting a minor modification of its licenses for Globalstar's earth station gateways located in the continental United States and Alaska and its blanket license for the operation of Globalstar mobile earth station terminals in the United States (call sign E970381). Finally, GCL Licensee LLC is requesting a minor modification of its licenses for Globalstar's earth station gateway located in Puerto Rico.

Globalstar's terrestrial systems will operate pursuant to the new rules the Federal Communications Commission ("Commission") adopted in its December 23, 2016 Report and Order (the "*R&O*").[2] With the requested license modifications, Globalstar will use 11.5 megahertz of its licensed spectrum for terrestrial broadband services that include a variety of voice, data, and text applications.

II. Globalstar's Satellite Business

Globalstar is a leading provider of global mobile satellite voice and data services. Globalstar is licensed for uplink transmissions (mobile earth stations to satellites) in the Lower Big LEO band at 1610-1618.725 MHz, and for downlink transmissions (satellites to mobile earth

---

[1] Globalstar Licensee LLC is the authorized licensee of the first-generation Globalstar satellite constellation (call sign S2115). GUSA Licensee LLC holds licenses for Globalstar's earth station gateways located in the continental United States and Alaska and a blanket license for the operation of Globalstar mobile earth station terminals in the United States, and is responsible for the provision of Globalstar mobile satellite services to end users in the United States. GCL Licensee LLC holds licenses for Globalstar's earth station gateway located in Puerto Rico.

[2] *Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Report and Order, 31 FCC Rcd 13801 (2016) (FCC 16-181) ("*R&O*"). *See also Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Notice of Proposed Rulemaking, 28 FCC Rcd 15351 (2013).

stations) in the Upper Big LEO band at 2483.5-2500 MHz.[3] Having invested over $5 billion to develop its global non-geostationary ("NGSO") MSS network, Globalstar uses its constellation of satellites and 24 ground stations on six continents to provide affordable, high-quality MSS to approximately 700,000 customers in over 120 countries around the world.[4]

Since initiating commercial MSS in 2000, Globalstar has been dedicated to providing state-of-the-art, mission-critical, and safety-of-life services to consumers, businesses, and governmental and public safety users in remote, unserved, and underserved areas not reached by terrestrial deployments, both in the United States and globally. In addition to individual consumers, Globalstar's customers include entities in government, the military, emergency preparedness, transportation, heavy construction, oil and gas, mining, forestry, and commercial fishing. Globalstar's MSS network provides critical back-up capabilities for public safety personnel during disasters when terrestrial facilities can be rendered unavailable, and public safety entities involved in relief efforts around the world have relied on Globalstar's satellite services after earthquakes, hurricanes, and other disasters. Globalstar's products are used daily for life-saving services, with its SPOT product line having resulted in over 5,000 rescues to date (currently averaging approximately two rescues per day).

In 2013, Globalstar completed the launch of a $1 billion second-generation satellite constellation, and it continues to invest in ground infrastructure upgrades and an expanded line of enterprise, consumer, and government products.[5] Globalstar will soon roll out its next-generation SPOT device providing "two-way" messaging capabilities in addition to its tracking and life-saving functions. Other new or upcoming Globalstar products include the next generation of Globalstar's "Sat-Fi" offering. Sat-Fi is a revolutionary voice and data technology that permits any Wi-Fi enabled device (*i.e.*, smartphones, tablets, laptops, etc.) to communicate over Globalstar's second-generation MSS constellation. Overall, utilizing its second-generation

---

[3] *Application of Loral/Qualcomm Partnership, L.P. for Authority to Construct, Launch, and Operate Globalstar, a Low Earth Orbit Satellite System, to Provide Mobile Satellite Services in the 1610-1626.5 MHz/2483.5-2500 MHz Bands*, Order and Authorization, 10 FCC Rcd 2333 (1995); *see also Spectrum and Service Rules for Ancillary Terrestrial Components in the 1.6/2.4 GHz Big LEO Bands; Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands*, Second Order on Reconsideration, Second Report and Order, and Notice of Proposed Rulemaking, 22 FCC Rcd 19733, ¶¶ 8, 18-20 (2007).

[4] Iridium is authorized to share spectrum with Globalstar at 1617.775-1618.725 MHz.

[5] Globalstar launched its second-generation Big LEO satellites in a series of launches from October 2010 to February 2013, and all 24 of these satellites are now in service. In March 2011, the Commission authorized Globalstar's U.S. gateway earth station facilities and mobile earth terminals to communicate with its second-generation Big LEO satellites. *Globalstar Licensee LLC; Application for Modification of Non-geostationary Mobile Satellite Service Space Station License; GUSA Licensee LLC; Applications for Modification of Mobile Satellite Service Earth Station Licenses; GCL Licensee LLC; Applications for Modification of Mobile Satellite Service Earth Station Licenses*, Order, 26 FCC Rcd 3948 (2011) ("*March 2011 Modification Order*").

constellation and ground facilities, Globalstar continues to provide the highest voice quality, fastest truly mobile data speeds, and most affordable service in the MSS industry.[6]

III. Globalstar's Planned Terrestrial Operations in the 2483.5-2495 MHz Band

On December 23, 2016, the Commission adopted new ancillary terrestrial component ("ATC") rules that will enable Globalstar to use its licensed MSS spectrum at 2483.5-2495 MHz to provide terrestrial wireless service throughout the United States.[7] The *R&O* required Globalstar to file an application to modify its Part 25 license before beginning any terrestrial operations.[8] As the *R&O* indicated, Globalstar's license modification application must include specific information and certifications describing its planned terrestrial operations, including certifications that its terrestrial facilities will comply with applicable technical restrictions.[9]

Globalstar plans to deploy a small-cell network architecture in this band that will support a Time Division LTE (TD-LTE)-based service. Operating in Time Division Duplex mode, Globalstar's TD-LTE small cells and end user devices will transmit on the same channel within the 2483.5-2495 MHz band, thereby eliminating the need for paired spectrum for its service. As described in the attached technical exhibit from Roberson and Associates LLC, *Technical Appendix to the License Modification Application for Use of LTE Technology for Terrestrial Communications in 2483.5-2495 MHz Band*,[10] small-cell networks have many different use cases and deployment models, and there are a wide range of potential applications and deployments for small-cell operations in Globalstar's licensed spectrum at 2483.5-2495 MHz. Globalstar expects that its small-cell facilities will provide mobile and portable broadband services, including voice, data, and text applications, to consumers, residences, commercial and industrial enterprises,[11]

---

[6] As certified *infra* at 10-11, Globalstar meets the Commission's requirement that it demonstrate that its MSS offerings are commercially available in the United States. *See* 47 C.F.R. § 25.149(b)(3).

[7] *See R&O*. Except for information collection requirements that must be approved by the Office of Management and Budget, the rules adopted in the *R&O* became effective on March 2, 2017. Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks, 82 Fed. Reg. 8814 (Jan. 31, 2017).

[8] In addition, we note that consistent with the ATC licensing process, Globalstar's application for a license modification will be evaluated, including details regarding the Network Operating System, prior to any authorization of the system in order to ensure compliance with these requirements.

[9] *R&O* ¶ 21.

[10] *Technical Appendix to the License Modification Application for Use of LTE Technology for Terrestrial Communications in 2483.5-2495 MHz Band*, Nat Natarajan, Michael Needham, and Kenneth Zdunek, Roberson and Associates, LLC (Apr. 10, 2017) ("Roberson Technical Exhibit"), appended hereto as Attachment A.

[11] Enterprise deployments will be indoors in offices, hospitals, malls, and other locations, providing a reliable and robust increased capacity, as well as outdoors in such areas as campus centers, stadiums, and shopping areas. *See* Roberson Technical Exhibit § 5.

public utilities, and government and public safety agencies.[12] This high-density network will operate in a variety of environments across the United States to provide consumers and other customers with high data rates and additional terrestrial broadband capacity, helping to satisfy the public's increasing demand for wireless and mobile broadband.[13] Globalstar's TD-LTE facilities will deliver these services to the same type of end-user equipment commonly used today in macro-cellular mobile networks, including smartphones, tablets, wireless-equipped laptops, and other available consumer devices. Globalstar also anticipates that its TD-LTE service will be heavily utilized for Internet of Things ("IoT") applications, including a wide diversity of Machine to Machine ("M2M") and general telematics systems.

The Roberson Technical Exhibit provides substantial detail on Globalstar's anticipated LTE small-cell network, including the radio access network and packet core architecture, as well as deployment alternatives for these small-cell facilities.[14] As the Roberson Technical Exhibit describes, the 3rd Generation Partnership Project ("3GPP") specifications for LTE radio access networks enable the deployment of a mix of micro-, pico-, and femto-cell systems. Globalstar will rely on a mix of these facilities to cover targeted areas and meet customers' capacity and service quality needs.[15] Globalstar will deploy its small-cell facilities at indoor locations such as buildings, residences, shopping malls, airports, and convention centers, as well as outdoors on street fixtures such as lamp posts and traffic lights. In some instances, Globalstar may choose (based on a demonstrated market need and business case) to serve as a neutral host for other mobile network operators who would share the use of the Globalstar network.[16] The concept and industry standard for network sharing have been defined in 3GPP for 3G/4G LTE and beyond, and Globalstar should have the flexibility to design and implement such sharing methods.

Globalstar anticipates that its planned TD-LTE operations will have an impact on broadband far beyond that which would otherwise be expected from its 11.5 megahertz band segment at 2.4 GHz. Globalstar's terrestrial-use spectrum at 2483.5-2495 MHz will be the only commercial wireless band in the world whose terrestrial use is dedicated exclusively to small-cell facilities. A dense network of small cells provides unique network capabilities and benefits, as mobile operators and industry observers have increasingly recognized in recent years. Small-cell facilities enable greater frequency reuse and can support far greater capacity and much

---

12 Small-cell facilities can improve public safety by serving as an excellent solution for emergency and Mission Critical services, including voice, push-to-talk, and real-time video applications.

13 The Cisco Visual Networking Index currently projects a seven-fold increase in mobile data traffic demand from 2016-2021, creating a need for capacity that cannot be met solely with the addition of new spectrum allocations. *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016-2021*, Cisco Systems, Inc., Document ID: 1454457600805266, at 3, 5 (updated Mar. 28, 2017), http://www.cisco.com/c/en/us/solutions/collateral/ service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html.

14 Roberson Technical Exhibit §§ 3-3.7.3.

15 *Id.* § 3.2.

16 *Id.* § 3.6.

higher data rates than macro-cellular systems. Given the rarity of new low-band spectrum allocations and the physical issue of self-interference for low-band small cells, wireless carriers are more frequently turning to mid- and high-band small-cell deployments in order to cost-effectively boost network capacity and improve service quality in high-traffic urban and suburban areas.[17]

Recent industry reports have highlighted the potential public interest benefits of small-cell 5G operations in the United States and around the world. A report from Accenture Strategy projects that the deployment of small-cell networks in the United States will boost annual gross domestic product by $500 billion and create approximately 3 million new U.S. jobs.[18] Accenture Strategy finds that American cities and local economies will particularly benefit from "Smart City" wireless infrastructure. Smart City solutions for vehicle traffic and electrical grid management will reduce energy usage, traffic congestion, and fuel costs, producing $160 billion in benefits and savings.[19] The 5G Americas Small Cell Forum reports that small-cell architecture will support, and can accelerate, new commercial applications such as mobile shopping and context-aware marketing, and can play an important role in providing vital post-disaster communications for emergency response teams.[20] It also points to the contribution that small-cell technology will make toward bridging the Digital Divide, by providing a more affordable, flexible way to extend coverage to remote and rural areas and hard-to-reach urban areas throughout the country.[21]

For a number of reasons, Globalstar's small-cell operations at 2483.5-2495 MHz are especially likely to generate the extraordinary public interest benefits described above. Unlike small-cell facilities in other commercial wireless bands, Globalstar's small-cell infrastructure will not have to share spectrum terrestrially with macro-cellular facilities in the same band.

---

[17] Small-cell capacity and data speed advantages are particularly pronounced in bandwidth-constrained urban areas, where buildings and environmental clutter allow robust cellular reuse over very short distances and across both horizontal and vertical dimensions.

[18] *Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities*, Accenture Strategy, at 1, 3 (2017), attached to Letter from Scott Bergmann, CTIA, to Marlene Dortch, Secretary, FCC, WT Docket No. 16-421 (Jan. 13, 2017) ("Accenture Strategy Report"). *See also The 5G Economy: How 5G Technology Will Contribute to the Global Economy*, IHS Economics & IHS Technology, at 4, 18-19 (Jan. 2017), https://www.qualcomm.com/media/documents/files/ihs-5g-economic-impact-study.pdf (projecting that the global 5G value chain will generate $3.5 trillion in output and support 22 million jobs in 2035).

[19] Accenture Strategy Report at 1-2, 7-9. As the Roberson Technical Exhibit describes, Globalstar's TD-LTE small cells could help create Smart Cities by promoting such capabilities as traffic monitoring, alarm detection, video camera operations, and weather and air quality monitoring. Roberson Technical Exhibit § 5.

[20] *Small Cell Siting: Regulatory and Deployment Considerations*, 5G Americas Small Cell Forum, Document 190.08.02, at 4, Table 2-1 (Dec. 2016), www.5gamericas.org/files/7714/8193/0832/SCF190_Small_cell_siting-final.pdf.

[21] *Id*.

Globalstar's terrestrial network will be comprised entirely of small-cell systems, and there will be no need in this spectrum to account for coexisting macro-cellular systems and associated self-interference limitations. In addition, the propagation characteristics of 2.4 GHz spectrum are particularly well-suited to the operation of densely deployed small-cell facilities. This spectrum supports true mobility, enabling the creation of continuous and interlocking coverage zones, while also providing the targeted coverage and signal confinement necessary for intensive frequency reuse.[22] Given these factors, Globalstar will be able to maximize frequency reuse and spectrum efficiency by deploying small-cell facilities at a higher density than seen in any other band. Broadband consumers and other customers will benefit from the additional capacity, higher data rates, and better quality of service provided by this spectrum.

Globalstar also expects to derive significant economies of scale as it deploys its small-cell TD-LTE network at 2.4 GHz. These economies should benefit the public by helping to lower the cost of consumer devices and services in this band. Globalstar will be able to rely on the existing, wide-ranging LTE infrastructure and device ecosystem,[23] and small-cell facilities should be able to utilize the same high-volume, low-cost LTE chipsets as used in ordinary end-user equipment.[24] In addition, Globalstar is authorized to provide MSS at 2483.5-2495 MHz around the world, and it intends to seek terrestrial authority for this spectrum in key international markets. Globalstar expects that TD-LTE equipment and end-user devices capable of operating at 2483.5-2495 MHz will ultimately be used by millions of customers in numerous countries, resulting in economies that reduce ecosystem costs and improve consumer welfare in the United States and globally.

Overall, Globalstar is well positioned to generate significant consumer and other public interest benefits associated with the emergence of small-cell technology. Globalstar's TD-LTE network will achieve a high level of spectrum efficiency, given the absence of co-channel macro-cellular operations in its band, the propagation characteristics at 2.4 GHz, and favorable economics for LTE equipment and end-user device development in this spectrum. With its dense deployment of femto and pico cells, Globalstar will help meet consumers' and enterprises' need for additional broadband capacity and higher data rates, while contributing to economic growth, innovation by utilities and other businesses, improved public safety, and a narrower Digital Divide.

---

[22] Globalstar's small-cell facilities at 2.4 GHz will in most cases deliver a higher quality signal to end users than macro-cellular systems. Compared to small cells, macro-cellular signals traverse longer distances and through greater environmental and structural clutter. Small cells are usually far closer to end users and, despite their lower power levels, typically achieve significantly higher signal-to-noise-and-interference ratios and throughput rates.

[23] There are a growing number of TD-LTE operator commitments, deployments, and trials worldwide. By April 2016, 76 TD-LTE networks were commercially launched in 43 countries, with 1.4 million base stations installed.

[24] Given that the LTE standard provides a "roadmap" for long-term development, Globalstar will also have a clear path to continual TD-LTE performance upgrades and service enhancements.

IV. Globalstar Compliance with Non-Interference and Network Operating System Obligations

Under the *R&O*, Globalstar's terrestrial service at 2483.5-2495 MHz will be subject to the same non-interference obligations that applied already to other terrestrial operations under the Commission's Part 25 rules. Globalstar is required to protect other licensed systems from harmful interference, and its terrestrial facilities would not be entitled to interference protection from other authorized operations.

By complying with applicable Commission rules limiting transmit power and out-of-band emissions, Globalstar will ensure that its terrestrial operations will not cause harmful interference to licensed services sharing the same frequencies or adjacent frequencies. In particular, as the Roberson Technical Exhibit describes in detail, Globalstar's network infrastructure as well as end-user devices at 2483.5-2495 MHz will meet the Commission's new out-of-band emissions requirements above 2495 MHz.[25] As a result, Globalstar's terrestrial operations at 2483.5-2495 MHz should not raise any interference issues for Sprint Corporation or other Broadband Radio Service ("BRS") licensees at 2496-2502 MHz or Educational Broadband Service ("EBS") licensees above 2502 MHz. As the Roberson Technical Exhibit further describes, Globalstar's terrestrial operations should also coexist successfully with Broadcast Auxiliary Service ("BAS") licensees in the 2.4 GHz and other bands, who have long shared this spectrum with Globalstar and other terrestrial providers.[26] As required by the Commission, Globalstar will coordinate its operations with BAS operations to avoid causing harmful interference to those grandfathered operations. As Globalstar certifies below, if Globalstar's terrestrial operations cause harmful interference to other licensed services, it will resolve any such interference as required by Section 25.255 of the Commission's rules.

In addition, under the Commission's rules, Globalstar must deploy a Network Operating System ("NOS") that is capable of controlling the operation of all small-cell facilities on its network, so that it can address any interference concerns through such steps as reducing power or terminating terrestrial operations at a given location.[27] Globalstar will comply with all aspects of the Commission NOS requirements, as certified below.[28] As described in the Roberson Technical Exhibit, to implement the NOS, Globalstar will leverage the relevant network

---

[25] Roberson Technical Exhibit §§ 4.3-4.3.3. Below at 10, Globalstar certifies that its terrestrial TD-LTE operations will meet the Commission's out-of-band emissions limit at the 2495 MHz band edge, as well as the out-of-band emissions requirement at 2483.5 MHz. *See* 47 C.F.R. §§ 25.149(c)(4)(v), (vi).

[26] Roberson Technical Exhibit § 4.3.4.

[27] *R&O* ¶¶ 39-42.

[28] Globalstar's NOS will be located at an operations center (or centers) and will have a point of contact available 24 hours a day, seven days a week with the technical capability to address and resolve interference issues. This contact information will be made publicly-available on the licensee's website. Through the NOS, Globalstar will also implement measures to control the availability of its network to user devices and prevent unauthorized use of the 2483.5-2495 MHz band.

management features capabilities defined in the 3GPP LTE standard.[29] Globalstar expects to manage its small-cell network using the standard system management solution of its vendor(s) of choice. In this architecture, the NOS will be used to control Globalstar's TD-LTE small cells in a manner similar to how traditional Commercial Mobile Radio Services ("CMRS") operators deploy and operate their micro-, pico- and femto-cellular network infrastructure. Globalstar will have complete and exclusive control over the configuration and location of each small cell and will be able to adjust power levels and other critical parameters to optimize performance and mitigate potential interference to other systems.[30] Globalstar's NOS will not only provide interference protection to other licensed services and systems, it will help to optimize Globalstar's network operations and ensure high-quality service to its terrestrial customers.

V. Conclusion

Globalstar urges the International Bureau to grant the requested license modifications as expeditiously as possible. Approval by the International Bureau will enable Globalstar to use 11.5 megahertz of its licensed spectrum for a variety of terrestrial broadband services that will benefit consumers and other customers throughout the United States.

---

[29] Roberson Technical Exhibit § 3.7.2.

[30] In addition to protecting BRS, EBS, and BAS operations, the operation of Globalstar's NOS will minimize interference to Globalstar's MSS offerings. For instance, in emergency situations, Globalstar will be able to dynamically give priority to mobile satellite service over its terrestrial operations.

COMPLIANCE WITH 47 C.F.R. PART 25 – REQUIRED CERTIFICATIONS

As required by the *R&O* and the Commission's rules, Globalstar provides the following certifications regarding compliance with Part 25 rules:

System Operations

47 C.F.R. § 25.149(a)(1). Under the Note to Paragraph (a)(1) adopted in the *R&O*, a 1.6/2.4 GHz band licensee is permitted to apply for terrestrial authorization on a non-forward-band mode of operation where the equipment deployed will meet the requirements of Section 25.149(c)(4). As indicated below, Globalstar's terrestrial transmitters will meet the Commission's Section 25.149(c)(4) requirements, and its proposed downlink duplex mode operations at 2483.5-2495 MHz (a non-forward-band mode of operations) are therefore permissible under Section 25.149(a)(1).

47 C.F.R. § 25.149(a)(2). Globalstar's terrestrial transmitters will transmit only in the 2483.5-2495 MHz band, as required under the rules adopted in the *R&O*. Because the only other currently authorized 1.6/2.4 GHz MSS system does not operate on these frequencies, no sharing or coordination with another MSS system is required.

47 C.F.R. § 25.149(a)(3). Globalstar's terrestrial operations will not exceed the geographic coverage area of Globalstar's mobile satellite system.

47 C.F.R. § 25.149(a)(4). Globalstar's terrestrial transmitters will comply with all applicable antenna and structural clearance requirements established in Part 17 of the Commission's Rules.

47 C.F.R. § 25.149(a)(5). Globalstar's terrestrial transmitters will comply with Part 1 of this chapter, Subpart I-Procedures Implementing the National Environmental Policy Act of 1969, including the guidelines for human exposure to radio frequency electromagnetic fields as defined in Sections 1.1307(b) and 1.1310 of the Commission's Rules.

47 C.F.R. § 25.149(a)(6). Globalstar's terrestrial transmitters are designed to operate on less than all available MSS frequencies. Under the *R&O*, Globalstar's terrestrial transmitters are permitted to operate at 2483.5-2495 MHz, while Globalstar's MSS satellite downlink operations are authorized at 2483.5-2500 MHz.

Consistency with International Agreements. As required by paragraph 240 of the Commission's 2003 *MSS Flexibility Order*, Globalstar's terrestrial operations will be consistent with all international agreements.[31]

---

[31] *Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L Band, and the 1.6/2.4 GHz Bands; Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands*, 18 FCC Rcd 1962 (2003) ("*MSS Flexibility Order*").

47 C.F.R. § 25.149(c)(4). Globalstar's terrestrial wireless equipment operating in the 2483.5-2495 MHz band will comply with the requirements contained in Section 25.149(c)(4) (including the resolution bandwidth provisions contained in subsection (c)(4)(vii), not shown below):

(i) The transmitted signal will be digitally modulated;

(ii) The 6 dB bandwidth will be at least 500 kHz;

(iii) The maximum transmit power will be no more than 1 W with a peak EIRP of no more than 6 dBW;

(iv) The maximum power spectral density conducted to the antenna will not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission;

(v) Emissions below 2483.5 MHz will be attenuated below the transmitter power (P) measured in watts by a factor of at least 40 + 10 log (P) dB at the channel edge at 2483.5 MHz, 43 + 10 log (P) dB at 5 MHz from the channel edge, and 55 + 10 log (P) dB at X MHz from the channel edge where X is the greater of 6 MHz or the actual emission bandwidth;

(vi) Emissions above 2495 MHz will be attenuated below the transmitter power (P) measured in watts by a factor of at least 43 + 10 log (P) dB on all frequencies between the channel edge at 2495 MHz and X MHz from this channel edge and 55 + 10 log (P) dB on all frequencies more than X MHz from this channel edge, where X is the greater of 6 MHz or the actual emission bandwidth.

47 C.F.R. § 25.254(a)-(d). Under the *R&O* and the Note to Section 25.149(c)(4) of the Commission's rules, terrestrial systems meeting the requirements set forth in Section 25.149(c)(4) are deemed to have also met the requirements of Section 25.254(a)-(d) of those rules. No further demonstration is needed for these systems with respect to Section 25.254(a)-(d).

47 C.F.R. § 25.255. Globalstar certifies that, if harmful interference is caused to other services by Globalstar's terrestrial operations, either from base stations or end user devices, Globalstar will resolve any such interference. If Globalstar claims to have resolved the interference and other operators claim that interference has not been resolved, then Globalstar may petition the Commission for a resolution of those interference claims.

Service Rule Requirements

47 C.F.R. §§ 25.149(b)(3), (g)(1). Under Section 25.149(g)(1), Globalstar is required to demonstrate the commercial availability of its MSS, without regard to coverage requirements. As indicated above, Globalstar has an operational MSS system and is a leading provider of global mobile satellite voice and data services. Globalstar currently uses its constellation of satellites and 24 ground stations on six continents to provide MSS to approximately 700,000 customers in over 120 countries around the world. Utilizing its second-generation constellation, Globalstar will continue to provide the highest voice quality, fastest truly mobile data speeds, and most affordable service in the MSS industry. Globalstar's satellite services are and will remain commercial available in the United States.

Equipment Certification

47 C.F.R. § 25.149(c)(1). Globalstar will obtain, market, and utilize only terrestrial transmitters and end user devices that have been demonstrated to comply with the requirements of Section 25.149(c)(4) and authorized by the Commission under its certification procedures in Section 2.803.

Network Operating System

47 C.F.R. § 25.149(g)(2). Globalstar's terrestial operations will utilize a Network Operating System ("NOS"), consisting of a network management system located at an operations center (or centers). The NOS will have the technical capability to address and resolve interference issues related to Globalstar's network operations by (a) reducing operational power; (b) adjusting operational frequencies; (c) shutting off operations; or (d) any other appropriate means. Globalstar's NOS will also have the ability to resolve interference from the terrestrial low-power network to the licensee's MSS operations and to authorize access points to the network, which in turn may authorize access to the network by end-user devices. The NOS operations center will have a point of contact in the United States available 24 hours a day, seven days a week, with a phone number and address made publicly-available by Globalstar.

47 C.F.R. § 25.149(g)(3). Globalstar's terrestrial base stations operating in the 2483.5-2495 MHz band will only operate when authorized by Globalstar's NOS, and all client devices operating in the 2483.5-2495 MHz band will only operate when under the control of such access points.

Declaration

I provide these certifications under penalty of perjury and declare that the engineering statements made in this License Modification Application are true and correct to the best of my knowledge.

/s/ Wen Doong
Wen Doong
Senior Vice President, Engineering & Operations

Dated: April 10, 2017

ATTACHMENT A

Roberson and Associates, LLC
Technology and Management Consultants®

Technical Appendix to the License Modification Application for Use of LTE Technology for Terrestrial Communications in 2483.5-2495 MHz Band

Nat Natarajan, Michael Needham, and Kenneth Zdunek

Roberson and Associates LLC

V1.0

April 10, 2017

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY 1
2 INTRODUCTION 1
2.1 RULES FOR TERRESTRIAL OPERATIONS IN GLOBALSTAR'S LICENSED SPECTRUM 1
2.2 PROPOSAL TO USE GLOBALSTAR TERRESTRIAL SPECTRUM TO DEPLOY LTE SMALL CELLS 1
3 TECHNOLOGY DESCRIPTION 1
3.1 LTE NETWORK ARCHITECTURE MODEL 2
3.1.1 RADIO ACCESS NETWORK (RAN) 2
3.1.2 EVOLVED PACKET CORE NETWORK (EPC) 3
3.1.3 USER EQUIPMENT (UE) 4
3.2 RATIONALE FOR LTE SMALL CELL DEPLOYMENT 5
3.2.1 SMALL CELL ENODEB 7
3.2.2 COMMON COMPONENTS AND INTERFACES 7
3.3 4G LTE SMALL CELL E-UTRAN DEPLOYMENT ARCHITECTURES 8
3.3.1 PASSIVE DISTRIBUTED ANTENNA SYSTEM (PASSIVE DAS) 9
3.3.2 ACTIVE DISTRIBUTED ANTENNA SYSTEM (ACTIVE DAS) 9
3.3.3 CLOUD RADIO ACCESS NETWORK (CRAN) 9
3.3.4 DISTRIBUTED VIRTUAL CLOUD-RAN 12
3.4 SMALL CELL TRANSPORT ARCHITECTURE 13
3.4.1 GLOBALSTAR MANAGED BACKHAUL TRANSPORT 13
3.4.2 3RD PARTY WAN FOR BACKHAUL TRANSPORT 14
3.5 KEY COMPONENTS FOR A DEPLOYABLE SOLUTION 14
3.5.1 OPERATING BAND / BANDWIDTH (2483.5 – 2495 MHZ) 14
3.5.2 LOCATION SELECTION 14
3.5.3 BACKHAUL / POWER 15
3.6 DEPLOYMENT OF SMALL CELL NETWORK AS A NEUTRAL HOST TO MULTIPLE NETWORK SERVICE PROVIDERS 15
3.7 NETWORK MANAGEMENT 17
3.7.1 MAIN OBJECTIVES 17
3.7.2 OPERATION, ADMINISTRATION, MAINTENANCE, PROVISIONING, PERFORMANCE (OAMPP) – MANAGED BY OSS/BSS SYSTEM 17
3.7.3 MANAGEMENT OF SHARED SPECTRUM BETWEEN TERRESTRIAL AND SATELLITE NETWORK 18
4 COMPLIANCE WITH FCC RULES ON TERRESTRIAL NETWORK EMISSIONS 20
4.1 ENODEB OPERATION 20
4.2 UE OPERATION 22
4.3 INTERFERENCE PROTECTION 23
4.3.1 PROTECTION OF OTHER SYSTEMS IN THE SAME OR ADJACENT BANDS FOR TERRESTRIAL NETWORKS 23
4.3.2 TERRESTRIAL NETWORK ENODEB INTERFERENCE CONSIDERATIONS 24
4.3.3 TERRESTRIAL NETWORK UE INTERFERENCE CONSIDERATIONS 27
4.3.4 TERRESTRIAL NETWORK – BAS INTERFERENCE CONSIDERATIONS 29
5 POTENTIAL APPLICATIONS OF TD-LTE SMALL CELLS 30
6 CONCLUSIONS 32

1 EXECUTIVE SUMMARY

In December 2016, the Federal Communications Commission (FCC or Commission) adopted rules to permit Globalstar, Inc. (Globalstar) to operate an Ancillary Terrestrial Component1 (ATC) in its licensed Mobile Satellite Service (MSS) spectrum at 2483.5-2495 MHz. Pursuant to these rules, Globalstar proposes to use its spectrum at 2483.5-2495 MHz for TD-LTE based small-cell terrestrial deployments throughout the United States. This document describes the general technical and operational characteristics of Globalstar's proposed small-cell deployments.

2 INTRODUCTION

2.1 Rules for Terrestrial Operations in Globalstar's Licensed Spectrum

In the *R&O*, the FCC modified its rules for terrestrial operations in Globalstar's licensed MSS spectrum at 2483.5-2495 MHz. The rule changes enable Globalstar to seek authorization from the Commission to deploy a terrestrial wireless broadband network in this spectrum and thereby expand terrestrial use of the band.

2.2 Proposal to Use Globalstar Terrestrial Spectrum to Deploy LTE Small Cells

Following a grant of the instant application, Globalstar plans to create a dedicated, high-density LTE small cell network in the United States at 2483.5-2495 MHz. This proposed network will benefit from the unique propagation characteristics and ecosystem economics associated with the 2.4 GHz band. This addendum provides technical detail on the following aspects of Globalstar's deployment plan: a) Description of the LTE small-cell network architecture including RF characteristics; b) Deployment alternatives for the LTE small cell network; c) Description of the use cases and applications of the small-cell network; and d) Provision for coexistence and interference protection between Globalstar's planned LTE system and its MSS network, as well as adjacent band and co-channel systems (BRS, BAS).

3 TECHNOLOGY DESCRIPTION

Globalstar plans to use a TD-LTE or related LTE radio access network and packet core architecture deployed in a small-cell configuration as a primary option for deployment in its terrestrial spectrum, for versions of the LTE specification up to and including Release 13.

---

[1] *Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Service Systems*, Report and Order, 31 FCC Rcd 13801 (2016) (*R&O*).

3.1 LTE Network Architecture Model

Long Term Evolution (LTE) is an evolution of the cellular network technology and was introduced in 3GPP Release 8.[2] LTE is implemented as an Evolved Packet System architecture (EPS) that consists of the Evolved Packet Core (EPC) and Evolved UMTS Terrestrial Radio Access Network (E-UTRAN). Figure 1 shows a conceptual view of an LTE network providing wireless access and services to a number of mobile user devices. The link labels indicate standardized interfaces between the network elements.

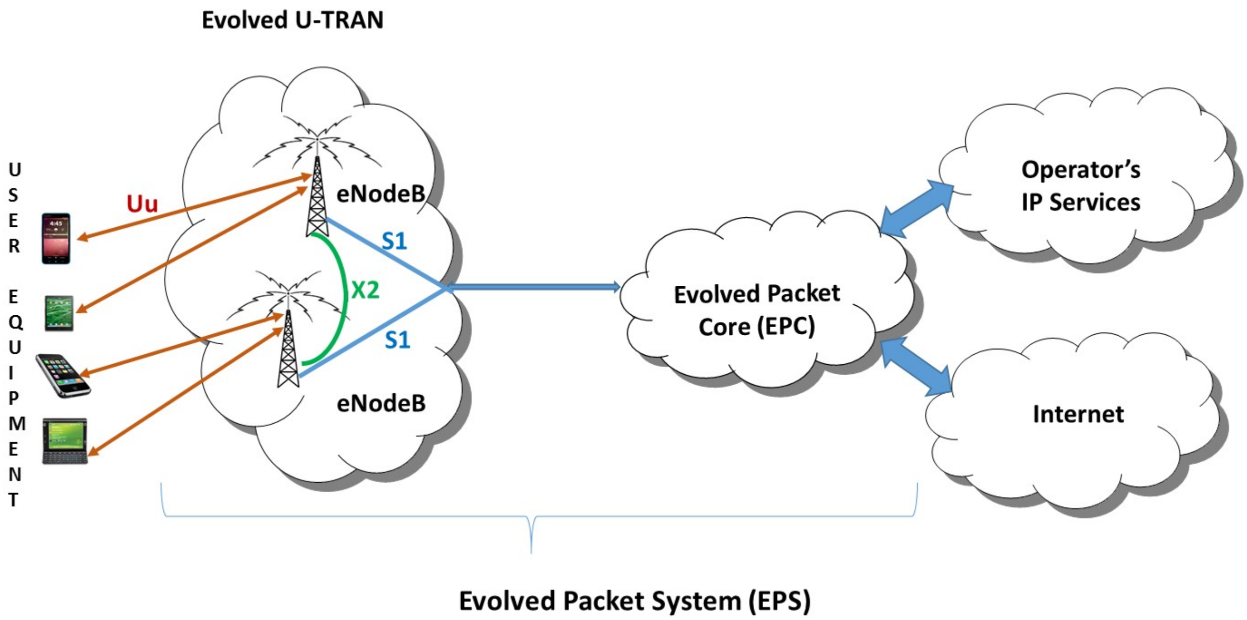

Figure 1: LTE Network Architecture

3.1.1 Radio Access Network (RAN)

LTE E-UTRAN (Evolved UTRAN) has an evolved Node B (eNodeB or base station) and an air interface based on Orthogonal Frequency Division Multiple Access (OFDMA) on the downlink and Single Carrier FDMA (SC-FDMA) on the uplink. The EPC provides a packet-switched data solution for carrying IP-based application traffic and includes mechanisms for providing Quality of Service and policy based services to end users.

The initial LTE standard (Release 8) defined a scalable OFDMA system supporting bandwidths of 1.4, 3, 5, 10, 15 and 20 MHz. Subsequent releases have enabled support for larger bandwidths on the uplink and downlink, multiple-antenna systems enabling use of a variety of diversity, MIMO, and beamforming methods, a number of Self-Organizing Network (SON) features to support efficient deployment and management of the network to maximize performance, mitigate interference, and adaptively optimize performance as the network evolves over time. LTE

[2] Sassan Ahmadi, *LTE-Advanced: A Practical Systems Approach to Understanding 3GPP LTE Releases 10 and 11 Radio Access Technologies*, ISBN: 9780124051621, Academic Press, (Oct. 2013).

standard has defined a Time Division Duplex mode of operation that will be utilized by Globalstar.

Subsequent to the initial LTE specification (Release 8), 3GPP has defined more advanced features and performance enhancements in Releases 9 through 14. These have been defined in the industry as LTE-Advanced (Release 10) and LTE Advanced Pro (Release 14). Current work is focused on the specification of 5G in two releases (Release 15 and Release 16). Globalstar intends to leverage the LTE features available in 3GPP Release 8 through 14 and beyond as applicable to effective small cell network implementation.

Release 9 introduced the definition of Home eNodeB for improved residential and in-building coverage using femtocells. Releases 12 and 13 provided support for enhanced machine-to-machine type communication.

LTE specifications support various forms of duplexing – Frequency Division Duplexing (Full Duplex), Frequency Division Duplexing (Half Duplex), and Time Division Duplexing. While FDD is based on separate carriers for downlink and uplink transmissions, TDD uses the same carrier for both downlink and uplink transmissions. The TDD approach is attractive for systems when there is high degree of asymmetry between traffic demands in uplink and downlink directions. TDD devices also benefit from not requiring a duplexer, thus helping reduce the cost of devices. Other LTE modes supporting downlink duty cycle up to 100% are also possible within the specifications.

3.1.2 Evolved Packet Core Network (EPC)

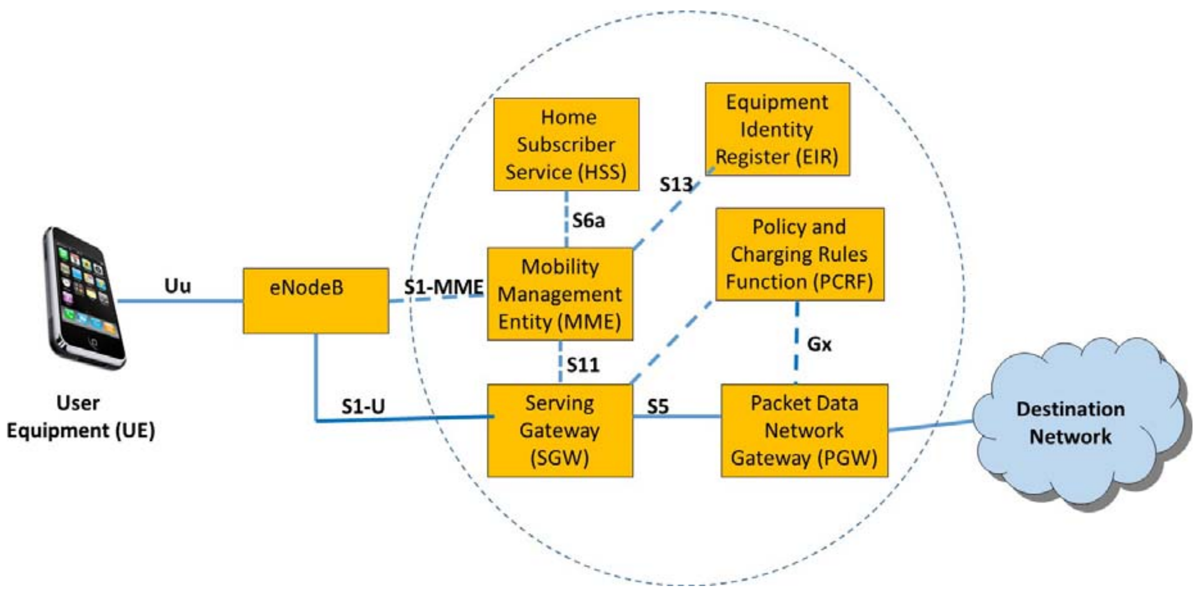

Figure 2: Key functions in an LTE Evolved Packet Core Network

The main functional entities in the Evolved Packet Core network are shown in the dotted circle in Figure 2.[3] These include the following:

- Mobility Management Entity (MME) – It is responsible for a variety of control plane signaling functions including providing continuity of service as devices move their network connection from one eNodeB to another.
- Serving Gateway (SGW) – Handles user plane data from/to eNodeB, signaling information exchange with MME for mobility and bearer management, and user and control plane data exchange with the Packet Data Gateway.
- Packet Data Network Gateway (PGW) – Provides connectivity to all IP services - both operator services as well as all external networks including the public internet.
- Home Subscriber Service (HSS) – Hosts a database consisting of subscription related information for the population of end users.
- Policy and Charging Rules Function (PCRF) – Provides Quality of Service and charging information to the PDN Gateway.
- Equipment Identity Register (EIR) – Contains the International Mobile Equipment Identities (IMEI) of the end user devices used within the network. User access to the network is controlled based on IMEI information.

The air-interface connection between the User Equipment and eNodeB is denoted as Uu. The interface between a pair of eNodeBs, denoted as X2, is used for transferring signaling and data between them. The interface between an eNodeB and the Evolved Packet Core (EPC), denoted as S1, is used for exchange of control plane signaling between eNodeB and MME as well as user plane (application data) exchange between eNodeB and the Serving Gateway (SGW). The interfaces S1 and X2 are logical specifications. In an actual implementation, the two interfaces may use a single physical connection at the eNodeB (e.g., Ethernet cable) to the IP-backhaul transport network.

3.1.3 User Equipment (UE)

3GPP has specified several categories of UE starting with an initial list of five categories in Release 8, and an additional three categories in Release 10. Table 1 highlights the main characteristics of device categories specified through Release 13.

---

[3] Magnus Olsson, Shabnam Sultana, Stefan Rommer, Lars Frid and Catherine Mulligan, *SAE and the Evolved Packet Core: Driving the Mobile Broadband Revolution*, ISBN: 9780123748263, Academic Press (2009).

UE Category	UE Transmit power (dBm)	Downlink MIMO	Modulation Scheme		Approximate Data Rates (Mbps)		UE Receive Bandwidth (MHz)	3GPP Release
			Uplink	Downlink	Uplink	Downlink		
1	23	Not applicable	QPSK, 16QAM	QPSK, 16QAM, 64QAM	5	10	20	R8
2	23	Up to (2x2) MIMO			25	50		R8
3	23				50	100		R8
4	23				50	150		R8
5	23	Up to (4x4) MIMO	QPSK, 16QAM, 64QAM		75	300		R8
6	23	Up to 2x2 or 4x4 DL MIMO	QPSK, 16QAM		50	300	Depends on Carrier Aggregation	R10
7	23				100	300		R10
8	23	Up to 8x8 DL MIMO	QPSK, 16QAM, 64QAM		1500	3000		R10
0	23	1						R12
Cat-M1	20	1			1	1	1.4	R13
Cat-M2	23	1			0.144	0.2	0.2	R13

Table 1: LTE UE Device Categories

The 3GPP specifications for a LTE RAN allow for deployment of a heterogeneous network consisting of macro-, micro-, pico- and femto- eNodeB, as well as relays and repeaters. Globalstar will utilize a small cell deployment model to achieve improved network quality, higher data rates and more system capacity. Small cell eNodeB products are significantly more compact compared to macro eNodeBs and have important SON features for facilitating deployment that include automatic configuration and optimization.

The output power range of the small-cell eNodeB's planned to be deployed by Globalstar will be limited to 4 Watts EIRP, and the eNodeB's will be controlled and managed by Globalstar's network management system.

3.2 Rationale for LTE Small Cell Deployment

Figure 3 shows a conventional macro eNodeB base station. Conventional cell sites, typically in macro-cellular networks, consist of radio equipment located at the base of the tower, transmitting RF signals via coaxial cables to antennas at the top of the tower. The coaxial cable based feeders are subject to inherent loss and interference. An LTE macro network design consisting of macro eNodeBs often has a primary objective of providing broad coverage, and secondary objective of providing capacity. In situations where there is a high density of users with demanding bandwidth requirements, a macro design may not have adequate capacity in some geographic areas. Small cells of the type proposed to be used by Globalstar provide a means for covering targeted areas in a focused manner so capacity needs are adequately satisfied. Small cell networks are designed and deployed for meeting the twin primary objectives of capacity and coverage requirements. Targeted small cells have the potential to leverage good signal quality and achieve higher peak rates for users and system cell capacity.

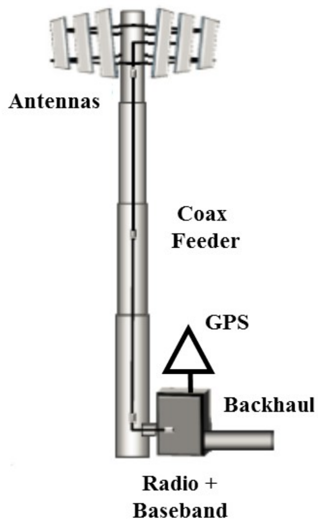

Figure 3: Components of a traditional Macro Cell eNodeB

3.2.1 Small Cell eNodeB

The small cell base stations to be deployed by Globalstar may include fully integrated hardware consisting of baseband, radio unit and antenna options into a single form factor base station as illustrated in Figure 4 below.

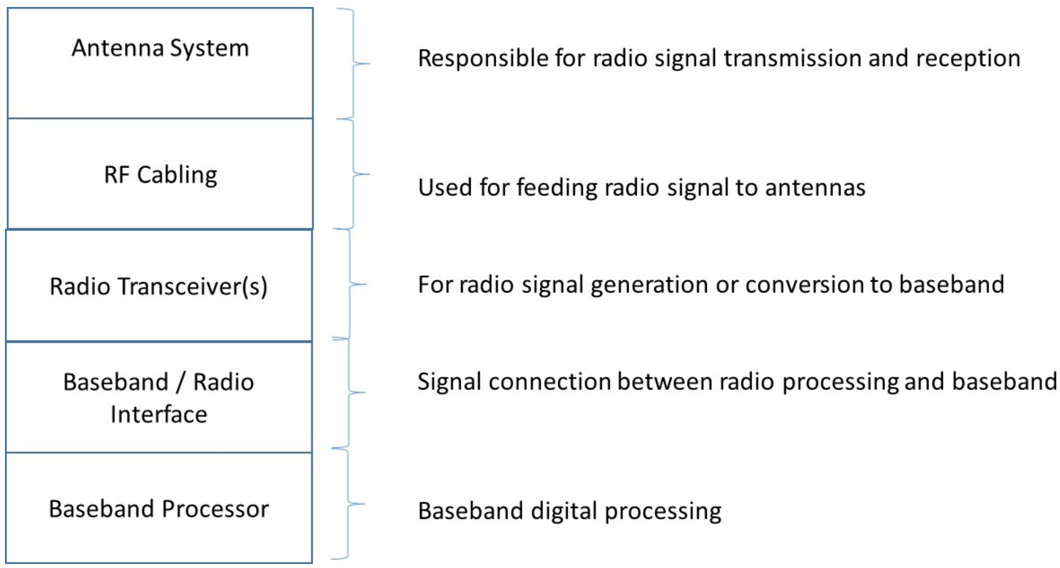

Figure 4: Basic Functions in a Small Cell eNodeB

3.2.2 Common Components and Interfaces

The components of a small cell eNodeB, essential to commercial products, include the following:

- An eNodeB baseband processor providing support of specific version of LTE, including features, performance and capacity
- An RF unit capable of operating at a specified LTE frequency band and bandwidth with requisite power
- Power Supply (AC, DC, backup)
- GPS Receiver/Synchronization – essential for multi-cell deployments – based on GPS, NTP, IEEE 1588

A small cell eNodeB typically includes the following connection interfaces:

- External antenna
- Ethernet interface (CAT5/CAT6) (including Power Over Ethernet)
- Power supply
- GPS/Timing
- Ground

- Test and diagnostics

There are numerous commercial vendors that offer small cell base stations, such as, Nokia, Ericsson,[4] Airspan, Juni, and others. Figure 5 below shows representative examples of small cell eNodeBs from different commercial vendors. They represent small cell eNodeBs that are used in femto, micro, and pico small cell environments.

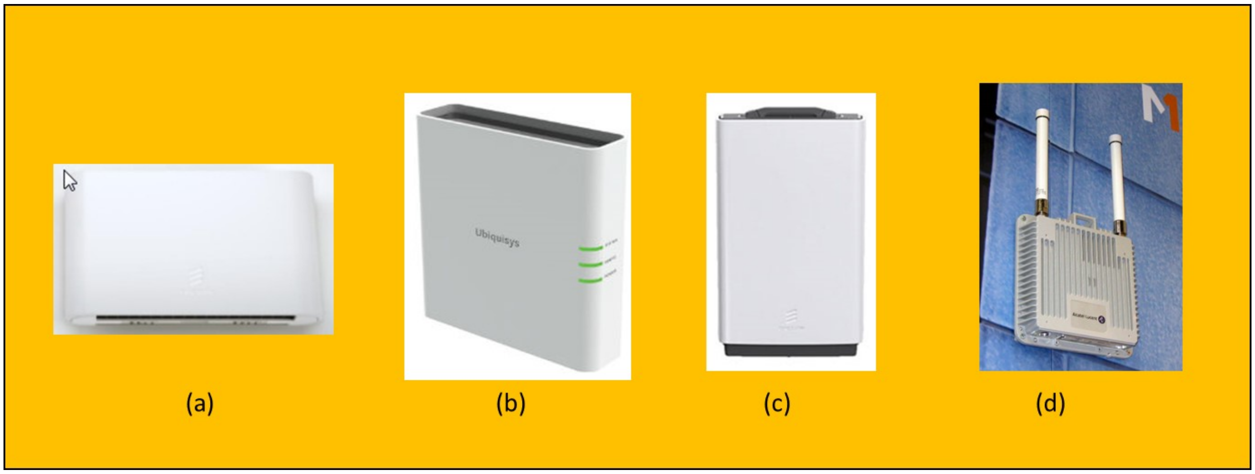

Figure 5: Example Small Cell eNodeB models from Commercial Vendors

3.3 4G LTE Small Cell E-UTRAN Deployment Architectures

This section describes the different small-cell deployment configurations and topologies that may be used by Globalstar, depending on coverage, capacity, and application requirements.

[4] *Ericsson Small Cells*, Ericsson, https://www.ericsson.com/ourportfolio/products/small-cells?nav=productcatagory (last visited Apr. 3, 2017).

3.3.1 Passive Distributed Antenna System (Passive DAS)

Passive DAS system designs are based on a radio system with centralized eNodeB baseband and radios and distributed passive antennas (Figure 6).

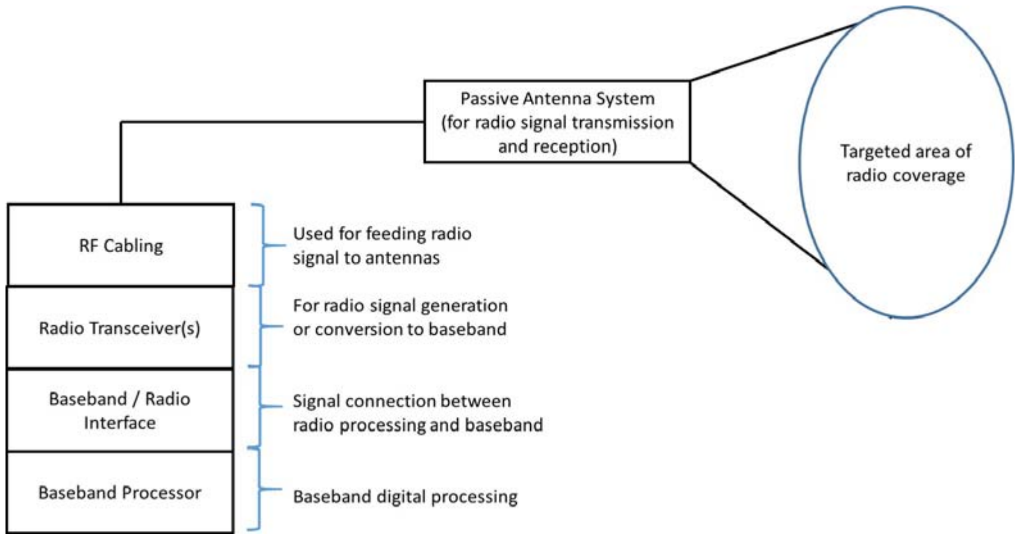

Figure 6: Basic Functions in a Passive DAS

3.3.2 Active Distributed Antenna System (Active DAS)

Active DAS system designs are based on a radio system with centralized eNodeB baseband processing and distributed LTE radios and antennas (Figure 7).

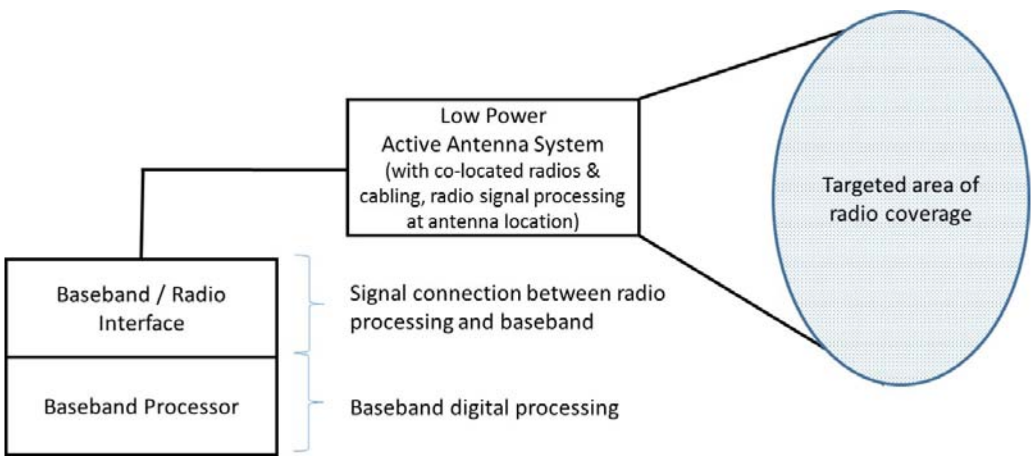

Figure 7: Basic Functions of an Active DAS

3.3.3 Cloud Radio Access Network (CRAN)

With increasing popularity of low power and smaller cell networks, modern base stations have adopted a distributed, decoupled architecture where the radio is partitioned into two major elements. The radio function unit, called the Remote Radio Head (RRH), is separated from the digital function unit, or baseband unit (BBU) by optical fiber. Digital baseband signals are carried over fiber, typically using Common Public Radio Interface (CPRI),[5] an industry standard specification for the internal interface of wireless base stations between the BBU and RRH. The RRH radio equipment performs RF functions on an analog domain and is installed next to the antennas at the top of the tower. This reduces significantly the signal losses compared to the traditional base station where the RF signal has to travel through a long coaxial cable from the base station cabinet to the antenna at the top of the tower. The fiber link between RRH and BBU allows greater flexibility in network planning and deployment. The two can be separated by a few tens of meters or a few kilometers away.

CPRI defines a serialized interface for different topologies such as chain, star and ring. These are illustrated in Figure 8.

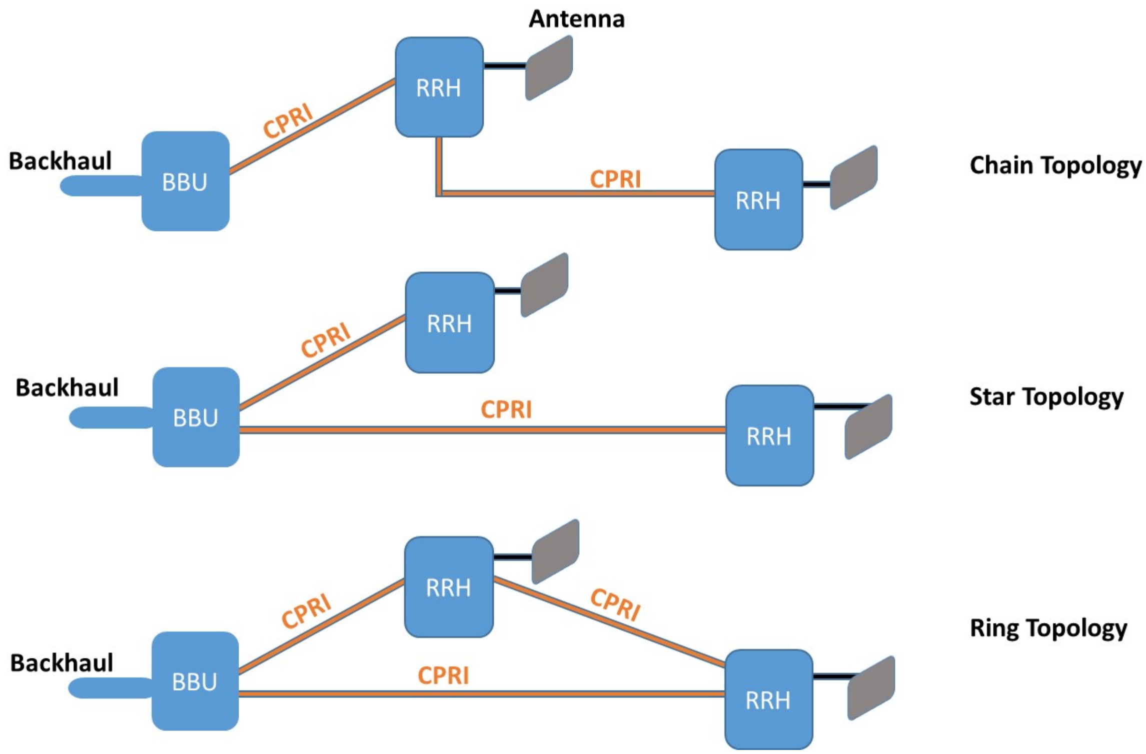

Figure 8: Alternative Topologies for Distributed Architecture

CRAN systems include radio designs with centralized eNodeB baseband serving a passive or active DAS. The antenna elements and the radios are distributed by locating them to provide coverage to targeted areas. The target coverage area could be outdoor, with a high density of users or indoor, in a high-density office, residential, or business environment located in a multi-story structure. With this approach, the centralized processing at the data center maximizes the utilization of RAN resources.

[5] *Specification*, Common Public Radio Interface, http://www.cpri.info/spec.html (last visited Apr. 3, 2017).

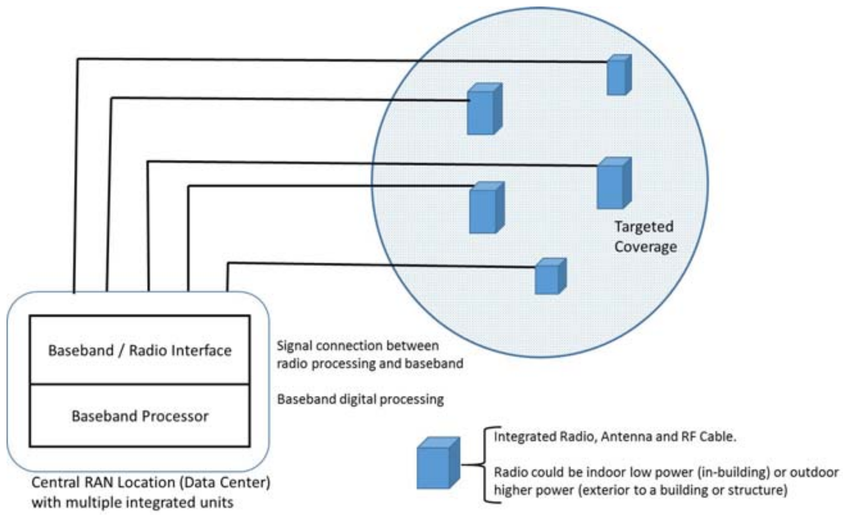

Figure 9: C-RAN (option 1)

Two variations or options are shown in Figures 9 and Figure 10. In Figure 9, the central location has multiple integrated units, each consisting of a combination of baseband processor and broadband/radio interface unit. In Figure 10, the central location provides a pool of resources (baseband processors as well broadband/radio interfaces) that are shared based on traffic dependent needs of the deployed small cells.

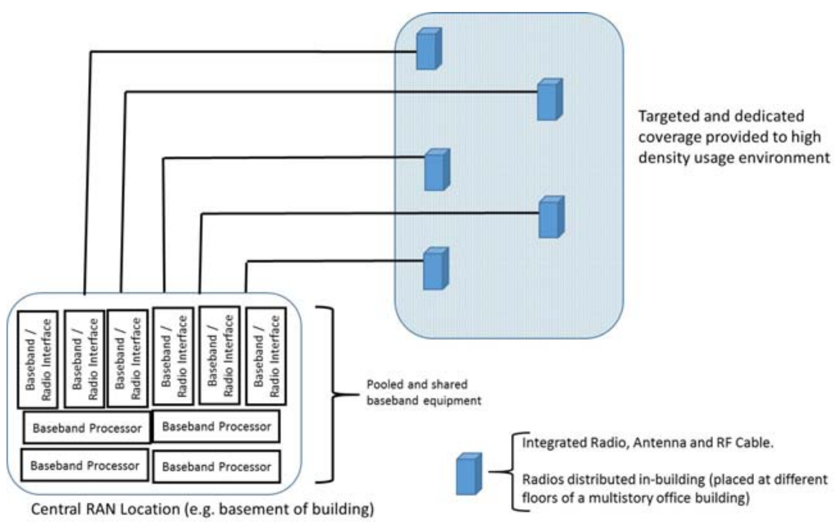

Figure 10: C-RAN (option 2)

3.3.4 Distributed Virtual Cloud-RAN

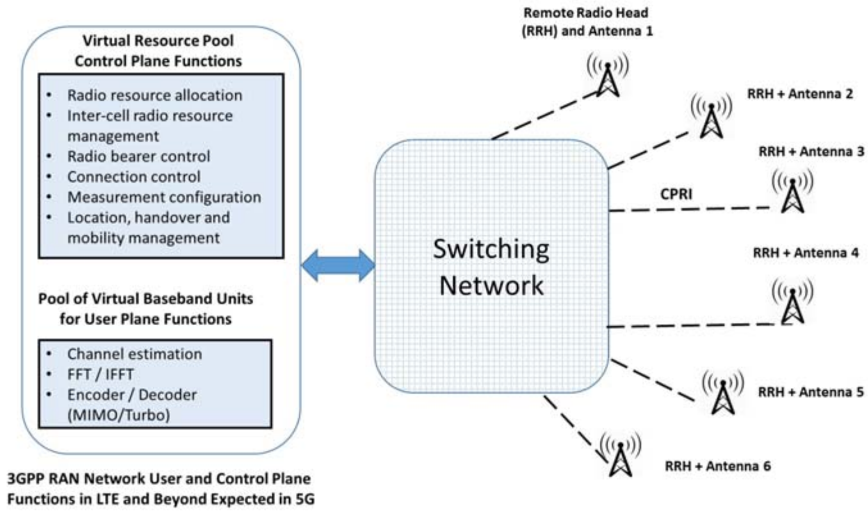

Figure 11: Virtual C-RAN[6]

The 3GPP LTE RAN functions can be classified as user plane and control plane functions (Figure 11). These functions are currently trending toward virtualized implementations in LTE, LTE-Advanced and 5G systems which are expected to include an increasing number of small cells. The Virtual C-RAN approach is attractive and likely to become pervasive in dense small cell deployments (Figure 12).

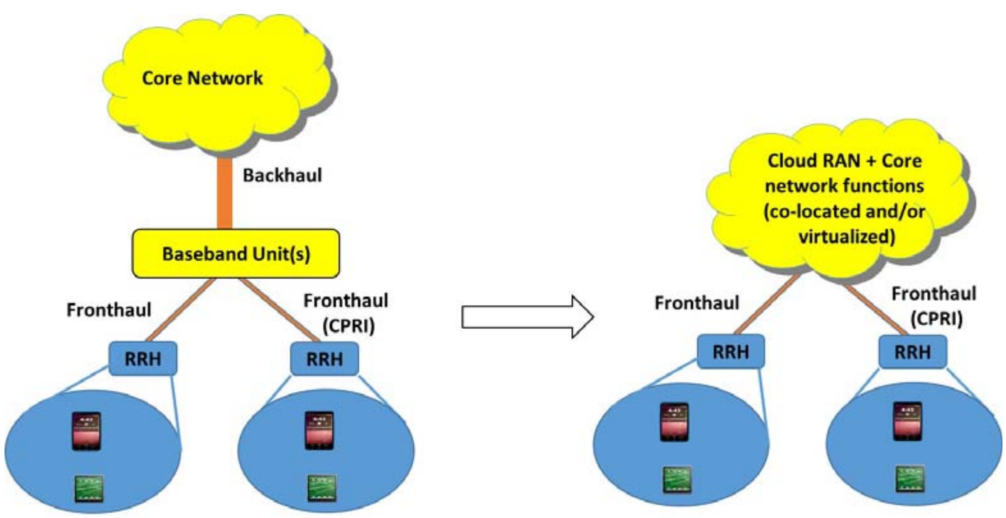

Figure 12: Virtual C-RAN with Network Function Virtualization of Core Functions

6 Sherif Abdelwahab, Bechir Hamdaoui, Mohsen Guizani and Taieb Znati, *Network Function Virtualization in 5G*, IEEE Communications Magazine (Apr. 2016), pp. 84-91.

3.4 Small Cell Transport Architecture

Small Cell eNodeBs will connect to the Evolved Packet Core network, with the MME and SGW being the entry points. There are at least two options for the transport network providing the connectivity. These are:

- Connectivity is managed by the service provider (Globalstar) who ensures the security of data transported over the Wide Area Network (Figure 13) between the eNodeB and the EPC entry points.
- Connectivity is provided by 3rd party network connecting the Small Cell eNodeB to the EPC network (Figure 14). This connection provides IP transport but is not under the direct management of the service provider (Globalstar). Secure transport of data between the eNodeB and the EPC network is ensured using secure IP tunnels (IPSec) between eNodeB and the Home eNodeB Gateway which serves as the entry point to the EPC network.

3.4.1 Globalstar Managed Backhaul Transport

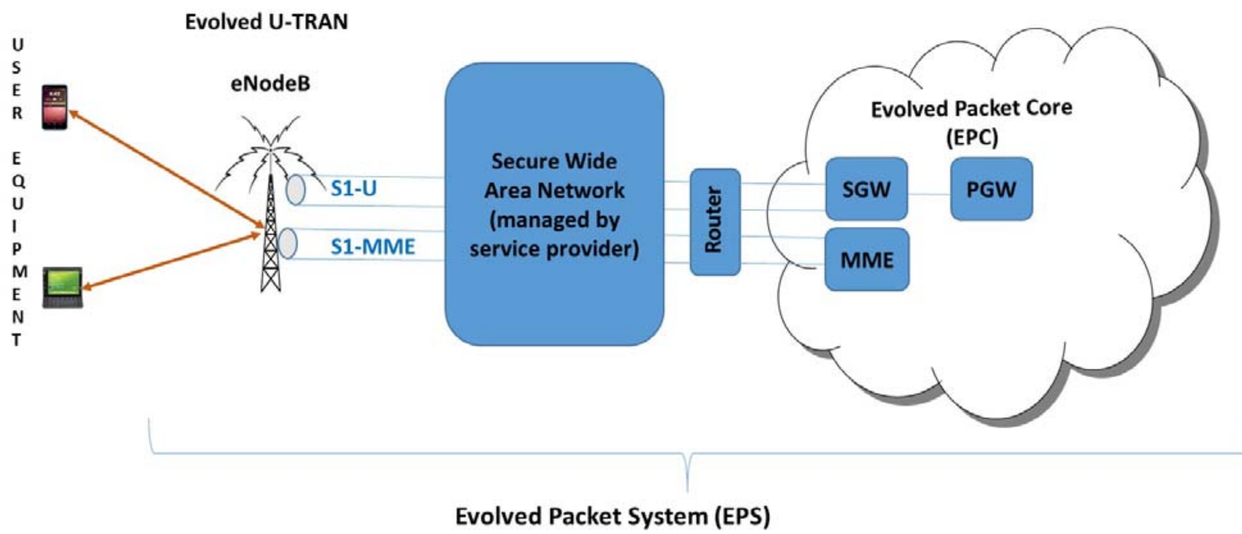

Figure 13: Secure Wide Area Network Provided by Service Provider

3.4.2 3rd party WAN for Backhaul Transport

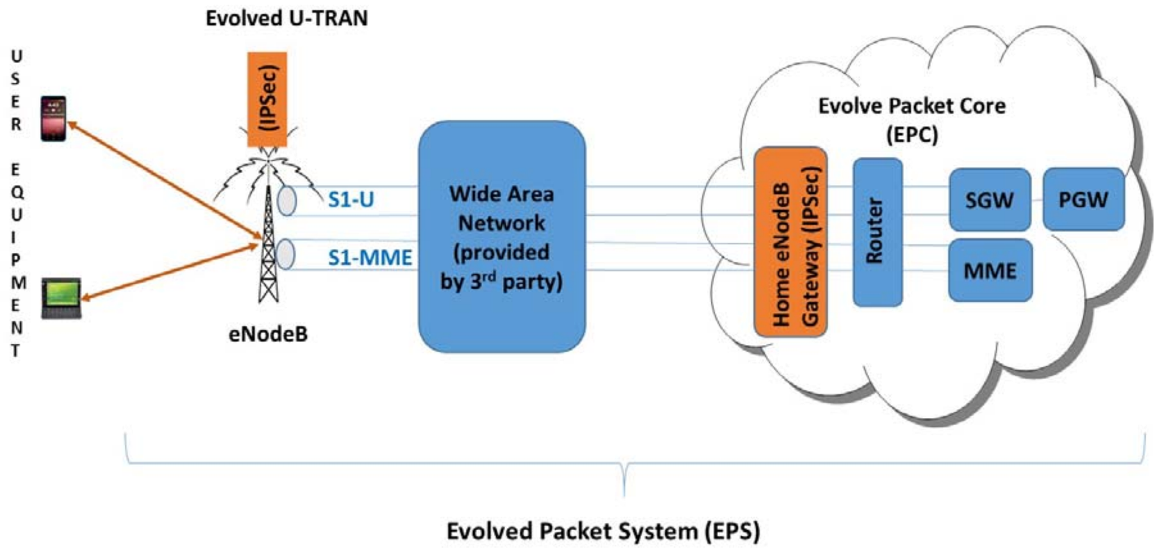

Figure 14: WAN provided by 3rd Party Secured by IPSec Tunnels

The secure connectivity between Small Cell eNodeB and EPC can be configured using a point-to-point private Ethernet circuit or multi-point to multi-point virtual private Ethernet circuit.

3.5 Key Components for a Deployable Solution

3.5.1 Operating Band / Bandwidth (2483.5 – 2495 MHz)

Small cell networks are predominantly deployed by service providers in the cellular industry. A service provider initially designs and deploys a macro LTE network using one or more of its licensed carriers. The same carrier is also re-used to deploy small cells. By sharing the same carrier, a higher utilization of the spectrum is achievable; however, the potential of mutual interference between macro cell and small cell needs to be managed by the operator.

Globalstar's terrestrial network operations will be based on the deployment of LTE small cell networks that will operate in its dedicated spectrum (2483.5 – 2495 MHz). Since the carrier frequency is dedicated to small cells and not shared with any macro network, the mutual interference with a macro network is not relevant.

3.5.2 Location Selection

Small cells enable high spectral efficiency gains without traditional costs associated with macro cell network design. Using sound traffic engineering and design principles, small cells can be targeted to provide coverage where traffic is high and macro cell coverage is poor. Small cells are deployed at both indoor locations (in buildings, residences, shopping malls, convention centers, etc.) as well as outdoor locations (e.g. lamp posts, traffic lights etc). Site acquisition issues for small cell base stations are common to the small cell industry and not unique to

Globalstar. Globalstar will follow industry best practices for small-cell design and deployment, including any streamlined procedures for small cell site acquisition.

3.5.3 Backhaul / Power

An important practical requirement for successful small cell network deployment is availability of suitable backhaul connectivity to the core network and power supply options. There are many available options for providing backhaul connectivity and power supply to meet small cell equipment (such as eNodeBs). A detailed discussion of the many possible backhaul technology options for connecting small cell equipment is provided in the industry document "Backhaul Technologies for Small Cells."[7]

Some of the backhaul options that are suitable for small cell eNodeBs include: a) Microwave backhaul (Line of Sight or Non-LOS), b) Optical fiber, and c) Ethernet/Metro Ethernet connectivity.

Two commonly available options for power are: a) Standard commercial power, and b) Power over Ethernet.

Globalstar plans to install small cells in areas where the options for backhaul and power are viable.

3.6 Deployment of Small Cell Network as a Neutral Host to Multiple Network Service Providers

One potential deployment model for Globalstar's planned small-cell terrestrial network is for the network to serve as a neutral host for multiple wireless service providers. Specifically, with the increasing deployment of small cell networks to provide coverage and capacity in indoor and outdoor urban and other environments, there is growing industry interest in using such infrastructure to support multiple operators with coverage and service needs. Given this trend toward multi-operator and neutral host small cells,[8] Globalstar at its own discretion, could also choose (based on a demonstrated market need and business case) to serve as a neutral host for additional mobile network operators that would share use of the Globalstar network. Such sharing will be mutually beneficial to all the operators and their respective customers' quality of wireless experience. The neutral host service is expected in a variety of venue types such as universities, enterprise buildings, public libraries, museums, shopping malls, convention centers, hotels, hospitals, etc. The organized sharing of the Globalstar small cell network will relieve the other mobile network operators from the burden of building and managing their own small cell network. As small cell networks proliferate to handle the coverage and capacity needs of mobile broadband users, they will become attractive and/or essential for network providers to achieve substantial savings in capital and operational costs through network sharing with a neutral host.

---

[7] *Backhaul Technologies for Small Cells*, Small Cell Forum, Release 7.0 (Feb. 25, 2014), http://scf.io/en/documents/049_Backhaul_technologies_for_small_cells.php.

[8] *Multi-Operator and Neutral Host Small Cells: Drivers, Architectures, Planning and Regulation*, Small Cell Forum, Release 8.0 (Dec. 15, 2016), http://scf.io/en/documents/191_-_Multi-operator_and_neutral_host_small_cells.php.

The concept and industry standard for network sharing have been defined in 3GPP for 3G/4G LTE and beyond. Two approaches to sharing an LTE radio access network (E-UTRAN) which differ in their core network aspects have been defined.[9] These are illustrated in Figure 15 below.

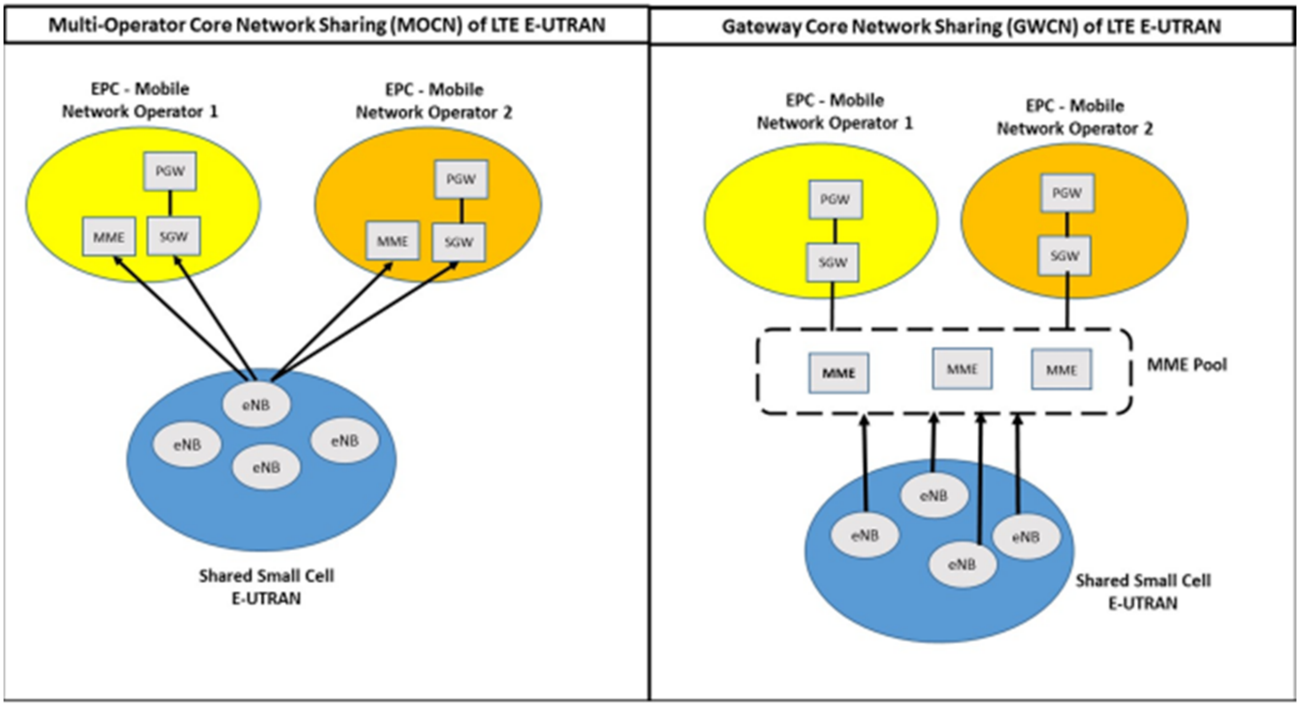

Figure 15: Two Approaches to a Neutral Host Small Cell Network Sharing

The first approach has been called a Multi-Operator Core Network (MOCN) approach (shown on left side of Figure 15) where each mobile network operator has its own Evolved Packet Core network. A strict separation between the core network and E-UTRAN enables service differentiation among the operators. The second approach has been called the Gateway Core Network (GWCN) approach (shown on the right side of Figure 15) where the network operators also share the Mobility Management Entity function of the core network while having their own network elements for the other packet core functions. The MME functions, such as bearer management and connection management between the mobile terminal and network, may be provided by any entity from an MME pool. This approach, though less flexible, enables additional sharing compared to the MOCN approach. For details of the sharing options, please see the citations.

Globalstar has the flexibility to design and implement sharing methods and act as a neutral host small cell network provider.

---

9 *Service Aspects and Requirements for Network Sharing*, 3rd Generation Partnership Project, Specification 22.951; *Network Sharing – Architecture and Functional Description*, 3rd Generation Partnership Project, Specification 23.251.

3.7 Network Management

3.7.1 Main Objectives

In its *R&O*, the Commission adopted a rule requiring that Globalstar deploy and utilize a Network Operating System (NOS), consisting of a network management system located at an operations center or centers,[10] to fulfill various operational requirements, including the need to coexist with adjacent band (BRS) and co-channel (MSS and BAS) systems. Accordingly, Globalstar will implement a NOS as an integral part of its design and deployment of the LTE small cell network. The NOS will have two primary goals: (1) Effective management of the small cell network to help ensure high-quality service to customers, and (2) Successful coexistence of the LTE small cell network with other licensed RF systems (MSS, BRS, BAS), in a manner typical of a terrestrial wireless licensee.

3.7.2 Operation, Administration, Maintenance, Provisioning, Performance (OAMPP) – Managed by OSS/BSS system

To optimize quality of service to customers, Globalstar will leverage the relevant network management features capabilities defined in the 3GPP standard. The standard has specified advanced interference management features and automated configuration options. A number of LTE small cell vendors have developed small cell management systems to address the deployment challenges. To enhance efficiency and lower operational costs, all key activation and management tasks are typically automated. A standards-based provisioning and management system for 4G LTE small cell eNodeBs has been used to provide the following small cell management functions:

- Activation
- Configuration
- Firmware management
- Fault management
- Performance management
- Status monitoring

Globalstar plans to manage its small cell network using the standard OSS/BSS system management solution of its vendor(s) of choice for implementing its NOS solution. The NOS will be used to control the small cell eNodeBs deployed throughout the LTE terrestrial network in a manner similar to how traditional Commercial Mobile Radio Services (CMRS) operators deploy and operate their micro-, pico- and femto-cellular network infrastructure. Globalstar will have complete and exclusive control over the configuration and location of each small cell eNodeB in its network and can adjust its power level (down to zero, if need be) and other critical

[10] *R&O* ¶¶ 38-42 (operational requirements).

parameters to optimize performance and mitigate potential interference to other systems (MSS, BRS and BAS).

The 3GPP LTE standard (Release 8 and later releases) has built in mandatory features and functionality to ensure network security. Globalstar will use the standard features to ensure authenticity of users and devices that will use its small cell network. This is a basic control plane function and will rely on the key functional entities (including eNodeB, MME, HSS and EIR) that were briefly described in Section 3.1.2. Details of how basic security is accomplished may be found in references in footnotes 2 and 3. In short, Globalstar will ensure only authenticated devices (small cell eNodeBs and users/devices) for access to its system. The system will be as secure as any standard LTE based solution. The management platform will help confirm secure, effective, and efficient operation of the small cell network, to ensure expected performance by operator and customers. The Globalstar solution will include many of the Self-Organizing Network features for its small cell network.

3.7.3 Management of Shared Spectrum Between Terrestrial and Satellite Network

Globalstar plans to ensure successful coexistence with other systems by implementing additional mechanisms as an integral part of its NOS design (BSS/OSS) for the small cell network. This section highlights the main concepts of the management of spectrum sharing achieved between the terrestrial and satellite network.

The small cell eNodeBs (i.e. terrestrial network transmitters) can impact satellite operations if there is an insufficient separation between satellite handset and terrestrial network transmitter.

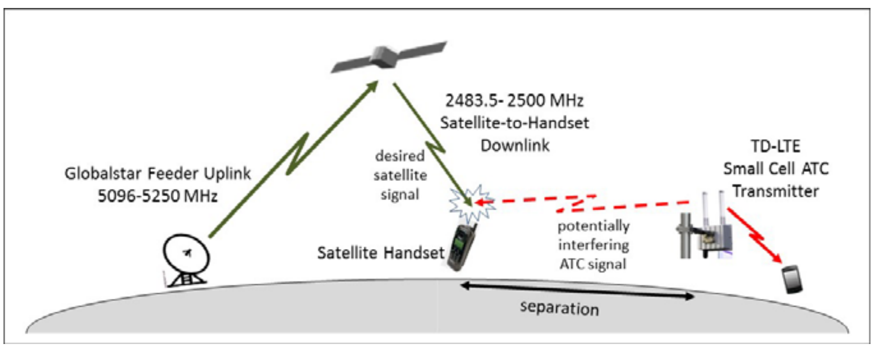

Figure 16: Potential Interference Scenario from Terrestrial Transmitter to MSS Receiver

Globalstar plans to deploy and manage its terrestrial network in a most effective manner by enhancing its OSS/BSS system to:

- Protect MSS operations with multiplicity of small cell locations, users and applications, and
- Achieve maximimum spectrum utilization

Globalstar's approach for co-existence between mobile satellite and terrestrial network services will have:

- Mechanisms for co-existence and protection of MSS

  - Initial location of small cell deployments where satellite service is not normally utilized or required
    - For example, in urbanized areas
    - MSS operator has best information of where MSS subscribers operate and MSS service is required
  - Real-time control of small cell terrestrial network transmitters via network management
    - For example, to provide satellite service in emergency situations in locations where MSS is not normally required
    - MSS operator has most immediate information about locations where MSS is needed
- Since terrestrial network will potentially be utilized by ***multiple entities*** nationally (enterprises, operators), MSS operator is in the best position to:
  - Protect MSS service by selecting locations of terrestrial network deployment
  - Dynamically give priority to MSS service over terrestrial network
  - Maximize spectrum utilization
  - Manage the terrestrial network operations

The following documents are relevant to the real-time control of terrestrial network operations via network management (enhanced OSS/BSS):

- Framework for dynamic control of terrestrial network provided by ETSI ECC Report 205, "Licensed Shared Access" (Feb. 2014)
  - Initially developed for spectrum sharing between two different spectrum licensees
  - Is applicable to controlling terrestrial network
  - Successfully demonstrated: Finland 2014, 2015 (Palola) (France 2016)
    - Reference: "Licensed Shared Access," Report for UK Spectrum Policy Forum, Plum (Oct. 2015)
- 3GPP TR 32.855 V14.0.0 (2016-03) Provides Standard Architecture for Implementing Spectrum Sharing by LTE Vendors
    - Technical Report: 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication Management; Study on OAM support for Licensed Shared Access (LSA)
    - Describes how LTE network management can support co-existence
    - Since terrestrial network will be based on TD-LTE, this approach can be utilized to manage and control Globalstar terrestrial network operations

4 COMPLIANCE WITH FCC RULES ON TERRESTRIAL NETWORK EMISSIONS

4.1 eNodeB Operation

Globalstar will ensure that its small-cell base station and base station antenna supplier(s) provide equipment and any necessary filtering in order to comply with applicable Commission rules. Specifically, the Commission's *R&O* established the following requirements for equipment authorization of terrestrial network equipment operating at 2483.5-2495 MHz (contained in Section 25.149(c)(4) of the Commission's rules):[11]

- The transmitted signal is digitally modulated.
- The 6 dB bandwidth is at least 500 kHz.
- The maximum transmit power is no more than 1 W with a peak EIRP of no more than 6 dBW.
- The maximum power spectral density conducted to the antenna is not greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.
- Emissions below 2483.5 MHz are attenuated below the transmitter power (P) measured in watts by a factor of at least:
  - 40 + 10 log (P) dB at the channel edge at 2483.5 MHz,
  - 43 + 10 log (P) dB at 5 MHz from the channel edge, and
  - 55 + 10 log (P) dB at X MHz from the channel edge where X is the greater of 6 MHz or the actual emission bandwidth.
- Emissions above 2495 MHz are attenuated below the transmitter power (P) measured in watts by a factor of at least:
  - 43 + 10 log (P) dB on all frequencies between the channel edge at 2495 MHz and X MHz from this channel edge, and
  - 55 + 10 log (P) dB on all frequencies more than X MHz from this channel edge, where X is the greater of 6 MHz or the actual emission bandwidth.
- Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or greater. (Special rules for resolution bandwidth are also given for measurements in the 1 MHz bands immediately above and adjacent to the 2495 MHz.)

---

[11] 47 C.F.R. § 25.149(c)(4); *R&O* ¶¶ 22-30. Earlier description of the proposed terrestrial system referred to rules in 47 C.F.R. § 25.254, however, in a note to paragraph (c)(4) of section 25.149, it states, "[s]ystems meeting the requirements set forth in this section are deemed to have also met the requirements of § 25.254(a) through (d). No further demonstration is needed for these systems with respect to § 25.254(a)-(d)."

- The emission bandwidth of the fundamental emission of a transmitter is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.
- When an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in this section.

Within the US, the Globalstar terrestrial base station and antennas will transmit and receive in the 2483.5-2495 MHz band. As a deployment example, Figure 17 below shows the measured transmitted spectrum of a representative 10 MHz TD-LTE eNodeB transmitted signal pictured as centered on 2490 MHz.[12] Signals of different bandwidths would have similar measured spectrum, but scaled in frequency on a proportional basis.

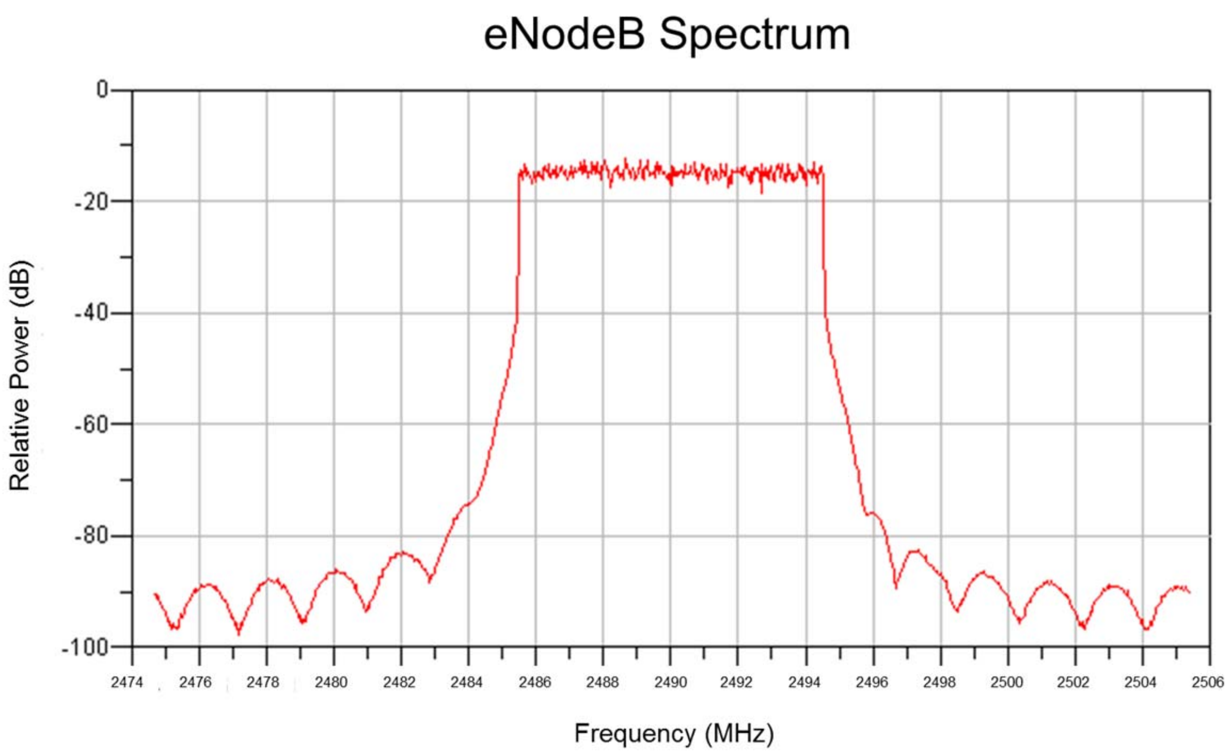

Figure 17: 10 MHz TD-LTE eNodeB Transmitted Signal Spectrum

Further details characterizing the terrestrial base station operation are provided in Section 4.3.2 below.

12 *3GPP LTE Design Examples*, Keysight Technologies, http://edadocs.software.Keysight. com/display/ads2008U1/3GPP+LTE+Design+Examples (last visited April 5, 2017).

4.2 UE Operation

Figure 18 below shows the measured transmitted spectrum of transmitted signals from multiple representative LTE UEs sharing a 10 MHz uplink channel, pictured as centered on 2490 MHz.[13] In LTE systems, UEs share the uplink channel using the SC-FDMA channel access scheme, by assigning different sets of resource blocks to each UE. Signals of different bandwidths would have similar measured spectrum, but scaled in frequency on a proportional basis.

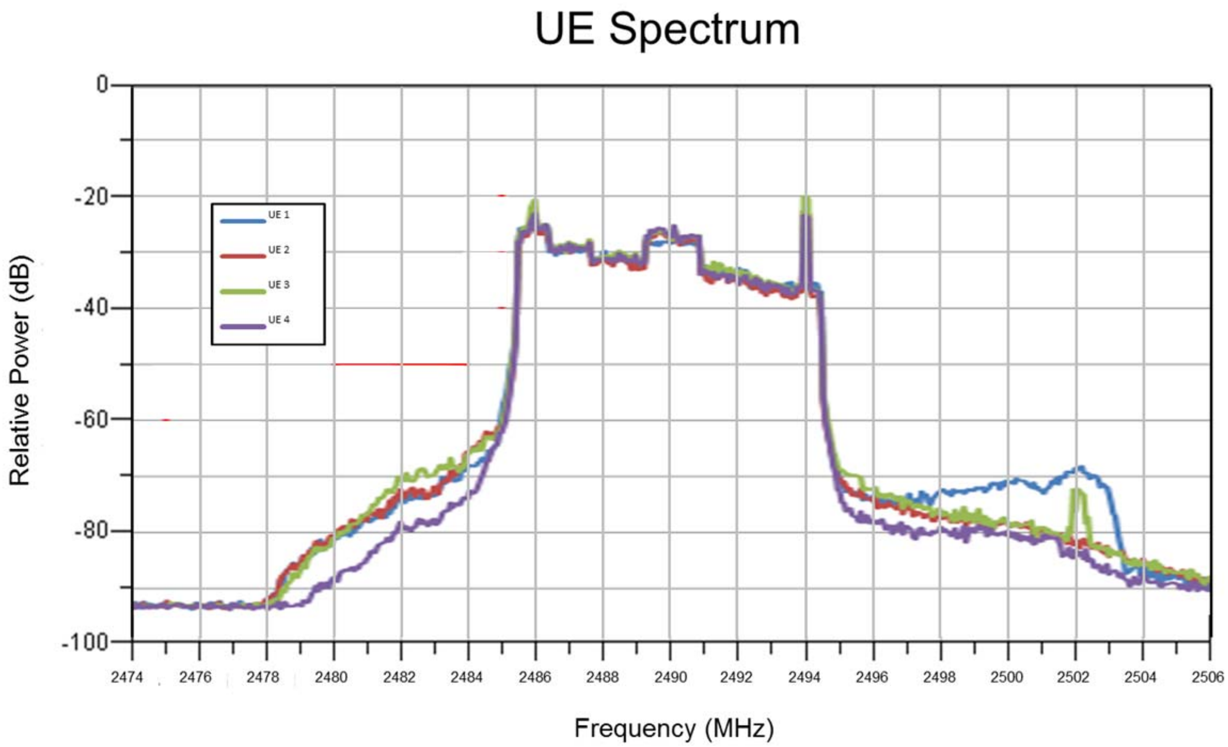

Figure 18: 10 MHz Multiple LTE UE Transmitted Signal Spectrum

The rules listed in Section 4.1 above, 47 C.F.R. § 25.149(c)(4), also apply to terrestrial network UE. Further details characterizing the terrestrial network UE operation are given in Section 4.3.3 below.

13 *Spectrum and OOB emissions of LTE User Equipment*, European Commissions Joint Research Center, 85th Meeting of the Electronic Communications Committee, Bohinj Slovenia (Mar. 18-19, 2014), www.cept.org/documents/se-21/16452/se21.

4.3 Interference Protection

4.3.1 Protection of Other Systems in the Same or Adjacent Bands for Terrestrial Networks

The primary concern for possible adjacent channel interference from terrestrial network deployments in the US is with respect to systems operating above 2495 MHz, including Broadband Radio Service (BRS) and Educational Broadband Services (EBS) systems. This section addresses the out-of-band emissions (OOBE) from terrestrial network TD-LTE eNodeB transmitters that would fall into receive bands above 2495 MHz, and determines how these emissions compare to the out-of-band emissions permitted under FCC rules adopted in the *R&O*. These rules were designed to protect services above the 2495 MHz terrestrial network band edge. This section also addresses OOBE from terrestrial network UEs into the same bands.

In addition, this analysis explains that no additional interference to Broadcast Auxiliary Service (BAS) licensees will be created by terrestrial network devices transmitting in the 2483.5–2495 MHz bands. BAS operates on Channel A10 between 2483.5–2500 MHz and on Channel A9 between 2467–2483.5 MHz.

For this analysis, we consider the parameters of the terrestrial network transmitters, and use a terrestrial network TD-LTE carrier with a representative 10 MHz bandwidth (9 MHz occupied bandwidth). For a worst case, we assume the terrestrial network carrier operates on the highest frequencies in the allocation, adjacent to the 2495 MHz band edge. This is shown in Figure 19 below.

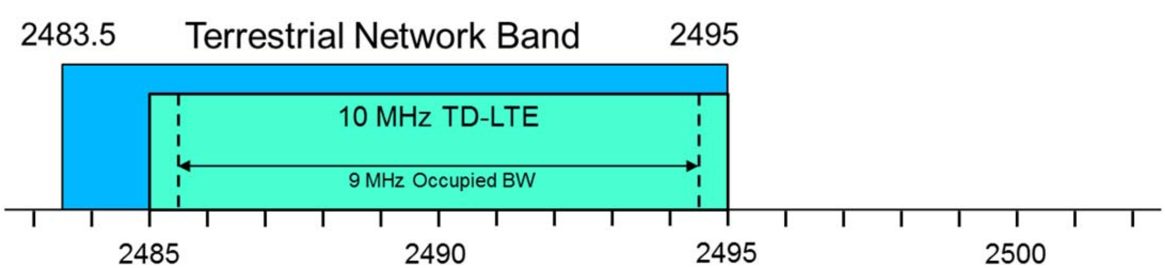

Figure 19: Terrestrial Network Spectrum in the US with Representative 10 MHz LTE Carrier

In wide-area systems, eNodeBs are usually sited on towers, with high gain antennas and large transmit powers. However, for terrestrial network operation based on a small cell architecture, the terrestrial network transmitters will be situated closer to the ground, with lower transmit powers and antenna gains, and smaller EIRP values.

4.3.2 Terrestrial Network eNodeB Interference Considerations

For this analysis, we shall assume a terrestrial network carrier with a representative 10 MHz nominal bandwidth (9 MHz occupied bandwidth) and a center frequency of 2490 MHz with a non-wide-area LTE eNodeB profile, and a transmitter with the parameters shown in Table 2 below.

Parameter	Value	Notes
Base station height[14]	6 m	Small cell outdoor
Transmit power EIRP[15]	36 dBm	4 W EIRP site
1st channel ACLR[16]	45 dB[17]	10 MHz offset
Configured Bandwidth[18]	9.0 MHz	50 Resource Blocks

Table 2: Parameters of LTE eNodeB Transmitter Operating in a Terrestrial Network

In the specification 3GPP 36.104, which pertains to LTE eNodeBs, the Adjacent Channel Leakage Ratio (ACLR) is defined as "the ratio of the filtered mean power centered on the assigned channel frequency to the filtered mean power centered on an adjacent channel frequency." The specification further states that the power is measured in an adjacent channel with the same configured bandwidth as the transmitting channel. For a representative 10 MHz transmitting channel, this configured bandwidth is 9 MHz. For a transmitter with an EIRP of 36 dBm, the adjacent channel interference power in a 9 MHz bandwidth would then be:

P(ACLR) dBm = 36 dBm – 45 dB

= -9 dBm

In terms of dBm per MHz,

P(ACLR) dBm/MHz = -9 dBm – 10 log (9 MHz/1 MHz)

= -9 dBm – 9.5 dB

= -18.5 dBm/MHz

14 *Characteristics of terrestrial IMT-Advanced systems for frequency sharing/interference analyses*, International Telecommunications Union, Report ITU-R M.2292-0 (Dec. 2013), p. 9, Table 3, https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2292-2014-PDF-E.pdf (*ITU-R M.2292*).

15 *R&O* ¶ 22.

16 *Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) Radio Transmission and Reception*, 3rd Generation Partnership Project, Release 14, Version 14.2.0, Specification 36.104 (Dec. 2016), p. 56, Table 6.6.2.1-2 (*3GPP 36.104*).

17 This is the ACLR criteria that would apply to non- wide-area eNodeBs with the transmit power specified in Table 2. For wide-area eNodeBs with the same power, the alternative absolute ACLR limits of -13 dBm/MHz or -15 dBm/MHz, for category A and B eNodeBs respectively, would apply.

18 *3GPP 36.104*, p. 36, Table 5.6-1.

The ACLR is illustrated in Figure 20 below.

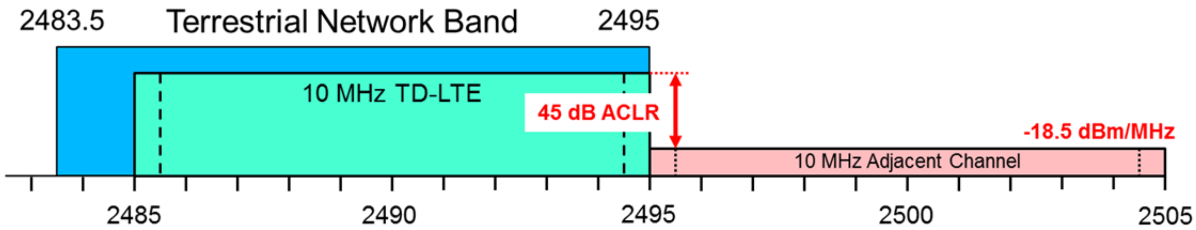

Figure 20: ACLR of 10 MHz terrestrial network TD-LTE eNodeB Signal

In addition to the ACLR specification, which defines OOBE as a function of transmit power, specification 36.104 also specifies that the OOBE must conform to absolute power levels as defined by the spectrum emission mask. The masks are defined based on the class of the eNodeB. Table 3 below lists the different classes defined in specification 36.104 and their associated maximum conducted transmit power, as rated by the manufacturer.19 As we can see, terrestrial network eNodeBs, with maximum conducted power of 30 dBm (1 Watt) would correspond to the Medium Range class.

eNodeB Class	**Max Rated Power**
Wide Area	No limit
Medium Range	38 dBm
Local Area	24 dBm
Home	20 dBm (single antenna port)

Table 3: eNodeB Classes and Maximum Rated Powers

The emissions mask for a Medium Range eNodeB is specified in Figure 21 below for a representative 10 MHz TD-LTE terrestrial network transmitter with maximum conducted power less than 31 dBm.[20] Although the masks are specified in terms of 100 kHz measurement bandwidths, the values are translated into dBm/MHz to be consistent with other specifications in this section.

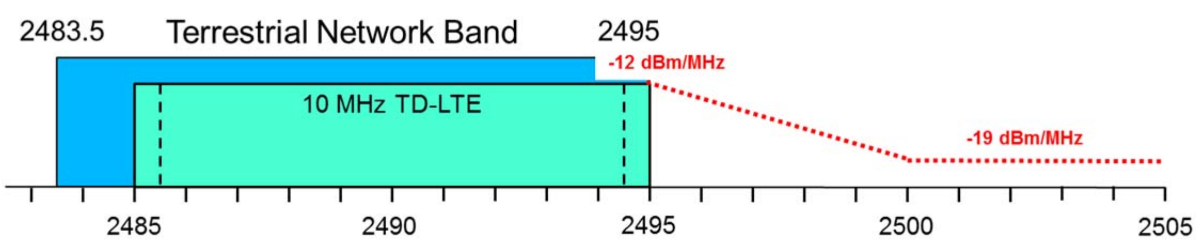

Figure 21: Emissions Mask of 10 MHz Terrestrial Network TD-LTE Medium Range eNodeB

19 *Id.*, p. 46, Table 6.2-1.

20 *Id.*, p. 72, Table 6.6.3.2C-6.

In this case, the emission limits per the mask from 2495 MHz (the assumed terrestrial network channel edge) to roughly 2500 MHz (5 MHz from the edge) exceed the levels allowed by the ACLR requirement for eNodeB devices transmitting with the maximum EIRP of 36 dBm, which was calculated to be -18.5 dBm/MHz. Since both criteria have to be met, the ACLR-based limits will apply up to roughly 2500 MHz. Past roughly 2500 MHz, the mask limit is -19 dBm/MHz, 0.5 dB lower than the ACLR based limits, so this more stringent limit would apply.

The above ACLR and emissions mask-based limits apply only to so-called operating band emissions, which apply only to frequencies within 10 MHz of the transmitter's operating band edge. For the case at hand, this means frequencies from 2495 MHz (the band edge) to 2505 MHz. Emissions outside of this region are governed by spurious emissions rules in specification 36.104. The general rules for spurious emissions specify emission levels of no more than -13 dBm/MHz for Category A limits (i.e. those outside of Europe)21. However, special spurious emissions rules are specified for emissions into E-UTRA Band 41, which runs from 2496 to 2690 MHz, of no more than -52 dBm/MHz.[22] So, in the frequency range 2505 to 2690 MHz, where these special spurious emissions rules would apply, the emissions are limited to -52 dBm/MHz.

The rules specified by the FCC in 47 C.F.R. § 25.149(c)(4)(vi) which pertain to out-of-band emissions (OOBE) into channel BRS-1 are repeated below:

> Emissions above 2495 MHz are attenuated below the transmitter power (P) measured in watts by a factor of at least 43 + 10 log (P) dB on all frequencies between the channel edge at 2495 MHz and X MHz from this channel edge and 55 + 10 log (P) dB on all frequencies more than X MHz from this channel edge, where X is the greater of 6 MHz or the actual emission bandwidth.

An LTE eNodeB with a 10 MHz carrier that is compliant with ACLR and emissions mask requirements could have an emission bandwidth of up to 10 MHz, so a value of X = 10 MHz is used. Consequently, in the range between 2495 MHz and 2495 + X = 2505 MHz, the OOBE must be attenuated by a factor of 43 + 10 log (P) dB (where P is in watts). It is further stipulated in the Commission's rules that the power is measured in an effective bandwidth of 1 MHz. The net result is that the OOBE in the 2495 to 2505 MHz range cannot exceed -13 dBm/MHz. Similarly, emissions above 2505 MHz must be attenuated by a factor of 55 + 10 log (P) dB, which corresponds to -25 dBm/MHz. This is illustrated in Figure 22 below.

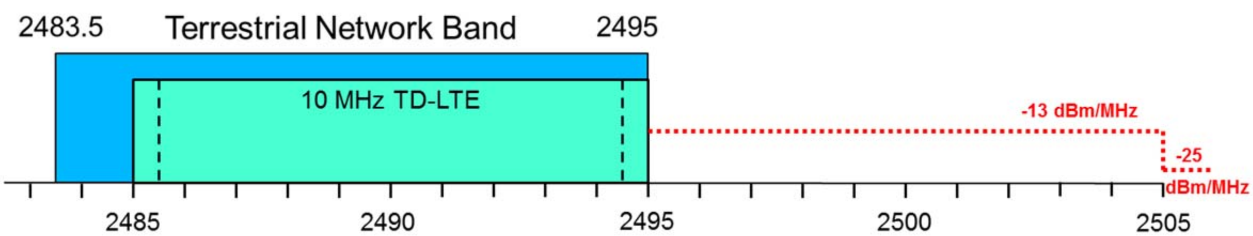

Figure 22: OOBE Emission Limits Above 2495 MHz, per 47 C.F.R. § 25.149 (c)(4)

[21] *Id*, p. 79, Table 6.6.4.1.1.1-1.

[22] *Id*, p. 84, Table 6.6.4.3.1-1.

The maximum operating band OOBE as calculated above for eNodeBs, based on LTE specification 36.104, for a transmitter with specifications per Table 2, was -18.5 dBm/MHz up to roughly 2500 MHz, and -19 dBm/MHz between 2500 and 2505 MHz. We see that these OOBE are below the maximum of -13 dBm/MHz allowed by the terrestrial network rules in 47 C.F.R. § 25.149, for frequencies below 2505 MHz. Frequencies above 2505 MHz, up to 2690 MHz, are governed by the special spurious emissions limit of -52 dB/MHz, which fall below the section 25.149 limit of -25 dBm/MHz. Therefore, eNodeB transmitters which comply with LTE specifications will also comply with terrestrial network rules specified by the FCC.

We note that the OOBE from actual deployed equipment would likely be lower than the limits specified in the LTE specifications - i.e., it has already effectively been subjected to additional transmitter filtering (see for example the measured spectrum in Figure 17 above).

4.3.3 Terrestrial Network UE Interference Considerations

In this section, we consider cases of interference from UE devices in terrestrial network systems at 2483.5-2495 MHz. As with the eNodeB case, for the UE analysis we shall assume a terrestrial network carrier with a representative 10 MHz nominal bandwidth and a center frequency of 2490 MHz, as shown in Figure 19 above, and a UE transmitter with the parameters shown in Table 4 below.

Parameter	**Value**	**Notes**
Antenna height	1.5 m	Representative UE height
Max transmit power[23]	23 dBm	Class 3 device
Maximum antenna gain[24]	-3 dBi	
1st channel ACLR[25]	30 dB	10 MHz offset, 9 MHz measurement bandwidth, power class 3
Occupied Bandwidth[26]	10 MHz	

Table 4: Parameters of LTE UE transmitter operating in a terrestrial network

The power into an adjacent channel due to ACLR from the terrestrial network UE may be calculated in the same manner as with the terrestrial network eNodeB in Section 4.3.2 above, but using the UE maximum transmit power of 23 dBm, a transmit antenna gain of -3 dBi (since transmit power specified here is conducted power, not EIRP), and an ACLR of 30 dB. This is shown in Figure 22 below.

---

23 *Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception*, 3rd Generation Partnership Project, Release 14, Version 14.2.1, Specification 36.101 (January 2017), p. 100, Table 6.2.2-1 (*3GPP 36.101*).

24 *ITU-R M.2292*, p. 11, Table 3.

25 *3GPP 36.101*, p. 207, Table 6.6.2.3.1-1.

26 *Id*, p. 200, Table 6.6.1-1.

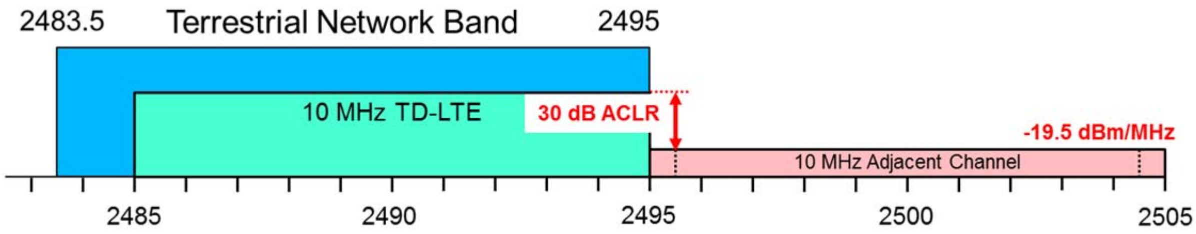

Figure 22: ACLR of 10 MHz Terrestrial Network TD-LTE UE Signal

The adjacent channel power due to UE ACLR would be:

P(ACLR) dBm = 23 dBm + (-3 dBi) – 30 dB

= -10 dBm

This would be the power into an adjacent 9 MHz channel. In terms of dBm per MHz,

P(ACLR) dBm/MHz = -10 dBm – 10 log (9 MHz/1 MHz)

= -10 dBm – 9.5 dB

= -19.5 dBm/MHz

In addition to the ACLR specification, which defines OOBE as a function of transmit power, *3GPP 36.101* also specifies that the OOBE must conform to absolute power levels as defined by the spectrum emission mask shown in Figure 23 below for a representative 10 MHz TD-LTE terrestrial network UE transmitter.[27]

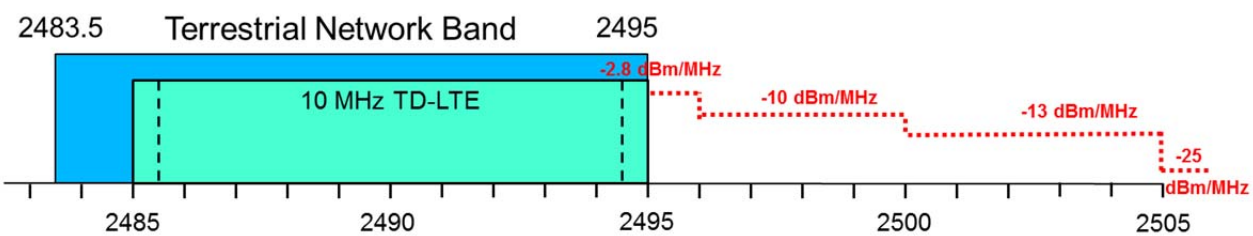

Figure 23: Emissions Mask of 10 MHz Terrestrial Network TD-LTE UE Signal

From 2495 MHz to 2505 MHz, the levels specified by the mask exceed the levels allowed by the ACLR requirement for UE devices transmitting with the maximum power of 23 dBm and a -3 dBi antenna gain, which was calculated to be -19.5 dBm/MHz. Since both criteria have to be met, the ACLR-based limits will apply out to 2505 MHz. For the part of the band above 2505 MHz, the emission mask limits will apply.

The OOBE limits above apply to frequencies in the so-called out-of-band emission domain, which for the case of UEs with a 10 MHz carrier, extends to 15 MHz above the operating band

[27] *Id*, p. 202, Table 6.6.2.1.1-1.

edge, *i.e.*, to 2510 MHz.[28] For frequencies above 2510 MHz, spurious emission limits would apply, which are -30 dBm per MHz for the frequencies in question.[29]

The maximum operating band OOBE as calculated above for UEs, based on LTE specification 36.101, for a transmitter with specifications per Table 4, was -19.5 dBm/MHz for frequencies up to 2505 MHz, and -25 dBm/MHz for frequencies between 2505 and 2510 MHz. For frequencies above 2510 MHz, the spurious emissions limit of -30 dBm/MHz applies. We see that these emissions are below the maximum of -13 dBm/MHz for frequencies below 2505 MHz, and -25 dBm/MHz for frequencies above 2505 MHz, as allowed by the terrestrial network rules in 47 C.F.R. § 25.149. Therefore, UE transmitters which comply with LTE specifications will also comply with terrestrial network rules specified by the FCC.

We note that the OOBE from actual deployed equipment would likely be lower than the limits specified in the LTE specifications – i.e., it has already effectively been subjected to additional transmitter filtering (see for example the measured spectrum in Figure 18 above).

4.3.4 Terrestrial Network – BAS Interference Considerations

The FCC repeatedly has acknowledged that terrestrial network and BAS operations can successfully operate in the same band through coordination. BAS operations in Channel A10 overlap the entire 2483.5–2500 MHz MSS allocation. Allowing terrestrial network UEs to transmit in the 2483.5–2495 MHz portion of this band along with the terrestrial network eNodeBs, albeit at lower power, would not result in any additional interference to BAS operations than already occurs from the existing users in the band. Moreover, as the FCC has acknowledged,[30] the number of active BAS licensees using Channel A10 is relatively small and should not increase over time, since no new licenses will be issued.

For BAS operating in Channel A9 (2467-2483.5 MHz), Globalstar's terrestrial network operations must meet the FCC required out of band emissions below 2483.5 MHz as specified in section 25.149(c)(4), described in Section 4.1 above, for all frequency offsets from the edge of the licensed assignment. In addition, if the BAS licensee were to deploy digitized equipment (which will be increasingly likely going forward), then only 12 MHz of bandwidth would be required for that channel, effectively creating a 2.25 MHz guard band.

28 *Id*, p. 214, Table 6.6.3.1-1.

29 *Id*, Table 6.6.3.1-2.

30 As the FCC has recognized, in 2005 there were only 77 BAS licensees authorized to on channel A10. See *Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands*, Memorandum Opinion and Order and Second Order on Reconsideration, 20 FCC Rcd 4616, ¶¶ 93-94 (2005).

5 POTENTIAL APPLICATIONS OF TD-LTE SMALL CELLS

Small cell networks have many different use cases and deployment models, and there are a wide range of potential applications and deployments for small-cell operations in Globalstar's licensed spectrum at 2483.5-2495 MHz. In particular, Globalstar's spectrum can be used in a variety of high density dedicated non-macro cell deployments (e.g., Pico, Femto, and Related Small Cell Deployments).

The Small Cell Forum has identified four major classes of small cells, each different in its scope and purpose. These four classes are identified and described below.

- Residential small cells
- Enterprise small cells
- Urban small cells
- Rural and remote small cells

Residential small cells[31] (or femtocells) are intended for home or small office applications. They typically operate indoors, in locations where a single small cell is sufficient.

Enterprise small cells[32] are generally deployed indoors, in customer premises. Their coverage is beyond home or small office areas with a primary focus on achieving highly reliable coverage with increased capacity as a secondary focus. Enterprise small cells may involve the cooperation of multiple parties for service, sites, and facilities.

Urban small cells[33] are licensed small cells deployed by operators in areas of high demand and density of users with open access to all customers of an operator. The deployment is either outdoors on street fixtures (such as lamp posts, traffic lights, etc.) or indoor public locations such as transportation hubs (airports, train stations), retail malls, hotels, and more.

Rural and remote small cells[34] enable operators to provide service to market segments with rural and remote characteristics. Some of these segments may include: a) rural, underserved (low or no coverage) communities, b) Remote industrial coverage for workers at a site that is hard to reach with existing infrastructure, c) Public safety coverage for first responders and emergency services, d) Disaster recovery and humanitarian operations, through rapid introduction of wireless coverage in areas affected by extensive damage to existing mobile infrastructure,

---

[31] *Release One: Home Overview*, Small Cell Forum, Release 7.0 (June 5, 2014), http://scf.io/en/documents/101_Release_One_Home_overview.php.

[32] *Enterprise Overview*, Small Cell Forum, Release 7.0 (Jan. 20, 2016), http://scf.io/en/documents/102_-_Enterprise_Overview.php.

[33] *Urban Small Cells: Release Four Overview*, Small Cell Forum, Release 7.0 (June 5, 2014), http://scf.io/en/documents/104_-_Urban_small_cells_Release_Four_overview.php.

[34] *Rural and Remote: Overview*, Small Cell Forum, Release 7.0 (Feb. 24, 2015), http://scf.io/en/documents/105_-_Rural_and_remote_Overview.php.

e) Special events where services are needed for large, planned gatherings of people (sports stadiums, convention centers etc.).

Small cell networks can provide a rich set of diverse product and service offerings across consumer, commercial and government markets. Spectrum exclusively used for small-cell operations can support an optimal set of applications (or use cases) in a given geographic area.

Potential applications include, but are not limited to, the following:

1. Broadband mobile
2. Private networks
3. Secure networks
4. Public safety or law enforcement networks
5. Internet of Things applications

Use Cases / Applications: The relatively "clean" nature of the 2483.5-2495 MHz band segment, Part 25 protections, use of the LTE standard, and the broad existing device and infrastructure ecosystem provide the foundation for an expansive set of potential use cases / applications.

1. Small Cell Capacity Deployments: Advantages include better user experience, a lower Total Cost of Ownership (TCO), and a flexible, robust environment
    a. Enterprise
        i) Indoor – Deployed in offices, hospitals, malls, etc. for reliable and robust increased capacity
        ii) Outdoor – Deployed in campus, stadiums, shopping centers, etc. to increase capacity
    b. Residential
        Indoor Femtocells – excellent home solution especially in underserved or congested locations
2. Smart Cities – The benefits of the exclusive nature of the Globalstar spectrum has some benefits for the unique requirements of Smart Cities
    a. Sensors – Whether traffic, alarm detection, video cameras, weather, air quality, etc. the benefits would be valuable for these applications – i) In-building and ii) Street Level
    b. Public Safety – Excellent solution for Mission Critical applications, e.g. real time Voice and PTT
    c. Emergency Services – Excellent solution for Mission Critical applications, e.g., real time video
3. IoT by Vertical: Each vertical has its own IoT requirements, which would need to be addressed individually
    a. Manufacturing/Warehouses

b. Heath Care
c. Utilities
d. Transportation/Airports
e. Education
f. Venues – Sports Stadiums, Theaters, Concerts,
g. Retail – In-store, supply chain

6 CONCLUSION

In this technical exhibit, we have described high-level technical details of Globalstar's proposed terrestrial network TD-LTE system in its licensed MSS spectrum at 2483.5-2495 MHz. We presented the main aspects of LTE small cell network architecture, as well as the variety of deployment alternatives for the LTE small cell network. A wide range of use cases and applications were described. Finally, we demonstrated the interference protection between terrestrial network LTE system and other systems.