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Qualcomm Incorporated would like to thank the Infocomm Development Authority of Singapore (IDA) for the opportunity to provide comments on its *Spectrum Framework for Fourth Generation (4G) Mobile Communication Systems in Singapore Consultation* ("Consultation Paper").

Qualcomm is a world leader in developing innovative digital wireless communications technologies and enabling products and services based on the technologies that it develops. It is one of the leading enablers of 3G wireless as well as other wireless solutions and services, including those based on Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM). The 3G CDMA family of wireless technologies, which includes CDMA2000/EV-DO and Wideband CDMA/High Speed Packet Access (HSPA), currently enables over one billion subscribers around the world to enjoy advanced, high speed, and ubiquitous voice and mobile broadband data services in rural, suburban, and urban areas.[1] Qualcomm is also a leading contributor to LTE technology and standards development. Qualcomm broadly licenses its technology to over 180 manufacturers around the world that make infrastructure equipment, handsets and other consumer devices and develop applications based on the 3G CDMA and HSPA air interfaces.

Qualcomm CDMA Technologies (QCT), a division of Qualcomm, is the world's largest supplier of wireless chipsets.[2] QCT has helped lead the diversification of mobile broadband into many new types of mobile broadband enabled devices, ranging from smartphones, PC cards and USB dongles to embedded laptops, netbooks, and a wide variety of pocketable computing devices with mobile broadband capability. These types of devices are already used today by millions of wireless users and provide low-cost, mobile access to the Internet and to broadband applications. Moreover, Qualcomm is uniquely positioned to support the first multimode LTE deployments with industry's first 3G/LTE multimode chipset solutions,

Qualcomm has also announced a new category of mobile broadband devices called "smartbooks." Smartbook devices are devices that bridge the functional divide between smartphones and laptops, delivering the best aspects of a smartphone experience on a larger display.[3] Constantly connected to a 3G mobile broadband network (as well

[1] Wireless Intelligence as of April 19, 2010 for the quarter ending March 31, 2010.
[2] http://www.qualcomm.com/who_we_are/businesses/index.html.
[3] In the territory of the Federal Republic of Germany, the use of the term "smartbook" in connection with portable computers is reserved exclusively to Smartbook AG, Germany.

as Wi-Fi and GPS), smartbook devices are ultra-portable, personalized, easy-to-use, and powered all day on a single battery charge. These devices deliver a unique mobile broadband experience different from any type of device on the market today.

Other divisions and subsidiaries of Qualcomm develop innovations in other aspects of wireless. Qualcomm is at the forefront of mobile multimedia broadcast technology development and has been instrumental in the development of the MediaFLO™ mobile broadcast platform, designed for the delivery of high-quality entertainment and information, including streaming video and audio, clipcasting media, IP datacasting and interactive services.[4] Invented for mobility, MediaFLO technology is designed to increase capacity and coverage, as well as reduce costs for multimedia content delivery to mobile devices. The FLO™ air interface is a globally-recognized standard based on coded OFDM modulation.

Qualcomm MEMS Technologies, Inc., a wholly-owned subsidiary, has developed the world's first MEMS display for mobile devices—a new display technology which offers dramatically lower power consumption and superb viewing quality in a wide range of environmental conditions, including bright sunlight. Qualcomm Internet Services offers software platforms which aim to bring any application to any device on any network in any location. These platforms began with BREW, a thin software layer which was the first platform that enabled the downloading of applications into wireless phones. More recently, Qualcomm Internet Services began offering Plaza Mobile Internet, a platform that allows mobile devices to access widgets, thereby bringing the features and interactivity of Web 2.0 applications to mobile devices, and Plaza Retail, which provides support for multiple app stores, giving wireless subscribers a uniform and easy shopping experience on a wide variety of wireless devices. Finally, Qualcomm recently formed a joint venture with Verizon Wireless by the name of nPhase. The joint venture will provide machine to machine communications and smart service offerings across a wide variety of market segments including healthcare, manufacturing, utilities, distribution, and consumer products over 3G mobile broadband networks.

Qualcomm is highly appreciative of the IDA's efforts to develop a framework and certainty for long term usage of the 2.3 GHz and 2.5 GHz frequency bands by mobile broadband communication systems. Allocation of suitable spectrum is essential to the long term viability of mobile broadband services and to ongoing economic development.

<u>Qualcomm responses to specific questions</u>

Question 1

IDA invites views and comments on the projected spectrum requirements to meet end users' demand for mobile broadband beyond 2015. To what extent can the existing wireless and mobile networks support the anticipated increase in mobile traffic?

IDA also invites views and comments on the likely technologies for the deployment of 4G mobile communication system that will meet end users' mobile communication needs beyond 2015.

Mobile telephony and mobile broadband usage is growing at an unprecedented pace. 3G technologies are currently providing mobile telephony and mobile broadband services to more than one billion subscribers worldwide.[5] On average, 23 million 3G subscribers were added every month in Q4 2009. ABI research estimates that worldwide wireless data traffic grew by 5,800 percent during the two year period from 2006 to 2008; and only slightly decreased growth rates of 4500 percent are forecast over the next few years.[6] Similarly, in the

[4] www.mediaflo.com.

[5] Wireless Intelligence as of April 2010.

[6] http://www.abiresearch.com/press/1466-In+2014+Monthly+Mobile+Data+Traffic+Will+Exceed+2008+Total.

United States, AT&T has reported that its mobile broadband traffic has grown more than 5,000 percent over the past three years.[7] In Singapore, IDA indicates that, between September 2008 and September 2009, 3G subscriptions grew by over 25 percent while High Speed Packet Access (HSPA) subscriptions grew by 240 percent.[8] This phenomenal growth is being driven by a variety of factors such as compelling multimedia applications, the rapid evolution of mobile devices and improved consumer experience, increased data speeds, increased shipments of smartphones and laptop dongles as well as innovative subscription plans and device bundles. The industry is indeed thriving.

The economic and social benefits of mobile telephony and mobile broadband to the Singaporean community have been proven. Broadband stimulates investment, increases productivity, drives innovation, enables economic growth, introduces new business models, creates jobs, and enhances competitiveness. In addition, the economic benefit of mobile broadband can be derived from the positive correlation between a country's broadband readiness and its economic competitiveness. According to an analysis performed by McKinsey, a 10 percent increase in broadband household penetration delivers a boost to a country's GDP that ranges from 0.1 percent to 1.4 percent.[9] These economic benefits refer to both the direct and indirect effects wherein some immediate value is created by the broadband investment as well as the multiplier effect realized downstream. In the UK, Ofcom has concluded that uses of the radio spectrum in the UK contribute £37bn, or 3 percent, to the GDP.[10] In many ways, the use of mobile broadband technology is increasing efficiency and productivity for society and generating welfare gains. In addition to the quantifiable economic benefits, mobile telephony and mobile broadband also provide a myriad of social benefits to the Singaporean community including:

- Mobile Health Care
- Education and distance learning
- Live Reporting
- Mobile Commerce (e.g., internet banking, stock trading)
- Mobile Advertising
- Enhancing Multimedia Applications
- Mobile Entertainment (e.g., videos, movies, music, gaming)
- Social Networking
- Work Telecommuting
- Efficient Transportation and Logistics System
- Mobile Location-Based Services, and
- Disaster preparation and response.

To meet the exponentially increasing demand for these types of applications and services, mobile broadband technologies such as HSPA+ and Long Term Evolution (LTE) are being deployed.

HSPA+ Technology Benefits

3G WCDMA operators have rapidly launched HSPA and HSPA+ services to capitalize on their mobile broadband capabilities and increased data capacity. The majority of HSPA/HSPA+ deployments are in the 1.9/2.1 GHz, 900 MHz and 850 MHz bands. As the natural evolution of WCDMA and HSPA, HSPA+ further enhances the mobile broadband experience and increases capacity through incremental investments and backward compatible handsets.

[7] http://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=30536.
[8] See IDA 3G Consultation Paper at para 3.
[9] "*Mobile broadband for the masses: Regulatory levers to make it happen*", McKinsey & Company, February, 2009.
[10] Ofcom "*Statement on the award of the 2.6 GHz and 2010 MHz bands*" April 2008.

HSPA+ Release 7 (Rel-7) is already commercial and HSPA+ Release 8 (Rel-8) will be commercial in 2010. Moreover, HSPA+ has a strong evolution path; Release 9 (Rel-9) is already standardized and Release 10 (Rel-10) is currently being defined. **See Figure 1 below**.

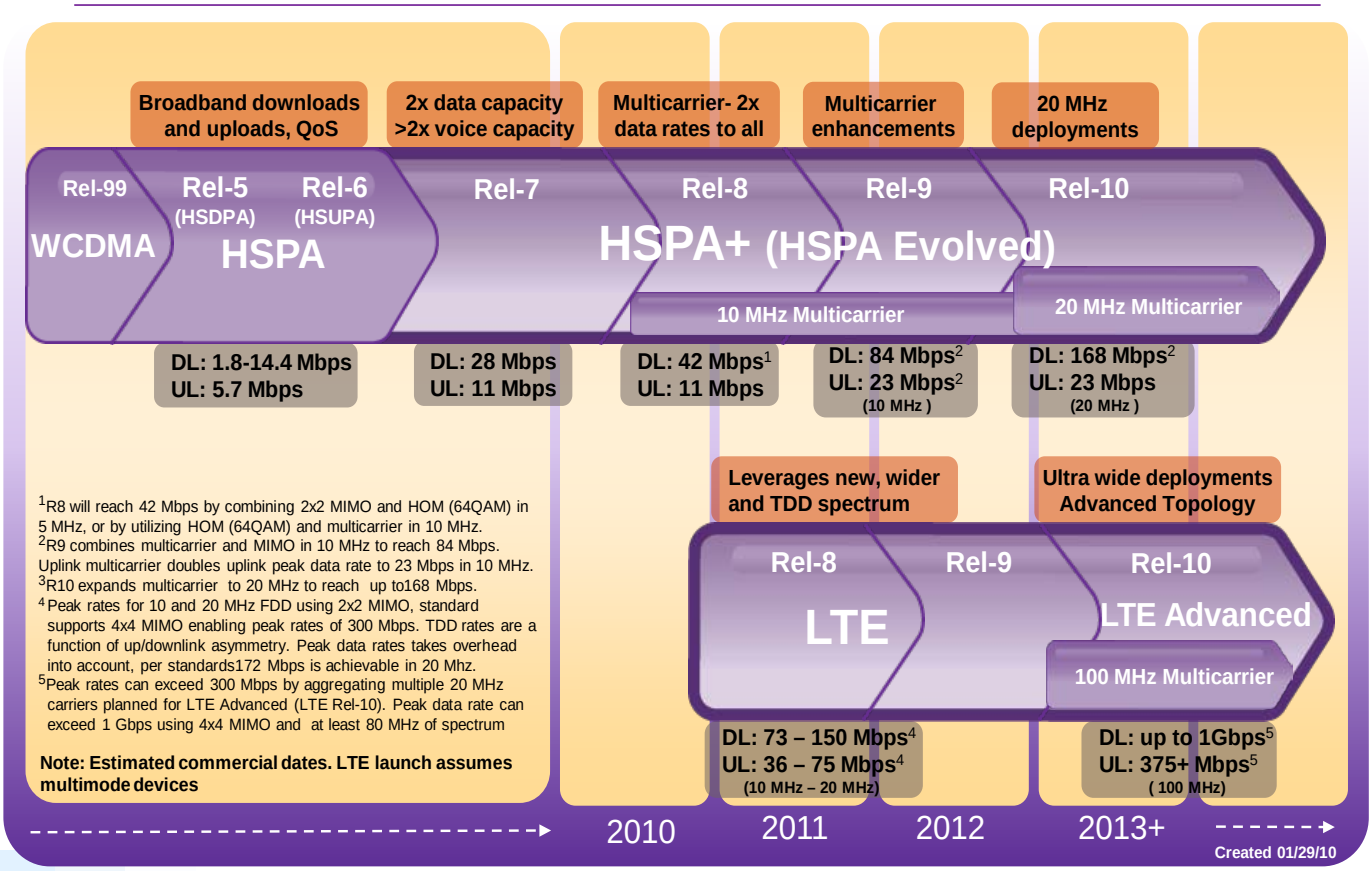


Figure 1: WCDMA/HSPA/HSPA+/LTE evolution roadmap

HSPA+ Rel-7 doubles the data capacity of HSPA, and more than doubles the voice capacity of WCDMA, enabling operators to offer mobile broadband and voice at even lower cost. HSPA+ Rel-8 introduces the first step of the multicarrier feature (a.k.a dual-carrier), aggregating two 5 MHz carriers in the downlink (DL), which doubles the data rates for all users in the cell. Rel-9 expands multicarrier to support aggregation across spectrum bands (e.g., 2.1 GHz and 900 MHz) as well as dual-carrier in the uplink (UL). These features, while significantly increasing capacity and user experience, allow operators to leverage all their spectrum assets. Rel-10 is targeting aggregation of up to four carriers, allowing 20 MHz deployments to achieve an impressive 168 Mbps peak data rate. HSPA+ provides up to 28 Mbps peak data rates in the DL in Rel-7, up to 42 Mbps in Rel-8, and up to 84

Mbps in Rel-9.[11] HSPA+'s strong roadmap continues to enhance performance offering a clear evolution path for current HSPA networks. **See Figure 2 below.**

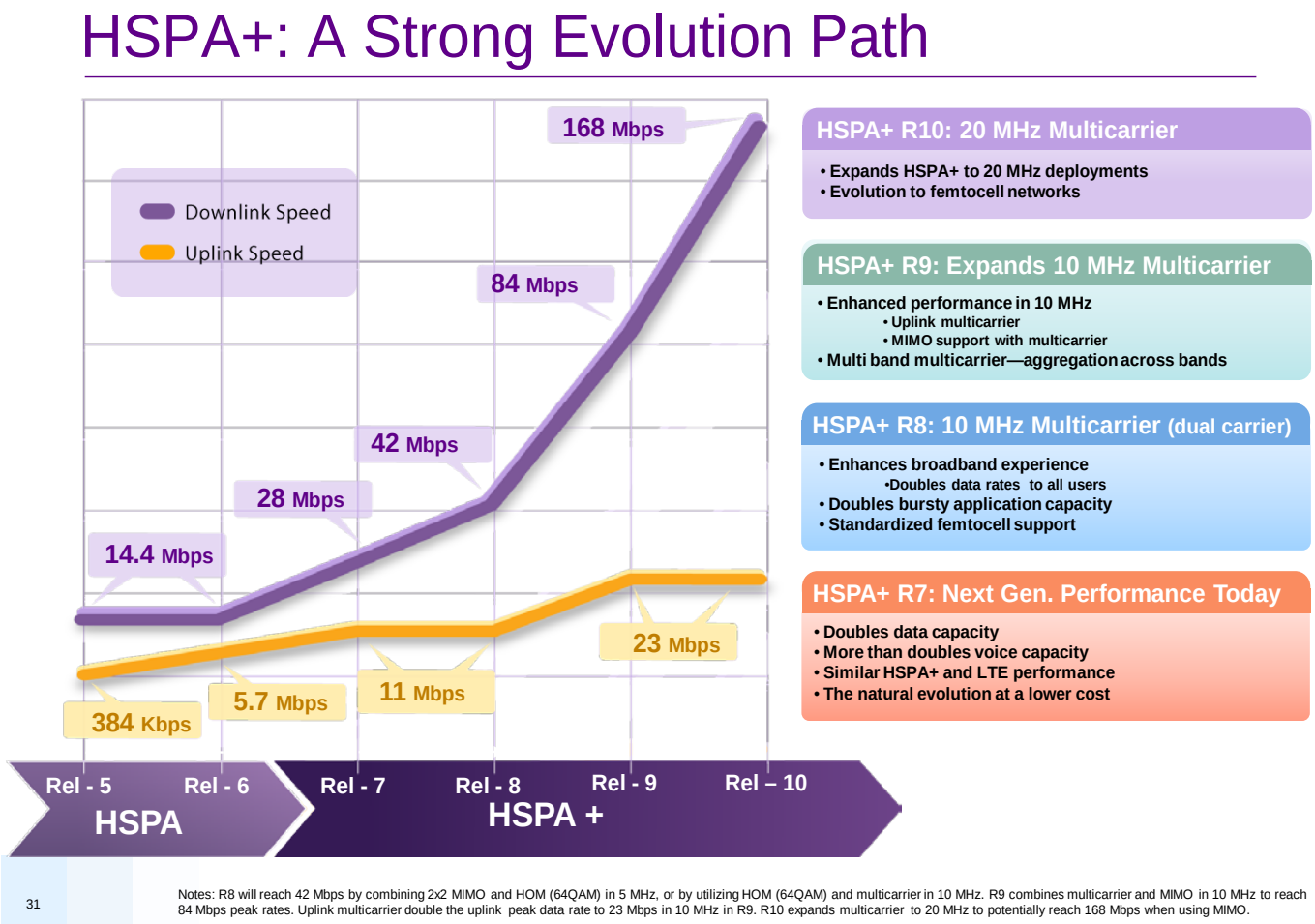


Figure 2: HSPA+ Evolution

Moreover, while HSPA already supports the full range of packet-based IP services with integrated Quality of Service (QoS), HSPA+ further enhances the end-user experience through higher peak rates, lower latency, improved "always-on" experience and extended talk time.

Nearly all 3G WCDMA operators across both developed and developing countries have launched HSPA services to capitalize on its excellent mobile broadband capabilities and increased data capacity. The Global Mobile Suppliers Association (GSA) confirms that as of 14 April 2010, 101 operators in 49 countries have committed to HSPA+ network deployments. Currently, there are 52 HSPA+ systems in commercial service in 32 countries, and

[11] Data rates are based on Qualcomm estimates.

this includes all three of the existing 3G operators in Singapore.[12] The vast majority of these systems support a peak downlink data speed of 21 Mbps, and the remaining six networks support 28 Mbps or higher (42 Mbps). By end 2010, GSA expects that an additional 39 HSPA+ systems will be in commercial service, increasing the overall number of systems to around 90. These figures are in addition to the large number of operators that have already deployed HSDPA and HSUPA technologies (Release 5 and Release 6). HSPA+ has wide industry support, leverages 3G's vast ecosystem, and provides a proven technology with economies of scale in device and network procurement. Consequently, 3G HPSA is expected to enable the vast majority of mobile broadband subscriptions over the next few years. **See Figure 3 below.**

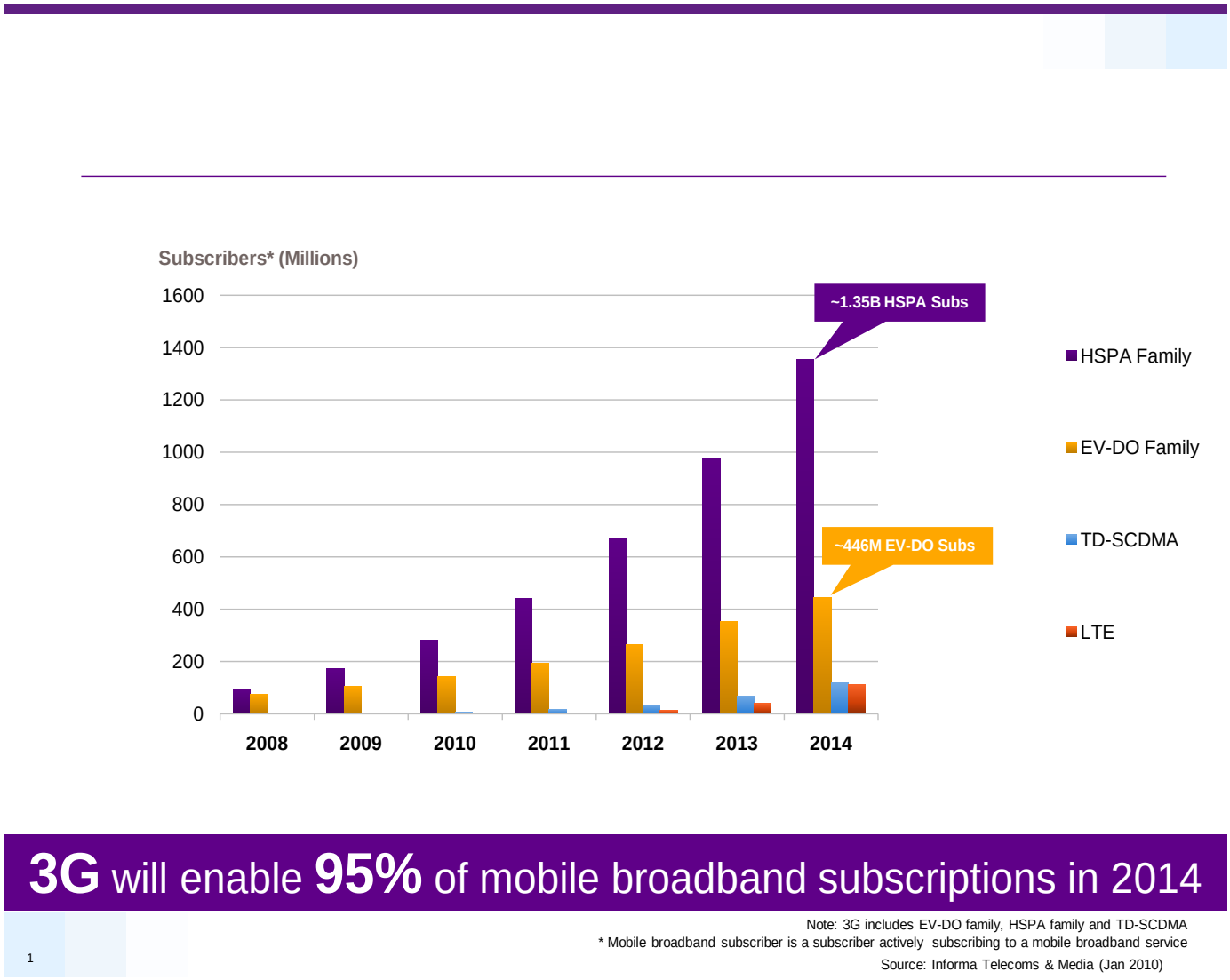


Figure 3: 3G HSPA will enable the majority of mobile broadband subscriptions

LTE Technology Benefits

[12] http://www.gsacom.com/downloads/pdf/Global_eHSPA_network_commitments.php4.

LTE is an optimized OFDMA solution that offers even higher data rates and an enhanced user experience by taking advantage of new spectrum and wider bandwidth channels. LTE will supplement 3G and its evolutions by boosting data capacity and complementing 3G's ubiquitous data and voice coverage. LTE is the natural migration choice for GSM/HSPA network operators as well as CDMA2000 operators since providers will be able to leverage their existing infrastructure as they roll out LTE. Approximately 100 LTE trials were underway or planned by Q4 2009, with more than 40 percent of these trials in the Asia-Pacific region. All of Singapore's mobile operators—SingTel, StarHub, and MobileOne—are currently conducting LTE trials. ABI estimates that there will be 32.6 million LTE subscribers by 2013.

LTE standardization is now complete and has been approved by 3GPP.[13] The standard supports both FDD and TDD modes with the same specification and hardware components. LTE Release 9 features were finalized towards the end of 2009 and LTE Release 10 is expected to follow later this year. LTE Release 10 (LTE-Advanced) is the prime candidate for IMT-Advanced or official "4G" which is currently being defined by the International Telecommunication Union (ITU). LTE peak data rates scale with bandwidth. For LTE Release 8, the peak data rates supported are listed in **Figure 4** below.

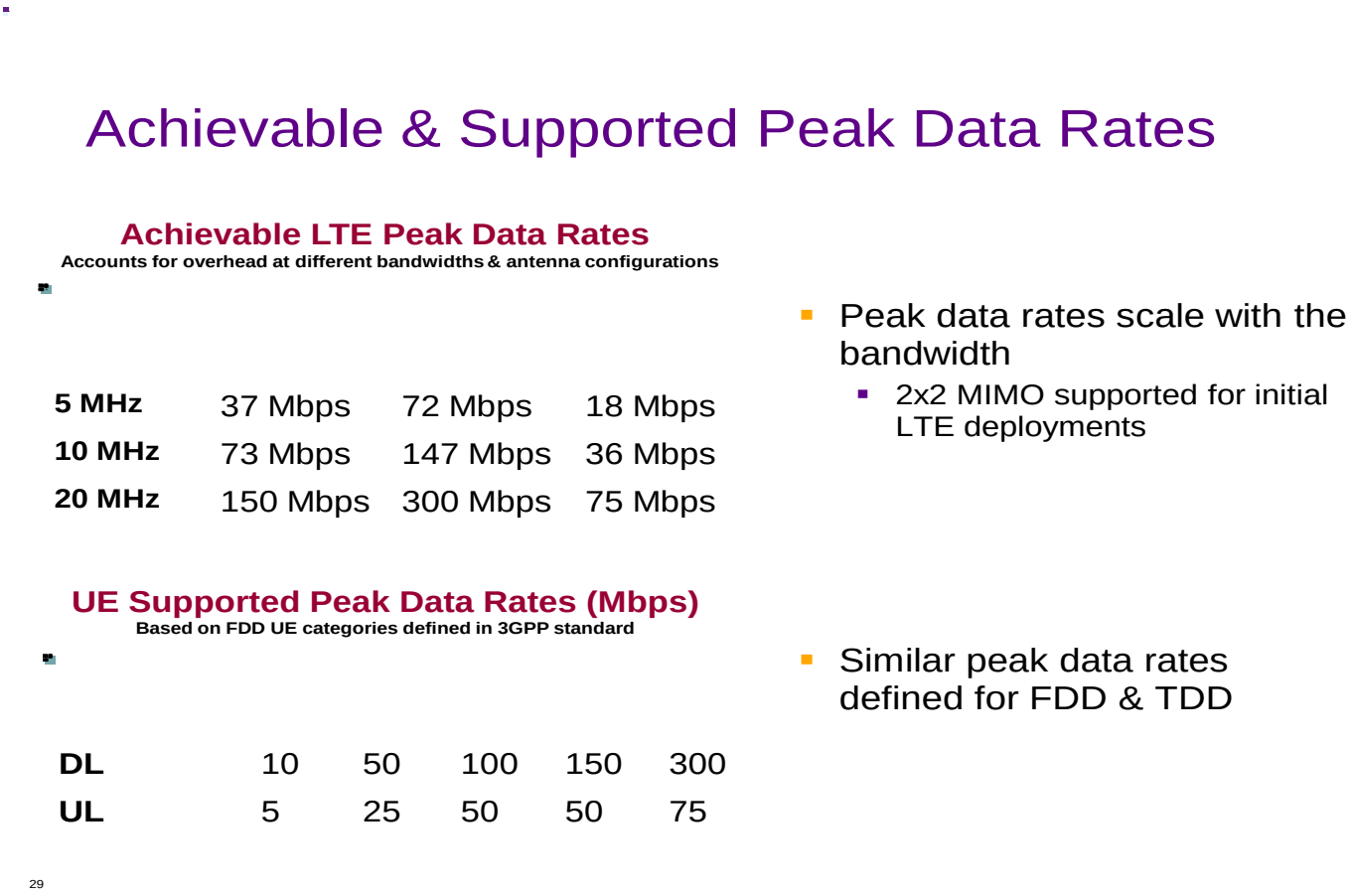


Figure 4: LTE Release 8 Peak Data Rates

[13] See www.3GPP.org.

While HSPA+ provides for optimal usage of existing 5 MHz and aggregated up to 20 MHz of FDD channel bandwidths, LTE is best suited for new wider FDD as well as TDD frequencies with channel bandwidths of 10 MHz or more. Thus, operation of LTE in larger channel bandwidths, such as 2x20 LTE FDD or 20 MHz TD-LTE, will enable the full promise of LTE to be achieved, i.e., very high data rates, enhanced user experience, and support for a large number of simultaneous users. Importantly, LTE has been designed to continue 3G's strong track record of mobility, interoperability, and high spectral efficiency.

Most importantly, LTE has wide industry support and leverages 3G's vast ecosystem. Numerous operators and vendors have made commitments to LTE. TeliaSonera in Sweden launched the world's first commercial LTE FDD network operating in the 2.5 GHz band in December 2009 with a single mode device. Multimode 3G/LTE launches are expected this year. Verizon in the United States and NTT DoCoMo of Japan are both expected to launch commercial LTE FDD services before the end of this year, in the 700 MHz and 1.5 GHz bands, respectively. AT&T is expected to launch commercial LTE services in the 700 MHz band as well in 2011.

TD-LTE support was initially driven by China Mobile, the largest mobile network operator in the world in terms of subscribers. China Mobile is currently conducting TD-LTE trials in the 2.3 GHz band at the Shanghai World Expo. Many major vendors are seen to be developing equipment for TD-LTE including Huawei, Alcatel-Lucent, Nokia Siemens Networks, Ericsson, Motorola, and Qualcomm.[14] Moreover, some WiMAX operators are seriously considering or have decided to migrate to LTE.[15] It is clear that TD-LTE is emerging as the mobile broadband technology of choice for unpaired spectrum. A large part of the global investment into the development of LTE will also be applicable to the TD-LTE variant. The common technical basis for TD-LTE and LTE FDD makes it likely that devices and infrastructure supporting both TD and FDD modes will be developed. Reportedly, such efforts are already underway. In early 2009, China Mobile, Verizon and Vodafone announced a joint effort to support the development of a convergent FDD/TD solution for LTE, i.e., networks and devices supporting both access modes within a single, unified solution.[16]

As of April 2010, the GSA reported 64 operators had already committed to launch LTE in 31 countries.[17] Moreover, the GSA forecasts up to 22 LTE commercial networks will be in service by the end of 2010 and 39 or more will be in service by the end of 2012. A total of 88 operators in 42 countries have committed to deploy LTE systems or are engaged in trials or other planning activities. This includes all three of the mobile network operators in Singapore who have each conducted LTE trials. Thus, we will see greater and greater LTE uptake in the next few years.

To provide seamless ubiquitous data coverage and voice services, and ensure backward compatibility, multimode 3G/LTE devices are essential. Qualcomm is uniquely positioned to support the first multimode LTE deployments with industry's first 3G/LTE multimode chipset solutions, Mobile Data Modem™ (MDM™) MDM9200™, MDM9600™ and Mobile Station Modem™ (MSM™) MSM8960™. MDM9200 and MDM9600 are data-optimized solutions providing peak downlink rates up to 100 Mbps and uplink rates up to 50 Mbps. Qualcomm's target is to deliver the first commercially available multimode (LTE FDD, HSPA+, EV-DO) components based on the MDM9200 by end-2010 in order to ensure the availability of the first USB dongles and data cards by mid-2011. Handset-optimized solutions based on the MSM8960 will follow shortly thereafter. MDM9x00 based

[14] *LTE TDD: The preferred choice for mobilebroadband in unpaired bands*, Claus Hetting & Stefan Stanislawski, Ventura Team LLP, March 2010.

[15] http://www.enterprisemobiletoday.com/news/article.php/3880971/Clearwire-Could-Add-LTE-to-WiMAX-Network.htm; http://www.themoscowtimes.com/business/article/wireless-firm-yota-chooses-lte-technology/406554.html.

[16] See note 14 supra.

[17] http://www.gsacom.com/news/statistics.php4.

TD-LTE trials in 2.3GHz band are underway this year and Qualcomm is targeting to deliver commercial 2.3 GHz TD-LTE chipset components based on the MDM9200 by Q2 2011.

The important point, however, is that band planning needs to be finalized in the near term. Long lead times are required to complete the frequency band planning, allocate and assign the spectrum, license the services, and deploy the networks. Qualcomm firmly believes that 3G HSPA/HSPA+ technology will continue to dominate the mobile broadband market for several years to come. **See Figure 3 above**. Nevertheless, due to the typical lead times required before networks can be deployed and services launched, it is necessary to finalize the policy decisions relatively soon.

While the term "4G" is being used somewhat liberally in marketing material, it is important to clarify that 4G technologies have yet to be defined by the ITU. The ITU has requirements that define the capabilities of International Mobile Telecommunication-Advanced (IMT-Advanced—also known as "4G"), and is currently evaluating two candidate technologies to determine if these radio access technologies meet the requirements. The technologies under consideration are LTE -Advanced (LTE Release 10) and a later version of WiMAX (802.16m). The ITU work on IMT-Advanced will be completed in the late 2011 timeframe and that is when "4G" will be defined.

Challenge: Access to Spectrum

Although anticipating how future demand for mobile data traffic will impact existing wireless and mobile networks may be challenging, it is clear that the phenomenal growth in traffic will put more pressure on current networks as more users adopt Internet-enabled wireless devices, increase their data consumption over each device and substitute wireless for wireline broadband. Although new technologies provide for greater spectral efficiency and throughput rates that will help to offset strains on existing networks, the rising demand for network capacity will outpace technological advances of currently deployed networks. The roll-out of 4G networks will only intensify the demand for mobile broadband service as new applications and devices take advantage of these advanced networks. This growth, however, depends on sufficient access to spectrum, particularly since the supply and demand of bandwidth are interdependent—increased access to bandwidth results in more data-intensive applications, which in turn leads to the need for more bandwidth.

One of the biggest challenges facing the mobile industry in Singapore is the need for additional spectrum to accommodate increasing data demand and allow for technological evolution. Technology advances have led to much improved spectral efficiency/throughput, but demand is still far outpacing current supply. The progression to 4G technologies will require appropriately sized bands, including larger blocks to accommodate wider channel sizes. Additional spectrum needs to be released to the marketplace to meet demand and to enable the deployment of advanced technologies, such as LTE. Importantly, this spectrum needs to be harmonized with other countries so that handset/user devices are readily available, affordable and have the capability to roam.

Question 2

IDA invites views and comments on the possible radio-frequency spectrum bands, besides the 700/800 MHz, 2.3 GHz and 2.5 GHz bands, that would be suitable for 4G mobile communication systems and the likely timeframe for deployment. To what extent are the 900 MHz, 1800 MHz and 2.1 GHz alternative bands for 4G deployment? Are there other frequency bands that are currently not allocated but could be potential candidates for 4G system deployment?

In order to satisfy consumer demands and support a wide range of application and services, mobile network operators will ultimately require access to both low and high frequency bands to meet coverage and capacity requirements. Industry has, therefore, been upgrading existing mobile networks to HSPA+ technology and is

targeting new spectrum bands to deploy LTE. In particular, the industry has been targeting the 700 MHz and the 2.5 GHz bands for LTE FDD because of the unique ability to deploy wider channel bandwidths, up to 2x 20 MHz, and to fulfill both coverage and capacity requirements. In certain countries, sufficient contiguous spectrum is also available at 1800 MHz, presenting an opportunity for introduction of LTE FDD in this band as well. More recently, the industry has been targeting the 2.3 GHz band to deploy TD-LTE because of the widespread availability of this band, especially in the Asia Pacific region, and because of the ability to deploy wider bandwidth 20 MHz TD-LTE. TD-LTE is becoming the favored global technology solution for unpaired spectrum. Operation of 2x20 MHz LTE FDD and 20 MHz TD-LTE enables the full promise of LTE to be achieved, i.e., support for a large number of simultaneous users and reduced price per Mbit/s. Thus, we expect to see the most deployments of 4G in the 700 MHz, 1800 MHz, 2.3 GHz and 2.5 GHz bands where economies of scale will be realized, and user equipment will be widely available and affordable. We may see some LTE deployments in other frequency bands as well; however, at this time Qualcomm does not anticipate these would be on the same scale and generate the same volumes as the frequency bands listed above.

Question 3

IDA invites views and comments on the demand for the 2.5 GHz band after 2015 in Singapore, and the technologies that are currently being developed for use in the 2.5 GHz band. Are these likely to complement or substitute existing networks? Please also comment on the availability of the network equipment.

As explained in our response to Question 1 above, mobile telephony and mobile broadband usage is growing at an unprecedented pace. Based on these figures, the 2.5 GHz band will be in great demand well before 2015. LTE is the technology best suited to address the growing demand for high bandwidth mobile broadband services. Commercial LTE networks have already been launched in some countries in this band and many others are conducting trials. Additional allocations and licensing are also anticipated in the next one to two years. This significant investment is based largely on the fact that the 2500-2690 MHz frequency band was allocated by the ITU for IMT-2000 10 years ago at WRC-2000. Therefore, government and industry all over the world have been planning the launch of mobile broadband networks in this band for some time, and it has been targeted by 3G operators as an "extension" band for provision of additional capacity.

Evidence of the demand for spectrum in the 2.5 GHz band may be seen in the growing number of countries that have allocated and assigned spectrum in the band in the last several years. For a list of recent assignments, please see **Annex A**.

The 2.5 GHz band is particularly significant in that it represents an opportunity for the first truly harmonized global IMT band. Given that the 2.5 GHz frequency band has been identified for IMT on a world wide basis and in all three ITU Regions, this band is likely to enjoy the minimum possible costs of handset equipment thus far for the mobile industry. It is in Singapore's best interests to harmonize its 2.5 GHz spectrum usage on a regional or multi-regional basis to the greatest extent possible. Such harmonization would generate economies of scale, reducing the cost of user equipment and ensuring the equipment is available, affordable and supports international roaming. Also of great significance for Singapore are the benefits harmonization would bring to cross-border coordination with neighboring countries. Spectrum harmonization with neighboring countries would allow each country to utilize a much greater portion of the scarce spectrum resource without having to resort to frequency segmentation.

LTE has been designed to fully complement existing 3G networks. It is a natural technology migration on the 3GPP evolution roadmap and all user equipment will be backward compatible with 3G networks allowing seamless connectivity and the ability to "fall back" to 3G network coverage in geographic areas where LTE coverage is yet to be deployed, as well as for voice services throughout the network.

Please refer to Qualcomm's response to Question 1 above regarding the availability of network equipment.

Question 4

IDA invites views and comments on the paired and unpaired spectrum arrangements in the 2.5 GHz band after 2015.

Irrespective of what technologies or services may be deployed, a common and harmonized band plan reduces the risks of interference and facilitates economies of scale and international roaming, which in turn brings benefits to consumers. Qualcomm strongly supports the 2.5 GHz channel arrangement contained in the ITU Radiocommunications Sector Recommendation M.1036-3 Option C1 for this frequency range, which corresponds to IDA's Option A. This Option designates 2500-2570 MHz for FDD uplink, 2570-2620 MHz for TDD, and 2620-2690 MHz for FDD downlink. The advantages to this band plan are that it provides separate band segments for FDD and TDD operations, maintains the 120 MHz duplex separation required by 3GPP specifications and ITU-R Rec. M.1036-3, and would be consistent with the 2.5 GHz channel arrangement expected to be used by most other countries around the world. Adopting another option would lead to Singapore-specific handsets which would be costly to produce and difficult, if not impossible, to be used to roam with other countries.

As the IDA correctly notes, the European Electronic Communications Committee (ECC) also acknowledged these benefits and adopted this same channel arrangement which has been included in ECC Decision (05)05 of 18 March 2005, "On harmonized utilisation of spectrum for IMT-2000/UMTS systems operating within the band 2500-2690 MHz." This decision has provided clarity to the stakeholders and a clear path forward for the 2.5 GHz band in Europe, allowing industry to proceed with product development in the band. To date, over 20 European countries have implemented or are committed to implementing ECC(05)05.[18] Norway completed its auction of this band in November 2007, Sweden in mid-2008, Finland in November 2009, Netherlands in April 2010, and Denmark and Germany in May 2010. Furthermore, France and the United Kingdom have each announced plans to auction this band within the next year.

Within the Asia Pacific region, Hong Kong and New Zealand have already auctioned the 2.5 GHz spectrum and licensed networks which are largely aligned with this channel arrangement. Australia also released a proposal earlier this year to allocate and auction 2.5 GHz spectrum for mobile consistent with the ECC/DEC/(05)05 channel plan.

Qualcomm does not support use of any type of "flexible" FDD/TDD band plan as these arrangements would result in a technically inefficient use of valuable spectrum. Studies in various fora have been conducted on the amount of guard band required between TDD and FDD applications in order to minimize the potential for interference between the differing networks. Qualcomm agrees with the general conclusion of these studies that a minimum designation of 5 MHz guard band is needed between TDD and FDD.[19] Consequently, in order to maximize usage and efficiency of this spectrum, it is necessary to minimize the number of FDD/TDD borders. This is best done through the allocation of a single TDD band segment between the FDD paired operations in 2500-2570 MHz and 2620-2690 MHz.

[18] http://www.erodocdb.dk/doks/implement_doc_adm.aspx?docid=2056.

[19] "To achieve compatibility a separation of 5 MHz is needed between the edges of spectrum blocks used for unrestricted TDD (time division duplex) and FDD operation (frequency division duplex) or in the case of two unsynchronised networks operating in TDD mode"; European Commission Decision of 13 June 2008 on the harmonisation of the 2 500-2 690 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community.

As stated above, both FDD LTE and TD-LTE have been optimized for frequencies with larger channel bandwidths. Nevertheless, our current understanding is that the 2.5 GHz band in Singapore has been targeted for many years to provide FDD LTE mobile broadband services and there are operator commitments to deploy FDD LTE networks in this band.

Question 5

IDA invites views and comments on whether the size of 5 MHz guard block at the frequency boundaries between paired and unpaired spectrum is sufficient to safeguard the adjacent band. IDA also invites views on our proposal not to specify guard block requirement between licensees using the TDD or FDD band.

Qualcomm supports the IDA's proposal and strongly encourages the designation of the 2570-2575 MHz and 2615-2620 MHz blocks as guard bands between FDD and TDD operations. Numerous studies have shown that a guard band is needed between FDD and TDD operations. In Europe, the European Commission has studied the interference and implementation constraints linked to terminals for the FDD/TDD scenario. ECC Report 131 contains the results of these studies and identifies technical conditions of access to the band for terminals.[20] In particular, ECC Report 131 identifies some mobile station to mobile station interference issues at the border between FDD and TDD blocks, and also between unsynchronized TDD blocks. The coexistence of terminals without harmful interference in the 2.5 GHz band imposes severe emission restrictions at the 2570 and 2620 MHz borders between FDD and TDD. If precautions are not taken in the band plan design, the potential interference constraints will go well beyond the filtering capabilities defined by 3GPP standards for terminals. This could result in the need for additional specific RF components (RF filters) for terminals with several adverse effects. Qualcomm recommends that the IDA carefully consider these interference issues. It is critical for operators to have an operating environment free from harmful interference, while also ensuring the availability of affordable mass market equipment.

In particular, Qualcomm urges the IDA to not adopt any technical conditions, particularly on mobile terminals, that are more constraining than those required by the European Commission (EC) Decision of 13 June 2008.[21] Most European countries will conform to the EC Decision technical conditions and not impose more stringent requirements. In particular, Qualcomm would have concerns with requiring any out-of-block power limits on mobile terminals due to the constraints this would place on mobile terminal design and the ability to realize the full benefits of LTE.

According to the conclusions of the CEPT Report 19 and ECC Report 131, the 2570-2575 MHz and 2615-2620 MHz frequency blocks can only be used under very stringent technical restrictions. Furthermore, the emission limits defined to protect adjacent frequency blocks indicate that these two frequency blocks will correspond to the RF-filter transition bands of the equipment and, therefore, will be subject to severe interference. Such constraints raise major questions regarding the value of these blocks, as well as the availability of equipment capable of operating in them.

Most countries have identified the guard band in the TDD domain and corresponding terminals are designed accordingly. Applying the guard band at any other place than the TDD spectrum would result in the requirement for terminals specifically designed and manufactured for this case and would entail a corresponding price premium. Qualcomm, therefore, recommends identifying the blocks 2570-2575 MHz and 2615-2620 MHz as

[20] http://www.erodocdb.dk/Docs/doc98/Official/Pdf/ECCRep131.pdf.

[21] European Commission Decision "on the harmonisation of the 2 500-2 690 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community"; 13 June 2008, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:163:0037:0041:EN:PDF.

guard band between the FDD and TDD blocks in order to reduce the interference risks between FDD and TDD networks and to ensure Singapore consumers have access to a wide variety of affordable user devices.

With respect to guard blocks between licensees using the TDD or FDD band, we agree there is not a need to specify guard band requirements between these licensees.

Question 6

IDA invites views and comments on whether allocating 5 MHz spectrum lot size is appropriate for the current technologies in the 2.5 GHz band. IDA also invites views on our proposal to allocate spectrum in individual blocks of 5 MHz and let operators who need a larger carrier size to combine multiple blocks together. Alternatively, should IDA allocate in larger blocks based on multiples of 5 MHz?

The full benefits of LTE will only be realized when larger channel bandwidths, such as 20 MHz, are made available, although it supports channel bandwidths from 1.4 to 20 MHz. Based on this, business plans are likely to envisage 20 MHz LTE carriers. Qualcomm's preferred approach would be to allocate spectrum in three 20 MHz blocks and one 10 MHz block, with the 10 MHz block comprising 2560-2570 paired with 2680-2690 MHz. This would be consistent with the 2.5 GHz band plans being developed in a number of other countries. In addition, allocating the narrower 10 MHz block adjacent to the 2570 MHz border would ease FDD/TDD adjacency considerations.

Given that LTE will be deployed in channel bandwidths that are a multiple of 5 MHz, the IDA proposal to allocate in 5 MHz lots may also be workable, provided bidders are able to combine multiple blocks together. However, there would be some uncertainty as to whether each final licensee would have the ability to deploy 2 x 20 MHz LTE, thus realizing the full benefits of LTE.

Question 7

IDA invites views and comments on our proposal for an interleaved band plan with combinations of 15 MHz and 20 MHz paired spectrum blocks as well as 25 MHz of unpaired spectrum blocks available for assignment in contiguous block of 15 MHz, 20 MHz and 25 MHz respectively by IDA and whether this would be appropriate. IDA also invites views and comments on the practical measures that operators would implement to allow coexistence of BSS and mobile services in the same band in the border areas so that more spectrum blocks can be made available.

We encourage IDA to continue discussions with neighboring countries on possibilities for greater mobile service access to this spectrum. Broadcast-satellite service usage of the 2.5 GHz band is somewhat unique and efforts to harmonize Singapore's usage of this band for mobile services on a regional or multi-regional basis should be explored.

As detailed above in our responses to Questions 4 and 5, Qualcomm supports Option A with blocks 15 and 24 designated as guard band. Mobile handsets rely on passive components (e.g., filters) in order to avoid interference to and from adjacent bands. These passive components cannot adapt to country specific band plans. Thus, it is necessary to align with a harmonized band plan such as the ECC/DEC/(05)05 band plan in order to benefit from mass market user equipment that is readily available and affordable. Singapore-specific terminals would be more difficult to source and more costly to consumers due to the inability to leverage mass market economies of scale. To ensure Singapore consumers have access to a wide variety of affordable user devices, Qualcomm strongly urges the IDA to adopt Option A.

Question 8

IDA invites views and comments on the likely technologies for the 2.3 GHz band and the availability of network equipments for use in the band. IDA also invites views on our proposal to retain the existing channeling plan for the 2.3 GHz band and to allocate the spectrum in blocks of 5 MHz when the band is re-allocated after 2015. Please also comment on whether the current amount of 50 MHz spectrum available in the 2.3 GHz band is sufficient to meet industry demands after 2015.

TD-LTE is emerging as the mobile broadband technology of choice for the 2.3 GHz spectrum. Due to the common technical basis it shares with FDD LTE, TD-LTE will be able to leverage the vast 3G/LTE ecosystem of vendors, infrastructure, and user devices. As is the case with FDD LTE, the full benefits of TD-LTE will only be realized when larger channel bandwidths, such as 20 MHz, are made available. Based on this, we believe business plans are likely to envisage 20 MHz TD-LTE carriers. Qualcomm's preferred approach would be to allocate spectrum in the 2.3 GHz band in 20 MHz blocks. Given that TD-LTE will be deployed in channel bandwidths that are a multiple of 5 MHz, the IDA proposal to allocate in 5 MHz lots may also be workable, provided bidders are able to combine multiple blocks together. However, there would be some uncertainty as to whether each final licensee would have the ability to deploy 20 MHz carriers, thus realizing the full benefits of LTE.

Also for the 2.3 GHz band, we encourage the IDA to continue discussions with neighboring countries on possibilities for greater mobile service access to this scarce and valuable spectrum resource which is in high demand. Other techniques in addition to full frequency segmentation could be explored. Harmonization of 2.3 GHz band usage could greatly assist coordination efforts, and we understand that efforts are already underway in the Asia Pacific Telecommunity Wireless Forum towards regional harmonization of this band.[22] In addition, the ITU Radiocommunication Sector (ITU-R) has developed a channel plan(s) for the 2.3 GHz band which is contained in ITU-R Recommendation M.1036-3.

Our views on the unprecedented growth and demand for mobile broadband services in the next few years are provided in response to Question 1 above. While this band has not been heavily utilized by mobile services in the past, mobile technology has evolved greatly in recent years and the industry, particularly in the Asia Pacific region, is now targeting the 2.3 GHz band to meet mobile broadband needs, specifically through the use of TD-LTE. This is based in part on the identification of the 2.3 – 2.4 GHz band for IMT at ITU World Radiocommunication Conference 2007. Thus, we anticipate a much greater utilization of the 2.3 GHz band than has been the case in the past, and we expect the vast majority of deployments and subscriber uptake to be based on TD-LTE technology.

Please refer to our response to Question 1 above regarding availability of equipment for use in this band.

Question 9:

IDA invites views and comments on what is an appropriate timeframe for IDA to allocate the 2.3 GHz and 2.5 GHz bands. Should the allocation of the 2.3 GHz band proceed separately from that of the 2.5 GHz band, given the greater uncertainty over the timeframe in which the 2.5 GHz band would be available? If so, when would be an appropriate timeframe for IDA to allocate the 2.3 GHz band?

Given the lead times typically required in planning and deploying a new network, Qualcomm encourages the IDA to finalize its policy decisions as soon as possible and to provide a timeline for allocation and licensing which would allow new services to be launched upon expiry of the current licenses on June 30, 2015, *if not sooner*.

Question 10:

[22] http://www.aptsec.org/APTAWF.

IDA invites views and comments on what would be a fair and efficient allocation mechanism for the 2.5 GHz band. In the case where there are existing deployments in the band, should IDA grant first rights of refusal for the current right-holders?

Qualcomm supports IDA's continued market-based approach to releasing spectrum and believes auctions have proven to be an effective method for assigning spectrum in a fair and efficient manner to those that value it most. Many of the 2.3 GHz and 2.5 GHz licensees have not launched commercial services or have limited networks/services. The IDA needs to carefully weigh the costs of migrating these limited users to alternative frequencies with the benefits of harmonized frequency band usage. Adopting non-harmonized channel plans will result in the need for Singapore-specific terminals that will be more difficult to source and more costly to consumers due to the inability to leverage mass market economies of scale. Moreover, the economic and social benefits of mobile broadband services, which have been highlighted in response to Question 1 above, clearly argue in favor of re-allocation and harmonization of the bands.

Question 11:

IDA invites views and comments on the proposal to impose both service provisioning and coverage obligations on the operators awarded the 2.3 GHz and 2.5 GHz spectrum after 2015. In particular, what would be an appropriate service provisioning obligation and the timeframe for deployment bearing in mind that the spectrum assignment is likely to take effect only from 1 July 2015? Similarly, what would be an appropriate measure for service coverage obligation and the timeframe for deployment?

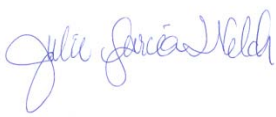
Qualcomm supports the IDA's proposal to impose service provisioning and coverage obligations as a means to ensure efficient and timely use of scarce and valuable spectrum resources.

Conclusion

In conclusion, Qualcomm appreciates this opportunity to provide comments on its *Spectrum Framework for Fourth Generation (4G) Mobile Communication Systems in Singapore Consultation.* Qualcomm strongly urges the IDA to reallocate the 2.3 GHz and 2.5 GHz bands based on the harmonized frequency arrangements that have been developed and to release this spectrum to the market as expeditiously as possible. The demand for this spectrum has been proven. We also encourage the IDA to maintain Singapore's technology leadership position and allow for the deployment of innovative new mobile broadband services based on LTE in these two frequency bands.

Should you have any questions or comments on this submission, please do not hesitate to contact me at +852 6348 6687 (mobile) or juliewelch@qualcomm.com.

Sincerely,



Julie Garcia Welch
Senior Director, Government Affairs
Southeast Asia & Pacific

cc: SengHee Tan, Director of Business Development and Country Manager for Singapore, Qualcomm Intl.

ANNEX A: Assignments in the 2.5 GHz Band

2.5 GHz Licenses				
Date	**Country**	**Licensees**	**Total MHz**	**Band block (MHz)**
10-May-2010	Denmark	TDC	40	2500-2520 MHz/2620-2640 MHz
		Hi3G	20	2520-2530 MHz/2640-2650 MHz
		Telia Nättjänster Norden AB	40	2530-2550 MHz/2670-2690 MHz
		Telenor	40	2550-2570 MHz/2670-2690 MHz
		Hi3G	25	2570-2595 MHz
		Telenor	10	2595-2605 MHz
		Telia Nättjänster Norden AB	15	2605-2620 MHz
26-Apr-10	Netherlands	Ziggo 4 B.V.	40	2510-2530/2630-2650 MHz
		Tele2 Mobiel B.V	45	2545-2565/2665-2685/2685-2690 MHz
		KPN B.V.	20	2535-2545/2655-2665 MHz
		Vodafone Libertel B.V.	20	2500-2510/2620-2630 MHz
		T-Mobile Netherlands B.V.	10	2530-2535/2650-2655 MHz
23-Nov-09	Finland	DNA Oy	40	2500-2520/2620-2640 MHz
		TeliaSonera Finland	50	2520-2545/2640-2665 MHz
		Elisa Oyj	50	2545-2570/2665-2690 MHz
		Pirkanmaan Verkko Oy	50	2570-2620 MHz
Nov-09	Peru	BWDC-Metsanco	24	2668-2692 MHz (Lima
30-Oct-09	United States (limited areas)	Cellular South Licenses Inc.	76.5	2496-2502/2602-2615/2616-2673.5 MHz
		Clearwire Spectrum Holdings III, LLC	76.5	2496-2502/2602-2615/2616-2673.5 MHz
		DigitalBridge Spectrum II, LLC	76.5	2496-2502/2602-2615/2616-2673.5 MHz
		McCotter, James E	76.5	2496-2502/2602-

				2615/2616-2673.5 MHz
		Stratos Offshore Services Company	76.5	2496-2502/2602-2615/2616-2673.5 MHz
		Trident Global Communications, LLC	76.5	2496-2502/2602-2615/2616-2673.5 MHz
		Twin Lakes Telephone Cooperative Corporation	76.5	2496-2502/2602-2615/2616-2673.5 MHz
		Utopian Wireless Corporation	76.5	2496-2502/2602-2615/2616-2673.5 MHz
		Vermont Telephone Company, Inc.	76.5	2496-2502/2602-2615/2616-2673.5 MHz
		Ztark Communications LLC	76.5	2496-2502/2602-2615/2616-2673.5 MHz
	Puerto Rico	Clearwire Spectrum Holdings III, LLC	76.5	2496-2502/2602-2615/2616-2673.5 MHz
	Guam	McCotter, James E.	76.5	2496-2502/2602-2615/2616-2673.5 MHz
	N. Mariana Islands	McCotter, James E.	76.5	2496-2502/2602-2615/2616-2673.5 MHz
Sep-09	Jamaica	Digicel		Not specified
30-Sep-09	Nicaragua	Yota de Nicaragua		Not specified
22-Jan-09	Hong Kong	Genius Brand	30	2500-2515/2620-2635 MHz
		Hong Kong CSL	30	2540-2555/2660-2675 MHz
		China Mobile Hong Kong	30	2555-2570/2675-2690 MHz
24-Sep-08	Bangladesh	BanglaLion Communications	35	2585-2620 MHz
30-Jul-08	Honduras	Digicel	20	2602-2612
		Digicel	24	2602-2626
		Digicel	24	2590-2614 MHz
16-Jun-08	Japan	42 regional licensees	10	2580-2590 MHz
8-May-08	Sweden	Tele2	40	2500-2520/2620-2640 MHz
		Hi3G	20	2520-2530/2640-2650 MHz
		TeliaSonera	40	2530-2550/2650-2670 MHz
		Telenor	40	2550-2570/2670-2690 MHz
		Intel Capital Corporation	50	2570-2620 MHz
21-Dec-07	Japan	Willcom	30	2545-2575 MHz
		UQ Com	30	2595-2625 MHz
18-Dec-07	New Zealand	Cayman Spectrum (NZ) Co. Ltd	20	2500-2520 MHz
		Telecom Leasing Ltd	20	2520-2540 MHz
		Vodafone Mobile NZ Ltd	35	2540-2575 MHz

		Cayman Spectrum (NZ) Co. Ltd	20	2620-2640 MHz
		Telecom Leasing Ltd	20	2640-2660 MHz
		Blue Reach Ltd	30	2660-2690 MHz
13-Nov-07	Norway	Craig Wireless	10	2570-2610 MHz
		Craig Wireless	10	2580-2590 MHz
		Craig Wireless	10	2590-2600 MHz
		Craig Wireless	10	2600-2610 MHz
		Craig Wireless	10	2610-2620 MHz
		Hafslund, NetCom	10	2500-2540/2620-2660 MHz
		NetCom	10	2505-2510/2625-2630 MHz
		NetCom	10	2510-2515/2630-2635 MHz
		NetCom	10	2515-2520/2635-2640 MHz
		Telenor	10	2520-2525/2640-2645 MHz
		Telenor	10	2525-2530/2645-2650 MHz
		Telenor	10	2530-2535/2650-2655 MHz
		Telenor	10	2535-2540/2655-2660 MHz
		Telenor	10	2540-2570 MHz
		Telenor	10	2550-2660 MHz
		Hafslund, Arctic Wireless	10	2560-2570 MHz
		Telenor	10	2660-2670 MHz
		Telenor	10	2670-2680 MHz
		Hafslund, NetCom	10	2680-2690 MHz
26-Jul-07	Taiwan	Fitel	30	2565-2595MHz
		Global On Corporation	30	2595-2625MHz
		Vmax Telecom	30	2660-2690MHz
		FET	30	2565-2595MHz
		Tatung Telecom	30	2595-2625MHz
		Vastar Cable TV Systems	30	2660-2690MHz
2.3 GHz Licenses				
-	Australia	Australia Unwired / Vivid Wireless	91 MHz	2300 – 2400 MHz
16-Jul-09	Indonesia	8 winning bidders	30	2360-2390 MHz
24-Sep-08	Bangladesh	Brac Bdmail Network	45	2320-2365 MHz
		Augere Wireless Broadband	35	2365-2400 MHz
30-Jul-08	Honduras	Telefonica Celular	10	2390-2400 MHz
		Autoconsa	5	2315-2320 MHz
		Autoconsa	5	2317-2322 MHz
		None	10	2305-2310 MHz/2350-

				2355 MHz
		None	10	2305-2315 MHz/2350-2360 MHz
		None	5	2320-2325 MHz
18-Dec-07	New Zealand	Kordia Ltd	35	2300-2335 MHz
		Woosh Wireless Ltd	35	2335-2370 MHz
Mar-07	Malaysia	Asiaspace Dotcom	30	2300-2330 MHz
		Bizsurf	30	2330-2360 MHz
		MIB Comm (P1)	30	2360-2390 MHz
		Redtone-CNX Broadband	25	2375-2400 MHz

* For purposes of this chart, "authorization" is an inclusive term that refers generally to spectrum rights, authorizations and licenses.

Source: Authorization information has been sourced from telecommunications regulators or spectrum management authorities.