WHITE PAPER

Spectrum Analysis for Future LTE Deployments

Abstract

LTE (Long Term Evolution) promises to deliver an unrivalled user experience with ultra fast broadband and very low latency and at the same time, a very compelling business proposition for operators with flexible spectrum bandwidth, smooth migration and the ability to deliver low cost per bit voice and data services. With LTE's ability to interconnect with other access technologies, operators will be able to converge their LTE and Fixed line broadband networks, creating the opportunity to deliver subscribers truly seamless communications.

Radio frequency is a valuable and finite resource and, today, there is simply not enough to satisfy demand. The need for spectrum is being driven by the pervasive convenience of mobile communications and the need for increased penetration combined with improved performance and the falling costs of wireless devices & services. Existing and new Mobile Broadband networks will quickly consume current spectrum allocations as they deliver a highly compelling user experience by allowing multimedia applications anywhere.

In the near future, operators will be presented with, and challenged by, new and exciting opportunities to deploy LTE based mobile broadband services – but, as with any new network technology, comes the question of spectrum.

This paper provides an overview of the spectrum trends relating to LTE, highlighting the issues and opportunities that potentially lie ahead.

Industry Perspective & Trends

The wireless industry has seen explosive growth in the demand for both voice and data services over the past several years. The number of mobile telephone subscribers, as well as usage rates, has grown considerably, and carriers have been upgrading their networks with advanced technologies to meet this growing demand for high quality voice services and innovative data services. Historically, spectrum has been heavily regulated. This is changing however, and regulation is becoming more flexible or technology neutral, ultimately allowing service providers to more effectively address the demands of the market place.

Service providers and equipment vendors are driving technical innovation and the latest wireless technologies show significant gains in the efficiency of spectrum used, providing more capacity out of a given bandwidth.

Emerging technologies such as WiMAX are also now lobbying for spectrum allocations for wireless/mobile broadband services, adding more fuel to the very hot topic of spectrum allocation in all regions.

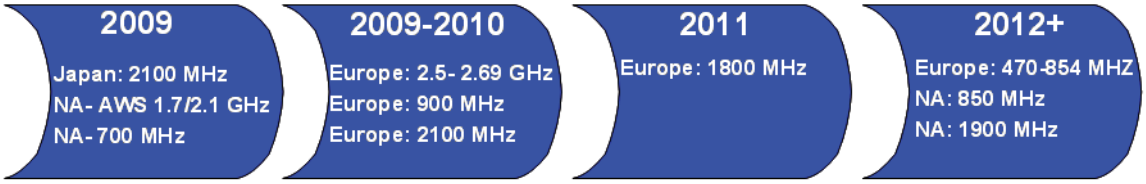


Figure 1. LTE Deployment Scenario

LTE Potential spectrum

LTE and WIMAX each have their own benefits and are suited to address different target market segments; one key differentiator is that WiMAX is primarily TDD (Time-Division-Duplex) and will address operators that have unpaired spectrum whereas LTE is FDD (Frequency-Division-Duplex) and will address operators that have paired spectrum. TDD allows the up-link and down-link to share the same spectrum, whereas FDD has the up-link and down-link transmit on different frequencies.

In this section, we look at the most probable FDD spectrum bands suitable for future deployment of LTE. 3GGP LTE standards are planned for completion in 2008, with the first deployments of LTE networks likely at the end of 2009 or beginning of 2010. Bearing in mind this schedule, and the current level of activity related to spectrum regulation and allocation, it is likely that the information contained in this paper will require regular revision to remain accurate. The information contained in this paper is believed to be accurate as of December, 2007.

Advanced Wireless Services (AWS)

In September 2006 the FCC completed an auction of AWS licenses ("Auction No. 66") in which the winning bidders won a total of 1,087 licenses. In the spirit of the U.S. government's free-market policies, the FCC does not usually mandate that specific technologies be used in specific bands. Therefore, owners of AWS spectrum are free to use it for just about any 2G, 3G or 4G, technology.

This spectrum uses 1.710-1.755 GHz for the uplink and 2.110-2.155 GHz for the downlink. The 90 MHz of spectrum is divided into six frequency blocks labeled A through F. Blocks A, B, and F are 20 megahertz each and blocks C, D, and E, are 10 megahertz each.

The FCC wanted to harmonize its "new" AWS spectrum as closely as possible with Europe's UMTS 2100 band. However, the lower half of Europe's UMTS 2100 band almost completely overlaps with the U.S PCS band, so complete harmonization wasn't an option. Given this constraint, the FCC harmonized AWS as much as possible with the rest of the world. The upper AWS band aligns with Europe's UMTS 2100 base transmit band, and the lower AWS band aligns with Europe's GSM 1800 mobile transmit band.

700 MHz

In the U.S. this commercial spectrum is scheduled to be auctioned in January 2008. This includes 62 MHz of spectrum broken into 4 blocks; Lower A (12 MHz), Lower B (12 MHz), Lower E (6 MHz unpaired), Upper C (22 MHz), Upper D (10 MHz). These bands are highly prized chunks of spectrum and a tremendous resource: the low frequency is efficient and will allow for a network that doesn't require a dense buildout and provides better in-building penetration than higher frequency bands.

In 2005, the President of the U.S. signed the Digital Television Transition and Public Safety Act of 2005 into law, designating February 17, 2009 as the date that all U.S. TV stations must complete the transition from analog to digital broadcasts, vacating the 700 MHz radio frequency spectrum, and thereby making it fully available for new services. The upper C block will have "open access" rules. In the FCC's context "open access" means that there will be "no locking and no blocking" by the network operator. That is, the licensee must allow any device to be connected to the network as long as the device is compatible with, and will not harm the network (i.e., no "locking"), and the licensee cannot impose restrictions against content, applications, or services that may be accessed over the network (i.e., no "blocking").

The upper D block will include a Public/Private Partnership obligation. As part of the 700 MHz FCC decision, the winner of the commercial license will combine this asset with an additional 10 MHz of adjacent spectrum licensed to a national Public Safety Broadband Licensee (PSBL), creating a public-private partnership. In exchange for constructing and operating the shared network to Public Safety specifications, the D Block commercial licensee will gain access to spectrum, on a secondary basis, held by the PSBL to provide it with additional capacity to furnish non-priority communications services to commercial subscribers.

Indications are strong that in Europe, and much of the rest of the world, the so-called digital dividend - the freeing up of spectrum brought about by the switch from analog to digital TV- will also allow a significant amount of spectrum to be carved out for wireless broadband in the UHF band. While the details of the digital dividend outside of the U.S are still being debated, the expectation is that allocations will align with, or as closely as possible with the U.S. allocations in order to facilitate Global Roaming.

Refarming GSM 900 MHz

The 900 MHz band is the most ubiquitous and the most harmonized worldwide wireless telecommunication spectrum band available today. It also has the benefit of increased coverage and subsequent reduction in network deployment costs compared to deployments at higher frequencies, making it a highly strategic spectrum band. Furthermore, 900MHz offers improved building penetration and is particularly well suited to supporting those regions that have a predominantly rural population.

The ongoing subscriber migration from GSM to UMTS taking place in over 150 countries worldwide is relieving pressure on the GSM900 networks and is starting to free up some spectrum capacity in that band.

Consequently, many operators are evaluating the potential for deploying UMTS (HSPA/HSPA+) in this GSM900 band. On the other hand a number of operators are considering keeping that freed-up GSM spectrum until LTE becomes available in the beginning of 2010. In effect from a planning perspective. UMTS deployments require a full 5 MHz of spectrum to be freed up before being deployed in that band. Additionally, the availability of mobile devices able to support 900 MHz is not planned until 2008-2009 at the earliest. In contrast, LTE will be able to be deployed in spectrum bands as small as 1.25MHz and it provides good initial deployment scalability as it can be literally "squeezed" in as the GSM spectrum is freed-up, and grow as more spectrum becomes available. These factors reduce the time advantage of deploying UMTS (HSPA/HSPA+) in the 900 MHz band.

In addition, with the improved spectrum efficiency, LTE deployment in the 900 MHz band would bring the highest capacity benefit and also provide operators the ability to deploy an LTE network with greater coverage at a much reduced cost compared to higher frequency spectrum hence provide a good mobile broadband data countrywide layer.

Finally, deploying LTE in 900MHz can also bring the additional cost and logistic benefits of being able to deploy LTE at existing GSM sites as the coverage of GSM/LTE in 900MHz should be very similar.

It is not envisioned that operators in Europe would shut down their GSM networks as GSM still provides the backbone of voice communication and global roaming. GSM networks with EDGE or future E-EDGE upgrades do provide a good data sub-layer to hand over to, when, initially, LTE coverage will not available. The most likely scenario is that LTE at 900 MHz could run alongside GSM900 for a 5-10 year period after which time a GSM shutdown might be considered. The willingness of operators to commit to refarming 900 MHz will in many cases hinge on discussions at the EU level on the continuing legal applicability of the GSM Directives. Based on recent development, it now looks like the EU Parliament has endorsed the refarming of GSM spectrum paving the way for potential deployments of LTE into 900MHz.

IMT Extension Band

WRC-2000 identified three additional bands for terrestrial IMT-2000 including 2500-2690 MHz. As a result, starting in 2008, as much as 140 MHz of IMT2000 FDD expansion spectrum will be allocated in Europe; 2500-2570 MHz for uplink and 2620- 2690 MHz for downlink. Additionally up to 50 MHz (2570 MHz-2620 MHz) will be allocated as an unpaired TDD band. [Note – the UK has a plan that expands the unpaired spectrum]. As a globally common band plan, this spectrum band will also enable economies of scale and global roaming. Austria, Norway, Sweden, and the U.K. will be among the first European markets to auction the 2500 MHz spectrum that will be used for mobile broadband.

Country	Spectrum	Date
Austria	2500 MHz - 2690 MHz	Q2 2008
Norway	2500 MHz - 2690 MHz	Completed
Sweden	2500 MHz - 2690 MHz	Q2 2008
United Kingdom	2500 MHz - 2690 MHz	Q1 2008

It is likely that LTE will be deployed in the FDD portion of this band due to its benefits as compared to HSPA/HSPA+. In addition, this band is the only one of 2 bands that offers the unique opportunity for the deployment of LTE in maximum spectrum bandwidth by providing channels of up to 20 MHz. In that sense, it is largely expected that current mobile operators will try and secure the maximum 20 MHz allocation to provide them with the ability to support future mobile broadband capacity requirement.

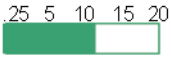
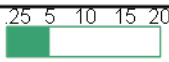
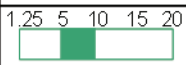
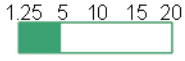
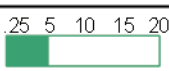
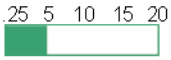
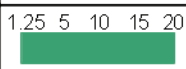
Band	Uplink (MHz)	Downlink (MHz)	Carrier Bandwidth (MHz)	Comments
700 MHz	746-763	776-793		Digital Dividend. U.S. commercial spectrum is scheduled to be auctioned in January 2008. Potential future alignment with Europe
AWS	1710-1755	2110-2155		U.S. Auctions completed September 2006
IMT Extension	2500-2570	2620-2690		Initially Western Europe. Offers a unique opportunity for the deployment of LTE in channels of up to 20 MHz.
GSM 900	880-915	925-960		Reallocate this spectrum to advanced networks, such as LTE, from 2009 onwards
UMTS Core	1920-1980	2110-2170		Europe and Asia Pac. Potential for unused WCDMA carriers
GSM 1800	1710-1785	1805-1880		Europe and Asia Pac. Refarm underutilized band along with GSM 900
PCS 1900	1850-1910	1930-1990		U.S. Refarm after new 700 MHz and AWS spectrum is consumed.
Cellular 850	824-849	869-894		U.S. Refarm after new 700 MHz and AWS spectrum is consumed.
Digital Dividend	470-854			Identified at WRC-07.

Figure 2. Candidate Bands for LTE

Other Candidate Bands

GSM 1800: Interest from Americas, Asia Pac and some countries in EMEA, especially for the refarming of existing GSM spectrum.

UMTS Core Band 2.1 GHz: This is the core 3-3.5G band for EMEA, AsiaPac & LAC with deployments of networks in over 150 countries. Most operators were awarded 2, 3 and in some limited instances 4 x 5 MHz carriers in this spectrum band. Most operators have so far only used one band, but with mobile data growth and subscriber migration to UMTS/HSPA, it is yet unclear if and how many carriers will be available in that band for LTE services in 2009-2010.

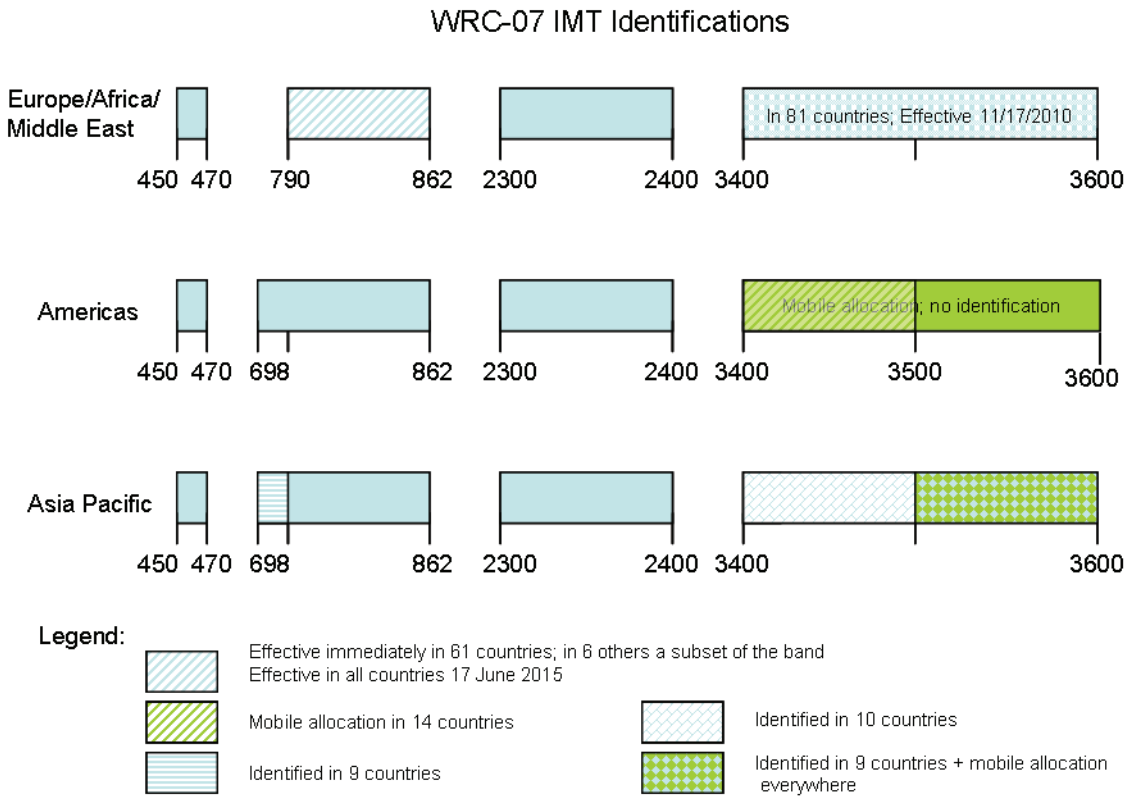
PCS 1900: Alternative to core band, which is not available in EMEA. Service providers may refarm this spectrum after the new 700 MHz and AWS spectrum is consumed.
Cellular 850: Refarm this spectrum after the new 700 MHz and AWS spectrum is consumed.

Future Spectrum Requirements

ITU (ITU-R M.2078) projects overall spectrum requirements for the future development of IMT-2000 and for IMT-Advanced. The results assert that additional spectrum demand of between 500 MHz and 1 GHz will be needed in all ITU Regions by 2020.

This report expresses traffic growth factors of 2 to 3 by 2010 for Europe compared to today. It is clear that existing bands will not be enough for IMT services approximately after the year 2015 and additional bands are needed. In order to deliver a true broadband experience, large blocks of spectrum will need to be identified and allocated.

One of the goals of WRC-07 was to identify additional, harmonized, worldwide spectrum, to enable global roaming services while bringing economies of scale to vendors. In this regard, WRC-07 identified the 450-470 MHz and 2300-2400 MHz bands for IMT (which includes both IMT-2000 and IMT-Advanced) on a global basis. In addition, WRC-07 identified portions or all of 698-862 MHz and 3400-3600 MHz. The identification and use of these bands varies from region-to-region and country-to-country as detailed in the Table 1. The Final Acts from WRC-07 provide full details on these identifications[1].



WC-07 made positive steps towards making spectrum available for future LTE deployments. In particular, WRC-07 began the process of migrating broadcast spectrum in the 698-806 MHz band to mobile applications. The next steps will be working with individual countries to ensure spectrum is recovered and licensed for mobile systems at a national or regional level around the world. In addition, achieving an internationally harmonized band plan for use of the spectrum is also important.

[1] See http://www.itu.int/md/R07-WRC07-R-0001

Conclusion

The ability to take advantage of new spectrum allocations and the opportunity to potentially refarm existing GSM spectrum are two key areas that will enable LTE deployments. Enhancing network capabilities presents new deployment opportunities, economies of scale and opens up markets that were previously inaccessible. Over the next several years the spectrum landscape will change significantly. The oncoming spectrum auctions in the (700 MHz and 2.5-2.6 GHz bands) will have a direct influence on the LTE ecosystem and in which band LTE will be deployed. Furthermore, the identification of new IMT mobile bands at WRC-07 (450-470 MHz, 2300-2400 MHz, 698-862 MHz and 3400-3600 MHz) will help fulfill the projected need for future bandwidth as well as facilitate global roaming.

Compared to HSDPA/HSDPA+, LTE is expected to substantially improve end-user throughputs, sector capacity and reduce user plane latency to deliver a significantly improved user experience. As such, the industry expects that Service Providers will wait to deploy LTE in the refarmed 900 MHz and newly licensed 2.5-2.6 GHz bands.

As with any new network, the early availability of highly functional and cost effective handsets and infrastructure equipment is essential to the success of LTE. As with the legacy network technologies, it is expected that the industry will agree on a unified LTE candidate band list in order to maximize availability and economy of scale as well as enable an LTE global roaming experience similar to what subscribers are enjoying today with GSM.

Motorola's LTE roadmap supports a wide range of frequencies, aligning with the growing needs of service providers globally as new bands receive the necessary regulatory approval and service provider allocation. Opportunities to reduce operating and capital expenses are created as Motorola helps you plan and optimize use of your spectrum allocations. Motorola's extensive OFDM experience will allow our network planning team to utilize our proven and proprietary tools to optimize network architecture and topology according to your new and existing allocated frequency bands. In addition Motorola can also recommend value added applications to further increase the effectiveness and competitiveness of your network.

Motorola will create compelling opportunities with a market leading LTE ecosystem and industry recognized services. Our Mobile Broadband solution will help you get the most out of your deployment opportunities and provide your subscribers a true seamless mobility experience.

For more information on LTE, please talk to your Motorola representative.

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