Globalstar Licensed 2.4 GHz Technical Review

January 2017

Globalstar Licensed 2.4 GHz Technical Agenda

U.S. RESOURCE

11.5 MHz of Nationwide Spectrum Representing 3.7 Billion MHz-POPs

PRIMARY USE CASES

High Density Dedicated Non-Macro Cell Deployments (e.g. Pico, Femto, and Related Small Cell Deployments)

PRIMARY STANDARD

TD-LTE

ECOSYSTEM

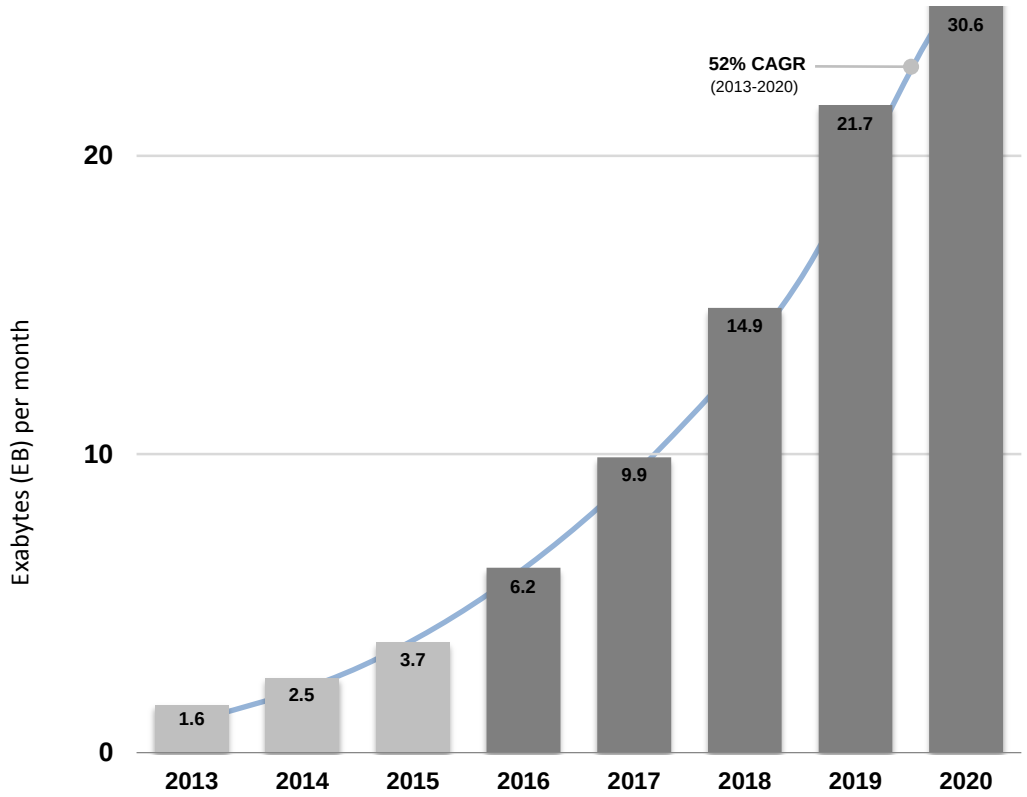
Broad Device and Infrastructure Ecosystem with Existing Chipset Architectures

GLOBAL

Potential for Harmonized Terrestrial Authority Across Many International Regulatory Domains

Mobile Data Demand and the RF Spectrum Resource

Between 2013 and 2020, conservative projections indicate that mobile data demand will have grown by a factor of 30. Given the finite nature of available RF spectrum for mobile applications, no realistically achievable amount of new spectrum resource will service this demand. Rather, network providers must rely upon spectrum allocations that are most compatible with high density indoor and outdoor small cell architectures.



30.6 Exabytes (EB) of data =

The LIBRARY of CONGRESS

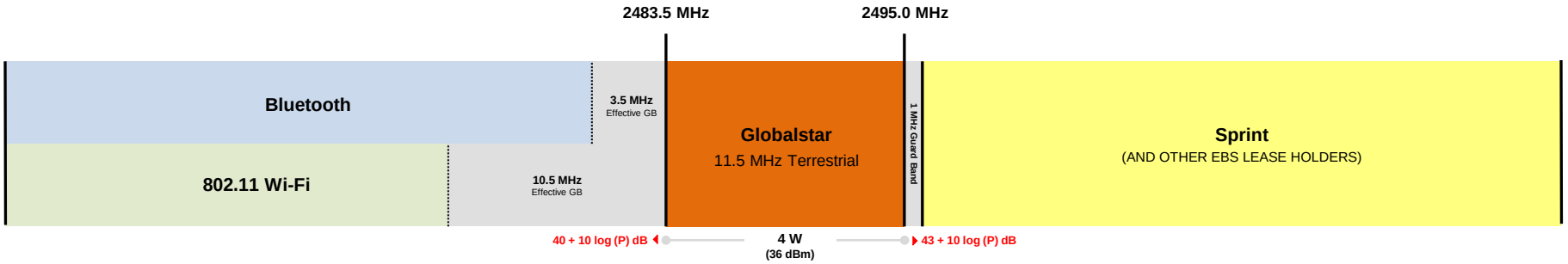
x 1.5 million

transmitted over wireless networks *each month*

Source: Cisco White Paper entitled "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015-2020" dated February 1, 2016.

Globalstar 2.4 GHz as a Small Cell Resource

The Globalstar terrestrial band provides 11.5 MHz (3.7 Billion MHz-POP) across the entire United States. As a resource for LTE networks, Globalstar 2.4 GHz is unique in its support of small cell deployment. The band holds physical, regulatory, and ecosystem qualities that distinguish it from other current and anticipated allocations.



Propagation + Interference

- Optimal 2.4 GHz Propagation Characteristics
- Part 25 Licensed Protection from Interference

Small Cell Exclusivity

- Small Cell Applications are Limited by Macro Cell Interference
- Regulatory Ability to Devote Resource Exclusively to Small Cell

Rapid LTE Ecosystem

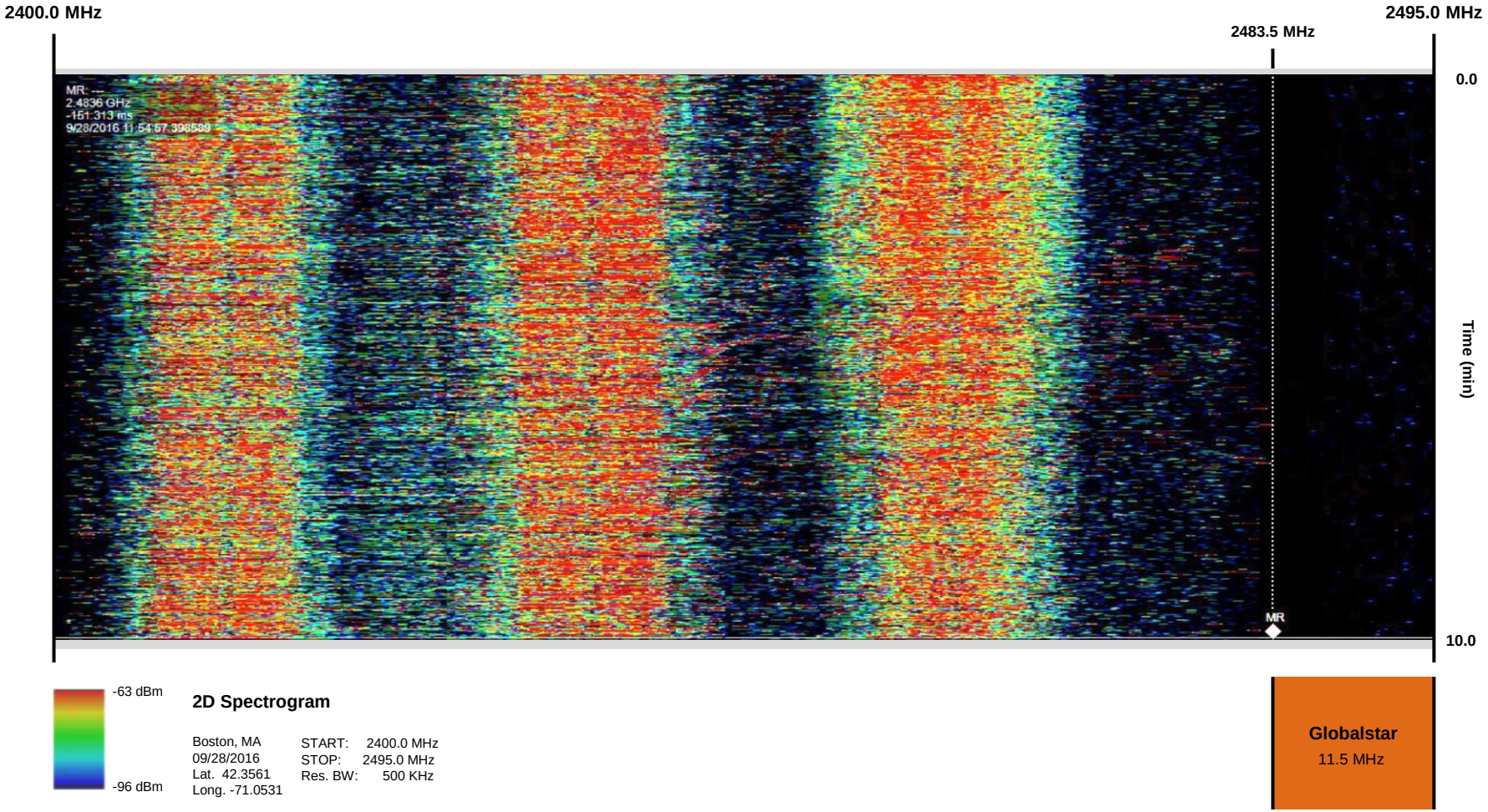
- Spectrum Readily Compatible with Existing Chipset Architectures
- Small Cell Infrastructure May Use Low Cost Device Transceivers

International Potential

- Harmonized Global Small Cell Band Has Been Elusive
- Unique Opportunity to Create a Global LTE Band at 2.4 GHz

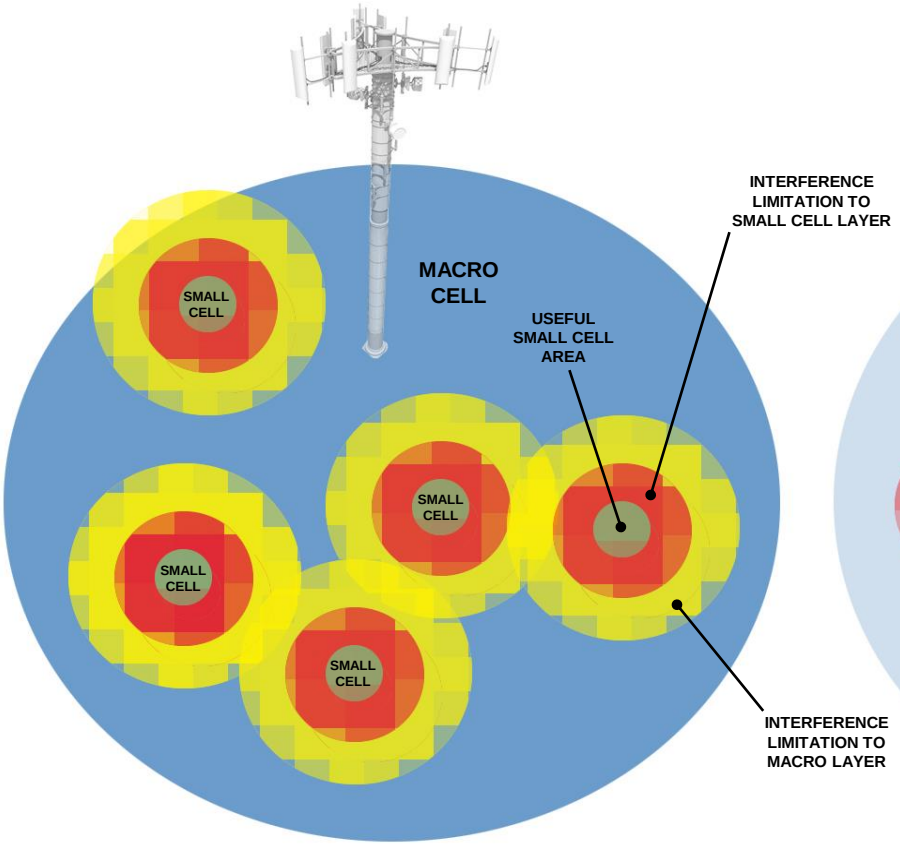
Spectrographic View of Globalstar 2.4 GHz

Due to favorable propagation characteristics, the globally harmonized unlicensed band at 2.4 GHz is both a uniquely important and polluted allocation. The 11.5 MHz licensed terrestrial allocation in Globalstar spectrum has been established under highly protective Part 25 rules. As a result, this band will enjoy full interference protection from adjacent services, permanently maintaining its performance characteristics for LTE.

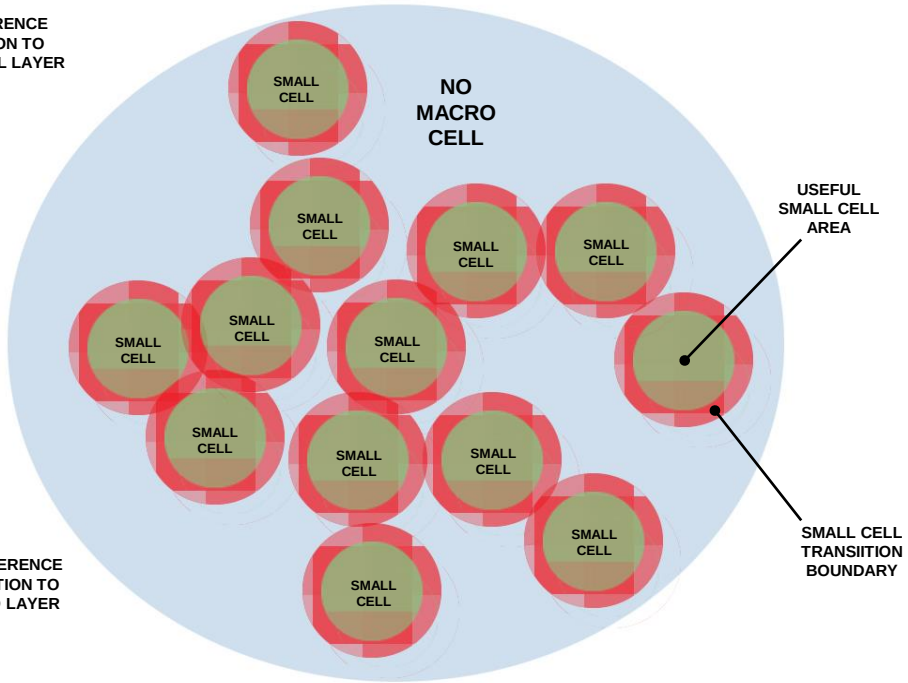


The Need for Dedicated LTE Small Cell Spectrum

Small cell dominated network topologies are essential to meeting wireless capacity demands. However, sharing spectrum across both macro and small cell layers introduces interference limitations that severely compromise network performance. Globalstar licensed 2.4 GHz provides a unique opportunity for operators to dedicate high quality spectrum exclusively to capacity producing small cell infrastructure.



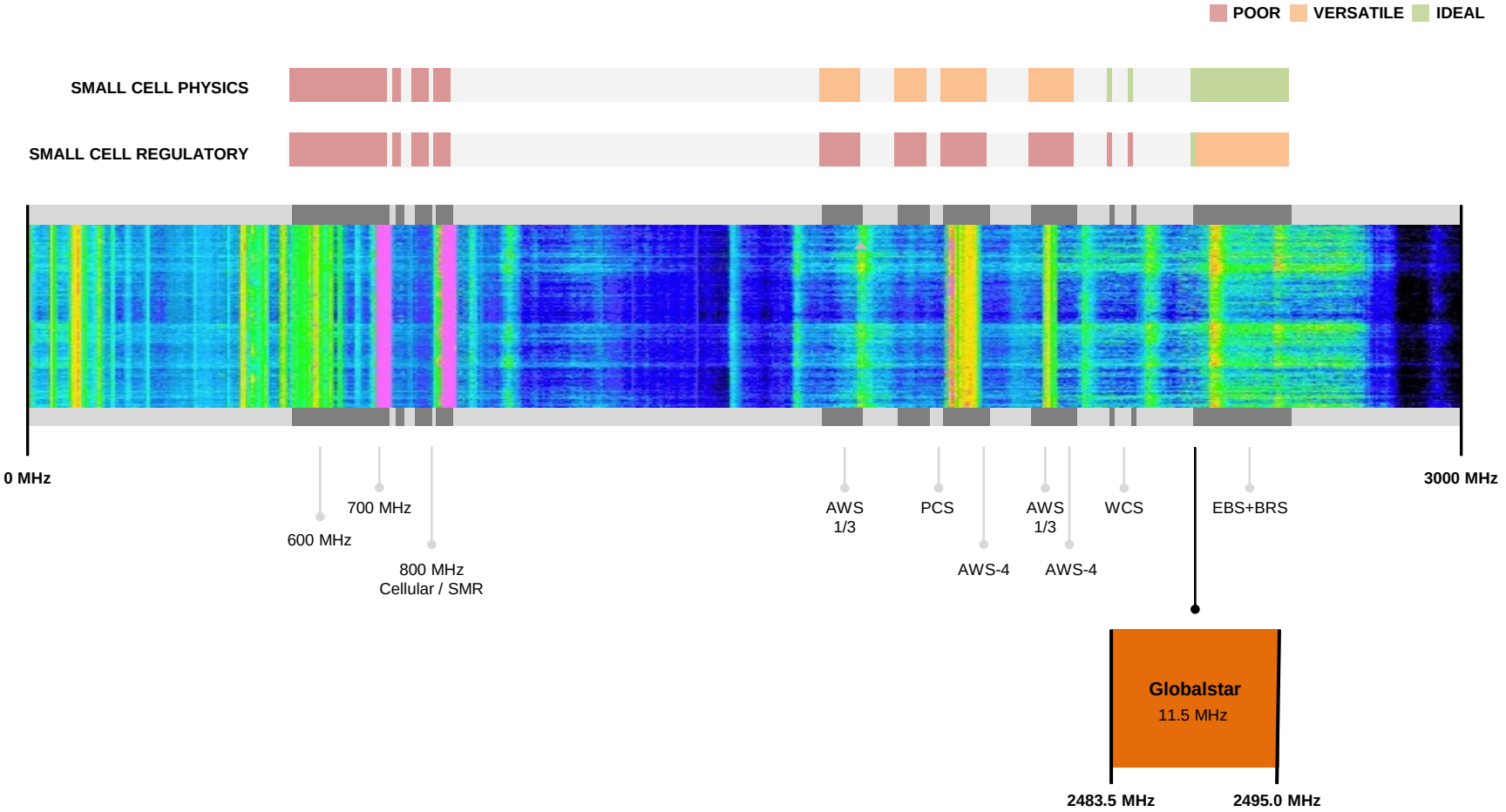
MACRO + SMALL CELL SPECTRUM



SMALL CELL ON DEDICATED SPECTRUM

Scarcity of Dedicated LTE Small Cell Spectrum

Conventional commercial wireless network allocations must meet minimum population coverage requirements, which effectively prohibits the exclusive use of most carrier spectrum for small cell. In addition, low frequency carrier spectrum is not physically well suited to high-density small cell topologies. Globalstar 2.4 GHz is at an ideal small cell wavelength and has no terrestrial population coverage requirements.

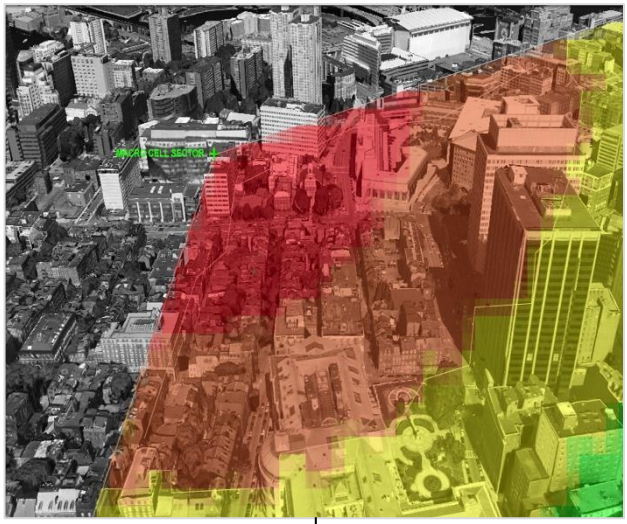


See: FCC, *Wireless Construction Requirements by Service*, https://www.fcc.gov/general/wireless-construction-requirements-service

Licensed 2.4 GHz Small Cell Impact

Small cell represents the most viable method of meeting the next wave of capacity requirements. At 2.4 GHz, physical and regulatory advantages enable the resource to produce multiples of the capacity possible on macro cellular spectrum in the same environment. Even minimal density of low power cellular infrastructure improves effective capacity by more than one order of magnitude.

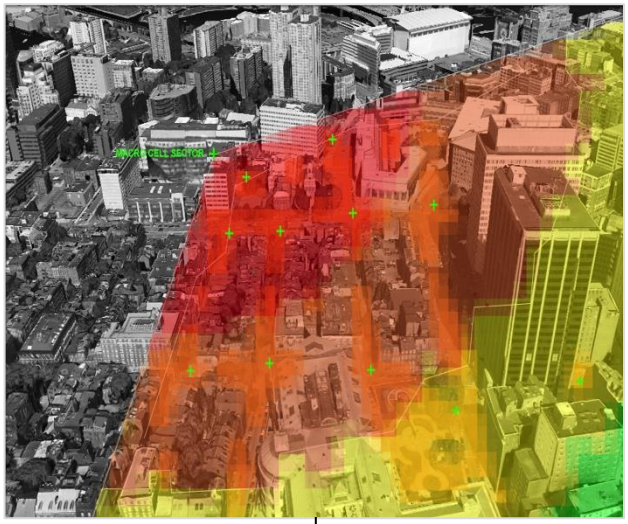
Conventional Macro Cellular Sector



Macro Performance Assumptions

- 10 x 10 MHz FD-LTE, Single 120 deg. Sector
- Peak Aggregate Throughput: <86 Mbps
- Significant Variation in QoS Near Cell Boundary

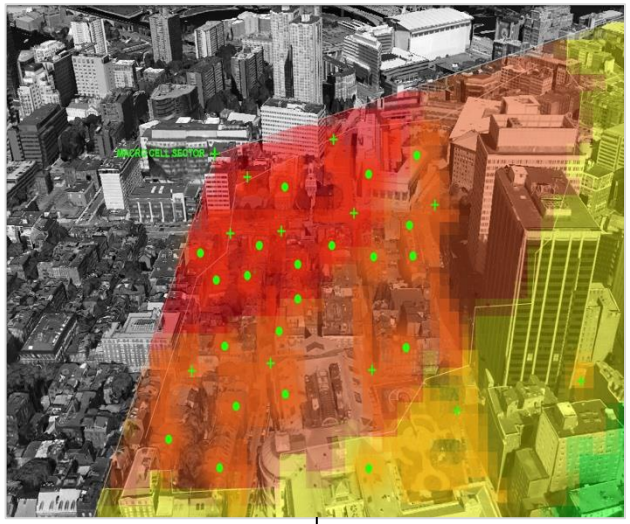
1 Watt Class 2.4 GHz LTE Small Cell



1 W Small Cell Performance Assumptions

- 10 MHz TD-LTE, 10-15 Outdoor Pico Cells
- Peak Aggregate Throughput: >500 Mbps
- High Signal Quality Near Point of Consumption

0.2 Watt Class 2.4 GHz LTE Small Cell

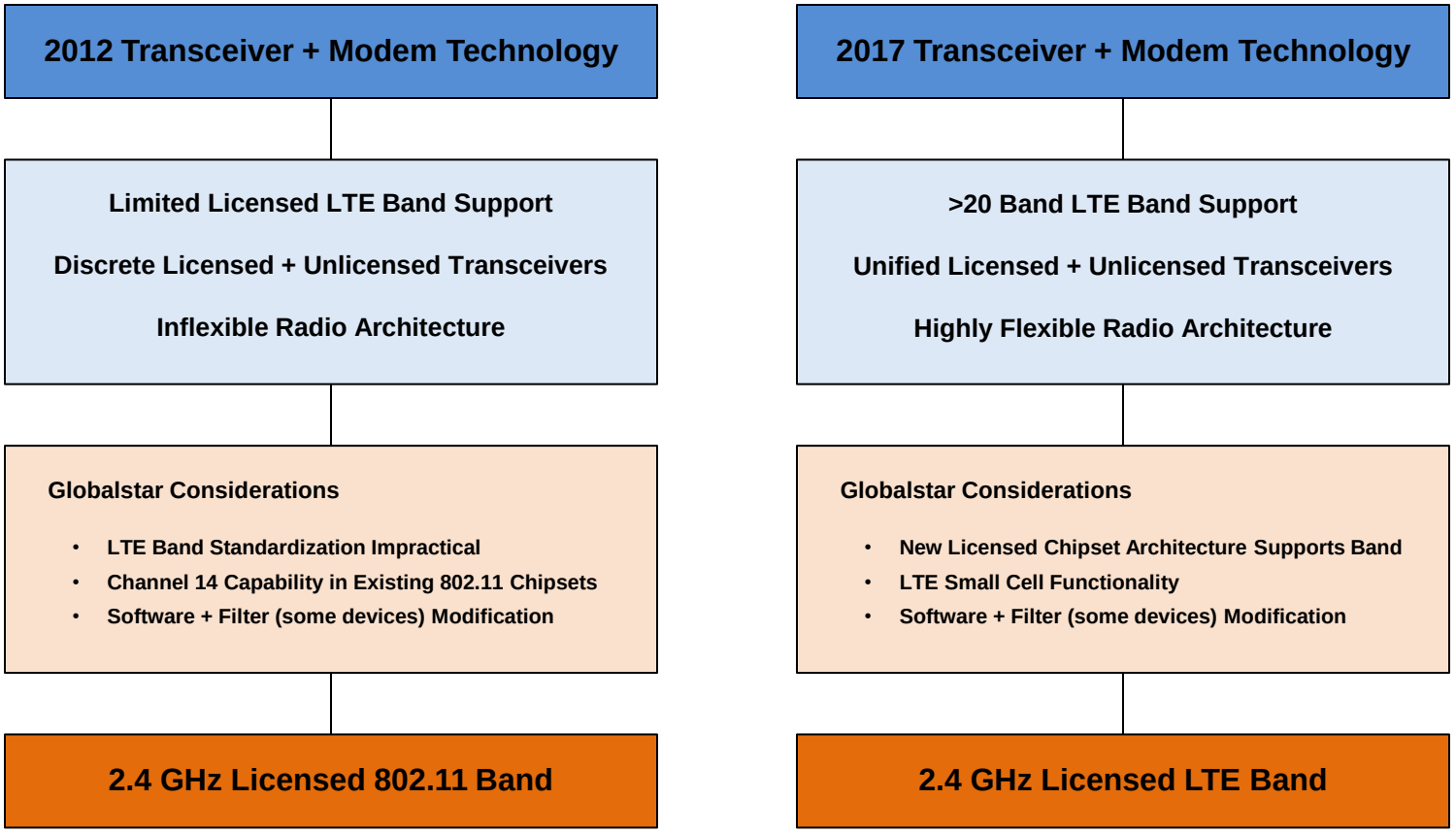


0.2 W Small Cell Performance Assumptions

- 10 MHz TD-LTE, 25-50 Indoor Femto Cells
- Peak Aggregate Throughput: >1 Gbps
- High Signal Quality Near Point of Consumption

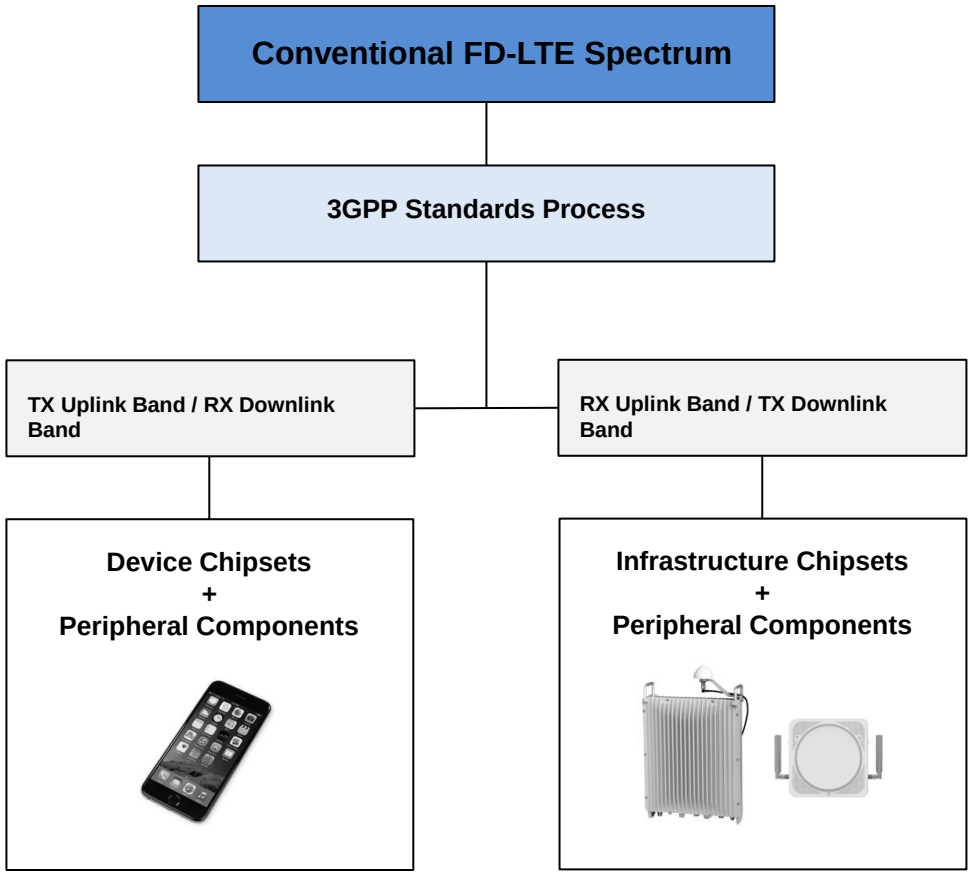
Globalstar 2.4 GHz LTE Ecosystem for Devices

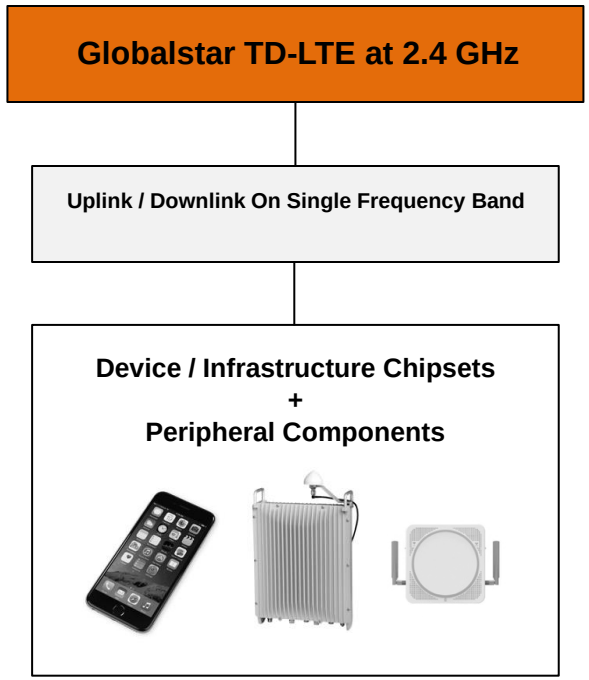
Transceiver technology has evolved significantly since Globalstar's original TLPS proposal. Whereas the RF chipset ecosystem of 2012 was highly inflexible and unable to accommodate LTE services in Globalstar spectrum, current and anticipated radio architectures present a rapid path to availability.



Globalstar 2.4 GHz LTE Ecosystem for Infrastructure

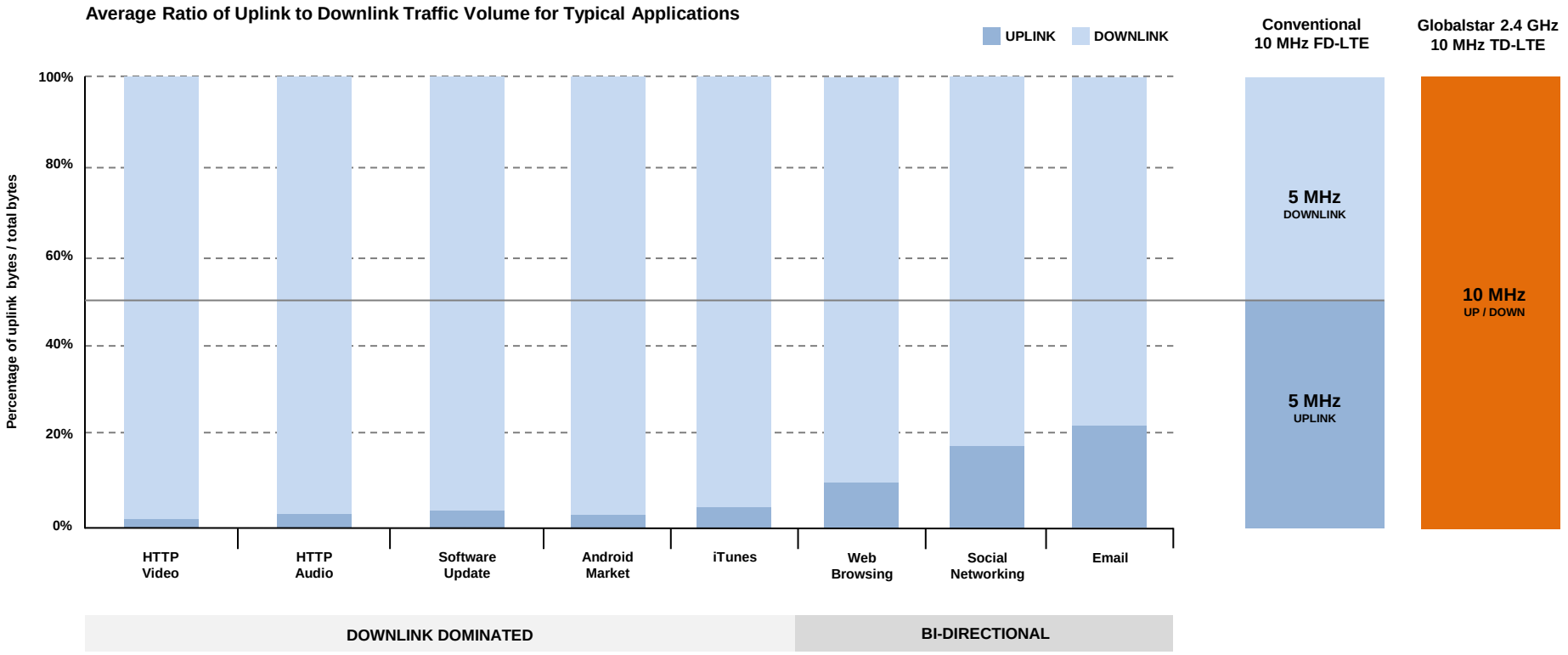
For conventional FD-LTE spectrum, transceivers used for infrastructure and devices are fundamentally different. This means that bulk quantities of transceivers and peripheral components (e.g. filters) may not be used to improve the economy of small cell ecosystems. For Globalstar 2.4 GHz, however, TD-LTE enables small cell infrastructure that may use the same high volume / low cost chipsets as ordinary user equipment.





The Performance Benefits of TD-LTE vs. FD-LTE

Symmetrically paired spectrum is an artifact of early 1G / 2G networks, where uplink and downlink bandwidth consumption was identical. Today, data usage is strongly biased towards the downlink. TDD (Time Domain Duplex) spectrum permits adjustment of the uplink / downlink ratio to match demand patterns. Thus, a TD-LTE channel may demonstrate significantly higher performance than an FD-LTE channel of the same size.



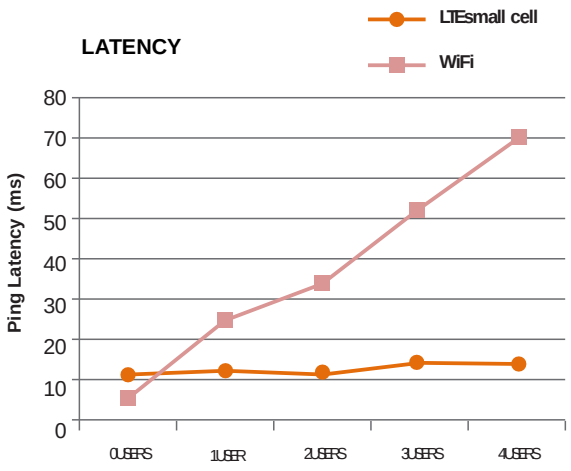
See: Ericsson, *Uplink Versus Downlink Traffic Volumes*, https://www.ericsson.com/res/docs/2015/mobility-report/emr-uplink-verus-downlink-traffic-volumes.pdf

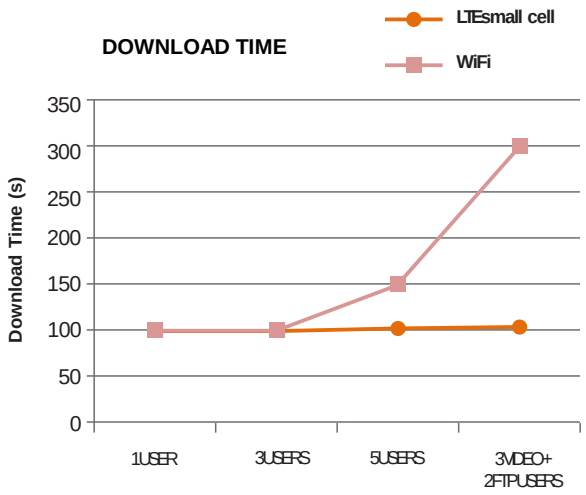
Representative Performance of Small Cell LTE Relative to 802.11 Wi-Fi

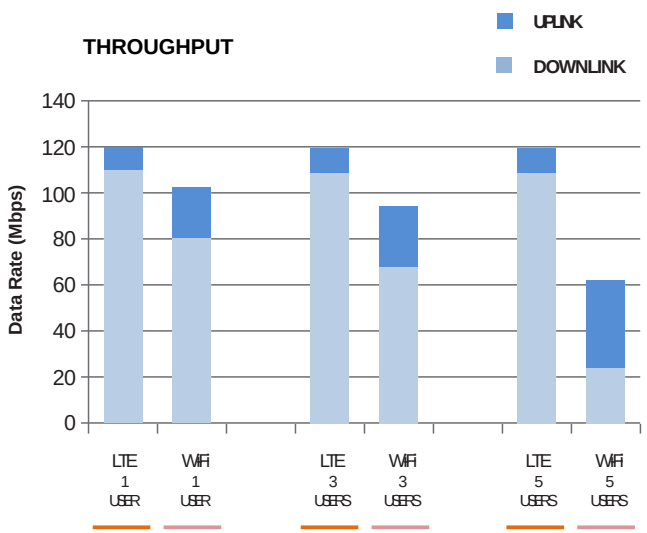
While 802.11 is a favorable protocol for many applications, LTE is a superior standard. This is especially true for carrier grade services that require low latency and consistent performance in high traffic environments. In moving to TD-LTE, Globalstar 2.4 GHz will enjoy a performance advantage relative to the original TLPS concept. The data below summarizes the difference between TD-LTE and 802.11 characteristics.

802.11 Wi-Fi **Frequency:** 2.4 GHz **TX Power Level:** 24 dBm (250 mW) **Antenna Configuration:** UL – 2x2 DL – 2x2

TD-LTE **Frequency:** 2.6 GHz **TX Power Level:** 23 dBm (200 mW) **Antenna Configuration:** UL – 1x2 DL – 2x2





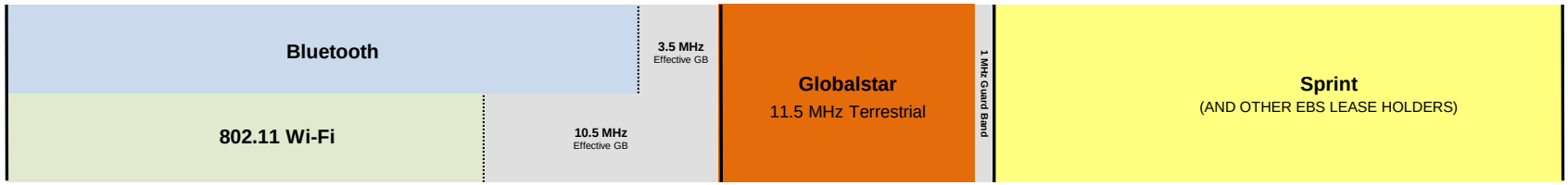


See: Huawei, *LTE Small Cell vs. Wi-Fi User Experience*, www.**huawei**.com/ilink/en/download/HW_323974

International Potential for Globalstar 2.4 GHz

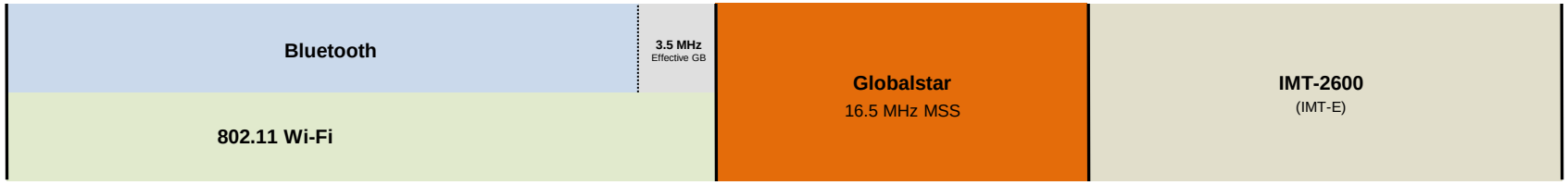
Due to its role as a worldwide Mobile Satellite Service (MSS) provider, the Globalstar spectrum footprint is consistent across all international regulatory domains. Following the recent FCC rule making, Globalstar expects to expand its terrestrial authority in key international markets.

New U.S. Terrestrial Authority



U.S. Satellite (MSS) Authority

Typical Existing Global Band Plan



Note: GB = Guard Band