A White Paper by
the NGMN Alliance

Spectrum Requirements for the Next Generation of Mobile Networks

Release Date: June 20th, 2007

Document Information

Editor in Charge	Hossein Moiin (T-Mobile)
Editing Team	Chunfeng Cui (China Mobile), Michael Krämer (KPN / E-Plus), Hiroyuki Atarashi (NTT DoCoMo), Yves Bellègo (Orange), Sung Youl Park (SK Telecom), Tajit Mehta (Sprint Nextel), Roberto Rodriguez (Telefonica), Fabio Santini (Telecom Italia), Raimund Walsdorf (T-Mobile)
Document status:	Approved
Version:	1.0
Date:	June 20th, 2007

Abstract

This document contains information that is confidential and proprietary to NGMN Limited. The information may not be used, disclosed or reproduced without the prior written authorisation of NGMN Limited, and those so authorised may only use this information for the purpose consistent with the authorisation.

The information contained in this document represents the current view held by NGMN Ltd. on the issues discussed as of the date of publication.

This document is provided "as is" with no warranties whatsoever including any warranty of merchantability, non-infringement, or fitness for any particular purpose. All liability (including liability for infringement of any property rights) relating to the use of information in this document is disclaimed. No license, express or implied, to any intellectual property rights are granted herein.

This document is distributed for informational purposes only and is subject to change without notice. Readers should not design products based on this document.

CONTENT

EXECUTIVE SUMMARY

NGMN is an alliance by a group of leading mobile operators, industrial partners, and academic advisors to provide a vision for technology evolution beyond 3G for the competitive delivery of broadband wireless services. The vision of the NGMN alliance is that of a global mobile society where any service can be accessed through a personal device connected via a wireless mobile network. The key objective of the alliance is to create a virtuous cycle of investment, innovation, and adoption of mobile broadband services with competitive price-performance ratios.

The NGMN alliance complements and supports the work within various industry standardisation development organisations by providing a coherent view of what the operator community will require in the decade beyond 2010 to meet the needs of end-users. Delivering the promise of this next generation technology requires significant cooperation between administrations, operators, infrastructure providers, device manufacturers, application developers, and content providers.

Our past experience indicates that the timely availability of sufficient and suitable spectrum for mobile communications is a prerequisite to extending the benefits of mobile broadband to all people, and to furthering the global success story of mobile communications. To continue to offer benefits to the users and societies, the mobile communication industry requires continued availability of radio spectrum in sufficient quantity within suitable bands and arranged in a consistent and harmonised manner so that global roaming is facilitated and economies of scale that produce cost efficiencies can be achieved.

For mobile communication the frequency bands between around 400 MHz to 5 GHz are the optimal choice. Using frequency bands below 400 MHz would lead to large terminals and requires large antennas which in turn limit mobility and increase environmental impact. Using higher frequency bands, on the other hand, in particular those above 1 GHz, starts to reduce the achievable cell size which in turn increases the required number of base stations[1]. By around 5 GHz, this reaches a point that makes providing service unviable.

[1] Due to the physical propagation characteristics of waves, lower frequency bands require fewer base stations to cover a given area when compared with higher frequency bands while higher frequency bands allow for higher carrier bandwidths which in turn allow for higher capacity.

In the view of its partners, achieving the objectives of the NGMN alliance and realising the vision of a global mobile society requires:

- Additional suitable spectrum in lower frequency bands (i.e. in the band between 470 to 806/862 MHz[2], currently mainly used for terrestrial broadcasting) in order to enable ubiquitous coverage,
- Additional suitable spectrum in higher frequency bands (above 1 GHz, and in practice above 2.2 GHz) to provide sufficient capacity and higher data rates to ensure end-user satisfaction, and
- Availability of contiguous blocks of spectrum suitable to accommodate channel bandwidths of up to 20 MHz in bands below 1GHz, and channel bandwidths of up to approximately 100 MHz in higher frequency bands. The above channel bandwidths are needed to allow the next generation of mobile networks to deliver their expected performance. For example, a channel bandwidth of 20 MHz is needed for throughput of 100 Mbit/s with high mobility and a channel bandwidth of 100 MHz is needed for a throughput of 1 Gbit/s with low mobility.

Allocation of sufficient and suitable spectrum in lower frequency bands (below 1GHz) to mobile communication services enables developed nations to bridge the digital-divide between the cities and rural areas, and enables developing nations to offer broadband services to their populace in the most cost efficient manner. This will reduce the economic challenges of providing a robust and sustainable service to communities that suffer from an infrastructural disadvantage. Furthermore, allocation of frequency bands below 1GHz also benefits the cities as indoor coverage of mobile broadband improves dramatically. The most suitable frequencies lie within the range 470 – 806/862 MHz which is currently mainly used for terrestrial broadcasting. As more spectrally efficient digital terrestrial TV (e.g. DVB-T) is introduced and adopted, less bandwidth is required to provide the same level of TV service. As a consequence, it will become possible to allocate the newly freed spectrum for mobile communications and by doing so, greatly increase the economic and social benefits generated from this spectrum.

[2] These two numbers reflect the different amount of spectrum used for terrestrial broadcasting in different regions.

Spectrum in lower frequency bands will enable the next generation of mobile networks to provide ubiquitous coverage. However, the expected demand for additional capacity and higher bit rate services in many areas will require additional spectrum that can be feasibly found only in higher frequency bands. Market analysis and forecast provided by the International Telecommunication Union (ITU) estimates that the demands of the end users for new services coupled with advances in technology will significantly extend the existing market for mobile broadband services. To meet the demands and to ensure a thriving ecosystem for mobile communication, however, requires allocation of a significant amount of additional spectrum.[3] The ITU will consider further requirements for spectrum for mobile communication later this year at WRC-07.[4]

The timely allocation of suitable and sufficient spectrum to IMT is of paramount importance for the continued development of mobile communications. The NGMN alliance strongly believes that it is essential that WRC-07 achieves a positive outcome on all aspects of agenda item 1.4. WRC-07 is the only time where the governments can come together to ensure that the technical, social, and economic benefits of mobile broadband access will be realised through harmonised allocation of sufficient spectrum for IMT. This will enable the mobile industry to fulfil its goal of offering ubiquitous and mobile access to the Internet, video streaming, Intranets, file sharing and many other applications at cost/performance ratios comparable to the fixed-line offering of that time.

A timely and globally aligned spectrum allocation policy will play a key role in the development of a viable ecosystem on a national, regional and global scale whose benefits will last well beyond the next decade.

- The 470 to 806/862 MHz band is allocated to the 'Mobile Service' on a co-primary basis with the broadcasting service so that usage for both services will become possible globally (i.e. in all three ITU regions).
- Sufficient bandwidth is made available for IMT within the 470 to 806/862 MHz band in a harmonised manner to allow multiple full deployments of next generation mobile networks.[5]
- Contiguous harmonised bands are allocated and identified for IMT in the spectrum between 1 GHz and approximately 5 GHz to satisfy the demands of broadband multimedia applications that require channel bandwidths of up to approximately 100 MHz. Within this range the most likely candidate is the range 3.4 to 4.2 GHz.

[3] Studies conducted by ITU in 2006 calculated that the total bandwidth requirements of mobile communication systems for the year 2020 for a single network case per country will be around 1720 MHz in a high market setting and around 1280 MHz in a low market setting (both of these values are and would be higher for multiple networks). This implies that significant additional spectrum (around 1 GHz for a higher market setting) will be needed in all 3 ITU regions to meet that demand.

[4] WRC-07, the World Radio communication Conference 2007, (held in October and November 2007 in Geneva, Switzerland) will consider this issue under agenda item 1.4. The "candidate frequency bands being considered are 410-430 MHz, 450-470 MHz, 470-806/862 MHz, 2.3-2.4 GHz, 2.7-2.9 GHz, 3.4-4.2 GHz, and 4.4-4.99 GHz.

[5] Full deployments of next generation of mobile networks require 20 MHz channels. More than 120 MHz of harmonised spectrum would be needed to accommodate commonly envisaged deployment scenarios (involving parameters such as number of channels, number of operators, and choice of FDD or TDD technology).

- Global harmonisation is kept in spectrum allocation as this avoids market fragmentation, enables users and the industry to benefit from global economies of scale and facilitates global roaming. The level of harmonisation that has been obtained for IMT-2000 through current footnotes and resolutions in ITU Radio Regulations should be maintained.
- The minimum number of clearly defined frequency arrangements (preferably one) is established to avoid market fragmentation and to enable global economies of scale.
- Protection of existing bands (those already identified as IMT-2000) from interference is ensured.

Our experience in the mobile industry has taught us the value of two concepts when dealing with complex issues; first, a vibrant ecosystem is a necessary element of success and second, an evolutionary approach towards an ultimate goal will yield better results. The long-term spectrum position of the mobile industry will be clarified in the WRC-07. However, even if the needs of the mobile industry are met in that conference, the spectrum identified for IMT will not become available for deployment for several years. In the meanwhile the mobile industry still needs to develop a vibrant ecosystem to succeed. This ecosystem will be built in a step-wise evolutionary fashion, which in turn will depend on an evolutionary development approach for harmonisation and interoperability of networks and systems. Such network will in turn require an evolutionary approach towards spectrum management. In our view an appropriate way to address this issue is to take advantage of the more immediate opportunities for harmonisation of existing bands followed by allocation and harmonisation of additional bands to ensure the emergence of a vibrant ecosystem and realisation of the ITU's vision of a global mobile system.

1 VISION AND MISSION OF NGMN

The vision of the NGMN alliance is to provide a platform for innovation by moving towards a network for the seamless introduction of mobile broadband services. Such a platform would enable mobile wireless access to any service on a global scale and thus, will realise the ITU's vision of a global mobile society. In addition, the next generation of mobile networks will coexist with other networks while it facilitates smooth migration from, and is capable of replacing, existing networks.

The mission of the NGMN alliance is to provide a set of recommendations to enhance the ability of mobile operators in offering innovative and cost-effective wireless broadband services for the benefit of their customers. These recommendations are intended to guide the activity of administrations, equipment developers and standards development bodies, leading to the development of a cost-effective network evolution path beyond HSPA and EVDO in the time-frame commonly referred to as 'beyond 3G'. The current NGMN alliance's recommendations do not prescribe a particular solution and currently the NGMN alliance has no technology preference. However, the NGMN alliance will evaluate candidate technologies to develop a common view on suitable solutions that meet its recommendations in order to facilitate the technology choice of individual operators based on their specific market conditions.

The NGMN alliance is made up of mobile operators, who are its members; commercial vendors, who are its sponsors; and non-profit organisations, who are its advisors. The NGMN alliance complements and supports standards development bodies by providing support for some critical issues (often referred to as "non-functional requirements") that are beyond their remit. In addition, standardisation activities of the past have tended to focus on a subset of the functional aspects of a system needed to ensure interoperability across certain interfaces. The partners of the NGMN alliance assist in focusing standards development to deliver timely, competitive products, which will meet the needs of mobile operators and their customers. All significant results of the NGMN alliance are shared with the relevant standardisation bodies for their unrestricted use.

For additional information on the NGMN alliance and its partners please visit its website at www.ngmn.org.

2 SCOPE OF THIS DOCUMENT

The vision of the NGMN alliance foresees a vibrant ecosystem of users, services, service providers, device manufacturers, infrastructure vendors, and application developers where a diverse set of services are made available to mobile individuals utilising a variety of devices.

This document argues that creating such an ecosystem, with its myriad social and economical benefits, requires not only the identification and allocation of sufficient and suitable spectrum in a timely manner but also clear rules of use to achieve economies of scale and avoid fragmentation. Therefore, the scope of this document is limited to spectrum matters and in particular to those aimed at WRC-07. To minimise duplications, when necessary rather than restating all the previous work this document refers to other source material in which the members of the NGMN alliance have contributed.

In addition to the identification of the spectrum needs of the next generation of mobile networks, this document provides a generic vision of the NGMN alliance and its mission, outlines the well established social and economical benefits of mobile communications, discusses the regulatory framework of the mobile industry, includes the envisaged deployment scenarios of the next generation of mobile networks, and discusses the importance of timely action. Lastly, this paper puts forward the notion that an evolutionary path towards achieving the long-term spectrum needs of the next generation of mobile networks is an appropriate way to capture the most benefits.

As the scope of this document is limited, issues such as technical architecture, business rationale, or ecosystem development are not dealt with in this document. Interested readers are referred to the web site of the NGMN alliance where they can download the alliance's white paper for additional information and can contact appropriate experts should their questions remain unanswered.

3 BENEFITS OF MOBILE BROADBAND COMMUNICATIONS

The last decade has seen the development of two key industrial engines of growth in developed economies, mobile communications and the Internet. These two industries have brought significant benefits to consumers, businesses, and national economies. For instance, in a 2006 report by Europe Economics for the Ofcom, the net benefit to the UK economy of public mobile communications is estimated at over €500 per capita[6]. Similarly, a study commissioned by Cisco in 2002[7] estimated that the adoption of Internet based business solutions in the USA alone would result in an annual growth of 0.43%. In addition, a recent study by the consultancy firm Deloitte and Touche[8] suggest that a 10% increase in mobile penetration will result in a direct increase of 1.2% in GDP. Finally, a study by the consultancy firm Ovum for the GSM Association[9] estimates that in 2004 the mobile services industry in the European Union (at the time a union with 15 member states) generated a gross domestic product (GDP) contribution of €105.6 billion making it the largest ICT industry and on a par with the electricity, gas, and water industries combined.

In the same study it was concluded that the industry was responsible for 2.8 million jobs in EU15 through direct and indirect channels and that the average mobile services worker generates 2.5 times the GDP than the average worker. This in turn provided the administrations with an income taxation estimated at €30.8 billion with total government revenue from the mobile services industry estimated at €83.9 billion. No other potential user of the spectrum can claim such benefits to the economy as a whole.

While the past direct and indirect positive economic contributions of mobile communication and Internet industries are beyond any doubt, these accomplishments are only the beginning of a new and exciting era which promises significant additional benefits. This is due in part to the fact that:

- The availability of mobile communications and Internet has been somewhat limited to urban areas in developed nations,
- The benefits of these industries include many social benefits that are difficult to measure and become visible only after users adapt their lives around their availability and absorb them into their daily lives (for example the increased personal security resulting from the ability to contact emergency services from anywhere at any time), and
- The confluence of these industries is in its nascent stage and mobilising the Internet will lead to new and additional benefits that cannot be accurately predicted when these industries operate as separate entities.

6 "Economic impact of the use of radio spectrum in the UK", report by Europe Economics for Ofcom, 2006.

7 "Net Impact Study: Projected Economics Benefits of the Internet in the US, UK, France and Germany", by Varian. Litan, Elder and Shutter, January 2002.

8 Research and Analysis by Paul Lee, Director, Technology, Media and Telecommunication Research, and Chris Williams, Partner, Economic Consulting, Deloitte & Touche.

9 "Let's talk numbers", GSM Association 2004.

The broad availability of mobile communications and Internet to the general public in the emerging markets and to those in rural areas of the developed nations will significantly enhance the positive impact of these industries. However, a further boost is expected when these two separate industries become fully intertwined. Such a scenario would unleash new innovations that would positively impact many other industries and would enable new social benefits that are hard to predict today. A key beneficiary will be governmental policies in wide-ranging areas including economic development through job creation and increased entrepreneurship; better access to universal services such as emergency, education, financial, or healthcare; and improved security through increased social inclusion, global interactions and cross cultural dialogue. Lastly, the broad availability of these technologies will lead to a significant increase in the number and the diversity of innovators which in turn will lead to additional benefits as innovation is "democratised".

Examples of the benefits enabled by the broad availability of next generation of mobile networks include existing applications such as browsing of the Internet or messaging, emerging applications such as portable video conferencing or mobile TV, and totally new applications. Examples of this latter type of applications include those that foresee the merging of the physical and virtual worlds as envisaged by some administrations around the world or remote health diagnostics as proposed by some governments. As a concrete example consider the case of physical objects such as buildings or roads that are tagged so that additional information about them can be obtained using a mobile device and a mobile network. The type of information can include static information such as history of a building and dynamic information such as traffic congestion.

Furthermore, the information could be made available in a language understandable to the person seeking such information without the need to impact the environment using alternative methods such as printing of the same information. The type and number of the applications that can be developed in this new era are only limited by our imagination and by the ability of the mobile networks to provide them in an efficient manner. This efficiency in turn, depends on many factors, chief among them, the availability of suitable spectrum.

While the benefits of providing mobile broadband are enormous, so are the challenges. To reap these benefits requires a close collaboration between the various members of the ecosystem including network operators, service providers, device manufacturers, administrations, application developers, and infrastructure vendors. The NGMN alliance calls on all members of ecosystem to collaborate with its member and sponsor companies to ensure that the benefits of mobile communications are extended across the globe and encompass true mobile broadband services.

To plot a successful path for the future, we can learn from our past. The mobile communications industry is a global success story whose contribution to the society and economy can be compared to those of other dominant infrastructures of past eras such as roads, railroads, or ports. However, the success of the mobile industry, just like other infrastructure counterparts, was not built overnight and required considerable foresight and insight. For example, GSM, arguably they most successful collaborative technology project ever, was founded 20 years ago and its impact has yet to reach full maturity. In February of 1987, a small number of European officials decided to take not one, but three giant leaps for Europe's tiny and fragmented mobile radio industry:

- a leap to provide a mobile radio service that would stretch the length and breadth of Europe,
- a leap from established analogue technology to new digital technology, and
- a leap from the car to the pocket for the mobile phone itself.

At the time there was significant resistance and scepticism regarding the future success of this project, however, the determination of the visionary officials led to the most successful technology project ever – with over 2.3 billion GSM subscriptions sold worldwide by the end of 2006, travellers able to arrive in over 200 countries/territories and find their mobiles automatically connected to the local mobile telephony service, and the digital mobile phone joining the wallet and keys as the items that nobody today leaves home without.[10] GSM subscriptions took over 12 years to break the 1 billion mark, but only two and a half years to add an additional billion. It is expected that the third billion subscriptions will be reached only in 18 months, i.e. by the end of 2007.

Many smaller factors contributed to the success of mobile telephony, in general, and GSM, in particular, however, the importance of the contribution made by uniform standards and clearly defined spectrum cannot be overstated. In particular, availability of a harmonised spectrum for GSM enabled mobile individuals to make and receive calls and messages on an international basis. This in turn was a key driver for the success of the GSM system. Other communication technologies that have used a harmonised approach towards spectrum allocation and identification have also seen similar dividends.

The mobile industry is at such a cross-road once again, where the possibility of mobilising the Internet in a truly meaningful manner is presenting itself. To succeed we need the collaboration, foresight, and insight of the industry and administrations on a global scale so that the substantial benefits of this new era can be reaped. The NGMN alliance was established to identify and remove barriers to establishing such a global ecosystem and it has identified spectrum allocation and identification as a key barrier to success. At the same time, the partners of the NGMN alliance are among the most active contributors to global standards development organisations as they realise the value of economies of scale, interoperability and ubiquitous availability for success.

[10] Draft ETSI Press Release, 16th March, 2007. Sophia Antipolis.

The rest of this document argues that in order to succeed in this new era of mobile communications requires allocation and identification of suitable spectrum in a timely and globally harmonised manner so that:

- The digital divide between cities and rural areas as well as between developed and developing world can be bridged in an economically viable fashion,
- There is sufficient capacity in the system to ensure true mobile broadband services can be provided to all users, and
- The economies of scale and suitability of terminals is guaranteed by implementing the same RF components worldwide.

Through the NGMN alliance, the mobile communications industry has taken on the task of providing mobile broadband data services on a global scale. However, its progress will depend very much on network and terminals costs, which in turn depend on timely availability and global harmonisation of appropriate radio spectrum. To overcome the digital divide the next generation of mobile networks require access to spectrum below those currently allocated to mobile services (i.e. below the 850 / 900 MHz bands). Such access not only overcomes the digital divide but also benefits the cities of developed nations by improving the availability of high quality indoor coverage and reducing the cost of providing such coverage. Furthermore, the social and economic benefits can only be realised if the availability of such spectrum occur on a harmonised, common and international basis. Such availability enables global roaming as well as sufficient manufacturing economies of scale so that inexpensive handsets and infrastructure can be built and deployed, services can be rolled-out quickly, and environmental impact is minimised.[11]

We finally note that the benefits of increased coverage arising from use of lower frequency bands can be substantial as these reduce the cost of providing service by increasing the coverage per base station resulting in a corresponding increase in the economically viable coverage area. As shown previously, this not only benefits large areas with dispersed population, but also urban areas through improved indoor coverage.

While the availability of appropriate and harmonised spectrum in the lower bands is essential, it is not sufficient on its own to ensure success. Success requires satisfying the projected traffic demand which in turn requires availability of significant additional spectrum. Such spectrum can only be found in higher ranges (above 1GHz) and its availability is necessary to ensure quality of service and experience for the end users when radio networks become heavily subscribed. In our view, an appropriate way to address this issue is via an evolutionary approach involving harmonisation of existing bands followed by allocation and harmonisation of additional bands to ensure suitable spectrum will be allocated to the next generation of mobile networks. This approach can be used for spectrum above as well as below 1GHz.

[11] "Continued Economic Development through Communication", GSM Association.

The partners of the NGMN alliance understand the value of spectrum and offer the administrations the best possible choice for its use. The mobile communications industry has had a stellar record in its past usage of spectrum bringing a wide-range of benefits to national, regional, and global economies and societies. Today and in the future, the mobile communications industry will continue to bring additional benefits to both the economy and society from availability of additional spectrum and protection of spectrum already made available for its use.

4 REGULATORY FRAMEWORK & DEPLOYMENT SCENARIOS

This section argues that the benefits of mobile communications are significantly enhanced if the availability of the spectrum is based on ITU-R processes to ensure harmonisation. Furthermore, this section discusses the envisaged deployment scenarios of the next generation of mobile networks. These deployment scenarios are used to motivate the coverage and capacity requirements of such networks in Sections 5 and 6 of this paper, respectively.

Global spectrum availability is the key to realising the vision of a global mobile society, where every person has mobile broadband access. The allocation and identification of common frequency bands on an international basis is needed, so that sufficient manufacturing economies of scale can be achieved and low cost handsets become available for worldwide operation and global roaming. Sufficient volumes to achieve such scale effects cannot be generated by national markets, especially in lower income countries where mobile penetration is lower and handset replacement less frequent than in developed markets. Agreement on common frequency bands, preferably at global level, will therefore, have a significant impact on lowering the cost of terminals. This is essential, if mobile phone users are to gain the full benefits of access to those frequencies.

Furthermore, harmonised global frequency allocation and identification will create an optimal innovation environment for the next generation of services and networks. This is further enhanced if the philosophy of spectrum management utilises a “spiral development” approach towards realising the ultimate ITU vision of a global mobile society by taking advantage of opportunities presented in spectrum allocation, identification and harmonisation.

As shown earlier, availability of globally harmonised spectrum and a consistent regulatory framework were the basis for the worldwide success of GSM. Similar conditions were established for IMT-2000 by the ITU at WARC-92 and WRC-2000 and have to date led to the deployment of more than 100 UMTS/IMT-2000 networks to the benefit of consumers globally enjoying affordable services and devices. Such conditions will also be required for the next generation of mobile networks and there is a need for additional harmonised spectrum to be allocated and identified for IMT at WRC-07. Furthermore, since the current 2G and 3G frequency bands are an integral part of the ITU's overall estimation of future spectrum demand, those bands need to be protected from interference by other applications operating in the same geographical area in adjacent bands or within the bands in other regions of the world. This is another key requirement by the NGMN alliance for WRC-07.

As mentioned previously, the key resource when deploying any new wireless communication system is the radio spectrum which provides the framework for its deployment. For the next generation of the mobile networks the NGMN alliance has identified the following requirements for spectrum:

1. The need for ubiquitous coverage to ensure satisfactory service quality and experience for individual users even in sparsely populated or unpopulated areas where users may pass through or where machines with communication needs may operate.
2. The need for sufficient capacity to ensure satisfactory service quality and experience for all users.
3. The need for affordability of both devices and networks so that end-users can benefit from affordable services.

The first and third requirements can be best fulfilled by using spectrum in the range of about 400 to about 1000 MHz. The lower limit is set by equipment size (mainly mobile terminal antennas) and the required throughput per user (equivalent to the carrier bandwidth). The upper limit is due to the fact that the propagation conditions become worse with increasing operational frequency which in turn leads to an increase in the number of base stations, and therefore, network cost. Thus, the frequency range 400 to 1000 MHz is the best suited to provide ubiquitous coverage.

To meet the second and third requirements and to achieve high total network capacity and high capacity per site, a sufficiently high bandwidth is needed which can only be found at higher frequency bands above 1GHz. These capacity bands realise smaller antenna size for terminals and base stations in higher frequency bands, which are key favourable features for implementing multiple-antenna techniques enabling high spectrum efficiency.

Given that initial deployments of the next generation of mobile networks will take place around 2010, this deployment will occur in spectrum already identified for IMT-2000. This spectrum has the benefit that it is harmonised at least on a regional basis, which allows for some manufacturing economies of scale for the radio elements of the network and terminals. However, as ecosystem of the mobile industry evolves in the future and incorporates embedded devices that have not been considered to date for mobile applications, a need for further short-term spectrum arises. It is our view that innovative and evolutionary spectrum management will be required by the administrations to meet the needs of a new mobile era. Such innovations can include sharing of the spectrum between different services in specific bands. Examples include the possibility of sharing bands in the range of 3.4 to 5 GHz between the fixed-satellite service and IMT systems which when used with new technologies, such as MIMO SDMA, minimises the interference in that range.

For the initial deployment of next generation of mobile networks in wide areas, the current GSM bands at 820 to 960 MHz, where they are available, could be of interest. However, even in the regions where such a band is made available for mobile usage, there is an urgent need for additional frequency allocation and identification for IMT systems below 1 GHz to ensure affordable ubiquitous coverage. Here the only realistic candidate band lies between 470 to 806/862 MHZ (part of the UHF band) as the following points demonstrate:

- The GSM bands at 820 to 960 are already heavily loaded and are expected to remain so for several more years. Therefore, deployments of the next generation of mobile networks in these bands may have to be initially restricted to the narrow bandwidth options with carriers up to 5 MHz with consequent limitations for the end-users.
- As terminals and systems for the next generation of mobile networks become more pervasive, additional bandwidth will be required, first carriers of 10 MHz and later carriers of 20MHz and beyond. There is limited opportunity to do that, but only if the GSM systems utilising these bands can be successfully phased-out.
- Due to the limited bandwidth below 1 GHz, not all operators in a given geography have access to the above GSM bands. Those operators without access can only deploy the next generation of mobile networks initially in higher bands like the GSM1800/1900 bands. This might reduce competition and economies of scale to some extent, which may ultimately impact the affordability of services offered to the end-users.

It is our goal and intention to have part of the UHF band between 470 and 806/862 be made available for "3G systems and beyond"[12] at the WRC-07.

[12] These systems are referred to IMT-2000 and IMT-Advanced (or simply IMT) in the ITU language.

To reach the full potential of next generation mobile networks, larger channels (up to approximately 100 MHz, in higher frequency bands) will be needed. Therefore, the NGMN alliance supports the ITU efforts to harmonise bands between 2.3 and 5 GHz and would like to see it as a model for global cooperation.

Given the benefits that the next generation of mobile networks will bring to the economy and society, it is our request and expectation that within each (national) spectrum management process sufficient attention is paid to ensure that future wide-area deployments of the next generation of mobile networks utilising bandwidth options of up to 20 MHz per operator will be possible without any interference problems. Furthermore, and given the existing and predicted market trends towards mobility and global ubiquitous availability of mobile broadband access, future deployments of the next generation of mobile networks will require further capacity and therefore, further additional bandwidth. These deployments include cases such as hot-spot or indoor coverage where significant additional spectrum will be required. The candidate bands for these deployment scenarios are in the frequency band above 1 GHz and it is our expectation that sufficient bandwidth within these candidate bands also need to be allocated and identified in WRC-07.

A key result of the above analysis is that the technology of the next generation of mobile networks will support refarmed 2G and 3G bands with multiple carrier bandwidth options from its initial deployment onwards. In addition, the next generation of mobile networks will support interworking with legacy technologies in each region. For terminals that means support of multi-band 2G and UMTS in addition to support for the next generation of mobile networks. Furthermore, support for networks used for international roaming might be needed which require support for yet additional bands. For the networks, the initial deployment is expected to be a macro or micro cellular overlay. This implies base stations will use platforms that are flexible and support multiple standards as they will have huge advantages in dealing with traffic migration from legacy technologies to the next generation of mobile networks and will simplify the phase-out of legacy technologies while minimising the impact on network costs. Moreover, we note that the final decisions on the initial deployment of next generation mobile technology may depend on future decisions that are not entirely within the control of the mobile operators and require cooperation from other members of the ecosystem such as administrations. Finally, we note that not all operators and administrations have agreed on the deployment scenarios for the next generation of mobile networks as issues such as legacy migration or specific customer requirements impact their final decisions.

5 SPECTRUM REQUIREMENTS FOR UBIQUITOUS COVERAGE

This section discusses the need for access to lower frequency bands, especially to those within the UHF band (i.e. 470 – 806/862 MHz), in order to ensure that ubiquitous coverage can be provided in an economically viable fashion.

As argued in section 3, in order to bridge the "digital-divide" between the cities and rural areas, as well as between developed and developing nations, sufficient spectrum in lower frequency bands need to be provided to the next generation of mobile networks. Specifically, we note that currently even in developed economies rural areas are at a disadvantage in terms of general infrastructure such as roads as well as in terms of new infrastructure such as broadband access or digital television when compared to densely populated cities.

Within the communication infrastructure this "digital-divide" exists in both fixed and mobile communications with cities enjoying DSL speeds of up to 20 Mbps and HSDPA or EV-DO mobile coverage while the rural areas have to do with ISDN and GPRS or cdmaOne. Key reasons for this disparity include the technical and economical challenges faced by network operators as they seek suitable technologies and business models to provide a robust and profitable service to rural areas.

We believe that the most efficient solution to bridging this "digital-divide" is the availability of sufficient and harmonised spectrum in low frequency bands to mobile systems so that a mobile VDSL-like service can be offered to increase the coverage of broadband penetration beyond what is economically viable via the fixed infrastructure. Availability of such spectrum for the next generation of mobile networks will also benefit the cities as indoor coverage of mobile broadband improves. This type of service can be best implemented using[13] a "Macro Cell, or Super Macro Cell" infrastructure covering large areas while providing the necessary performance for a true mobile broadband experience.

The most suitable spectrum for wide-area coverage of the next generation of mobile networks is within the UHF band (i.e. 470 – 806/862 MHz) which is currently used for terrestrial broadcasting in many countries. With the introduction of more spectrally efficient digital terrestrial TV parts of this band will become available for alternative use ("digital dividend"). As claimed previously, the NGMN alliance feels that the most benefits in terms of economy and society in usage of spectrum are derived by making a significant portion of the UHF band between 470 and 806/862 available to mobile broadband communications as soon as such spectrum can be made available (in some countries already by 2010) as analogue TV is switched off and the more spectrally efficient digital TV is adopted.

[13] Please see "Next Generation Mobile Networks Beyond HSPA & EVDO" Version 3.0, December 2006, for definition of these terms.

The impact of such an alternative use of parts of the UHF band for mobile broadband communication on broadcasters would be minimal as the more efficient use of spectrum allows the broadcasters to continue to provide their existing services and other means exist for delivery of broadcast services that complement traditional terrestrial TV (e.g. cable, satellite or IPTV). Furthermore, in developing nations, these bands have not been fully used and therefore, there is a genuine opportunity for global harmonisation with all its benefits for the end-users.

In this respect we think that the European Commission's definition of the "digital dividend" as "Spectrum capacity over and above frequencies necessary to continue all existing TV programmes" is a good starting point. In our view mobile communications systems of the future will be able to maximise the socio-economic benefits of the digital dividend. The transition to digital terrestrial TV and the analogue switch-off will thus bring a unique opportunity to meet new demands and facilitate innovation and as such support high-level policy goals regarding the digital divide and social inclusion as set out e.g. in the ITU WSIS agenda and the European Commission Lisbon agenda. Furthermore, and as mentioned previously, the next generation of mobile networks can provide unparalleled broadband data services both to the developed markets as well as to emerging markets in an economically viable fashion. However, progress will depend very much on network and terminal costs, which in turn will depend on timely access to appropriate and harmonised radio spectrum. In particular, access to the UHF band (i.e. 470 – 806/862 MHz) would extend the coverage of the next generation of mobile networks to rural populations and developing nations that would otherwise go without.

Access to the UHF band between 470 to 806/862 MHz will also directly benefit developed countries by improving the availability of high quality indoor coverage available from existing network infrastructure. In densely populated countries, up to 25% fewer sites may be required to provide high quality indoor coverage if lower frequencies are available. This results in lower infrastructure costs, faster service rollout and a reduced environmental impact. Both developed and developing countries urgently need frequencies below 1GHz in order to offer mobile broadband services outside the 30% of territories that are currently covered using the 2.1 GHz band. The existing mobile bands below 1 GHz (850/900 MHz) do not provide a viable solution, since these frequencies are heavily used by 2G networks today and in many countries, not all operators currently have access to those bands. Such increase in coverage will bring a myriad of benefits, but they depend on affordability of systems and terminals which in turn depend on the availability of suitable spectrum as outlined in section 3.

Therefore, and in order to ensure that benefits of section 3 can be realised through continued expansion of mobile broadband coverage on a global scale, two key requirements for radio spectrum must be fulfilled:

a. Access to sufficient spectrum in the UHF band between 470 to 806/862 MHz, in order to reduce the number of base stations and hence the infrastructure costs. This will make it possible to serve sparsely populated areas and provide reliable, high quality indoor coverage. Therefore the UHF band between 470 to 806/862 MHz should be allocated to the mobile service on a co-primary basis at WRC-07, and

b. Identification of common frequency bands on an international basis for IMT, so that sufficient manufacturing economies of scale can be achieved and low cost handsets become available. Details of the harmonised IMT sub-band (e.g. channelling arrangements) should be agreed on soon after WRC-07 as was done for the 2.6 GHz band in the past.

The above requirements, based on our internal analysis lead to the following points:

- Sufficient spectrum needs to be allocated within the 470 to 862 MHz band to allow multiple full deployment of next generation of mobile networks. More than 120 MHz of harmonised spectrum would be needed to accommodate commonly envisaged deployment scenarios (involving parameters such as number of channels, number of operators, and choice of FDD or TDD technology).
- The channelling arrangement within the band needs to be defined taking into account the possible asymmetry of traffic due to services such as mobile TV.
- Sufficient guard-band will be needed to reduce the threat of interference between the digital dividend services and DVB-T.
- The spectrum for IMT should be harmonised globally, if possible and at least on a regional basis. As an example of regional harmonisation we note that across Europe we need two contiguous sub bands, to minimise guard-band requirements and we need to overcome limitations on specific channels.
- The standard duplex direction may have to be reversed, with uplink in the upper band as this will minimise interference between a mobile uplink and a broadcast downlink in the user equipment. Furthermore, this scheme would minimise the interference from broadcast or next generation mobile network transmitters and GSM base station receivers. This is not an issue since the usual argument for mobile to transmit low to maximise link budget is less valid once antenna size restrictions begin to take effect.

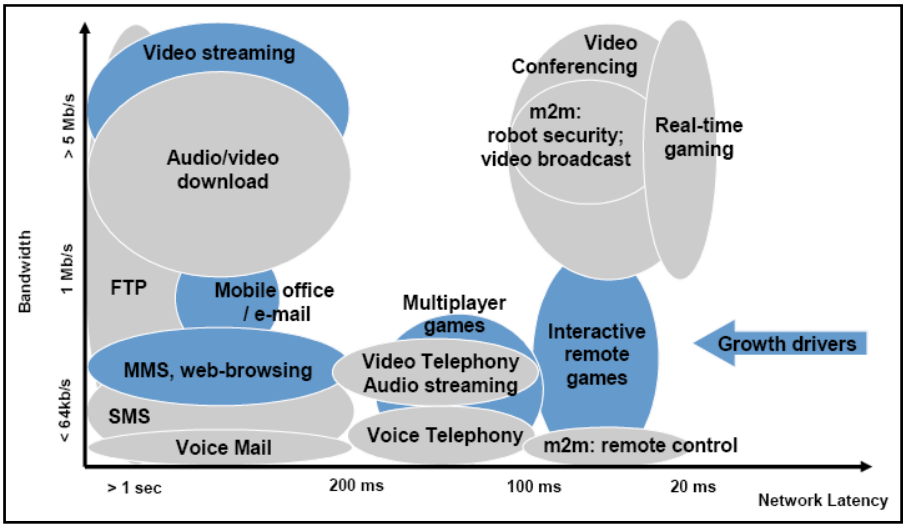
6 CAPACITY REQUIREMENTS

This section argues that significant additional spectrum needs to be made available to mobile communications to meet the expected demand for broadband communications with higher data rates and significant capacity using sufficiently wide blocks of spectrum. As shown in Recommendation ITU-R M.1645, the future development of IMT-2000 and systems beyond IMT-2000 (now referred to as IMT-Advanced by the ITU) will encompass the capabilities of IMT-2000 and new capabilities will be introduced to achieve mobile broadband communications.

Market Drivers

Currently, the mobile market as a whole is experiencing tremendous changes. New service requirements posted by end-users, comparable with those for fixed networks, new business models introduced by competitive market entrants and, last but not least, enhanced radio and networking technologies are hallmarks of this increasingly aggressive but extremely valuable market. However, service evolution is worthless if the end-user cannot be satisfied. User behaviour in terms of evolution of service demand is difficult to predict. It depends on factors such as life-style, fashion, or other needs which may vary in a rather short-term manner. Therefore, flexibility and speed of deployment are essential to meet users' demands. In the future, services must be deployed faster and in a more personalised fashion than today. This calls for suitable service delivery and control platforms and a powerful underlying network. While voice continues to be a core and universal application, a number of recognizable trends will influence the mobile communications over the next few years:

- Internet access, once for retrieval of text and pictures, has advanced to exchange of moving images;
- Mobile TV, i.e. distribution of individual video content by use of streaming services, is emerging as a favourite key application;
- Mobile interactive remote gaming and real-time gaming are about to win recognition as entertainment;
- Peer-to-peer voice and video over IP applications are expected to emerge;
- Service bundles of video, data and voice known from DSL providers are entering the mobile market and replacing traditional fixed line voice services by mobile voice services both at home and in the office.



Therefore, new services will essentially centre on data and multimedia communication in parallel to or in context with voice. Some of these services together with their typical bandwidth and network latency requirements are shown in the above figure. Services highlighted above are expected to be major growth drivers bringing many benefits to the users and the industry. Many of these services (e.g. video based services or machine-to-machine communication) require high user data rates or low response delays – or both – in the network to be accepted and attractive to the end-user. They are expected to consume half the entire network capacity in about 2008/9. Therefore, major attention must be given to:

- the peak and effective user data rate which can be supported in the network;
- the latency (or response time) of the data communication path and the signalling channels;
- the radio coverage which can be guaranteed for the optimal usage of those services up to the edge of the cell;
- appropriate means to invoke and maintain quality of service (QoS) of the individual connection and the entire system.

New Radio Capabilities in the Next Generation of Mobile Networks

According to Recommendation ITU-R M.1645 there may be a need for a new wireless access technology for the terrestrial component, around the year 2010 which will complement the existing radio systems. It is predicted that potential new radio interface(s) will need to support data rates of up to approximately 100 Mbit/s for high mobility such as mobile access and up to approximately 1 Gbit/s for low mobility such as nomadic/local wireless access, which could be widely deployed from around the year 2015 in some markets. NGMN radio systems will also support these new capabilities in the future, and their deployment schedule calls for large trials and selected offering to be made available by around the year 2010.

In order to investigate the feasibility of such new radio interface(s), research activities for the next generation of mobile networks are being actively conducted in many organisations in the world. It should be noted that some of the results experimentally confirmed the achievement of data rates of more than 100 Mbits/s for high mobility and more than 1 Gbits/s for low mobility in a real environment. Therefore, realisation of the target data rate in the next generation of mobile networks is technically foreseeable from around the year 2010 which paves the way for selected offering in that timeframe.

Taking full advantage of the above capabilities will require additional spectrum. Much of this spectrum can be spatially shared as the deployment in some scenarios will be based on "Micro or even Pico Cells"[14] where the radius of coverage is relatively small and the potential for interference is low. Such "hot spot" deployments allow the operators to address areas with particularly high demand such as a home or an office or areas with a large concentration of users such as urban centres.

Spectrum Bandwidth Calculation

Report ITU-R M.2078 calculated that for a single network deployment per country the overall spectrum requirements for the future development of IMT-2000 and for IMT-Advanced to be around 1280 MHz in a low market setting and 1720 MHz in a higher market settings for the year 2020. This results in an additional spectrum demand of around 500 MHz and 1 GHz respectively in all ITU Regions as shown in Table 1. The total traffic volume (voice and data) in mobile networks is expected to grow significantly. For example, Report ITU-R M.2078 expresses growth factors of about 2 to 3 by 2010 for Europe compared to today. The traffic increase originates from both voice and non-voice traffic. Fixed voice substitution, broadband Internet access and mobile TV will be major contributors along this way. Therefore, sufficient network capacity is a must to satisfy the end-user expectations in terms of service quality, namely throughput and latency.

		Region 1		Region 2		Region 3	
Market Setting	Predicted total (MHz)	Identified (MHz)	Net additional (MHz)	Identified (MHz)	Net additional (MHz)	Identified (MHz)	Net additional (MHz)
Low	1 280	693	587	723	557	749	531
High	1 720	693	1 027	723	997	749	971

[14] Please refer to "Next Generation Mobile Networks Beyond HSPA & EVDO" Version 3.0, December 2006, for definition of these terms.

Table 1: Predicted spectrum requirements by the year 2020 for future development of IMT-2000 and for IMT-Advanced

Although Report ITU-R M.2078 calculated the spectrum requirements based on both higher and lower market settings, for identification of a globally harmonised spectrum, such spectrum should satisfy the spectrum requirements both for higher and lower market settings' scenarios to ensure global roaming and terminal cost reduction through economies of scale. Therefore, the spectrum identification should be based on higher market setting for two reasons:

1. To avoid national or regional bands used for IMT, which would lead to potential difficulty in frequency arrangement and consequentially lose the merits of globally harmonised spectrum, and
2. To allow maximum flexibility and commonality as administrations wishing to implement IMT based on the low user-needs setting scenario, could do so within a part of the identified spectrum bands for higher market setting and also benefit from global economies of scale.

Even when the spectrum identification is based on the higher market setting, each administration still has a freehand to deploy IMT in a part of these identified bands, according to their own national market consideration and the remaining need for other services. Consequently, the significant merits of globally harmonised identification for IMT at WRC-07 should be realised. As an example consider that external market studies have predicted that in Europe in the year 2010 more than 90 million mobile subscribers will use mobile multimedia services, generating about 60% of the traffic in terms of transmitted bits.

Clearly, there are expected to be regional differences in the market development, i.e. in some parts of the world a particular level of market development may be reached earlier or later than in the (average) "global common market". However, it should be noted that a sufficient amount of globally harmonised spectrum can ensure sustainable development of the world mobile market, including future growth of the lower market after 2020.

Candidate Bands for IMT-Advanced

Report ITU-R M.2079 provides useful information for administrations to consider when selecting spectrum bands for the future development of IMT-2000 and IMT-Advanced (generically referred to as IMT) in preparation for WRC-07. The selection process for candidate bands must consider compatibility, coordination and sharing with other primary services.

With regard to the capacity bands, which are envisaged with large bandwidth and would provide significant capacity to accommodate future development of IMT systems the frequency bands 2.3-2.4 GHz, 2.7-2.9 GHz, 3.4-4.2 GHz and 4.4-4.99 GHz are being considered as the possible candidate bands under agenda item 1.4 in WRC-07. These capacity bands realise smaller antenna size for terminals and base stations in higher frequency bands, which are key favourable features for implementing multiple-antenna techniques enabling high spectrum efficiency.

In addition to the above considered capacity bands, spectrum in the band 470 – 806/862 MHz is also part of the needed overall spectrum demand of around 1GHz (please see chapter 5) and consequently part of the candidate bands for IMT-Advanced.

It is desirable to identify sufficiently wide blocks of spectrum to accommodate large channels as this should result in the efficient use of spectrum. This is because fragmented band usage requires more guard bands, increases multi-band device complexity, leads to the lack of scalability of channel bandwidth, and complicates spectrum arrangements for IMT.

Spectrum Availability on a Global Basis

In the entire candidate bands described above, administrations have implemented various systems and services, as listed in Report ITU R M.2079, so that these bands are not currently available for the worldwide or regional deployment of IMT 2000 and IMT Advanced. It is anticipated that IMT-Advanced will implement advanced features that will ease sharing with these existing services. In particular, it is anticipated that satellite services and IMT-Advanced will co-exist with geographical and frequency separations.

The partners of the NGMN alliance are cooperating with each other as well as with other relevant bodies to ensure that adequate assistance is provided to national administrations as they develop their national spectrum strategies for IMT-Advanced. These co-operations involve providing both technical support and sharing the market experiences gained through operation of IMT-2000 systems in order to ensure globally harmonised spectrum for IMT-Advanced. In addition, and in order to maintain the harmonisation currently reached for IMT-2000, the partners of the NGMN alliance support the notion that the essence of the current footnotes and resolutions in ITU Radio Regulations should be retained.

7 TIMING REQUIREMENTS

This paper has shown that significant additional spectrum needs to be made available to mobile communications in order to satisfy projected traffic demand for high bandwidth mobile services and to bridge the "digital-divide". We require that suitable bands, as mentioned earlier in this paper, need to be allocated and, where appropriate, identified at WRC-07 so that they will be available during the next decade as we move towards a global mobile society. Our past experience with the existing processes shows that it has typically taken about a decade between the time when the spectrum is identified and when it is initially made available for deployment. For example:

- From WARC-92 until 2001-2002 timeframe when IMT-2000/UMTS deployment started in the band 1920-1980 MHz and 2110-2170 MHz, and
- From WRC-2000 until 2008-2009 timeframe when IMT-2000/UMTS extension band 2500-2690 MHz will become broadly available

In this respect, a WRC-07 decision to allocate and identify additional harmonised spectrum for IMT would enable the next generation of mobile networks (in IMT-Advanced) to become widely deployed in the 2015 to 2020 timeframe. It is, therefore, our expectation that the future spectrum needs for IMT must be addressed at WRC-07 if we are to respond to the future demands of a global mobile society. We note in passing that WRC-03 set the agenda for WRC-07 in anticipation of the rapid market growth of mobile communications, which is a reality today. Furthermore, our own analysis , confirmed by other international studies, shows that WRC-07 is the right time to address the spectrum needs of mobile communications industry. A delay for a decision, for example postponing it to WRC-11, would have a negative impact on the market developments as availability of spectrum would then be deferred beyond the year 2020. Furthermore, this will also hamper the realisation of ITU vision of a global and mobile society, a vision shared by the NGMN alliance. Additionally, regional and possibly even national fragmentation is likely to occur if WRC-07 does not provide a globally harmonised spectrum identification for IMT, as several countries may choose introducing IMT systems according to national situations due to the lack of global harmonisation.