



# Optimising spectrum for future mobile service needs

## Abstract

This white paper looks at two important issues surrounding the future use of the 3G extension bands (2.5 – 2.690 GHz). The first issue is the importance of reserving this spectrum for IMT-2000 technologies. The second is the importance of planning this spectrum band in an efficient manner, and the choice of FDD<sup>1</sup>/TDD<sup>2</sup> channelling arrangements chosen.

The first part of the paper looks at the benefits of spectrum harmonisation, and how this has led to the reduction in costs of GSM handsets, which spurred extra take-up. This in turn has created a virtuous circle, making GSM the most popular worldwide mobile technology, with over 1.7 billion users today. In 1995 GSM had some 13 million users worldwide, with around 10 million users in Western Europe (nearly 80%)<sup>3</sup>. The paper argues that there is a need similar support for 3GSM in the nascent start up phase today, as was shown for GSM in the early 1990's.

The second part of the paper deals with spectrum efficiency and planning issues to do with the ITU channelling arrangements chosen. The ITU proposed three options, the first has FDD and TDD<sup>4</sup> technologies separated in frequency. The second allows for only FDD use in the bands. The third option allows the flexible use of FDD and TDD, which requires significant spectrum guard bands to prevent interference. This mixed use also imposes significant costs on operators in the deployment of 3GSM in the extension bands. This white paper argues that only options one and two from the ITU should be adopted (ie with FDD and TDD not operating in the same spectrum).

Founded in 1987, the GSM Association has played a pivotal role in the development of the GSM platform and of the global wireless industry.

Since its introduction GSM Association's members and staff have created the landscape of success for global mobile communications via GSM.

The GSM Association (GSMA) is the global trade association that exists to promote, protect and enhance the interests of GSM mobile operators throughout the world. At the end of April 2006, it consisted of 699 second and third generation mobile operators and more than 150 manufacturers and suppliers. The Association's members provide mobile services to more than 1.7 billion customers across more than 213 countries and territories around the world.

The GSMA aims to accelerate the implementation of collectively identified, commercially prioritised operator requirements and to take leadership in representing the global GSM mobile operator community with one voice on a wide variety of issues nationally, regionally and globally.

[www.gsmworld.com](http://www.gsmworld.com)



<sup>1</sup> Frequency Division Duplex.

<sup>2</sup> Time Division Duplex.

<sup>3</sup> Source: Informa WCIS

<sup>4</sup> Frequency Division Duplex and Time Division Duplex.

## Introduction

Economic growth, the pace of technical change, and the element of mobility in modern lifestyles, will continue to drive demand for mobile services and spectrum. Mobile services will grow in number and variety, and will come to include much that is mainly available from fixed access only today, such as music downloads and podcasting. Spectrum demand will also grow fuelled by innovative mobile services, such as picture and video messaging. We can also expect to see the increase in mobile camera resolutions drive this spectrum demand even further.

The GSM Association (GSMA) also believes that there will be future demand for the spectrum for Mobile TV services. Technologies such as Multimedia Broadcast and Multimedia Services (MBMS), which is available in both FDD and TDD carrier formats can offer Mobile TV to 3GSM users, by taking advantage of the 2.5/2.6 GHz extension bands<sup>5</sup> that have been identified for IMT-2000 by the ITU. As Ms Reding, the European Commissioner of Information and Society Media noted in her speech at CeBIT<sup>6</sup> "If we want Mobile TV to be the next economic carrier wave of technological, industrial, and consumer services growth, we had better make sure that we create enough space for these services to take off."

A further advantage of using the extension bands for Mobile TV is that they are fully harmonised across Europe and the greater part of the rest of the world. The value of a harmonised approach for Mobile TV spectrum is recognised by Commissioner Reding in her speeches and the extension bands deliver this requirement without any need to further regulate or re-allocate existing bands. This will ensure that the Mobile TV growth is allowed to flourish unhindered by capacity constraints within the existing core bands.

Such growth is also dependent on the availability of low cost mobile terminals that have the capabilities to exploit the added value that data services can offer. This means mobile terminals with good screen resolution, sufficient memory, and processing power. It also means user interfaces that allow easy and intuitive use of mobile devices. Offering such mobile devices involves the industry investing in major upfront costs, such as R&D, silicon development, new software, and testing, etc. Large volumes of terminals are required to spread these upfront costs. If only low volumes of terminals are produced the recovery of upfront (fixed costs) will drive up the costs of terminals significantly. This will translate into less consumer up-take of these new and innovative mobile services, which can have a negative impact on employment, the economy and competition.

Figure 5 on page 8 shows the impact such economies of scale can have on handset prices. In 1997 the average sale price of low-end GSM handsets was \$250 USD. By 2004 this had fallen to around \$50 USD, and has continued to fall. Part of this is due to handset subsidies, but these existed in 1997. Figure 5 also shows that the cost of silicon components (which are not subsidised) has also fallen at around the same rate. The period (1997-2004) saw GSM subscribers go from around 70 million worldwide (@40 million in western Europe)<sup>7</sup> to just over one billion worldwide (with only a third in Western Europe)<sup>8</sup>. This might indicate that economies of scale have delivered a reduction in terminal prices of up to 500%. However some of this reduction will have come from reductions in elements common to all mobile phones<sup>9</sup>. As Commissioner Reding noted in her

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<sup>5</sup> 2500 – 2690 MHz.

<sup>6</sup> 8 March 2006, Television is going Mobile.

<sup>7</sup> Source: Informa WCIS

<sup>8</sup> Source [www.wirelessintelligence.com](http://www.wirelessintelligence.com)

<sup>9</sup> ie batteries, memory, screens, chargers etc.

CeBIT speech, "--the choice of a widely accepted standard – such as GSM for mobile telephony – is of paramount importance to get economies of scale"

The GSMA believes that the uptake in the early years of 3GSM is critical to its long-term success, as it was to the success of GSM. We are in that early phase for 3GSM, with some 74 million UMTS terminals worldwide (June 2006)<sup>10</sup>. Over 90% of this is in Western Europe and Japan. As we have seen with GSM, Europe can serve as the initial "breeding ground" to allow sufficient production scale to emerge, then allowing the service to flourish globally. We need to ensure that a virtuous circle is set up where more handset sales lead to cheaper handsets (because of the spreading of upfront costs). This will allow the 3GSM/UMTS market to grow the same way GSM did. Fragmenting 3G spectrum by allowing fixed wireless technologies to be the primary users<sup>11</sup> of such bands undermines this model. It sends a signal to other markets and regulators that might be interpreted as a lack of confidence.

The GSMA also fears that developing nations will be the hardest hit by the fragmentation of spectrum usage, as people in these countries are the most price-sensitive, especially for handsets. The net effect might be less mobile broadband internet penetration. This could deny these economies the full benefits that internet might bring to increasing their economic productivity.

The second half of the white paper outlines the benefits of spectrum harmonisation. The paper pays special attention to benefits associated with a structured channelling plan for 3G. Spectrum harmonisation, focused on optimising spectral efficiency for IMT-2000 technologies, will promote and ensure a competitive environment for mobile services. Based on the present analysis, the GSMA concludes that a continued successful development of the mobile market depends on reserving the 3G extension band for IMT-2000 technologies.

### **Why not let the market decide this?**

The GSMA has studied the output of the CEPT<sup>12</sup> and the European Commission on this issue. The Commission makes the point that there is already sufficient spectrum for 3GSM reserved in other bands such as at 2.1 GHz, and likely 900 MHz and 1800 MHz bands (although the dates for refarming are not yet clear in all member states). It could be argued that, in the absence of a market failure, the spectrum should be awarded on a technology neutral basis. This would allow bidders to decide what technology to use, as long as the technology causes no more interference than an IMT-2000 technology would have done. The GSMA believes that this is an over simplified view.

This "leave it to the market" view fails to appreciate where we currently are in terms of spectrum regulation. We are moving from the old "command and control" spectrum regime (where use and technology are mandated) to a more market-based regime. We have not yet arrived at a point where the market is able to work efficiently in assigning and allocating spectrum. This is due to the lack of "liquidity" of the current spectrum market in the EU and elsewhere<sup>13</sup>. For such a market to work there needs to be clearly defined (and technology neutral) spectrum property rights. This would allow for market failures such as such as the unintended consequences of interference.

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<sup>10</sup> Source [www.wirelessintelligence.com](http://www.wirelessintelligence.com)

<sup>11</sup> Technologies such as WiMax might be useful for cellular backhaul, or rural wireless local loop.

<sup>12</sup> ECC/DEC/(05)05.

<sup>13</sup> With the possible exception of Guatemala.

There seems to be no common agreement on what a technologically neutral spectrum property right is. Such rights are essential to allow change of use, which is needed to allow spectrum to flow from low to high value uses. There is also no common understanding of what constitutes harmful interference. In such circumstances, we do not have a properly functioning market for spectrum; one that is liquid enough to arrive at market clearing prices for various spectrum bands. Even if the spectrum market were sufficiently liquid, it might be that in some circumstances the benefits afforded by harmonisation in general, and frequency harmonisation in particular, may not be properly accounted for sufficiently in the market place. For example in helping new strategic technologies such as GSM in the early days, and 3GSM now, and Mobile TV in the near future.

In Europe and elsewhere, we are in a transition phase from a "command and control" system of spectrum management, to a more liberalised spectrum market. During such a transition, special care needs to be taken with key strategic spectrum industries such as 3GSM. We have seen the vital role GSM has played in increasing the economic welfare of countries, this economic welfare relates directly into providing jobs and tax revenues for governments. According to a study by Ovum, commissioned by the GSMA, some €106 billion was generated by the supply of mobile services in the EU15 alone in the year 2004. Some 1.7 million jobs are directly employed by the mobile industry, or depend on the mobile industry. This is some 1.1% of GDP (2004 figures). Mobile technology is an area where Europe has maintained a competitive advantage in terms of its technology.

This economic success is built on GSM, but future economic welfare will depend upon the growth of new technologies such as 3GSM. Any regulatory changes or uncertainty that jeopardises that needs to be considered very carefully. As the Commission Communication on radio spectrum policy<sup>14</sup> notes, "The EU's timely provision of harmonised frequencies "triggered" the development of new pan-European digital cellular system (GSM)". It further states that "this coherent approach was instrumental in the emergence of an industry which generated in 2004 a GDP contribution of €105.6 bn for the EU 15 alone."

The GSMA would argue that one of the dangers of this transition phase in spectrum management is in realising the benefits of frequency harmonisation, particularly economies of scale. The danger is that the competitive success of 3GSM is diminished because regulators allow the market for such services to fragment into a myriad of competing technologies. The private incentives of actors in the market are driven by issues such as IPR. The market for spectrum is not sufficiently liquid to allow such fragmentation to be reversed easily. Even if it were this would take time<sup>15</sup>. In the early start-up period time is a commodity that can be in short supply, as Commissioner Reding put it at CeBIT, "We cannot afford to sleep on this". Although she was referring to Mobile TV, we believe the same logic applies to the 2.5/2.6 GHz extension bands, which can be used for Mobile TV.

The EC Commission Communication on a market based approach to spectrum management<sup>16</sup> notes that net gain from spectrum trading and flexible spectrum property rights would amount to €8-9 billion per year. The GSMA is not in a position to say if this is accurate or not. This figure might be used as an argument to allow flexibility in the 3G extension bands. Trading within use could still be allowed without any impact on the benefits of spectrum harmonisation. Logically,

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<sup>14</sup> Brussels, 6.2005 COM(2005) 411 final.

<sup>15</sup> Due to problems such as hold-out issues. I.e. sellers and buyers can't agree a price.

<sup>16</sup> Brussels, 14.9.2005 COM(2005) 400 final.

the main benefit from liberalisation must come from spectrum flowing from low to high value uses<sup>17</sup>. It is clear from previous economic studies that mobile (GSM and in the future 3GSM) will be the highest value users of spectrum<sup>18</sup>. So the action of reserving this spectrum for 3GSM is not likely to have any significant negative impact on the benefits of trading and liberalisation.

### **What is required**

In order to ensure the growth of 3GSM, a stable development phase is required within at least Europe. This can be achieved by reserving the 3G extension band for current IMT-2000 technologies, with an understanding that future enhancements of IMT-2000 will be allowed to ensure operators have access to the most advanced technologies.<sup>19</sup> Allowing the extension bands to be used by quasi-fixed services<sup>20</sup> fragments this market. There are a number of technologies that are part of the IMT-2000 family, and inter-standard competition is ensured by the choice operators have between these five. It does not appear to the GSMA that this would in any way be counter to the letter or spirit of WTO rules. These rules state that international standards should be used where they apply. Any new technology that feels excluded is free to enter into the IMT-2000 family; if it can demonstrate it meets certain objective and proportionate qualification criteria. The major one is "is it an open and standardised fully mobile service?" Technologies that are nomadic (ie do not allow seamless handover) are not likely to qualify. If a technology cannot meet even that basic hurdle, then it should not qualify as the primary use of IMT-2000 extension spectrum.

### **Strong growth in mobile penetration and usage indicates a need for the 3G core and 3G extension bands**

The year 2002 was a turning point in the world of telephony. For the first time, the global number of mobile subscribers overtook the number of fixed-line subscribers. Various factors point towards continued rapid growth in penetration and usage for mobile:

- Demand for 3G mobile services is growing rapidly
- Demand for general mobile services is growing, especially in markets with underdeveloped fixed line infrastructure
- Communication services are migrating from fixed to mobile networks
- The need for location-independent broadband access is forecast to grow

### ***Growing traffic will drive the need for spectrum***

Long-term forecasts for service demand are never certain since parts of them necessarily are based on forecasts of economic growth and how consumers will react to new services. Such forecasts have inbuilt assumptions, and the final demand can be very sensitive to the exact figures chosen. However, current trends and historical experience from the development of the internet both indicate an increased service demand and a substantial growth in traffic.

The UMTS Forum forecasts a typical Western European country will generate 250 Tbytes of traffic per day in 2012 and as much as 5750 Tbytes per day in 2020. The massive growth in traffic will be driven by image transfer, video transfer and internet access provisioning, the Forum predicts.<sup>21</sup>

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<sup>17</sup> Unless we assume spectrum is efficiently assigned now – which is unlikely.

<sup>18</sup> Based on consumer and producer surplus figures.

<sup>19</sup> Vodafone does not endorse the view that the 3G extension band should be reserved for IMT-2000 technologies only.

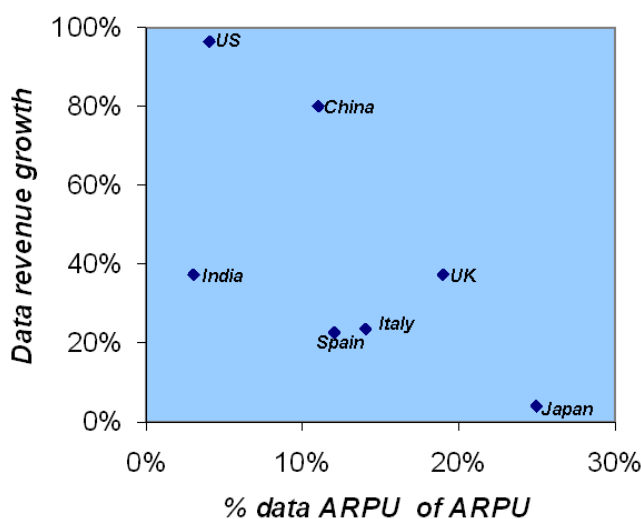
<sup>20</sup> Services that describe themselves as "mobile" but do not offer standardised roaming, or seamless handover, or authentication etc.

<sup>21</sup> Magic Mobile Future, UMTS forum, April 2005

When trying to meet increasing demand, there will be a choice between using additional spectrum and investing more in infrastructure, ie deploying additional base station sites. In deciding between these two options one needs to judge the difference in costs. This will depend on the difference between the savings in the cost of building new sites and the extra site rental costs, and extra cost of transceivers to use the extra spectrum (as well as the cost of acquiring more spectrum). Using typical values today, the cheaper option is to acquire more spectrum.

We are also dealing with new mobile services in their early start-up phase, so the exact dates, when consumer demand requires network capacity expansion, could be significantly sooner than the year 2020. Certain high-volume scenarios for 3G uptake predict the capacity of a typical 3G network will be exceeded in a few years.

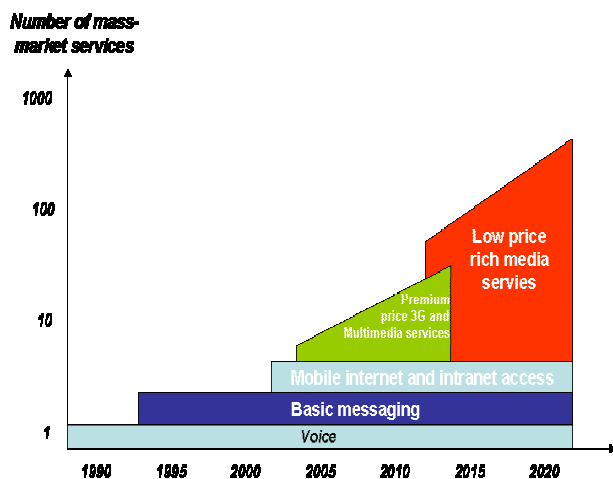
**Strong growth expected for mobile data services**



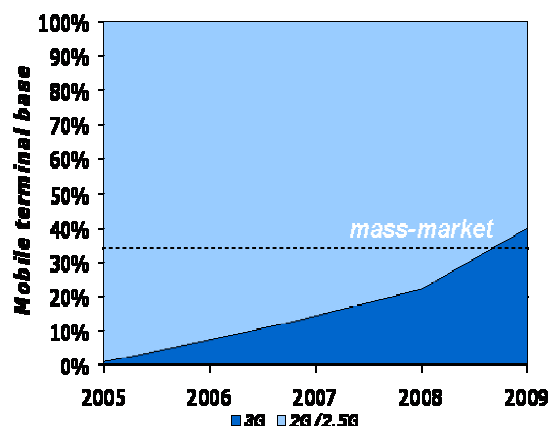
Operators' revenue from data services shows strong growth (Figure 1). In 2005, a number of operators generated 20-25% of their revenues with non-voice applications. Advanced data services show particular growth. These are beginning to break the dominance of text messaging as major data revenue source.

**Figure 1 Mobile data ARPU YoY growth in selected markets Q1 2005 (Merrill Lynch, 2005)**

As usage grows, end users' expectations on usability and performance will grow as well. An abundance of services and service developers are entering the



**Figure 2 Mobile service availability outline 1990-2020 (Northstream)**



**Figure 3 Penetration of 3G handsets 2005-2009 (Northstream)**

market to meet these expectations. This occurs not least with 3G services. Already, operators offer a variety of interesting 2.5G data services. The 3G service market will offer an even richer set of services by all accounts (Figure 2).

Penetration remains the key indicator for 3G traffic levels. Mass-market mobile data usage and subsequent massive traffic growth assumes 3G penetration will reach mass-market levels (Figure 3).

***Growing demand for mobile broadband***

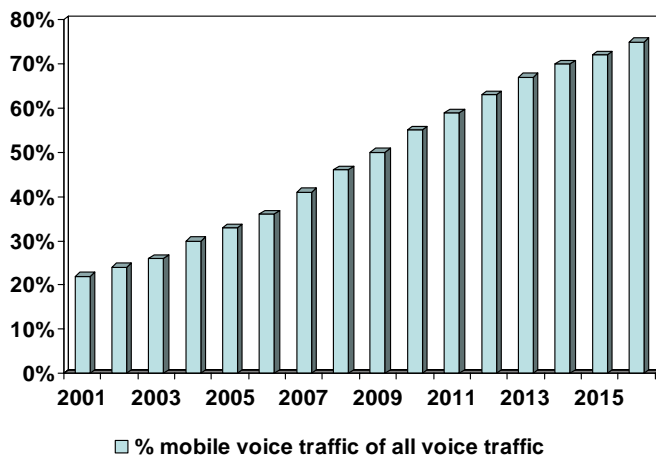
The penetration of broadband internet access is increasing globally. In 2005 in the US, close to 45% of households access the internet using a broadband connection. By 2010, penetration is expected to reach 80%.<sup>22</sup> Broadband access today is mainly offered over fixed networks. Penetration development is heavily dependent on the availability and quality of last-mile fixed-line infrastructure.

In regions with poor last-mile fixed-line infrastructure, 3G networks may provide a cost-efficient alternative. Compared with single-application access solutions, 3G provides a compelling alternative as the infrastructure cost can be spread over multiple services, including mobile voice. Internet penetration, the availability of fixed-line infrastructure, user density and affordability will determine demand for broadband over 3G.

3G can also serve as an attractive mobile alternative or complement to fixed-line broadband in markets where fixed-broadband penetration is already high. Early 3G operator experience shows that users are likely to use 3G to access the internet, especially when on the move. Ubiquitous 3G coverage, increased customer awareness and attractive price packages will drive users' willingness to access the internet via a 3G device.

***Migration of basic fixed line voice services to rich mobile communication services***

Fixed-line voice traffic is rapidly migrating to mobile networks. The fixed-to-mobile substitution trend indicates that 70-80% of all voice traffic in Europe will be carried over mobile networks by 2015 (Figure 4). The substitution trend in Europe correlates with increasingly mobile lifestyles and an ever-increasing focus on individual values and needs. A similar development is expected in other urban markets with well-developed fixed-line infrastructure.



***Figure 4 Assessment of fixed mobile substitution in EU-15 market (Northstream)***

<sup>22</sup>US Online Population Forecast, 2005 to 2010 Jupiter Research, May 2005

In addition to the fixed-to-mobile substitution trend, there is an ongoing trend where basic person-to-person voice communication is substituted for richer person-to-person communication. The addition of multimedia components to basic communication services will intensify the demand for network capacity.

In countries where fixed-line infrastructure is less developed, mobile service is the natural choice for person-to-person communication. In these cases, mobile connections are the principal means of communication rather than a substitute for fixed lines. The cost and speed of rolling out fixed-line infrastructure in such markets is unattractive compared with mobile alternatives.

However, large-scale migration of fixed-line traffic to mobile networks will challenge network performance. The current strict standards for service availability and quality will need to be maintained. It will also further increase the demand for spectrum and for a 3G extension band.

### **Spectrum harmonisation will boost the development of mobile services**

Historically, spectrum harmonisation has positively impacted mobile service markets. The three major reasons are:

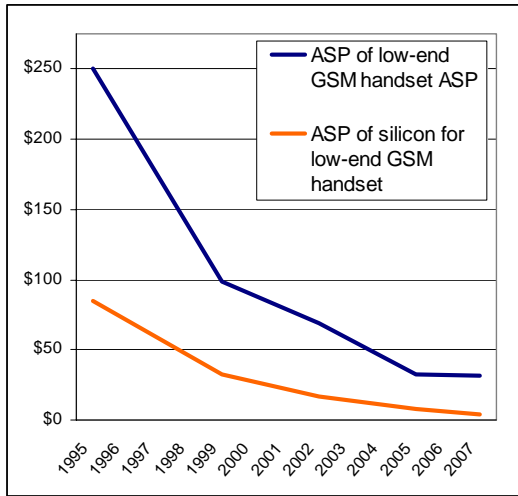
- Better economies of scale
- Lower financial risk for vendors of infrastructure and handsets
- Improved conditions for roaming

#### ***Harmonisation expands the market for equipment and services***

Spectrum harmonisation enables globalization of markets for mobile network infrastructure and handsets. Globalization means better use of economies of scale, reduced manufacturer risks, shorter time-to-market and lower costs. Globalization also benefits buyers as it drives global competition and brings lower prices on infrastructure and handsets.

**Economies of scale and competition improve efficiency in handset manufacture and distribution**

GSM and WCDMA are the most dominant network technologies in the world, serving 74% of all mobile subscribers in 2005.



**Figure 5 Average sales price (ASP) of low-end GSM handsets and their silicon chip components 1995-2007 (Arete)**

GSM and WCDMA handset suppliers have benefited from better economies of scale in development, manufacture and distribution than, say, their CDMA counterparts. Economies of scale combined with intense competition among GSM and WCDMA suppliers at several levels (handset, chipset etc.; see Figure 5) have resulted in a rapid handset price decline. Ultra-low-cost GSM handsets, at \$20 USD or less, will reach the market in 2H 2006<sup>23</sup>. WCDMA handsets are expected to follow a similar development path.

Handsets supporting cellular technologies such as CDMA, TDMA and iDEN address a substantially smaller community than GSM and WCDMA.

Global competition between handset suppliers has intensified price pressure and terminal feature development, bringing market growth. The availability and variety of entry-level handsets is an important component of growth. In January 2003, less than 5% of all CDMA handsets were priced below \$180 USD. The corresponding proportion of GSM handsets was greater than 40%.<sup>24</sup>

**Fragmentation delays feature development and service interoperability**

The development of GSM and WCDMA handsets has benefited from global demand for features and performance – and continues to do so. It is fair to say that GSM handset features historically have had shorter time-to-market than CDMA counterparts. Standardisation and spectrum harmonisation represent the most time- and cost-efficient path towards interoperability of networks.

**Harmonised spectrum lowers the threshold for establishing roaming**

When a mobile radio technology and a spectrum plan have an international base of users, it is easier for operators to make an attractive service to customers when roaming overseas.

The most obvious incompatibilities between different technologies and between different spectrum plans can be overcome technologically with multi-band, multi-mode terminals. However, the multiple radio interfaces needed in such terminals drive up the costs of development and manufacture.

<sup>23</sup> Arete September 2005

<sup>24</sup> EMC, Terminals statistics from Chinese market, total volume from February 2002 to January 2003.

Despite the fact that a significant multi-system handset base exists, inter-standard roaming remains a niche business opportunity. Inter-standard, multi-band mobile roaming is well behind mainstream GSM and WCDMA in commercial and technological development. Consider the following examples of challenges faced:

- Sprint PCS introduced international roaming in 2000, four years after GSM was launched in the 1900 MHz band
- The first GSM-CDMA inter-standard global roaming agreement was announced in 2002 at the FIFA World Cup in Korea, a full decade after the first GSM roaming agreement had been established between Telecom Finland and Vodafone UK

Experience from the GSM community proves that harmonised spectrum combined with standardized roaming processes lowers the threshold for successful roaming. Harmonisation of technology and of spectrum plans creates necessary momentum for roaming and distributes roaming establishment costs among a larger community.

The GSMA fears that those hardest hit by market fragmentation will be developing markets. In these markets consumers are very price sensitive. Thus if the overall increase in price is say \$30, then this will have a much greater impact on users who pay say \$60 for a basic terminal, as opposed to users who pay \$100's of dollars for high end feature rich phones.

Studies have shown the benefit that increasing mobile phone penetration can have on developing markets. Studies have also shown the increased efficiency gains that developed economies have gained in productivity from internet usage. It seems likely that developing markets would also gain in productive efficiency from increased broadband internet penetration. Frequency harmonisation is likely to raise the costs, and or lower the performance, of mobile broadband terminals. If terminals have lower performance specifications, this will mean that to provide the same quality of service will require extra infrastructure investments.

Neither of these outcomes (lower performance phones, or higher cost phones) is desirable, as they will limit mobile broadband penetration in these countries.

The case study below of the US, shows the detrimental impact of fragmentation on handsets costs and performance. If this is the impact on a strong developed market economy, it is likely that the impact on developing markets will be even more profound, and negative.

### Case study: Harmonisation in Europe vs. fragmentation in the United States

During the 1980s, Europe and the United States saw a similar development in their respective markets for mobile communications. In different regions, mobile operators deployed diverse mobile communication systems in a range of frequency bands, creating many cases of incompatibility. In the latter part of the decade, however, the situation started changing in Europe as international mobility was prioritized as part of unification processes. Spectrum harmonisation thereby became an important part of ongoing technology standardization efforts.

The US approach was different. International roaming was deemed of little importance, and in 1987 the FCC declared it would not mandate what technologies should be used to transmit in the 800 MHz band.

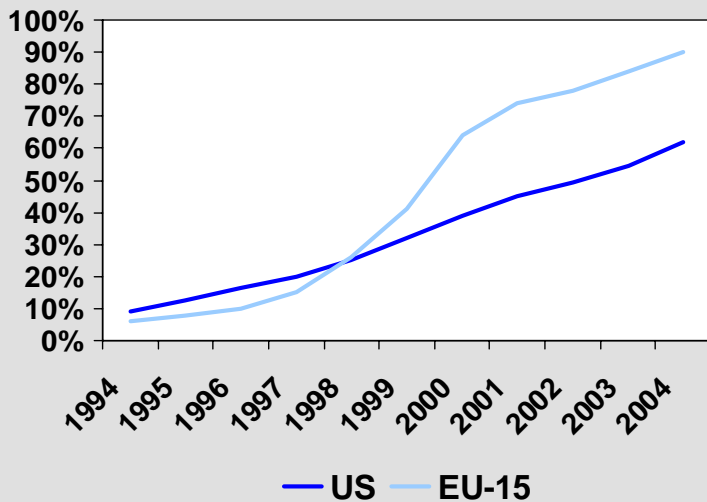


Figure 6 Mobile penetration 1994-2004  
(FCC, Merrill Lynch, [www.europa.eu.int](http://www.europa.eu.int))

The US approach resulted in a fragmented technology situation. The US was pushed towards continued focus on regional markets and limited interest for global spectrum harmonisation. The decision to license the 1900 MHz band as opposed to the 1800 MHz band to meet growing demand for mobile services was another step in this inward direction. Major GSM vendors rapidly developed a GSM variant customized for the 1900 MHz band but international roaming was not widely offered until the advent of handsets supporting multiple frequency bands. GSM and GSM/CDMA roaming across the 800, 1800 and 1900 MHz

bands was offered. GSM/CDMA roaming in particular added substantial complexity and cost to the handset.

The fragmentation of the US market has impaired its ability to quickly make handsets available and affordable. US handsets have continuously lagged behind mainstream European GSM handsets in terms of features, performance, size and weight. Handset manufacturers have been forced to focus on basic mobility performance for the US market, at the expense of feature development.

The decision not to join the global band plan made the US handset market a local one, set apart from global mainstream competition. Market fragmentation limited the number of handset manufacturers that were able to reach economies of scale, which in turn reduced the level of competition. Differences between US and European handsets were particularly notable during the late 90's. Average US handsets, irrespective of technology were out-performed by mainstream European GSM handsets on availability, features, size, and weight.

The mass-market European service penetration in 1998-2001 (Figure 6) was catalysed by the availability of cheap mass-market handsets. GSM had been introduced to support the growing demand for mobile services as well as to satisfy the emerging demand for international roaming. Comparable US penetration was not reached for another four years. Higher handset prices and less attractive business models (receiving party pays) negatively affected take-up in mass-market segments.

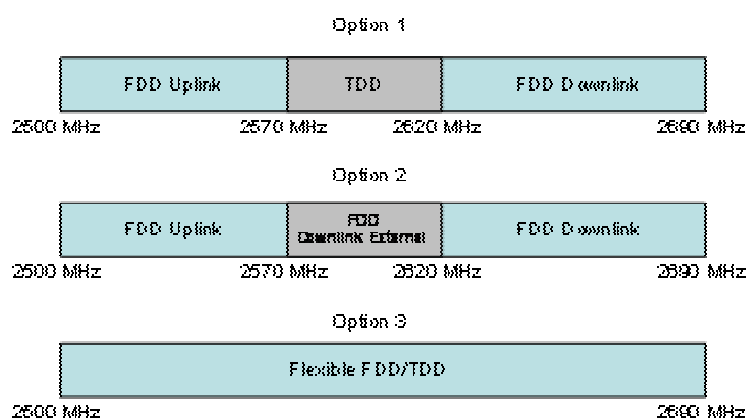
The lesson from Europe and the US (handset markets benefit from economies of scale brought by harmonisation) continues to be relevant as one studies mobile markets, not least in developing countries.

## The benefits of a structured channelling arrangement for 3G extension band harmonisation

The fundamental argument for WCDMA is its ability to offer high-capacity service to great numbers of voice and data customers, building on existing GSM investments. In urban areas especially, WCDMA offers higher data rates and better spectral efficiency than GSM, at lower incremental cost.

The core band plan (in which 3G services are typically allocated) was decided upon at the World Radiocommunication Conference of 1992 (WRC-92). The usage of IMT-2000 services in the extended band was discussed at WRC-00 and WRC-03. Parts of the extension band were, in early proposals, reserved for IMT-2000 services offered via satellite. Actual use of such services has however been small in relation to the success of terrestrial services. There are some half a million satellite users worldwide<sup>25</sup> compared with over two *billion* 2G and 3G users<sup>26</sup>. Since spectrum for satellite services could potentially be made available outside the IMT-2000 extension band, it has been proposed that the band should be reserved for terrestrial services.

The ITU recommends two options for the extension band – one entailing FDD channelling and the other TDD channelling<sup>27</sup>. A third option suggests that regulators leave it to individual operators to decide on whether to use FDD or TDD technologies. The three options are shown schematically in Figure 7.



**Figure 7 ITU Channelling options**

The first two options separate FDD from TDD in the frequency domain. This guarantees maximum efficiency in spectrum usage, minimum interference between the two modes, and minimum costs for operators.

The third option, where no channelling arrangements are made, is likely to be inefficient in terms of spectrum usage. It would increase the need for guard bands and could drive costs for spectrum owners since they would need to negotiate with each other to ensure efficient coexistence.

<sup>25</sup> The Mobile Satellite Users Association (MSUA), 2002

<sup>26</sup> Wireless Intelligence, September 2005

<sup>27</sup> FDD and TDD are two means of achieving two-way (duplex) communication. In FDD, signals on two frequencies are used, one for each traffic direction. In TDD, a single frequency is used, and traffic is distributed in time instead.

### ***FDD and TDD coexistence***

Interference management is an important method for achieving efficient spectrum use in mobile systems. Allocating spectrum to specific uses is a key component in interference management. If FDD and TDD systems are to operate in close physical proximity, interference management suggests they be decoupled. This is most easily achieved by allocating separate frequencies for the two systems. Due to the out-of-band emissions that all systems experience, guard bands also need to be allocated. The size of required guard bands depends on factors such as:

- deployment characteristics (e.g. cell sizes, antenna types, power levels)
- performance levels of the FDD and TDD equipment used
- implementation (other) interference management techniques
- coordination between the systems

An ITU study<sup>28</sup> on coexistence aspects between UTRA-FDD and UTRA-TDD shows that the physical separation distance needed between UTRA-FDD and UTRA-TDD equipment ranges from less than 1 m (indoor pico cell with 10 MHz guard band) to up to 10,000 m (outdoor line-of-sight macro cell with no guard band). The study vividly highlights how interference dynamics impact radio planning and deployment complexity.

FDD technologies other than UTRA-FDD have different implications for guard bands than those discussed above. The same is true for TDD technologies other than UTRA-TDD.

Regulators use different strategies when allocating guard bands. Some predefine what guard bands to use before spectrum allocation is finalised. Others define out-of-band emission limits. The first strategy simplifies the coordination process whereas the second strategy makes it easier to adjust guard band sizes according to specific needs. The second alternative is difficult to control and execute however, as licensees get responsibility for coordination. The interaction between licensees can sometimes be difficult since they are often also competitors on a market.

If the flexible option for FDD/TDD channelisation is chosen, allocation of spectrum (including allocation of guard bands) across geographies will become complicated. The flexible alternative also offers poorer spectrum efficiency since multiple guard bands will be needed. Option 1 with 5 MHz wide guard bands<sup>29</sup> means 5% (10 MHz) of the available 190 MHz extension band will be non-utilized. For the flexible Option 3, the amount of non-utilized spectrum can be much higher, as it depends on the ability of spectrum regulators and owners to place the two modes of technology in consecutive blocks of spectrum. Every non-consecutive allocation of TDD will add another 5% of non-utilized spectrum. It therefore seems advisable to group technologies with similar radio characteristics to achieve maximum spectrum efficiency.

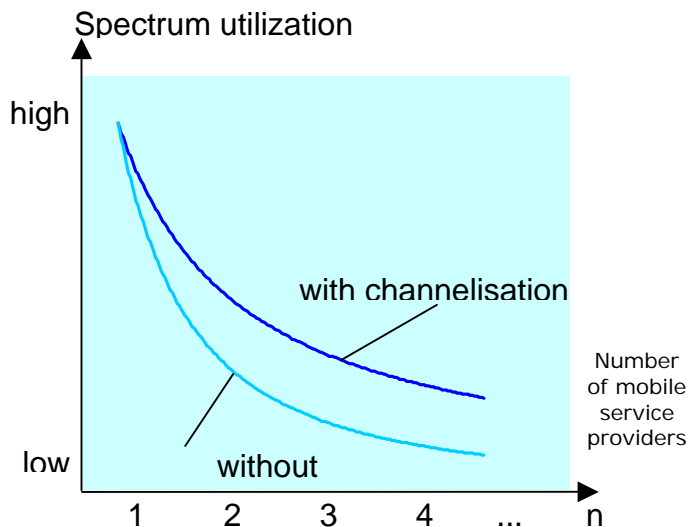
The European Commission recommends Option 1 or Option 2 as a channelling arrangement for the member states of the European Union.

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<sup>28</sup> ITU-R M.2030

<sup>29</sup> Five MHz is equivalent to the bandwidth of one carrier of the two UTRA modes

### **Channelisation improves spectrum efficiency in competitive markets**



As previously discussed, mobile operators will need more spectrum to meet demands in the marketplace. Intense competition promotes efficient markets from an economic perspective, but degrades spectrum efficiency due to trunking losses (Figure 7). FDD/TDD channelisation minimises spectrum efficiency loss in competitive markets, and hence removes a technological obstacle for sound continued competition.

**Figure 7 Spectrum utilization efficiency in competitive environments (Northstream,**

### **Other issues for the successful implementation of a harmonised extension band structure**

A few countries have allocated parts of the 2.6 GHz band for services like MMDS and wireless broadband. Authorities are encouraged to be aware of the efforts of harmonisation and the value it can bring to all markets. The schedule suggested by CEPT for implementing IMT-2000 services in the 2.6 GHz band by 2008 is preferred for Europe; however market demand will grow at different paces in different regions.

In some Asian countries, parts of the extension band are used for satellite services. This is a critical issue because of interference with services in the band in neighbouring countries. This is a highly unfortunate situation where non-harmonised use of the band in one country interferes with harmonised use in other countries, hindering the benefits of harmonisation. Efforts are needed to migrate the satellite services to other bands. Pending such a migration, interference management measures such as power regulation need to be implemented.

There is currently some momentum for offering 3G services in frequency bands lower than 2.5 GHz, such as 450-470 MHz. Many regulators are evaluating allocation of the 450 MHz band and the band has recently been licensed to public 3G like services in a number of countries. Examples are the Nordic countries where 450 MHz spectrum has been allocated for CDMA450 and Flash-OFDM services. These lower bands can bring successful 3G services to areas where the customer density would otherwise have been considered too low. Care needs to be taken however, as non-coordinated allocation may become a barrier to harmonisation.

Re-farming GSM spectrum to accommodate 3G services in the 900 and 1800 MHz bands is under discussion. Re-farming is expected to start within five years. This will complement existing spectrum to support continued 3G service development rather than eliminate the need for a 3G extension band.

## **Conclusions**

Mobile lifestyles are driving the demand for mobile services. In parallel with increasing utilization of mobile services, broadband penetration and service usage is growing vigorously. Current trends and historical experience from internet usage development suggests that mobile traffic, driven by increasing service demand, will grow dramatically in the next ten to fifteen years.

The 3G extension band needs to be made available in order to support continued development of mobile services. Maximum economic value will be gained if the 3G extension band is made available in a harmonised way.

The ITU has proposed three options for FDD and TDD channelling arrangements. The first two options suggest well-structured channelling, whereas the third option suggests that FDD versus TDD channelling decisions should be flexibly made on a regional basis. It is the GSMA contention that the flexible option for FDD/TDD channelling will make for a complicated process of coordination. This unnecessary complexity will ultimately degrade spectrum efficiency, and increase the costs of deployment. This may well lead to consumers having to pay more for such services, or there being less spectrum to accommodate new and innovative services that consumer's value.

Finally it would be valuable to end with the concluding part of Commissioner Reding's speech at Cebit in March 2006 as follows: -

*"Ladies and gentlemen, the elements I have outlined are my proposals to develop a European approach on mobile TV issues in Europe. Little will happen without the readiness of Member States, industry and other stakeholders to act jointly with the Commission, by actively helping to develop a European strategy for Mobile TV. This is just one more concrete example that we need a partnership on a coherent European approach to spectrum. I am prepared to promote the much-needed dialogue at European level. But you should also be prepared to deliver your part of the deal. The opportunities for growth are there. Many new European jobs can be created. Mobile TV is a perfect and concrete example of the opportunities that digital convergence offers. It is a key step towards the deployment of innovative wireless technologies in Europe. Let's face this challenge together. Thank you very much for your attention".*

Clearly spectrum harmonisation, focusing on efficient use of spectrum for IMT-2000 technologies, will secure a competitive environment for mobile services, which favours consumers and economic growth to deliver the vision set out by Commissioner Reding.

## **GSM Association July 2006**

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