The Demand for Future Mobile Communications Markets and Services in Europe
The mission of the IPTS is to provide customer-driven support to the EU policy-making process by researching science-based responses to policy challenges that have both a socio-economic as well as a scientific/technological dimension.
The Demand for Future Mobile Communications Markets and Services in Europe

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Preface

The CEPT-ECC (Conference of Postal and Telecommunications Administration – Electronic Communications Committee) recently recognized that the issue of market research in mobile communications is an area which has not yet been adequately addressed in Europe and that there is an urgent need to develop research activities on this subject.

As part of the EU’s preparations for the 2007 World Administrative Radiocommunication Conference, the Institute for Prospective Technological Studies (IPTS), part of the European Commission’s Joint Research Centre, was asked by the Information Society Directorate General to study the future demand for services which could make use of frequency spectrum. This request was taken up within the FISTE (Foresight on Information Society Technologies in an Enlarged Europe) project and a consortium was commissioned to carry out a study. It consisted of Simon Forge (SCF Associates plc, UK), Colin Blackman (independent consultant and editor of the journals ‘Info’ and ‘Foresight’, UK) and Erik Bohlin (IMIT, Sweden). The consortium worked in close cooperation with the Commission Team (Ruprecht Niepold and Andreas Geiss from DG INFSO and Bernard Clements and Carlos Rodríguez Casal from DG JRC-IPTS) who guided the project, followed the research and participated in the validation exercise.

The report presents the conclusion of this study, completed in March 2005. It presents alternative socio-economic scenarios from which potential demand for wireless services in the European Union in the years 2010, 2015 and 2020 is derived. Potential usage patterns, service characteristics and traffic volumes are highlighted. Calculation of potential demand is based on many assumptions and approximations and therefore should not be treated as a prediction of the future. Instead, it should be thought of as an estimate of wireless traffic, given the assumptions and conditions of each scenario.

The report may be downloaded from: http://www.jrc.es or http://fms.jrc.es
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Executive Summary

In order to prepare for the International Telecommunications Union (ITU) World Radio Conference in 2007 (WRC’07), where national delegations will consider the future demands of wireless services for radio spectrum, efforts are being made to reach agreement on future traffic volumes within the European Union. This study forms part of this effort and was led by the Institute for Prospective Technological Studies (IPTS), on the request of DG INFSO. It aims to explore (qualitatively) the way that citizens will use future wireless communications services over mobile networks, and to assess (quantitatively) the traffic that will be generated by 2010, 2015 and 2020.

This study built on two previous studies carried out by IPTS: “Prospects for Third Generation Mobile Systems” and “The Future of Mobile Communications in the EU: Assessing the potential of 4G”. A new methodology was developed to build socio-economic scenarios in which future traffic demands could be estimated. Though this method was initially developed for the EU, it is equally applicable to other regions, or even globally.

Sets of economic scenarios with user motivations and needs were constructed. Two sets of parameters were obtained from each scenario: on the one hand potential applications and services, and on the other, user profiles (usage). Future traffic was estimated by crossing this information. The whole process was guided by expert consultation, carried out at three workshops and through a survey.

Methodology and validation

Economic development drives up disposable incomes and this, combined with real user needs, controls consumption – what is bought and how much is bought. For this reason scenarios were developed that allow the examination of choices by both consumers and business customers from a socio-economic perspective.

Five scenarios of different socio-economic conditions were constructed to explore user needs and motivations. After expert consultation, it was agreed that three were enough to reflect the range of possibilities facing Europe over the next 15 years. These scenarios were:

1. ‘Smooth development’: EU economies unite to provide growth and development, in a fair and managed way that brings prosperity across all 25 members.

2. ‘Economic stagnation’: the EU economy slowly declines, as did the Japanese economy between 1988 and 2003. Outputs gradually shrink and government policy reactions to strong deflation are unsuccessful or frozen. EU economic growth falls behind that of Asia.

3. ‘Constant change’: The economy overall follows a moderately positive trend, with ups and downs. Ad hoc growth and recession often occur in parallel in different areas or countries, with stop-go progressions and regressions in specific areas of the EU. However, prosperity slowly increases for many in the EU.

Each of these scenarios was analysed to identify typical behaviour patterns in view of three aspects: disposable income, age, and motivations and needs driven by economic and social conditions of the particular scenario. For example, in the constant change scenario, the need for migrant workers to stay in touch with
1. Executive Summary

distant family members, maintaining continuity and accessibility, is identified.

The last two scenarios – ‘Financial Crash’, and ‘Physical Disaster’ - were eliminated, as it was considered that these events could happen in any of the previous scenarios.

Users were analysed in each scenario. First, they were separated into consumer and enterprise users. Then consumers were categorised according to two main criteria – age (0-14, 15-64 and 65+) and income (low, medium, high) – to produce nine types of users. Enterprise users were categorised by number of employees (micro, small and medium – SME - and large enterprises) and by broad sector (service or non-service) to produce six user types. It was assumed that customers in 2020 (consumer and business) will be far more educated in using and creating a lifestyle around advanced services, having grown up with the technology.

Analysis of the types of services that could support the citizen and business-users’ particular motivations and needs produced a “basket of services”. For consumers, these were Lifestyle, Communications, and Entertainment Services and for enterprises, Business Applications. These “baskets” contained 30 subgroups made up of a total of 139 services with specific characteristics.

Finally, the traffic volumes were calculated by crossing user populations with needs-driven usage, in terms of both the average number of communication sessions per day and the average duration of each session.

A consultation process was carried out in order to achieve consensus on the methodology and the approach adopted in the study and also on the interpretation of its overall results. Three workshops were organised, which brought together some 80 experts representing market players, academia and regulators. There was also dialogue with research projects in the area, including the Sixth Framework Programme projects: WINNER,\(^3\) E2R,\(^4\) Ambient Networks and MAESTRO.\(^5\) A set of messages was relayed to the key stakeholders for comment, especially the European Communications Committee – Project Team 1 of the CEPT (Conférence Européenne des administrations des Postes et des Télécommunications), which contributes to the debate within ITU-Radio Working Party 8F initiative for the 2007 World Radio Conference, and the ITU Working Party itself.

Also considered part of this process was the launching of the web-based questionnaire seeking views on the scenarios proposed. The questionnaire yielded forty-three full responses, most of them broadly endorsing the scenarios.

Results

Major motivations and needs varied considerably across the scenarios, as the economic conditions in each drove users in different directions. In the ‘Smooth Scenario’ the need arose for sophisticated services such as education support, whereas in the ‘Stagnation Scenario’, low-cost services aimed at more basic lifestyles were more important. In the ‘Change Scenario’, the need arose for wireless services as an essential link for migrant workers to maintain family ties and organise a new life away from their home countries. Logically, the most important driver for growth in the use of wireless technologies in all scenarios was the general economic development and financial conditions. Apart from this, different drivers were seen as being critical for each scenario. According to the survey no single application was seen to be dominant, though simple voice was important in all scenarios, especially in ‘Economic Stagnation’.

The questionnaire responses rated the ‘Constant Change Scenario’ as the most realistic,

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\(^3\) Wireless World Initiative New Radio  
\(^4\) End to End Reconfigurability  
\(^5\) MAESTRO (Mobile Applications & Services based on Satellite & Terrestrial Interworking) project
while ‘Smooth Development’ was seen as slightly less convincing than ‘Economic Stagnation’. Figure 1 shows the estimated traffic for the ‘Constant Change Scenario’, differentiating consumers and business users.

Figure 2 shows total estimated traffic for each of the three scenarios. It should be noted that growth may have different origins. In the ‘Smooth Scenario’, huge growth came from individual consumers, whereas in the ‘Change Scenario’, growth from consumers was steadier, most of the growth resulting from increased use by enterprises. In the ‘Stagnation Scenario’, consumer traffic was very limited indeed and almost all of the traffic resulted from enterprise use.

Analysis of the results showed that between 2010 and 2015 the differences between the scenarios are relatively small. It is only after 2015 that big differences in traffic volumes become apparent. An increase in the number of users from 2015 was supported by evidence such as the consolidation of a European internal market for mobile services, the expansion of Machine to Machine communications (M2M) or the fact that consumers will be familiar with and will demand mobile broadband services.

An important finding in comparing the scenarios was that economic stagnation will affect consumption, and the decline in consumption may be more severe than expected. It should
be noted that an assessment of demand in these circumstances requires that the structure of the supply side and its inherent ability to react to the economic conditions be taken into account. The scenarios indicate that in a stagnating economy, the industry will tend to seek a protectionist stance from government and will hold on to existing services longer, not having the will or the funds to move to new and apparently riskier offerings.

This traffic results need to be interpreted with care since they are based on many assumptions and approximations. Moreover, the temptation to consider the calculations as predictions of the future is to be resisted: the value of a scenario approach is to compare and contrast starkly contrasting pictures of possible futures and they should be thought of as estimates of wireless traffic, given the assumptions and conditions of each scenario.

All documents related to this study can be accessed on the websites:
http://fiste.jrc.es/pages/mobility.htm
or
http://fms.jrc.es

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Institute for Prospective Technological Studies

Structure of the Main Report

The report is structured as follows:

In Chapter 2 we examine the reasons why an approach to traffic calculation based on socio-economic factors is useful and necessary, and outline the project structure and schedule.

Chapter 3 gives the methodology used, and all factors employed in the calculations, with a description of the scenario-generation process and the three key tables that form the basis of the approach.

In Chapter 4 we start to examine the EU case by briefly exploring the scenarios, their contents and their differences.

Chapter 5 examines the results of the questionnaire survey, which includes responses from experts in sociology and economics and the telecommunications industry who were asked to judge scenarios and usage of certain types of traffic.

Chapter 6 gives the main results of the traffic volume calculations for each scenario, using the user profiles and the consumption of the various service types for the ‘epochs’ considered up to 2020.

It was felt necessary to give a dimension of financial realism to the study. Chapter 7 therefore develops business plans by estimating costs and revenues for each of the scenarios described, with simulations based on accepted methods of business analysis. Plans for network deployment with operational and capital expenses are considered here, taking into account the equipment density achieved by the new topologies for providing a new range of services.

Chapter 8 briefly describes the consultation process which brought together the key stakeholders in the WRC-07 preparations and was integrated into the overall study. This activity formed a key part of the project and took up much time and effort in visits and workshops. It also made the project much more than simply a research project.

Chapter 9 briefly summarises the trends in applications and services that came to light and were used during the study. These were thrown up by the scenario research and indicate possible user take-up (the demand side of the market), and technical directions (the supply side).
2. The Need for a Socio-economic Approach

2.1 Study aims and objectives

This study was commissioned by IPTS/JRC/EC at the behest of DG Information Society with two major objectives:

1. To carry out a foresight study exercise to address future wireless electronic communication services that will be used in the EU highlighting potential user patterns, service characteristics, supporting technologies and traffic volume

2. To prepare a document that can support a consolidated European input into the ITU process of determining spectrum requirements for systems beyond IMT-2000 relevant for the preparatory work of WRC-07 (World Radiocommunication Conference-2007)

One initial major condition was made for the study - that it be based on a socio-economic foundation for its estimates of future demand, rather than a supply-side 'hope and prayer'. Just why was this? Table 1 illustrates the need for this requirement by highlighting some of the successes and failures in predicting the impacts of telecommunications innovations, showing the view of the industry of the product or technology at the time of launch.

Thus the attempts at understanding future success of a communications product may need a far more socio-economic basis, and not one based on a supply-side, techno-centric view.

What is required is a new look at demand along the lines of customer appeal. Following work by Sawhney on the progressive replacement

While some of the biggest product launches in communications services over the last 20 years have delivered flops, seemingly trivial services have exploded.

<table>
<thead>
<tr>
<th>New services have often been mysteries to the industry - greatly underestimated or overestimated</th>
<th>Telecommunications industry view at launch</th>
<th>The consumer speaks the &quot;street&quot; view</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISDN</td>
<td>The next generation of telecoms - replace POTS</td>
<td>UK / USA: &quot;Idiot Services users Don't Need&quot;</td>
</tr>
<tr>
<td>WAP</td>
<td>The mobile user will really go for this technology</td>
<td>&quot;WAP is crap&quot; - expensive, no services, difficult to use</td>
</tr>
<tr>
<td>Iridium LEOs</td>
<td>Just what the remote businesstraveler needs</td>
<td>20 times too expensive</td>
</tr>
<tr>
<td>Internet/WWW</td>
<td>Ignore... Oh still there ??!! ..horror - stifle! ..VoIP wins</td>
<td>Just use it (@ no cost)</td>
</tr>
<tr>
<td>GSM - digital mobile</td>
<td>An extra (minor) feed for our fixed networks</td>
<td>Just what we need! - till we see the bill ! - so PAYG rules</td>
</tr>
<tr>
<td>SMS</td>
<td>Minor supplementary service (CLASS for Mobile)</td>
<td>The only service (mobile or fixed) for many users</td>
</tr>
</tbody>
</table>

Table 1: Successes and Failures in Predicting Impact.

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of technologies by those with higher accessibility, and combining this with a measure of utility in terms of the consumer’s values together with pricing of services against disposable income, we can re-examine what will fail and what will succeed. In the three dimensions of these parameters, we can identify the optimal space, where demand is high, as illustrated in Figure 3.

Following this we can map successes and failures, against these three dimensions for a range of services offered publicly in Figure 4.
Moreover the locus of the driving forces in the wireless and mobile telecommunications market are likely to change, in part because a large enough quantitative change signals a qualitative change in the way wireless will be used. The context for analysis will change to be set by the explosion of usage in developing countries, principally Asia. This sets our whole direction. We can see the potential take-up to 2020 building a market of perhaps 5 billion users, with the most sophisticated devices ever seen in the consumer world in the hands of billions. An estimate of wireless users is shown in Figure 5.

The impact of this growth outside the OECD community is perhaps two fold:

- The technology, applications and digital content directions (types of services, content available) will be driven far more by the needs of the new mass markets, which by necessity will be low cost markets, largely outside the EC and the more OECD generally.

- Take-up and subsequent usage will be as it always has been, controlled for the mass market by pricing against typical disposable income for the majority of the public. Note that for wireless services, this must include the price of the handset. Again this will be set by world prices, rather than OECD market prices, as the basis of handsets will be a platform designed for the developing world - its tastes and levels of disposable income.

Demand against price for public services has been studied for some time. More recent analyses suggests that demand can go non-linear at some price point, where the user sees a ‘perception of freeness’ – the price point where the user views the service as free and will use at will, not inhibited by costs. Thus demand can take off very suddenly. This is the phenomenon that has driven take-up in 2G and SMS in particular. The pattern is illustrated in Figure 6.

Consequently, we see demand as set by price point as the key forecasting parameter. If the price point is correctly combined with ‘product’, five developments could also drive up demand:
2. The Need for a Socio-economic Approach

1. The evolution of whole new segments of demand for wireless services, specifically machine to machine (where this involves a wireless service of some form - not just a Bluetooth connected keyboard to a PC for instance) and may become a major segment of the business market.

2. The move towards lifestyle services using wireless communications – for instance m-commerce and m-banking. But many such lifestyle services for personal organisation and convenience will only become major products if secure wireless communications can provide a trusted transaction environment for the consumer.

3. The trend for the handset to be used for a range of entertainment media, some of which may be the major users of bandwidth among consumer services. Also, the segment may move towards peer to peer content exchange, in which the consumer originates pictures, text/blogs, music, etc, as much as content sales by third party content providers to customers.

4. Arrival of sophisticated positioning–related services, such that location-enabled applications take off for both business and consumer segments.

5. Transformation of the business processes of whole industry segments- for instance health – by the availability of ubiquitous communications at low cost.

So we need more than the blind launch of a particular wireless service or technology. A new product or service must fit the purpose and pocket of their intended (and unintended) customers, as Alfred P. Sloan noted over eighty years ago.

2.2 Project structure

The project was carried out by a small team consisting of a project leader and two main research workers. Simon Forge, project leader for SCF Associates, was scenarios lead author for work package 1, with review by the two research workers, Erik Bohlin and Colin Blackman. Colin Blackman, with support from Simon Forge was responsible for specific work packages in services, user population and traffic. Erik Bohlin carried out the analysis of Business Plans for next
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Figure 7: Plan of the Study

The significant actions performed during the study were:

- The development of five scenarios, three main and two discontinuity wild-card scenarios, that might occur in any of the three main ones
- A questionnaire survey on the service types indicated by the scenarios, replied to by experts in economics and sociology, not just by those within the industry
- Development of novel business models for 4G mesh networks, using new concepts to accommodate the topology of the new technologies capabilities
- Visits to CEPT meetings and especially the ITU WP8F meetings in Shanghai and Geneva as part of the consensus building exercise
- A number of workshops in which the scenarios were developed further, the early results were presented, and also the final results
- Analysis of a large number of other projects and their scenarios, not just those from IPTS but companion projects in the FP6 initiatives such as Winner and those under the WWI forum such as Muse and Mobilife, with their scenarios and synopses of their collected scenarios
3. Methodology

How may we complement the ITU methodology for estimating markets and services? Our approach is to use scenarios, to build a picture of take-up based on demand side factors.

3.1 Outline of the overall socio-economic method with use of scenarios

The demand side is constructed from scenarios that focus on the economic and financial situation of the individual consumer, as well as the state of business usage. Note that the latter is closely related to the consumer condition in a consumerist economy. To discover this, we focus is on understanding user needs, the demand side. This drives and is also balanced by the market conditions and offerings of the supply side, as illustrated in Figure 8:

This differs significantly from those forecasts that resemble industry dreams of desired market objectives from the supply side. Instead we concentrate on the user profile and her or his needs for services, derived from scenario analyses of motivation and needs, dominated by the micro-economics, most specifically disposable income as illustrated in Figure 9:

3.2 Supporting the ITU methodology

However our socio-economic form of analysis must supply useful input for the ITU WRC-07 spectrum deliberations. ITU-R Recommendations
M1390, M1460 form a basis for preparations for WRC-7 but a subsequent series of associated working papers from the ITU WP 8F international study group referring to IMT 2000 and ‘Systems Beyond IMT 2000’ have further evolved the concepts. Thus, the FMS approach must not only supply inputs in a suitable form for the generic ITU methodology, but also be flexible enough for a method that may change as its study group contributors evolve their ideas.

The ITU approach relies on assessing key market parameters, and specifically, ITU WP8F document 8F/343-E, October 2004 notes that:

- “The market size of the future development of IMT-2000 and systems beyond IMT-2000 can be estimated from parameters such as density of potential users, call/session duration, service bandwidth and so forth.
- It is also necessary for the market size estimation to take account of key issues such as services usage and usage environments”

The ITU’s questionnaire (REF, ITU WP8F/343) on future requirements, to be discussed in WRC-07 for systems beyond IMT-2000, requests parameters on markets and users, with respondents asked to make a selection from several sets of parameters:

- “Please list the key parameters and issues you consider necessary for the market size estimation, and comment on the impact of each parameter and issue on the market.
- A2-1: Key parameters - List parameters to be utilised for estimation of traffic volume in the future development of IMT-2000 and systems beyond IMT-2000. The parameters correspond to those for calculation of spectrum according to the Methodology Recommendation.
- A2-2: Key issues - List related issues to be considered in estimation of traffic volume in the future development of IMT-2000 and systems beyond IMT-2000, which seem difficult to provide as quantitative values.
- A2-3: Minimum set of the parameters for market size estimation - Select a set of the above parameters that are essential for estimation of market size”

**Figure 10: ITU Model**
Consequently we may view the ITU methodology as building a model, see Figure 10, based on several sets of parameters, which are summarised.

The ITU Generic Spectrum Calculation Methodology goes on to use the selected parameters in a set of steps, presented as a flowchart of actions, in which multiple radio access techniques (RATs) are assigned to services, by assessing needs for spectrum in accordance with their propagation characteristics for a given traffic load, see Figure 11:

This process forms the basis for identification of services and their requirements for spectrum. It considers the cellular structure carefully – from use of pico, micro and macro cells to the conditions of propagation, the density of users and degrees of mobility. The FMS contribution can enter into the process at stages 2 and 3 of the flowchart, as shown above.

The latest documented version of the ITU method available at this time (ITU WP8F document 192, distributed 21 February 2005) has the key tables of Market related parameters for spectrum calculation. It proposes the following as its methodology to be used to specify hypotheses for the mobile penetration level, and the “shape” of the penetration evolution for each country, within the forecast timeframe. Figure 12 shows a simplified view of the ITU methodology. Grey boxes depict inputs (available data and specified hypotheses), white boxes describe results.

The ITU method uses tables of market related parameters for spectrum calculation, as in the latest documented version of the method available at this time (ITU WP8F document 192, distributed 21 February 2005), see Figure 13.

However, there are some questions as to whether this approach, which might be viewed as based on conventional existing cellular engineering, may be open to review in consideration of the longer term directions, with new factors being considered in the ITU WP 8F process. Questions might also be raised on requirements for further analysis for future system parameters such as total volume of bits per session, and to incorporate mesh technology networks.
3. Methodology

Figure 12: Synoptic view of the ITU Mobile Penetration Forecast Methodology
(Inputs are in Grey, Outputs are in White)

Figure 13: Mapping Services onto Service Categories (SC)

<table>
<thead>
<tr>
<th>Traffic class Service types</th>
<th>CBR</th>
<th>VBR Real time</th>
<th>Non-real time</th>
<th>ABR</th>
<th>UBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low bit rate (e.g. Speech &amp; SMS) (&lt;16 kbps)</td>
<td>Voice</td>
<td>Low data transmission for restaurant reservation in Town monitoring system</td>
<td>Low data transmission for town monitoring</td>
<td>Low priority E-mail</td>
<td></td>
</tr>
<tr>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td>Video phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High multimedia (&lt;30 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Super High Multimedia (30 Mbps to 100M/1 Gbps)</td>
<td></td>
<td></td>
<td>File transfer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
and also non-cellular wireless technologies, some of which operate in unlicensed bands, such as WiFi (IEEE 802.11x) and WiMax (IEEE 802.16x) and ZigBee (IEEE 802.15.4). However the current focus is towards mobile cellular access techniques.

FMS adds a view from the user, based on socio-economic factors. Such an analysis can flexibly reinforce the ITU methodology and fit with the key ITU tables, feeding into their parameters. Consequently there is a supporting relationship between the FMS project’s approach and the ITU Generic Spectrum Calculation Methodology whereby the FMS approach provides the initial analysis of users, services and usage, leading to traffic generated, by scenario and by timeframe or ‘Epoch’ (2010, 2015, 2020).

Effectively, FMS provides a model of the environment, to 2020, via scenarios, in terms of economic/social/ political drivers and trends to assess demand for mobile services, exposing:

- Motivations
- Types of users by scenario
- Their needs
- Consequent behaviour – ability to pay, priorities in life
- Applications and content services
- Numbers of users of each type, and age group

From this, the FMS approach can give inputs to the ITU Model of service types and traffic types to assist in the identification of spectrum requirements using several sets of traffic parameters such as bit rate, asymmetry, or traffic classes in terms bit stream parameters (available, constant, variable, unspecified) for input to the next steps of selection of the Radio Access Technique.

Note that the FMS approach is deliberately not closed or restrictive as to which parameters can be generated for the subsequent steps of RAT assessment. It is flexible and can be modified easily if the desired output parameters must be changed. In particular, it offers the opportunity to use simpler assessment methods and different parameters, if these are considered more useful for future forms of spectrum analysis.
3.3 Building the scenarios

Planning with scenarios has the aim of bringing together useful future views with events, attitudes, surroundings, new forces and players. Scenarios, as we use them are not intended give a prediction but a supposition of what might happen in certain circumstances, by asking the right questions, rather than always answering them completely. They describe plausible future eventualities, not predictions. They cannot forecast exact outcomes in economies or technologies. But they do offer a perspective to provoke ‘what if’ analysis, to discuss and identify the relevant factors and directions. Our goal here is to improve the collective understanding of how possible future wireless services may develop. There are too many parameters and chance events involved to give precise figures of demand in 2020.

In a scenario, we combine two worlds - a world of a future perceptions, usually centred on a theme or significant change - and the world of plain facts. We can build several pictures of a specific domain of interest in which hypotheses can be set out to obtain a range of future views - a small set of contrasting stories about the future. Each scenario must be noticeably and fundamentally different in some explicit way to be valuable. Scenarios should be as convincing, yet as startling, as possible because the expected is often not reality, and should incorporate all the chaos and complexity of the real world. They will involve every element, as naturally as possible, to construct daily life at some or all of the three levels of personal, corporate and national/global environments. These elements will be included in the premises of the scenario, perhaps as initial conditions and expected events. From this preparation, a scenario can be constructed via a set of standard components of facts and logic as shown below, including core drivers, the dynamics of the ‘plot’ and identifying weaknesses and areas of uncertainty, see figure 16.

In particular, the real forces of change must be identified – be they widespread and long term or specific and short-term, e.g. the increasing youth segment in the developing world (to be 40% soon); or that OECD populations will age faster; or the rise of the NICs (newly industrialised countries) which will dominate the global economy by 2020 - by 2015, China may represent 20% of the
global GDP, up from 3% in 1980. The process of scenario formulation used here follows a series of steps, in a formalised approach, Scenario Construction for Forecasting, built up over a decade of large studies looking and macro and micro-economic affects of telecommunications on the economy and industry segments.

Effectively, the method formalises the creation of alternative scenarios by trying to rationalise and understand the mechanisms of possible change and potential rates of change through:

- Identification of key parameters, leverage points, triggers and long term trends
- Including the impacts of major discontinuities—likelihood and secondary effects
- Use of causal effect chains, wherever possible, and their relative strengths, to form an overall impact analysis, of both external forces and internal
- Building the central logic of the scenario (the plot) as a framework and dynamics. This may centre on a basic theme, issue or decision (e.g. oil at $100/barrel).

Thus each scenario requires a distinct ‘theme’ or basic premise, one that is singular and also relevant to the subject area of interest. Initial conditions that drive all of the scenarios are also considered at this time and may affect the choice of themes. Assumptions can then be made. From all of this come simple assertions. With the assumptions, they may be grouped into more adventurous and encompassing Hypotheses, from which the framework and plot dynamics of the scenario can be derived. The main stages of scenario construction are:

- Firstly give each scenario its distinctive ‘theme’. This may be an iterative process with the gathering of assumptions and also with the forming of a set of known facts that will be true across all scenarios, as initial conditions.
- Assumptions are listed, possibly shaped by the one central theme or issue (for example a “what if”) based on surmises of ways markets, social factors technology, economic forces, politics, physio-geographic situations may go.
- Then, which are the real key variables (including the unknowns) for this scenario are decided - values now and in the future for the knowns, are included. These first stages may take some effort and time, as to what is both significant and relevant.
- From these inputs, simple assertions can be made about the scenario (almost one line sentences) and the causal effects and interworking are can be checked and traced in an impact analysis, perhaps with use of a relevance tree for secondary and interlinked impacts. The inter-relationships and dependencies are reviewed.
- Simple hypotheses can then be formed as the foundation of a scenario, for instance, the roles of key actors, based on the above; they are then reviewed.
- All the relevant hypotheses are then combined to build a scenario’s “plot” – its framework and dynamic behaviour; further reviews can then identify weak points.

An outline of the overall process is shown in Figure 17.

General lessons learnt from previous studies include:

- Avoid over-confidence – scenarios are stories about the future, they are not predictive forecasts about situations or events far into the future in highly precise quantitative terms and expecting any robust detailed analysis beyond 5 years is unrealistic. Rather than predictions,
any figures or statistics of a quantitative nature should be treated as estimates of, at best, a direction. Detail and high-expected accuracy should be confined to quite short-term horizons (perhaps 1-4 years).

- Identify qualitative changes with temporal precision only if we can identify the trigger conditions, probably from a causal chain, with some precision, and over the short term, as defined.
- Understand the real aims - what do the final users of the scenarios really need
- Emphasise the demand side (pull) by users, over supply side (technology push) from vendors, governments and researchers, as among the critical issues and drivers. Supply side predictions have a notorious history of over- and under-estimation, depending on the commercial position of the sponsors of the study.
- Review the scenarios with a peer group – in a formal structured workshop and/or by a survey questionnaire to gauge reactions from a larger peer group. We followed both paths, to get the most balanced view.

### 3.4 The FMS method - from scenarios to users, usage and services

Certain ground rules must be introduced to the scenarios to obtain results for the target subject in the domain required, that is wireless services in a future Europe to 2020.

For the FMS scenarios, an approach for a user-focused model of wireless service demand is required. This user-centric model is founded on economic analysis, see Figure 18

From economic scenarios we can give a description of:

- Social, Lifestyle and Workstyle patterns, based on economic constraints
- Motivations for lifestyle- motivations are considered to drive user type behaviours and to some extent define the user types. Note that motivations are considered distinct from needs, in that motivations drive the needs of users. For instance a scenario may indicate that users are strongly motivated to seek self-improvement in their vocation in order to survive and progress economically and socially. The need that stems from this is some form of training or education, that
must fit with the situation of being a mature adult and already time poor, in that a low level job must be carried out each day. The need generates demand for an application such as distance learning for education.

- Consumption (or penetration) of applications which varies by user type and motivations
- How the Demand Side interacts with a Supply Side scenario – which has its own dynamics, which are also based on the economic conditions of the scenario

However we must note here that the overall task is ambitious. There are a large number of input parameters that we can identify which affect demand but data for all of such parameters is not completely available. And we may still have not included all possible relevant parameters. So in practice, we can derive a set of comparative pictures of the future, the scenarios, but the outputs are only as good as the input data. They will yield major trends in approximate terms and allow comparison between the scenarios.

For the FMS study, five scenarios were initially evaluated, a process which included comparisons with published scenarios of others – e.g. Bo Karlson, Aurelian Bria, et al, Wireless foresight scenarios for the mobile world in 2015, also Scenarios Europe 2010, by the Forward Studies Unit, European Commission Gilles Bertrand (Coord.) et al, 1999, as well as that of the EC FP6 research projects, in particular those of the Worldwide Wireless Initiative, WWI (see References).

Strengths and weaknesses of scenarios were compared, for the final selection for Workshop 1 Seville, 26/27 October 2004, and these were first discussed with IPTS. Then five chosen scenarios were drawn up in outline form with a written descriptive brief, which included:

- Micro and macro-economic factors - the impacts of economic output and disposable income
- Political and social pressures regarding such changes
- Social elements – use of wireless and mobile telecommunications in everyday life, sometimes with ‘vignettes’ – small sketches of everyday life in the scenario envisaged
- Social and cultural barriers to use of new services

![Figure 18: Our perspective of demand is economic - it sets social and technical parameters and features](image)
• Changes expected on the supply side in regulatory environments and the market forces regarding such changes – e.g. positions of the incumbents

• Overseas economic and market developments likely to influence the European scenario

Of the five scenarios, Workshop 1 then reclassified the scenarios into three ‘main’ scenarios for further study and two wild card scenarios, discontinuities due to disasters of different kinds, which could occur in any of the main scenarios. A range of scenarios gives an understanding of the contrasting patterns of future living and working, driven by needs of economic and social pressures, to build alternative pictures of future demand.

To move to the next stage, elucidation from scenarios of the wireless services, and their traffic, the overall steps in the process are shown in Figure 19.

In more detail, we can view the approach for deriving services used and their traffic patterns as a series of interdependent calculations:

• Use scenarios to segment the user population, according to the conditions laid out in the scenario, especially on economic output and disposable income.

• This generates user profiles, in terms of number of consumers who may be placed in categories of low, medium, and high income and disposable income, so we have user populations by type, with their needs, also generated from motivations.

• Their needs drive the choice of application types and the demand for those applications in terms of usage frequency and session length.

• Applications can be transformed to services, through the applications and their attributes, giving the content form of the application, and then its network service characteristics.

• Finally traffic can be calculated using the minutes of daily usage and the applications presented as network services.

The related activities may be illustrated as the causal chain in Figure 20.
To formally work through the method, this chain can be reduced to a 6-stage programme:

1. Generation of scenarios, specifically the economic forecasts (which form the basis for motivations, needs and applications in demand)

2. Analysis of differences in disposable incomes between scenarios and the likely motivations of consumers and business users

3. Analysis of user types in terms of their economic power and psychology of usage in terms of their needs, for both the user segments of consumer and business.

4. From this can be deduced which applications are more likely to be chosen by which user group, and the relative degree of usage, considering motivations, needs and income.

5. Applications then can be translated into services at a content and network level. Note that from a demand point of view the granularity of service analysis is arbitrary – usage at an application level can be examined as, for instance:
   - a single service (such as TV entertainment on a mobile handset screen), or
   - a group of like services (e.g. Healthcare), or
   - a ‘basket of services’ covering many applications which may be taken up together in a future wireless context, (e.g. entertainment in its widest sense)

6. From the services and their characteristics, the traffic types, and their volumes can be estimated. Also we note that not just the granularity of the services package but also the range of characteristics used for the services is arbitrary; we can add and assign a value for parameters as required, be they asymmetry, ATM traffic class, isochronocity, environment of usage (home/office/street/car), etc. and assume any statistical measure to be the ‘average’ for a parameter – for instance a service’s bit rate can be measured as peak, mean, median or mode.

Overall, we can view the process as illustrated in Figure 21.

Thus we start with identifying user types and their needs, before considering services, for both the business and consumer segments of the market. From this we can derive the different

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**Figure 20: Scenarios generate motivations & user types with needs analysis**

![Diagram showing the process of generating scenarios and identifying motivations, user types, and needs analysis.](attachment:diagram.png)
views of the future. How we parameterise the information derived from the scenarios, in choice of output parameters and level of detail, has been deliberately left open the users if the method. The range of output parameters may be minimal, or more detail may be added, but at the risk of less confidence as the Epochs progress and the basic input data becomes less certain. Scenarios are only scenarios – they are open to different interpretations and divergences and so extreme detail for the long term must be treated with balance. We now work through this method using the results from the study.

### 3.5 Overview of estimating traffic from users, usage and services characteristics

**How do we move forward?**

To do this we translate the flow of activities outlined in the steps in the previous section into a more complete approach outlined in Figure 22.

**Figure 22: The Methodology to calculate Traffic volumes from User types and Services, in outline**
As indicated in Figure 22, the following three key tables (Tables 2, 3 and 4) used.

- A scenario analysis table showing motivations, needs and applications deduced from working and living patterns
- User profiles table in terms of age and income levels for each scenario, for the three epochs (2010, 2015, 2020), derived from user types, with their needs and applications to satisfy those needs
- Services available, within a timeframe of 2020, from applications, with their characteristics grouped functionally by usage into sub-groups and super-groups (termed: baskets of services’)

3.6 Estimating motivations, needs and the corresponding applications

The first task is to analyse the scenarios from the point of view of likely needs of its population.

The start of such an analysis is shown in Table 2.

From this it can be seen that the patterns of living and working are described succinctly and motivations are made explicit. This may be done using direct analysis or brainstorming with a group, or a combination of these. Needs and corresponding applications are then derived from the motivations. To analyse the needs, we can use each motivation to indicate what these might be. This stage must be carefully thought through. It usually takes several iterations and requires peer review. From the needs, applications are mapped that satisfy the needs. Again this requires multiple attempts and peer review. It demands a combination of understanding:

- what are the possible applications, against the underlying nature of the needs, and
- what would be the key attributes of the applications to satisfy these needs.

### Table 2: Table of Scenarios - from Scenarios to Needs, into services

<table>
<thead>
<tr>
<th>Scenario Development</th>
<th>Socio - economic patterns</th>
<th>Motivations</th>
<th>Needs</th>
<th>Applications - Service Usages required</th>
<th>Application Attributes (Security, affordability etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Smooth</td>
<td></td>
<td>Self realisation and assertion</td>
<td>Control of service - words - control with remote presence of proxies for presence</td>
<td>Transactional capability -</td>
<td>Security, Privacy, Robustness, Audit, Tracking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provision of social networks</td>
<td>Control of interruption -</td>
<td>Business - peer</td>
<td>Assurance of safety, Control of several control of personal security, and screen with remote presence or intelligent agents that compensate for disabilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Support to emergency by augmented control of daily life for aged population</td>
<td>Accessibility for medical services</td>
<td>Very simple usage of use - e.g. phone to talk for medical services, and screen with augmented readiness or completely visual for your sight</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Special needs (quality, educational, etc)</td>
<td>Support for services physical and mental using mobile access to conversation service and intelligent agents that compensate for disabilities</td>
<td>Usage by access</td>
<td>Ubiquity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Security</td>
<td>Military use of application group with adaptation to location</td>
<td>Location enabled applications</td>
<td>Security user interface</td>
</tr>
</tbody>
</table>

The Demand for Future Mobile Communications Markets and Services in Europe
A helpful move here is to consider being placed as the user in the scenario and Epoch under consideration and to try to imagine the need and an ideal service which would best meet that need in that situation, here based on wireless access to information or communication. Thinking about the vignettes, the example stories attached to the scenarios may often be of help here to set the scene. Note that applications may not be very precise— for instance they may indicate that m-commerce of some form or entertainment may be the service to satisfy the need, with some attributes on accessibility. They give approximate indications only of the service in content or networking terms.

3.7 Estimating the user population

Note that from the whole scenarios Work Package we have concentrated on three ‘Main’ scenarios for this further analysis, as these are the key focus for the FMS project. These scenarios are also used to formulate a set of proposed user types with the key parameters for each type:

- The user type, with available disposable income
- Which applications are in use for each user type, from the needs analysis
- The degree of usage of each application, and therefore of each service type

The approach here is perhaps best explained using an example. An extract from a user profile table for consumers is shown in Table 3. It incorporates the applications used and the degree of usage.

We now examine each of the main parameters, the columns of the table above:

### 3.7.1 The user type, with available disposable income

In terms of user types, if we can obtain the statistics, with the projections to 2020, we should be able to segment them through a number of general parameters:

- EU member country - for EU 25 plus accessions
- Disposable income (e.g. high; medium; low) for consumers
- Age (e.g. 0-14; 15-64; 65+) for consumers

#### Table 3: Portraits of User Types (consumer)

<table>
<thead>
<tr>
<th>User type</th>
<th>Applications used</th>
<th>Degree of usage of Applications</th>
<th>Time per day by basket of services</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-64 years</td>
<td>Communications, entertainment</td>
<td>1-1.5 hour per day, most in comm</td>
<td></td>
</tr>
<tr>
<td>2 Up to 14 years</td>
<td>Communications, entertainment</td>
<td>less than 30 minutes per day, 50% entertainment</td>
<td></td>
</tr>
<tr>
<td>Post 65 years</td>
<td>Communications, entertainment</td>
<td>less than 30 minutes per day</td>
<td></td>
</tr>
<tr>
<td>2010 Medium income</td>
<td>Communications, entertainment, lifestyle support services such as shopping, news &amp; PSB, education services</td>
<td>Total of 1 to 2 hours per day, up to 1 hour in communications, rest in high level services</td>
<td></td>
</tr>
</tbody>
</table>
If the statistics data can be refined by addition of new data for further segmentation, then other breakdowns can be made but they may not add value for traffic estimates (such as gender against age group of the workforce and population). Often they are difficult to obtain for the EU-15, or unavailable, and certainly may not exist for an EU-28 with future accessions, for instance:

- Work-life situation (e.g. migrant worker; non-migrant)
- Culture/lifestyle
- Family situation (e.g. Nuclear family; single parent family; single household; other)

The final result would be a segmentation of the market into many, many cells. However, as the underlying demographic and population statistics in this detail for the EU 25 or 29 are not available, we cannot say that ‘In Europe in urban areas the number of males between the ages of 13 and 30 who are in a single parent family with medium disposable income who are migrant workers who will do online gaming in scenario 3 in 2015 = n 000,000’. In consequence we cannot do market forecasts for every conceivable service to 2020 at a level of detail beyond currently available statistics for member countries, without exceeding the (limited) scope of such a project. Thus we need another way of looking at it, and also it has to be kept relatively simple.

The way forward lies in the fact that we are able express potential demand as a subset of the total population by first considering disposable income, then those old or young enough to reach the addressable market.

Then we estimate what percentage would use each application considered as a type of Basket of Services, for each scenario in 2010, 2015 and 2020, that being a best estimate taking into account all the factors inferred from the scenario, which we feel it is the most useful and practical, in consideration of having the statistics we have for the EU-25 covering the three age groups, and the accessions of Bulgaria, Croatia and Rumania.

The disposable income differences we can infer by generating relative prosperity from the scenarios. Even limiting the study to the factors we have chosen requires in the order of over 600 calculations of market demand:

- 9 user categories for consumer, and 3 for business x 3 scenarios x 3 time horizons x parameters for 3 types of baskets of services for consumers, and 2 for business x proportion of active users x usage per day

Data is available to support these estimations although in some cases obtaining these data has required significant work as they may not be collated in the way required for the study. Nevertheless, in general we believe that the task is manageable.

Note that we have two main categories of user, not just consumer but also business enterprise. For the latter, Business users - these are separately classified by micro-enterprises of up to 9 staff (the major growth segment in many EU members), small and medium enterprise, and SMEs, 10-249 staff and also large corporate and Public sector organisations, more than 259 staff.

In detail, the FMS technique of user assessment is outlined in the box on the next page.

### 3.7.2 Which applications are in use for each user type, from needs analysis?

For each user class in each Epoch in each Scenario, we assign applications, as services, at some level of granularity. We can assign services at any granularity from a single service, up to sub-groups of multiple and super-groups of whole classes of services.

From the first analysis table, of needs and motivations by scenario, we obtain applications that are expected to be in demand for each epoch. These give a service type but at the level drawn from needs. This level of service definition given by an applications is closest in granularity to one of a super-group of services, or a ‘Baskets
We first define the user population. The task starts by categorising users into a number of types, according to the following parameters:

1. Individual consumer vs. business users
2. Age
3. Disposable income

This allows us to categorise users into four main types, each further sub-divided into three sub-groups:

- Individual consumers, low income
- Age 0-14, low income family
- Age 15-64, in employment, low income
- Age 65+

1) Individual consumers, medium income
- Age 0-14, medium income family
- Age 15-64, in employment, medium income
- Age 65+

2) Individual consumers, high income
- Age 0-14, high income family
- Age 15-64, in employment, high income
- Age 65+

3) Business users - these are separately classified by
   - Micro enterprises (the major growth segment in many EU members) of up to 9 staff
   - SMEs, 10-249 staff
   - Large corporate and Public sector organisations, >259 staff

For each of the four baskets of service types we now estimate the number of each type of user within the EU-25.9

This is presented in a spreadsheet and repeated for each of the three main scenarios at each of the three time horizons. The ‘baseline’ data we need to make these market estimates include:

- Population projections for the EU-15, new member states and applicant countries, by age.
- Employment data for the EU-15, new member states and applicant countries, broken down by size of employer and private v public sector.
- Estimates of the proportion of each category of users with high, medium and low disposable income.
- Estimates of the proportion of each category of users who would use each service type.

Using data predominantly from Eurostat but also from other sources as necessary, we build a ‘control template’ using current statistics for the EU. We then estimate the number of users for each category, and for each service type drawing on all the information available to make a best judgement. Once we are satisfied with this control template, we produce spreadsheets for each of the three scenarios, at the three time horizons. This may be done essentially by varying the parameters in the control template, again using our best judgement of how different scenario conditions will affect market demand for each service type and for each category of user. We then make an estimate of average usage for each user category and service type to build up a comprehensive picture of services and their usage within each scenario over time.

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9 In addition we must allow for expansion, towards an EU population by 2020 of some 500 million people – and so are making the assumption that Bulgaria, Croatia and Romania join the EU by 2010. We would note that the accession of Turkey is still uncertain and it may occur but not before 2015 (or after), so we have decided not to include it in calculations.
of services’ which is the top-most level, and has four main types of Entertainment, Lifestyle, Communications and Business Applications (further explanation of the levels of classification of services, and the types is given in the section below on services analysis).

Choice of applications against user needs is made by inspecting the table of needs by scenario and assessing the degree of attraction of the service for the type of user, in view of age and income, which indicates capability to pay from level of disposable income expected.

This requires a dual approach of:

- First, visualising the user and the surrounding context from the scenario descriptions.
- Second, performing a verification by looking at relative usage parameters between classes of user and between epochs and between scenarios, to follow trends and to act as a sanity check.

3.7.3 The degree of usage of each application, and therefore of each service type

For calculating traffic, the session length must be attributed for each class of user, by scenario and by epoch, in terms of total degree of usage as minutes per day. This is done by assessing the user type and disposable income for each epoch/scenario and including a view of the influence of several assumed trend parameters, including:

- the expansion of usage of wireless services during the waking (and working) day as a general trend, as the services offered become richer and more attractive and costs reduce as take-up advances (the virtuous circle of the networking effect – the more users there are of a network service, the greater its value and the greater the possibility, and pressure, to reduce price to the user, especially in a competitive market).
- in a work situation, the degree of usage of ICTs as a part of the working day (be they attached to fixed or wireless services) as knowledge working becomes the norm – but this migration to knowledge work varies widely by scenario and the variation must be included.
- the replacement of fixed communications in general, for reasons of cost and convenience, as wireless infrastructure costs reduce, both in the home and the workplace.

The latter points mean that figures that may seem unreasonable today, especially for length of usage in the workplace, would be the likely case as we approach 2020 for certain scenarios.

3.8 Estimating the services and their characteristics

The services are listed as shown in Table 4. Extra parameters have been added as an example on the right hand side for each service, although all may not be used, according to the complexity of calculation required. Even further parameters may be added as desired.

Note that by a service we imply a communication or application that relies on an external carriage of data by some form of service provider, be it an operator or an unlicensed service provider using perhaps unlicensed spectrum. This excludes a communication or application that is part of the equipment such as a Bluetooth connection from a keyboard to a computer of some kind, used as an internal transfer mechanism.

The application service description describes the attributes of the traffic, in terms of symmetry, isochronocity and latency requirements and can also be assessed in the ITU classes such as:

- Constant Bit Rate (CBR) – peak bit rate takes a constant fixed value, guaranteed.
- Variable Bit Rate (VBR) – dynamically vary throughput as required for the service.
- Available Bit Rate (ABR) – no delay or delay variation requirements, non-real-time.
- Unspecified Bit Rate (UBR) – no traffic related service guarantees, for non-real-time.
3. Methodology

However, there is the question of whether such complexity is necessary and justifiable. Debate continues over what are useful parameters (in the sense that they are in any way reliable for a fifteen-year time frame). As a general rule it may be advisable to reduce the detail in parameters, in a reductionist approach, to what is absolutely necessary and can be reasonably defended for such long timeframes.

For the purposes of traffic calculation, we can use (at least) three levels of granularity in services. We can go to the next level down from a Basket of Services, to sub-groups, but could expect that to result in a list in the order of over 30 types. Going down to an individual service level would require choice from over 130 different possibilities, making allocation difficult, in that it becomes far more arbitrary for the long term and far longer to calculate, but with less justification for each service choice.

Thus we see advantages in course granularity. We proceed by matching the Baskets of Services with characteristics of ‘Network service types’, which can be in the terminology, definitions and concepts used within the ITU WP8F deliberations and the CEPT/operators etc, for instance a bit rate. That means we use a matrix of, say, four Baskets of services, for nine types of user, in three scenarios, with three Epochs for both consumer and business usage (a calculation from 648 market conditions).

The characteristics of parameters chosen to represent the service in a statistical sense must
also be carefully considered, as to what will be most useful and valid. For instance, the key parameter for wireless channel engineering is perhaps the bit rate as it gives the indication of throughput required to carry the service, and the network capacity required, when multiplied by numbers of expected subscribers. However, a Basket of Services will contain many traffic types and whether an average or peak bit rate is used can lead to severely underestimating – or overestimating – demand.

Thus a judicious choice for what really represents the class may require a balance between degree of commonality and adequate capacity. Of the choices therefore between an average or a peak value, some form of suitably balanced average may be preferable, for reasons of overestimation for peak – as a peak may well refer to a service that is very little used in terms of usage per day and numbers of users.

But what form of average? The measures of mean and median may give an underestimate being skewed by low values of the analytic parameter, so it may be better to examine the mode, the most commonly found bit rate across the services. However, we may need to take the highest in a case of even a fairly close tie. For instance, if we were examining a Basket of Services with 40 component services, and 14 required ATM class 4 (<2Mbps) while 17 were at class 3 (<384kbps) it would be prudent to take the mode value as class 4 for the Basket of Services in estimating traffic, in view of the trend that higher bit-rates will be rolled out as time progresses, if demand justifies it and the technology allows it – i.e. there is a trend towards always-higher bit rates.

However we also have to moderate this somewhat by the impacts of the advance of computing power for data compression against raw bandwidth, again with variation of compensation for bandwidth to have more effect as 2020 approaches and for the scenarios which point to a greater rate of technical advance.

<table>
<thead>
<tr>
<th>CONTENT TYPES</th>
<th>SERVICE TYPES OR CATEGORIES</th>
<th>CBR</th>
<th>VBR TRAFFIC CLASS</th>
<th>ABR</th>
<th>UBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entertainment – Broadcast streaming</td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td>40%</td>
<td>60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High multimedia (&gt;30 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entertainment – Narrowcast, VoD for sports etc. Games, Music downloads and streaming</td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td>20%</td>
<td>20%</td>
<td>30%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Possibly High multimedia (&gt;30 Mbps))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entertainment – Peer to peer: own content, including hived Games</td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Possibly High multimedia (&gt;30 Mbps))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEALSBS</td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td>30%</td>
<td>20%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-commerce: shopping etc. with transactions, and (interactive) video</td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td>10%</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-banking – transactions/biometrics</td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td>20%</td>
<td>80%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine 2 Machine (industrial sensors, telemetry etc and consumer smart home/entertainment centre)</td>
<td>Very low bit rate (&lt;16 kbps)</td>
<td>30%</td>
<td>30%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health services, telemedicine</td>
<td>Very low bit rate (&lt;16 kbps)</td>
<td>10%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
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<td></td>
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<tr>
<td></td>
<td>High multimedia (&gt;30 Mbps)</td>
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</tr>
<tr>
<td>Public service applications including urban management, security etc</td>
<td>Very low bit rate (&lt;16 kbps)</td>
<td>10%</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Business applications</td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td>20%</td>
<td>20%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service sector business applications including file transfer, web browsing, secure transactions, DB access, etc</td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td>20%</td>
<td>20%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Medium Multimedia (&lt;2 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communications – voice incl. VoIP</td>
<td>Very low bit rate (&lt;16 kbps)</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communications – video interactive</td>
<td>Medium Multimedia (&gt;2 Mbps)</td>
<td>10%</td>
<td></td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>Communications Messaging MMS, SMS, IM, email</td>
<td>Very low bit rate (&lt;16 kbps)</td>
<td>20%</td>
<td></td>
<td>30%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Multimedia &amp; Low rate data (&lt;144 kbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium Multimedia (&gt;2 Mbps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In contrast to a reductionist approach, far more complex analyses can be given from the FMS process - for instance if so desired, the breakdown of the content type of each major application set can be viewed against traffic class and service category, as a percentage traffic in each of the ITU Traffic Classes, see Table 5.

This may be used to create the table of ITU Service Category and Type, as shown in Table 6.

### 3.9 Traffic volumes estimation

Traffic volumes are calculated by identifying the network traffic generated by each service type at a network level, transformed from the application level, for each class of user. The traffic volumes are generated using a table of the user types, with the services they select and the degree of usage of each service. A spreadsheet is used for each scenario and epoch to calculate the traffic generated by each type of user (consumer and enterprises) for a basket of services. An example is shown below for illustration. Each spreadsheet has built into it parameters that can be varied for each scenario and epoch.

For the consumer segment users, these variables are:

- Population by age group
- Proportion of population by income
- Proportion of users within each user category

- Usage of a basket of consumer services
- For business or enterprise users, the variables are:
  - Population
  - Employment rate
  - Proportion employed in service or non-service sector
  - Employment by size class of enterprise
  - Usage of a basket of enterprise services

The network traffic level per minute is multiplied by the estimated daily duration of usage of the service in minutes, to generate a traffic load, which may be in bits per second, and is expected to add up to the level of Terabits per second at the level of a single service or a group of network services, as shown in Table 7 using the Smooth Scenario as an example.

### 3.10 Estimation of ITU generic methodology input parameters

The input parameters for the ITU generic methodology can be generated using the scenarios and the traffic characteristics as estimated in Section 3.10 above. The ITU tables (see section 3.2) may be completed by inspection using the scenarios as a market guide to the service environments, session durations and session attempts, as shown in the table below of main input parameters for the RAT (radio access technique) analysis of subsequent stages.

---

**Table 5: Service Category - service description and category number, SCx, against Traffic class.**

<table>
<thead>
<tr>
<th>Traffic class</th>
<th>CBR Constant</th>
<th>VBR Variable Bit Rate</th>
<th>ABR Available</th>
<th>UBR Unspecified (no guarantees)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE</strong> Service types</td>
<td></td>
<td>Real time</td>
<td>Burst-real time</td>
<td></td>
</tr>
<tr>
<td>1 Very low bit rate (e.g. Speech &amp; SMS) (&lt;14 kbps)</td>
<td>Voice SC1</td>
<td>SC1-12 Low delay traffic transactions e.g. RFID</td>
<td>SC18 VAP, SMS, low rate data transmit e.g. monitoring</td>
<td>SC26 Low priority Email, SMS, MMS, ALARM</td>
</tr>
<tr>
<td>2 Multimedia &amp; Low rate (data&lt;144 kbps)</td>
<td>SC2</td>
<td>SC2-8 Slow user Surveillance video monitoring &amp; transactions</td>
<td>SC24 Video streaming, Video download, Secure commerce, M-banking, Business applications</td>
<td>SC28 Low priority Email, SMS, MMS, ALARM</td>
</tr>
<tr>
<td>3 Low/Medium Multimedia(&lt;256 kbps)</td>
<td>Video interactive mobile TV SC3</td>
<td>SC9 Security transactions (Biorobots), Telemedicine, Video interactive, Streamed video (ports events), IP Video-Radio</td>
<td>SC15</td>
<td>SC2 Video streaming, Video download, Secure commerce, M-banking, Business applications</td>
</tr>
<tr>
<td>4 High/Medium Multimedia(2 Mbps)</td>
<td>Video interactive mobile TV SC4</td>
<td>SC10 Security transactions (Biorobots), Telemedicine, Video interactive, IPTV (Broadcast TV, IP Radio, Streamed video (ports events))</td>
<td>SC16 Security downloads and networking, video interactive, video conferencing</td>
<td>SC3 Consumer &amp; business Mobile internet/ Business intranet/ extranet, Email, Business applications</td>
</tr>
<tr>
<td>5 High multimedia(&gt;30 Mbps)</td>
<td>SC5 Mobile HDTV &amp; Video</td>
<td>SC11 High volume business applications, IP (Broadcast, HDTV &amp; video)</td>
<td>SC17 High volume business applications</td>
<td>SC4 Video download &amp; streaming, Business applications</td>
</tr>
<tr>
<td>6 Super High Multimedia(30 Mbps to 100M/1 Gbps)</td>
<td>SC6</td>
<td>SC12</td>
<td>SC18</td>
<td>SC5 Mobile intranet/ extranet, Business applications</td>
</tr>
</tbody>
</table>
The demand for future mobile communications markets and services in Europe is large, and it is expected to grow significantly. The key step is to create a master matrix as shown below using the table of ITU Service Categories (see section 3.9). This will be modulated by the FMS findings on two areas - traffic overall and urban growth, which affects each Service Environment population:

The steps are as follows:

- The Master matrix is drawn for up for the reference situation (e.g. Epoch 1, Scenario1) using input from the scenarios on applications usage and the service categories associated with those applications (section 3.9). The Master Matrix is taken as the start point, to be modulated by the findings from the traffic analysis.

- A matrix of total traffic levels (as generated in section 3.10) for each Scenario and its Epochs, expressed as ratios with this start point (Epoch 1, Scenario1 in the FMS project) is then created and used to modify the session characteristics of duration and session attempts per day.

### Table 7: Smooth Scenario.

<table>
<thead>
<tr>
<th>Epoch: 2010</th>
<th>Consumers</th>
<th>Enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(x 1000)</td>
<td>(x 1000)</td>
</tr>
<tr>
<td>Age 15-64</td>
<td>82,241.25</td>
<td>69,905.06</td>
</tr>
<tr>
<td>low income</td>
<td>66.52</td>
<td>80,503.06</td>
</tr>
<tr>
<td>Age 0-14</td>
<td>17,811.75</td>
<td>35,625.35</td>
</tr>
<tr>
<td>low income</td>
<td>28.86</td>
<td>95,755.97</td>
</tr>
<tr>
<td>Age 65+</td>
<td>21,260.75</td>
<td>63,763.29</td>
</tr>
<tr>
<td>low income</td>
<td>11.52</td>
<td>73,477.15</td>
</tr>
<tr>
<td>Age 15-64</td>
<td>21,387.25</td>
<td>203,135.85</td>
</tr>
<tr>
<td>med income</td>
<td>23.04</td>
<td>456,025.65</td>
</tr>
<tr>
<td>Age 0-14</td>
<td>45,310.55</td>
<td>139,833.17</td>
</tr>
<tr>
<td>med income</td>
<td>40.32</td>
<td>560,172.41</td>
</tr>
<tr>
<td>Age 65+</td>
<td>55,277.95</td>
<td>22,111.16</td>
</tr>
<tr>
<td>med income</td>
<td>23.04</td>
<td>509,441.59</td>
</tr>
<tr>
<td>Age 15-64</td>
<td>32,998.59</td>
<td>31,251.88</td>
</tr>
<tr>
<td>hi income</td>
<td>44.16</td>
<td>138,007.97</td>
</tr>
<tr>
<td>Age 0-14</td>
<td>71,247.70</td>
<td>28,498.88</td>
</tr>
<tr>
<td>hi income</td>
<td>40.32</td>
<td>114,907.16</td>
</tr>
<tr>
<td>Age 65+</td>
<td>85,043.30</td>
<td>42,521.15</td>
</tr>
<tr>
<td>hi income</td>
<td>48.00</td>
<td>204,013.30</td>
</tr>
<tr>
<td>Total</td>
<td>485,255.00</td>
<td>357,339.58</td>
</tr>
<tr>
<td></td>
<td>268.80</td>
<td>842,248.62</td>
</tr>
<tr>
<td></td>
<td>180,930.75</td>
<td>189,767,552.26</td>
</tr>
</tbody>
</table>

Total Consumer + Enterprise Usage: 27,400,434.03

### Table 8: Master Matrix.

<table>
<thead>
<tr>
<th>Master Matrix</th>
<th>SC</th>
<th>SE</th>
<th>Comments &amp; Description</th>
<th>Market</th>
<th>Number of session attempts</th>
<th>Average End to End BIT Rate (Mbps)</th>
<th>Average Session Duration (sec)</th>
<th>Mobility Ratio (%)</th>
<th>Stationary</th>
<th>Low</th>
<th>High</th>
<th>Super High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very low bit rate &lt; 16 kbps</td>
<td>1</td>
<td>5</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mobile voice</td>
<td>2</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Backhaul</td>
<td>3</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Metro</td>
<td>4</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rural Access</td>
<td>5</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multimedia &amp; Low Data</td>
<td>1</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Broadband</td>
<td>2</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CoS switched</td>
<td>3</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>4</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fixed Medium Mult Access</td>
<td>5</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Voice Interactive</td>
<td>6</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mobile TV</td>
<td>7</td>
<td>0</td>
<td>0.016</td>
<td>100</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Also modified by Scenario and Epoch are the proportions of rural to urban and suburban user population in the degree of urbanisation expected by scenario, using a table of urban development by Epoch for each Scenario which applies to both consumer and business (mainly office) traffic.

To differentiate the traffic parameters, the duration and number of sessions are multiplied by the traffic ratios for that Scenario/Epoch, using a square root factor on session and duration, as it is their product which is used in total traffic estimation, by service environment and service category, as shown in the rows of the Table 8.

This process produces a new table of ITU input parameters for each ITU market situation (Scenario/Epoch) – in all, nine such parameter tables by Scenario/Epoch for the FMS project. The overall process is illustrated diagrammatically in Figure 23.

The interesting question is whether the resultant Master Matrix can be used more generically, regionally across the world, although it has been drawn up for an EU situation. Certainly the scenarios may be more widely applicable, but it is open question on how applicable they are to other regions or individual countries.

3.11 Factors for completing the key tables for User Profiles and ITU Parameters

In completing the key tables for User profiles and ITU parameters, the team has used a certain number of factors which require further exposition. These factors are based on insights from the scenarios but with a depth of knowledge which is more than inspection – it requires a comprehensive understanding of the motivations and needs table for each scenario and of the applications services table, of what is available to match needs.

We note that the factors are applied universally across the set of EU countries, without analysing deep national differences since a major tenet of the scenarios is that the EU acts as unit. Where differences do arise in economic pace by geography (see Scenario 3) they do not follow national boundaries but more internal regional sub-national environments.

This assertion of uniformity is only justifiable under the assumption that the new accessions...
will quickly catch up, because they will tend to act like NICs (such as China), rapidly advancing in the right context of opportunity, with the advantage of not having so much of a legacy telecommunications environment to resist change and so able to leapfrog generations of technology. The assertion is further made that already by 2010 this gap will have closed to some extent, enough such that continuity is justifiable, even in the less optimistic scenarios.

A summary of factors is given below, with the most obvious first:

1. Overall level of usage varies by scenario, as does rate of take-up for any epoch, driven by scenario conditions of disposable income, and consumer and business confidence

2. Overall level of sophistication of usage varies by scenario and epoch

3. Analysis of the consumer by disposable income (high/medium/low income) must be carefully weighed, as must behaviour pattern by age-group.

4. Business users’ usages in volume and type of application must be set in the context of growth in the numbers of micro-enterprises and SMEs by the economic situation of the scenario, and the ongoing trend to shed of staff in large organisations as we move through the epochs, especially outside the public sector.

5. Communications (the main application service set today) progressively give way to a mix of communications and applications services, with a rate of take-up and degree of usage varying strongly by scenario. In the most extreme scenarios, networked applications such as entertainment, or lifestyle such as location enabled applications or banking, exceed communications (such as voice or messaging). The take-up of the more advanced generation of applications is assumed to take at least two epochs.

6. New drivers of traffic, never seen before, will arrive with a second generation of applications, especially in sophisticated machine to machine communications, M-government etc. The general future trends in applications are discussed as set in Chapter 9.

7. A strong driver in sessions and session length is the migration to radio/mobile connection from fixed. This occurs progressively as prices of radio-based services fall, so fixed line eventually is more expensive, while the quality of service for radio becomes equal to fixed lines.

8. The most commonly used access to the web progressively becomes a mobile radio access channel for the mass of EU citizens.

9. As applications become more sophisticated, in the more optimistic the scenario, the more consumer traffic will tend to equal or exceed business traffic, as its utility becomes an essential toll for everyday living that is both affordable and accessible.
4. The Scenarios, in Summary

4.1 The basic premise of the scenarios

The basic premise put forward by DG Information Society, and from an initial survey of other studies, is that the market development in wireless services depends on a range of different classes of factor, with economics being dominant. For instance, the Iridium project for a LEO MSS (Low Earth Orbit Mobile Satellite Service) offered global mobile communication coverage. But not at a price that world-travelling business users, let alone consumer markets, were prepared to pay. Moreover, the target market of global business travellers and remotely located businesses may not be that large, as a separable segment. While the concept was excellent, perhaps what was needed was a later generation of the technology to bring prices down from several US dollars per minute to a fraction of a cent. Until that occurs, the terrestrial mobile communications offerings would appear to dominate through affordability.

So our scenarios start with a socio-economic perspective. This perspective usually sets the scene in the European market - taking in economic/financial/geopolitical factors, combined with a strong basis in the reality of social and cultural factors - to understand demand and the premises of a realistic business case. Discontinuities may also appear. To start, we need a range of scenarios, with an economic-social foundation and then consider the issues in more detail to do with the supply of applications and services and demand for these and other services.

4.2 Common initial conditions

Our scenarios start with choice of a common set of initial conditions, founded on today’s conditions inside and outside the EU:

**INITIAL CONDITIONS**

1. New accession states have expanded the EU - impacts expected are mostly positive.
2. The set of the ‘EU fifteen’ is largely a set of linked national economies which are all consumerist, so the micro-economics of personal wealth and its formation are strong deciding factors in the macro-economy, especially the cost of housing and the borrowings to pay for that. This implies that personal debt levels are high in the EU 15 and will spread to the new accessions, as housing inflation arrives.
3. Global instability exists in the Middle East major wars ongoing; Russia is destabilising.
4. Global capitalism is becoming a significant, if not the dominant, driver straddling the regional trade blocks (EU, NAFTA, ASEAN, Mercosur) and has put pressure on Europe to focus on its competitive stance as a region for investment.
5. World trade is liberalising but there are still major barriers to free trade that tend to favour either the developed world, or ordinary people and their jobs in the EU. In the light of this, globalisation itself is not always seen in Europe as having benign impacts on employment, free competition and lifestyles, and counter measures are viewed as sometimes necessary for a healthy balance.
6. Until now, the EU has been in a period of relative regional calm, with a growing standard of living which favours an emerging European lifestyle norm, based on consumerism, while alternative lifestyles have tended to die out in the member countries.

7. China and India are becoming new centres for products and services globally, in high technology, so that their growth rates can be expected to vary between 4% and 10% each year to 2020. The NICs are increasing their share of global GDP, expected to rise from under 10% to over 20% by 2020.

8. The USA, the largest market globally is decreasing in relative economic power for the first time in fifty years, while its current foreign policies may lead to a future isolationist stance. Moreover its ascendency in ICTs is reducing as mobile technology (the largest software and hardware component challenge for the next ten years) is increasingly centred in Europe, Japan and China. It is driving those economies in service and product revenues.

9. Current annual global spend on defence is near US$ 1 trillion. But spend on development assistance is only 5% to 6% of that.10

10. The EU faces major challenges in reforms of agricultural subsidy, and in most member states in the areas of labour laws and restrictive bureaucracy, especially regarding company operations.

11. Major assets inflation in housing is under way across the EU, and globally - a new economic threat as more people try to own their own home seeing it as a way of saving, of giving them stability.

12. Families are retreating from the outside world - so the home become the office, the cinema, the playground - thus the home is has more individual private space, as people spend more time there.

13. The price of energy - natural gas, and not just oil - is rising and has done over the last two years, with oil from under $30/barrel to over $50 at its recent peaks (Oct 2004).

14. Education systems and health systems across the EU are patchy, often poor and subject to high costs inflation, while the demands on these services are increasing rapidly, especially for retraining.

15. With an ageing European population, there are crises in active-population work-ratios (exacerbated by forced early retirement), failures of pension funds with poor planning and reserves, and in overloading of health and care services, with a situation expected to get worse, unless intelligent remedial action can be brought into play in retraining an older workforce, without age limits. Over half the voting population of the E-15 will be over 50 years old by 2020.11

16. Global warming is eroding the economy, not just the environment, in that new patterns of weather, and sea and land disposition disturb development, or may destroy it completely (increased hurricane seasons, droughts, floods, El Nino, etc) while pollution (smog, radioactive leaks, chemical waste) causes major health problems and so heavier health service costs (asthma, 

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cancer, birth defects, etc). Strong secondary affects include the insolvency of large insurance companies and the raising of insurance premiums by over 100%, with creation of government insurers of last resort.

17. Dependence on high-risk financial instruments, specifically derivatives, is rising following the crash in equities from 2000 – 2003, as investors seek new high return schemes.

18. AIDS and other pandemic diseases are in check in Europe but increasing rapidly in South Africa, Africa as whole, India, Russia and Asia generally.

19. Outsourcing offshore from the EU is occurring, but under non-extreme conditions will not impact employment levels as seriously as current headlines may predict. 60% of jobs moved are from one member, the UK. Net offshored jobs to India and elsewhere will be largely in the services sectors of IT and call centre support, as well as back office clerical processing, with a total predicted of 1.2 million jobs by 2015 (<1/2% of EU).12

20. Migration into and out of the EU is fairly stable. The future depends on extreme conditions (war, financial failure and famine) usually elsewhere in the world, as well as the general internal economic climate in the EU and its regions. Rapidly growing markets such as China now attract engineers and managers, once drawn to the USA’s Silicon Valley. Overall, a net loss of workers, through emigration may be expected under some scenarios.

4.3. Comparing the five scenarios

We constructed five contrasting economic scenarios for the period 2005 – 2020, as three Main scenarios and two Discontinuity or wild card scenarios applicable to any main scenario.

The Scenarios were:

1. Smooth development (main) – EU economies unite to provides growth and positive progress in development, but in a fair and managed way that brings prosperity across all 25 members.

2. Economic stagnation (main) – the EU continues peacefully, following a slow but general decline, rather like the Japanese economy between 1988 and 2003, with gradually shrinking output and unsuccessful, or frozen, government policy reactions to strong deflation; EU left behind in growth by Asia.

3. Constant change (main) – up and down, but overall moderately positive trend, through ad hoc growth and recession, often in parallel in different areas or countries – a strong flux of stop-go progressions and regressions in specific areas of the EU. Slowly prosperity does increase for many in the EU.

4. Financial crash in EU (discontinuity) – an economic disaster within the EU and spreading beyond, comparable to the 1929 crash, but with affects for over 5 years.

5. Disaster (discontinuity) – natural disaster, major war or nuclear / chemical/biological accident or terrorist attack - seriously impacts EU economy long-term, to 2020 and beyond, possibly making a small part of the EU uninhabitable temporarily. Other regions (ASEAN, NAFTA) affected but not so seriously.

4. The Scenarios, in Summary

Mapping scenarios against economic and social conditions positions and differentiates them, see Figure 24.

4.4 Comparison by analysis of need

One of the main challenges with a set of scenarios is maintaining strong links to the

Figure 25: Comparing development of Five Socio-Economic Scenarios
The Demand for Future Mobile Communications Markets and Services in Europe

original objectives – what the scenarios were supposed to illuminate – in this case, to highlight trends in services demand. A first step in this comparison, is to examine EU economic growth, as relative economic output and the social/cultural conditions in terms of affordability, with disposable income, see Figure 25.

Viewing the needs and the temporal change in needs across the scenarios, as indicated by the each socio-economic picture, is the next step to providing a link between services and scenarios, without pre-empting valuable insights.

Then outside experts may deduce from that information whether specific services can be identified. However even this should be taken carefully, as only one possible view, because other interpretations of what are the real needs, or their relative significance can be made. Need should be expressed at several levels - in terms of personal needs (for instance affordability, or belonging) and also at the EU level for macroeconomic success and then at the level of business, for the types of business that are likely to be dominant at the time. Effectively, this approach can also be used to compare and contrast the scenarios.

The changing needs, with time, for each scenario, are summarised in Table 9.

### 4.5 A brief examination of the scenarios

We now examine in a brief synopsis of each scenario, from extracting the key points.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. SMOOTH</strong></td>
<td>Generating knowledge work through affordable re-training. Ubiquitous employment discovery, access and retraining.</td>
<td>Control of everyday life - ease of access to convenience services. Support for extended family ‘tribes’. Ease of trade at low cost. Expansion of business reach geographically.</td>
<td>Advanced support services at low cost for health, social requirements, education International co-ordinated working across the EU / globally</td>
</tr>
<tr>
<td><strong>2. CHANGE</strong></td>
<td>Access employment - find - retrain Simpler infrastructure and laws for SMEs</td>
<td>Support to (re)build life in new regions Support for clustered communities of SMEs Conserve cash to live through downturn</td>
<td>Build remote environment – through constant contact with remote family, perhaps remote work and training Distributed business operations across EU</td>
</tr>
<tr>
<td><strong>4. MAJOR DISASTER</strong> (discontinuity)</td>
<td>Prevent attacks Limiting damage. Immediate physical survival</td>
<td>Long term survival. Physical support – health, protection, location. Rebuild physical infrastructure Participation and control of political environment.</td>
<td>Rebuild society. Advanced support services at low cost for health, social needs, and education. Working in a fragmented physical environment across EU.</td>
</tr>
</tbody>
</table>

| Table 9: Analysis of needs by scenario and Epoch. |
4. The Scenarios, in Summary

**Economic and social factors**
- Knowledge work for some 80% of the population
- Increased move towards single parent families, single person households.
- High disposable incomes of a median of €6000 per year across EU.
- ICT is a positive force, accelerating the economy. Sophisticated systems based on ICTs give better service at far lower cost.
- The service sector, makes up some 75% of the EU’s output – it is supported by a new generation of ICTs based on mobile (radio) technology which contribute measurable benefits.
- A key example is in health systems, which have enormous potential for cost cutting and whose cost would be increasing without the new technology. Public service wireless systems for m-government, and operation of the environment in policing and surveillance are important.
- Europe uses 4G wireless judiciously to generate new demand just as GSM did, for high technology services and products, as a way to turbo-charge the economy. After 2010, new EU services and technology to exploit the free bands take off, despite protests from governments and incumbent mobile operators, who have received or paid fortunes for 3G licences, giving a lower cost mobile infrastructure.

**Usage of Services**
- Spread of distance working
- Most people’s waking day is spent in use of some form of communication or processing
- Complex online shopping experiences, popular from about 2012 onwards.
- Distance learning services over mobile networks assure through-life learning and retraining
- Equipment for the interactive services connected over WiMax 2
- Voice-SMS
- The entertainment market in services and their support gadgets for entertainments, especially sports and music/videos and new growth from 2010 of 3D immersion soap operas but is small compared to lifestyle services
- Machine to machine communications at all levels from industrial plant to consumer goods like cars becomes important in the final Epoch, as 2020 approaches.

**Industry structure and Technical offerings**
- From 2007 onwards Europe invest heavily in early forms of 4G, often built on 3G protocols with ad hoc mesh structures and new optimisation policies for routing, all being founded on a new security structure.
- Investment in a new secure IT infrastructure beyond today’s Internet and PCs. The majority of devices, but especially smartphones and PDAs, move away from anything resembling a Wintel architecture. By 2011, a new generation of software, firmware and hardware structures will be designed around secure operations
- From around 2006 on the Internet and current computing technology (PCs especially) are considered unsuitable foundations for communications and processing in a computing and networking world that has become highly malicious. From 2008 the Internet is replaced by communications structures expectant of attack and which are highly robust. This is essential to conserve the trust of users. Mobile handsets and portable computers become strongly resistant to attacks as their usage spreads and users’ dependence becomes absolute.

---

### Scenario 1 - Smooth development

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMOOTH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Generating knowledge work through affordable re-training.</td>
<td>• Control of everyday life - Ease of access to convenience services.</td>
<td>• Advanced support services at low cost for health, social requirements, education.</td>
<td></td>
</tr>
<tr>
<td>• Ubiquitous employment discovery, access and retraining.</td>
<td>• Support for extended family ‘tribes’.</td>
<td>• International co-ordinated working across the EU / globally.</td>
<td></td>
</tr>
<tr>
<td>• Ease of trade at low cost.</td>
<td>• Expansion of business reach geographically.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Scenario 2 - Economic stagnation

<table>
<thead>
<tr>
<th>Scenario 2</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
</table>
| STAGNATION | • Belts tighten in the family and the firm. Disposable income and consumption restricted.  
• Search for lower costs of doing business.  
• Simple SME support.  
• Search for security. | • Reducing outlays. Seeking employment either in conventional or in underground economies.  
• Operating business at low cost.  
• Simple business services.  
• Support for rural communities at low cost. | • Simple lifestyle at minimal cost.  
• Support for trading and bartering in a non-enterprise based economy.  
• Support for migrant workers overseas including financial remittances. |

### Economic and social factors
- White collar employment continues to fall, accelerated by offshoring of the most mundane business processes. Technology is used to create simple efficiencies in routine work, not to open new doors to employment in new pursuits, so it eliminates employment generally.
- The EU stagnates with active employment gradually falling from its already low 2002 level of 64.3% of the active population to 60% after 2010, reaching less than 55% by 2020.
- In initial stagnation years the unemployment rate reaches an EU average of 15%, rising to over 20% by 2020 (but for <25 years and >50 years it is nearly 50% in many countries)
- The effective taxable base reduces by 20% between 2005 and 2020 as the population ages, and unemployment increases while salaries diminish in real terms by 2% annually over this period.
- Deflation in most consumables occurs except in housing, whose price is stagnant and so it increases in real terms. Energy prices for heating, lighting and transport are also growing in real terms far more rapidly, while average interest rates are kept fairly high at around 7%.
- The costs of higher education are increasing across the EU at around 5% to 10% per year so fewer can afford to enter higher education and gain better paying skills, apart from an elite. This pushes the disparity of incomes further forming a pyramidal class structure and excluding many.
- The unemployed gradually turn to alternatives in bartering. A grey economy of undeclared revenues becomes near 25% of GDP by 2020. A new “green” economy flowers in agricultural regions centred on barter in agricultural products, services and manufactured goods. By 2020, the combined green and grey economies in many EU members account for over 60% of the total GDP.
- The number of citizens below the poverty line increases to over 12%, reached in 2010, then 15% in 2015 and 18% by 2020. Under-nourishment and poorer health affects 20% of people in the EU.

### Usage of Services
- Due to industry structure, and the falling disposable income, consumer prices in all telecommunications services remain comparatively high and may even increase in relative terms.
- ICTs, especially advanced wireless systems, tend to be used only in large business organisations and their spread into consumer segments is slow and even reverses. Around 2009-2011, a new “green” economy flowers in agricultural regions centred on barter in agricultural products, services and manufactured goods. By 2020, the combined green and grey economies in many EU members account for over 60% of the total GDP.
- EU citizens have an increasingly negative view of IT and tend to reject it
- Only very minimalist very low cost services succeed in the consumer segment, predominantly prepaid so costs can be controlled. Advanced consumer services are limited to a high end elite.

### Industry structure and Technical offerings
- Telecommunications is dominated by the incumbents – in the uncertain trading conditions, incumbents convince government to protect them against cheap VoIP, new small operators and MVNOs, and any new technologies undermining the 3G mobile investments of the incumbents in mobile or fixed line services by wireless broadband.
- There is a conflict between traditional pricing of services based on a growth economy, in line with an incumbent’s traditional expectations, and the real desires of consumers, which cannot be satisfied on lower pricing due to the lack of competition.
- Effectively there are no new market entrants as market access is held back by the incumbents, through predatory pricing and cross-subsidising services.
- A phased succession model is enforced for any follow-on from 3G mobile systems so many operators (and some key suppliers) are slow to implement 4G. Governments and operators consort to preserve 3G mobile licence dominance and resist 4G takeoff so that 3G systems dominate the market. No real evident or latent market pressures for 4G services arise. In the EU, the market stays with 2.5G, 3G and 3.5G (faster data download, etc) though globally there may be some more advanced initiatives.
4. The Scenarios, in Summary

Economic and social factors

- Constant economic output change, up and down with ad hoc growth and recession, often in parallel in different geographic markets, but moderately positive overall.
- European level initiatives do not set the scene or rule except as background of moderation and scene setting in employment laws, company law and bureaucracy.
- SMEs are the key to growth, employing 85% of the active population with 95% of the new jobs.
- Everyone is a migrant from some other part of the EU, or possibly far further afield.
- Thriving local regions appear that have all or some of the following – low cost of living (specifically housing to keep down salary costs, the key cost driver in a knowledge-based society), an educational surplus of well-qualified people (all ages), centres of excellence in a high technology.
-Disposable income is generally low and employment is highly fragmented by geography, sector and working conditions. Disparity in incomes is large, but instead of being between the working poor and the rich with non-earned wealth, it is between the working and the unemployed.

Usage of Services

- To meet the needs belonging and social comfort, long distance links are required to talk to family and also to find new work when the local economy fails.
- Communications are an essential household expense to stay in touch with disparate families at home and friends and family in multiple regional centres, and also for searching for new work, in another region perhaps, and for reskilling.
- Communications needs displace other items in a personal budget giving a relatively large spend on telecom services.
- Lifestyle services become crucial to support a migrant lifestyle. Convenient access to secure financial transactions is a must for the legions of migrant workers, and for all the financial sector. The services must be highly easy to use and convenient as most people are time-poor, and they must be trusted, that is secure for remote transactions.

Industry structure and Technical offerings

- ‘Guerrilla’ markets arise, as an outgrowth from opportunistic investments in parallel technologies to 3G and 2G mobile. New entrants appear, starting with VoIP over WiFi, combined with early unlicensed spectrum for long distance WiFi (low cost point to point forms an alternative infrastructure). Good quality IP Voice over WiFi (dual mode handsets) is offered. Security problems of WiFi solved, and power requirements of WiFi become refined (to microwatts).
- Regulators allow unlicensed bands for WiFi voice and high speed data services, with a major spurt in unlicensed bands beginning from 2010.
- WiFi networks spread in an ad hoc pattern across the USA, Asia and into Europe. WiMax pushes in fast behind, to interconnect and finally displace WiFi, due to its roaming option, and a range of 50 kms and up to 70Mbps bit rates with a base station switch price of €100,000. WiMax 2.0 also challenges CATV and fixed line broadband access. A niche industry appears to serve the long distance market with rock-bottom equipment costs, especially in LDDPG’s (long distance directional propagation ducting guides i.e. recycled Pringles tins).
- A complete 4G mobile system with roaming handover and mesh working appears from Asia and is implemented to act in dual mode and so augment WiFi, and subsequently, WiMax. 4G grows fast (increasingly so after 2010), starting through a limited offering from the new market entrants, such as the WiFi service providers. In the EU, some new entrants are offshoots of the incumbents, with a business model based on economy pricing of voice and data.
- The pattern of take off in Europe is with dual-mode and then multiple-mode handsets - first stage is existing mobile systems (2G-GSM/GPRS/3GPP) and WiFi-WiMax, with customer contracts over multiple bundled networks. In a second stage, a limited form of 4G mesh technology appears as high speed mobile with WiFi air interfaces and WiMax (after 2010) but a complete 4G environment takes some 6 years to arrive (up to 2016), in the form of pockets of access across the EU, that cover economic, not political regions.
**Scenario 4 - Financial meltdown**

<table>
<thead>
<tr>
<th>Scenario 4</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
</table>
| FINANCIAL CRASH | • Consumerism, gratification up to Crash  
                 • Complex, rich business services up to Crash  
                 • Crash occurs around 2009 | • Family and personal survival on very low funds.  
                 • Minimise cost of living.  
                 • Substantially reduce cost of doing business.  
                 • Public services repair employment and economy. | • Retrain and rebuild stable life and income.  
                 • Expand public services to positively invest in the economy and improve SME survival chances. |

**Economic and social factors**

- From 2010 to 2016, the crash’s combined impact on derivatives and an over-mortgaged population also destroys personal wealth.
- EU GDP shrinks, for around 6 years by an average of 3% to 5% per year, then around 2016, economic shrinkage bottoms out. Growth resumes at a slow rate (0.5%) until 2020.
- Following the crash average salaries decline in real terms faster than prices, resulting in lower purchasing power. Average discretionary per capita annual disposable income shrinks from an average of €6000 in 2007 across the EU to nearer €1500 in 2016 but then increases to 2500 € by 2020.
- Saving in the EU has fallen to low levels (under 1% of GDP) by 2011 as repaying housing takes all available income.
- EU household sector debt has reached 85% of EU GDP by 2009, that is, at USA levels, due to rapid house-price inflation.
- Recovery begins to appear from 2016 onwards.

**Usage of Services**

- Cost is the key, following the Crash, both cost of the transaction itself and in the value of the goods and services.
- Starting in 2005 with an average monthly subscription of €60, 3G services are slow to take off but finally do so up to 2009 (the Crash) fuelled by a reasonable economic situation, and rapidly falling mobile service and handset prices.
- Low cost m-commerce transactions at a fixed price appeal to merchants unable to reach the mass of consumers trapped in remote regions following the Crash.
- The need to telework and teleshop from remote locations interleaved packets for around 0.05 Euro for half an hour of backwards and forwards instant texting.
- Prices for voice calls are now going to 0.1 Euro per call, any length on pre-pay from a new MVNO.

**Industry structure and Technical offerings**

- The Crash takes the operators, regulators and suppliers completely by surprise so that a year later, consumer and business revenues have fallen by over 50% and many telecoms players are downsizing rapidly, or entering receivership. The priority of all operators becomes how to cut costs to the consumer by 90% and more.
- Up to the Crash, European market recover slowly from overspend in 3G auctions with rollout of over 100 limited 3G networks so a form of wideband services are available in pockets across the EU. Following the Crash, the ICT sector recovers through very low cost, highly useful products and slashing the prices of services with new technologies and pricing plans.
- Regulators and government decide to turn to new technology from new entrants to provide a far lower cost of service, with the aim of costs at 10% of those in 2009.
- By 2012, major swathes of spectrum have been converted to unlicensed bands, the EU, NAFTA and the ASEAN community are financing rapid research programmes to launch complete standards and products for a 4G mesh system capable of replacing and/or integrating current networks, using the new IPv8 for high quality voice and a secure mobile Internet, aiming at fixed costs which are a fraction of 2G and 3G networks.
The Scenarios, in Summary

Economic and social factors

- Following the disaster, the EU economy shrinks 20% in the following year. As the scale of the catastrophe becomes clear, it is realised that the EU has been fragmented into go and no-go areas – where travel is impossible, or extremely hazardous. These areas form economic wastelands, possibly devoid of most life forms.
- Large migrations away from areas 200 kms around numerous sites occur with the major cities affected all being evacuated and temporary accommodation being necessary on a large scale.
- Recovery from the primary economic effects takes two years, during which EU is in recession with major loss of business confidence. Overall recovery takes ten to twenty years. Success in recovery depends on developing survival technologies for the disaster zone.
- The economy becomes dependent on intelligent application of advanced technology to recover, especially communications. In a second phase, new forms of administrative systems based on accessible IT systems that truly augment productivity are used for health and public infrastructure.
- One long term impact is likely to be a strong reduction in the numbers employed clerically, as a series of uniform business administration systems make it easier for companies to reduce and outsource clerical procedures and administration, in order to continue in existence. Such jobs are unlikely to return when stability is restored afterwards.

Usage of Services

- Mobile and wireless products move to the survival level in Maslow's hierarchy of need, from the higher levels, which respond to in self-assertion and convenience. They become a far more important part of the total economy, with a range of new products and services for reconstruction.
- Communications substitute for many activities, both business and leisure, where presence is difficult or impossible. Services such as m-business including banking will become far more important to avoid travel. Thus 'Tele-doing' of all kinds flowers - telemedicine, teleshopping, m-shopping, m-banking and secure financial transactions, tele-voting, remote instant interaction with emergency, social and administration services etc. M-government systems may enable constant participation in government, not just representation, may come from a radical restructuring of people's lives by disaster.
- The substitution effects of (wireless and mobile) communications can restore industries fractured by attacks, by coordinating activities across multiple sites to replace headquarters or whole businesses located in the disaster zones.
- Consumer attitudes to technology change by necessity, forced by experience and usage of highly sophisticated systems to rebuild the infrastructure by remote control, and to operate a consumer economy for fragmented households and businesses. A new reliance on all communications technologies, especially mobile technologies arises as a 'survival kit' - mentally and physically.
- Wireless and mobile will be essential as protective services with alerts, personal location for individuals in disaster areas. In total far more security preparations will be required. Technologies of vision, monitoring and remote control expand, to produce rebuilding tools at low cost, including remote care for heavily radioactive/chemo/bio contaminated personnel.

Industry structure and Technical offerings

- The first phase recovery is dependent on intelligent application of advanced technology, especially communications for interaction between machines as well as people.
- Communications become dependent on a minimum of fixed, built infrastructure. A fast way to put in infrastructure, without entering radioactive areas, for monitoring equipment etc will be necessary (e.g. a third generation of MSS LEOs, or HALES, for low cost and rapid deployment).
- Regulators endorse new radio services, possibly forcing transition of military and entertainment broadcast bands to the new technology demands for unlicensed spectrum suited to new generations of radio technology for communications, remote sensing, and control of rebuilding.
- Thus 4G mobile might possibly come to the fore as the technology of choice for narrow band and wide band communications, driven by the need for non-physical infrastructure.

Scenario 5 - Disaster incident

<table>
<thead>
<tr>
<th>Scenario 5</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAJOR DISASTER</td>
<td>• Prevent attacks</td>
<td>• Long term survival</td>
<td>• Rebuild society</td>
</tr>
<tr>
<td></td>
<td>• Limiting damage</td>
<td>• Physical support – health, protection, location</td>
<td>• Advanced support services at low cost for health, social needs, and education</td>
</tr>
<tr>
<td></td>
<td>• Immediate physical survival</td>
<td>• Rebuild physical infrastructure</td>
<td>• Working in a fragmented physical environment</td>
</tr>
<tr>
<td></td>
<td>• Participation and control of political environment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.6 Identification of needs from the scenarios – creating new markets

The central premise of needs analysis is that it identifies those needs which are the key drivers of consumption of goods and services. Behind needs stand the motivations for higher level goals, such as self realisation (which drives needs and their goal-directed activities). From the scenarios, the needs identified for mobile and wireless services in the EU may include up to nine key groups of drivers, at least, which may have different levels of applicability:

1. Social relations including family

2. Social welfare and inclusion, including government/administration access amid cultural diversity and multiple communities

3. Working efficiently and conveniently for all sizes of firm

4. Self assertion, including reskilling and education (from self improvement motivations) and personalisation

5. Ageing population support, in living and working

6. Health and disability support

7. Transport and mobility

8. Stress relief, leisure, relaxation and escapism

9. Security, at several granularities – individual – group – nation – and at several levels – personal physical survival/protection, data protection, financial protection

4.7 User segmentation

As a consequence of the scenario descriptions, and its needs analysis, we can identify certain groups in each scenario who will form the mass of the customers – for both business and consumer population - and who will have to some lesser or greater extent needs as described above in section 4.3. For the three main scenarios these users are shown in Table 10.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Main segments (may overlap)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Smooth Development</td>
<td>• Knowledge workers (largest segment of workers)</td>
</tr>
<tr>
<td></td>
<td>• Single parent families</td>
</tr>
<tr>
<td></td>
<td>• Single person homes</td>
</tr>
<tr>
<td></td>
<td>• Mobile workers</td>
</tr>
<tr>
<td></td>
<td>• Children</td>
</tr>
<tr>
<td></td>
<td>• Aged and working</td>
</tr>
<tr>
<td></td>
<td>• Infirm/disabled and working</td>
</tr>
<tr>
<td></td>
<td>• Aged/infirm not working</td>
</tr>
<tr>
<td></td>
<td>• High net worth individuals/families</td>
</tr>
<tr>
<td></td>
<td>• SMEs – largely in EU</td>
</tr>
<tr>
<td></td>
<td>• Corporates and multinationals – inside EU and global footprint</td>
</tr>
<tr>
<td>2 Stagnation</td>
<td>• Those without work (up to 50% of active population)</td>
</tr>
<tr>
<td></td>
<td>• Working but on low or minimum wage (majority in work) including public sector employment</td>
</tr>
<tr>
<td></td>
<td>• Within those working, workers who have downshifted (to a lesser career) probably having a family, more techno-phobic</td>
</tr>
<tr>
<td></td>
<td>• Knowledge workers</td>
</tr>
<tr>
<td></td>
<td>• High net worth individuals/families</td>
</tr>
<tr>
<td></td>
<td>• SMEs</td>
</tr>
<tr>
<td></td>
<td>• Corporates and multinationals – inside EU and global footprint</td>
</tr>
<tr>
<td>3 Change</td>
<td>• Those in work (in growth regions) – large proportion of migrants who are also knowledge workers</td>
</tr>
<tr>
<td></td>
<td>• In reskilling education/ training</td>
</tr>
<tr>
<td></td>
<td>• Those outside growth regions, on fixed or reducing incomes</td>
</tr>
<tr>
<td></td>
<td>• SMEs – largely in growth areas</td>
</tr>
<tr>
<td></td>
<td>• Corporates and multinationals – inside and outside growth areas and outside EU</td>
</tr>
<tr>
<td></td>
<td>• High net worth individuals/families</td>
</tr>
</tbody>
</table>
5. Questionnaire Survey and Results

5.1 Objectives and survey design

The objectives in conducting a survey of stakeholders and experts were twofold:

- To provide feedback on, and validation of, the scenarios.
- To review established services, identify future services and explore their market potential.

In conducting the survey, it was also recognised that consulting more widely through a questionnaire survey would be beneficial in terms of helping to build a consensus view of the future for wireless services in Europe.

Thus, the questionnaire was designed to elicit responses on the plausibility of the three main scenarios, requesting comments and suggestions for amendments or alternatives. The questionnaire then went on to explore respondents’ views on the likelihood of take up of different types of wireless service.

Research on service types was carried out largely by desk research, eventually identifying some 139 application services. For the sake of simplicity and manageability, questions on service types were structured by reference to the UMTS Forum’s classification into six main service types:

- Mobile Internet Access
- Mobile Intranet/Extranet Access
- Customised Infotainment
- Multimedia Messaging Service
- Location-based Services
- Voice (including videophone)

Respondents were invited by email to complete the questionnaire, which was posted on the project website. A database comprising almost 200 potential respondents was compiled, mainly Europeans but with some North American, Asian and Australasian representation. The database also sought to balance stakeholders (operators, service developers, equipment manufacturers, regulators and policy makers and industry analysts) with other experts and academics, and include business strategists, technical researchers, regulatory experts, economists, social scientists and futurists. In addition to these individual invitations, those contacted were invited to pass on the questionnaire to relevant colleagues. A general invitation to participate was also distributed to attendees at the First Wireless World Initiative Symposium.

Participants were assured that their contributions to the survey would be anonymous and that no comments would be attributed to any individual in any reports produced by the study. Responses to the questionnaire are included in anonymous form.

5.2 Response rate and characteristics of respondents

A total of 43 useable responses was received, the breakdown of respondents by organisation and main responsibility is shown in Tables 11 and 12.
Table 11. Breakdown of respondents by organisation.

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Number</th>
<th>% of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher education/research institute</td>
<td>23</td>
<td>53.5</td>
</tr>
<tr>
<td>Telecom operator</td>
<td>7</td>
<td>16.3</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>6</td>
<td>13.9</td>
</tr>
<tr>
<td>Regulator/government</td>
<td>3</td>
<td>7.0</td>
</tr>
<tr>
<td>Market/industry analyst</td>
<td>4</td>
<td>9.3</td>
</tr>
<tr>
<td>Total</td>
<td>43</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 12. Breakdown of respondents by main responsibility.

<table>
<thead>
<tr>
<th>Main responsibility</th>
<th>Number</th>
<th>% of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy/marketing sales</td>
<td>12</td>
<td>27.9</td>
</tr>
<tr>
<td>Technical R&amp;D</td>
<td>8</td>
<td>18.6</td>
</tr>
<tr>
<td>Regulation</td>
<td>4</td>
<td>9.3</td>
</tr>
<tr>
<td>Social/economic/futures research</td>
<td>11</td>
<td>25.6</td>
</tr>
<tr>
<td>Other/no response</td>
<td>8</td>
<td>18.6</td>
</tr>
<tr>
<td>Total</td>
<td>43</td>
<td>100</td>
</tr>
</tbody>
</table>

Perhaps unsurprisingly, the response rate from non-European residents was low, with only two replies being received from outside Europe.

5.3 Overall impressions of the scenarios

Broadly speaking, the vast majority of respondents (72%) thought that the three ‘evolutionary’ scenarios did reflect the range of possibilities facing Europe over the next 15 years. There does not appear to be any broad difference in acceptance of the scenarios by organisational affiliation or responsibility of the respondent, but of course the numbers in the samples are small, i.e. those from higher education/research institutes were just as favourable as those from telecom operators.

Of those who thought the scenarios were lacking in some way, three thought that a scenario describing growth was missing. One respondent commented that “huge growth is missed”, another that “a best case scenario with growth beyond expectation should also be included as a very useful reference”, and a third suggested a need for “Economic boom - the counterpart to the major crisis scenarios”. The Smooth Development scenario, of course, is predicated on a sustained period of significant economic growth, a ‘long boom’ such that the EU economy grows by 50% over 15 years. Similarly, one respondent thought that a scenario depicting ‘boom and bust’ would have been helpful, although to some extent this was characteristic of the Constant Change scenario.

More subtly, perhaps, was the suggestion for a scenario “reflecting uneven development, which is different from stop-go development, considering the varying levels of development particularly in the New Accession Countries”. Another suggestion was to split the Constant Change scenario into two – “one reflecting constant change but modest growth; the other reflecting constant change by modest decline. The important element in this second sub-scenario would be price wars for basic voice as data on mobiles is carried over IP”.

In a similar vein, there was a suggestion for a scenario reflecting “Political Diversity - pressures from USA, Middle East and Africa as well as from EU citizens divide EU as nations pursue political and national alliances whilst maintaining an economic foothold in the EU”.

One participant thought that a “more dynamic scenario” was missing “where phenomena of technology-push or demand-pull stimulate an accelerating growth path”. Another thought that the scenarios focused too much on telecommunications and did not fully reflect the impact of, for instance, “more complex business environment, the impact of convergence, or the impact of world economy”. Moreover, the same respondent would have liked the scenarios to have emphasised “positively extreme issues that would create enthusiasm and trust that there will be services that need spectrum...”. This view was echoed by one other, who saw it as intrinsic to the study’s to project an optimistic future for Europe:
“Considering the target of this study (input to the long term forecast for the ITU studies on spectrum for IMT-2000), the study should focus on optimistic scenarios. Pessimistic scenarios are also possible but are not of major interest in that context.”

Aside from these comments there were three replies that questioned more fundamentally the basis for the scenarios. One respondent thought that “the three main drivers of telecom evolution are not presented,” which they saw as the ability to “work with your office environment anywhere, to entertain yourself with voice, Internet and pay-TV anywhere, and tele-operation of devices”. They also thought that “extrapolation of the last four years should be a credible 4th scenario, ie slight growth with some time limited and domain limited crisis”, with “telecom becoming in 15 years a utility network amongst others like water and power”.

Another thought that there was a lack of logic to explain why differences might exist between the scenarios. As an alternative, this respondent described “three sets of possible drivers of change: the conflict of socio-economic philosophies continues; geographic concentration and isolation increase; and external pressures on the EU develop. Any combination of these can yield different and plausible scenarios.”

Only one participant was highly critical throughout, describing the scenarios as “severely flawed”, based on assumptions that were “very unrealistic”, and with a “totally inconsistent understanding of the role of communications”.

We asked whether the three main scenarios seemed plausible, whether they contained incorrect assertions and requested suggestions for enriching them. The intention here was to ensure that the scenarios were internally consistent and based on reasonable logic. However, some respondents interpreted the question to mean, ‘do you think it likely that the scenario will come to pass?’, and this should be borne in mind when interpreting the numbers shown in Table 13.

<table>
<thead>
<tr>
<th>Table 13. The most plausible scenario?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plausible</td>
</tr>
<tr>
<td>Yes?  No?</td>
</tr>
<tr>
<td>Smooth Development</td>
</tr>
<tr>
<td>Economic Stagnation</td>
</tr>
<tr>
<td>Constant Change</td>
</tr>
</tbody>
</table>

What we can probably safely say is that Constant Change was seen as the most realistic, with Smooth Development being seen as slightly less convincing than Economic Stagnation.

5.4 Impressions of the individual scenarios

**Smooth Development**

This scenario was recognised as the one describing the most optimistic future and was the most desirable for politicians and the telecommunications industry. However, it was widely thought of as being overly optimistic, one describing it as a ‘dream scenario’. A typical comment was that it painted “too rosy a picture for the whole of the 25 Member States, considering the political economy especially of the New Member States vary distinctly”. One thought that it “appears to be predicated on the widespread and benign use of wireless broadband and a level of stability rarely observed”.

However, one compared the scenario with the not-too-distant past and drew this parallel: “the fixed-line network enjoyed a period of smooth growth in the 1980s and early 1990s and the mobile network is at a similar stage.”

**Economic Stagnation**

Views on this scenario differed more widely than on the other two although, again, we have to draw the distinction between plausibility and likelihood. At one extreme were comments to the effect that there was far too much riding on success for Europe to get it so wrong and for its economy to fall into stagnation. On the other
hand, others saw this is “a likely path unless Europe can continue to improve productivity”, some perceiving that “technological and social progress in Asia will persist and continue to increase over the years. We see a widening gap between the Asian and European economies.”

A couple of respondents pointed out that the vignette was more pessimistic and extreme than the scenario itself, and this was thought to be highly unlikely. One participant, however, imagined the situation could be very much worse with the outbreak of economic warfare between North and South or between the Dollar v Euro zone.

One respondent particularly questioned the hypothesis that governments and operators would collude to preserve 3G and resist the takeoff of 4G thinking this not very likely – of course depending on the definition of 4G.

**Constant Change**

This was seen by many, but by no means all, as easily the most likely scenario, although many thought that it would not come about evenly across Europe but would be more likely to occur in pockets. It was thought by one to be the “most likely due to the destabilisation caused by US foreign and economic policies, unstable markets, and possibly ineffective EU policies. The potential for China to impact world economics is real, and very likely in a 15-year window.”

One respondent, however, disagreed with some hypotheses, suggesting that “clusters make for congestion, communications allows dispersal, economics of dispersal are strong due to housing price differentials, with dispersal comes service economy and a wide range of activities brought about by those with links elsewhere”. Another wondered why this scenario was the only one to mention use of unlicensed bands.

### 5.5 Market development within the scenarios

The most important factor driving the development of the market for wireless services in all scenarios was thought to be the general economic and financial conditions (see Table 14), although this was seen to be even more important in Smooth Development than the other scenarios. The ability to pay for services was next as a driver in all scenarios, and the role of services in employment and geopolitical stability were fairly consistently seen as important influences on market development in all scenarios. After these drivers, there is less consistency across the scenarios.

In Smooth Development, other important drivers were seen as the ageing population, and migration, although this was seen as equally important in Constant Change. Respondents took a similar view on the importance of

| Table 14. Main factors driving development (Number of responses – max = 43) |
|-----------------------------|-----------------------------|-----------------------------|
|                            | Smooth development | Economic stagnation | Constant change |
| General economic/ financial conditions | 32               | 24             | 27             |
| Geopolitical stability      | 16               | 13             | 13             |
| Ability to pay for services | 23               | 22             | 22             |
| Wide take up of distance learning | 12             | 3              | 12             |
| Ageing population           | 20               | 14             | 10             |
| Single parent families      | 9                | 7              | 8              |
| Energy prices               | 7                | 14             | 12             |
| Migration                   | 14               | 8              | 14             |
| Rise in home ownership      | 10               | 3              | 5              |
| Role of services in employment | 19             | 18             | 21             |
| Role of services in survival | 4                | 15             | 13             |

16 The scenario did in fact begin its life as more pessimistic, a state of absolute rather than relative decline, but was modified after the scenario workshop.
distance learning. The rise in home ownership, while perhaps not being seen as a key driver, was significantly more influential in Smooth Development that the other two scenarios.

In Economic Stagnation, the role of services in survival and energy prices were seen as having more influence on the development of the market than in Smooth Development. Distance learning and home ownership were seen as not being important drivers.

Almost all respondents expect to see growth in the overall market in both the Smooth Development and Constant Change scenarios (see Table 15). While about half of respondents thought there would be no growth in Economic Stagnation, a significant proportion still imagined some growth would take place.

In terms of expected growth in the take up of different types of service, Table 16 shows that for all service types more respondents expect growth to occur in Smooth Development, somewhat fewer expect growth in Constant Change with the least number expecting growth in Economic Stagnation. The only other thing to note is that Simple voice would be expected to be even more important in conditions of Economic Stagnation.

Table 17 confirms this. Participants were asked to nominate the single service type they thought would be in greatest demand. In Economic Stagnation, most respondents mentioned Simple voice. Otherwise there was a surprising lack of consensus: for Smooth Development, the services seen as most in demand were simple voice and customised infotainment with Mobile Internet not

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**Table 15. Expected market development (Number of responses – max = 43)**

<table>
<thead>
<tr>
<th></th>
<th>Smooth development</th>
<th>Economic stagnation</th>
<th>Constant change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth</td>
<td>38</td>
<td>15</td>
<td>37</td>
</tr>
<tr>
<td>No growth</td>
<td>4</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Decline</td>
<td>0</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 16. Services expected to grow (Number of responses – max = 43)**

<table>
<thead>
<tr>
<th>Service</th>
<th>Smooth development</th>
<th>Economic stagnation</th>
<th>Constant change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple voice</td>
<td>26</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>Rich voice</td>
<td>32</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Mobile Internet/intranet/extranet</td>
<td>36</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Location-based services</td>
<td>35</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Text messaging</td>
<td>29</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Multimedia messaging</td>
<td>35</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>Customised infotainment</td>
<td>34</td>
<td>11</td>
<td>30</td>
</tr>
</tbody>
</table>

**Table 17. Service in greatest demand (Number of responses)**

<table>
<thead>
<tr>
<th>Service</th>
<th>Smooth development</th>
<th>Economic stagnation</th>
<th>Constant change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple voice</td>
<td>9</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>Rich voice</td>
<td>5</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Mobile Internet/intranet/extranet</td>
<td>8</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Location-based services</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Text messaging</td>
<td>3</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Multimedia messaging</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Customised infotainment</td>
<td>9</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Total (max 43)</td>
<td>39</td>
<td>36</td>
<td>37</td>
</tr>
</tbody>
</table>
Figure 26. Percentage of the population anticipated to use each service type in the different scenarios
In Constant Change, Mobile Internet was expected to be the service most in demand.

The survey also asked respondents to estimate the percentage of the population they expected to be using each service type within each scenario. The charts in Figure 26 show the number of responses for each service type and scenario. So, for instance, a large majority thought that over 90% of the population would be using Simple voice in the Smooth Development scenario. In contrast, in Economic Stagnation, most respondents thought that penetration would be between 50 and 90%.

There is a considerable amount of data presented in these charts, and the messages they convey are not very clear. What is most surprising is the lack of a very clear consensus about penetration of the different service types across the scenarios. This in itself is perhaps the most interesting finding.

5.6 Conclusion

A questionnaire survey of this nature is caught between two stools. In order to achieve an acceptable response rate, it needs to be simple and understandable to a wide range of participants from different backgrounds, and be easy to complete within a reasonable amount of time. However, the subject is complex and unless it is covered in sufficient depth, the responses will be superficial. We were fully aware that this survey was very ambitious and that striking the right balance would be difficult. Nevertheless, the outcome is more than satisfactory.

Respondents have engaged very deeply with the study, absorbing the scenario material and, by and large, entered into the spirit of the exercise. Not surprisingly, not all participants agreed with all of the assumptions and hypotheses but most broadly endorsed the scenarios. The comments have provided a rich source of feedback and insight that has informed the study considerably.

In summary, the main results of the survey were:

- Almost 200 experts and stakeholders were invited to participate in the survey, and 43 responses were received.
- The majority thought that the scenarios offered an acceptable range of possible futures for Europe, and that the three main scenarios presented were plausible. However, since some respondents answered in terms of likelihood (believability) and others answered in terms of internal consistency within the scenarios, the answers that were constant across all scenarios are the most useful.
- The Constant Change scenario was seen as the most realistic, with Smooth Development being seen as slightly less convincing than Economic Stagnation.
- The most important driver for growth in wireless in all scenarios was thought to be general economic development and financial conditions. Apart from this, different drivers were seen as being critical for each scenario.
- In terms of types of service, it was felt that simple voice would important in all scenarios, especially in Economic Stagnation. No single application was seen to be dominant in the other scenarios.
- The stability of responses across the scenarios suggests that the approach has been useful, and that the socio-economic basis for the analysis is valuable in understanding the evolution of future wireless demand.

6.1 Method of calculation

As described in chapter 3, the estimation of traffic volumes follows several logical steps. A control template for each scenario is constructed and then the parameters that vary over time for each scenario are manipulated for each epoch to estimate the traffic volumes. Separate calculations are made for ‘consumer’ and ‘enterprise’ user types before being combined to produce a single estimate for traffic volume in Mbps per day.

6.2 Variables for calculating traffic volumes for consumer users

In our model, consumers are defined by three age groups (0-14, 15-64 and 65+) and three classes of income (low, medium and high) to produce nine user types. Thus, for consumer users, the variables that we manipulate for each scenario (S1, S2, S3) and epoch (E1, E2 and E3) are:

- **Population (P)**: the population for each age group - \( P_{0-14}, P_{15-64}, \) and \( P_{65+} \). We use population projections from Eurostat\(^{17}\) for the European Union\(^{18}\) for 2010, 2015 and 2020. Population figures for the Stagnation scenario are assumed to decline by 10% between 2010 and 2020.

- **Disposable income (I)**: the proportion in each group with low (L), medium (M) and high (H) disposable income are estimated for each epoch based on judgement of the economic conditions within each scenario and its impacts on household income. Low disposable income in our model is broadly defined as those living ‘at-risk-of-poverty before social transfers’.\(^{19}\) Currently, almost 25% of the population of the EU-25 would fall into this category. The high income category is defined simply for the purpose of this study as the top 10% of the population by income. Table 18 shows the proportions used for each scenario and epoch.

In the Smooth scenario, the proportion with low income shrinks by half by 2020 and those with middle and high income grows. In contrast, in the Stagnation scenario,

<table>
<thead>
<tr>
<th>Table 18: Proportion of population group by income distribution.</th>
<th>Low</th>
<th>Med</th>
<th>Hi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Smooth</strong></td>
<td>2010</td>
<td>0.25</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>0.125</td>
<td>0.775</td>
</tr>
<tr>
<td><strong>Stagnation</strong></td>
<td>2010</td>
<td>0.25</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>0.375</td>
<td>0.525</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Change</strong></td>
<td>2010</td>
<td>0.25</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>0.225</td>
<td>0.675</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>0.2</td>
<td>0.7</td>
</tr>
</tbody>
</table>


\(^{18}\) It is assumed that Bulgaria, Croatia and Romania accede to the European Union by 2010.

more people fall into poverty and half the population are in low-income families by 2020. In the Change scenario, the proportion on high incomes remains the same while some families are lifted out of poverty.

- **Penetration rate** (N): within each group, the proportion of the population who use mobile services is estimated. This will depend primarily on levels of household income for each of the age groups of the user categories, and will vary according to the general economic climate prevailing within the scenario at different epochs. Table 19 shows the proportions used in the calculations.

In all scenarios, it is assumed that of those aged 0-14, about half would be too young to be users (i.e., maximum penetration would be 0.5), and about 30% of those 65 and over would be not be users owing to health, disability and other reasons. In the Smooth scenario, the proportion of users within all categories is assumed to rise, even for those with low incomes. Maximum penetration (98%) is reached by 2020 for all categories on high income and for those in work on middle income. In the Stagnation scenario, the proportion of users declines for all categories and age groups except for those of working age on high incomes, which increases slightly. In the Change scenario, there is a more gradual increase.

### Table 19: Proportion of population/income group who use wireless services.

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Med</th>
<th>Hi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Smooth</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>15-64</td>
<td>0.85</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>65+</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>0.3</td>
<td>0.4</td>
<td>0.45</td>
</tr>
<tr>
<td>15-64</td>
<td>0.9</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>65+</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>0.4</td>
<td>0.45</td>
<td>0.5</td>
</tr>
<tr>
<td>15-64</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>65+</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Med</th>
<th>Hi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stagnation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>15-64</td>
<td>0.75</td>
<td>0.8</td>
<td>0.85</td>
</tr>
<tr>
<td>65+</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>0.15</td>
<td>0.25</td>
<td>0.35</td>
</tr>
<tr>
<td>15-64</td>
<td>0.6</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>65+</td>
<td>0.15</td>
<td>0.25</td>
<td>0.35</td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>15-64</td>
<td>0.4</td>
<td>0.7</td>
<td>0.9</td>
</tr>
<tr>
<td>65+</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Med</th>
<th>Hi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Change</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>15-64</td>
<td>0.8</td>
<td>0.9</td>
<td>0.95</td>
</tr>
<tr>
<td>65+</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>0.3</td>
<td>0.4</td>
<td>0.45</td>
</tr>
<tr>
<td>15-64</td>
<td>0.85</td>
<td>0.95</td>
<td>0.98</td>
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<tr>
<td>65+</td>
<td>0.35</td>
<td>0.45</td>
<td>0.55</td>
</tr>
<tr>
<td>2020</td>
<td></td>
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<tr>
<td>0-14</td>
<td>0.4</td>
<td>0.45</td>
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</tr>
<tr>
<td>15-64</td>
<td>0.9</td>
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<td>0.98</td>
</tr>
<tr>
<td>65+</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>
6.3 Variables for calculating traffic volumes for enterprise users

Use of wireless services by enterprises, broadly speaking, is a function of the number of employees, but use will also vary according to the size of the enterprise and its activity. Thus, in our model types of user for business and the public sector are first defined by employment by size of enterprise (micro, SME or large), and then by sector. Employment data, however, are complex and have limitations. First, unlike population, projections for employment are not available. Therefore our estimates rely on extrapolation of current employment data according to the conditions that would prevail within each scenario and for each epoch.

Second, ideally we would wish to separate public sector use since its use of wireless services will differ somewhat from the private sector. However, employment data classified according to NACE\(^\text{20}\) do not allow a distinction to be made easily between the public and private sector. Theoretically it would be possible to use NACE statistics to generate a sectoral dimension to types of user (i.e., agriculture, mining, manufacturing, etc), but the data are not consistent across all sectors, are not available for some of the EU’s newest members and involves a level of complexity that cannot be justified for this study.

Instead we introduce a sectoral dimension by considering use either in service sector enterprises (including the public sector) or non-service enterprises. This results in six enterprise user types by size and sector, which we believe strikes a reasonable balance between the availability of data, its simplicity and accuracy.

Thus the variables we manipulate for each scenario and epoch for enterprise use are:

- **Population (P):** to generate projections of employment, we use the same population data for the age group 15-64 for consumer user types, which in 2003 accounted for over 95% of those employed.\(^{21}\) As for consumer user types, population figures for the Stagnation scenario decline by 10% by 2020.

- **Employment:** full-time equivalent (FTE) employment is the simplest measure since it takes into account part time working. It is calculated by applying a factor to the population aged 15-64. Our baseline data is for 2003 from Eurostat\(^{22}\) and varied according to how the proportion of the population in employment would change within each scenario and epoch. Table 20 shows the factors used in our calculations.

---

\(^{20}\) NACE = Nomenclature Générale des Activités Économiques dans les Communautés Européennes


\(^{22}\) Ibid.
In the Smooth scenario it is assumed that the booming economy will bring about a significant increase in proportion of the population in employment over the period to 2020, while in the Stagnation scenario the proportion in employment declines. In the Change scenario there is a more gradual but still significant increase.

- Service v non-service employment: the proportion employed in service (S) and non-service enterprises (NS) is based on data for the EU-25 in 2003 and again varied according to the impact of economic conditions within each scenario and at each epoch (see Table 21). Currently about 66.4% of employment in the EU-25 is in services.

In the Smooth scenario, there is an acceleration in the shift from agriculture and manufacturing to the service sector. In the Change scenario, the shift is less marked whereas in the Stagnation scenario, the proportions remain unchanged.

- Employment by enterprise size class: a factor is included for employment in micro-enterprise (CM), SME (CSME) and large enterprise (CL). Although employment by size of enterprise would likely change under different scenario conditions and over time, we have chosen to use the same proportions for employment by size of enterprise throughout the scenarios and in all epochs. Data for this breakdown is shown in Table 22 and is based on figures for the EU-15 in 2000.

- Usage of services (U): the amount of usage of a basket of typical services in minutes per day for each of the nine types of consumer users. Chapter 3 describes the basis used for calculating the use of services.

Thus, the calculation of traffic volumes for enterprise user types TE for a given scenario and epoch can be expressed by the following function:

**Table 20: Full-time equivalent (FTE) employment rate (15-64).**

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth</td>
<td>55</td>
<td>65</td>
<td>75</td>
</tr>
<tr>
<td>Stagnation</td>
<td>55</td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>Change</td>
<td>55</td>
<td>60</td>
<td>65</td>
</tr>
</tbody>
</table>

**Table 21: Proportion in service/non-service employment.**

<table>
<thead>
<tr>
<th></th>
<th>Smooth</th>
<th>Stagnation</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>2015</td>
<td>0.775</td>
<td>0.7</td>
<td>0.725</td>
</tr>
<tr>
<td>2020</td>
<td>0.85</td>
<td>0.7</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>0.225</td>
<td>0.3</td>
<td>0.275</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>0.3</td>
<td>0.25</td>
</tr>
</tbody>
</table>

**Table 22: Proportion in service/non-service employment.**

<table>
<thead>
<tr>
<th></th>
<th>Micro enterprise (1-9)</th>
<th>SME (10-249)</th>
<th>Large enterprise (250+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Services</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Non-services</td>
<td>0.15</td>
<td>0.4</td>
<td>0.45</td>
</tr>
</tbody>
</table>

23 European Commission, Employment in Europe 2004: Recent Trends and Prospects, Directorate-General for Employment and Social Affairs, Unit EMPL/A.1, Chapter 1, p. 42.
24 European Commission, Business in Europe Statistical Pocketbook, 2003, Table 2.3: Number of enterprises and persons employed broken down by size-class, 2000, p.14.
The Demand for Future Mobile Communications Markets and Services in Europe

\[ \text{TESE} = (P \times \text{FTE} \times S \times C_{SM} \times U_{SM}) + (P \times \text{FTE} \times NS \times C_{SM} \times U_{NSM}) + (P \times \text{FTE} \times S \times C_{SME} \times U_{SME}) + (P \times \text{FTE} \times NS \times C_{SME} \times U_{NSSME}) + (P \times \text{FTE} \times S \times C_{L} \times U_{SL}) + (P \times \text{FTE} \times NS \times C_{L} \times U_{NSL}) \]

6.4 Results of calculations

Estimates for traffic volumes for each scenario over time are shown in Table 23-25.

Table 23: Smooth scenario: estimated wireless traffic in Mbps x 10^3 per day.

<table>
<thead>
<tr>
<th></th>
<th>Consumer</th>
<th>Enterprise</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>8423488.62</td>
<td>18976755.26</td>
<td>27400243.88</td>
</tr>
<tr>
<td>2015</td>
<td>95171251.25</td>
<td>41969591.78</td>
<td>137140843.03</td>
</tr>
<tr>
<td>2020</td>
<td>671684692.90</td>
<td>246340834.74</td>
<td>918025527.64</td>
</tr>
</tbody>
</table>

Table 24: Stagnation scenario: estimated wireless traffic in Mbps x 10^3 per day.

<table>
<thead>
<tr>
<th></th>
<th>Consumer</th>
<th>Enterprise</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>5332662.92</td>
<td>15903485.54</td>
<td>21236128.45</td>
</tr>
<tr>
<td>2015</td>
<td>2121484.97</td>
<td>13088830.58</td>
<td>15210315.54</td>
</tr>
<tr>
<td>2020</td>
<td>3182239.53</td>
<td>53526816.25</td>
<td>56709055.78</td>
</tr>
</tbody>
</table>

Table 25: Change scenario: estimated wireless traffic in Mbps x 10^3 per day.

<table>
<thead>
<tr>
<th></th>
<th>Consumer</th>
<th>Enterprise</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>7309205.01</td>
<td>20244891.65</td>
<td>27554096.66</td>
</tr>
<tr>
<td>2015</td>
<td>72506096.31</td>
<td>38919507.03</td>
<td>111425603.33</td>
</tr>
<tr>
<td>2020</td>
<td>87721699.75</td>
<td>244907863.20</td>
<td>332629562.95</td>
</tr>
</tbody>
</table>

These data are presented in graphical form in Figures 26-28, and a summary graph showing trends in traffic volumes for all scenarios is shown in Figure 30 (Note that the scale for the y-axes is not constant).

We are able to break down the figures for each scenario further to give an approximation of the proportion of total traffic associated with the various baskets of services. For consumers, traffic was estimated for three baskets of...
services – Communications, Entertainment, and Lifestyle. Figures 31-33 show the breakdown of consumer traffic for each basket of service by scenario. Figures 34-36 presents data for consumer traffic for each scenario by basket of service.

For enterprise users traffic for two baskets was estimated – Communications and Business Applications. The breakdown of enterprise traffic for each basket of service is shown by scenario in Figures 37-39, whereas Figures 40 and 41 show traffic for the three scenarios by basket of service.
Figure 31: Smooth scenario: traffic for consumer baskets

Figure 32: Stagnation scenario: traffic for consumer baskets

Figure 33: Change scenario: traffic for consumer baskets
Figure 34: Consumers: traffic for communications baskets

Figure 35: Consumers: traffic for entertainment basket

Figure 36: Consumers: traffic for lifestyle basket
Figure 37: Smooth scenario: traffic for enterprise baskets

Figure 38: Stagnation scenario: traffic for enterprise baskets

Figure 39: Change: traffic for enterprise baskets
6.5 Analysis of results

- Care should be taken when interpreting the results presented in this chapter since they are based on a great many assumptions and approximations. Moreover, the temptation to consider the calculations as predictions of the future should be resisted—rather they should be thought of as estimations of wireless traffic given the assumptions and conditions of each scenario. Having made these caveats, what messages can we draw out from these calculations?

- First, if we consider total traffic (for consumers and enterprises combined), it is striking that, between 2010 and 2015, the differences in traffic volume between the scenarios are relatively small (see Figure 30). Indeed the Smooth Development and Constant Change scenarios show almost identical, steady growth. However, in Economic Stagnation, there is a real but gradual decline in traffic.

- It is only after 2015 that significant differences between the scenarios become apparent. Not surprisingly, by 2020 traffic is least in Economic Stagnation, although there is significant growth with traffic volumes exceeding their 2010 level by almost a factor of three (see Figure 28). Growth in traffic in Constant Change, meanwhile,
is much more marked, growing three fold between 2010 and 2015 (Figure 29). Even this remarkable growth is dwarfed by the Smooth Development scenario, where traffic grows almost seven times in the five-year period (Figure 27). By 2020, there is six times as much traffic in the Constant Change scenario compared with Economic Stagnation, and 16 times as much in the Smooth Development scenario.

- The significant post-2015 growth in the Smooth Development and Constant Change scenarios results from different sources. In Smooth Development, the huge growth in traffic is driven mainly by individual consumers (Figure 27), whereas in Constant Change, growth from individual consumers is steadier, while most of the growth results from greatly increased use by enterprises (Figure 28). In the Stagnation scenario, consumer traffic is very limited indeed and almost all of the traffic results from enterprise use (Figure 28).

- If we examine estimated traffic for consumers by scenario in more detail, we can see that in the Smooth Development scenario (Figure 31) all three baskets of services (Communication, Entertainment, and Lifestyle) show steady growth between 2010 and 2015. Growth in all three speeds up after 2015 with Lifestyle outstripping Entertainment which, in turn, outstrips Communications. Figure 32 shows the decline between 2010 and 2015 in Economic Stagnation, particularly for Communications and Entertainment and the pick up after 2015. Figure 33 shows how all three baskets grow steadily between 2010 and 2015 and then flattens between 2015 and 2020, mainly owing to saturation in Communications services.

- If we examine the evolution of traffic for the Communications basket of services by scenario (Figure 34), we see that traffic is low in Economic Stagnation throughout the period. In Constant Change, we see growth followed by saturation. The picture in Smooth Development is very different, growing at a similar rate to Constant Change to 2015 but then increasing rapidly thereafter. Figures 35 and 36 tell a similar story for Entertainment and Lifestyle services – it is individual consumers who drive the growth in Smooth Development but there is almost no demand for these in Economic Stagnation and modest demand in Constant Change.

- Turning to graphs showing traffic for enterprise users by scenario (Figures 37-39), Smooth Development again shows significant increase after 2015, although not as dramatic as for consumer users. Enterprise traffic is split pretty equally between Communications and Business Applications. In Economic Stagnation traffic declines at first and then increases quite sharply, again with traffic split equally between the two baskets. The Constant Change scenario also shows business traffic growing very strongly particularly after 2015, even outstripping enterprise traffic in the Smooth Development Scenario.

- This latter point is well illustrated in Figures 40 and 41 with enterprise traffic in Constant Change outstripping Smooth Development by about one third.
7. Business Modelling for 4G Networks

7.1 Introduction

Background

It was felt necessary to give a dimension of financial realism to the study and so business modelling has been carried out for next generation networks beyond 3G. Generations of mobile communications infrastructures have in the past been introduced in a sequential manner, beginning with first generation (1G) analogue solutions (e.g. NMT and AMPS) in the early 1980s. In the 1990s, the first digital solutions (e.g. PDC, GSM and D-AMPS) replaced the analogue, later called 2G solutions, and then 3G solutions followed suit. In the race to leadership in fourth generation (4G) technologies, the stakes have been raised by both Asian and US actors. Building credible scenarios for mobile futures as well as building, simulating and evaluating possible business models are small parts of the puzzle for European policy makers and industry to acquire an understanding of the challenges that lie ahead.

What is 4G?

Although the implementation of 3G telecommunications infrastructure systems is well underway, work on developing a fourth generation has only begun. Still, neither industry nor academia have reached consensus regarding the future characteristics of 4G systems, much less reached any agreements on technological specifications. Many disparate views of 4G futures have emerged (see e.g. Forge, 2004 and Bohlin et al. 2004), ranging from a complete successive technology generation (comparable with 1G, 2G and 3G), to solutions built on seamless integration of existing and coming communications technologies (e.g. 3G, WLAN, etc.). The European Commission IST programmes have used the term “Beyond 3G” to denote the plentiful systems and standards likely to interact with 3G. Slowly, a view on 4G solutions as “umbrella technologies” connecting and interworking with a wide array of radio communications protocols and technologies has emerged as a common future vision. In addition, the adding of new capabilities, e.g. ad-hoc networking in mesh network structures has been suggested to become a probable way forward to solve the needs for increased bit rates at lower costs.

Still, many questions about future developments remain unanswered. It is, however possible to make some general hypotheses about the characteristics of future mobile communications systems. In the following section, these hypotheses will be presented in more detail. Many of the characteristics presented below are closely connected, sometimes even proportionate to each other, and some of the characteristics may seem obvious to the reader. We still choose to present them individually in order to sketch the future as detailed as we believe is possible.

Important characteristics of a 4G network used in our models include:

- Licensed AND unlicensed spectrum
- Increased data usage
- Multi technology usage
- Decreased cell sizes
- Introduction of ad-hoc (mesh) network capabilities
- Leading to reduced density of radio equipment
- Increased bit rates
- Increased importance of software (e.g. SDR)
- New pricing schemes

In our models we have used two radio access points: APs and UAPs, which will be discussed more below:
– UAPs are defined to function as ordinary base stations with backhaul connections.
– APs are defined to function as repeaters and signal amplifiers, relaying radio signals to allow extensions of hops.

Unlicensed spectrum.

New spread spectrum technologies (e.g. OFDM) provide new ways of sharing the spectrum without dividing it in chunks of frequencies allocated to each operator. Using spread spectrum technologies, far higher spectrum efficiency can be reached, without the need to licence the frequencies in advance. A factor contributing to unlicensed spectrum is the convergence between telecommunications and computer communications. The rapid diffusion of data communications products using the unlicensed 2.4 GHz band, including WLAN (Wi-Fi) is suggesting how standardization and increasing returns affect technology adoption and usage. The computer industry has a longer history of using standardized technology solutions, competing with technology integration, standard-based innovation and product development, and innovative marketing. Interesting examples for comparison are the Ethernet, IP, Wi-Fi, etc.

**Increased data usage**

Mobile communications is continuously substituting for fixed communications, be it mobile telephony or cordless usage of data networks (WLANs) in office settings. This trend is likely to continue, and even accelerate as mobile data transfer costs are driven down by technological improvements and increasing scale economies. With mobile voice over IP (VoIP) solutions close to or even below the costs of fixed voice communications, the need for fixed telecom subscriptions will all but disappear, in both home and office settings. Thus, the combined amount of traffic today transferred via mobile and fixed connections, will likely be transferred over merely mobile systems in a not so distant future.

To recoup the enormous investments made in 3G systems, involved actors have increasingly put their hope to increased usage of data services to counterbalance the gradual slump in voice revenues. Although still in early phases, service experimentation is gaining pace. Picture and video services have been introduced, and m-commerce services are increasingly advertised in all sorts of media. Mobile data services will most certainly be the strongest drivers for a new fourth generation infrastructure. Just as increased computing power and storage size have gone hand in hand with increasing data communication bandwidth in recent years, it seems reasonable to expect that increased handset capabilities will drive the need for higher mobile bandwidth solutions. Even in a 4G setting, it seems unlikely that all conversations will be held in an audiovisual setting, but if only, say, 30% of all conversations would be held over video telephony, the impact on data traffic would be enormous.\(^{25}\)

Considering the mobile telephony penetration levels in the EU today, in many countries over or around 80% and growing, and the ongoing transition from fixed to mobile, it seems reasonable to assume between 80% and 90% penetration in a 4G setting (the youngest and oldest will probably not use the technologies).

**Multi technology usage**

At the introduction of first generation analogue mobile communications solutions, the installed base of mobile communication equipment was very small. Today, the installed base of e.g. WiFi base stations is large and rapidly growing. Bluetooth radio capabilities are included in a vast amount of electronic gadgetry. WiMax solutions are expected to be rolled out in a near future, as are UWB technologies. In addition, at the time of a 4G rollout the 3G infrastructure

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25 For sure, this would spur innovation in data compression solutions. It is however unlikely that such technological improvements would completely offset the increased traffic.
will offer a comprehensive network of high bit rate capacity base stations. Although the costs of integrating these existing technologies with a 4G network may be high (both development costs and costs for reduced 4G capabilities) it is likely that the costs for developing a completely new infrastructure will be even higher. Thus, there is a high probability that 4G telecommunications will make use of the multiple technologies already implemented on a wider scale.

This development is already taking place today. A IEEE 802 Handoff Study Group is addressing roaming and hand-offs between heterogeneous 802 networks, allowing mobile devices to switch the connection from one base station to another, from one 802 network type to another (e.g. from 802.11b to 802.16). The aim is to reach standardized solutions for hand-off, making devices interoperable as they move from one network type to another (Johnston & LaBrecques).

**Decreased cell size**

Following the laws of physics, the size of average cell coverage will have to be reduced in order to increase bandwidth. This development follows the same pattern as seen in the shifts from analogue to digital to 3G solutions (see Figure 42). At the same time, a different development trajectory can be seen in the wireless LAN industry. Early versions in the 1980s (based on IR) provided very short range connections at low data rates. During the 1990s, in particular the latter part, technological development was rapid, leading to increased coverage and data transfer rates. In a not so far off future, it is likely that these development tracks will converge.

To what extent this development will take place, i.e. what the average cell size will be, is difficult to predict. It will depend on the throughput data rates needed, the number of users per cell, the bandwidth available, etc. It is, as mentioned earlier, likely that a number of different technologies will be used to satisfy different needs.

**Increased bit rates**

Closely connected with increased data usage and decreased cell size is the characteristic of increased bit rates. New services will most likely put new demands on data throughput rates, similarly to how broadband connection are substituting dial-up Internet connections in a fixed Internet setting. When memory size and

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**Figure 42: Schematic description of performance development tracks**

![Diagram showing performance development tracks](image)
computing capabilities of mobile handsets are increased, the demand for multimedia services (including music and video download) will likely drive the demand for higher bit rates. It is thus safe to assume that 4G communications solutions will offer much higher data rates than today's 3G, at least in the range of 10-100 Mbs.

**Introduction of ad-hoc network capabilities**

Although most people would say that today's telecommunications solutions are efficient, at least in comparison with yesterdays, much development work remains in order to make full use of the physical capabilities. Ad hoc mesh connections, creating multi-hop paths enhance the cost efficiency of 4G over previous generations as less need to be spent on (SCF Associates Ltd., 2004):

- Real estate and site leasing for base stations
- Obtaining planning permission
- costs due to delays in planning, getting sites’ permission, building and testing
- Costs for procuring, building, testing and integrating masts, network equipment radiation shielding, and the backhaul network

The introduction of mesh networks, where network components function as routers, can be compared with how the Internet replaced proprietary data communications solutions in the 1970s and 1980s (see e.g. Lindmark et al. 2004). And just as fixed monthly payment schemes have emerged as standard ways of charging for Internet access in a fixed data communication setting, it is not unlikely that the mobile counterpart will experience a similar development. Thus, again comparing with the fixed Internet, APs (and, depending on battery developments, perhaps even terminals) functioning as Internet routers is a probable development track in the next generation of mobile communications solutions.

Today, the IEEE has started work on projects for fast roaming and mesh applications in wireless local area networks (WLAN). The fast roaming project, IEEE 802.11r, will make it easier to use real time interactive applications as wireless voice over IP (VoIP). The mesh project, IEEE 802.11s, will extend WLAN range by allowing data to pass through wireless nodes in mesh networks in a router-like fashion (Kerry et al., 2004). As in the fixed Internet, adding nodes will become a scalable and redundant task (Wexler, 2004). Although work on mesh networks have been carried out in university and company research laboratories all over the world for a number of years, no single standard has. Even if the IEEE standardization is successful, further standardization efforts will be needed if mesh networks across technology boundaries are to become realities.

**Increased importance of software**

In traditional telecommunications solutions, the frequencies and the protocols to use have been integrated into the hardware. This means that the transceiver units cannot be adjusted to use multiple protocols and frequencies. The software defined radio (SDR) technology emerging puts more intelligence in the transceiver unit, making them able to switch frequencies as required to reduce cost or avoid congestions (Forge, 2004). SDR technologies could have an important role in a 4G world, where multiple technologies are believed to communicate and interact.

**New pricing schemes**

In the fixed Internet access market, attempts to charge consumers for their actual data usage have been largely unsuccessful. Instead, the dominant pricing scheme has become charging for available bit rates, with low capacity fixed connections available at a low cost. In a European mobile telecom setting, pricing schemes are today migrating from per-minute charges based on time of the day (with business hours minute charges being much higher than at night) to flat minute charges, independent of time of the day. If (or, rather, when) mobile
data services become the predominant means for mobile handset usage, the logical next step would be to introduce pricing plans similar to those seen in the fixed broadband Internet.

7.2 Business Models

Methodology

Constructing a business model simulation for technologies that do not exist today, calculating diffusion figures, investment costs, ARPU levels etc. involves a large number of estimations and approximations. In fact, the usefulness of forecasts as far off in time as 15 years could be seriously questioned; what use is there if all input figures are rough estimations? The business model used in this report does not aspire to provide an altogether true picture of costs and revenues. The aim is rather to put a figure on the table for open discussion about the user needs that must be fulfilled, the utility that must be created, and the affordability, in order for a 4G network investment to make economic sense. Schematically, the business model has been created according to the model presented in Figure 43.

In order to generate useful results from financial simulations, a number of conditions must be fulfilled. Firstly, proper definitions of the technological world must be established, including a basic notion of the network structure to be implemented. Secondly, cost elements of future technologies and components must be analytically estimated. Thirdly, estimations of revenue levels, far off in the future, must be made. And, finally, a geographically defined market, virtual or real, must be constructed. All these elements will be introduced below.

Figure 43: Model characteristics - Schematic overview
For the 4G network structure, the simulated network can be depicted as in Figure 44 below. In the model used, three main communication components have been introduced: Universal Access Points (UAPs), Access Points (APs) and SDR capable handsets. The major difference from an existing mobile communications network is the ad-hoc mesh capabilities that are introduced. In the model, all three communication components are thought to have mesh capabilities, and only UAPs are connected to a backhaul network.

Because all 4G network elements are depicted to have mesh capabilities, multihop paths between SDR handsets, APs and UAPs are believed to be possible, and redundant paths are often available, as illustrated in the figure.

A final starting point of the business model is linking the results to the scenarios of the FMS project. In the following, the scenarios used in the business model correspond to the Smooth Development (Scenario 1), Economic Stagnation (Scenario 2) and Constant Change (Scenario 3). The three different main scenarios have been translated into user adoption levels as follows: high (Scenario 1, 90% maximum diffusion), low (Scenario 2, 50% maximum diffusion) and medium (Scenario 3, 75% maximum diffusion). In order to provide simple comparison between scenarios all scenarios have been set to a base line (years 0 to 11). In reality, the scenarios are assumed to have different starting years (Scenario 1 starts in 2010, Scenario 2 in 2015, Scenario 3 in 2012). See Figure 45 for an overview how these assumptions play out, using a common base line.

With these aspects in mind, the simulation provides:

- an interrelated set of technology, geography, costing and demand levels, based on scenarios
- indications about the economic viability of 4G communications networks
- an early (first?) comprehensive financial analysis of 4G networks

**Geographical scope simulation**

In order to generate useful results from financial simulations, a number of conditions must be fulfilled. Firstly, proper definitions of the technological world must be established. Secondly, cost elements of future technologies and components must be analytically estimated. Thirdly, estimations of revenue levels, far off in the future, must be made. And, of course, a robust financial model must be constructed. However, without a geographically defined market to simulate, virtual or real, no results can be generated.
be produced. And, in order for the results to be useful for a broader audience, e.g. the whole of Europe, a market representing the combined markets in question must be simulated. In general, this can be done by simulating a number of countries or regions, and then draw general conclusions from the individual simulations, or by simulating a virtual market that is designed to provide results applicable to a number of markets. The simulations presented here are based on the latter solution.

Eurolandia

In order to simulate the financials for covering a country with 4G network reach, a fictive geographical area, Eurolandia, has been created for the financial simulations of a 4G network. The population has been assumed to be 46,400,000. This figure is the average of a number of randomly chosen European countries (France, Germany, Italy, Netherlands, Spain, Sweden & UK populations). Demographically, Eurolandia consists of:

- A few very dense urban areas, with large suburbia (compare Paris or London)
- A number of suburban areas
- A large number of rural areas
- Very few truly remote areas

In the financial model, we have assumed a well developed country with a proportionately small part of the population living in rural areas. The assumed figures are provided in Table 27 on the next page.

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (km²)</th>
<th>% of total area</th>
<th>50% of pop. (m)</th>
<th>Area (km²)/m pop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eurolandia</td>
<td>63561.1</td>
<td>17.6</td>
<td>23.2</td>
<td>2330.6</td>
</tr>
<tr>
<td>UK</td>
<td>13526</td>
<td>5.6</td>
<td>29.8</td>
<td>454</td>
</tr>
<tr>
<td>Netherlands</td>
<td>11148</td>
<td>26.8</td>
<td>8.3</td>
<td>1343</td>
</tr>
<tr>
<td>Germany</td>
<td>90002</td>
<td>25.2</td>
<td>42</td>
<td>2143</td>
</tr>
<tr>
<td>Italy</td>
<td>64143</td>
<td>21.3</td>
<td>28.1</td>
<td>2283</td>
</tr>
<tr>
<td>Spain</td>
<td>60817</td>
<td>12</td>
<td>20.6</td>
<td>2952</td>
</tr>
<tr>
<td>France</td>
<td>95852</td>
<td>17.6</td>
<td>29.3</td>
<td>3271</td>
</tr>
<tr>
<td>Sweden</td>
<td>43474</td>
<td>9.9</td>
<td>4.5</td>
<td>9861</td>
</tr>
</tbody>
</table>

Source: Based on Björkdahl (2003)
Urban areas are estimated to have around 6000 inhabitants per km², similar figure to population density in Singapore and Hong Kong. This figure is probably high in a European setting, but high figures have deliberately been used since true population densities in European cities are believed to be increasing. Using demographic data from the Netherlands as a proxy for suburban areas, as the whole country is a fairly densely populated area, suburban areas are estimated to have on average 500 inhabitants per km². Relatively sparsely populated countries as Sweden and Estonia have been used as models for rural areas, estimated to approx. 30 inhabitants per km² (see Table 28).

Table 28: Population density in selected countries

<table>
<thead>
<tr>
<th>Area</th>
<th>Population (km²)</th>
<th>Population/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>6 900</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>6 352 892</td>
<td>633</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>6 655 125</td>
<td>1 042</td>
</tr>
<tr>
<td>Suburban</td>
<td>460</td>
<td></td>
</tr>
<tr>
<td>The Netherlands</td>
<td>16 318 199</td>
<td>33 883</td>
</tr>
<tr>
<td>Rural</td>
<td>482</td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>410 934</td>
<td></td>
</tr>
</tbody>
</table>

**Costs and investments**

The investment costs required for an operator to cover a market are dependent on a number of factors. The most obvious are 1) the size of the population, and 2) the geographical area to cover. By combining these into population density figures, coupled with technical capabilities of the networks, as average base station reach, estimates of how many base stations are needed can be made. The number of base stations multiplied by the average investment cost per base station provides us with a proxy for operator network investments.
In the urban network unit the population density is high, indicating a large potential for mesh networking. High-bandwidth short-reach base station units can be used to cover large parts of the population. In the suburban network unit, far-reaching technologies will play a more important role than in the urban network unit. With lower population density the base station must have a higher average coverage in order to cover the population in an economical way.

The economically most unsound areas to cover are of course the rural areas. With very low population densities, the 4G business case would probably be impossible if the same technologies are used as in the urban areas.

Using the population density figures provided in the previous section, and estimations of average area reach and number of subscribers served by a single network unit, we arrived at the Network Unit characteristics presented in Table 29.

Based on the figures provided in the table above, estimations of the number of different components (UAPs, APs and SDR handsets) needed to cover each network unit were made. For SDR capable handsets, the number taken is the same as the number of subscribers. For reasons of simplicity, it is assumed that the same components are used in the different network units (with the same average reach), and the number of components needed is simply in proportion to

<table>
<thead>
<tr>
<th>Area type</th>
<th># Subs./km²</th>
<th># Subs./network unit</th>
<th>Average area reach (km²)</th>
<th>Network unit radius (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>6 000</td>
<td>100 000</td>
<td>17</td>
<td>2.3</td>
</tr>
<tr>
<td>Suburban</td>
<td>500</td>
<td>50 000</td>
<td>100</td>
<td>5.6</td>
</tr>
<tr>
<td>Rural</td>
<td>30</td>
<td>25 000</td>
<td>833</td>
<td>16.3</td>
</tr>
</tbody>
</table>
the average area reach in the different network units. The total number of APs and UAPs needed is presented in Table 30.

In order to calculate the total costs of building and operating the network, a number of cost assumptions were needed, and they are presented in the following section.

**CAPEX**

In the following, the various assumptions on the elements relating to CAPEX are described and explained. As described above, they are assumed to have different starting years (Scenario 1 starts in 2010, Scenario 2 in 2015, Scenario 3 in 2012). However, in order to provide simple comparison between scenarios all scenarios have been set to a baseline (years 0 to 11). Thus the images shown below are based on the baseline measurements, although the computations of Net Present Values are modelled according to the actual starting years.

**UAPs and APs**

In the financial model, it is assumed that the network is built in 4 years in all scenarios (during years 0-3). Using the network unit model presented above to full extent would mean that incremental network units are added only when new subscribers are added. However, given the strong network effects available in a mobile communications network, especially when discussing mesh capable networks, it is likely that customer utility will only exist when the network is built-out in large scale. Thus, all UAPs and APs are modelled to be installed in the first 4 years (covering 90% of the population). The network coverage develops as follows in all scenarios:

- 36% coverage in year 0
- 64% coverage in year 1
- 83% coverage in year 2
- 90% coverage in year 3

The equipment costs are mainly calculated as AP & UAP costs. From starting levels of 12 000€/unit (for UAPs) and 10 000€/unit (APs) equipment costs are expected to decrease rapidly due to economies of scale and due to a move down the learning curves. As shown in Figures 47 and 48, cost reductions are modelled to be falling by up to around 80% during the period.

In addition to the equipment investment costs, 10% replacement investments for UAPs and APs are estimated. Since the network is modelled to be built during the first four years, the lowest equipment costs (in years 10 to 11) will only appear in the equipment replacements.

Through usage of mesh networking capabilities fewer APs and UAPs will be needed in 4G networks than if existing network architectures are used, leading to lower equipment costs per subscriber.

**SDR capable handsets**

The important communication component beside the actual network, the mesh/capable handsets, follow a different diffusion pattern. Investments in mesh capable handsets are made in line with customer diffusion each year.
The additional cost for a SDR Handset with mesh networking capabilities is estimated to be a maximum of 160€ (in year 0) (see Figure 48). In the model, the 160€/subscriber are considered operator investment costs. This is because the additional handset cost will most likely have to be subsidized by the operator in order to acquire subscribers and persuade them to use a new network.

An additional 100€ per subscriber in acquisition cost, the same figure during the whole simulated period, is added to the additional SDR costs in the financial simulations.

The total subsidies in the first year (260€) are similar to estimations of the company 3’s handset subsidies to acquire 4G subscribers in early 2005 (Economist, 2005).

**OPEX**

**Data backhaul**

The model assumes that only UAPs are connected to a backbone network for data backhaul, APs function as repeaters. Data backhaul costs are estimated to be 700€ per site per month.
Site rent

In the model, the annual rental cost for AP and UAP sites are assumed to be

- 3000€ in Urban Areas (or 250€/month)
- 1500€ in Suburban Areas
- 1000€ in Rural Areas

The rental costs include electricity. Urban area cost figures are based on research made by Björkdahl & Bohlin (2004).

Maintenance

Maintenance costs have been modelled as costs for maintenance personnel. Each maintenance personnel is estimated to handle service of 50 APs/UAPs at a cost of 100 000€ annually (including material, salary, vehicle, etc.). Maintenance cost figures are based on research made by Björkdahl & Bohlin (2004).

Marketing costs

In the model, an important part of the marketing cost has been included in the CAPEX figures since an average acquisition cost, or subsidy, has been added to each acquired subscriber. Other marketing costs have been estimated as advertising costs of ~1.9 € per inhabitant (not actual users) in country/operator/year. The figure is based on advertising figures for telecom operators in Sweden in 2003 & 2004 (not including customer acquisition costs!). The four mobile operators in Sweden spent around SEK 300 million (~33.5 M€) on marketing the first 6 months 2004. Since 3G telephony was launched by most operators during this period, we use this figure as a proxy for marketing costs during service launch. We calculate that SEK 600 million (~67 M€) will be invested in marketing during 12 months (300*2) to cover a population of 9 million people, equivalent to SEK 67/person and year (~€ 7.4). With four operators, this would translate into 7.4/4 = 1.85 € / person / operator.

Administrative costs

The administrative costs have been estimated as an addition of 10% on other operational costs. The low-cost telecom company Tele2 is used as a benchmark. Tele2 had administrative expenses equivalent to 10% of other costs in 2003 and 9% in 2002 (according to annual income statements).

ARPU levels needed

The output of the business modelling activity is minimum ARPU levels needed recoup investments (CAPEX) and cover operational costs (OPEX). ARPU levels needed are thus defined as CAPEX+OPEX in each year, discounted to year 0.
and the annualized over the whole period. The formulas used are:

$$NPV = \frac{c}{\left(1 + \frac{p}{100}\right)^t}$$

Net Present Value (NPV). The capital c falls due in t years at rate of interest p

$$A = c \cdot \left(1 + \frac{p}{100}\right)^t \cdot \frac{p}{100} \cdot \frac{1}{\left(1 + \frac{p}{100}\right)^t - 1}$$

Annuity (A). Yearly instalment on a loan c, paid during t years by equal amounts, at rate of interest p

7.3 Results

Three different main scenarios have been simulated, as mentioned in previous sections. In this section the results are presented, followed by a sensitivity analysis.

CAPEX

In each scenario, the diffusion in urban areas has been modelled to be a bit more rapid than in suburban or rural areas. The maximum overall diffusion levels are reached in years 10 to 11 in each scenario. The highest numbers of users are added in the middle of the period (years 5 to 7).

The CAPEX curves are very similar in the three scenarios, as seen in Figure 50 to Figure 52. The early years are dominated by CAPEX for UAPs.
Figure 51: CAPEX and diffusion developments in Scenario 2

Figure 52: CAPEX and diffusion developments in Scenario 3
and APs. In the middle of the period SDR handset CAPEX is most significant, and replacement costs are only significant late in periods.

The accumulated CAPEX figures are similar for the three scenarios in the early years due to same network build-out paces. From year 4, when SDR handset costs are increasing in importance, the total CAPEX curves start to differ somewhat, as seen in Figure 53. The total CAPEX is naturally highest in Scenario 1 and lowest in Scenario 2 due to the total diffusion levels.

**OPEX**

The operational costs (OPEX) have been calculated as set out above. The total accumulated
OPEX and monthly OPEX per subscriber in each year are presented in Figure 54. The total accumulated OPEX is rather straightforward and grows in proportion to the number of users in the network. The monthly OPEX per subscriber in each year follows a bath tub-shaped curve due to the low number of subscribers in the early years. Once, the subscriber base has reached a significant number of users, the OPEX costs grow in proportion to the number of added subscribers. The impact of fixed operational costs is naturally highest per subscriber in Scenario 2, where user diffusion is low.

**ARPU needed**

When CAPEX and OPEX costs in each year are discounted to a Net Present Value (see sections above) and annualized, ARPU levels needed to cover investment and operational costs can be estimated. The monthly ARPU needed to cover CAPEX+OPEX in a 4G network vary between 15 and 19 € according to our simulations (see Figure 55). More exactly, the obtained results for each Scenario are:

- 15.8€ in Scenario 1
- 18.8€ in Scenario 2
- 16.6€ in Scenario 3

In our calculations, the costs have been discounted at an interest rate of 12%. This figure has been chosen by using the low interest rates available in 2005 (Eurosowp, STIBOR, etc. around 2-3%) as risk free interest, and adding a risk premium of 9-10% to account for the financial and market risks associated with the endeavour.

**Sensitivity analysis**

In order to evaluate the impact of the assumptions made, some parameters have been changed in sensitivity analyses conducted on the three base scenarios. In the first analysis, the equipment cost curves have been altered. In the second analysis the impact of an added licence fee has been evaluated.

**Changed equipment costs**

In order to evaluate the impact of the cost development curve on the final ARPU levels, three different price scenarios have been simulated. The cost figures used in the base scenarios (Scenarios 1 to 3) presented above are here labelled “High starting cost, low cost reduction”. Two sensitivity check scenarios with different cost development curves have been added, here labelled “Low starting cost, very slow cost reduction” and “Medium starting costs, slow cost reduction”. As seen in Figure 56, both sensitivity check cost scenarios start at a slightly lower equipment cost than in the base scenarios, but the price reductions are slower. The reason for using lower starting costs is that we ha deliberately used high starting cost values in the base scenarios.
In the same way as presented above for UAP and AP costs, the costs for SDR capable handsets have been altered, as shown in Figure 57.

The impact of the changed cost development curves on the ARPU levels needed is not very high, as indicated in Figure 58. The ARPU levels needed are not affected by more than 1.1€ Euro per month in any of the three base scenarios. If considering both diffusion patterns and cost development patterns impact increases to a maximum of 3.5€ difference between lowest and highest ARPU needed.
**Introduction of a licence fee**

The licence fees introduced in the 3G business cases in many countries through spectrum auctions heavily impacted the ARPU levels needed. In order to evaluate the impact of spectrum cost in a 4G setting, licence fees ranging from 652€ per capita (maximum paid in Europe for 3G licences, in UK, according to Liikanen, 2001) to 0$ per capita have been added to the ARPU levels needed (Figure 59).

Perhaps without any surprise, adding a licence fee has strong effects on ARPU levels needed to recoup investments and cover operational costs. The impact depends on the total diffusion levels, and the greatest impact is seen in Scenario 2. Overall, the maximum licence fee (652€/capita) raises the ARPU levels needed by:

- 130% in scenario 1
- 200% in scenario 2
- 150% in scenario 3

**Further extensions**

**Modelling competition**

The model thus far has assumed that a prospective mobile operator builds a nation-wide network but does not face direct competition. A fully worked out model that considers competition in all its dimensions and complexities is beyond the scope of this contribution. Such a fully-worked out model should consider competitive impacts from various substituting networks, have a view on pricing strategies, consumer demand and elasticises, and other strategic variables. A
fully worked out model in such a vein should build on foundations of economics and game theory. However, a rudimentary way to model competitive impacts is to provide a sensitivity analysis with the following assumptions:

- the prospective operators constructs a nationwide network.
- due to competition, the market share is varied according to rough estimates such as 25%, 50% and 75%, for all three scenarios.

With such a basic competition analysis, results will be obtained for the required ARPU levels. It is likely that such market share development will have significant impact on the required ARPU levels for the assumed network. This conclusion is already apparent in the results from the basic three scenarios above. Note that the three scenarios themselves can be considered variation in market share development, since the network roll-out schemes are similar for the three scenarios. For instance, Scenario 2 has a 50% market penetration, corresponding to a 50% market share for a 100% uptake market potential, while Scenario 1 and 3 translates into 90% and 75% market share respectively. Results in Figure 55 suggest that such market shares will in fact have considerable impact on the minimum required ARPU. Reducing the market share further will for each scenario have correspondingly larger impact on the break-even ARPU. For instance, assuming a 25% market share within the parameters of Scenario 2 unchanged will raise the required ARPU considerably. Certainly, competition will also put a downward pressure on prices but on the other hand stimulate demand (depending on price elasticity). Evaluating possible break-even ARPU scenarios with such a more finely calibrated model is an interesting further extension of this contribution.

Modelling interconnect charges

A further extension is to explicitly model interconnection and roaming regimes and their impact on the required ARPU levels. Again, having a view of the impact of interconnect and roaming impacts on ARPU requires a model of higher complexity. On the one hand, there is the possibility that regulatory regimes will change, including introduction of new cost calculation schemes for interconnect charges. On the other hand, the impacts of the charges depend on the market share of the typical operator, and how the typical operator interfaces with the fixed network providers. If the operator in question has a significant market share, the inflow of revenues relating to interconnect charges within its mobile network is likely to be greater than the outflow of charges. Thus, interconnect can become a net gain. For the smaller players, the situation is reversed. Moreover, the gain vs. loss consequences will be impacted by the relationship between projected wireless and fixed traffic. If the wireless network is highly dependent on the fixed network operator, or the opposite is obtained, the benefit/loss of interconnection charges to the typical mobile operator will look correspondingly different. For the roaming, the net inflow or outflow will depend on the attractiveness of the country in question with respect to roaming subscribers. It is well known that major business and policy meeting hubs, and major vacation regions will have a relatively higher positive inflow of roaming revenues. Again, the estimation of roaming impacts will also have to reflect some perspective on regulatory or market developments. The roaming charges will be influenced by changed regulatory regimes and costing methods. The impact of roaming for a given player will also be impacted by its size in a given country, but also whether the player in question will have operations in other countries. The possibility of multinational mobile operators to optimise their roaming obligations and benefits would be an additional complexity in such a model.

If one should go ahead with the most basic and simple sensitivity analysis for interconnect and roaming charges, it would be to provide a percentage surcharge or reduction of the required ARPU levels considered in Figure 55. The impact
of could vary considerably depending on the type of actor and the type of country. It has been reported that surcharge could be in the range of 25% of net ARPU for certain players, suggesting that such charges could have significant impact on break-even ARPU in certain circumstances. Evaluating impacts on break-even ARPU with a more finely calibrated model is an interesting further extension of this contribution.

7.4 Conclusions

Our simulation indicates minimum ARPU levels of 15-19 € monthly will be needed for 4G business cases to become viable, under our assumptions. However, this figure should be considered with great caution. A more precise estimate depends on a wide array of factors. Some of these factors have been evaluated above, including varying diffusion levels, equipment cost developments, licence costs, competitive impacts, and interconnect charges. Many more factors could be added, but this model provides a first comprehensive analysis of a future 4G network.

The impact analyses regarding certain factors’ impact on 4G business cases indicate the following degree of importance for ARPU levels needed:

- The cost of spectrum licences: High
- The 4G diffusion levels: Medium
- Equipment cost development curves: Low
- Competitive impacts: Medium to high
- Interconnect charges: Possibly significant

In terms of the overall purpose of this report, the business model provides a viability validation of the costs of the new technology but it is not a supply side equivalent to the demand study. Its usefulness is in verifying that the new technologies could offer infrastructure cost and pricing advantages, and thus be a viable business proposition should demand be there. However, the required ARPU levels should be taken with the caveats that interconnect charges and licence costs could intervene to make it more costly and thus the break-even ARPU cost much higher.
8. Study Consultation Process

8.1 Objective

Our objective was to carry out a consultation process with stakeholders, both official bodies in Europe having interests in this area, in particular the CEPT PT-1 working party, and the ITU-R WP 8F initiative for WRC-07 and through dialogue with research projects in the area including the FP6-projects WINNER, the (WWI) Worldwide Wireless Initiative with its projects (E2R, Ambient Networks and Maestro). The end-goal has been to produce brief (10-page) document to support a consolidated European view, as input to the preparatory work for the ITU process in WRC-07, for spectrum requirements of systems beyond IMT-2000.

8.2 The consultation-building exercise

Consultation required an information exercise for specific events and communities such as the national administrations, the research groups, and radio regulatory community, with preparatory documents and suitable messages. This has been closely supported by DG Information Society and IPTS. It involved a series of workshop events, organised with IPTS and by team visits and submissions of material to official meetings of international bodies such as the ITU-R WP 8F committee on IMT-2000 and CEPT. The steps taken were:

- The first consensus building event took place in Cambridge, UK, at the start of the study, on 07 September 2004. One team member, Colin Blackman, presented the aims of the study to the CEPT group concerned with a European response to the ITU WRC-07 preparations and the ITU questionnaire. Essential early feedback was gained here.
- The second event in consensus building was to meet the ITU international delegates at the WP8F meeting in Shanghai, 12th to the 20th October 2004, on preparation for WRC-07. We also met the European attendees (largely the CEPT group) at the ITU meeting for spectrum decision preparation for IMT 2000 systems and systems beyond IMT 2000.
- The third major event was a working meeting, a 2-day workshop in Seville, on 26-27 October 2004 at which not only was the work on scenarios progressed through validation and improvements but the beginning of a European caucus was formed going forward.
- The FMS team also attended the WWI conference Brussels, on the 9th December 2004, to meet with the research teams and review the projects such as E2R and Maestro.
- The fourth major event for consensus building was a one-day open workshop presentation and seminar for the relevant parties and major stakeholders, in order to expose the early findings and set future directions. This IPTS FMS Workshop, on 11 January 2005 in Brussels, started with a presentation. Input was given by a selected panel of speakers including Lara Srivastava (ITU), Martin Cave (Warwick University), Volker Reitz (T-Mobile Systems) and Bill Lehr (MIT Communications Futures Program).
- A brief paper was prepared on the FMS approach and put forward, with a full presentation to the CEPT conference in Uppsala on the 12th January 2005, supported by CEPT members from 02 Germany and T-Mobile. Entry of the position paper as a complementary approach to the ITU’s spectrum management methodology was agreed.
- This paper was then advanced with attendance at the 15th ITU WP8F conference in Geneva from the 31st January to the 7th
February 2005 to enter as a paper that may be submitted to CEPT and to the ITU WPF8 working process.

- We were invited to give a presentation on the FMS methodology to The Radio Spectrum Policy Group (RSPG) in Brussels on 23rd February 2005.

- Finally we created the report for DG Information Society to present as an ITU submission via CEPT. Using research into previous submissions, as well as our findings, we have prepared a suitable content, level and format paper on a socio-economic approach to analysis to spectrum requirements for projected services in Europe.
9. Conclusion: Future Trends in Services and Applications

At this point it is perhaps useful to conclude on the general directions in services and applications thrown up by the scenario research in terms of user take-up (the demand side of the market), technical directions (the supply side) and the economic perspective. In summary seven main directions stand out:

- For take-up (the demand side of the market) the phases of application types, as driven by pricing to the user may viewed as three phases, as shown below moving from a communications based industry to one more driven by a whole range of high level sophisticated applications, including machine to machine (telemetry sensors etc) as much as by human interactions (Figure 60).

The business of supplying mobile and wireless services of all kinds will move progressively towards applications services with content provision for lifestyle, business and entertainment services and away from simple carriage of bit streams for communications. Applications services can be seen as occurring in two steps or generations. First would be the fairly slow take-up of a limited range of applications, led by entertainment and followed by the immediate high utility lifestyle services of m-banking and credit remittances, as long as creditable security can be given. In a second phase, the far more complex radio infrastructure would start to be used, driving machine to machine communications both in the business sector (especially industrial usage) and in the consumer segment (smart home/domestic devices and entertainment centres).

Figure 60: User population numbers against base price trends - user population size is driven by pricing of services
9. Conclusion: Future Trends in Services and Applications

- Spectrum allocation as a way of stimulating the economy may well also become uppermost in the discussion as the debate moves away from technical requirements of the industry towards economic requirements at the level of the ITU member countries. Its allocation then turns on the returns to the economy, not to the government administration or the nominal ‘owner’ of spectrum.

- The analysis of the technical problems of spectrum and appropriate data speeds for each service may be resolved by a move to simple single standard bit rate. It is reasonable to consider that by 2020, the ideas of carefully matching bit rates, cell size, ATM class, symmetry, etc by network service will give way to a single fast bit stream encapsulating both slow and high-speed bit rates. A radio ‘bus’ in the manner of the local are network would supply all requirements, just as in the 1980s there were many types of LAN, in theory with specific applications in mind; but they all gave way to 100Mbps Ethernet largely. Evidently it would have to be high enough for a single standard to cope with all needs and so would be of the order of 30 Mbps or perhaps 100Mbps to give the actual throughput required in view of security requirements.

- Machine to machine communications may take off in the final Epoch of the high output scenarios. This implies information being carried as a service in the local loop or for wider area in industrial applications, office communications, also in industrial plant for sensor, telemetry, inter-road-vehicle control, city operation and surveillance, and medical usage in hospitals or for remote telemedicine. Market forecasts on proportion of all traffic being machine to machine communications have often indicated large percentages (e.g. 20% by 2008). But our scenarios are only optimistic on this front in the Smooth Development, scenario 1, and even here not till the last Epoch (2020).

- Mobile melds into wireless with alternative wireless technologies (AWTs) by 2020, and ‘wireless’ becomes all forms of radio communications, mobile and non-mobile, non-cellular. (Figure 61)

- Mobile displaces fixed as its costs fall, so communications becomes all forms of radio

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**Figure 61**

![Diagram](image1)

**Figure 62**

![Diagram](image2)
communications, for all segments by 2020 including alternative wireless technologies (AWTs) such as WiMax. (Figure 62)

• Engineering a trade-off between raw bandwidth and use of cheaper computing power will lead to lower bandwidth networks with high effective throughput. They will offer lower cost and more robust communications. Sophisticated compression at low cost in the handset and transceiver will enable effective higher data rates under poor propagation conditions - for more reliable, more ubiquitous networks.
References

References used in Scenario Building

4. Book – RH Anderson, TK Biks et al, Universal access to email, feasibility and societal implications, RAND Corp, 1995, Santa Monica, Ca, USA
11. Paper - Ian Pearson, BT Exact, Living in an uncertain world
12. Paper - Ian Miles, April 2004, Be Here Now, IoIR, University of Manchester, UK
15. European Commission, Forward Studies Unit, Gilles Bertrand (Coord.) et al, 1999, Scenarios Europe 2010, Five Possible Futures For Europe
16. Paper - The Contribution of Mobile Phones to the UK Economy, mmO2, MAY 2004 mmO2 plc, Wellington Street, Slough, Berkshire, United Kingdom, SL1 1YP Copyright mmO2 plc, 2004, available from O2
17. Paper - Gerard Bloch-Morhange, Ouverture Internationale, Paris and Emilio Fontela, Professor of Economics Universidad Autónoma, Madrid. Mobile communication from voice to data: a morphological analysis, MARCH 2003, to be published in Info
References

24. Paper - Flying carpet – towards the Fourth generation mobile communications system, version 2.0 Japan, April 2004 Mobile IT Forum, Japan (from MITF Website)


26. Article - the Economist, 02 Sep 2004, Mobile Telecommunications

27. Article - Telecoms.com, Mobile subscriber numbers exceed 1.5 billion, China subs to 2009, EMC database 24JUN 2004


29. Paper - R. Ling (Telenor), Leslie Haddon (London School of Economics), Dec 2002, Mobile telephony, mobility and the co-ordination of everyday life.

30. Paper - Peter Cochrane’s Uncommon Sense: Mobile Guesses - Here’s what the future of mobile communications will look like. Sept 2004

31. Paper - Mathias Ottisch, Erik Bohlin, Alois Frotschnig, Culture as a driver towards a sustainable information society, Institute for Prospective Technological Studies (IPTS), Joint Research Centre, European Commission Isla de la Cartuja snE-41092 Seville, Spain


33. Paper - Consolidation of the Scenarios from the Wireless World Initiative (WWI), Dr Andrew Aftelak, (Motorola Ltd), June 2004, andrew.aftelak@motorola.com

34. Paper - Börje Ohlman et al , Wireless World Research Forum (WWRF), Sep 2004, Experiences from using scenarios to derive requirements for the Ambient Networks project


39. Article – FT, N. Timmins, 20 Dec 2000, Digital divide grows as internet access grows (UK model)


41. Article – FT, R. Donkin, 26 Jun 2003, Working poor continue to walk the line

42. Article – FT, G.Silverman, 30 Aug 2004, Young and trendy are shunning the sex sell (Europe)

43. Article – FT, S.Voyle, 12 Dec 2003, Online sales - Shoppers spend record £1.17Bn over Internet

44. Article – FT, A Skorecki, 31 March 2004, Derivative Trading Volumes Soar

45. Article – FT, M.Wolfe, 6 Dec 2000, Risking a hard landing

46. Article – FT, D. Roberts, 20 Aug 2003, Service industries go global: skilled white collar jobs are starting to migrate

80. Article – FT, M. Wolfe, 10 Dec 2003, Until Japan tackles its old troubles, recovery is doomed

81. Article – FT, J. Leahy, 30 Aug 2001, Pets show the way for China’s mobile services – virtual pigs take off

82. Article – BW, Asian Business, 26 May 2003, Deflation Nation – how ordinary Japanese are living, suffering and even thriving in an era of ever-falling prices

83. Article – FT, A. Ward, 06 Oct 2003, Founders of chaebol have too much control

84. Article – FT, M. Wolfe, 07 July 2004 China should not worry about a little overheating

85. Article – FT, M. Dickie, 06 Apr 2004 Low cost, High quality and eager to please – why chips groups are shifting more work to China

86. Article – FT, C. Mandil, A. Binks, 19 Oct 2004, Oil: is the sense of crisis over?

87. Article – FT, A. Skorecki, 31 Aug 2004, Hedge funds change bond investors’ world

88. Article – FT, C. Nuttall, 21 Oct 2003, China makes its mark on the telecoms world stage

89. Article – FT, A. Ward, 25 Sep 2003, South Korea feels the chill in China’s growing shadow

90. Article – FT, 21 Oct 2003, UNDP graph figures, developing vs OECD for GDP/capita, and developing countries for Years of schooling,

91. Article – FT, E. Luce, 23 Sep 2003, India starts to see China as land of business opportunity

92. Article – FT, R H Wade, 29 Aug 2003, Held hostage by the anti-development round – developing countries locked in as commodity suppliers

93. Article – www.worldbank.com, Improving the investment climate in India, also FT article, Wolf, E. Luce, 04 Apr, 2003, Developing countries – India ‘s slowing growth – why a hobbled economy cannot meet the country’s needs – Dynamic China shows how it is done


95. Article – FT, M. Wolfe, 2 June 2004, Oil is more vulnerable to politics than geology – 10% of global output vanishes with Saudi regime collapse

96. Article – FT, P. Coggan, 11 Jul 2001, Confidence and concern, a structural or cyclical change in productivity and profitability?

97. Article – FT, K. Hille, 10 Aug 2004, Chipmakers are trying to see the light, views about what lies ahead for the technology sector vary

98. Article – BW, R. Miller, P. Coy, 17 Feb 2003, Productivity’s second wind

99. Article – FT, Graphs, 04 Sep 2003, World trade has grown faster than the global economy


101. Article – FT, S. Brittan, 20 June 2003, The gap in our knowledge about output and inflation

102. Article – The Economist, graphs in FT, 21 Jul 2003 House prices index, Household debt as % age disposable income, interest rates, USA, Japan, EU

103. Article – FT, C. Giles, 3 Apr 2003, Every budget Gordon Brown reveals fresh initiatives yet the higher productivity promised remains elusive – and New Growth theories of Paul Romer

105. Database source Eurostat – NACE statistics for employment and demographics


References used in the Financial Analysis


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