Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matters of	
International Comparisons and Consumer Survey Requirements in the Broadband Data Improvement Act	GN Docket No. 09-47
A National Broadband Plan for Our Future	GN Docket No. 09-51
Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act	GN Docket No. 09-137

Comments of 3G Americas—NBP Public Notice #6

3G Americas, LLC, the leading industry association in the Americas representing the GSM family of technologies, including HSPA and LTE, submits these comments in response to the Commission's Public Notice ("*Notice 6*")[1] in the above-referenced proceeding concerning the Commission's development of a National Broadband Plan pursuant to the American Recovery and Reinvestment Act of 2009.[2] 3G Americas requests that the Commission allocate spectrum for mobile broadband that has been recommended by the International Telecommunications Union for IMT Advanced, since globally identified spectrum benefits U.S. consumers of mobile broadband by allowing

1 Comment Sought on Spectrum for Broadband, NBP Public Notice #6, GN Docket Nos. 09-47, 09-51, and 09-137 (Sept. 23, 2009)..

2 American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, 123 Stat. 115 (2009).

carriers economies of scale in infrastructure, devices and the delivery of innovative applications

3G Americas has a broad membership of leading wireless operators and vendors promoting, facilitating, and advocating the deployment of the GSM family of technologies throughout the Americas.[3] In these comments, 3G Americas seeks to answer the questions posed in *Notice 6* by the Commission about the sufficiency of current spectrum allocations.

Response to Questions

1. What is the ability of current spectrum allocation to support next-generation build-out and the anticipated surge in demand and throughput requirements?

a. How should we think about the capacity of existing allocations and their ability to support growth in wireless broadband? How can we further characterize the impact of a shortage of spectrum available for mobile wireless services?

1. Existing Allocations and the Move to Increase Allocations for Mobile Broadband.

The U.S. has been, and should continue to be, the world leader in wireless mobile broadband. Because of U.S. leadership in this area, the American public has been fortunate enough to "use wireless service at a much higher rate than their counterparts in other countries."[4]

Despite its traditional leadership, the U.S. has not acted as quickly as have most European countries to provide spectrum for the exploding growth of mobile broadband.

3 3G Americas Board of Governor members include Alcatel-Lucent, Andrew, AT&T, Cable & Wireless, Ericsson, Gemalto, HP, Huawei, Motorola, Nortel Networks, Nokia, Openwave, Research in Motion, Rogers, T-Mobile USA, Telcel, Telefónica, and Texas Instruments.

4 Comments of T-Mobile, USA, Inc. at 18, WT Docket No. 09-66, GN Docket Nos. 09-157 and 09-51 (filed Sept. 30, 2009) ("T-Mobile Comments").

As T-Mobile and CTIA have explained to the Commission, most European countries have and are continuing to make plans to allocate additional spectrum for wireless services. For example:

> The U.K. currently has 352.8 MHz assigned for commercial wireless spectrum and has 355 MHz of spectrum suitable for commercial mobile services, including an auction of 2.6 GHz spectrum expected in 2010. Spain has announced plans to begin allocating spectrum in the 2.6 GHz and 3.5 GHz bands by the end of 2009, including moving spectrum in the 900 MHz and 1800 MHz from 2G to 3G use. Italy and Belgium have announced plans to sell or auction 3G spectrum, and during 2008, Scandinavian countries held several auctions in the 1.8, 2.3, 2.6 and 10 GHz bands. According to CTIA, France currently has 374.6 MHz allocated for commercial wireless use and has 72 MHz of potentially useable spectrum in the pipeline. Germany's current commercial wireless spectrum allocation sits at 305 MHz, and the country has identified 340 MHz of additional spectrum for wireless services.[5]

In the United States, by contrast, only a limited amount of spectrum – 50 MHz – is in the "pipeline" – that is allocated for commercial use and waiting to be assigned.[6] Beyond this AWS-2, AWS-3 and D-block spectrum, no additional spectrum is actively being considered for allocation for licensed mobile broadband.[7]

By 2010, "mobile broadband penetration will surpass fixed penetration globally. Countries that are behind the curve in spectrum allocation will lag behind as a lack of spectrum will delay the launch of broadband services."[8] The United States must act now to continue to lead the world in mobile broadband.

2. *Growth of Demand for Mobile Broadband and the Necessity of Additional Spectrum.*

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5 *Id*. at 18-19 (internal citations and quotation marks omitted).

6 *Id*. at 20.

7 *Id*.

8 Chetan Sharma Consulting, *Managing Growth and Profits in the Yottabyte Era* 16 (2009), http://www.chetansharma.com/yottabyteera.htm.

This is a critical time in the industry. Networks technologies must enable more efficient use of spectrum, but the Commission also must supply the spectrum needed for the industry to meet the needs of consumers. Over the last several decades, mobile services have grown at an exponential rate.[9] With the increased demand for wireless data, traffic volume has reached saturation, with the consensus being that wireless data traffic volume is "more than doubling" every year.[10] AT&T projects that by 2018, 3G/4G traffic will expand by a factor of at least 250 and possibly as high as 600.[11]

The need for additional spectrum already has been recognized by the Commission, with Blair Levin, head of the Commission's National Broadband Plan task force, noting that a "key input" in the plan "is spectrum, and everyone agrees there is not enough of it. Moreover, demand curves from new uses by smartphones suggest a massive increase ahead for that input."[12]

The chart below depicts the anticipated growth of broadband through 2014, and in particular, the explosive growth of mobile broadband.[13]

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[9] Comments of CTIA-The Wireless Association® at 69-71, GN Docket Nos. 09-157 and 09-51 (filed Sept. 30, 2009)("CTIA Comments").

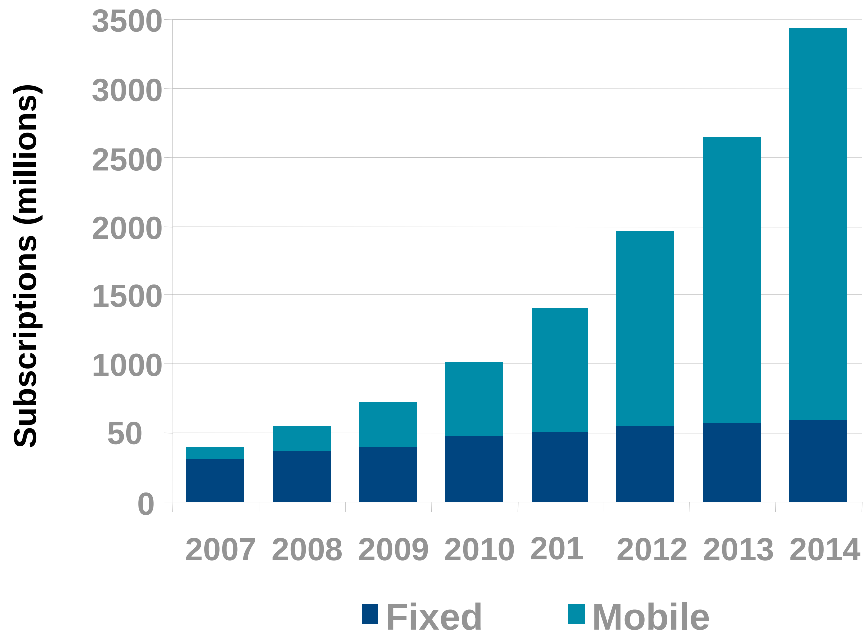
[10] *Id*. at 71.

[11] Rysavy Research, *Mobile Broadband Spectrum Demand* 12-13 (2008).

[12] Kim McAvoy, *FCC Floats Cash-For-TV Spectrum Scheme*, TV NewsCheck, Oct. 21, 2009, *available at* http://www.tvnewscheck.com/articles/2009/10/21/daily.4/.

[13] Neville Ray, Chairperson, 3G Americas, *The Mobile Braodband Evolution and Revolution* (2009).

Projected Broadband Growth



It has become evident that "[a] technological limit is approaching for which more spectrum is the only solution."[14] If innovation and the corresponding provision of new and innovative services to the American public is to continue, there is no escape from the conclusion that services must have access to additional spectrum.[15]

This is the conclusion that also has been reached by the International Telecommunication Union ("ITU"), which analyzed how much additional spectrum will be needed to support commercial wireless services in members' markets. The ITU has concluded that, including currently assigned spectrum, spectrum requirements by 2020

14 T-Mobile Comments at 18.

15 CTIA Comments 69-71.

for a *single network* within a *single country* will range from 1280-1720 MHz.[16] The NGNM Alliance extrapolated from the ITU's forecast to determine that Region 2, the Americas, will need a net additional 557-997 MHz by 2020.[17] 3G Americas provides a more comprehensive analysis of these studies in a white paper that is attached as Exhibit 1 to these comments.

2. What spectrum bands are best positioned to support mobile wireless broadband?

a. What is the current stock of spectrum available to support mobile wireless broadband? What is the proper methodology to compute this quantity?

3G Americas urges the Commission to conduct a comprehensive spectrum inventory to identify bands that can be allocated for mobile broadband. As an initial step in this inventory, the Commission should look to the international allocation of spectrum for mobile broadband to attempt to achieve global harmonization. 3G Americas discusses global harmonization of spectrum in greater detail below in response to question 2.d.

Another critical aspect of the spectrum inventory should be to identify government spectrum usage, because it is likely that underutilized spectrum currently assigned to the Federal government will be a critical source for spectrum that can be repurposed. The inventory should not simply identify bands, but research the intensity of

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16 International Telecommunication Union, *Estimated spectrum bandwidth requirements for the future development of IMT-2000 and IMT-Advanced*, ITU-R Report M.2078 (2006); 3G Americas, LLC, *3GPP Technology Approaches for Maximizing Fragmented Spectrum Allocations* 20 (2009), http://www.3gamericas.org/documents/3GA%20Underutilized%20Spectrum_Final_7_23_092.pdf ("3G Americas Fragmented Spectrum White Paper").

17 *See* A White Paper Update by NGMN Alliance, *Next Generation Mobile Networks Spectrum Requirements Update* (October 5, 2009), available at http://www.ngmn.org/fileadmin/user_upload/Downloads/Technical/NGMN-WP_Spectrum_Requirements.pdf.

use of bands, on a temporal and regional basis. For example, some federal spectrum use is limited to a handful of stations, yet is assigned on a national basis.

Since it is established Federal policy that government users should rely on commercial radio services where possible, federal users would be beneficiaries of repurposed spectrum. For a variety of reasons, the public is well served by opening underutilized government spectrum for non-government use.

The spectrum inventory should also identify within existing commercial allocations where the spectrum can be used more efficiently.

b. Which other spectrum bands might be most appropriate to repurpose to support mobile wireless broadband? Would these bands support shared use or would they need to be reallocated? What specific mechanisms should be used to facilitate transitions from incumbents?

In ascertaining which spectrum bands are best positioned to support mobile broadband, the Commission should keep in mind certain considerations.

First, spectrum allocated for commercial mobile wireless broadband should, in general, reside below 4.2 GHz to ensure that it can be used economically to deliver mobile broadband services. Below that threshold, certain bands have additional beneficial characteristics for advanced mobile services. For example, the 3.4-3.6 GHz band was identified in 2007 at the ITU's World Radiocommunication Conference for mobile use.[18] Use of the 3.4 – 3.6 GHz band could therefore benefit U.S. mobile users through economies of scale more readily achieved through global spectrum allocations.

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[18] International Telecommunication Union, *World Radiocommunication Conference: Provisional Final Acts* (2007) (adding in Region 1, international footnote 5.AAA designating entire band for mobile; adding in Region 2, international footnote 5.ZZZ designating 3400-3500 MHz for mobile; and adding in Region 3, international footnotes 5.AAA1 and 5.BBB to designate 3400-3500 MHz for mobile and 5.CCC 3500-3600 MHz for mobile); International Telecommunications Union, *Results of WRC-07* 11 (2008), http://www.itu.int/ITU-R/space/support/workshop/doc_presentation_en/WRC07%20results_FL.pdf.

Second, spectrum allocated for commercial mobile broadband should be as contiguous as possible. Current allocations are primarily based on 5 and 10 MHz blocks. Such allocations may have been appropriate for second, and even third, generation data services, but they are not sufficient to support advanced data services. Wider bandwidth allocations are better suited for future, data-intensive wireless broadband services. Blocks of 2x20 MHz spectrum pairs would be an improvement, but even that may not be enough spectrum for future broadband use given the current trajectory of demand. It is instructive that European regulators are planning 2x30 MHz pairs for LTE wireless deployment.

Third, for reasons elaborated below in response to question 2.d, spectrum allocated for mobile broadband in the U.S. should be globally harmonized to the greatest extent possible. Globally harmonized spectrum provides the critical mass of customers to network vendors to produce network equipment at a more affordable incremental unit price, which, in turn, allows operators to deploy advanced networks more rapidly. For the same reasons, harmonized spectrum will result in lower cost handsets.

The spectrum inventory is a good first step, but is insufficient without a concrete framework for the relocation process, including a firm timeframe for decision-making regarding relocating users. Firm deadlines are essential both to expedite the deployment of mobile broadband services and to avoid creating disincentives for robust bidding in future spectrum auctions.[19] This is the same approach recommended by NTIA's public

[19] *See* Comments of 3G Americas, LLC, NTIA Docket No. 0906231085-91085-01 (filed Aug. 21, 2009).

advisors, the Commerce Spectrum Management Advisory Committee, with regard to the Commercial Spectrum Enhancement Act.[20]

d. Are there bands usable for mobile wireless broadband in other countries that might also be used in the United States? Which bands? What would be the benefit and viability of making these bands available in the United States?

3G Americas urges the Commission to allocate spectrum for mobile broadband in a manner consistent with global spectrum allocations identified on a global or regional basis by 3GPP, CITEL, and the ITU, to the greatest extent possible. Allocating spectrum to increase global harmonization will benefit the public in numerous ways. U.S. consumers will benefit from lower-cost handsets and manufacturers will be able to take advantage of global economies of scale instead of building network equipment solely for the U.S. market. American consumers will benefit from a greater number of innovative applications that will arise from a global development base, offered over lower incremental-cost handsets. An early alignment of spectrum in various markets will expedite the deployment of LTE Advanced, thereby benefitting the U.S. public by facilitating the delivery of advanced, high-speed mobile broadband to handsets and other mobile devices.

As an immediate step, the Commission can pair 25 MHz of contiguous spectrum in the 1755-1780 MHz government band with the 25 MHz "extended" AWS-3 (2155-2180 MHz) band. This would harmonize those bands within the U.S. with recommendations from 3GPP, CITEL, and the ITU. Specifically, the ITU recommends that for advanced wireless services, administrations pair 2110-2170 MHz as a downlink

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20 Commerce Spectrum Management Advisory Committee, *Transition Report* 30-31 (2008), http://www.ntia.doc.gov/advisory/spectrum/meeting_files/CSMAC_Transition_Report_(121208b_-_CLEAN).pdf.

band with an uplink band at either 1920-1980 MHz or 1710-1770 MHz.[21] In Region 2, the Americas, CITEL has also endorsed pairing the 2110-2170 MHz band as a downlink band with the 1710-1770 MHz uplink band.[22] 3GPP has recommended international allocation of 2110-2170 as a downlink band paired with 1710-1770 as an uplink band.[23]

that the American public can realize the benefits of rapid and cost-effective deployment of mobile broadband.

Respectfully submitted,

Patricia Paoletta
Wiltshire & Grannis LLP
1200 Eighteenth St., NW
Washington, D.C. 20036

Counsel for 3G Americas

Chris Pearson
1750 112th Ave SE
Suite B220
Bellevue, WA 98004

President of 3G Americas

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EXHIBIT 1

3GP

P TECHNOLOGY

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JULY 2009

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EXECUTIVE SUMMARY

An emerging challenge confronting spectrum stakeholders involves how to permit wider spectrum usage by operators using various technologies, while at the same time maximizing use of “fragmented” or non-standard spectrum bands.

The FCC AWS-III proceeding is perhaps the latest and the most visible example of this challenge, wherein the issue has centered on whether wireless operators employing different duplexing technologies can coexist in adjacent portions of the radio spectrum without some form of interference mitigation and/or more stringent limits on power and out of band emissions.

Going forward, in addition to AWS-III, the challenges of non-standard or fragmented spectrum bands may manifest themselves in other areas. Country specific allocations of the 2.6 GHz IMT band and “Digital Dividend” spectrum are other potential illustrations.

One of the most critical principles for spectrum managers around the globe is to allocate spectrum so that it aligns as much as possible with regional and global allocations. This permits leveraging scale economies that redound to the benefit of consumers both in terms of device costs and for international

1. INTRODUCTION

1.1 DEFINING FRAGMENTED SPECTRUM

A threshold matter in undertaking the examination embodied by this document is to clarify what is meant by fragmented spectrum. In essence, we refer to spectrum that diverges from regional and/or global spectrum allocations, and consequently fails to benefit from scale economies and other advantages that flow from such spectrum alignment. The optimal utilization of these spectrum "islands" by countries, operators and consumers will in important respects be difficult to realize.

It bears emphasizing at the outset, however, that suboptimal spectrum allocations are not necessarily resources that cannot be put to use. In fact, standards bodies and other groups have and continue to develop innovative approaches in order to take advantage of these divergent assets. These technological advancements, however, cannot take the place of sound spectrum management, including the vital role played by spectrum harmonization. In fact, such advancements may presuppose that national spectrum managers have properly allocated nearby spectrum bands in such a way, for example, that they can be effectively paired or otherwise used with spectrum fragments. Nonetheless, these innovations can help to ensure that scarce spectral resources are put to use.

It is the principal aim of this paper to present and review some of the main techniques established and being developed by different entities in this area. Prior to doing so, mobile broadband should be situated in the larger macroeconomic and technological environment.

1.2 MOBILE BROADBAND

The world is at the precipice of the full-scale convergence of two powerful and sweeping forces: wireless mobility and broadband Internet access. Each of these forces on its own has made its mark indelibly on the global consumer consciousness. Wireless voice and data services have literally transformed telephony from a fixed place-to-place communications medium into mobile person-to-person interactions. The clunky telephones of yesterday have been revolutionized into the iconic wireless handsets of today. Similarly, the Internet has revolutionized the computer world, turning PC devices into interconnected windows to the World Wide Web. Totally new domains of information and interaction have been opened up in the process of creating the Internet.

Together these merging juggernauts, wireless mobility and the Internet, promise to unlock vast new capabilities for consumers, enterprises and governments. The mobile Internet clearly creates more value than merely the sum of its parts. The underpinning of this new domain is mobile broadband technology– bringing much of the rich fixed-line Internet experience to the mobile world. But technology alone cannot make mobile broadband happen. It must be coupled with an appropriate spectrum framework in order for mobile broadband to thrive in the marketplace. Because spectrum is such an important resource, optimal utilization is necessary and requires driving maximum efficiencies from all sources, both existing as well as impending allocations.

1.2.1 CATALYST FOR ECONOMIC GROWTH

The tremendous growth over the past two decades in wireless mobility and the Internet promises to compound when the two are coupled together on a mass market scale. While broadband is growing overall, the rate of growth for mobile broadband is outpacing broadband in general. Globally, fixed broadband is expected "to grow at a [compound annual growth rate] CAGR of 9 percent from 2008 to 2014, whereas mobile broadband computing will grow about three times as fast, totaling $69 billion by 2014 – 30 percent the size of fixed broadband."[1] Ovum has similarly concluded that users access the Internet via mobile broadband enabled laptops and handsets will generate revenues of $137 billion globally in 2014, 450 percent more than in 2008, and that during the same period mobile broadband users will climb from 181 million to over 2 billion worldwide.[2] Further, a recent report by McKinsey & Company noted that "mobile broadband is uniquely positioned to stimulate economic growth and welfare in areas that lack adequate fixed-line broadband infrastructure."[3] McKinsey estimates that "a 10 percent increase in broadband household penetration delivers a boost to a country's [gross domestic product] GDP that ranges from 0.1 percent to 1.4 percent."[4]

Mobile broadband promises to help level the playing field, enabling whole new categories of users to experience broadband. Rural consumers beyond the reach of wired DSL and cable systems are but one example of the opportunity. Lower income subscribers unable to afford both fixed-line and wireless access services are another.

A 2008 Pew Research Report surveying Internet experts and specialists concluded that in 2020, "the mobile phone . . . [will be] the primary Internet connection and the only one for a majority of the people across the world."[5] There are 4 billion people around the world that use a cell phone. In contrast, less than a billion people have a personal computer.[6] Clearly, most people in underserved markets will first access the Internet and experience broadband over a mobile device.[7]

1.2.2 ENGINE FOR INNOVATION AND COMPETITION

Both the Internet and wireless have become synonymous with innovation and competition. They have spawned new industries and broken down traditional barriers to entry. Mobile broadband is driving growth and innovation to entirely new levels. Social networks are one illustration of how the Internet, now "mobilized," can deliver value to end users that could hardly have been envisioned a few years ago. Gaming is another example of an industry now squarely moving into the mobile domain. Yet these examples pale in comparison to the economic and commercial impact of enterprise applications, for which mobile broadband can drive additional significant efficiencies into countless industry sectors.

With the convergence of wireless and the Internet also comes dramatically enhanced competition, with companies from both domains scrambling to address the combined market. Such competition, fully

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[1] *Mobile Broadband Computing Services – Complement or Substitute for Fixed Broadband,* Pyramid Research (Mar. 2009), *excerpt available at* http://www.pyramidresearch.com/store/RPMOBILEBROADBAND0903.htm?sc=TL_RPMOBBB0903.

[2] *Mobile Broadband to be Worth $137 Billion by 2014,* Ovum Research (25 Mar. 2009), *available at* http://hspa.gsmworld.com/upload/news/files/08052009110918.pdf.

[3] *Mobile Broadband for the Masses,*

unleashed, stimulates creative forces that would otherwise remain dormant. One leading technologist has dubbed this the "application innovation effect" a virtuous cycle in which "capability encourages innovation" and more robust networks beget more attractive applications leading to greater attach rates and ultimately a richer environment for even further market growth.[8]

Spectrum is an essential raw material for existing and new entrants into the mobile broadband space, and is necessary "table stakes" in order to compete. Ever smarter spectrum approaches will be needed in order for mobile broadband services to thrive and for creativity to flourish in the sector.

1.2.3 COMPARISON WITH NARROWBAND

During the past decade, wireless service providers have added data services in addition to voice as integral parts of their offerings. For a long time now, in fact, wireless has been much more than just a voice service, and wireless data Average Revenue per User (ARPU) has grown at a faster rate than voice ARPU for the past several years.[9] While wireless web and data offerings have made great strides, wireless data speeds have lagged behind fixed-line approaches, like DSL and cable modems, due to bandwidth and technology constraints.

This difference between wireless and fixed-line data rates has two root causes: technology and spectrum. Earlier wireless technologies were voice-centric, with data added as an incremental or parallel offering. Voice is inherently a narrowband application compared to data services like web browsing, streaming video, interactive gaming and a myriad of others. In contrast, the vision for mobile broadband is one where every service, including voice, is offered as an application on a unitary network.

Earlier spectrum allocations were designed around the needs of voice services or voice with incremental data. However, data will in the not too distant future become the dominant traffic mode. As a result, spectrum planning and usage must account for the fact that mobile broadband services that customers find attractive will require both appropriately allocated and sufficiently large quantities of spectrum.

Spectrum planning and usage must also reflect the characteristics of the services and traffic. A case in point is Internet traffic, which as a general matter is highly asymmetrical in nature, with downlink traffic exceeding uplink traffic by average ratios of 5:1 in the near term – increasing to 6:1 in the future. Notably, these asymmetries are usually greater for consumer data than for business data.[10]

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[8] *Mobile Broadband Spectrum Demand*, Rysavy Research (Dec. 2008) at p. 9 ("Rysavy Report"), *available at* http://www.rysavy.com/Articles/2008_12_Rysavy_Spectrum_Demand.pdf.

[9] *See TelMeDaily*, UBS Investment Research (5 Jun. 2009) at p. 3 (noting "the dramatically weakening trends in voice service revenue globally, [and that] operators are increasingly pointing their strategic emphasis towards mobile data. This has been a trend already experienced in Europe/US and is now taking hold in emerging markets.")

[10] The WiMAX Forum projects traffic asymmetry of about 8:1 for consumer data versus 6:1 for business data by the year 2015. *See A Review of Spectrum Requirements for Mobile WiMAX Equipment to Support Wireless Personal Broadband Services*, WiMAX Forum (Sept 2007) at pp. 27, 31, *available at* http://www.wimaxforum.org/sites/wimaxforum.org/files/document_library/spectrum_requirements_for_mobile_wimax_sept2007.pdf ; *see also 3G Offered Traffic Characteristics Final Report,* UMTS Forum, Report No. 33, (November 2003), *available at* http://www.umts-forum.org/component/option,com_docman/task,cat_view/gid,228/Itemid,98/.

1.3 GLOBAL SPECTRUM ALLOCATIONS

In important respects, wireless service is truly boundless – radio frequency emissions do not respect geopolitical boundaries. In the context of the present task, this takes on additional meaning. Wireless service delivers best for consumers when the industry can leverage scale economies in the manufacturing of equipment and end user devices. To do so most effectively, it is vital that industry players have globally established technology standards designed for use with globally coordinated spectrum bands.

Historically, regional- or country-specific standards and spectrum allocations have not succeeded. For example, North America's IS-136 digital cellular standard ultimately gave way to GSM, even though both were based on TDMA techniques. And CDMA2000 has evidently failed to gain enduring global traction, ceding the floor to UMTS-HSPA and LTE in the most pervasive approaches to evolving beyond 3G technology.[11] In a similar fashion, harmonized spectrum allocations have proven most effective in delivering the scale and scope economies needed to produce low cost consumer devices.[12]

A brief overview of global spectrum allocations for 3GPP based technologies follows. Subsequently, several examples – beginning with the U.S. AWS -III proceeding – are presented in order to illustrate some of the key challenges presented for optimal spectrum utilization when allocations differ either on a country- or region-specific basis.

1.3.1 OVERVIEW OF CURRENT 3GPP ALLOCATIONS

The Third Generation Partnership Project (3GPP) is a collaborative agreement established in 1998, comprised of six regional telecommunications standards bodies. 3GPP's mandate is to produce technical specifications (organized into documents commonly referred to as "Releases") and other reports for the development of 3G mobile systems based on evolved GSM core networks and radio access technologies.

As depicted in the following charts, 3GPP has fostered global harmonization of 3G and evolving 3G services by framing its Releases in accordance with the frequency bands most commonly used across the globe for commercial mobile services. Figure 1 lists commonly used FDD spectrum bands; Figure 2, common TDD bands. The second column in each figure identifies the countries and regions of the world in which these bands have been allocated for commercial mobile services.

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[11] *See DoCoMo Shells Out on LTE*, Light Reading Asia (9 Jun. 2009), *available at* http://www.lightreading.com/document.asp?doc_id=177740 (reporting that NTT DoCoMO plans to launch LTE in 2H2010, a timeframe similar to Verizon Wireless, TeliaSonera, and China Mobile, the latter with the TD version of LTE). *See also NGMN Alliance and TD Industry Association Initiate Cooperation on Next Generation Mobile Networks,* News Release (4 Jun. 2009), *available at* http://www.ngmn.org/nc/news/partnernews/newssingle0/article/ngmn-alliance-and-td-industry-association-initiate-cooperation-on-next-generation-mobile-networks.html?tx_ttnews%5BbackPid%5D=3&cHash=016288ba43 (announcing cooperation agreement between the two organizations to promote TD-LTE worldwide and ensure development of convergent standard for FDD- and TDD-based next generation mobile networks).

[12] *See Written Submission of Verizon Wireless to House Energy & Commerce Committee* (21 May 2009) at pp. 17-18, *available at* http://energycommerce.house.gov/Press_111/20090507/testimony_verizon.pdf ("Global harmonization of spectrum allocations can lead to significant public benefits, including lower equipment cost, more rapid deployment, and greater interoperability of advanced wireless systems worldwide").

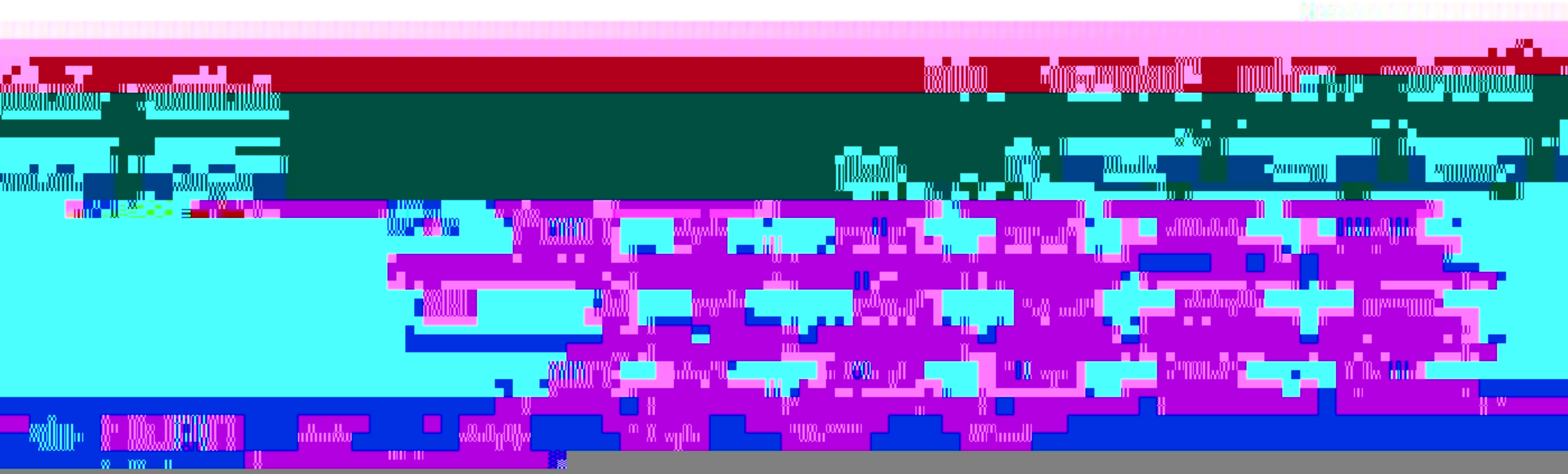

Figure 1. 3GPP FDD Spectrum Bands (Source: 3GPP TS 36.104)

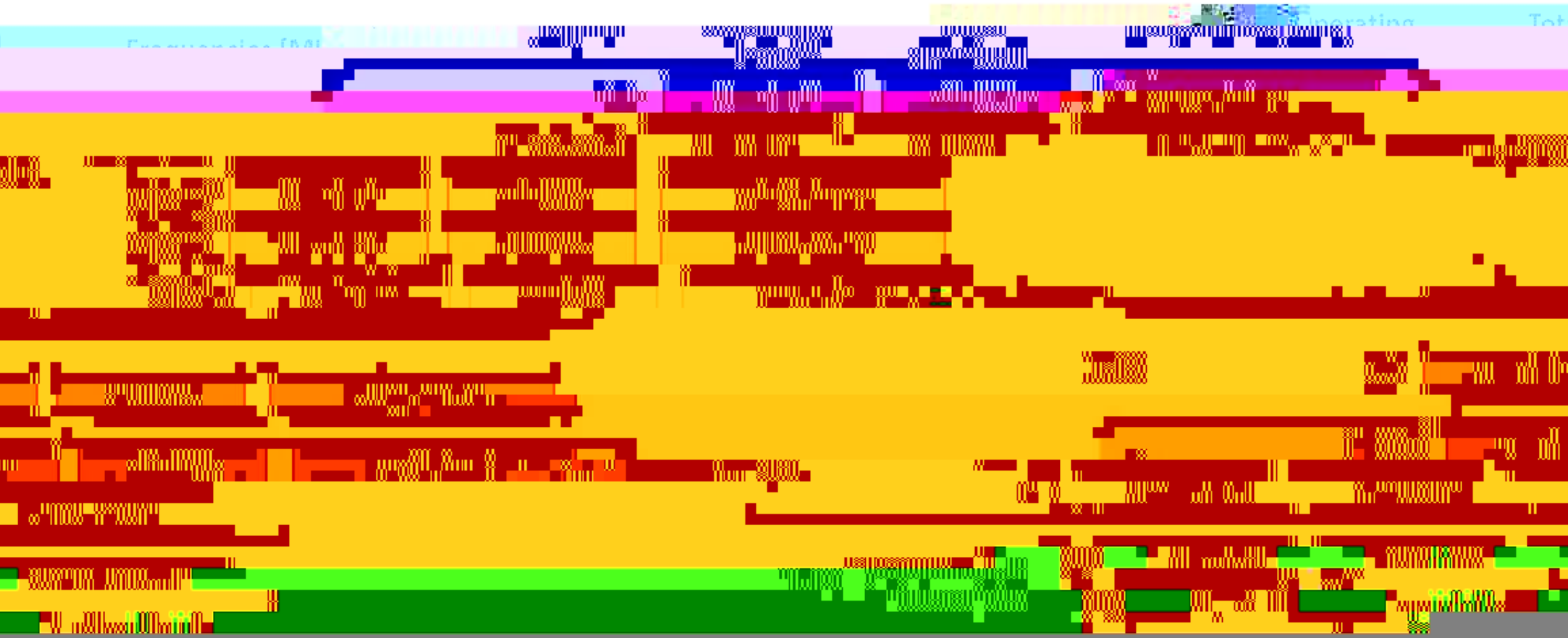

Figure 2. 3GPP TDD Spectrum Bands (Source 3GPP TS 36.104)

3GPP Release 5 includes the specifications commonly referred to as HSDPA; Release 6 HSUPA; Release 7 HSPA and HSPA+; and Release 8 HSPA+ and initial LTE specifications. These Releases provide participants in the mobile value chain – including chipset manufacturers, software developers, handset and infrastructure vendors, service providers and others – with an indispensable framework to realize scale economies that redound to the benefit of consumers across the globe. Deviations from this framework invariably result in challenges to delivering the compelling mobile services to consumers in a cost-effective manner. The following section provides several illustrations of currently divergent, or potentially divergent, spectrum allocations.

1.3.1.1 ILLUSTRATIONS OF CURRENT SPECTRUM ALLOCATION CHALLENGES

US AWS-III PROCEEDING

The FCC has an active proceeding to determine service rules and requirements for use of the AWS-II and AWS-III bands. The AWS-III band is adjacent to AWS-I, as shown in the band plan below. The AWS-III allocation consists of 20 MHz unpaired spectrum at 2155-2175 MHz. The AWS-II band consists of the H Block (1915-1920/1995-2000 MHz) and J Block (2020-2025/2175-2180 MHz). To minimize fragmentation, a number of parties have proposed pairing the AWS-III band with the adj established at WRC-2000. The European Commission (EC) has instructed National Regulatory Administrations (NRAs) to recognize that accommodating TDD and FDD in the 2.6 GHz band requires restricted blocks (i.e., reduced power and filtering).[14]

> 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 unsynchronized networks operating in TDD mode. Such separation should be achieved by either leaving these 5 MHz blocks unused as guard blocks; or through usage that complies with parameters of the restricted BEM when adjacent to an FDD (uplink) or between two TDD blocks; or through usage that complies with parameters of either restricted or unrestricted

advantage of preserving the 120 MHz duplex spacing for the paired spectrum but the disadvantage that it could require an extra guard channel. This is reflected in Figures 5 and 6 below.[17]

Figure 5. CEPT Band Plan from ECC Decision (05)05 with Predetermined Amounts of Paired and Unpaired Spectrum

Figure 6. Ofcom Illustration of Expansion Amount of Unpaired Spectrum at Top End of 2.6 GHz

in adjacent frequency blocks in the same frequency band is not feasible without consideration of suitable interference mitigation techniques.[18]

Further on, the study notes that "the results of our analysis suggest that interference will be noticeable when the distance between mobiles is less than 10 meters."[19]

In April 2008, Ofcom published the final results of its investigations on the impact of interference from TDD terminals to FDD terminals in the 2.6 GHz band.[20] Ofcom confirmed the need for restricted blocks to mitigate inter-system interference, as depicted in an illustrative block diagram reproduced below.

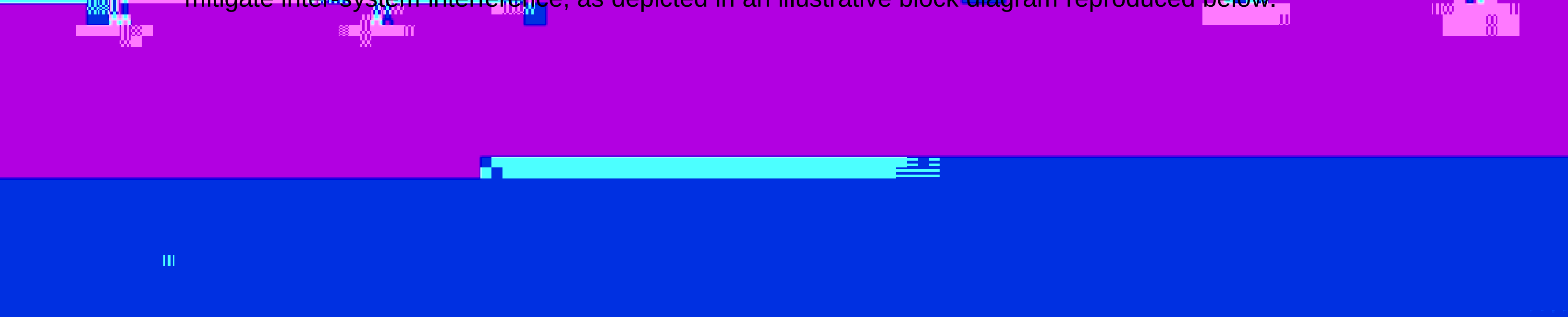

Figure 7. Ofcom Illustration of Restricted Blocks for Example of a Specific Award Outcome (Arrows Indicate Direction of Potential Terminal-to-Terminal Interference; Restricted Blocks Marked with "R")

Ofcom found that "[al]though the restricted blocks are primarily intended to mitigate base-to-base interference, they also have important implications with respect to terminal-to-terminal interference."

Ofcom noted risks of "significant" first adjacent-block interference from TDD terminal stations towards FDD terminal stations existed where the TDD terminal stations are served by high power macro-cellular base stations, and where there is a high density of TDD terminal operating in the spatial vicinity of the FDD terminal stations. Ofcom goes on to note that the restricted blocks address the important, collateral scenario of TDD terminal to FDD terminal interference. Interference risks would be minimized if TDD terminals are:

> [S]erved by low power pico-cellular base stations. This is consistent with the case of TDD terminal stations that operate in the restricted blocks immediately below and above the FDD downlink spectrum (i.e., block #24 and block "x" in Figure 7). In other words, the restrictions on in-block EIRP imposed on TDD base stations in the aforementioned two restricted blocks remove the circumstances in which FDD terminal stations might suffer from interference caused by TDD terminal stations.[21]

[18] *2500-2690MHz, 2010-2025MHz and 2290-2302MHZ Spectrum Awards – Engineering Study (Phase 2),*

Recently, the U.K. has proposed a wide ranging overhaul of its plan for allocating spectrum for mobile broadband services. Released May 12, 2009 by the U.K. Ministry of Culture, Media & Sports, the *Report of the Independent Spectrum Broker*,[22]

In fact, the EC recently launched a consultation on Digital Dividend spectrum. Noting that importance of taking prompt action "to prevent the emergence of fragmented national legacy situations" that would stymie the development of future equipment and services in the 800 MHz band, the consultation proposes that the EC undertake two urgent actions by autumn of 2009: (1) Member States that have not completed the digital switchover would be requested to confirm switch off of analogue TV under national law by 1 January 2012; and (2) the EC would draft a Commission decision, for regulatory opinion in the autumn of 2009 and formal adoption at the beginning of 2010, on technical harmonization measures for transitioning the 790-862 MHz band to non-broadcast uses.[29]

2. SPECTRUM POLICY GOALS

with higher bills of materials and manufacturing costs. This translates into significant cost penalties on the lower volume products delivered to countries or regions that have chosen not to align their spectrum with global allocations

U.K. research firm RTT has undertaken several studies related to the impact on spectrum harmonization

2.2 TECHNOLOGY FACILITATION

The mobile and Internet industries have repeatedly demonstrated the tremendous value in allowing the market to sort out winners and losers. Technologies continually evolve and leapfrog one another, and today's underdog can easily emerge as tomorrow's front runner. Technology Facilitation, [31] allowing the market to sort out which technologies will prevail, is – and should continue to be – a fundamental policy tenet.

The clear lessons from the emergence of the Internet apply equally to mobile broadband. Once a technology backbone platform is in place, companies are apt to view the commercial significance of that platform in different ways. Business models are diverse and must necessarily adapt over time to recognize new realities. Flexibility allows companies to test different business models to see what works, as well as change business strategies as warranted.

Mobile broadband offerings are not about just voice services or just the wireless web. Like the fixed Internet, mobile broadband delivers high performance data transport services upon which a multitude of different applications can ride. This implies that spectrum policy should refrain from dictating which technology or service is offered in particular spectrum bands. Enabling flexibility is paramount for operators to have the opportunity to succeed in this rapidly evolving market. [32]

At the same time, it is important to clarify that facilitating different technologies does not mean that regulators should refrain from making any technology decisions in their spectrum allocations. The often-mentioned goal of "technology neutrality" merits pursuit, but only if properly interpreted.[33] Technology Facilitation comes closer to the mark, conveying the point that proper spectrum management is neutral as to the particular air interface technology (e.g. WiMAX, UMTS-HSPA, LTE) preferred by the licensee, and should facilitate entry by licensees regardless of the technology chose by the operator. However, this does not mean that regulators should abdicate the role of grouping "like" services together as required. Specifically, service providers need clarity – before spectrum is auctioned or otherwise assigned – as between spectrum designated for FDD (whether WiMAX- or UMTS-HSPA- or LTE-based FDD) and spectrum designated for TDD (again, regardless of air interface technology). Related to duplexing designations, there is also a concomitant need to define proper technical and operational parameters where different duplexing schemes may be employed in spectrum directly adjacent to each other, given the well understood interference concerns, as described above.

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[31] This concept is closely aligned with the concepts of "technology neutrality" and "spectrum flexibility" often used in policy discussions in various regions of the world. However, as explained below, important considerations need to be brought to greater relief regarding those concepts.

[32] In March 2009, Industry Canada announced a consultation on the transition to Broadband Radio Service (BRS) in the 2.6 GHz band, and on the criteria to be used in the issuance of BRS licenses to operators of qualified Multipoint Communication System (MCS) licenses and Multipoint Distribution Service (MDS) authorizations. Industry Canada noted that BRS licenses are often referred to as "flexible use" licenses in that they support a mix of services, including mobile, fixed and broadcasting (although in practice operations in this band have been fixed). The Department expressed its "commit[ment] to taking the necessary steps for the implementation of BRS in order to increase flexibility in service provision that would benefit Canadians by enabling the development of competitive high-speed mobile services." *Consultation on Transition to Broadband Radio Service (BRS) in the Band 2500-2690 MHz*, Notice No. DGRB-005-09 (6 March 2009) at p. 1, *available at* http://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/dgrb-005-09-eng.pdf/$FILE/dgrb-005-09-eng.pdf

[33] *See* McKinsey Report at pp. 13-14 (describing the regulatory levers that will enable mass market mobile broadband to take root, including the primacy of spectrum availability, which includes "technology neutrality" to ensure innovation, but that neutrality "needs balancing against the desire to standardize.")

To illustrate, there is an initiative within the European Union to allow more flexible use of spectrum in its Member States. This initiative is called Wireless Access Policy for Electronic Communications Services (WAPECS).[34] WAPECS establishes similar and minimal technology conditions to allow the use of the spectrum for mobile, broadcasting and fixed services on a technology and service-neutral basis, subject to certain coexistence parameters to avoid harmful interference.

These coexistence concepts include both Block Edge Mask (BEM) and Restricted Blocks and are intended to facilitate coexistence between coordinated and uncoordinated services and technologies. In the CEPT 2.6 GHz band plan, as discussed previously, spectrum is organized with individual TDD and FDD allocations. The operators have the flexibility to implement technologies and services as the market dictates. In an uncoordinated spectrum environment, where allocations are not separate, there are cost and deployment consequences that may diminish the possibility to create economies of scale. Such an environment may also diminish device selection and possibly introduce demands on filter technology that could create market introduction delays.

2.3 BROADBAND DEPLOYMENT & ADOPTION

Spectrum policy should also strive more generally to stimulate broadband deployment and adoption. Mobile broadband is not just "more of the same" wireless voice or cell phone services. Spectrum policies which do not foster mobile broadband and enable it with sufficient spectrum resources could inadvertently restrict future offerings to "more of the same." Such policies could also very well stifle efforts to bridge the "digital divide" in instances where mobile broadband can offer unique solutions, particularly in geographic areas and for particular demographic groups.

As discussed earlier, mobile broadband deployment and adoption can be an integral part of stimulating overall economic recovery and growth. The migration of the Internet to the mobile domain fuels further cycles of innovation and ecosystem creation, which bolsters healthy and sustainable economic growth. Thus, this goal indirectly serves to address the most pressing goal currently facing countries across the globe.

Demand for mobile broadband products and services are, as Cisco characterizes, "hard to overestimate." Cisco forecasts that globally, mobile date2(pl)-9(ow 2.518 0 ( )T)3(o)iquwt m3((di)3(r)-6d)16(,)ub12(adb)-12evces

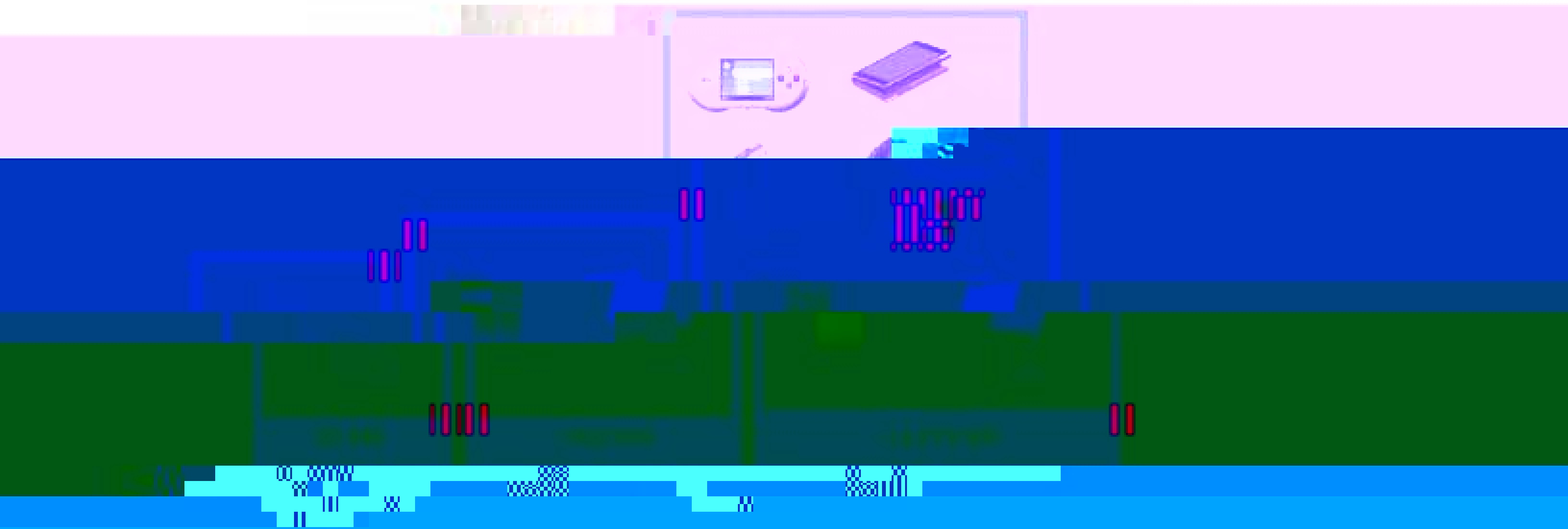

Figure 10. Potential Growth in Data Traffic from a Single Mobile Subscriber (Source: Cisco)

Confronted with burgeoning demand, mobile network operators have three options for responding: build more cell sites; increase spectral efficiency of existing spectrum assets; and deploy more spectrum into their networks. Operators cannot pick and choose among these options, but must invoke all of them in the hunt for capacity.[36]

Cell site builds, however, reach a point of diminishing returns if the task consists solely of cell splitting an operator's existing frequencies. Investments in 2G and 3G technology enhancements have brought impressive spectral efficiency benefits for operators, but those benefits are constrained if channels of sufficient bandwidth are not available for deployment (putting aside the question of whether the spectrum is green field or whether legacy customers on older, incompatible technologies must be moved elsewhere). Thus, NRAs across the globe will play a critical role in allocating additional new spectrum to meet the needs of their residents.[37]

The amount of spectrum required by operators to meet the new broadband imperatives is a topic investigated by the International Telecommunication Union (ITU) in 2006. Specifically, the ITU undertook to determine how much spectrum would be needed for the case of a single network per country in the years 2010, 2015 and 2020. The table below summarizes the results of the ITU's analysis, which are broken down by "higher" or "lower" market development status compared to a single "global common market," as well as by Radio Access Technology Group (RATG). RATG 1 covers pre-IMT and IMT, as well as enhancements to IMT and RATG 2 is comprised of IMT-Advanced.

[36] *See* Rysavy Report at pp. 19-20.
[37] *See How Much More Spectrum Do We Need*

Market setting	Spectrum requirement for RATG 1			Spectrum requirement for RATG 2			Total spectrum requirement		
Year	2010	2015	2020	2010	2015	2020	2010	2015	2020
Higher market setting	840	880	880	0	[illegible]	[illegible]	0.026	[illegible]	[illegible]

around the world. Given the lengthy lead times needed to identify spectrum, and in particular regionally or globally harmonized spectrum, NRAs must begin the process of

3. CURRENT APPROACHES TO ADDRESSING FRAGMENTED SPECTRUM CHALLENGES

3.1 ASYMMETRIC PAIRING & DUAL CARRIER/DUAL BAND AGGREGATION

There is considerable promise for mobile broadband services in the option to deploy frequency division duplex with asymmetrically paired spectrum channels, resulting in more downlink than uplink bandwidth. Asymmetric pairing facilitates the deployment of robust, two-way mobile broadband services. Such pairing matches well with the demand for broadband capability, which experience indicates is predominately focused on downloads. For example, with 25 MHz of downlink spectrum, a provider could offer average download speeds of up to 35 Mbps per sector, based on modeling using emerging next generation technolog0 Tc 0 Tw2]TJ ocused (o)-144T(,)5.33 0 TT(,)5.3 Td ( )Tj -0.002 T1 0.23 Tw 0.494 0 Td [(us)d [(t)0(MH

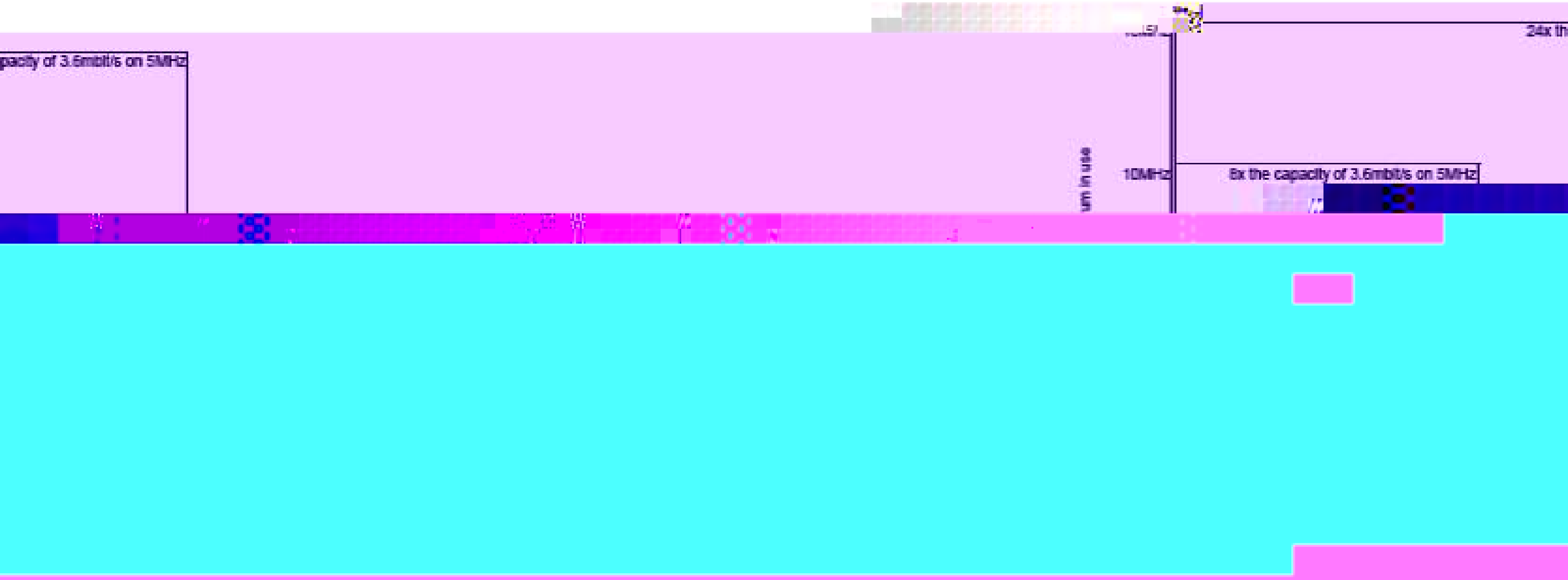

Figure 13. Benefits of Carrier Aggregation for HSDPA Scale More than Linearly (Source: Deutsche Bank)

The multiplicative rate of capacity gains results from scheduling efficiencies involved in employing multiple carriers.[41]

3.1.1 3GPP RELEASE 99 THROUGH RELEASE 7

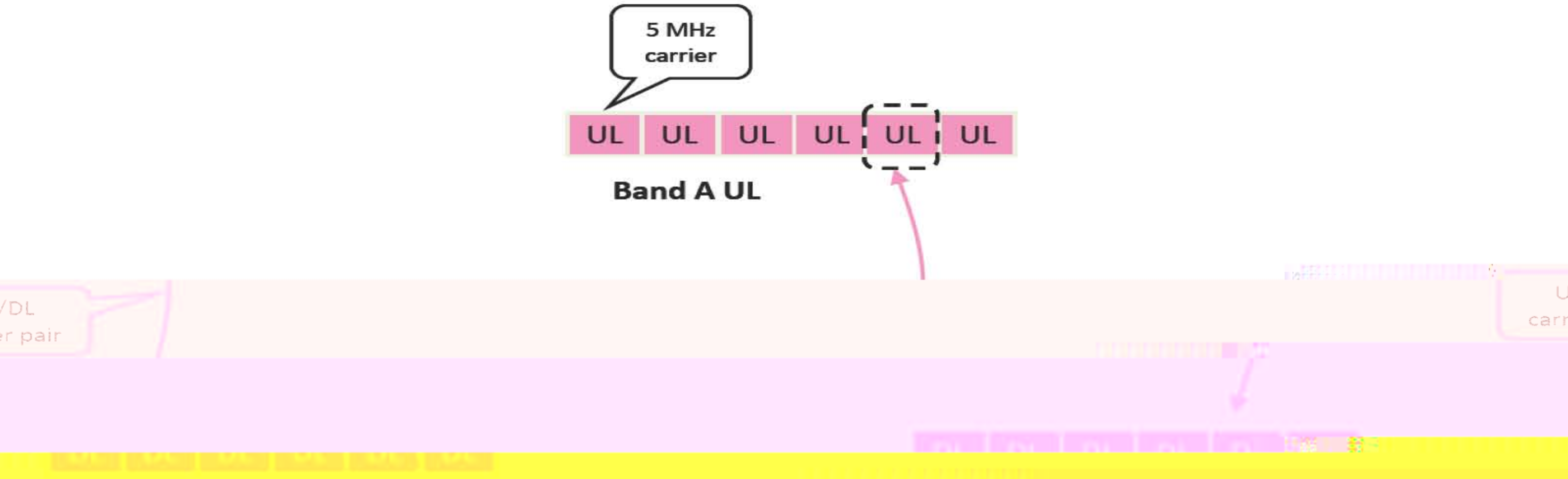

Figure 14. WCDMA/HSDPA UL& DL Carrier Pairing in Single Carrier Operation

3.1.2 3GPP RELEASE 8 INTRODUCED DUAL-CARRIER HSDPA

In December 2008, 3GPP froze Release 8 specifications. Release 8 introduced support for DC-HSDPA. However, the specifications permit only two DL carriers (5 MHz per carrier) adjacent to each other and in the same frequency band, with one of the DL carriers preserving the fixed duplex spacing from the UL carrier. This is depicted in Figure 15.

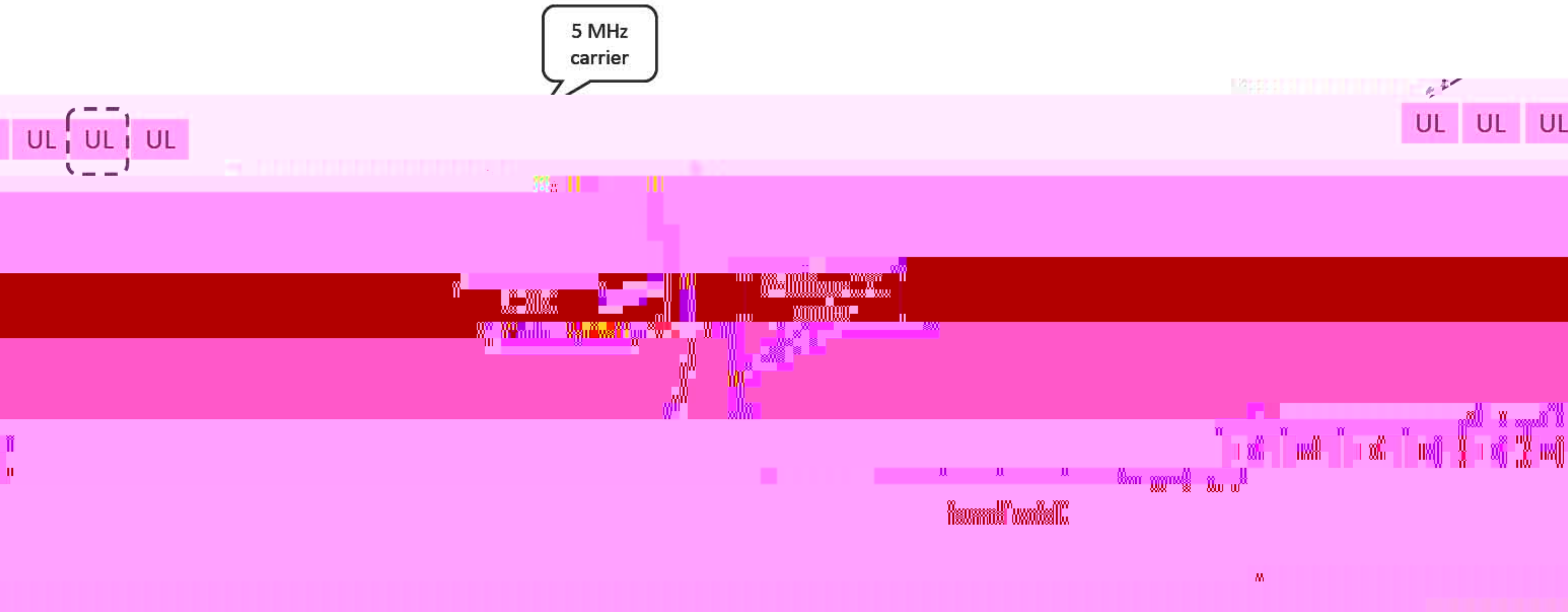

Figure 15. DC HSDPA on Adjacent Carriers: 1 UL Carrier, 2 DL Carriers (3GPP Release 8)

3.1.3 3GPP RELEASE 9 WOULD INTRODUCE DUAL-CARRIER HSDPA/HSUPA

The development of technical specifications that permit additional resource aggregation continues to the present. In March 2009, 3GPP RAN WG4 presented findings of an open Study Item (SI) investigating the performance of HSDPA and HSUPA under several aggregation scenarios, namely:

- Dual Cell HSDPA on two separate frequency bands
- Dual Cell HSDPA together with MIMO in a single frequency band
- Three and four carrier HSDPA for both single as well as two separate frequency bands
- Dual Carrier HSUPA on adjacent carriers

3GPP RAN WG4 confirmed that peak improvement rates for all the features were as expected, and further in certain modeled scenarios average user burst data rates are substantially improved compared to Release 8. 3GPP RAN WG4 noted that the Layer 2/Layer 3 impacts, and UE RF performance/complexity related implications especially for multi-band and multi-mode UEs, needed further investigation. Meanwhile, a parallel work group, 3GPP RAN WG1, did not identify any problems in its focus area that would make any of the studied techniques infeasible.[42] New Work Items (WIs) related to these features were adopted in March 2009, and are scheduled for finalization at the RAN #44 Plenary set for December 2009.

[42] *RAN1 Findings of the UTRA Multi-Carrier Evolution Study*, Third Generation Partnership Project, RP-090318 (March 2009), *document available for download at* http://www.3gpp.org/Radio-Access-Network-status-after.

Successful conclusion of Release 9 specifications would facilitate several important aggregation enhancements to what is currently embodied in Release 8. In particular, Release 9 would introduce Dual Carrier HSUPA (DC-HSUPA). In this scenario, DC-HSUPA is envisioned to operate only together with DC-HSDPA to enable bundling two adjacent 2x5 MHz UL/DL carrier pairs within the same spectrum band. This is depicted in Figure 16 below.

Figure 16. DC HSDPA/HSUPA - 2 UL and 2 DL Carriers (3GPP Release 9)

3.1.4 3GPP RELEASE 9 WOULD ALSO INTRODUCE DUAL-BAND HSDPA

Release 9 would also enable another important resource aggregation enhancement – Dual Carrier/Dual Band HSDPA (DC/DB HSDPA). This would enable the deployment of DC-HSDPA (which, per Release 8, pairs one 2x5 MHz UL carrier with two 2x5 MHz DL carriers), but now with the ability to locate the DL carriers on different frequency bands. This is illustrated in Figure 17 below.

Figure 17. DC/DB HSDPA: 1 UL Carrier, 2 DL Carriers (3GPP Release 9)

3GPP has focused its initial work

Advanced resource aggregation scenarios for ITU-R submission purposes.[43]

3. **Spurious emissions** are emissions other than the desired transmit signal which are caused by undesired transmitter effects such as harmonics, parasitics, intermodulation products or frequency conversion products, but exclude out of band emissions. Harmonic emissions occur at multiples of the transmitter's fundamental carrier frequency due to nonlinearities in the processing; hence, they will often be far removed from the victim receive band. Parasitic emissions are undesired oscillations that can occur within the transmitter at frequencies typically far removed from the carrier frequency, so would often be expected to be far removed from the victim receive band. Intermodulation or frequency conversion products come from nonlinear mixing of various signals in the transmitter processing. In well designed transmitters, these products would typically be at levels below those of OOBE; therefore, spurious emissions are often not the dominant source of interference when mobile technologies are operated in adjacent bands.

Based on the above three interference mechanisms, appropriate protections need to be established to balance access to the spectrum with de-risking the potential for harmful interference. Such protections can include transmit emissions masks (i.e. transmitter filtering) and transmit power limitations.

4.1 TECHNICAL SPECIFICATIONS

The interference mechanisms described above require different treatment to effectively mitigate the potential for harmful interference, because the underlying causes of the interference are fundamentally different. There is no "one size fits all" solution for adjacent band interference problems. Instead, specific solutions are required that address the specific root causes of the interference.

For example, OOBE interference leaks through the transmit filter of the device causing the interference to the victim receiver. The result is radiation from the source terminal device inside of the victim downlink mobile receive band, causing co-channel interference. Under such circumstances, even a perfect brick wall filter on the victim receiver would not reject the OOBE interference because it arrives directly in the nominal receive channel. It is therefore a misnomer to assume that better receive filters on the victim receiver can solve such a problem − this OOBE interference mechanism *must* be controlled by the OOBE specifications defining the transmit filter performance of the interfering transmitter and by transmit power limitations for the interfering terminal device.

On the other hand, adjacent channel interference is received by the victim mobile due to the roll-off skirts of the victim receive filter. Some energy from adjacent channels leak into the victim receiver tuned to an adjacent channel. The adjacent channel energy acts as interference, reducing the carrier-to-interference ratio of the desired serving signal. If the adjacent channel interference is strong enough, then it can cause saturation overload or blocking of the victim receiver. Receiver saturation overload occurs when the interfering signal is so strong that it drives the receiver into the nonlinear operating region causing potentially severe degradation of the desired signal performance. The adjacent channel interference can be reduced through better receive filter or receiver specifications in the victim receiver, or by transmit power limitations for the interfering terminal device.

These two primary interference mechanisms are distinct and as such require uniquely different mitigation approaches. OOBE is caused by leakage from the interfering transmitter radiating directly into the victim receiver band causing co-channel interference; therefore it can only be controlled at the interfering source terminal device by appropriate OOBE specifications and transmit power limits. Adjacent channel interference results from leakage in the victim receive filter; therefore it can be controlled by the victim mobile receiver specifications or by transmit power limits on the perpetrating terminal device.

In sum, regulatory bodies and industry players must work together to establish appropriate rules which mitigate these interference problems, by addressing the specific causes through well-engineered selection of emissions specifications.

4.2 GUARD BANDS

Interference due to the coexistence of TDD and FDD systems operating in adjacent frequency bands can be especially acute because frequency separation cannot be used to isolate the uplinks and downlinks, unrestricted blocks.[51] As Ofcom has shown, these EC rules effectively limit TDD to being deployed in small picocells in these restricted blocks to reduce the potential for interference.[52]

This and other proceedings previously discussed (e.g. the U.S. AWS-III proceeding) illustrate the need to manage the potential interference issues associated with FDD and TDD adjacency, primarily through the creation of sufficient guard bands and secondarily by establishment of appropriate service rules.

Finally, it is critical for policy makers to utilize multiple methods of analysis to assess the risk of interference to achieve informed decision making on spectrum policy. Although statistical analyses, such as system simulations, can be powerful tools to analyze dynamic processes and complex statistical relationships, it is not by itself sufficient for assessing the risk of interference. Other approaches, such as deterministic studies, are required to gain a complete picture of interference potential to users. In fact, a detailed examination of recent studies of coexistence, demonstrates that using a variety of methods is extremely important for evaluating interference risks. [53]

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[51] CEPT Report 19 at p. 74.

[52] *See* Ofcom 2008 2.6 GHz FDD/TDD Technical Report at p. 15 ("[I]t is likely that these restricted blocks could only be used for deployment of TDD pico-cells.").

[53] See *Ericsson Ex Parte Notice to FCC, Service Rules for Advanced Wireless Services in 2155-2175 MHz Band*, WT Docket No. 07-195(9 Sept. 9, 2008), *available at* http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520066376.

5. CONCLUSION

Studies have persuasively shown that there is a significant impact of fragmented spectrum allocations on the cost and performance of mobile devices. These impacts hold true in virtually every corner of the globe. Handset cost and size constraints place limits on the number of bands and technologies that typical small and low-cost consumer wireless devices can incorporate. This means that support for fragmented spectrum allocations is frequently minimized in favor of the more common global bands.

Regulators have an important– and challenging – role in obtaining addition spectrum and bringing it to market to meet the demands of consumers. 3G Americas would offer that in undertaking this effort, regulators should bear in mind the following:

1. Spectrum should be harmonized and coordinated to the maximum extent feasible;
2. New spectrum should facilitate access by new technologies of all stripes;
3. At the same time, appropriate protections should be established for incumbent and/or adjacent service providers to protect against interference;
4. Spectrum policy should foster as far as possible the efficient use of spectrum; and
5. The rules covering the allocation, auction and deployment of spectrum should be predictable and transparent, prior to auctions.

Notwithstanding, where support for fragmented spectrum bands is pursued, regulatory bodies and industry players must work together to develop technological solutions and appropriate technical rules to balance access to these bands with service provider coexistence.

APPENDIX A: ABBREVIATIONS

2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
4G	Fourth Generation
ARPU	Average Revenue per User
AWS	Advanced Wireless Services
Bits/s/Hz	Measure of spectral efficiency, determined by dividing the net bit rate or throughput by the bandwidth in Hertz
Bps	Bits per second
BRS	Broadband Radio Service
BSC	Base Station Controller
BTS	Base Transceiver Station
BW	Bandwidth
C/I	Carrier to Interference Ratio
CA	Carrier Aggregation
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CC	Component Carrier
CDMA	Code Division Multiple Access
CEPT	European Conference of Postal and Telecommunications Administrations (consists of policymakers and regulators from 48 states)
CITEL	Inter-American Telecommunications Commission (part of the Organization of American States)
CPE	Customer Premises Equipment
CS	Circuit Switched
dB	Decibel
dBm	Decibel ratio of watts to 1 milliwatt
DC-HSDPA	Dual Carrier High Speed Downlink Packet Access
DC-HSPA	Dual Carrier HSPA
DC-HSUPA	Dual Carrier High Speed Uplink Packet Access
DL	Downlink
DSL	Digital Subscriber Line
EC	European Commission
ECC	Electronic Communications Committee (CEPT committee comprised of telecommunications regulators from member states)
E–DCH	Enhanced Dedicated Channel (also known as HSUPA)
EDGE	Enhanced Data Rates for GSM Evolution
EPC	Evolved Packet Core, also known as SAE (refers to flatter-IP core network)
EPS	Evolved Packet System (the combination of the EPC/SAE and the LTE/EUTRAN)
EUTRA	Evolved Universal Terrestrial Radio Access

FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FOMA	Freedom of Mobile Multimedia Access (brand name for 3G services offered by Japanese mobile phone operator NTT DoCoMo)
GB	Gigabyte
Gbps	Gigabits per Second
GERAN	GSM EDGE Radio Access Network
GHz	Gigahertz
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
GSMA	GSM Association
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access (HSDPA with HSUPA)
HSPA+	High Speed Packet Access Plus (also known as HSPA Evolution or Evolved HSPA)
HSUPA	High Speed Uplink Packet Access
Hz	Hertz
IEEE	Institute of Electrical and Electronic Engineers
IMT	International Mobile Telecommunications
IP	Internet Protocol
ISP	Internet Service Provider
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union, Radiocommunication Sector
Kbps	Kilobits per Second
kHz	Kilohertz
LTE	Long Term Evolution (evolved air interface based on OFDMA)
LTE-A	LTE-Advanced
Mbps	Megabits per Second
MHz	Megahertz
MIMO	Multiple-Input Multiple-Output
MSC	Mobile Switching Center
NGM	Next Generation Mobile
NRA	National Regulatory Authority
Ofcom	U.K. communications regulatory authority
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access (air interface)
OPEX	Operating Expenses
PCS	Personal Communications Service
PS	Packet Switched
QoS	Quality of Service
RAB	Radio Access Bearer
RAT	Radio Access Technology
RATG	Radio Access Technology Group (committee within the ITU-R)

RB	Radio Bearer
RAN	Radio Access Network
RAN1	Working group within 3GPP focused on physical layer specifications
RAN4	Working group within 3GPP focused on radio performance and protocol aspects
Rel-X	Release 99, Release 4, Release 5, etc. from 3GPP standardization
RF	Radio Frequency
RNC	Radio Network Controller
SC-FDMA	Single Carrier Frequency Division Multiple Access
SAE	System Architecture Evolution, also known as EPC
SGSN	Serving GPRS Support Node
SG	Study Group
SI	Study Item
SIR	Signal to Interference Ratio
SNR	Signal to Noise Ratio
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
TS	Technical Specification
UE	User Equipment
UGC	User Generated Content
UL	Uplink
UMB	Ultra Mobile Broadband
UMTS	Universal Mobile Telecommunications System
UTRA	Universal Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
WCDMA	Wideband CDMA
WG	Working Group
WI	Work Item
WiMAX	Worldwide Interoperability for Microwave Access
WRC	World Radio Conference

APPENDIX B: REFERENCES

STANDARDS DOCUMENTS

RAN1 Findings of the UTRA Multi-Carrier Evolution Study, Third Generation Partnership Project, RP-090318 (March 2009), document available for download at http://www.3gpp.org/Radio-Access-Network-status-after

Study of UE architectures for LTE-A deployment Scenarios, Third Generation Partnership Project, R4-091204 (March 2009), document available for download at http://ftp.3gpp.org/tsg_ran/WG4_Radio/TSGR4_50bis/Documents/

POLICY & REGULATORY DOCUMENTS

Commission Decision of 13 June 2008 on the Harmonization of the 2500-2690 MHz Frequency Band for Terrestrial Systems Capable of Providing Electronic Communications Services in the Community, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:163:0037:0041:EN:PDF

Report from CEPT to the European Commission in Response to the Mandate to Develop Least Restrictive Technica BT 812(nda)-12(t)-1(e t)pt f-12(s) 0 Tc 0 Tw 14.94 0 Banor

APPENDIX C: LTE-ADVANCED RESOURCE AGGREGATION

3GPP RAN WG4 has begun investigating possible UE RF architectures to enable four LTE-Advanced resource aggregation scenarios for ITU-R submission purposes.[54]

Figure C.1. Possible UE RF Architectures for LTE-Advanced Resource Aggregation

ACKNOWLEDGMENTS

The mission of 3G Americas is to promote, facilitate and advocate for the deployment of the GSM family of technologies including LTE, throughout the Americas. 3G Americas' Board of Governor members include Alcatel-Lucent, América Móvil, Andrew Solutions, AT&T (USA), Cable & Wireless (West Indies), Ericsson, Gemalto, HP, Huawei, Motorola, Nokia Siemens Networks, Nortel Networks, Openwave, Research In Motion (RIM), Rogers Wireless (Canada), T-Mobile USA and Telefónica.

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