Final Report for

UMTS Forum

Global Mobile Broadband: Market potential for 3G LTE (Long Term Evolution)

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Analysys Research Limited

20-23 Greville Street

London EC1N 8SS

Tel: +44 (0)20 7061 3700

Fax: +44 (0)20 7061 3701

www.analysys.com

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0 Executive summary

This report examines the prospects for 3G Long Term Evolution (hereafter LTE) from 2007 to 2015, by considering what mobile services are likely to develop; what the level of demand for these services is likely to be; and how the business case for LTE varies between different types of operator and under different deployment options.

The way in which consumers and businesses use communications services is evolving. In order to support these changing needs, and deliver innovative new services, mobile operators need to invest in their own networks. LTE, as will be discussed in the rest of this report, has the potential to transform how users receive, consume and interact with information and content distributed over mobile networks. Deployed on a mass market scale, the benefits, not just for individual users, but communities and businesses could be considerable. A super fast, efficient and highly reliable mobile network will support the delivery of a wide range of services to multiple devices, improving not just the user experience, but driving efficiency gains for businesses using mobile services, enabling the rollout of new applications, such as M2M (machine to machine) and supporting the exchange of information within community-based projects.

Until now, the majority of non-voice revenues have come from messaging (particularly SMS) and personalisation (e.g. ringtones, wallpaper). However, much of mobile operators' focus has been on providing a more varied service mix, including entertainment content, business applications and the provision of access to corporate networks. By providing a combination of very high downlink/uplink speeds and much more efficient use of spectrum, LTE could revolutionise way in which existing services are consumed, as well as enabling the delivery of a whole new range of high-value services and applications, thereby addressing the trend of declining ARPU common to many mobile markets.

Previous services classifications by the UMTS Forum reflected the downlink/uplink speeds available at the time and which are still available now. Looking forward, the range of services supported by downlink/uplink speeds of the type provided by LTE would take the user experience to another level.

We can view how these services will evolve and form the basis of the new classification as shown in Exhibit 0.1 below:

Service category	*Current environment*	*LTE environment*
Rich voice	Real time audio	VoIP, high quality video conferencing
P2P messaging	SMS, MMS, low priority e-mails	Photo messages, IM, mobile e-mail, video messaging
Browsing	Access to online information services, for which users pay standard network rates. Currently limited to WAP browsing over GPRS and 3G networks	Super-fast browsing, uploading content to social networking sites
Paid information	Content for which users pay over and above standard network charges. Mainly text-based information.	E-newspapers, high quality audio streaming
Personalisation	Predominantly ringtones, also includes screensavers and ringbacks	Realtones (original artist recordings), personalised mobile web sites
Games	Downloadable and online games	A consistent online gaming experience across both fixed and mobile networks
TV / video on demand	Streamed and downloadable video content	Broadcast television services, true on-demand television, high quality video streaming
Music	Full track downloads and analogue radio services	High quality music downloading and storage
Content messaging and cross media	Peer-to-peer messaging using third party content as well as interaction with other media	Wide scale distribution of video clips, karaoke services video-based mobile advertising
M-commerce	Commission on transactions (including gambling) and payment facilities undertaken over mobile networks	Mobile handsets as payment devices, with payment details carried over high speed networks to enable rapid completion of transactions
Mobile data networking	Access to corporate intranets and databases, as well as the use of applications such as CRM	P2P file transfer, business applications, application sharing, M2M communication, mobile intranet/ extranet

Exhibit 0.1: *Development of mobile service classification [Source: Analysys Research/UMTS Forum, 2007]*

LTE will enable significant further development and, compared with existing and competing technologies, more efficient delivery of these services. There is also the potential to provide converged services whereby operators can offer services across both fixed and mobile networks with a consistent user experience.

In forecasting demand for these services, and the extent to which they will be delivered over existing and new networks, a scenario-based approach enables the complexities and uncertainties to be accommodated. Three scenarios were developed to explore the different ways that the industry may evolve, though all the scenarios share some common assumptions:

- agreement on a LTE standard will be achieved by 2008/9
- commercial launch of LTE networks and services will begin in 2010
- an appropriate LTE ecosystem will develop through the efforts of vendors
- enabled handsets are widely available.

In Chapters 4 and 5, we present demand forecasts and business case analysis based on one core scenario, characterised essentially by the persistence of current market trends. The other two scenarios, presented in Annexes A and B, are based on alternative views of market development and the related impact on the potential for LTE. These alternative scenarios account for some of the uncertainty that exists when we look several years into the future. They should be considered in conjunction with the demand forecasts and business case analysis presented in Chapters 4 and 5.

In the forecasts presented in Chapter 4, mobile subscriber numbers and revenues are forecast to grow strongly, with revenues from LTE services forecast to reach around EUR150 billion by 2015. Although the Western Europe and Developed Asia regions are likely to account for the majority of LTE subscribers, developing markets will grow strongly and account for a significant share of the LTE market by 2015.

Another important trend is the contribution of LTE to revenues provided by non-voice services. These are estimated to account for 36% of global LTE revenues by 2015. This is significantly higher than current rates of around 10–15% in developed markets.

For established operators in a developed Western European market, a developed North American market and a developing market in Eastern Europe, we have developed high-level business cases to show what incremental revenues would arise from LTE given the additional costs associated with the deployment and operation of LTE (both capital expenditure and operating costs) for four different roll-out models (hotspot coverage, urban

coverage, national coverage and home base stations). We assessed the free cashflow that would be generated and the net present value of LTE to an individual operator.

Home base stations are also referred to as picocells and femtocells. Picocells are for indoor use only and provide coverage to an area within a building, such as a floor of a company's headquarters. They are usually installed by mobile operators and are designed to connect to established fixed broadband services, such as corporate LANs. Femtocells are also for indoor use only, but are intended to provide coverage for a typical home. They use established fixed broadband connections, such as DSL or cable, as the backhaul from the home to the cellular network. In order to appeal to consumers, femtocells need to be small, inexpensive, easy to install (by consumers) and aesthetically attractive.

The results of the analysis generally shows a positive case for LTE deployment:

- Our business model projections for LTE suggest there is a strong case for deployment in developed markets. The modelling indicates that break-even for operators could occur three to four years following deployment (which is likely to begin on a commercial basis in 2010), with net present value to the operator from 2008–15 being of the order of EUR1–3 billion[1]. The case for operators in developing markets is however more marginal and is dependent on the competitive environment.

- For operators in these markets, the commercially optimal coverage level lies somewhere between urban and national coverage. Although it is likely initial LTE deployments will be based on either hotspot or urban coverage, as operators assess the technical and commercial aspects of the technology on a trial basis.

- Home base station deployment could be viable if the retail price is similar to that of a CPE in the European market. Industry efforts are working towards bringing this retail price down, making the case for base station deployment a real one.

- For new market entrants, the business case may be more challenging – our assessment assumes established operators can reuse existing GSM/W-CDMA infrastructure.

1 These figures are based on incremental revenues, i.e. the revenues generated by LTE users, in excess of those that would have been generated by HSPA users, and not total LTE revenues in each year

In conclusion, we recommend the following actions for the industry:

- **Vendors need to offer a cost-effective evolution from existing network infrastructure.** Compared to complementary technologies such as WiMAX and DVB-H, DVB-SH, MediaFlo, a potentially significant advantage of LTE is its cost-effective evolution from (and integration with) existing 3G infrastructure. Vendors need to convince the operators that LTE will minimise investment requirements, enabling them to re-use existing network assets. They also need to demonstrate that despite high initial capex (e.g. infrastructure upgrade), the low opex of LTE (i.e. cost per megabyte) compared to HSPA and W-CDMA could see operator investments breakeven within three to four years following deployment.[2] Further detail on this last factor is provided in Exhibit 3.3 (Chapter 3).

- **Investment needs to be made in raising awareness of LTE and its capabilities, with strong marketing and business cases.** Widespread deployment of LTE will be critical to generating revenue for cellular infrastructure vendors. Given the already significant investments in 3G, additional capital investment in 3G may be far from the minds of mobile operators. Vendors of cellular infrastructure must attempt to drive the market for their LTE products by using marketing to raise awareness and by developing strong business cases for the deployment of 3G LTE, including forecasts of investment costs.

- **Vendors and operators alike must be proactive in driving 3GPP standardisation**. While LTE potentially provides an important step change in capabilities, mobile operators need to ensure that the standard comes to fruition quickly. Mobile operators need to introduce clear commercial requirements into the 3GPP standard-setting process and maintain momentum to ensure timescales are achieved so that commercial launch is achieved as of 2010.

- **A regional appreciation is required when considering the potential threat posed by complementary technologies.** In some markets (most notably in some developing countries), low penetration of the fixed network is a potential indicator of a more active

[2] The cost of licence acquisition has not been included in the business case analysis due to the variation that is likely to occur between markets

and supportive environment for complementary technologies, such as WiMAX, which impinges on the business case for 3G LTE. However, such situations could represent an opportunity for operators able to offer LTE. Rather than invest in fixed infrastructure, governments of countries with limited fixed infrastructure may view wireless technologies as the primary means of providing broadband access services to users. In such cases, LTE may provide a more viable, countrywide, network to enable the delivery of broadband services (as it could build on any existing mobile infrastructure), although it may be positioned next to complementary technologies, such as WiMAX, in urban areas.

- **Vendors need to model the limitations of 3G and pre-3G networks in order to understand when and where LTE may be needed.** This report has demonstrated the benefits of LTE based on a number of business cases. These results need to be interpreted, taking into account specific network topology and number of customers. It is then possible to determine when LTE would be required.

- **Mobile operators should consider both the reuse of existing spectrum and lobbying regulators for early access to spectrum at reasonable prices**. 20MHz allocations would achieve the highest throughputs with 3G LTE. However, there are ways of deploying LTE within existing spectrum (e.g. 900MHz), and further options available for using different spectrum in urban areas compared to rural areas. These are discussed further in Chapter 3.

1 Introduction

The purpose of this report is to provide the UMTS Forum with a clear understanding of the potential for 3G Long Term Evolution (hereafter LTE). This potential includes an assessment of the technology issues involved, subscriber forecasts, expected revenues, likely deployment scenarios and finally provides recommendations for operators and vendors to be considered when addressing the LTE opportunity.

With true Wireless broadband up take, 3GPP is working on the evolution of mobile radio access networks which targets capacity and data rate enhancements beyond HSPA to meet the future demand of the traffic growth and services.

1.1 Definition

Taking the advantages of an *orthogonal frequency division multiplexing* (OFDM) approach, LTE can achieve performance levels beyond what will be practical with CDMA approaches, particularly in larger channel bandwidths. It will coexist with both 3G systems and 2G systems fitting into current operator owned spectrum, or in new spectrum to be acquired. For performance to be optimised, 20MHz would be needed.

It will support any multimode device compliant with LTE: in particular mobility will be defined for multimode devices supporting LTE/3G, LTE/3G/2G and any other technologies, depending on market circumstances and industry support.

In order to realise the full benefits, LTE requires the System Architecture Evolution (SAE) as core network architecture (defined by 3GPP). It is suited for future network broadcasting services at high-data-rates, low latency and reduced cost per bit.

1.2 LTE will take mobile network performance beyond anything which is currently available

LTE is an emerging technology standard that is being developed by 3GPP. The process of formalising and establishing the standard is ongoing and is expected by industry players to be completed by March 2008. This report has been commissioned in order to aid this process, by providing the analysis mentioned in the paragraph above. Although the specifications of the LTE standard may be refined through ongoing work in the near term, ultimately, it will enable significantly improved throughput and download/uplink speeds (in excess of any existing mobile technology standards). It will also support the delivery of a range of services, some of which are available today, but many more that have the potential to transform the way businesses and consumers use mobile devices.

Significantly, LTE also represents the next step in the evolution of the GSM/WCDMA/HSPA cellular family and the delivery of a range of services more comparable to a PC-based environment. HSPA is a first progressive step towards delivering 'triple-play' type services to mobile users (telephony, broadband and TV). There are now some 135 HSDPA networks operating commercially worldwide, accounting for around 10 million subscribers. Widespread use and acceptance of these services is likely to raise the need for an evolved UMTS, due to the demand for higher data rates, continued cost reductions and the need to keep up with competing technologies, such as WiMAX. These were amongst the key factors considered in the development of the LTE standard.

From an operator perspective, LTE will provide both technical benefits, such as more flexible spectrum usage and fewer nodes; and economic benefits, such as increased spectrum efficiency and optimised backhaul compared with current HSPA networks. Aside from the obvious appeal of LTE to WCDMA/HSPA operators, one major wireless carrier has expressed interest in LTE as an evolutionary option for its CDMA operations. If this interest is confirmed-possibly followed by other CDMA operators- it will result in a significant expansion of the 3GPP-compliant "footprint" globally. From a consumer perspective, improved latency (of around 0.5ms-10ms) and far superior data rates would enable a significantly enhanced user experience.

The basic technical specifications of LTE in comparison to existing technologies are provided in Chapter 3 of this report.

1.3 The report follows a structured approach using industry benchmarks, market modelling and industry opinion

We have followed a structured approach in producing this report. Initially, using desk research and published Analysys Research material, we have positioned LTE in the context of current mobile market conditions, looking at overall mobile market growth rates, and economic conditions by region. Following on from this, the range of services that will be delivered via mobile networks are discussed, with particular emphasis on how LTE could transform the way in which these services are consumed and the new services and applications that it will enable the delivery of. There is also consideration given to contributory factors with regard to the potential for LTE, such as standardisation, handset availability and expectations of commercial launch dates.

On this last point and throughout the rest of the report, we have used industry input gathered via a formal survey of equipment vendors and operators. The outputs from this survey have been used to inform our analysis of LTE potential, in terms drivers, issues, technology specifications, as well as demand side forecasts and the business case.

1.3.1 A scenario-based approach was used in order to account for potential variations in market conditions that could occur in the next eight years

The demand side forecasts and business case analysis presented in Chapters 4 and 5 are based on set of explicit market conditions. Due to the long-term nature of the analysis, it was important to try to account for other possible scenarios that would have a bearing on the success of LTE. Therefore, we have also created both demand side forecasts and business case analysis based on two alternative scenarios, which are presented in Annexes A and B. Of these two alternative scenarios, one is based on a high degree of fixed mobile substitution in coming years and as such is potentially more favourable to LTE; the other is based on more widespread rollout of competing technologies, such as WiMAX, and as such is potentially less favourable to LTE.

The demand side data is based on a thorough market modelling exercise, which used inputs from existing Analysys Research data as well as general macro and socio-economic

indicators. Operator benchmarks and a number of other assumptions were then applied to generate the forecasts that are detailed in Chapter 4 of this report.

The business case analysis has been based on three operator types and a number of different coverage options. For each operator type, a cost model has been applied (using operator benchmarks), so that the most viable coverage scenario can be identified based on the costs and revenues that are generated. Outputs from the demand side data are used to drive the business case analysis.

Finally, we have provided key conclusions and recommendations. The full report structure is summarised below:

- Chapter 1 introduces the report and the scope of the work
- Chapter 2 provides the market context and the rationale behind investments in LTE
- Chapter 3 discusses the services that will be used by mobile services in the coming years and the effect LTE will have on their consumption
- Chapter 4 contains the demand side analysis with forecasts provided in terms of subscribers, revenues, technology, ARPU and variation by scenario
- Chapter 5 presents the business case analysis
- Chapter 6 contains our conclusions and recommendations
- Annex A contains demand forecasts for the alternative scenarios
- Annex B contains business case analysis for the alternative scenarios

2 Market conditions mean investment in mobile services is necessary to secure long-term growth

Mobile markets across the world continue to present challenging conditions, with high penetration of mobile subscribers, and low growth in revenues from voice services, particularly in developed markets. Mobile operators have been quick to launch and promote new services, such as mobile TV, music and gaming, for which demand is growing rapidly. This investment (in handsets, infrastructure and promotion) has helped raise awareness and usage of these services, but more is required so that a broader range of services can be delivered to users in an efficient and more profitable way. How LTE can help mobile operators achieve this will be discussed in more depth in the rest of this report.

In this chapter, we will focus on the underlying mobile market conditions as well as a number of key macro and socio-economic indicators that will have a bearing on the demand forecasts for LTE that are presented in Chapter 4, and in turn the operator investment cases that we examine in Chapter 5.

2.1 Mobile growth will be driven more by service innovation than subscriber gains in saturated markets

The total global number of mobile users at the end of June 2007, reached around 2.6 billion. Overall mobile penetration, in terms of subscribers, has reached, or is reaching saturation levels in a numbers of markets. Western Europe has already reached a mobile penetration rate in excess of 100%, while Developed Asia is above 80%. North America and Eastern Europe have also seen significant increases in the number of mobile users, with penetration rates close to 80% as of mid-2007. While there is still capacity for further

growth in the remaining mobile markets shown below, operators in saturated markets will need to generate demand for new services in order to drive overall revenue growth in the coming years.

Exhibit 2.1 shows the total number of mobile subscribers and population penetration rates for each region as of mid-2007.

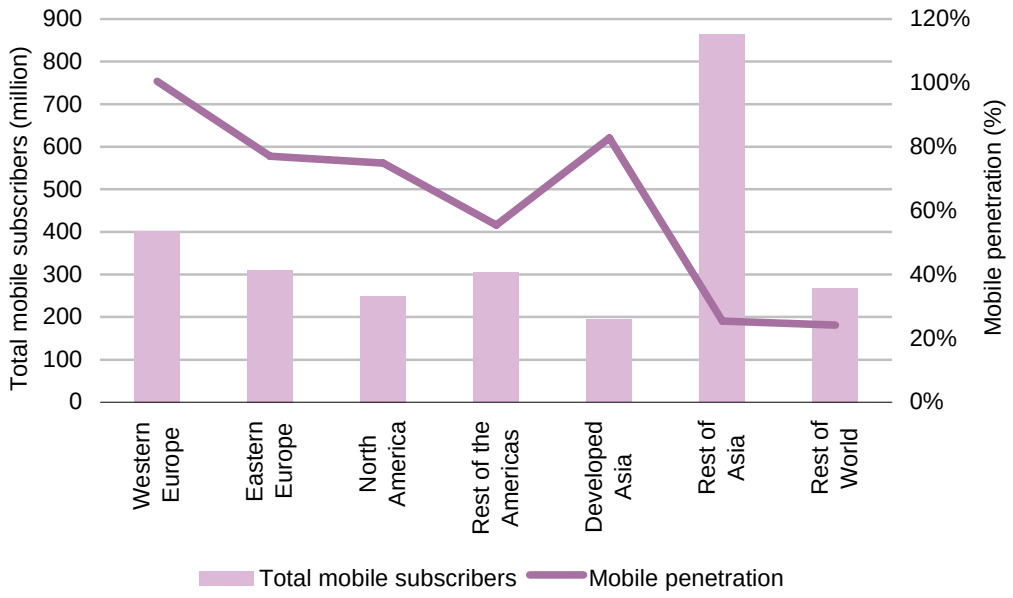

Exhibit 2.1: *Total mobile subscribers and penetration rates by region as of mid-2007 [Source: Analysys Research, 2007]*

2.1.1 Mass-market adoption and increases in competition levels have forced down mobile ARPUs

Many operators have struggled to maintain ARPU levels in recent years. High levels of competition and low-price entry points mean a significant proportion of consumers, in both developed and developing markets, have access to affordable mobile phone services. Although stable ARPUs would be more acceptable in an environment where subscriber numbers are growing strongly, in markets where saturation has occurred or is likely to occur, significant pressure will exist to boost subscriber spend. By providing users with

massively increased download speeds, LTE can help generate additional revenues from the kinds of high-value services that operators have begun to launch.

Exhibit 2.2 below illustrates overall ARPU performance (pre-paid and contract combined) across a number of representative markets

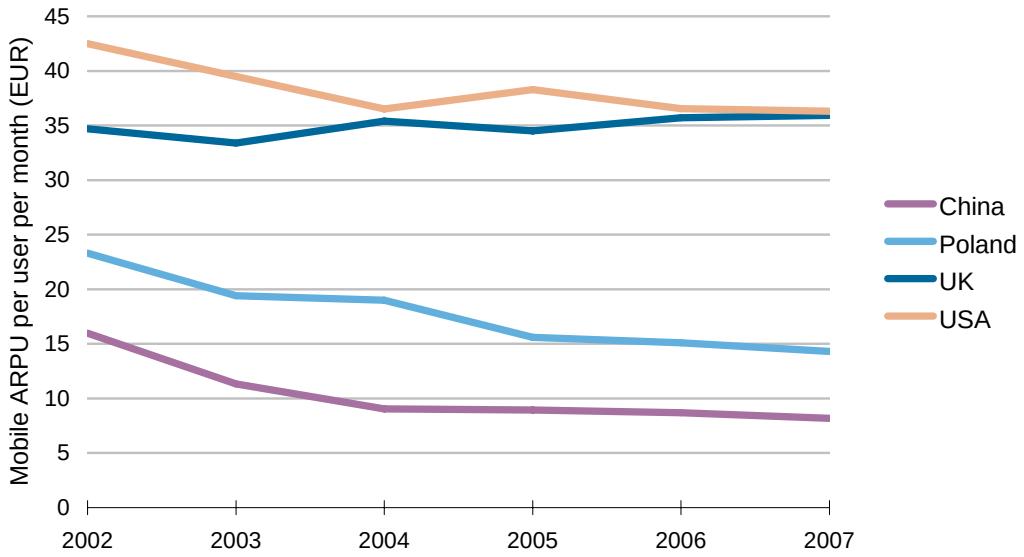

Exhibit 2.2: *Mobile ARPU in selected countries 2002–07 [Source: Analysys Research, 2007]*

2.1.2 Overall spend on mobile services is increasing

Exhibit 2.3 demonstrates how mobile revenues as a proportion of GDP in Eastern Europe are almost at the same level as Western Europe, whilst they continue to rise in the USA and China as well.

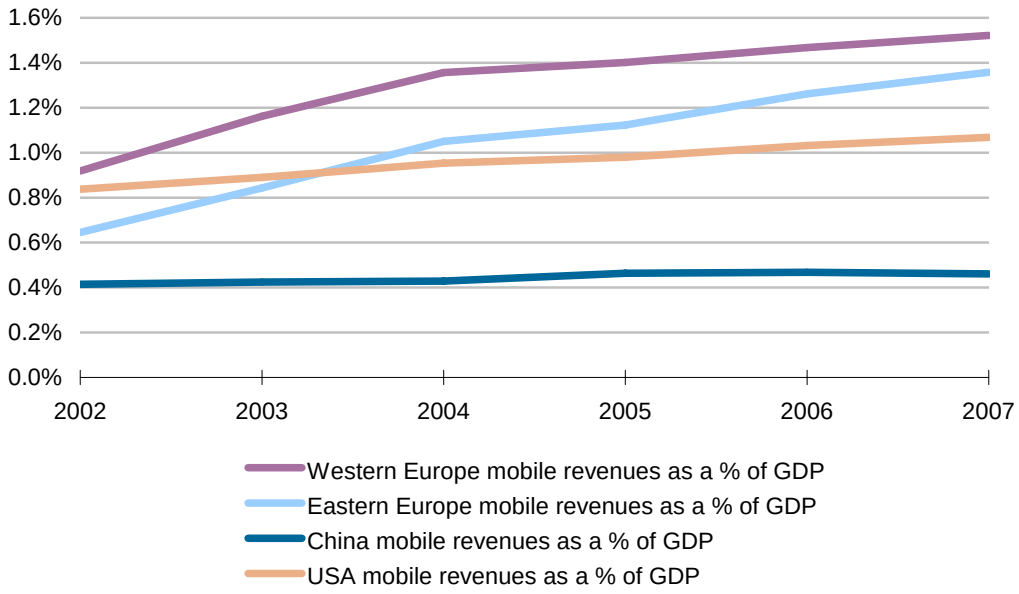

Exhibit 2.3: *Mobile revenues as a proportion of GDP in various markets, 2002–7 [Source: Analysys Research, 2007]*

2.1.3 Operators are still heavily reliant on voice services for revenues

Across all of the regional markets, voice remains the predominant contributor to revenues, accounting for around 80% of ARPU, as shown in Exhibit 2.4. A wide range of non-voice (data) services is now available as operators attempt to reduce their reliance on voice. The launch of mobile TV, mobile music and Internet browsing has helped boost non-voice revenues, but not to the extent where they comprise a major proportion of overall revenues.

Exhibit 2.4 shows the proportion of ARPU accounted for by voice and data in each region as of mid-2007.

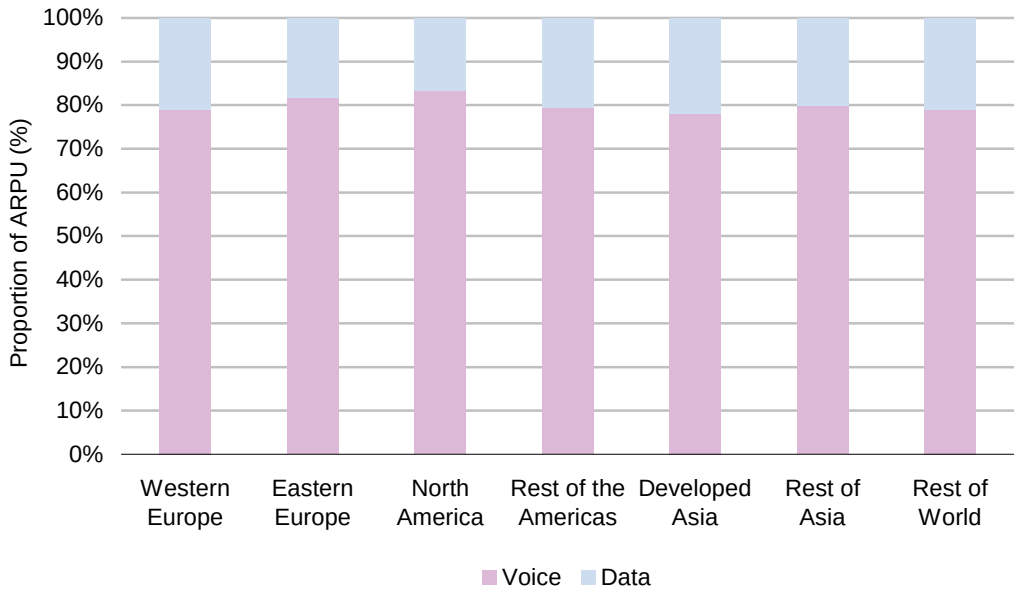

Exhibit 2.4: *ARPU split by voice and data services by region as of mid-2007 [Source: Analysys Research, 2007]*

2.2 Economic conditions will have a strong bearing on the successful migration of mobile users to higher-priced services

Operator efforts in migrating customers towards higher-priced services, especially those that will be enabled by LTE, will be partly dependent on favourable economic conditions. In all regions, population growth needs to be matched by economic growth in order to sustain and increase demand for new services. The prevailing conditions present in each of the geographic regions have been factored into the demand forecasts presented in Chapter 4 and are discussed below.

2.2.1 Overall mobile penetration will be boosted by developing markets

Of all the regions, the Rest of the World, Rest of the Americas and Rest of Asia feature the highest population growth rates. The countries represented by these groupings, such as those in Latin America, Africa and Southern Asia, generally have low mobile penetration

and therefore represent some of the mobile markets with the greatest overall potential for operators. In these same markets, the proportion of mobile users prepared to pay for more expensive mobile services is likely to be smaller than would be found in the developing markets of Western Europe and North America, for example. For this reason we would expect LTE to be most prevalent in developed markets, with the outlook for developing markets being longer term.

Exhibit 2.5 presents population growth rates for each of the regions for the period 2007–11[3].

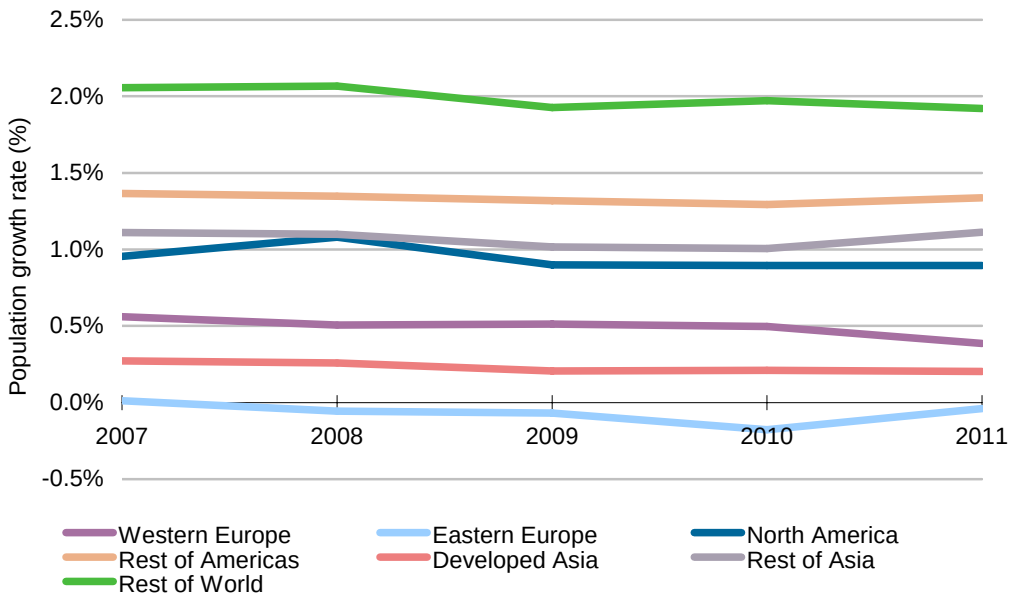

Exhibit 2.5: *Regional population growth rate per annum, forecast 2007–11 [Source: EIU, 2007]*

[3] Forecasts run up to 2011 due to availability of relevant EIU data

2.2.2 Sustained economic growth across all regions will give operators confidence in future demand

The overall outlook for GDP growth is positive across all regions. Again, developing regions will see the highest growth, specifically the Rest of Asia, Eastern Europe and the Rest of the World. The strong economic growth experienced in India and China in recent years is set to continue, driving demand for mobile phones and related services. Eastern Europe will benefit as countries from the region continue to join the European Union, creating a more advantageous trading environment. Encouragingly, all of the developed regions will see GDP growth above 4% for the period. A favourable economic environment is conducive to investment, which many mobile operators will be reliant on to find LTE roll-out plans. This data suggests confidence in economic conditions is generally high.

Exhibit 2.6 presents GDP growth for each region for the period 2007–11[4]

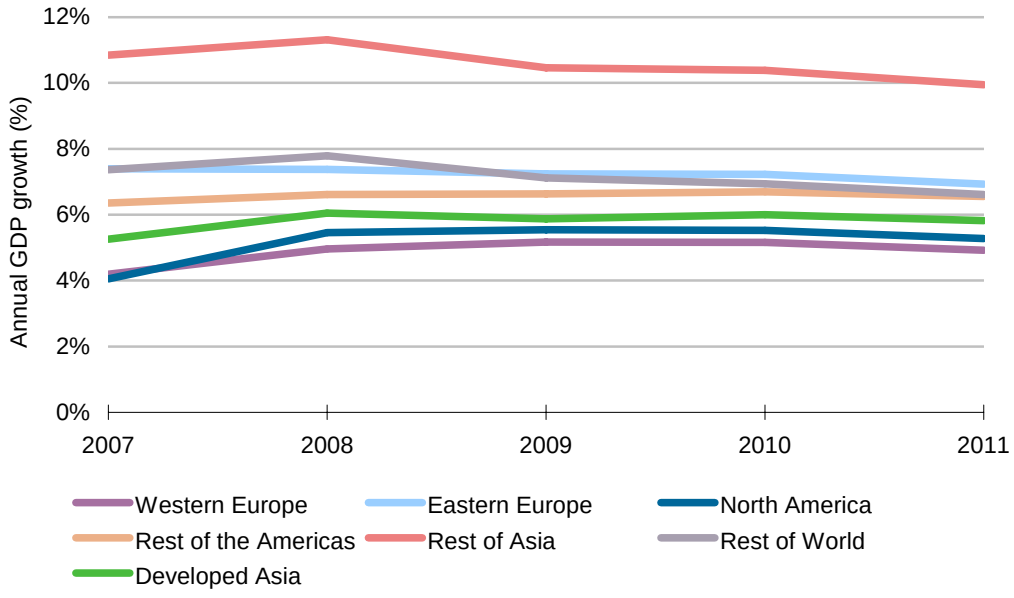

Exhibit 2.6: *GDP growth rate per annum, forecast 2007–11 [Source: EIU, 2007]*

[4] Forecasts run up to 2011 due to availability of relevant EIU data

2.2.3 As an indicator of consumer spending power, GDP per capita growth will remain positive

Continued GDP per capita growth suggests population increases will be matched by economic expansion across all regions. Conditions vary between the regions, but the overall message is that GDP per capita growth rates will increase overall for the period 2007–11 for all regions. The Rest of Asia will see the highest rates of growth, followed by Eastern Europe and the Rest of the World. Western European will see steady growth over the coming years.

Exhibit 2.7 presents GDP per capita growth rate by region for the period 2007–11[5].

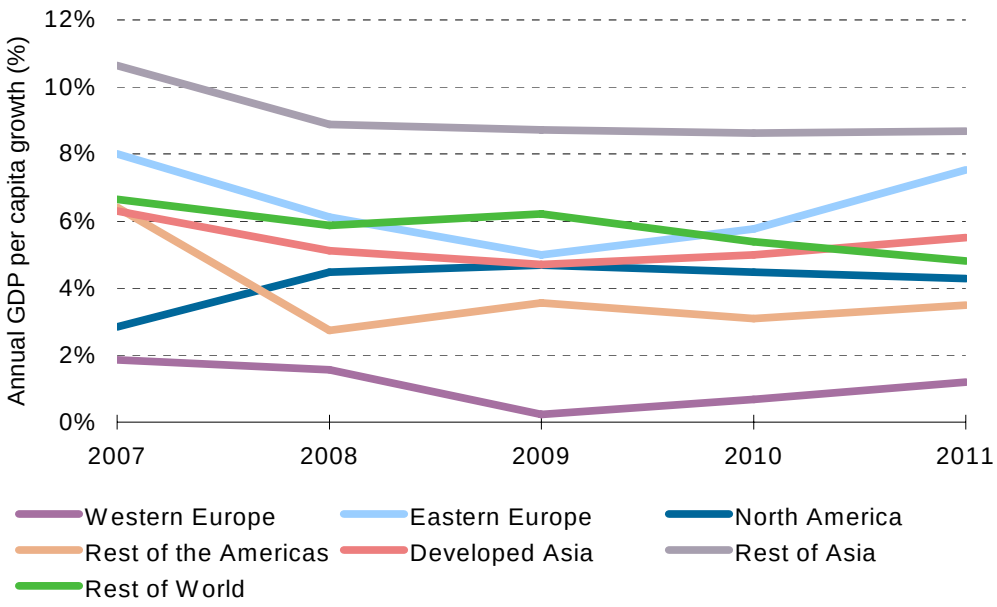

Exhibit 2.7: *Annual GDP per capita growth rate, forecast 2007–11 [Source: EIU, 2007]*

These economic trends suggest that consumers will have additional wealth (disposable income) to spend on mobile services, but only if they are compelling in terms of value-for money. This is an important consideration for operators contemplating investing in LTE.

[5] Forecasts run up to 2011 due to availability of relevant EIU data

3 LTE has the potential to transform the way mobile services are consumed

In establishing a set of standards for the evolution of high-speed mobile networks, it is essential to understand the range of services that those networks will distribute in the coming years. Mobile providers have expanded their portfolios to include such elements as television, video on demand, gaming and music in order to drive both usage and revenue growth. Due to the bandwidth-hungry nature of such services, widespread distribution to consumers is dependent on an effective delivery infrastructure.

As a technology, LTE offers a number of clearly identifiable benefits in comparison to other mobile technologies:

- high-end user data rates
- lower distribution cost per unit of traffic
- reduced latency
- an all IP platform enabling convergence with fixed NGNs.

In this chapter we define the services that will be discussed throughout the rest of this report and assess the impact of LTE on their delivery.

3.1 LTE will support increasing diversification of non-voice services

Up until now, the majority of non-voice revenues have come from messaging (particularly SMS) and personalisation (e.g. ringtones, wallpaper). However, enabled by significant investment in infrastructure, much of operators' focus has been on providing a more varied

service mix, including entertainment content, business applications and the provision of access to corporate networks.

3.1.1 This report provides further granularity to the service categorisation used in previous UMTS Forum reports

In previous reports, the UMTS Forum has categorised services as follows:

- rich voice services
- MMS (including SMS)
- mobile Internet
- location-based services
- customised infotainment
- mobile intranet.

The new categorisation used in this report reflects the importance of entertainment-based content such as games, television, video on demand and music, which were previously bundled together in the customised infotainment category. ‘Location-based services’ has also been removed as an individual category. Rather we consider that as mobile users are not necessarily reliant on being in a specific location to access relevant information about that location, we consider location-based services to be a small, specialist part of each of a number of the more fundamental service types that we have created to replace the customised infotainment category. We have also considered the IMT-Advanced classification that maps services to traffic class, giving further indication of how LTE could support an entire new ecosystem of services.

The revised services categories are listed and defined in Exhibit 3.1.

Service category	*Description*
Rich voice services	Real time audio or audio-visual communications, with LTE this will move towards VoIP and high quality videoconferencing
P2P messaging	Messaging via SMS, MMS and low priority e-mails, moving towards photo messages, instant messaging (IM), mobile e-mail and video messaging in an LTE environment
Browsing (free information)	Information services for which users only pay standard network access charges and not for the information itself. The majority of usage in this area is WAP browsing using GPRS networks, but with LTE, usage is likely to be closer to the PC experience, with super fast browsing speeds and greater interaction with social networking sites such as MySpace
Paid information	Premium-rate information and content other than that delivered via downloadable applications, for which users pay over and above standard network charges. Examples include location- or context-sensitive information, such as traffic updates for travellers, but with higher network speeds, this will move towards advanced services, such as e-newspapers and high quality audio streaming
Personalisation	Services that involve content used to personalise mobile devices, such as ringbacks, ringtones and screensavers. Of these, audio personalisation (i.e. ringtones) remains the largest revenue stream. Realtones, featuring original artist recordings, will become more popular as network speeds and handset capabilities continue to improve, likewise, there will be greater personalisation of mobile sites, whereby users can upload pictures and other content to their own mobile portal
Games	Includes both downloadable games (delivered to a device over a mobile network) and online games (played on mobile devices over a mobile network). Development continues in this area, with the first mobile massively multi-player online role-play game (MMORPG) launched by KTF in June 2006. The gaming experience will be further enhanced by LTE which will enable a consistent gaming experience across both fixed and mobile networks
TV/video on demand	Video on demand (VoD) and broadcast television services. VoD services comprise streamed and downloadable video content and have been available for several years over 2.5G networks and, more recently, 3G networks. TV services comprise point-to-point access to TV programmes and multicast TV services offered via dedicated spectrum. Television content delivered in this way has only become available more recently, with German operator MFD, the first European provider to launch a broadcast-based (T-DMB) service in May 2006. In contrast to the multicast nature of DVB-H, for example, LTE will enable efficient delivery of on-demand television content, either through downloading or high quality video streaming
Music	Full-track music downloads and subscriptions, as well as radio services. Many mobile operators have launched music services that enable users to download full tracks either on a one-off or subscription basis. Some of these also provide a link for downloading tracks onto a PC at no additional cost. In terms of radio, operators such as Vodafone with its Radio DJ service, now offer subscription-based services, which allow subscribers to select tracks to stream. Device development and the faster download speeds enabled by LTE will help transform mobile handsets into the default mobile music player for many users
Content messaging and cross-media	P2P messaging using third-party content and mobile communications used to interact with other media. Users can now use content purchased from third parties to send in greetings cards, amongst other formats. Cross-media services involve

	users interacting with, for example, TV programmes, whereby the user votes (usually via SMS) in a competition or comments on news information. Interaction will be taken a step further by LTE by creating an environment whereby people can upload content to their operators' portal as their contribution to karaoke and dating services, as well much greater usage of video clips in greeting cards and mobile advertising, for example. Another form of interaction might be PVR services, which enable mobile users to view and record forthcoming television content
M-commerce (including gambling)	Includes the commission on electronic transactions and payment facilities undertaken over mobile networks, from portals, mobile shopping sites, banks, share trading sites, as well as booking and ticketing sites. Commission on gambling transactions is also included as is any advertising revenue earned from such sites. Japanese operators have begun to make investments in mobile commerce, which are likely to increase further as network speeds and handset functionality improve.
Mobile data networking	The use of mobile networks to access corporate intranets and databases, as well as the use of related shared applications, such as CRM or sales force automation (SFA). In an LTE environment, there will be far greater potential for P2P file transfer, application sharing, M2M communication and access to mobile intranets and extranets

Exhibit 3.1: *Service categorisation for LTE [Source: Analysys Research,/UMTS Forum 2007]*

3.2 The delivery of each service places different demands on infrastructure

Much of the investment in infrastructure by mobile operators has been based on the inability of existing infrastructure to sustain widespread distribution of bandwidth-hungry services, in terms of both capacity and cost, and this is expected to be a major influence on operators' decisions regarding investment in LTE.

Exhibit 3.2 compares the downlink data consumption for a number of non-voice services.

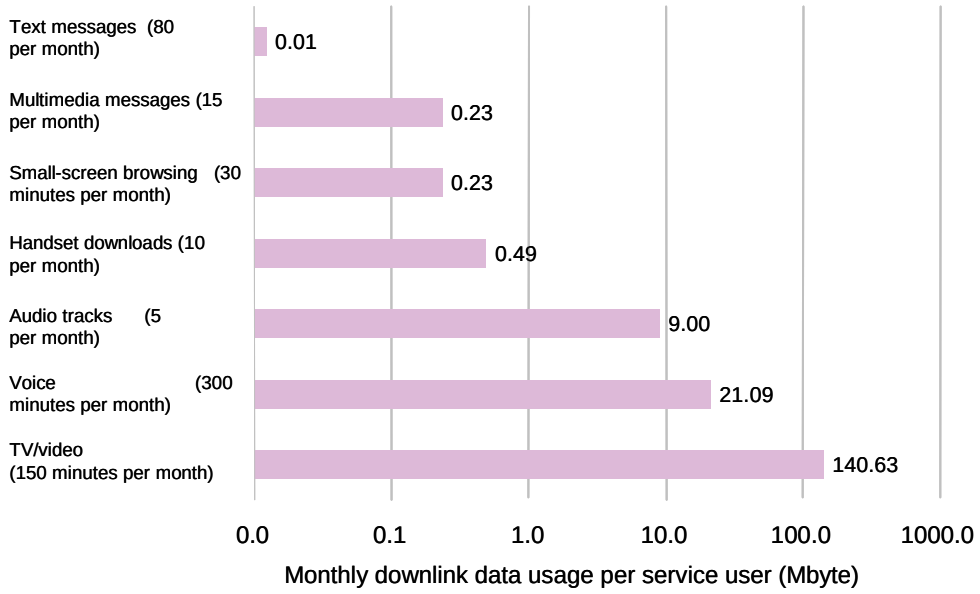

Exhibit 3.2: *Comparison of downlink data consumption of TV and video services with voice telephony and other mobile data services [Source: Analysys Research, 2007]*

3.2.1 LTE offers considerable efficiency gains compared to other network types

When comparing the capacity and cost of different network types for delivering the range of services mentioned in Exhibit 3.1, the benefit of LTE is apparent. This is based on research carried out for Analysys Research's report "Prospects for the Evolution of 3G and 4G," (2006). As shown in Exhibit 3.3 below, in terms of throughput and cost per megabyte, HSPA and W-CDMA are slower and, for operators, also more expensive. Aside from faster download/uplink speeds for end users and financial benefits to the operator (in terms of cost per megabyte), LTE will also allow further innovation in services. Mobile TV services providing a greater range of high quality channels, voice over IP and seamless video conferencing could all be delivered by LTE, and these services and others are considered in more depth below.

	Basic W-CDMA	*HSPA (2x5MHz)*	*LTE (2x5MHz)*
Theoretical average wide-area throughput	128-384kbit/s	1Mbit/s	4Mbit/s
Theoretical maximum throughput	2Mbit/s	14Mbit/s	20Mbit/s
Monthly downlink traffic	230TB (5MHz) 500TB (10MHz)	500TB	1800TB
Typical cost per (downlink) megabyte at maximum use of the network.	EUR0.06	EUR0.03	EUR0.01

Exhibit 3.3: *Estimated throughput, capacity and access cost per megabyte for 3G, HSPA and LTE modelled for a 10 000 base-station network deployment, assuming 5MHz band is used [Source: Analysys Research, 2007]*

3.2.2 Options are available for LTE within existing spectrum and candidate bands

One of the key advantages of LTE is the potential to use existing spectrum. The 900MHz band could be used, likewise refarmed spectrum for 3G services. In addition, a number of candidate bands below 5GHz have been identified by the ITU as being suitable for IMT Candidate bands. These include the IMT-2000 frequency bands (1.9-2GHz) and extension bands (2.5GHz), as well as at 850-900MHz, 1800MHz, AWS spectrum (1.7GHz-2.1GHz) and portions of the UHF band recently identified at the World Radiocommunications Conference (WRC-07) for mobile services in some parts of the world. Although the bands of 5GHz and higher would enable LTE to offer the sort of throughput speeds mentioned in Exhibit 3.3, for the purposes of achieving national coverage, these lower frequency bands could provide a viable alternative.

3.2.3 LTE is an evolution from HSPA

As mentioned, there have been a large number of HSDPA launches in recent years, as operators continue to upgrade mobile infrastructure, offering improved data rates on the downlink and better coverage. The next step will be upgrades to HSUPA, which will offer higher data rates on the uplink and is expected to become widely available after 2008. HSUPA will enable the delivery of yet more advanced services and an improved user

experience. The next step in this evolution, to LTE, will be largely based on the operators confidence that the technology can deliver a user experience better still than that of HSUPA. In this respect, mobile operators will need to be convinced that the necessary investment in infrastructure upgrades to LTE will be more than matched by the related increase in average spend among mobile users.

3.2.4 Operators will struggle to deliver mass-market mobile television and video services with existing infrastructure

If mobile TV is considered for a moment, a user viewing just 5 minutes per day of TV, streamed at 128kbit/s would consume the same downlink traffic as 2000 minutes of voice telephony per month. Based on current infrastructure, widespread use of 3G TV and video services could completely fill 3G networks and leave little space for other services. In contrast, LTE would enable a typical operator to offer ten TV broadcast channels, ten radio broadcast channels and 30 minutes per day per user of TV or radio on demand. It should be noted here that the way in which mobile TV is packaged and marketed is essential to the demand for this service from mobile users. In order to improve upon nascent mobile television services (based on DVB-H, MediaFlow and other broadcast technologies), mobile operators will need to carefully package television services to appeal to their customers, offering high value on-demand services for example, rather than trying to provide a similar number of channels.

The ability of a number of high-speed mobile networks to carry TV content is illustrated in Exhibit 3.4 below.

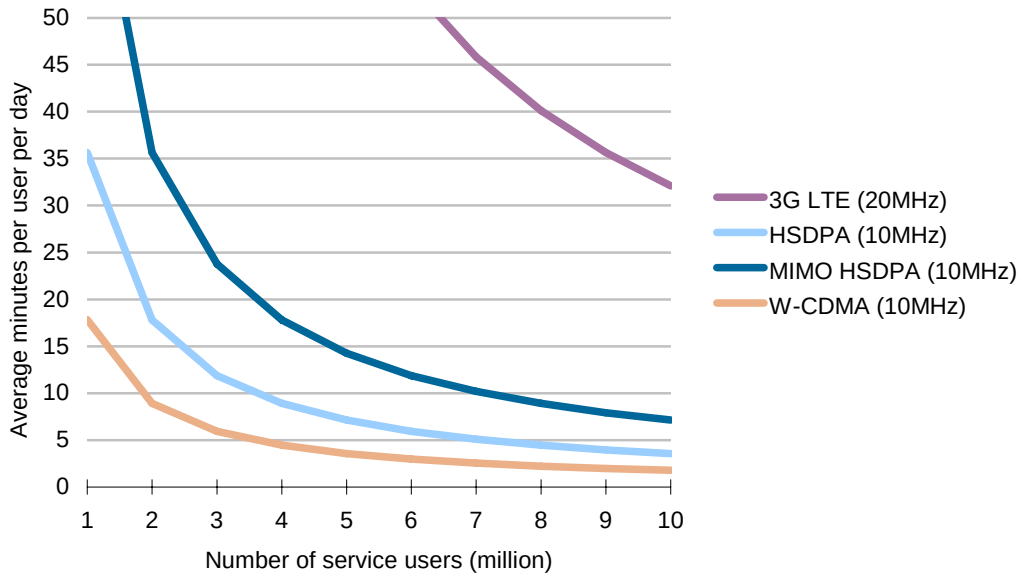

Exhibit 3.4: *Capacity of typical 3G LTE, HSDPA, MIMO HSDPA and W-CDMA networks to carry TV content [Source: Analysys Research, 2007]*

3.2.5 The browsing experience would be transformed by LTE

Browsing is a service that would clearly benefit from faster download speeds. Although LTE would not be able to match the speeds offered by VDSL and optical fibre, it would enable mobile operators to target fixed broadband users. Specifically, it could be used to deliver a fast browsing experience to customers who can not access the most advanced fixed services, for instance because they are too far from the nearest local exchange.

3.2.6 Significant network capacity could be required if demand for full-track downloads continues to grow

Network resources will also be put under pressure by sustained growth in demand for full-track downloads. A number of mobile operators have launched such services, with a single track typically using several megabytes (e.g. a three-minute 128kbit/s music track consumes 2.8MB). A mobile user downloading ten music tracks per week would consume

121MB per month, whilst intensive users could consume much more. Although established alternatives exist for downloading music elsewhere (e.g. online music services accessed via PCs attached to fixed broadband lines), further deployment of business models such as that employed by 3, which allows users who have purchased a track via their handset, to download the same track to their PC, could result in rapid growth in these music services.

LTE would also give content providers and mobile operators greater freedom to develop music services further. One important development in this area has been the recent launch of Apple's iPhone, which offers a converged device with 4Gb of storage, sufficient for around 1000 music tracks. Handset manufacturers will be keen to respond with enhancements to their own music-enabled devices. Widespread deployment of LTE would allow operators to cater to increasing demand for mobile music, enabling fast downloads, live streaming of exclusive audio content and a more enjoyable user experience.

3.2.7 Voice services could benefit from the deployment of LTE in two key areas

The efficiencies enabled by LTE would make mobile VoIP a possibility for operators as many of the overheads currently associated with it would be removed. In the short term, operators could take advantage of VoIP service opportunities, such as presence information, messaging and multimedia. Cost savings in relation to launching VoIP have not been calculated in this report, but are likely to become increasingly relevant if general usage of the technology continues its current upward trend and fixed operators maintain next generation network investment.

Videotelephony (part of the rich voice category shown in Exhibit 2.1) is now available via a number of mobile operators: 3 has been offering it in the UK and Italy for several years now, while O2, Orange, Proximus, T-Mobile, Telefónica Móviles and Vodafone have all launched similar services. Meanwhile, integrated operators Telecom Italia and France Telecom have both achieved reasonable take up for their videotelephony services since launch.

Despite a number of false starts, the integration of videotelephony with applications such as Instant Messaging (IM), VoIP and file sharing, could lead to faster growth in the future.[6] If videotelephony adoption and usage rates increase significantly (as part of messaging bundles), existing high-speed mobile networks may struggle to deliver adequate quality of service.

A number of issues have hampered growth in mobile videotelephony, including low screen refresh rates (8–12 frames per second is common), as well as limited battery life of handsets effecting overall performance. With an LTE-based network supporting delivery, there are number of additional applications which would make videotelephony more attractive, such as enabling deaf users to use mobile devices for sign language and remote surveillance.

3.2.8 Results from other markets suggest messaging has further growth potential in line with network capacity

Messaging remains a key source of revenue for operators, contributing around 15% of total revenues in some European markets. In considering future trends in messaging, the Japanese market, with its high adoption of services, provides some indicators. Mobile messaging has become a key application in terms of usage, with over 400 e-mails per month per 3G customer, compared to just 50 messages per month per customer in Western Europe and the USA. Increases in messaging usage of this magnitude in Europe will obviously boost data traffic levels over 3G networks in Europe and the USA, although at the same time, the implementation of effective pricing strategies will be necessary to avoid cannibalisation of existing data revenues.

Network capacity is a factor in determining the success of both mobile e-mail and mobile instant messaging. Growth of the latter will be facilitated by the deployment of LTE, which offers reduced latency to support near real-time messaging. Mobile e-mail will benefit from the enhanced speed of LTE, which will permit e-mails with attachments to be quickly transmitted, making the mobile e-mail experience similar to that in fixed networks.

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6 For further discussion of the role of videotelephony in the overall service mix and adoption forecasts, see Cox. I, *Creating a Mass Consumer Market for Videotelephony: opportunities and challenges*, Analysys Research, 2006).

Operators – in concert with vendors and service providers – are rolling out high-end handsets with mobile email capabilities. 3 UK has launched the Yahoo! Go client, initially on the Nokia N73 handset, which gives users access to their Yahoo! email, address book, diary and IM. At the same time, RIM's dominance of the OS market is being challenged by Microsoft, and its Windows Mobile system: in March 2006 Vodafone launched a range of devices that use Windows Mobile 5.0 with Direct Push technology, aimed at corporate and SME customers in France, Germany and the UK. All this suggests that messaging is likely to be an application area with considerable activity and innovation over the medium term.

3.2.9 Free information services will remain an important source of revenue for operators

Operators have stimulated adoption of mobile broadband services by offering flat-rate browsing tariffs. Users are able to view a wide range of free information services at comparatively low cost. The strategy has been successful in Europe, with free content helping to generate around 15% of mobile content revenues. Potential revenues from this service would be enhanced further by LTE, as downlink speeds would no longer be an issue for browsing.

3.2.10 Charging for information on a per-event basis is becoming more popular

Pay-per-event and subscription SMS/ MMS are the most prevalent payment methods for this category. Examples include TIM's news alerts (TIMSpot), which are free of charge but contain advertising, while Vodafone offers free news headline browsing on-portal but charges EUR2.20–4.40 per month for access to full articles. The same operator also charges premium rates (EUR3.50 per megabyte) for portal browsing. More generally, SMS alerts, which in the past have been largely provided for free, are now charged at two or three times standard SMS rates. Further developments on the back of LTE might be the launch of e-newspapers and high quality audio streaming, such as live commentary from sporting events.

3.2.11 Personalisation will remain a strong contributor to non-voice revenues

Evidence suggests revenue from mono- and polyphonic ringtones has peaked; average prices remain firm at around EUR2–4 per download in Western Europe, for example. Operators have begun to introduce realtones but perhaps not as enthusiastically as they might due to the lower margins available compared to polyphonic ringtones. Another possible contributor in this category in the future is ringbacks. These have been highly successful in Asia; the Chinese ringback market was worth over EUR400 million in 2006. In Europe, Telefónica Móviles and Vodafone Italy have introduced ringbacks with growing success. Overall, personalisation currently accounts for around 40% of mobile content revenues in Western Europe. Personalisation as an activity could be transformed by LTE with users able to create their own mobile portals by uploading images and other content.

3.2.12 Ease of access and use is key to the future of mobile games

The initial popularity of embedded games has been translated into strong sales of J2ME downloads. Widespread availability of Java-enabled handsets has helped foster this growth. Among UK operators, 3 has been the most successful in this area, achieving 6.4 million games downloads in 2006. Online mobile games have generally replicated console and PC-based games but have been slower to take off, partly due to the limitations in screen size and keypad controls, and also due to concerns over latency and cost.

The latency issue would be addressed by LTE, while increasing availability of specialised handsets and a broader portfolio of mobile massively multi-player online role-play games (MMORPG) should encourage ‘hard-core’ gamers, thereby providing a significant boost to online gaming revenue in the long term.

3.2.13 Content messaging is threatened by user-generated content, but cross-media services have been successfully implemented across developed markets

Although many operators have successfully established full MMS interoperability within national boundaries, interoperability across national boundaries has been an obstacle. There

has been greater focus on driving usage of MMS user-generated content rather than that provided by third parties. SMS voting has been a popular addition to television programmes, especially in the reality TV genre. *Pop Idol* has been particularly successful in this area: the US version, *American Idol*, generated 64.5 million SMS votes in 2006. Since the programme's inception it has earned over EUR500 million in revenues in this area globally.

An example of how interactivity could be taken further is an EPG (Electronic Programme Guide) available on handsets, whereby users can view the programming schedule for their television service provider, and potentially select programmes that they wish to record via a PVR (personal video recorder).

3.2.14 The development of m-commerce services continues and will be driven by further technological innovation

The ability to purchase goods and services via mobile handsets is dependent on both the development of new technology as well as agreements between operators and retailers. Some of the investment in this area centres on handsets being used as payment devices, whereby the phone is enabled to exchange information and initiate applications with a variety of electronic devices. Japan has been the most advanced market in the development of this technology. FeliCa (a mobile payment standard developed by Sony) readers and writers have been installed in around 60,000 shops as of mid-2007 in the country, while in the region of 25 million FeliCa-enabled handsets are in use.

Mobile gambling services comprise casino, lottery and betting services but have yet to realise significant revenue. These services have evolved from simple text-based lotteries and betting to downloadable applications such as Casino Lobby and Wild Jack mobile casino. The majority of activity in this area has been off-portal with further service roll-out limited by a number of political, technological and social factors.

Such deployments of m-commerce infrastructure would need the support of a high-quality network. Widespread availability of LTE would enable rapid processing of transaction data across a large number of sites. The additional benefit to operators is a share of transaction

value, which could be considerable if mobile payment initiatives were rolled out on the same scale as FeliCa has in Japan.

3.2.15 Data networking has become an essential element of mobility services

Providing access to company intranets and databases has become an essential tool for many companies with remote workforces or mobile sales forces. This enables employees to send and retrieve data that is essential for their job role. Examples include utilities workers who send back data from meter readings to a central server, which then updates customer records and issues the appropriate bill; as well as sales staff who are able to capture, process and send orders from a single hand-held device, initiating the delivery of relevant products or services.

An increasing number of people work remotely on a daily basis. By providing high-speed access to corporate networks and intranets, LTE would enable rapid exchange of information and documentation between remote workers and a central office. For example, field engineers requiring up-to-date drawings or plans would not have worry about download times to a handheld device or laptop. The scope for operators and third parties to develop innovative services based on high-speed mobile networks is considerable: we are currently only at the beginning of this market opportunity. Further enhancements could also include M2M communications, P2P file sharing and application sharing.

3.2.16 Converged services will become a reality with LTE

The all-IP nature of LTE means converged services could become a reality. LTE will work effectively with the Next Generation Networks being deployed by fixed operators, as backhaul will be based on IP/MPLS. End users will be able to roam from fixed to mobile networks, with no disruption in their use of a service or application, the device automatically registering on and using the relevant network. Such innovation could be applied to gaming for example, with users of the mobile massively multi-player online role-play games (MMORPGs) mentioned above, who can spend extended periods in the virtual gaming environment, able to change location with no obvious effect on their user experience.

3.2.17 The mobile industry will create an LTE ecosystem that will drive the development of new services

By investing in LTE, mobile operators will migrate to efficient, high-speed networks that will allow greater innovation in the development of services and applications. Operators will be able to provide ample capacity on an all-IP network for developers to create new mobile services, in much the same way as next-generation fixed network operators will. Equipment vendors, for example, have already begun to innovate with their application and service portfolios, creating mobile payment and music download applications, such as those mentioned above. Without the constraints of current mobile infrastructure, this innovation can continue, but at a much faster pace.

In this report, and in the business case analysis presented in Chapter 5, we have assumed that fixed operators will continue their next generation network investments and gradually move towards all-IP core networks (using IMS-based technology for example), at the same time as LTE investments begin and rollout commences. LTE-based services will benefit from the all-IP nature of fixed and mobile networks, especially in the area of converged services. In the business case analysis presented in Chapter 5, the financial data is based on investment in the radio network only.

In considering future demand for LTE services, it is also important to remember the role played by handsets in helping to stimulate and drive demand. Handset manufacturers have a key role to play in helping the rest of the industry realise the benefits of LTE. Amongst other possible innovations, the development of larger, higher resolution handset screens on which to view video content, larger capacity with which to store music tracks and dedicated keys to use solely for gaming, would all contribute to increasing demand for, and the usage of services that LTE will be better suited to deliver to a mass market.

Despite taking this analysis into consideration, forecasting demand for mobile services is notoriously difficult, especially when we are dealing with a timeframe up to eight years in the future. For this reason, the following chapter uses a scenario-based approach to take into account a number of complicating factors including competing network technologies, infrastructure ecosystems (including handsets) and operator strategies to provide forecasts for the services described, and to show revenues that are attributable to LTE networks.

4 LTE could generate EUR150 billion in revenues by 2015

The long term nature of LTE means it is essential to consider a broader range of contributory factors when assessing its potential success than may be necessary for standards which are well established, or have recently been launched. Not only is important to consider perspectives related to broad agreement on standardisation, but it is also necessary to consider when operators are likely to launch LTE as well as the likely market conditions in which they will do so.

4.1 A balanced view of the potential for LTE has been adopted

The forecasts of growth in LTE revenues and subscribers that are presented in this chapter are based on a comparatively neutral view of the market for the period 2006–2015. This means that potential developments such a significant increase in demand for non-voice services or the adoption of aggressive fixed-mobile substitution (FMS) strategies by operators, which would have a positive effect on the potential for LTE, are not included as contributing factors in the forecasts. Also considered as neutral in the assumptions are those developments, such as migration towards complementary technologies and limited adoption of FMS strategies by operators, which could have a negative effect on the potential for LTE.

However, we have accounted for the effects of such developments as part of the overall work for this report, and market growth forecasts and business case analysis for two alternative scenarios are presented in Annexes A and B. These alternative scenarios take into account some of the uncertainties in the market going forward, such as those

mentioned above, and were formed through consensus views from the Forum members and others. Details of the market conditions which form the basis of these scenarios, and the process by which they were arrived at, are also included in Annex A.

The market conditions, which form the basis of the forecasts presented in this chapter and the business case analysis presented in Chapter 5, are as follows:

- In this scenario consumers predominantly continue to demand the same range of mobile voice and P2P communications they currently purchase
- Demand for other non-voice services grows slowly
- However, particularly in regions with poor existing fixed infrastructure the level of FMS increases and in those regions mobile devices are used extensively for Internet access and other typically fixed-line services
- LTE performs well but upgrades are deployed only gradually in the absence of competition from WiMAX and strong demand for non-voice services

4.2 Market forecasting methodology

The forecasts have been produced through a combined 'bottom-up' and 'top-down' approach. Bottom-up forecasts have taken account of a wide range of factors including:

- typical adoption rates for new technologies
- typical adoption rates for mobile services
- constraints on adoption such as handset replacement rates
- churn rates
- benchmarks of actual ARPUs for individual services in each region
- consideration of the likely evolution of ARPUs as services became widely adopted.

Top-down estimates have provided cross-checks as to the reasonableness of the bottom-up forecasts – for example in terms of overall levels of affordability evaluated in terms of projected levels of spend on mobile services as a percentage of GDP. These cross checks have been applied to the forecasts to ensure that the range of outcomes remains credible and reasonable.

The forecasts have been based on actual data and estimates for the level of adoption in each region as of mid-2007 and on service ARPU as of mid-2007. Where available, these have been derived from figures used in Analysys Research reports. The remainder of this chapter is dedicated to analysing key trends in subscribers, revenues, technologies and ARPUs across all regions.

It is important to note at this stage that the demand side data provides absolute figures, in terms of both revenues and subscribers. LTE data from the demand side model has been used in the business case analysis, but only in terms of incremental growth. This isolates the subscribers and revenues attributable to LTE only, i.e. the additional revenues earned from LTE in excess of those earned from users of other technologies. It is this growth that will be the focus for operators when assessing the business case for LTE – what it can offer them in the way of revenues that other technologies cannot.

4.3 Agreement on the LTE standard is expected in the next two years

Discussion continues on the specifics of the LTE standard. The willingness of operators to maintain momentum in this area will have a direct effect on roll-out and launch dates of LTE. Feedback from operators and equipment providers spoken to for the purposes of this report suggests that many think agreement of the LTE standard could be reached by the end of 2008, and in modelling the demand for services based on LTE, this has been assumed. The speed with which agreement can be reached is dependent on further discussions between operators and equipment vendors, in order to ensure that both are clear on what they actually want to do with LTE and the benefits it has in comparison to other technologies.

Operators could be tempted by other wireless technologies, such as WiMAX, proprietary BWA systems and broadcasting technologies (e.g. DVB-H, DVB-SH, MediaFlo etc.). These other technologies have received more attention than LTE, due in part to the promotional efforts of vendors. A number of standards for these alternatives have been established, such as IEEE 802.16, 802.16e and 802.20. However, LTE is aiming to adopt many of the same radio and core network techniques as alternative wireless technologies and can therefore achieve significant improvements in performance.

4.4 Market opinion suggests that full commercial launches of LTE are unlikely before 2010

Further feedback from operators and equipment vendors was sought regarding the commencement of LTE network roll-out and commercial launch of LTE services. From this survey, the participants supported the view that full commercial roll-outs were expected to begin around 2010.

The expected cost of deployment is a key factor in determining launch dates and the onus is on vendors to provide operators with a clear migration path to LTE. Opinions in this area are mixed, based on comments from operators and vendors, with a general understanding of costs at the radio interface level, but less clarity regarding the costs at the network level. The general understanding is that costs are unlikely to be similar to those required to migrate from 2G to 3G[7], but closer to those associated with the upgrade from 3G to HSPA. These views have been used as inputs into our business case modelling work, and cross-checked with the demand side model.

Furthermore, experience with GPRS, EDGE and W-CDMA shows that widespread availability of network infrastructure, and perhaps more importantly, handsets can come later than planned. In this respect, it is essential for operators and vendors to drive developments in order to achieve their desired commercial launch dates.

4.5 Anticipated dates for device availability suggest further investment in this area is required

The availability of handsets and other devices is critical to the success of LTE. Large screens, high quality resolution and long battery lives are amongst the specifications that will enable effective delivery and an enjoyable user experience. In this respect further co-operation between operators, application developers and handset manufacturers is essential in order for a reasonable choice of handsets to be made available in time for future commercial launch dates.

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7 In referring to 3G, we include W-CDMA and EV-DO 1x RTT, whereas EV-DO (which refers to EV-DO Rev. A) and HSPA are considered 3.5G technologies

Exhibit 4.1 below provides details of the handset specifications that will enable users to benefit fully from the services LTE can deliver. The range of innovative functions presented here demonstrates the need for significant investment in handsets and devices over the next 5–6 years, in order to enable the unique user experience that LTE promises.

	Potential consumers	*Preferred handset functions*
Music	Music fans, amateur and professional performers	• large storage capacity • high sound quality • long playing hours • manageability of tracks across multiple music-playing devices • adaptability to multiple playback environments (e.g. car, home and plane)
P2P messaging	Heavy users, such as self-employed professionals needing a combined work and private handset and those relying heavily on emails for daily communications with families and friends	• QWERTY keypad layout • effective text-input methods
Gaming	Gamers	• multiple dedicated gaming keys • 3D graphics and high screen refresh rate • multi-player connectivity
TV	Commuters, sports and soap fans	• large screen • high resolution
Videotelephony (part of rich voice)	Business users, remote workers	• high sound quality • high resolution
Mobile data networking	Business users, field workers, mobile sales force	• pre-loaded enterprise applications • effective data input methods

Exhibit 4.1: *Major market segments for specialist handsets worldwide [Source: Analysys Research 2007]*

Respondents to the survey carried out as part of this report broadly recognised the need for investment in the area of handsets, and to an extent this had a bearing on when they felt LTE services would be launched on a commercial basis.

4.6 Strong growth in the number of mobile users is expected

The broad picture in terms of subscriber growth is positive. The total number of global mobile subscribers is expected to grow with a CAGR of nearly 6%, as markets with low mobile penetration continue to see high numbers of net additions to pre-3G services.

4.6.1 The total number of mobile subscribers could reach nearly five billion by 2015

Exhibit 4.2 shows the forecast growth in global mobile subscribers between 2008 and 2015.

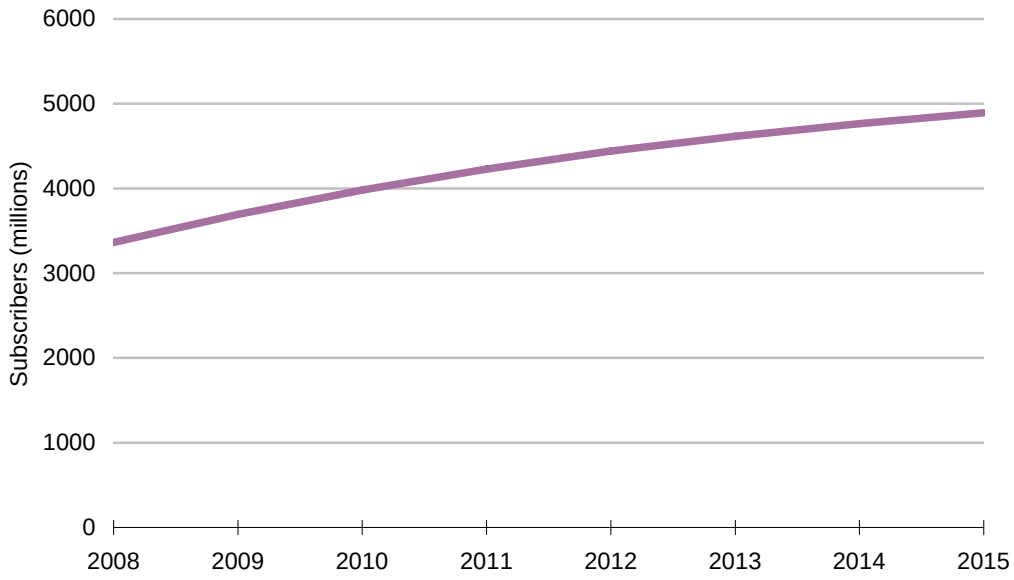

Exhibit 4.2: *Forecast global mobile subscribers, 2008–15 [Source: Analysys Research, 2007]*

Over the period 2008–15, the number of mobile subscribers worldwide could increase by up to 1.5 billion. The major driver of overall uptake will be market growth in regions with comparatively low mobile penetration, such as the Rest of Asia region.

4.6.2 LTE is likely to gain a strong foothold in the market by 2013

Exhibit 4.3 shows the forecast split of subscribers by technology between 2008 and 2015.

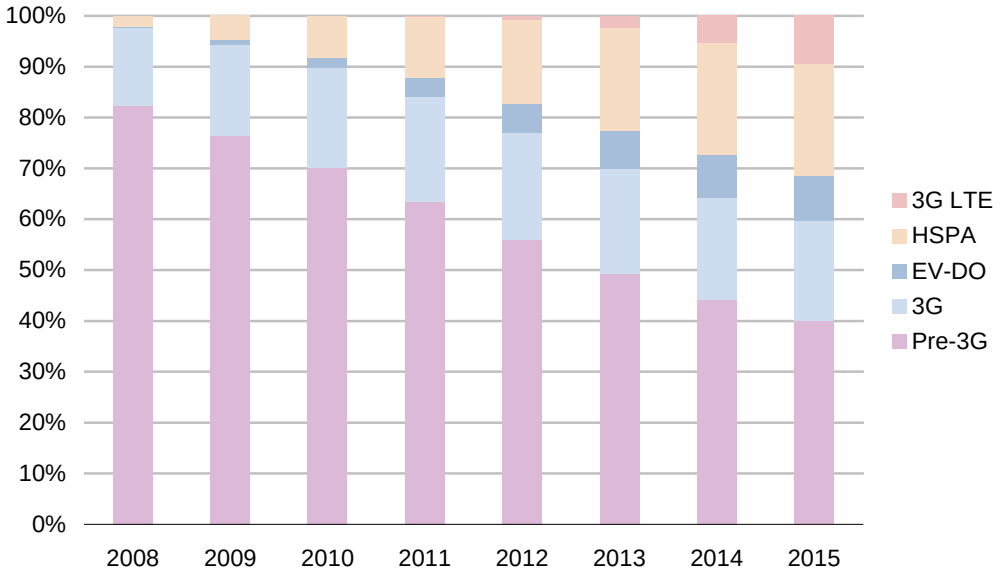

Exhibit 4.3: *Forecast share of global mobile subscribers by technology, 2008–2015 [Source: Analysys Research, 2007]*

LTE is expected to account for around 9% of all mobile subscribers by 2015. Another key trend to note is the change in the proportion of the global market using pre-3G technology – a major shift from around 80% of users in 2008 to approximately 40% in 2015. The migration to faster mobile services will continue, with 60% of the global market using 3G, EV-DO[8], HSPA or LTE devices services by 2015.

[8] It should be noted that EV-DO forecasts include Rev A, B and C. EV-DO Rev C capabilities are expected to be similar to those of LTE

4.7 The number of LTE subscribers could exceed 400 million by 2015

Focusing now on the total number of LTE subscribers, we expect to see rapid growth from launch dates around 2010 depending on the growth of HSPA and the fast take up of multimedia services..

4.7.1 The growth in LTE subscribers will be strong

Exhibit 4.4 shows the forecast growth in LTE subscribers between 2010 and 2015.

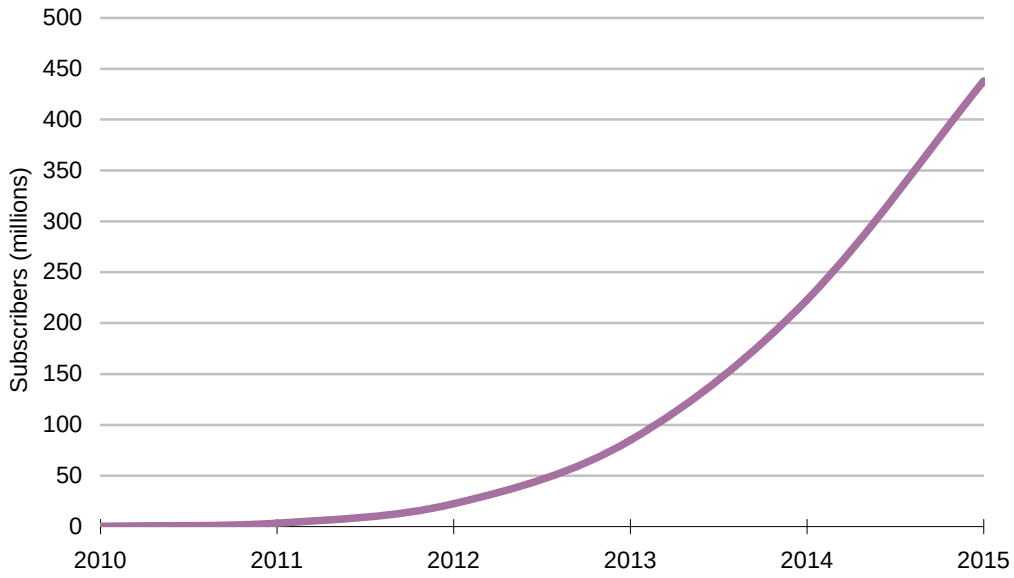

Exhibit 4.4: *Forecast LTE subscribers, 2010–15 [Source: Analysys Research, 2007]*

Commercial launches of LTE are not expected to begin until around 2010, with the number of LTE subscribers forecast to reach just over almost 450 million by 2015.

4.7.2 The proportion of LTE subscribers in developing markets will grow quickly

Exhibit 4.5 shows the forecast split of LTE subscribers by region between 2011 and 2015.

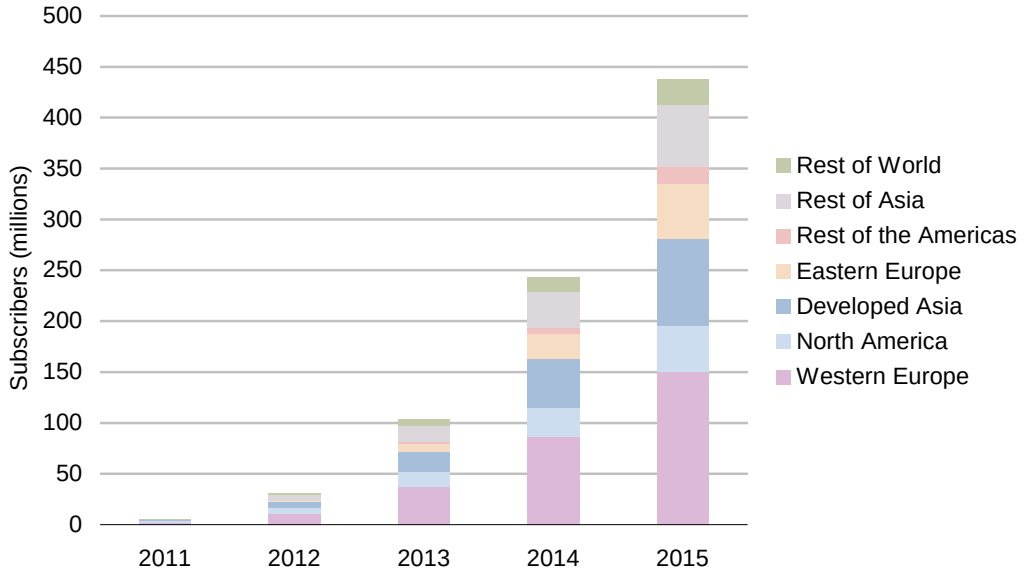

Exhibit 4.5: *Forecast LTE subscribers by region, 2011–15 [Source: Analysys Research, 2007]*

Although the developed regions will account for at least half of all LTE subscribers, due to high mobile penetration and investment in high-speed mobile networks, growth will be strong in developing regions (Rest of World, Rest of Asia, Rest of Americas and Eastern Europe).

The LTE subscriber base reaches 437 million, with Western Europe contributing 150 million of those by 2015 (34% of the total global LTE subscriber base). Overall though, the proportion of LTE subscribers from developing regions will rise from 23% in 2011 to 36% by 2015.

4.8 Global mobile revenues are forecast to reach almost EUR1 trillion

Total mobile revenue growth is expected to be positive, driven by the strong increases in subscriber numbers mentioned previously.

As a macro economic cross check it is worth noting that mobile revenues as a percentage of GDP in 2011 (the latest year that reliable GDP forecasts are available), reach 1.5% in Western Europe 1.6% in Developed Asia, 1.2% in North America and 0.7% in the Rest of Asia. These percentages are consistent with current ratios of mobile revenues as a percentage of GDP in these regions.

4.8.1 Growth in mobile revenues will be sustained through the period to 2015

Exhibit 4.6 shows the forecast growth in global mobile revenues between 2008 and 2015.

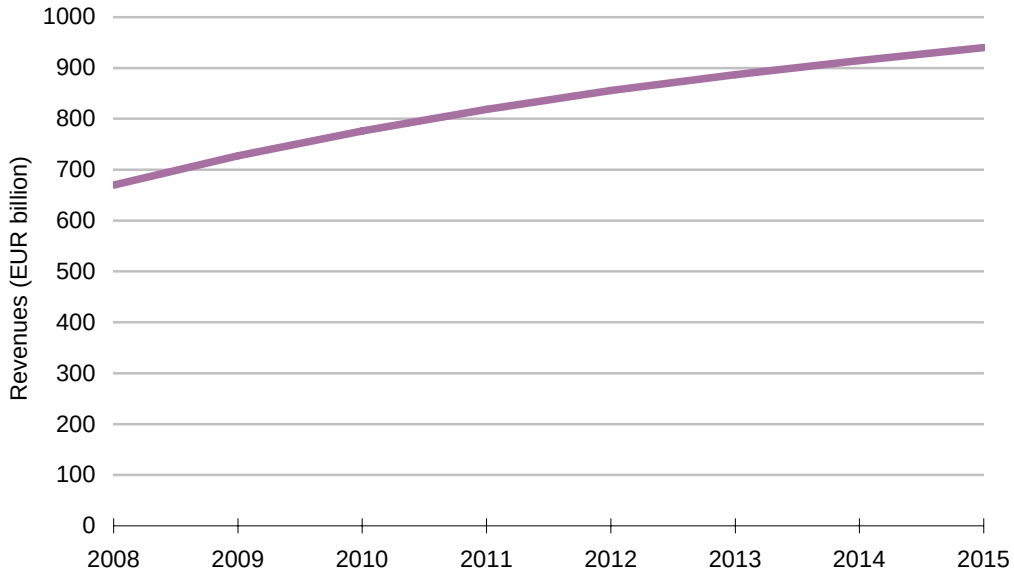

Exhibit 4.6: *Forecast global mobile revenues, 2008–15 [Source: Analysys Research, 2007]*

This is a positive outlook for the industry in general, with further detail on the contribution by region and technology provided below.

4.8.2 Mobile revenues from developing regions will continue to grow as a proportion of global mobile revenues

Exhibit 4.7 shows the forecast growth of mobile revenues for the period 2008 to 2015

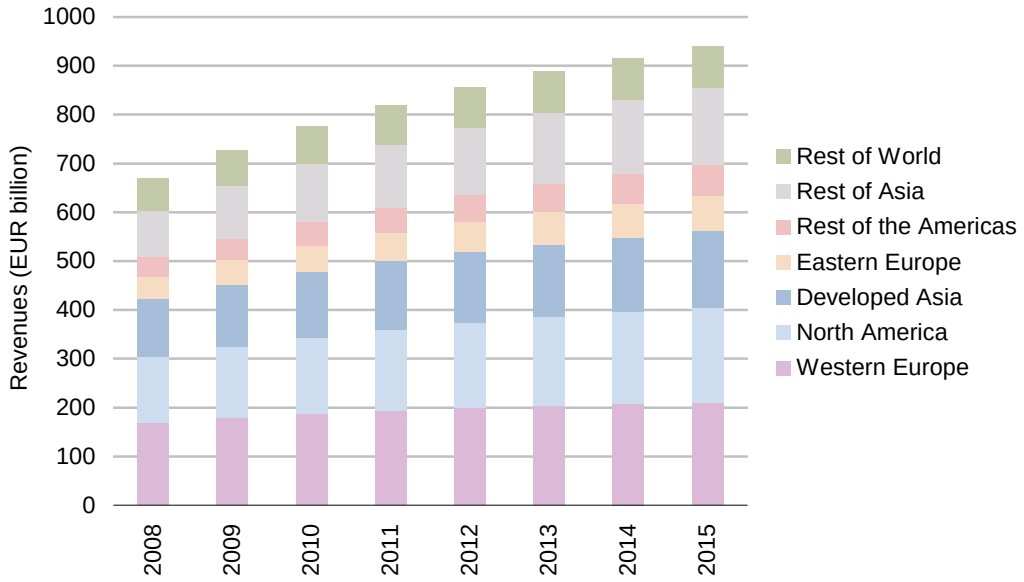

Exhibit 4.7: *Forecast global mobile revenue by region, 2008–15 [Source: Analysys Research, 2007]*

Strong growth in mobile revenues is a feature of all regions, but it will be fastest in Eastern Europe, the Rest of the Americas and the Rest of Asia. By 2015, each of these regions, will see their share of the global mobile market increase at the expense of developed regions.

4.8.3 LTE could have a strong foothold in the mobile market by 2015

Exhibit 4.8 shows the forecast revenue share split only by 3GPP and 3GPP2 cellular technologies between 2008 and 2015 .

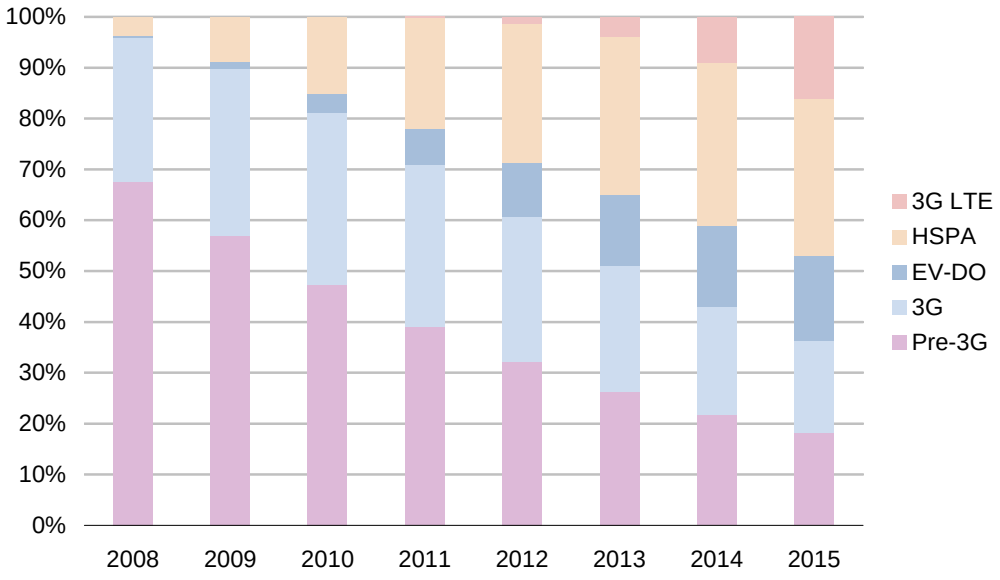

Exhibit 4.8: *Forecast revenue share by technology, 2008–15 [Source: Analysys Research, 2007]*

LTE revenues will account for around 16% of total mobile revenues by 2015 on the back of strong growth following the commercial launch of services. This is interesting when considering that LTE will comprise around 9% of the global total in terms of subscribers in the same year. This points to the higher than average spending expected of LTE users.

4.9 LTE revenues could exceed EUR150 billion globally by 2015

Due to higher average spending by LTE subscribers, their contribution to overall mobile revenues will be even more significant in comparison to users of other technologies. As will be discussed later in this chapter, their greater propensity to consume higher-value services, will result in significant revenues for operators.

4.9.1 LTE revenues will grow quickly following commercial launch

Exhibit 4.9 shows the forecast growth in LTE revenues between 2010 and 2015

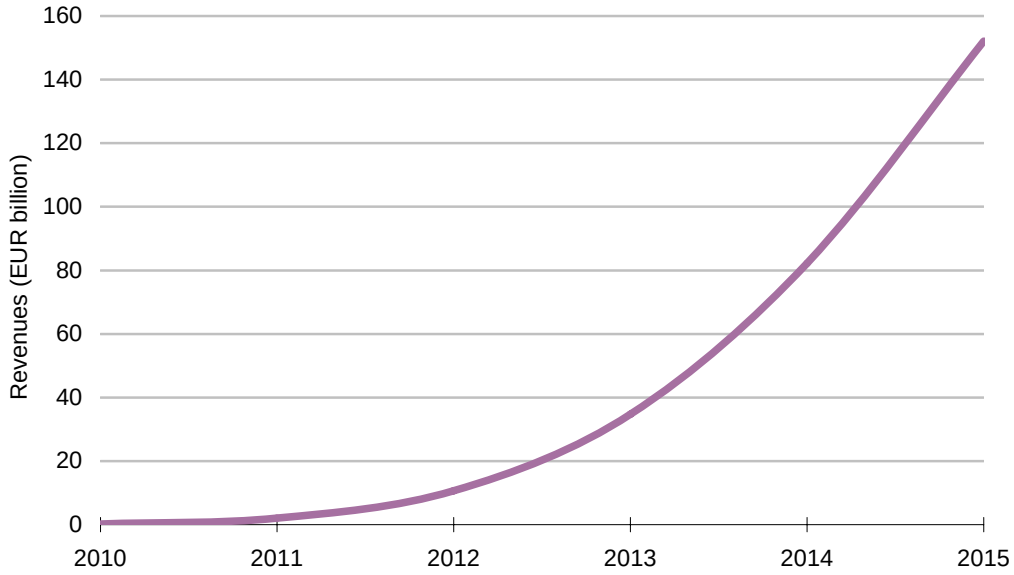

Exhibit 4.9: *Forecast LTE revenues, 2010–15 [Source: Analysys Research, 2007]*

Growth in LTE revenues is expected to be rapid as existing mobile users migrate from other mobile technologies, such as HSPA. There is also the potential for LTE deployments in those markets where fixed line penetration is comparatively low, with operators using the technology to support the distribution of broadband services to PC and mobile users.

4.9.2 Developed markets will contribute most to LTE revenues

Exhibit 4.10 shows the forecast revenue share split by technology between 2010 and 2015

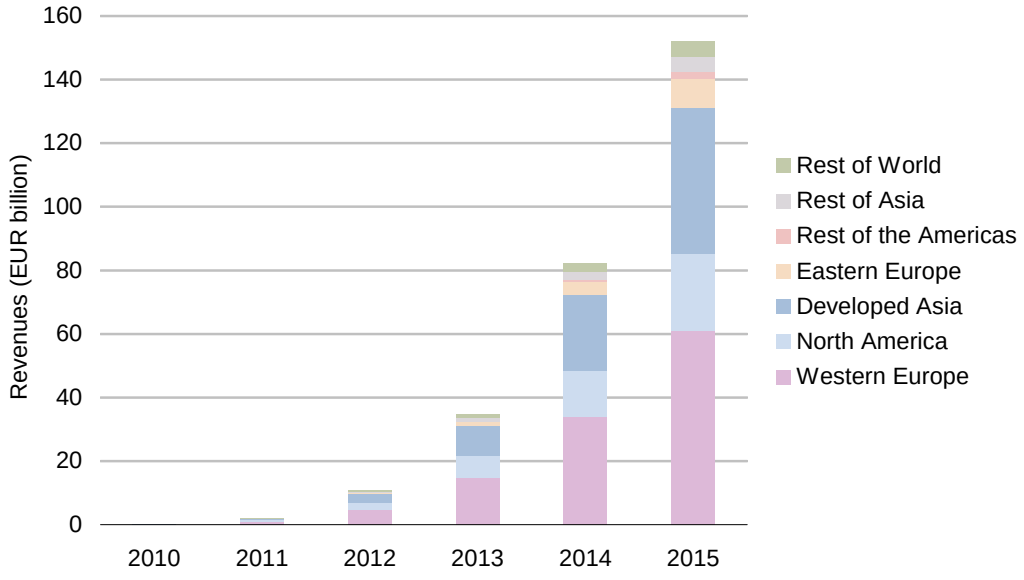

Exhibit 4.10: *Forecast LTE revenue by region, 2010–15 [Source: Analysys Research, 2007]*

Developed markets will contribute most to LTE revenues but developing regions will become increasingly important. Although the proportion of LTE revenues stemming from developing regions in 2011 will be negligible, by 2015, 14% of the total will come from these regions, representing almost EUR21 billion.

4.10 Revenues from bandwidth-hungry non-voice services are expected to increase rapidly with LTE

Enabled by the super fast downlink/uplink speeds and low cost per MB distribution costs, non-voice services such as mobile TV, games, browsing and data networking will become the main contributors to operators' data revenues.

In total, it is expected that LTE non-voice services will provide revenues of over EUR50 billion globally by 2015. This is more interesting when the contribution of LTE subscribers to non-voice revenues to the mobile market in general. By 2015, 9% of mobile subscribers are expected to be using LTE, but they will generate 18% of all non-voice revenues.

4.10.1 Non-voice services will account for a significant proportion of LTE revenues by 2015

Exhibit 4.11 illustrates the contribution to LTE revenues made by voice and non-voice services.

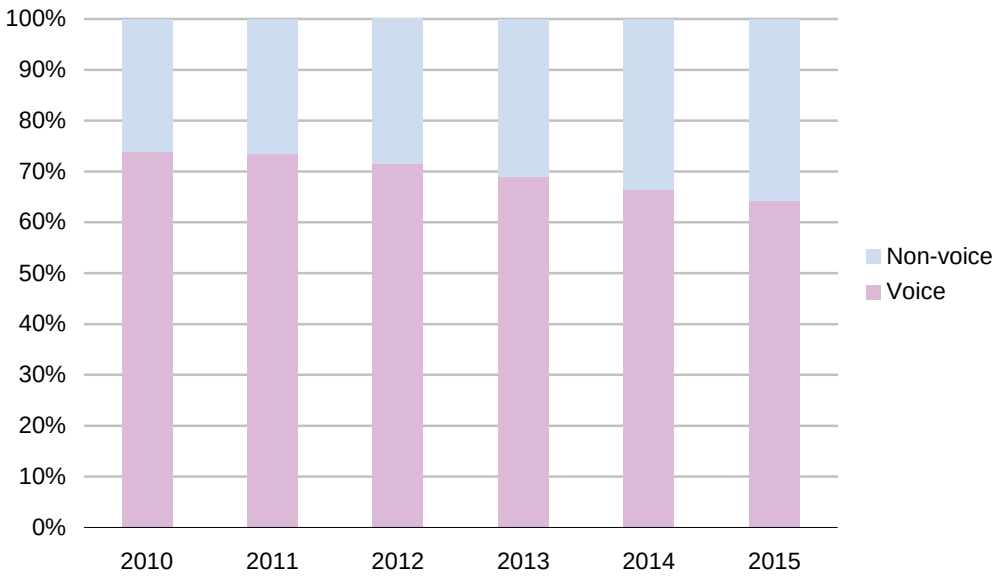

Exhibit 4.11: *Percentage of global LTE revenues accounted for by voice and non-voice services [Source: Analysys Research, 2007]*

LTE could help increase the non-voice contribution to overall revenues considerably. Following commercial launch of services, the overall proportion of global LTE revenues accounted for by non-voice services will rise from 26% to 36% by 2015.

4.10.2 Gaming, television and music services will drive growth in non-voice services

Exhibit 4.12 shows forecast non-voice revenues by service for LTE

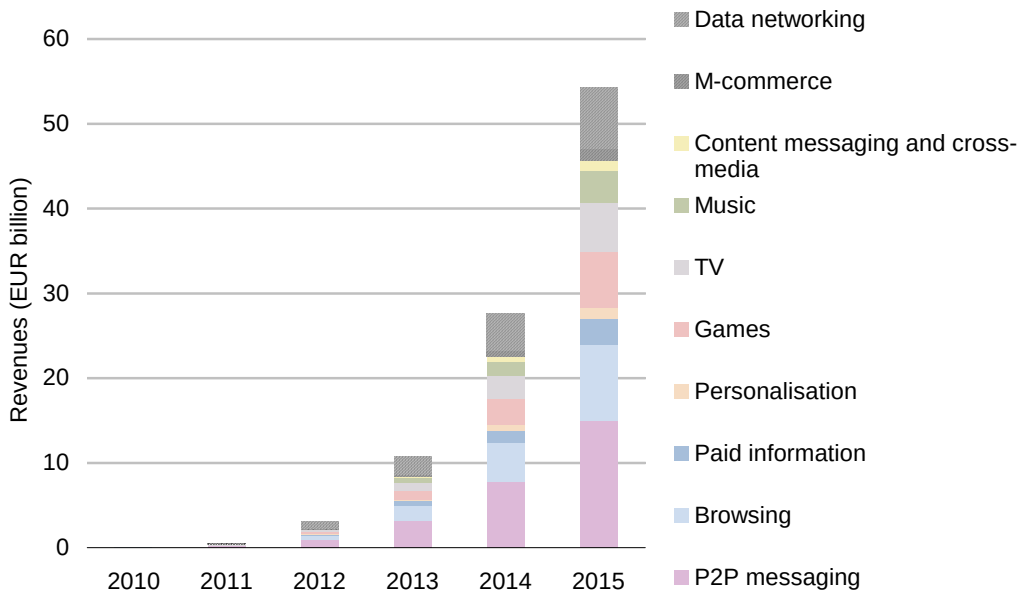

Exhibit 4.12: *Global non-voice LTE revenues by service, forecast 2010–15 [Source: Analysys Research, 2007]*

Initially dominated by the more traditional messaging and data networking categories, gaming, television and music will become more important, contributing nearly a third of LTE non-voice revenues by 2015. There will also be strong growth in paid information services and m-commerce.

4.10.3 LTE should provide an ARPU uplift on HSPA

LTE is expected to provide higher ARPU figures than HSPA. Taken as an average of all mobile subscribers in 2015, LTE ARPU could reach EUR27.3 per month compared to EUR22.5 per month for HSPA. This will be due to the expected higher spend on services, especially those which are more effectively delivered by LTE as has been discussed previously

The business case analysis that will be presented in the following chapter is not based on all of this LTE revenue per user being required to generate a sufficient return on investment for operators, but is based solely on the LTE revenues per user which are in addition to those generated by HSPA. According to the ARPU figures mentioned above, this will be almost EUR5 per user per month by 2015. This data makes a convincing case for LTE

The forecasts provided in this chapter have demonstrated the viability of LTE from a demand-side perspective. We expected there to be an established market of LTE users and LTE-based subscribers by 2015. As the analysis shows, the developed markets will account for the majority of demand for LTE services, but developing markets will become increasingly important, not just because of growing spending power in those regions, but also due to the potential for LTE deployments as an alternative to fixed infrastructure rollout. Overall though, the key to the future success of LTE lies with operators, who will need to invest heavily in marketing the services that can be most effectively delivered via the technology.

The following chapter takes the incremental growth in LTE from the demand side model on to the next stage, and uses it as the basis for assessing the business case for investment in the technology. This will provide the balanced view operators, vendors and investors require to put the potential demand for LTE into a practical context.

5 The business case for LTE

The deployment of LTE is obviously subject to its financial viability from the perspective of mobile operators. In this section of the report, we explore the nature of the business case for LTE, through high-level financial modelling of the potential business case for operators. We present details of our approach in Section 5.1 and details of the results of our assessment in Section 5.2.

5.1 Our business modelling encompasses a range of alternative deployment options

5.1.1 Our overall approach encompasses the modelling of incremental revenues and costs arising from LTE from an individual operator's perspective

The underlying approach to the assessment of the business case for LTE is to develop a high-level financial model of LTE from the perspective of an individual mobile operator. As shown in Exhibit 5.1, we consider what incremental revenues would arise from 3G LTE, the additional costs associated with the deployment and operation of LTE (both capital expenditure and operating costs) and then assess the free cashflow that would be generated and hence the net present value (NPV) of LTE to an individual operator. As shown in the exhibit, we model solely the *incremental* revenues and costs associated with LTE in order to determine the NPV to the operator. Due to the potential variation across markets, the cost of acquiring spectrum licences is not accounted for in this analysis.

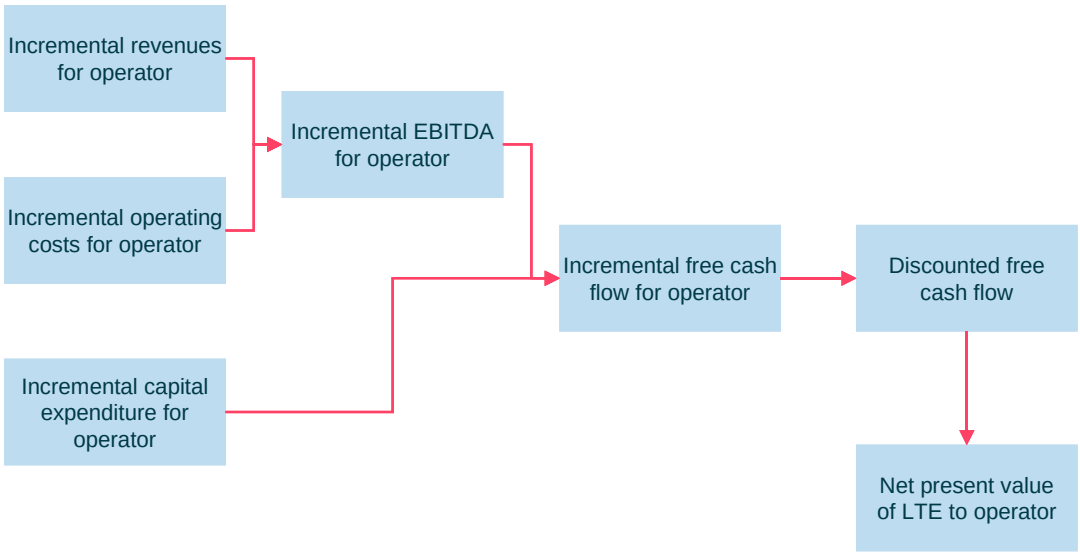

Exhibit 5.1: *Overview of approach to modelling business case for LTE [Source: Analysys, 2007]*

5.1.2 Our demand forecasts form the basis of the revenue side of the model

We have used the demand forecasts presented in Chapter 4 as the basis of our modelling of revenues in the business case for 3G LTE. The regional revenue forecasts presented in Section 5.2 have been scaled down to reflect the *incremental* revenues an individual operator may secure.

It should be noted that as there are two alternative demand forecasts contained in Appendix A, the related business case analysis for those alternative scenarios has also been carried out and is presented in Appendix B. These alternative scenarios will provide further context to the analysis presented in this chapter.

5.1.3 We have modelled the deployment of LTE in three different markets

Our business case modelling has been undertaken for three alternative markets in order to identify if the underlying feasibility of the business case varies between these markets:

- developed market in Western Europe
- developed market in North America
- developing market in Eastern Europe.

5.1.4 We have modelled four alternative options for LTE deployment

Our business case modelling also encompasses four alternative network deployment options for LTE:

- **Hotspot coverage** – under this option, the deployment of LTE is limited to major urban hotspots, analogous to current WiFi hotspot deployments, although the area covered by LTE is much greater than the localised low power coverage of WiFi hotspots

- **Urban coverage** – under this option, LTE is deployed in urban centres and the surrounding suburbs – reaching total population coverage of the order of 70%

- **National coverage** – under this option, LTE is deployed to provide the same coverage as existing 2G and 3G mobile networks

- **Home base stations** – here LTE is assumed to be deployed in individual subscriber's homes, communicating with core network infrastructure either through the subscriber's home broadband connection or through other LTE home base stations through a mesh network

The general opinion of the operators and vendors spoken to for the purposes of this report was that the urban roll-out model was the most likely model for LTE deployment. This seems logical when full commercial launches of LTE are still some years away (beginning in 2010, as mentioned in the previous chapter), in that operators will focus on the most populous areas initially. Hotspot coverage was also considered a viable roll-out option, with deployment focusing on major urban areas, whilst most respondents did not expect many operators to purse national coverage as a roll-out strategy. However, as will be demonstrated below, the optimal roll out strategy, in terms of NPV, is likely to be somewhere between urban and national coverage. The business case for home base station

deployment is based on the retail price required to generate a NPV value of 0 for each of the relevant operator types.

Our business case models assume that existing mobile operators deploy LTE utilising their existing infrastructure (e.g. existing 2G and 3G cell sites, radio frequencies). We have not modelled the costs associated with deploying new base station sites specifically for LTE or purchasing new radio frequencies. We assume that operators will optimise their use of available mobile spectrum (e.g. 900MHz spectrum for rural deployment, higher frequencies for urban deployment).

The view of the operators and vendors spoken to for this report was that the most likely frequency bands that operators will use to deploy LTE services will be 900MHz, 1800MHz or 1.9–2.0GHz as well as 2.5-2.7MHz and the new US bands 700MHz, AWS (1.7-2.1GHz). A small number mentioned 3.5GHz as likely to be used. In terms of the channel bandwidths over which LTE will be distributed, most operators and vendors spoken to expected 10MHz to be most commonly used.

Opinions about the cost of moving from a 3G network to an LTE network were divided, with around just under half of those asked expecting the cost to be comparable to the migration from 2G to 3G, whilst the remainder expecting costs to be closer to those involved in moving from a 3G network to an HSPA network.

5.1.5 Summary of key assumptions

In this section, we present a summary of the key assumptions underlying the business case models.

The business case model uses relevant subscriber and revenue data presented in the previous chapter. Specifically, the growth in LTE subscribers and revenues has been fed into the business case analysis in order to calculate the profits and costs associated with the roll-out of LTE services.

Exhibit 5.2 presents the numbers of base stations we have assumed will be deployed under three of the deployment options. For the home base station option, we assume a ratio of

one home base station to two subscribers to reflect deployment in households rather than per individual subscriber.

Deployment option	*Western European developed market*	*North American developed market*	*East European developing market*
Hotspot coverage	500	1500	100
Urban coverage	4750	12 000	1200
National coverage	10 000	40 000	2000

Exhibit 5.2: *Assumed number of LTE base stations deployed [Source: Analysys, 2007]*

We have assumed the following geographic coverage per LTE base station

Deployment option	*Western European developed market (km²)*	*North American developed market (km²)*	*East European developing market (km²)*
Hotspot coverage	0.6	1.3	0.9
Urban coverage	1.9	10.4	2.6
National coverage (suburban)	5.1	65.0	5.9
National coverage (rural)	34.3	137.3	34.3

Exhibit 5.3: *Assumed geographic coverage of LTE base stations [Source: Analysys, 2007]*

Our projected incremental capital expenditure costs are shown in Exhibit 5.4.

Item	*Details*
LTE equipment and deployment costs	We have assumed that LTE equipment will cost on average EUR55 000 per base station site (2008) falling by 7% per annum, broadly in line with GSM and UMTS equipment price trends. We have also assumed a labour-related deployment cost of EUR10 000 (Western European developed market), EUR12 000 (North American developed market) and EUR7 000 (East European developing market) per base station site (2008), which is projected to increase in line with inflation. For the home base station deployment option, we have calculated the price to which home base stations would need to fall to in order to present a viable business case to operators. In our calculations, we assume that home base station equipment needs to be replaced by subscribers every 3 years.
Backhaul upgrade costs	Our assumption is that operators will incur a cost of EUR2 000 to upgrade the existing backhaul (microwave link) on each base station site.

Exhibit 5.4: *Assumed capital expenditure [Source: Analysys, 2007]*

The assumed incremental operating expenses associated with the deployment of LTE are summarised in Exhibit 5.5.

Item	*Details*
Content costs	Several of the services generating incremental LTE revenues include the provision of content to users. We have made an allowance of 20% of total LTE incremental revenues to account for content purchase/royalty payments.
Equipment maintenance/site costs	The deployment of LTE equipment could result in increased maintenance and site costs for the operator. We have estimated these to amount to EUR1 200 per base station site (2008), increasing in line with inflation. For the home base stations deployment option, extra maintenance and additional customer support costs are assumed at an equivalent of 10% of total LTE incremental revenues.
LTE handset subsidies	Early LTE handsets may require subsidies above 'normal' levels in individual markets. We have made an allowance for this of EUR200 per subscriber in 2010 rapidly falling such that it reaches 0 by 2013.

Exhibit 5.5: *Assumed operating expenses [Source: Analysys, 2007]*

Key financial assumptions are summarised in Exhibit 5.6. Please note that all financial projections are modelled in nominal terms.

Item	*Details*
Time period for NPV	We have estimated the NPV of LTE to the operator over the period 2008 to 2015. No terminal value has been included in this assessment. It could be argued that this short time period understates the value of LTE to the operator – although it may also be argued that by 2015, upgrades to 4G technology are required.
Weighted average cost of capital	We have applied a discount rate of 11% to the nominal undiscounted cashflow in the developed Western European and North American markets. In the developing East European market, we have applied a discount rate of 13%.
Taxation	We have not sought to calculate corporate taxation of any incremental profits for the business resulting from the deployment of 3G LTE. It is therefore possible that our NPV calculations may overstate the benefits of LTE to the operator.

Exhibit 5.6: *Financial assumptions [Source: Analysys, 2007]*

5.2 The results of our analysis generally show a positive case for LTE deployment

By employing the methodology described above, four possible outcomes were generated for each operator type. For the purposes of brevity, only the most viable outcomes have been selected for presentation in the following analysis.

Exhibit 5.7, Exhibit 5.8 and Exhibit 5.9 present the financials for a West European operator, North American operator and East European operator. The NPV for a West European operator is projected to be EUR1.3 billion, the NPV for a North American operator is projected to be EUR2.2 billion and the NPV for an East European operator is projected to be marginal.

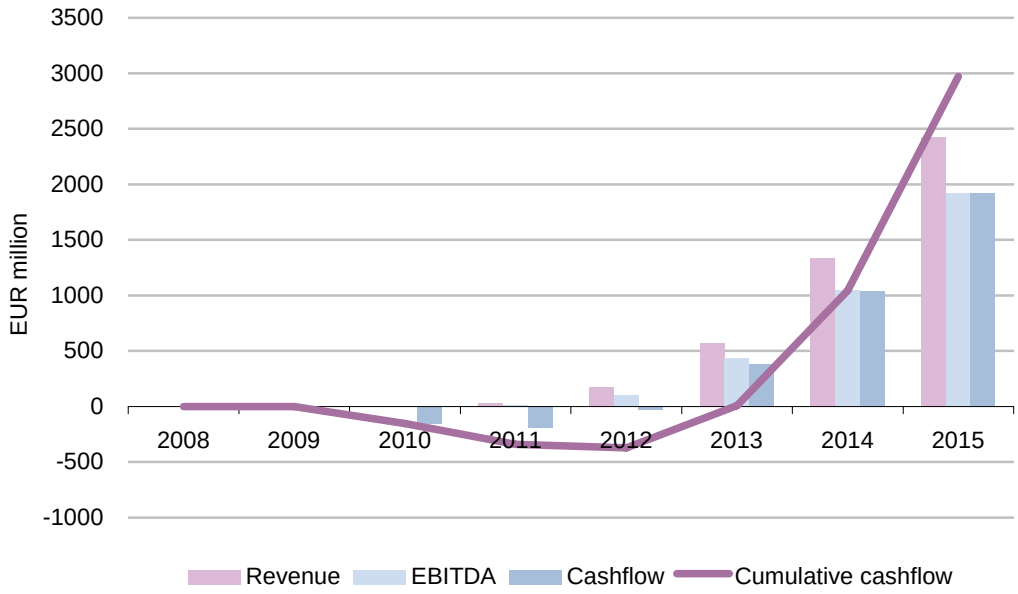

Exhibit 5.7: *Financials for West European operator, national coverage deployment [Analysys, 2007]*

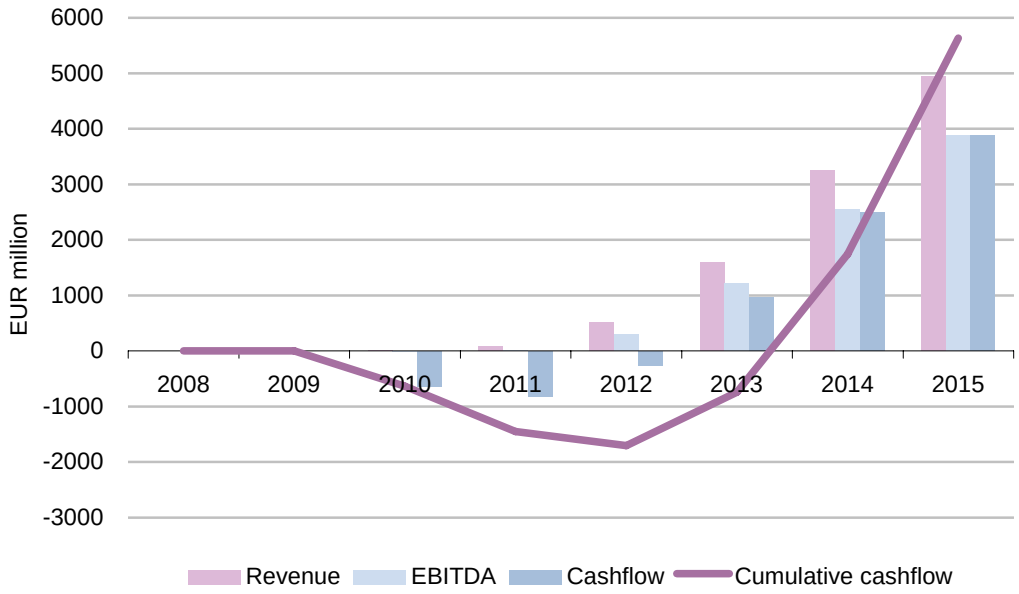

Exhibit 5.8: *Financials for North American operator, national coverage deployment [Analysys, 2007]*

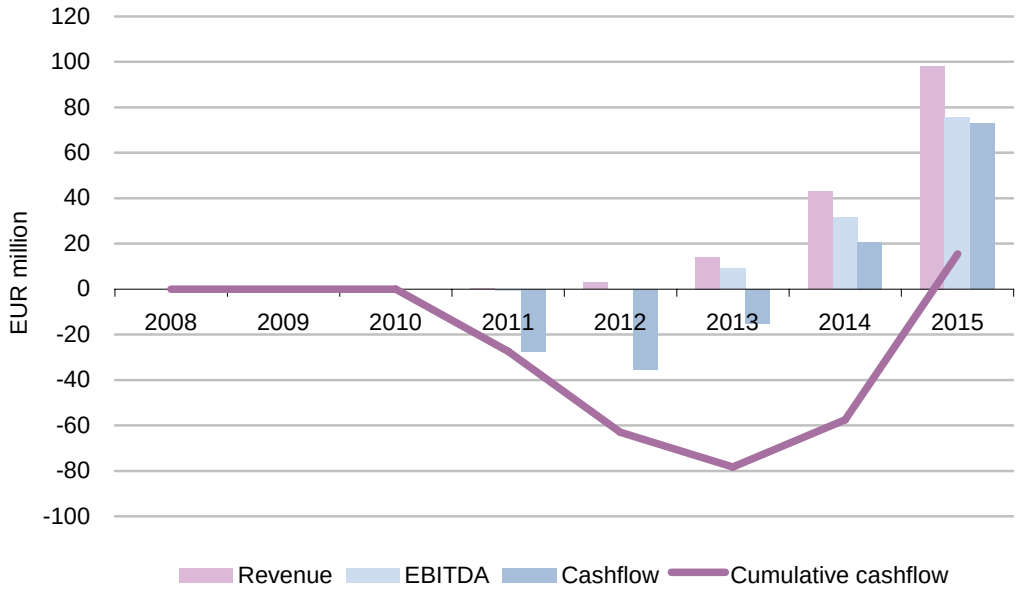

Exhibit 5.9: *Financials for East European operator, national coverage deployment [Source: Analysys, 2007]*

The estimated number LTE subscribers as a proportion of total mobile subscribers in 2015 for each operator type is as follows:

- West European operator: 8%
- North American operator: 3%
- East European operator: 5%

On the basis of these cashflow projections, we envisage that existing mobile operators will probably finance LTE deployment from the existing cashflow generated by the business.

In summary, we conclude that the business case for LTE is likely to be positive for mobile operators in developed markets. However, the case for operators in developing markets is more difficult and is discussed later in this chapter. We note that these conclusions are based on the assumptions that LTE will generate the incremental revenues as described in Section 5.2 and that deployment utilises network operators' existing base station sites and radio frequency assets.

5.2.1 The commercially optimal coverage level likely to lie somewhere between urban and national coverage

Exhibit 5.10 presents our net present value projections for the deployment of LTE by a West European operator, North American operator and East European operator respectively, under a range of alternative coverage deployment options. It can be seen that the value to the mobile operator is generally greatest either for urban coverage or national coverage for operators in developed markets. In practise, we expect that the 'commercially optimum' point of network deployment is likely to arise somewhere between full coverage of urban areas and nationwide coverage.

Regarding the East European operator, it can be seen that the business case in such a market is much more marginal, under all deployment options. This is as a consequence of the incremental revenues generated by LTE deployment being limited. Overall penetration of LTE in Eastern Europe, in terms of subscribers, will remain relatively low throughout the forecast period, reaching 19% by 2015 in comparison to 33% in Western Europe, for example.

	Hotspot	*Urban*	*National*
Western Europe	284	1198	1284
North America	637	2660	2247
Eastern Europe	7	9	-6

Exhibit 5.10: *NPV of LTE deployment by operator type (EUR millions) under alternative network deployment options [Source: Analysys, 2007]*

5.2.2 Home base station deployment in developed markets could be viable if the price is below EUR1000

Home base stations are an alternative deployment option for LTE. According to output from the survey carried out in this report, it is the least likely strategy to be pursued by operators, but may nonetheless be used in isolation. Our assessment of the scope for home base station deployment is based on the evaluation of what the price of a home base station would need to reach in order to result in an NPV of 0 to the mobile operator. The results of our assessment are summarised in Exhibit 5.11.

	Retail price including installation (EUR)[9]
West European operator	972
North American operator	1470
East European operator	392

Exhibit 5.11: *Required home base station price for deployment to be viable [Source: Analysys, 2007]*

[9] These prices do not bear relevance to current retail prices and are purely to illustrate the point at which the business case becomes viable, i.e. an NPV equal or greater than zero. Retail prices for femtocells/home base stations are likely to be between EUR50 and EUR200 upon full commercial launch

It can be seen that the price would need to be around EUR1000 in developed markets, whilst in Eastern Europe the price would need to reach around EUR400 for the business case to become viable, based on the rollout scenarios presented.

Please note that the above estimates are retail price estimates including installation. The actual cost of production of the equipment will need to fall to a lower level in order to allow for any sales and marketing costs. This is borne out by comments from operators and vendors, which suggest that BTS may not be a financially viable option for consumers until around 2011–12 when demand for related infrastructure is sufficient. Indeed, as mentioned towards the start of this report, the industry is aware of the need for a lower retail price in order to encourage demand for home BTS, and has made steps to position the product at a more affordable level.

5.2.3 The business case for a new market entrant may be more challenging

Our business case modelling has been undertaken on the basis of the deployment of LTE by an existing GSM/W-CDMA mobile operator in each of the three markets. Other organisations may also be interested in deploying LTE, for example new entrants (e.g. fixed telecoms operator without an existing mobile network). Our expectation is that the business case for such a new entrant is likely to be much more challenging since it will be more difficult for the operator to generate revenues, particularly in early years as subscribers will need to be acquired. Network deployment costs will be significantly above those that we have modelled (e.g. development of new base station sites) and the operator will suffer from poor economies of scale (e.g. in relation to advertising/marketing, customer care etc). However, the business case may be altered should some form of government subsidy be available, for instance if the deployment is considered to be of public benefit.

5.2.4 Recent experience suggests that operators will need to make a strong case for LTE to investors

According to comments gained from the survey conducted in relation to this report, some doubts exist regarding how to finance the migration to LTE. The money invested in 3G

licence acquisition and roll-out has not yet been justified based on revenue and subscriber growth, so operators are likely to face some concerns from investors about LTE potential for the same reason. Although LTE deployment will require significant capex investment in the short term, a strong case can be made for the opex benefits. However, with greater market stability and further consolidation in the mobile sector, it is expected that a reasonable number of operators may well be able to fund the necessary investment largely by themselves.

6 Conclusions and recommendations

6.1 Conclusions

- **LTE will provide significant efficiencies over existing 3G technologies**. Mobile providers have expanded their portfolios to include a diverse range of mobile service elements in order to drive both usage and revenue growth. Due to the bandwidth-hungry nature of such services, widespread distribution to consumers is dependent on an effective delivery infrastructure, for which LTE offers the most efficient progression path (at maximum use of the network) with a cost per MB of EUR0.01 for LTE compared to EUR0.03 for HSPA and EUR0.06 for W-CDMA.

- **Availability of handsets will drive the service uptake**. Large screens, high-quality resolution and long battery lives are amongst the specifications that will enable effective delivery and an enjoyable user experience, especially for the services that LTE will enable more effective distribution. Comments from industry representatives spoken to for the report confirm that there is a need to invest in handset innovation in order to meet commercial launch dates starting in 2010.

- **LTE could begin in 2010.** General industry opinion is that full-scale commercial launches of LTE will not begin before 2010.

- **Western Europe and Developed Asia are likely to account for the majority of LTE subscribers.** These combined regions will account for between 50–60% of subscribers and between 70–80 % of revenues. The contribution from developing markets will continue to increase throughout the period though.

- **Our business model projections for LTE suggest there is a strong case for deployment in developed markets.** The modelling indicates that break-even for operators could occur 3–4 years following deployment with net present value to the operator from 2008–15 being in the order of EUR1–3 billion. These projections assume that deployment utilises an operator's existing base stations sites and radio spectrum assets. The case for operators in developing markets is more marginal and is dependent on the competitive environment.

- **The 'commercially optimum' point of network deployment is likely to arise somewhere between full coverage of urban areas and nationwide coverage.** This expectation differs slightly from comments from industry contacts who expected the most viable roll-out model to be based on urban coverage.

6.2 Recommendations

- **Vendors need to offer a cost-effective evolution from existing network infrastructure.** Compared to complementary technologies such as WiMAX and DVB-H, DVB-SH, MediaFlo, a potentially significant advantage of LTE is its cost-effective evolution from (and integration with) existing 3G infrastructure. Vendors need to convince operators that LTE will minimise investment requirements, enabling them to re-use existing network assets. They also need to demonstrate that despite high initial capex the low opex of LTE compared to HSPA and W-CDMA could see operator investments breakeven within three to four years

- **Investment needs to be made in raising awareness of LTE and its capabilities, with strong marketing and business cases.** Widespread deployment of LTE will be critical to generating revenue for cellular infrastructure vendors. Given the current under-utilisation of 3G networks, additional capital investment on 3G may be far from the minds of mobile operators. Vendors of cellular infrastructure must attempt to drive the market for their LTE products by using marketing to raise awareness and by developing strong business cases for the deployment of LTE, including forecasts of investment costs

- **Vendors and operators alike must be proactive in driving 3GPP standardisation**. While LTE potentially provides an important step change in capabilities, mobile operators need to ensure that the standard comes to fruition quickly. Mobile operators need to introduce clear commercial requirements into the 3GPP standard-setting process and maintain momentum to ensure timescales are achieved so that commercial deployment is achievable by 2010.

- **Vendors need to model the limitations of 3G and pre-3G networks in order to understand when and where LTE may be needed.** This report has demonstrated the benefits of LTE based on a number of business cases. These results need to be interpreted, taking into account specific network topology and number of customers. It is then possible to determine when LTE would be required.

- **Mobile operators wanting to make the most of LTE need to lobby regulators for early access to spectrum at reasonable prices**. 20MHz allocations will be essential to achieving the highest throughputs with 3G LTE. Mobile operators need to lobby for early availability of spectrum (such as the 3G extension band) and present a convincing case that LTE will be as spectrally efficient as other technologies, to increase the probability of securing spectrum assignment.

Annex A: Alternative demand scenarios

The market conditions that form the basis of the scenarios presented in this report were based on a consultative process. Initially, we assessed, with Forum members, the key market drivers that would have a bearing on the success of LTE in terms of impact and uncertainty. These factors ranged from demographic trends, through to the level of fixed mobile substitution that would occur in forthcoming years. The outputs from this discussion are summarised in Exhibit A.1 below.

Driver	*Impact*	*Uncertainty*
Device evolution – e.g. usability, functionality, capacity and battery life	✸✸	✸✸✸
Level of **fixed –mobile substitution**	✸✸✸✸✸	✸✸✸✸
Supply side change – e.g. consolidation and entry of new players	✸✸	✸✸
Availability of spectrum for LTE services	✸✸✸✸✸	✸✸
Level of **demand for non-voice services** requiring higher performance networks	✸✸✸✸✸	✸✸✸✸✸
Evolution of an **LTE ecosystem**	✸✸✸✸✸	✸✸
Impact of **alternative wireless standards** (e.g. WiMAX and proprietary BB FWA)	✸✸✸✸	✸✸✸✸
Actual **LTE network performance**	✸✸✸✸	✸✸✸
LTE standards convergence of UMTS and CDMA2000 evolution	✸✸✸	✸✸✸✸
Global **macroeconomic environment**	✸✸	✸✸
Demographic trends	✸✸✸	✸
Investor **willingness to finance new network rollout**	✸✸✸✸	✸✸✸
Timing for LTE network and device availability	✸✸✸✸	✸✸✸

Exhibit A.1: *Summary of impact versus uncertainty for market drivers of LTE success [Source: Analysys Research, 2007]*

These drivers were then mapped against two axes, which allowed us to identify the key market conditions that would form the basis of the alternative market scenarios, as illustrated in Exhibit A.2 below.

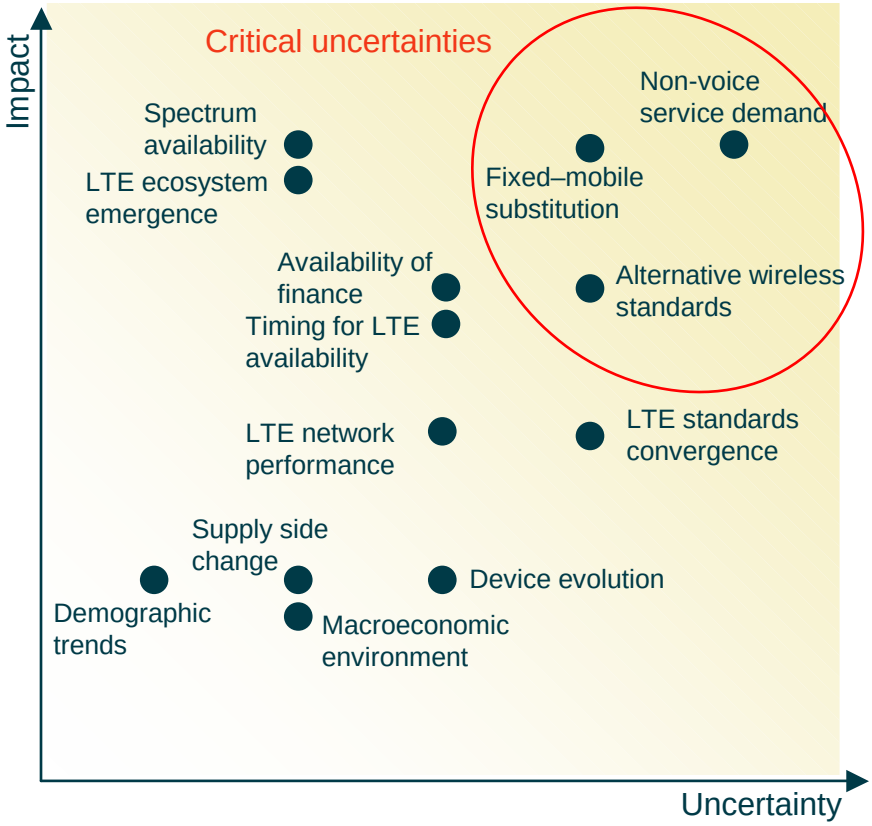

Exhibit A.2: *Impact versus uncertainty for critical drivers [Source: Analysys Research, 2007]*

The key market drivers that were identified as having the greatest impact on the potential for LTE, and about which there was the greatest uncertainty, were non-voice service demand, fixed mobile substitution and the availability of alternative wireless standards. The three alternative scenarios presented in this report are based on variations in these drivers, i.e. low, medium and high degrees of fixed mobile substitution, and likewise for the other drivers. Such variations in market conditions would clearly have an effect on demand for services, and are therefore reflected in the demand side forecasts provided in this report.

The demand forecasts and business case analysis presented in Chapters 4 and 5 were based on a relatively neutral view of the future mobile market; i.e. moderate levels of fixed mobile substitution, steady growth in demand for non-voice services and more strategic

than widespread deployments of competing technologies, such as WiMAX. However, the two alternative scenarios presented in this annex account for greater potential variations in these conditions, which obviously have an effect on demand forecasts and the related business case analysis. It should be noted that in both the alternative scenarios presented, care has been taken to ensure that the levels of adoption and ARPU are realistic.

A.1 Alternative Scenario 1

- In this scenario there is a strong demand for non-voice services including mobile Internet access, gaming, mobile TV and music

- Operators aggressively pursue FMS in all markets taking advantage of consumer adoption of non-voice services and hence penetration of suitable devices

- In-building coverage is massively improved and mobiles become the default communications device

- In the face of strong demand for non-voice services the finalisation and commercial availability of LTE is accelerated

- WiMAX is currently only deployed by a minority of operators due to concerns about roll-out costs, performance and integration risks

6.2.1 In alternative scenario 1, the Rest of Asia region is likely to account for the majority of subscriber additions

Exhibit A.3 shows the forecast growth of mobile subscribers split by regions for alternative scenario 1 between 2008 and 2015.

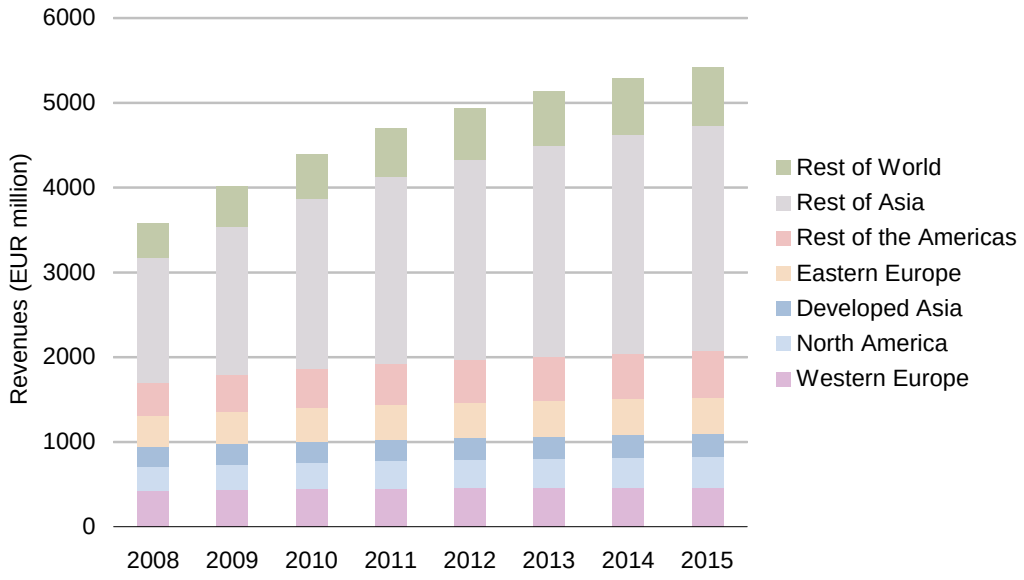

Exhibit A.3: *Forecast global mobile subscribers, alternative scenario 1, 2008–15 [Source: Analysys Research, 2007]*

Western Europe, Developed Asia and North America, which already have high mobile penetration rates, will add a combined 150 million subscribers and account for 8% of the net additions in alternative scenario 1 between 2008 and 2015. In comparison, 64% of net additions will come from the Rest of Asia region, the majority of these from the populous markets of India and China. Growth in mobile subscriptions is higher in this scenario than that presented in Chapter 4, mainly due to the aggressive FMS strategies pursued by operators.

6.2.2 LTE subscribers as a proportion of total global mobile subscribers could be over 10% by 2015 in alternative scenario 1

Exhibit A.4 shows the forecast split of subscribers by 3GPP and 3GPP2 technologies only for alternative scenario 1 between 2008 and 2015.

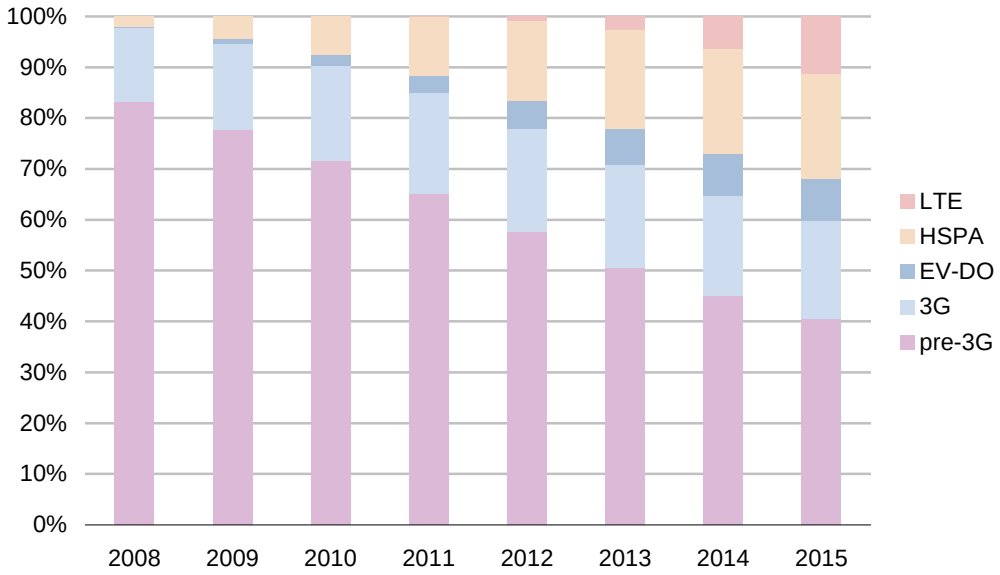

Exhibit A.4: *Forecast share of global mobile subscribers by technology in alternative scenario 1, 2008–15 [Source: Analysys Research, 2007]*

In alternative scenario 1, LTE subscribers will comprise around 11% of all subscribers by 2015. Regarding the other mobile technologies, we expect 3G services to peak in 2012 at around 20% market share across all scenarios. EV-DO and HSPA are continuing to grow in 2015, albeit at a slower rate compared to 2011–13, where the market shares for both technologies approximately doubled.

6.2.3 In alternative scenario 1, 600 million LTE subscribers are forecasted by 2015

Exhibit A.5 shows the forecast split of LTE subscribers by region for alternative scenario 1 between 2010 and 2015.

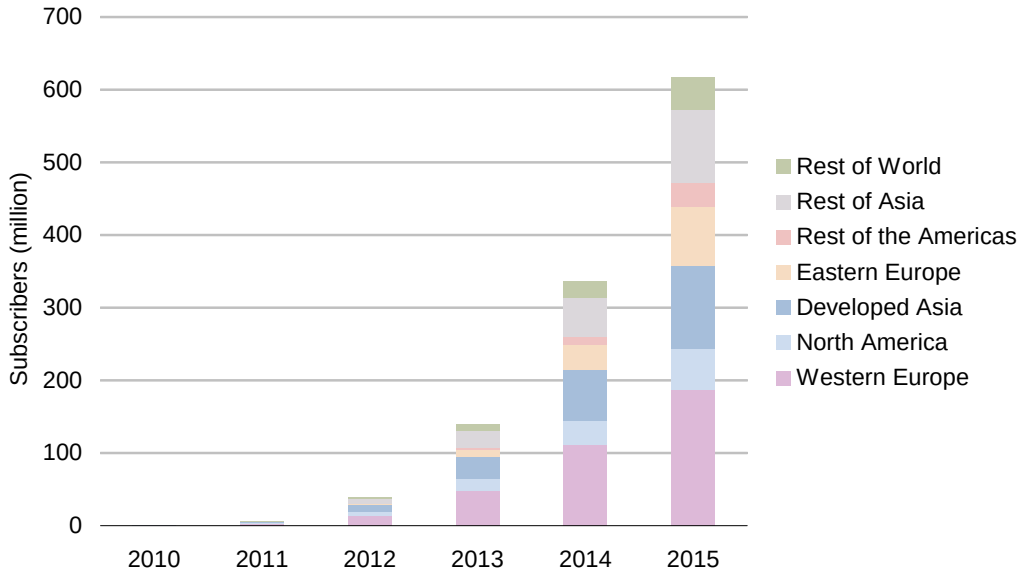

Exhibit A.5: *Forecast LTE subscribers by region for alternative scenario 1, 2010–15 [Source: Analysys Research, 2007]*

The total number of LTE subscribers could be in excess of 600 million globally in alternative scenario 1. Western Europe will provide the largest proportion of these, around 30%, with developed Asia and the Rest of Asia region also contributing significantly to that number. Growth will be rapid following the launch of services, the market more or less doubling in size each year between 2011 and 2015. In this scenario, aggressive FMS strategies and the acceptance of handsets as the 'default' communication device will drive growth.

6.2.4 In alternative scenario 1, LTE could account for over 20% of global mobile revenues

Exhibit A.6 shows the forecast revenue share split by technology for alternative scenario 1 between 2008 and 2015.

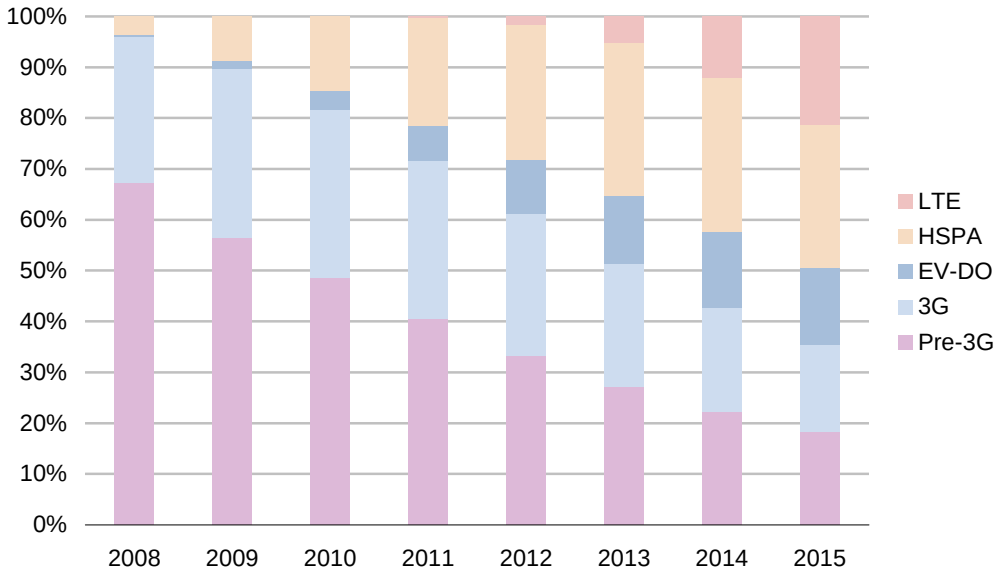

Exhibit A.6: *Forecast revenue share by technology in alternative scenario 1, 2008–15 [Source: Analysys Research, 2007]*

Based on alternative scenario 1, LTE could account for over 20% of global mobile revenues by 2015. HSPA will comprise the largest proportion at 28% as by this stage it will be well established with a large user base.

6.2.5 Western Europe and Developed Asia are likely account for the majority of LTE revenues

Exhibit A.7 shows the forecast growth in global LTE revenues for alternative scenario 1 between 2010 and 2015.

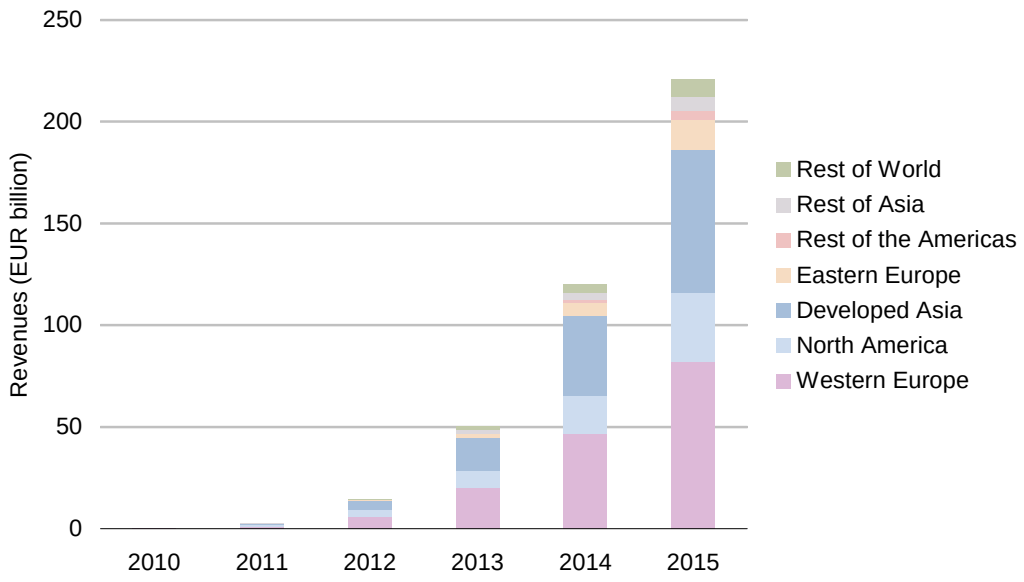

Exhibit A.7: *Forecast LTE revenue by region in alternative scenario 1, 2010-2015 [Source: Analysys Research, 2007]*

In alternative scenario 1, Western Europe's share of LTE revenues will be 37% by 2015 (or EUR82 billion). By the same year, Developed Asia will account for 32% (EUR70 billion), whilst North America around 15% (EUR34 billion). The developing markets' share will be higher than in the analysis presented in Chapter 4 (14%), at around 16%. This share is likely to continue growing at the expense of developed regions.

6.2.6 LTE non-voice revenues could grow rapidly in alternative scenario 1 with TV, games and data networking becoming key by 2015

Exhibit A.8 shows forecast non-voice revenues by service for LTE in alternative scenario 1.

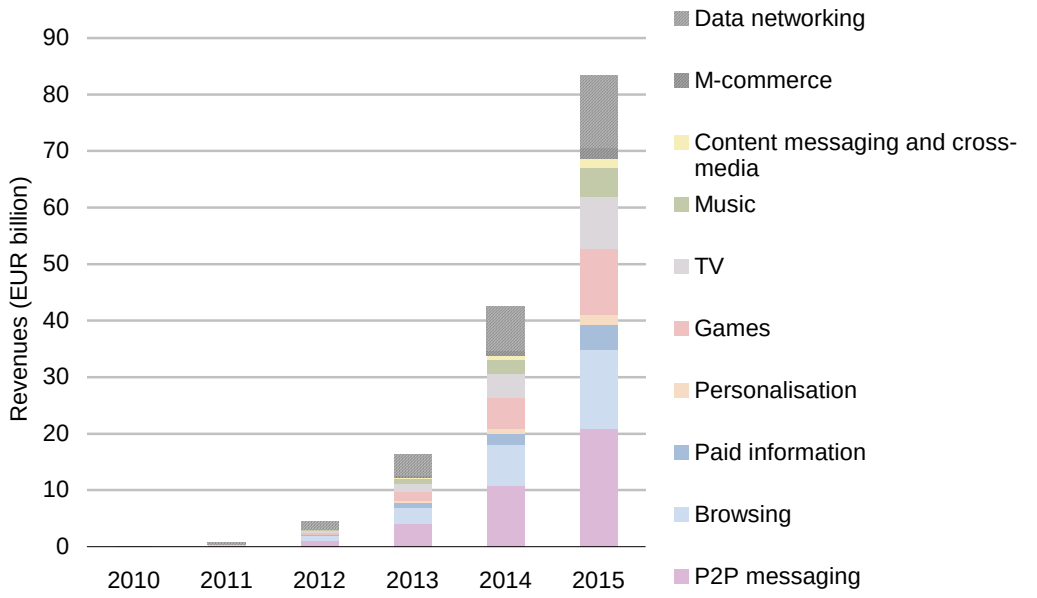

Exhibit A.8: *Global non-voice LTE revenues by service in alternative scenario 1, forecast 2010–15 [Source: Analysys Research, 2007]*

The conditions in alternative scenario 1 will transform the usage of non-voice services, providing the basis for a highly developed and well-established market for non-voice services. Such conditions will also encourage greater involvement from content providers who will want to address the large numbers of LTE subscribers, who are capable of accessing and downloading a wide range of content services. The high speed connectivity they enjoy will also reassure content owners that the quality of their content will not be diluted by poor connection speeds and slow download times.

A.2 Alternative Scenario 2

- In this scenario moderate demand emerges for non-voice services including mobile Internet access, gaming, mobile TV and music
- However, operators decide not to aggressively pursue FMS in developed markets judging the cost of providing good in-building coverage to be too high
- However, in markets with poor existing fixed infrastructure FMS is extensive
- WiMAX is extensively deployed by operators, particularly in markets experiencing high levels of FMS, prior to commercial availability of LTE networks and devices
- LTE must compete with existing WiMAX deployments

A.2.1 In alternative scenario 2, LTE will take longer to gain a foothold in the market

Exhibit A.9 shows the forecast split of subscribers by technology for alternative scenario 2 between 2008 and 2015.

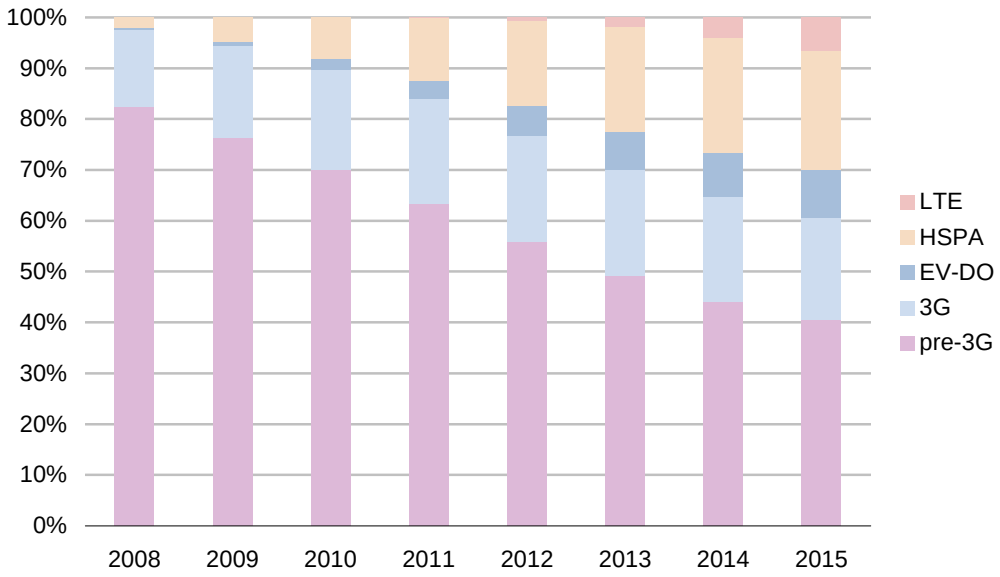

Exhibit A.9: *Forecast share of global mobile subscribers by technology in alternative scenario 2, 2008–15 [Source: Analysys Research, 2007]*

In alternative scenario 2, LTE subscribers will account for 7% of all mobile subscribers by 2015. Although launch dates for LTE will be the same in this scenario as in others, uptake will be slower due to less aggressive FMS strategies and investments in other technologies.

A.2.2 The total number of LTE subscribers will be lower in alternative scenario 2 in comparison to other scenarios

Exhibit A.10 shows the forecast split of LTE subscribers by region for alternative scenario 2 between 2011 and 2015.

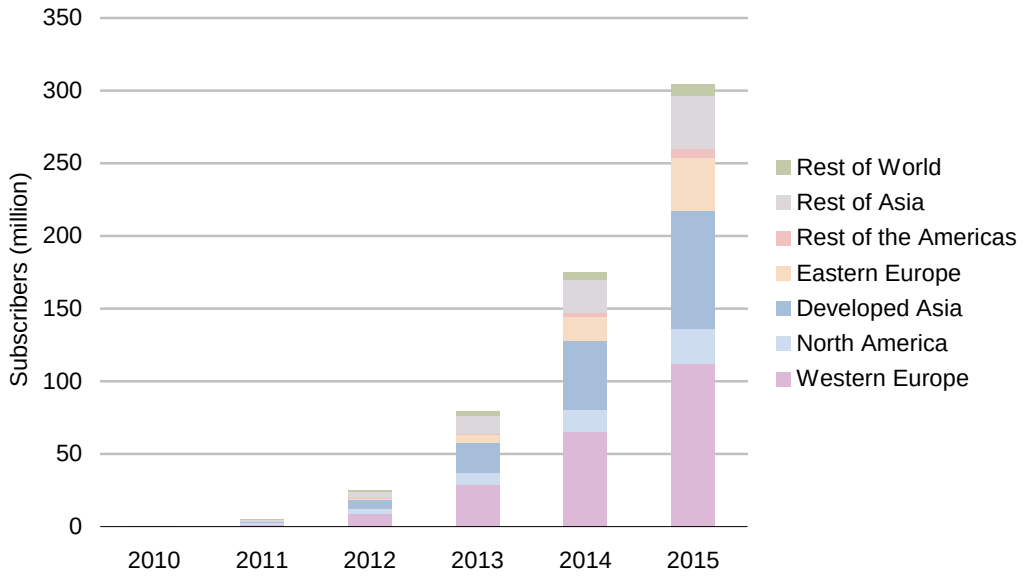

Exhibit A.10: *Forecast LTE subscriber forecast by region for alternative scenario 2, 2011–15 [Source: Analysys Research, 2007]*

In alternative scenario 2, as would be expected, the total number of LTE subscribers will be lower. It is still expected that commercial launches of LTE will start in 2010 as is the case in the other scenarios, but there will be fewer of them globally in comparison. There is not expected to be significant variation in the geographic breakdown of LTE subscribers across scenarios.

A.2.3 HSPA is likely be the main mobile technology in alternative scenario 2 but LTE will still be on the rise

Exhibit A.11 shows the forecast revenue share split by technology for alternative scenario 2 between 2008 and 2015.

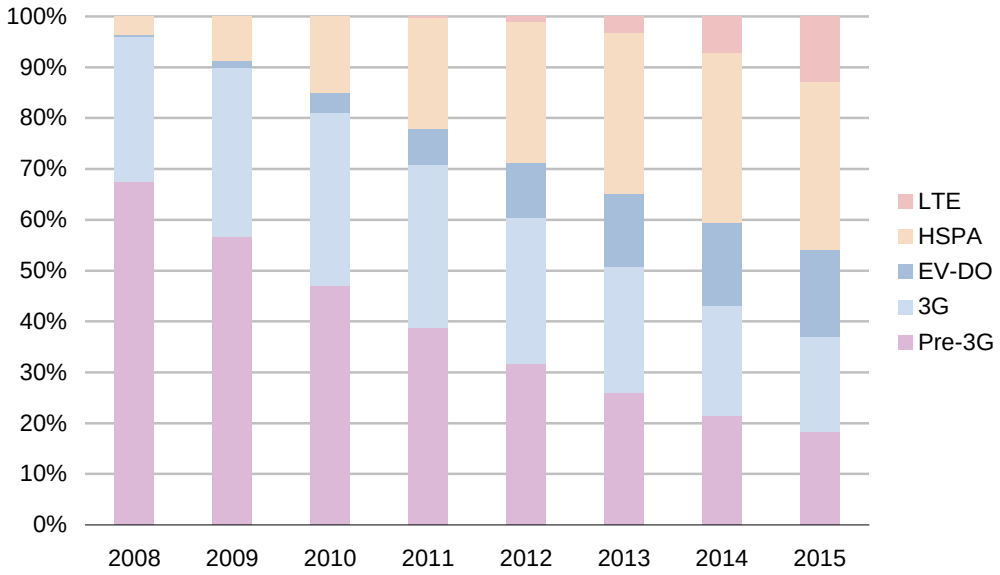

Exhibit A.11: *Forecast revenue share by technology in alternative scenario 2, 2008–15 [Source: Analysys Research, 2007]*

LTE revenues as a proportion of total global mobile revenues will still be significant in alternative scenario 2, at 13% in 2015. HSPA will account for the majority of revenues at 33%.

A.2.4 The share of LTE revenues accounted for by the developed regions could be even greater in alternative scenario 2

Exhibit A.12 shows the forecast growth in global LTE revenues for alternative scenario 2 between 2010 and 2015.

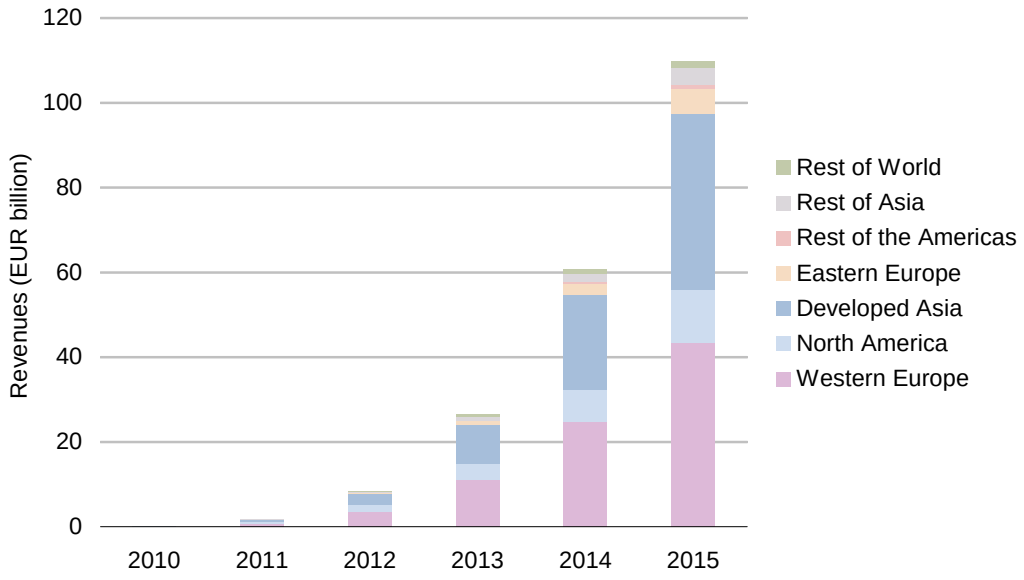

Exhibit A.12: *Forecast LTE revenue split by region in alternative scenario 2, 2010–15 [Source: Analysys Research, 2007]*

In alternative scenario 2, the developing regions provide the smallest contribution to global LTE revenues of the scenarios, at 11% or EUR12.5 billion.

A.2.5 Alternative scenario 2 is likely to create a smaller, but still significant market for LTE non-voice revenues

Exhibit A.13 shows forecast non-voice revenues by service for LTE in alternative scenario 2.

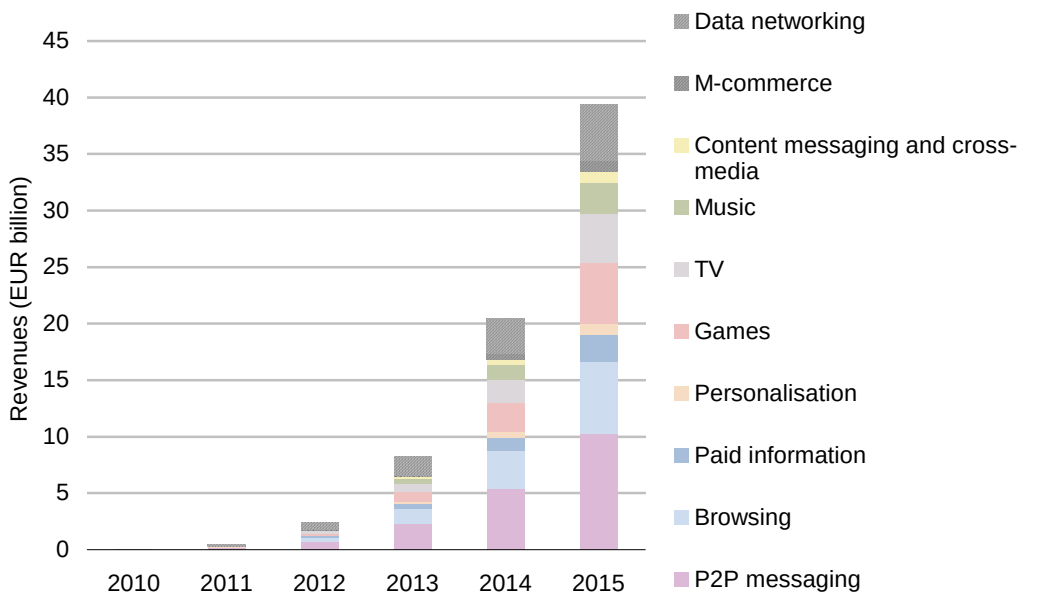

Exhibit A.13: *Global non-voice LTE revenues by service in alternative scenario 2, forecast 2010-2015 [Source: Analysys Research, 2007]*

Non-voice LTE revenues in alternative scenario 2 will be about half those of alternative scenario 1. However, conditions are not such as to prevent a large market for LTE non-voice services from developing.

Annex B: Alternative business case scenarios

B.1 Alternative Scenario 1

6.2.7 There is a good case for LTE deployment in developed markets under all three market scenarios

Exhibit B.1, Exhibit B.2 and Exhibit B.3 present the financials for a Western European operator, North American operator and East European operator, respectively, under alternative scenario 1 for a national deployment of 3G LTE. It can be seen that break-even is achieved in 2013 for the West European operator, 2014 for the North American operator and 2015 for the East European operator. All of the following forecasts are based on operators using existing infrastructure to rollout LTE (and not deploying additional base stations). This should be noted when viewing cashflow forecasts

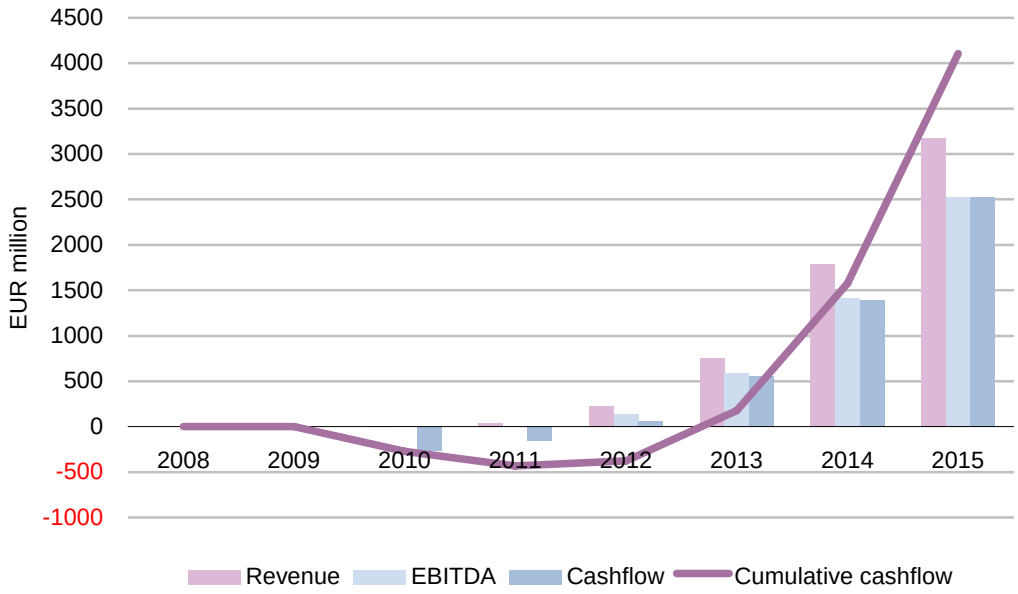

Exhibit B.1: *Financials for West European operator, alternative scenario 1, national coverage deployment [Analysys, 2007]*

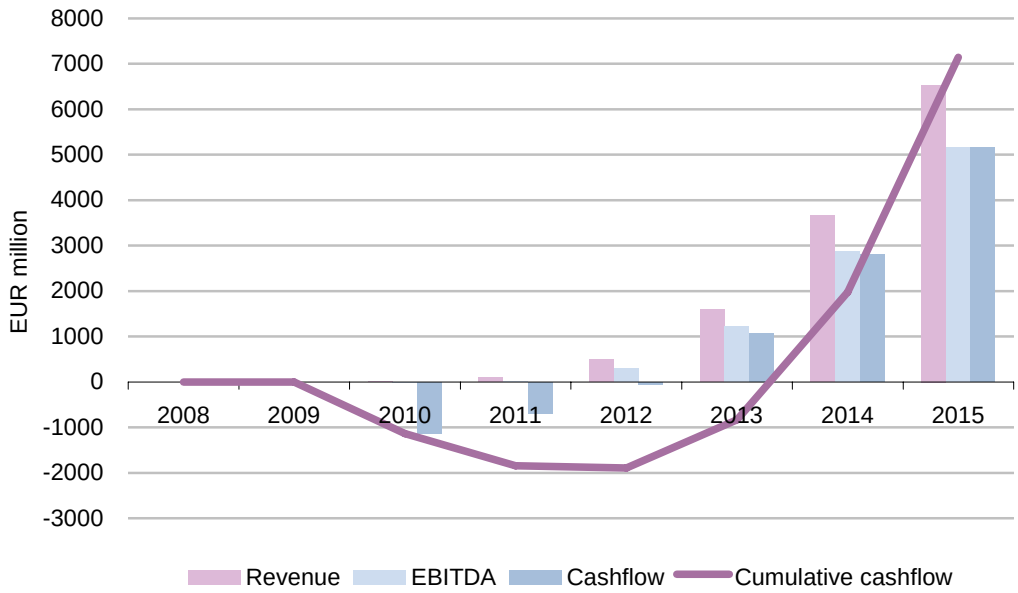

Exhibit B.2: *Financials for North American operator, alternative scenario 1, national coverage deployment [Analysys, 2007]*

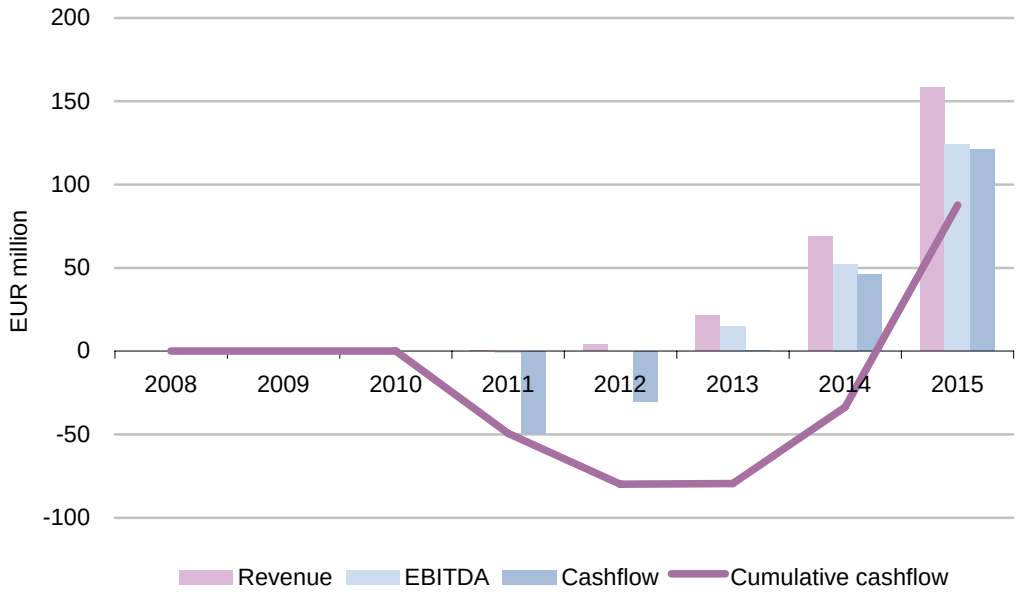

Exhibit B.3: *Financials for East European operator, alternative scenario 1, national coverage deployment [Source: Analysys, 2007]*

As shown in B.4, the NPV from 2008 to 2015 for the West European operator amounts to EUR1.8 billion and for the North American operator to EUR2.8 billion, while for the East European operator to just EUR24 million.

	Hotspot	*Urban*	*National*
Western Europe	380	1630	1796
North America	758	3214	2836
Eastern Europe	13	34	24

Exhibit B.4: *NPV of LTE deployment by operator type (EUR millions) under alternative network rollouts, alternative scenario 1 [Source: Analysys, 2007]*

B.2 Alternative Scenario 2

Under alternative scenario 2, as shown in Exhibits B.5, B.6 and B.7 it can be seen that break-even is projected to take an extra year in developed markets (2014 for the West

European operator and 2015 for the North American operator), but is not achieved during the time period for East European operator.

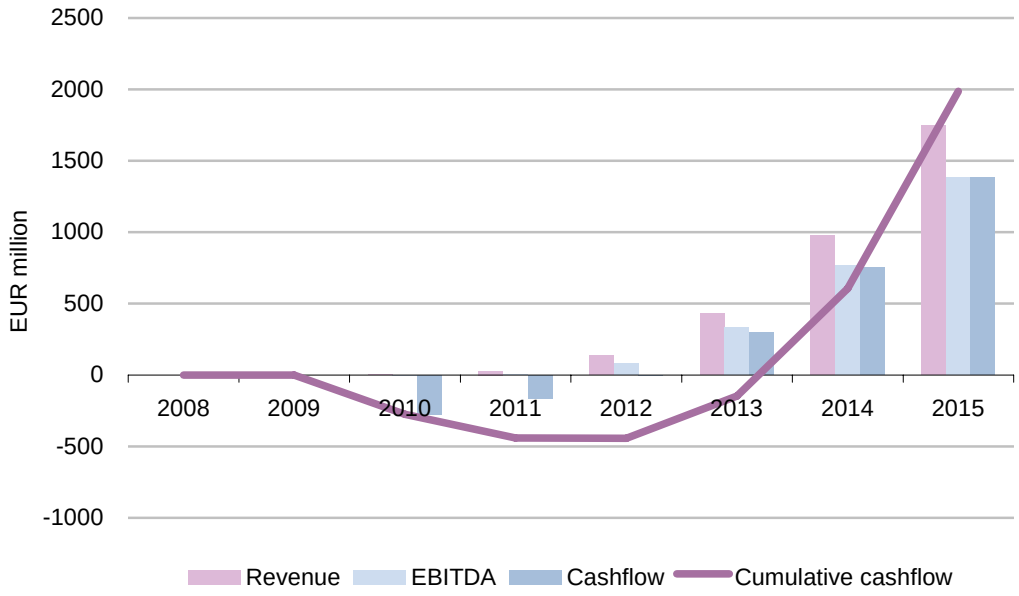

Exhibit B.5: *Financials for West European operator, alternative scenario 2, national coverage deployment [Analysys, 2007]*

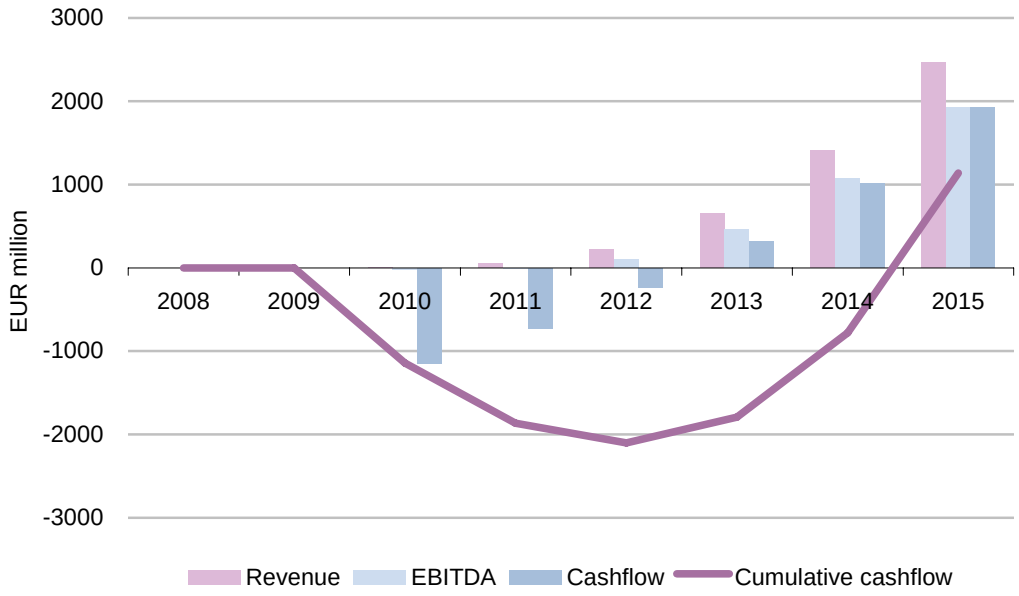

Exhibit B.6: *Financials for North American operator, alternative scenario 2, national coverage deployment [Analysys, 2007]*

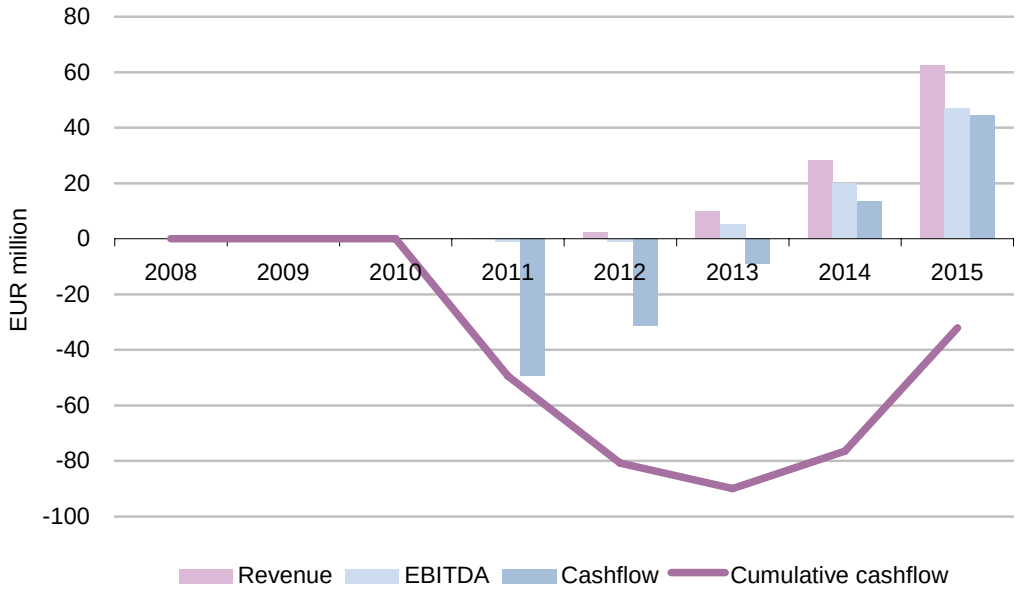

Exhibit B.7: *Financials for East European operator, alternative scenario 2, urban coverage deployment [Source: Analysys, 2007]*

The overall business case over the period 2008–15 is positive for operators in developed markets (NPV of EUR0.8 billion for the West European operator and NPV of EUR34 million for the North American operator), but is marginal for the East European operator (–EUR30 million), as shown in Exhibit B.8. The difference in NPV from alternative scenario 1 arises due to lower projected revenues as a consequence of lower overall demand for non-voice services and competition from other technologies.

	Hotspot	*Urban*	*National*
Western Europe	201	815	808
North America	255	920	34
Eastern Europe	3	–10	–30

Exhibit B.8: *NPV of LTE deployment by operator type (EUR million) under alternative network rollouts, alternative scenario 2 [Source: Analysys, 2007]*