SCF Associates Ltd

Benchmarking Impacts of EU Policy

Options for Economically Efficient Management of Radio Spectrum

Final Report
SCF Associates
for DG Information Society and Media
06 December 2006
Simon Forge, Colin Blackman and Erik Bohlin

FINAL REPORT

Invitation to tender Reference number	INFSO 2006 PJ/MP D(2006) 731090
Document Authors	Simon Forge, Colin Blackman, Erik Bohlin
Contract	EC Study Contract REF : 30-CE-0088817/00-13
Document Date and version:	06 December 2006, version 5 FINAL
Contractor	SCF Associates Ltd
Contact email	simon.forge@whsmithnet.co.uk
Attention of:	Ms May Pettigrew, Mr Bjorn Thegeby

The views expressed in this report are those of the authors and do not necessarily reflect those of the European Commission

SCF Associates Ltd
4 Chiltern Close
Princes Risborough, Bucks HP27 0EA
United Kingdom
Tel + 00 44 7866 6013 52

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

3G	Third Generation Mobile
AWT	Alternative Wireless Technology
BAN	Body Area Network
CDMA	Code Division Multiple Access
CR	Cognitive Radio
DSL	Digital Subscriber Line
ERT	Emerging Wireless Technology
Flash OFDM	Flash Orthogonal Frequency Division Multiplexing
GDP	Gross Domestic Product
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications (originally Groupe Spécial Mobile)
IPR	Intellectual Property Rights
IPv6	Internet Protocol Version 6
ISDN	Integrated Services Digital Network
ISV	Independent Software Vendor
MAN	Metropolitan Area Network
MMS	Multimedia Messaging Services
MIMO	Multiple In Multiple Out
MNO	Mobile Network Operator
MS	Member State
NFC	Near Field Communication
NICs	Newly Industrialised Countries
NRA	National Regulatory Authority
PSTN	Public Switched Telephone Network
RFID	Radio Frequency Identification
SMS	Short Message Service
SDR	Software Defined Radio
UMTS	Universal Mobile Telecommunications System
UWB	Ultra Wide Band
VAR	Value Added Reseller
VoIP	Voice over Internet Protocol
W-CDMA	Wideband Code-Division Multiple-Access
WiBro	Wireless Broadband
WiFi	Wireless Fidelity
WISP	Wireless Internet Service Provider
WLAN	Wireless Local Area Network
WiMax	Worldwide Interoperability for Microwave Access
xDSL	Refers collectively to all types of digital subscriber lines

Foreword

This study was undertaken within the context of the Review of the EU Regulatory Framework for Electronic Communications. Before preparing legislative proposals to amend the Regulatory Framework, the European Commission has committed to undertake a rigorous impact assessment. Following on the first impact assessment and the public consultation, this short study was commissioned in support for the preparation of the second impact assessment.

The study was carried out by a small team and took place over a six week period in October and November 2006. Thus, we would note that the study was highly ambitious given the time available. Moreover, and as is well known, studies such as these are highly constrained by the availability of data. This is doubly true for a study concerned with looking to the future use of the radio spectrum. Furthermore, the study team was challenged by the European Commission not only to make a useful contribution to this particular impact assessment but also more generally to achieve some methodological advances in the realm of benchmarking and impact assessment more generally. Consequently the study sought to develop a new modelling approach. While we consider the approach taken to have been successful, not least given the time constraints, we would also recognize it as still being experimental. Thus, the study's conclusions should be considered in this light.

The rest of this report is structured as follows. Chapter 1 sets the context by describing the context and the study's objectives and initial approach to addressing the problem. Chapter 2 considers the methodological approach in more detail including the construction of scenarios, the choice of indicators and issues concerning data sources. The third chapter describes the scenarios themselves and their assumptions and initial conditions. It should be noted at the outset that these scenarios are not predictions and should also be seen as highly stylized caricatures or extremes designed to help draw the main picture, contrast the differences and so to create an evidence base. Findings, both qualitative and quantitative, are described in Chapter 4. The final chapter discusses all the policy issues, both methodological as far as impact assessment is concerned and also conclusions and recommendations with regard to policy options for future use of the radio spectrum. A number of Appendixes are included in support of the study.

CHAPTER 1. The problem before us

1. The spectrum allocation problem

1.1. EU policy context

The importance of radio spectrum as a production factor for electronic communications services and networks (such as mobile; wireless and satellite communications; TV and radio broadcasting) and other applications (short range devices, defence, transport, radio location and GPS/Galileo satellite systems) has increased dramatically during the last decade. As noted in the Communication on the Review of the regulatory framework for electronic communications,[1] the total value of radio spectrum-dependent services in the EU is estimated to be up to 2,5% of annual European Gross domestic product.

The review process will lead to legislative proposals for modification of the electronic communications regulatory framework, including reforming spectrum management to better achieve overall EU policy goals. The Commission proposes to do so by liberalising the use of spectrum, adopting common approaches to distribution of frequency usage rights and introducing more EU coordination where beneficial. The overall strategy has been described in a Communication of 2005 (Second Annual Spectrum Report).[2]

Liberalisation of spectrum use would include the introduction of more flexibility in the management of spectrum, by reinforcing the principles of service and technology neutrality.

Furthermore, in order to close the gap between market demand and supply under the current spectrum distribution practices, which lead to an inefficient use of spectrum, the proposals aim at introducing spectrum trading in certain bandwidths as well as making available certain spectrum resources on an unlicensed basis. The general approach to spectrum trading, combined with the principle of technology and service neutrality, was presented in a Commission Communication in 2005.[3]

On a different level, the review proposals aim at reinforcing a coordinated, pan-European approach by improving the regulatory and administrative mechanisms allowing for a coherent spectrum management at EU level, especially where this is necessary for Internal Market reasons. This may reinforce the internal market and thereby promote investments through economies of scale while preventing cross-subsidizing effects.

Thus, the allocation of the radio spectrum is seen as a key activity for the development of the European economy, and its dependent high technology user industries, particularly in terms of the Lisbon strategy where it is viewed as critical for development. The EC's Commissioner for the Information Society and Media, Viviane Reding, stated:[4]

[1] COM(2006) 334 on the review of the EU regulatory Framework for electronic communications networks and services. 28 June 2006. http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/com334_en.pdf

[2] COM(2005)411 "A forward-looking radio spectrum policy for the European Union: Second Annual Report", 6 September 2005 http://eur-lex.europa.eu/LexUriServ/site/en/com/2005/com2005_0411en01.pdf

[3] COM(2005) 400 "A Market based Approach to Spectrum management in the European Union", 14 Sep. 2005 http://eur-lex.europa.eu/LexUriServ/site/en/com/2005/com2005_0400en01.pdf

[4] Text available at: http://rspg.groups.eu.int/doc/documents/meeting/rspg7/rspg_vr_speech.pdf

> I would like to assure you that the Commission intends to work further in partnership with the Member States ……. to enact a pro-innovation EU spectrum policy. This policy should be based on three main foundations:
>
> - Low entry barriers for industry to assist the current dynamics of technology evolution. This will in turn ensure greater flexibility and freedom of choice for consumers;
> - A gradual policy convergence in spectrum regulations to reflect the ongoing technology convergence, notably between broadcasting and mobile communications;
> - A fully functioning internal market for spectrum-based equipment and services, relying on proper EU coordination.

1.2. The historical context of European spectrum licensing

GSM has shown that European industry can successfully generate large volumes of business and jobs if the enablers are in place, and the primary need is for spectrum but allocated in the correct way. The UMTS third generation spectrum allocation mechanisms via auctions have been a different story.

One conclusion to be drawn from the history of these initiatives is that spectrum licensing in a successful fashion is a key to successful industrialisation and commercial usage. Naturally there are a wide range of choices for a licence allocation, with an equally wide range of freedoms and constraints in a commercial context.

Currently the main legal focus is for commercial licensing, with a set of laws designed to protect the rights of users of commercial spectrum, as if it were an intellectual property. These laws apply to an agreement between the service provider and its regulators, and define the spectrum's range and conditions of usage.

The commercial premise seemed reasonable until unlicensed ('open') spectrum with WiFi and WiMax (which is also often used in licensed bands) demonstrated that a plentiful supply of unlicensed spectrum with a completely open usage and re-use approach, one which has no place for the constraints of proprietary licence, makes the use of closed licences seem limiting on the freedoms that the market could have, and which can be reshaped. Moreover the technical advances in spectrum sharing through advanced spread spectrum and cognitive radio techniques changes our conceptual basis for spectrum usage.

1.3. Understanding the perspective of different stakeholders

Among the various communities of interest there are quite different standpoints. In understanding the spectrum usage world and the future market, we need to understand who the principal stakeholders are and their point of view:

- Operators – use spectrum as an input factor in their services offering
- Consumers – use spectrum as the delivery medium for service consumption. The spectrum is therefore viewed in terms of need, convenience and ultimately of dependence.
- Business users – their focus is on applications and the benefits from revising existing business processes or by or enabling the new, with radio access to applications, or novel business tools (such as RFID) which exploit radio in some way. The processes are viewed in terms of profitability, functionality, reliability, costs and availability and spectrum is seen as a constraint, or an enabler, depending on its regulation.
- Major equipment vendors, who are in a symbiotic relationship with the telecommunications operators – keen to build on top of a common technical framework in a manner that assures market access and power while defeating rivals, they are wary of the pitfalls of any radio technology's IPR and also of unsuitable spectrum licensing mechanisms, as has occurred in

the 3G market. Such conditions can immediately curtail their investments in new technology, as being too high risk to be taken up by operators.

- Other commercial players – this includes content providers, both entertainment and non-entertainment (eg m-commerce), and software providers, ISVs and VARs, and wireless system integrators, that is whosoever benefits in business terms from the spectrum providing opportunities for enterprise.
- Government users, both civilian and military, who traditionally have controlled large regions of spectrum without challenge, including essential services such as air traffic control
- Government regulators, both for telecommunications and competition, treasury functions and confiscatory taxation authorities.

1.4. New Directives on spectrum allocation

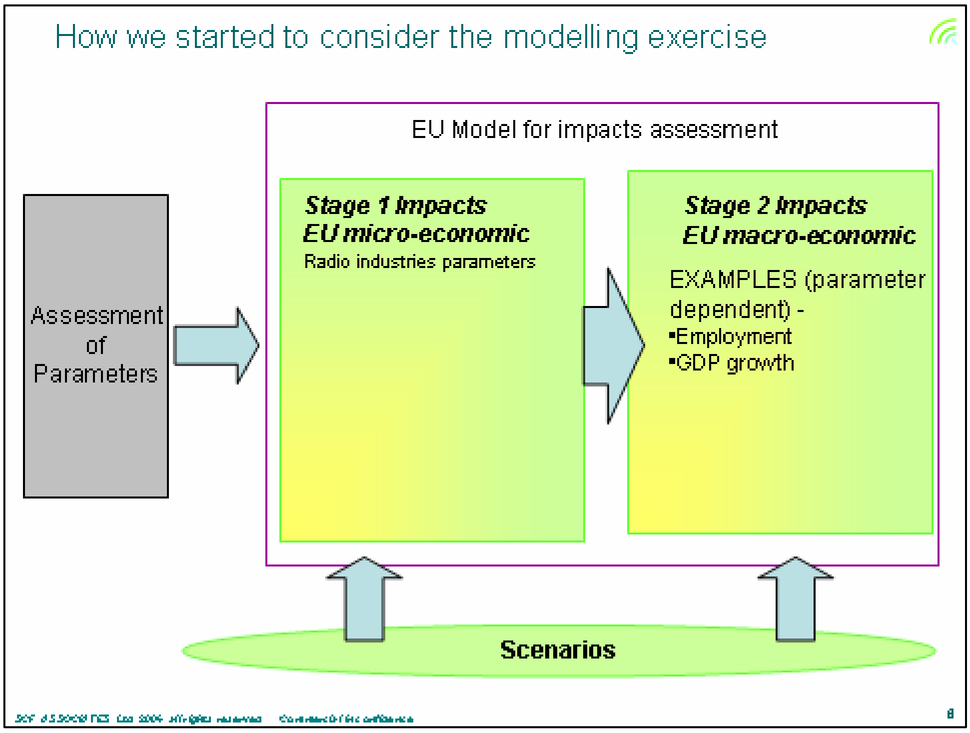
It is at this point that the Commission has chosen to launch new initiatives in the forms of a regulatory framework, chosen to embed spectrum within its proposals, and in particular, allocation mechanisms. As required by the five directives of the eComms regulatory framework, the first phase of the Review was presented by the European Commission in its Communication on 29 June 2006. The current review of the EU Regulatory Framework for electronic Communications (the 'eComms' Review) is a key element for realising the goals of the information society and economy. The Impact Assessment will evaluate in detail the concrete impact of the new legislative proposals, for Radio Spectrum Management. The results of this study will be used as a support for the preparation of the second impact assessment by the Commission.

2. Objectives of the study and impact assessment methods

Thus the essential aim of the study is to provide as rigorous and empirically based assessment as is possible given the constraints on time, data sources and estimation reliability, for the impact that proposed changes will have in comparison with the status quo. The assessment is to be based on SMART impact assessment parameters (Specific, Measurable, Accepted, Realistic, Time-dependent). The conceptual orientation and methodology of the study uses benchmarking, i.e. a comparative assessment from a baseline of the current EU situation relating to spectrum use, allocation and assignment, and to service provision, compared to the possible future.

The task of the study is to consider the economic factors involved in spectrum assignment, finally at a macro-economic European level, and so construct a framework for assessment of their impact that will underpin future EU Directives in this area. The need to consider the impacts of different spectrum allocation methods lends itself to analysis through multiple scenarios of allocation, which can also to be used for benchmarking of future impacts. Thus our initial approach to meeting the study's objectives is shown in Figure 1.1.

Figure 1.1. Initial approach to the study



However, we quickly realized that such a framework was too simplistic for our needs. In particular, neo-classical economics is notoriously poor in linking the micro and macro-economies – we were far from convinced that simply multiplying average effect at the micro level would enable us to model macro-economic effects. Thus, in order to project impacts at the macro-economic level, eg employment in Europe, GDP, etc, we need a bridging stage and so have designed an approach using the concepts of meso-economics to give appropriate linkages.[5]

Meso-economics describes economic arrangements which are not based either on the microeconomics of buying and selling and supply and demand, nor on the macroeconomic reasoning of aggregate totals of demand. Instead, meso-economics recognizes that what is also important is the context and structures in which micro and macro-economic forces operate – and these may be at the household, sectoral or even national level. We acknowledge that a meso-economic approach is an underdeveloped and non-mainstream branch of economic analysis, but we feel strongly that it has an important role to play in a benchmarking and impact assessment exercise such as this. Our overall methodological approach is described in Chapter 2.

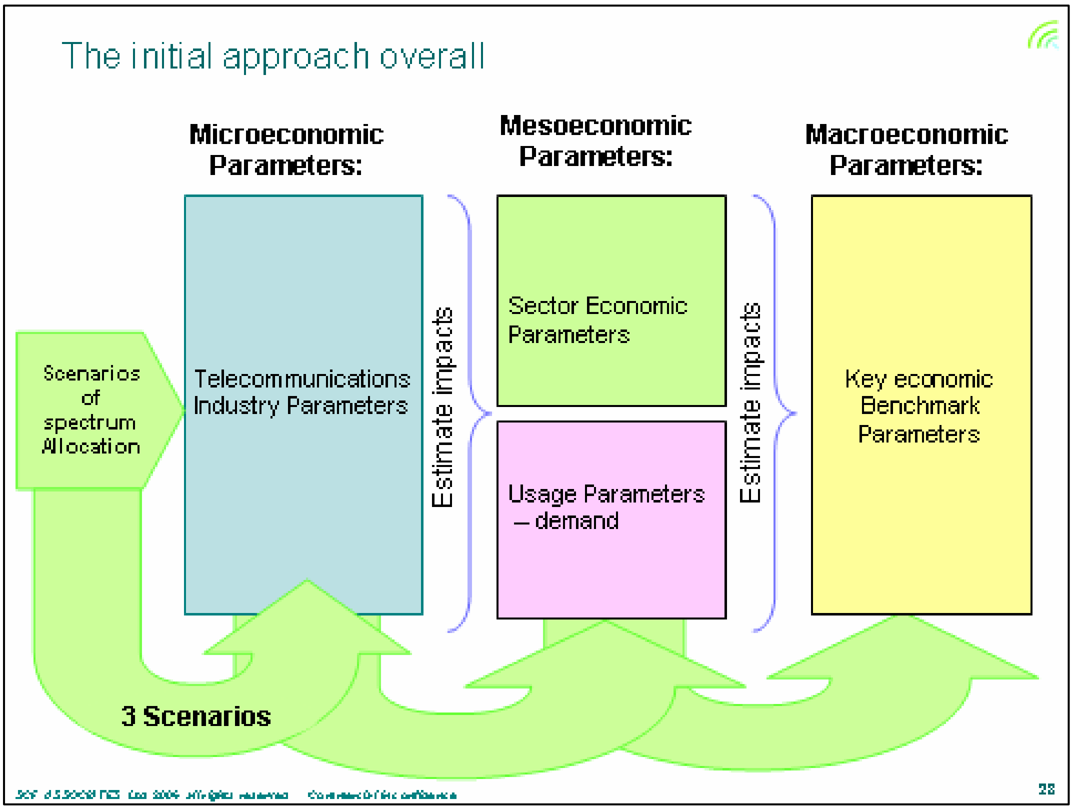
[5] Kurt Dopfer, 'The Origins of Meso Economics: Schumpeter's Legacy', Papers on Economics and Evolution, August 2006, https://papers.econ.mpg.de/evo/discussionpapers/2006-10.pdf

CHAPTER 2. The approach

1. Overall method

Our approach to the study is to use three scenarios to simulate the impacts of different approaches to spectrum allocation. These different spectrum allocation methods can be viewed as acting at the micro-economic level of the enterprise and of the individual and to some extent, and also at sector and social levels, as well as limited macro-economic levels. The overall approach is shown in Figure 2.1:

Figure 2.1. Overall methodology for the study



Our objective is to assess the impacts of the spectrum regulation directives on the economy and the telecommunications environment (its industry and market) by using a model of development based on a selection of carefully chosen parameters, with multiple scenarios. Our modelling approach consists of:

1. Scenario building

First, we have constructed scenarios using the SCF approach of a key theme and initial key drivers, with known initial conditions to yield the assumptions, assertions, leverage points, hypotheses, points of doubt and inaccuracy and finally the scenarios. This is described in more detail below.

2. Constructing the model
The model is constructed using impact trees wherever possible to give the links for a composite structure of dependence, with the three levels of scale. This requires building the model as a set of dependent variables, following the impact tree, to which the baseline data can be applied, then modulated by the scenarios.

3. Applying the data and exercising the model
The data gathered to give the status quo acts as the starting point. Projection by scenario of the data can then be applied to the parameters. From the scenarios' influence on the key parameters at each stage of the model we can see the outcomes, finally at the macro-economic level.

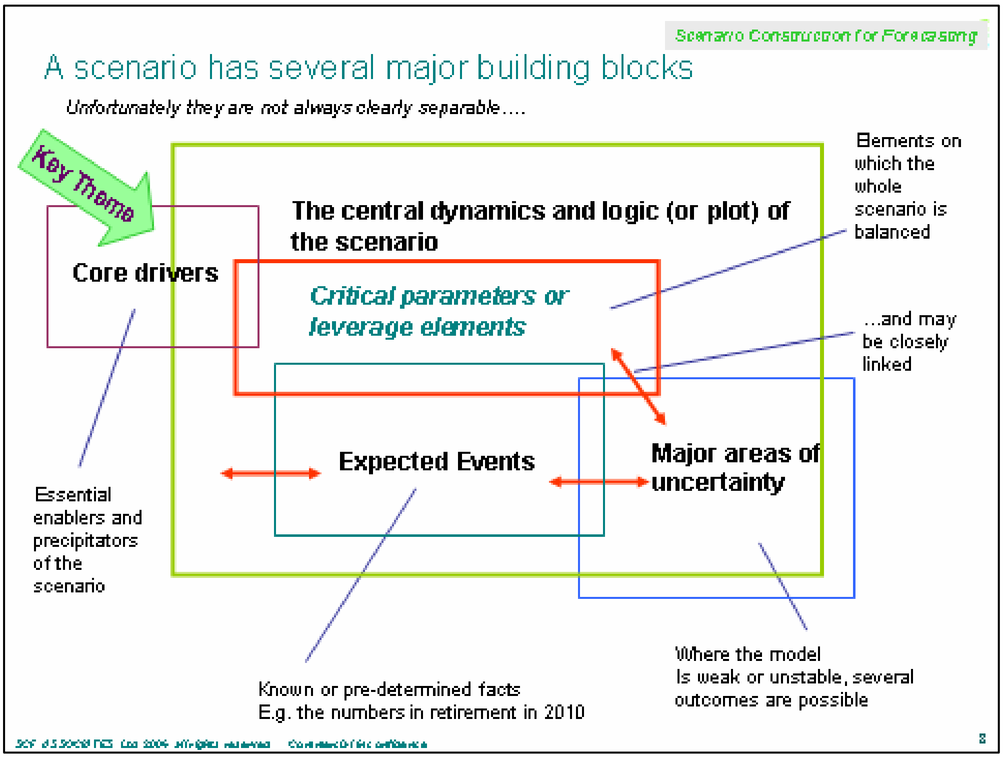
2. Scenarios and their justification

We have used a tried and trusted method – Scenarios Construction for Forecasting – to build three scenarios, which are described in Chapter 3. Here we give an overview of the scenario building method.

Planning with scenarios has the aim of bringing together useful future views with events, attitudes, surroundings, new forces and players. Scenarios should not be seen as predictions as such but a supposition of what might happen in certain circumstances. 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.

In a scenario, we combine two worlds – a world of 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 2.2)

Figure 2.2. Constructing the scenarios



In particular, the real forces of change must be identified – be they widespread and long term or specific and short-term, eg 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:

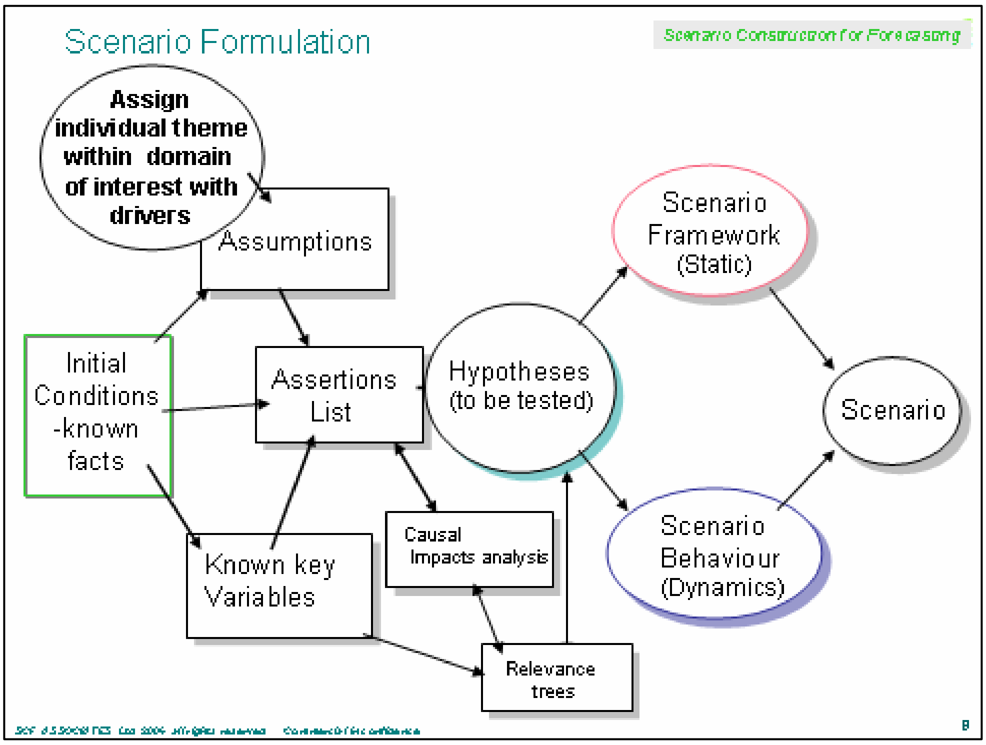
- Identification of key parameters, leverage points, triggers and long term trends
- Including the impacts of major discontinuities –likelihood and secondary effects
- Use of causal effect chains, wherever possible, and their relative strengths, to form an overall impact analysis, of both external forces 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 2.3:

Figure 2.3. Scenario formulation



In this way, three scenarios were developed:

1. Scenario 1: Radio Europe Mix – Trading and unlicensed spectrum allocation for all MS equally
2. Scenario 2: Radio Drop-outs – Each Member State has its own situation for allocation leading to many and diverse positions across Europe
3. Scenario 3: Radio Bazaar – Spectrum trading across EU for all MS equally

These three scenarios are described in detail in Chapter 3.

3. The choice of parameters

As many other researchers have found, measuring the impact of any kind of information and communication technology is difficult for many reasons. Like any kind of industrial development, the growth in industries producing ICT goods and services is thought to be important to the growth of the economy. However, it is difficult to find evidence of a direct impact of ICT on economic activity – the so-called Solow Paradox, named after the Nobel laureate in economics, in which he stated: "You can see the computer age everywhere these days, except in the productivity statistics". The picture is similar for communications, although it has long been held that there is a correlation between telephone use and GDP,[6] and recent research by Len Waverman has shown a correlation between mobile telephony and the economy.[7]

Perhaps of more importance, socially and economically, are the indirect impacts of the diffusion and use of ICTs, which has the ability to transform the way individuals, businesses and society interact, work and communicate. But measuring indirect benefits is even more difficult. The latest *ITU World Telecommunication/ICT Development Report* notes:[8]

> One way of understanding the difficulty of measuring the impact that ICTs have, is to imagine the impact that electricity has had on the economy and society. As with ICTs, there is no denying that electricity has had important impacts on individuals, businesses and society at large but its measurement is elusive.

Clearly the choice of appropriate parameters as indicators for measurement is one of the keys to this study. Our choices have been guided in several ways – by the desire to make a methodological advance in benchmarking, by the literature on measuring impacts of ICTs, and by good practice in impact assessment in keeping with the concept of SMART objectives, the principles of which are set out in the box below:[9]

Objectives should be:

Specific: Objectives should be precise and concrete enough not to be open to varying interpretations. They must be understood similarly by all.

Measurable: Objectives should define a desired future state in measurable terms, so that it is possible to verify whether the objective has been achieved or not (see III.6). Such objectives are either quantified or based on a combination of description and scoring scales.

Accepted: If objectives and target levels are to influence behaviour, they must be accepted by all of those who are expected to take responsibility for achieving them.

Realistic: Objectives and target levels should be ambitious – setting an objective that only reflects the current level of achievement is not useful – but they should also be realistic so that those responsible see them as meaningful.

Time-dependent: Objectives and target levels remain vague if they are not related to a fixed date or time period.

---

[6] Andrew P. Hardy. "The Role of the Telephone in Economic Development." *Telecommunications Policy*, Vol. 4, No. 4, pp. 278-286, December 1980.

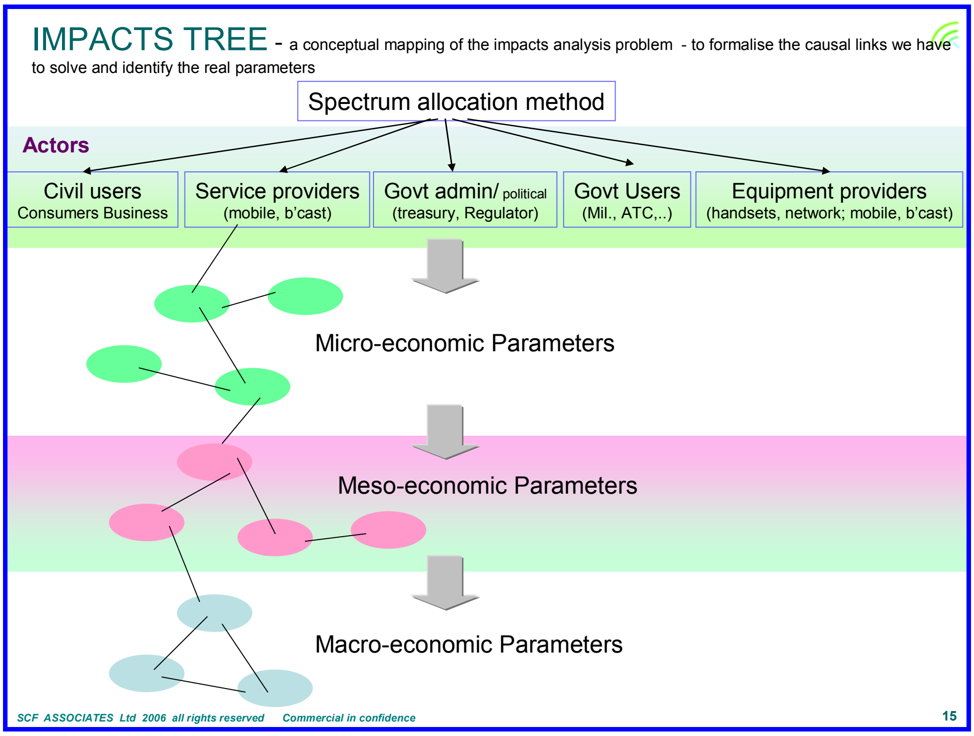
[7] Leonard Waverman, Meloria Meschi and Melvyn Fuss, 'The Impact of Telecoms on Economic Growth in Developing Countries', http://web.si.umich.edu/tprc/papers/2005/450/L%20Waverman-%20Telecoms%20Growth%20in%20Dev.%20Countries.pdf

[8] ITU, *World Telecommunication/ICT Development Report 2006: Measuring ICT for social and economic development*, 8th edition, 2006, http://www.itu.int/pub/D-IND-WTDR-2006/en

[9] European Commission, *Impact Assessment Guidelines*, SEC(2005) 791, June 2005, p.20.

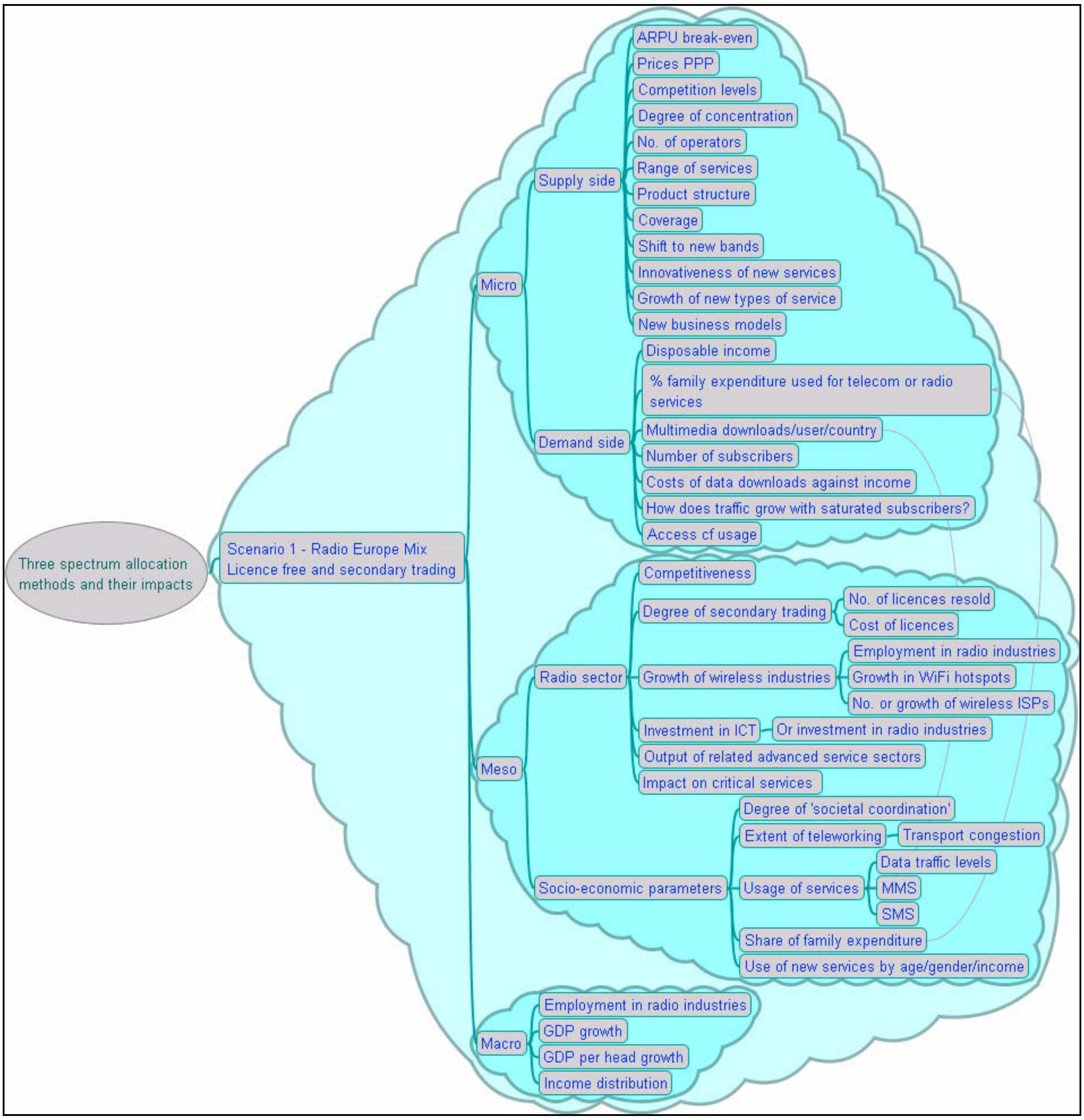
A minimal number of parameters were chosen for final analysis both to avoid 'metrics madness' and also because of the limited time available for the study. We have used impact trees to assist in the conceptual mapping process, to help identify causal links and hence useful parameters, as well as enriching the scenarios.

Figure 2.4. Impact tree analysis



Note that the impacts tree can be used both forwards and backwards. In some appropriate cases coefficients of influence can also ascribed between parameters. This feature of the method enables a cross impact type of analysis with the potential for sensitivity analysis. We used mind-mapping software to drill down further as illustrated below in the figure.

Figure 2.5. Mind mapping for one scenario



Thus, our initial analysis enabled us to make a selection of parameters at a general level, as follows:

- Micro economic parameters: telecommunications industry
- Micro economic parameters: user / demand side
- Meso economic parameters: Sector – investments, take-up etc
- Meso economic parameters: Infrastructures
- Meso economic parameters: Socio-economic
- Macroeconomic parameters: Employment, GDP, etc

We then tested the efficacy of these parameters through a limited survey of experts, with a short questionnaire emailed to a small selected group of industry and socio-economic experts. The questionnaire and a summary of the responses received are included in the Appendix. This process both stimulated ideas for other parameters and also focused attention on the ease and likely availability of data. We therefore spent significant time in researching the availability of data to support possible parameters (see section below on sources of data) before we drew our conclusions on which parameters were proportionate to policy objectives and which were appropriate and could be worked with in the context of this study. The final list of parameters chosen is shown in Table 2.1:

Table 2.1. The final list of parameters chosen

Micro-economic parameters	Meso-economic parameters	Macro-economic parameters
1. Average Revenue per User (ARPU) break-even	1. Growth of wireless industries (WiFi hot-spots)	1. EU employment in knowledge industries (% total)
2. Range of services	2. Average mobile subs per 100 pop EU-25	2. EU GDP growth rate
3. Coverage by most advanced services available	3. 3 e-Readiness index[10]	3. EU GDP/head (EU25 Euros/inhabitant)
4. Subscriber growth rate as mobile subscribers above saturation per 100 pop. For the EU-25	4. Consumer expenditure on communications	4. Socio-economic opportunity, as measured by inward investment (FDI)
	5. Comms expenditure as % total disposable income	

The micro level parameters were all forward simulations, for three ‘epochs’ (2010, 2015, 2020) effectively set by the degree of competition across the three scenarios.

4. Data sources

A significant amount of time was spent in researching sources of data. As has already been indicated, the choice of parameters was strongly influenced by the availability of data, which had to have a number of characteristics. As noted in the *ITU World Telecommunication/ICT Development Report*:

> The lack of comprehensive, timely and comparable data remains a major barrier to analyzing the status and progress of Information Societies, identifying reliable targets and adapting policies. To analyze the real use and potential of ICTs, it is imperative that countries carry out representative household and individual ICT surveys.

To be suitable and useable in this study, data had to be available ideally:

- for the whole of the EU-27, or failing that for EU-25, or even for the EU-15. Often we found that some promising data sets were only haphazardly collected and available for a partial set of Member States. Often Eurostat data is still only available for the EU-15. OECD data, which is generally very good, often is not categorized for the EU.
- as time series data over several years, eg 2000-2006, or at least allow interpolation to build a reasonably robust time series.

The major sources of data consulted included databases from:

- Eurostat
- OECD
- ITU Telecommunications Development Database (including extra telecommunications indicators database for up to 2005, purchased)

[10] E-readiness is the “state of play” of a country’s ICT infrastructure and the ability of its consumers, businesses and governments to use ICT to their benefit. It is based on over 100 separate quantitative and qualitative criteria in six weighted categories: 1. Connectivity and technology infrastructure (25%); 2. Business environment (20%); 3. Consumer and business adoption (20%); 4. Legal and policy environment (15%); 5. Social and cultural environment (15%); 6. Supporting e-services (5%).
See http://graphics.eiu.com/files/ad_pdfs/2006Ereadiness_Ranking_WP.pdf

- World Bank
- UNCTAD
- EITO

Our final list of parameters and the sources of data we used to support them are shown in Table 2.2 (see also Appendix for references).

Table 2.2. Data sources for the chosen parameters

Micro-economic parameters	**Data source**
1. ARPU break-even	For comparison only for forward simulation: ITU Telecommunication Database; OECD, Communications Outlook, 2005;Teligen, Telecom Price Developments from 1998 to 2005, Report for DG InfSo, December 2005
2. Range of services in common usage	Forward simulation
3. Coverage of advanced services	Forward simulation
4. Subscriber growth rate	Forward simulation

All of the above parameters were set by the scenarios, specifically be the degree of competition.

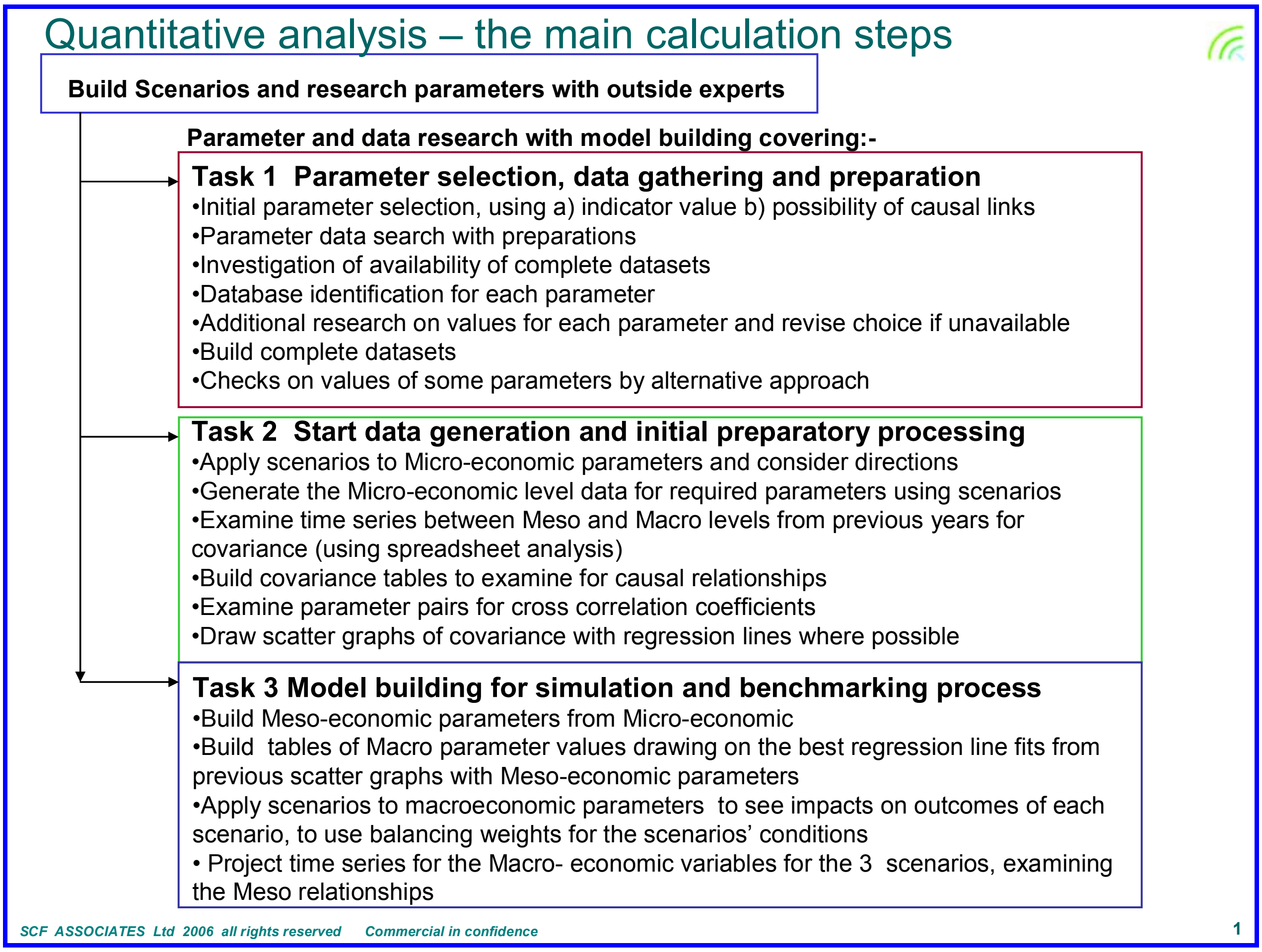
Meso-economic parameters	**Data source**
1. Growth of Wireless industries	WiFi hot-spots, jiwire http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm
2. Average mobile subs per 100 pop EU-25	ITU Telecommunication Database
3. 3 e-Readiness	EIU e-Readiness index, 2000-2006 http://www.eiu.com/site_info.asp?info_name=eiu_2006_e_readiness_rankings
4. Consumer expenditure on communications	Eurostat, household expenditure
5. Comms expenditure as % total disposable income	Eurostat, household expenditure

Macro-economic parameters	**Data source**
1. EU employment in knowledge industries (% total)	Ian Brinkley and Neil Lee, The knowledge economy in Europe, The Work Foundation, 2006, http://www.theworkfoundation.com/products/publications/azpublications/knowledgeeconomyineurope.aspx; Science and Technology Indicators for the European Research Area (STI-ERA), http://cordis.europa.eu/indicators/ind_eu15.htm
2. EU GDP growth rate	Eurostat; updates, *Financial Times*, 13 Nov 2006
3. EU GDP/head (EU25 Euros/inhabitant)	World Bank, http://devdata.worldbank.org/external/CPProfile.asp?PTYPE=CP&CCODE=EMU OECD, Eurostat, ITU
4. Socio-economic opportunity, as measured by inward investment (FDI)	*World Investment Report*, UNCTAD, 2006, http://www.unctad.org/Templates/Page.asp?intItemID=1465

5. The main steps in the calculation process

Our approach has been to take the above steps and combine them into a complete calculation process as shown in the flowchart below. It includes the steps of data acquisition and preparation before generation of the time series tables for the parameters at the three levels of economic aggregation using linking coefficients:

Figure 2.6. The overall process for calculations



The above approach is straightforward but requires a number of spreadsheets to be constructed covering:

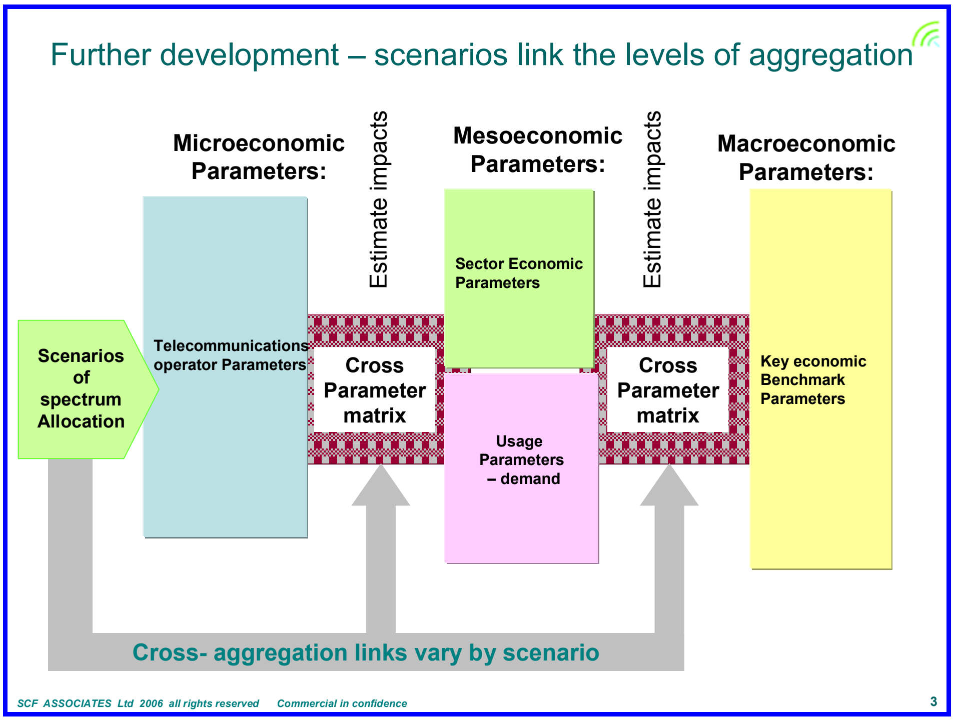
- Time series for each parameter- the original past history of these may stretch over 10 years and was drawn from the original sources. These are used to give trends and histories for future time series in simulations by scenario
- Linking tables for parameters to show any relationships
- Charts for scatter diagrams of pairs of parameters, from appropriately prepared tables
- Preparation tables for derivatives of time series using simple difference equations
- Preparation of covariance series
- Preparation of correlation coefficients from co-variance series of calculations

Note that changes had to be made due to absence of some data sets – for instance e-Readiness was substituted for ICT investments as consistent complete data could not be found. I many time series, interpolation and estimates had to be made wherever the data required was absent. These all detract from the accuracy of the results, which must be taken as indications of trends and no more.

6. Use of the approach in benchmarking

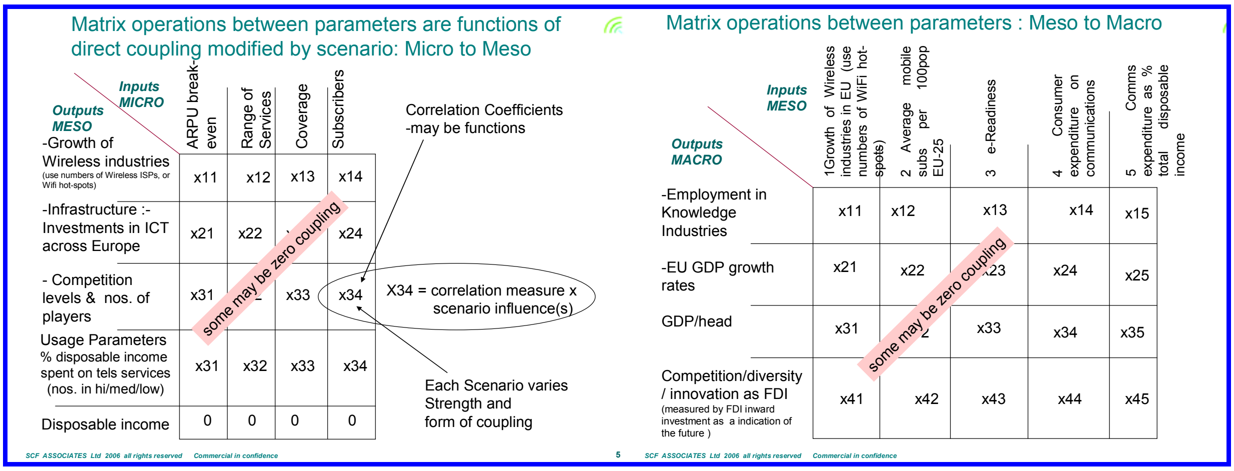
One goal is to be able to use the approach in benchmarking. Thus it is perhaps useful to examine the approach, in general terms, so that it may be used in the future projects In outline the various steps explained above can be viewed as the interaction of the parameters at each level of aggregation via matrices of coefficients. The process overall is illustrated in the diagram below:

Figure 2.7. The overall approach with scenarios both driving and linking levels of aggregation



Each level of aggregation is connected by a coefficients matrix. Its elements are based on simple time series aggregations of the input time series elements, weighted to modify the form of the output time series according the impacts dictated by the scenarios. This weighting can vary from a simple constant multiplier that changes between scenarios (eg an extra 5% linear growth per annum for a growth scenario, being made zero for a stagnation case) and/or simulation of a non-linear form such as an S-curve, with early fast growth tailing off in later decades, by using an inverse relationship with time.

Figure 2.8. The cross parameter matrices for Micro to Meso and from Meso to Macro

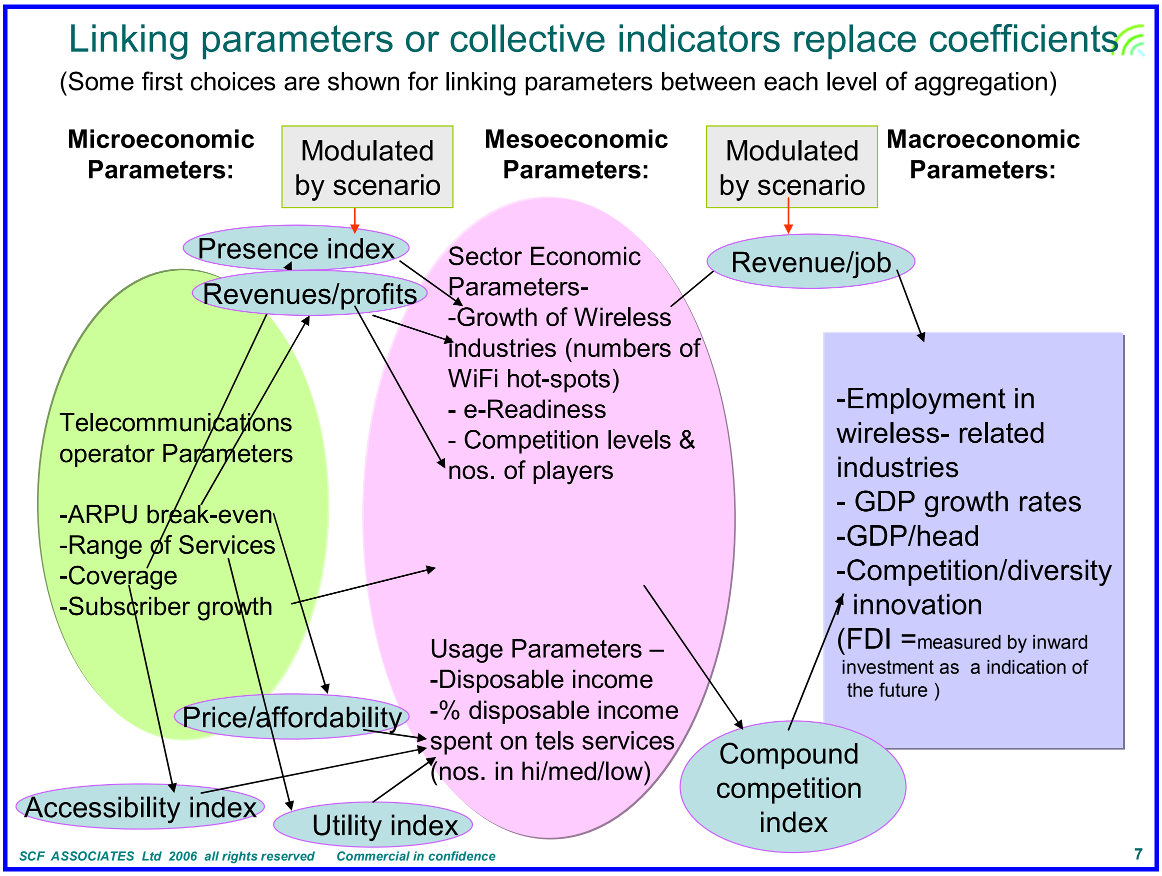


These connecting coefficients matrices can be made quite different for each pair of levels, but we used similar connections, based on simple weightings of time history.

In essence these types of quantitative approaches supplement the qualitative approach of the scenarios, and lend themselves to benchmarking, in that we can compare the simulations of possible events with what has actually happened in a measured way.

If the project had had more time we might have modified our approach as shown below. This introduces the notion of a different set of intermediate parameters with higher causal links on each side, between each level of aggregation. These parameters may be compound indexes which group several parameters to show a trend with direct causal links to an output parameter. It requires far more time and effort but could be useful.

Figure 2.9. Future extension of the methodology



CHAPTER 3. Description of scenarios

1. Introduction

Future pictures of possible impacts are not clarified by economic models which leave out complex interactions and environments and the fact that major players may have different agendas and goals, some to preserve the status quo, some to obtain better services or business conditions, in their view. Thus, important issues which each scenario must address include:

- What are the overall market impacts of the different spectrum allocation choices?
- What are the positions of consumers and the operators, both existing and new entrants?
- What protection from interference is offered? (A lack of availability of signal delivery, as for spectrum in traditional usage, could be disastrous for users of the service, especially in applications that may have safety implications, e.g. emergency services, or health monitoring in medical usages, or civil aviation applications).
- Services and service levels attainable

The various scenarios of licensing to be considered here differ in several key areas related to subsequent commercial exploitation, and are threefold:

1. Scenario 1: Radio Europe Mix – Trading and unlicensed spectrum allocation across all MS
2. Scenario 2: Radio Drop-outs – Each Member State has its own situation for allocation leading to many and diverse positions across Europe
3. Scenario 3: Radio Bazaar – Spectrum trading across EU for all MS

These are described below and are followed by cross scenario assertions and initial conditions that apply to all three scenarios.

2. The three scenarios

Scenario 1: Radio Europe Mix

Theme

The scenario is based on a mixture of open bands of spectrum being available with some bands reserved for traditional uses (eg military) and the rest of the spectrum being freely traded, across all MS. The transition to more unlicensed and more bands being traded increases gradually over time.

Assumptions

- Liberal use of unlicensed spectrum for any application
- In the traded bands there is a completely free market for those frequencies – there is no administrative control or interference with the market deals, or in ownership, market share or pricing etc.
- Primary markets (by auctions) ands secondary (resale) markets can exist unhindered.
- Trading centres on the current most-used bands (< 1GHz, bands for mobile and broadcast propagation and satellite/terrestrial digital TV etc)

- Unlicensed bands are not too thin and are at several useful points (2.4Ghz, 3.x GHz, some part of 4.x GHz)
- Unlicensed usage has no regulatory limits or government restrictions but as a new technology, its equipment market opens with relatively high prices
- Initially there is considerable volatility – the technologies are in their infancy and are unproven; there will be some interference problems and some disputes will arise which are resolved in the courts, allowing precedents to be set

Assertions

- The total market quickly separates in to two markets - with the traditional established services (that is G, 2.5G and 3G mobile services as well as radio and TV broadcast) being at the centre of the trading markets with the frequencies are highly sought after.
- As unlicensed becomes crowded, with a range of 4G type services and other applications of radio, new technologies appear to share spectrum (cognitive radio/SDR, new spread spectrum, MIMO, etc)
- New social uses – for a high radio dependence lifestyle - grow out from licensed cellular into unlicensed 4G as it provides the new accessibility of wider bandwidth plus new applications such as body area networks (BANs).
- All this tends to drive major new usages, for controlling and experiencing several worlds of family, work and leisure
- Support for the 2 markets brings 2 user groups, and 2 industry sectors, each with its own services and products.
- Market demand for voice and data via Internet access over unlicensed bands spreads, in ad hoc pattern across Europe
- The overall market builds on several different technologies at once – with random growth and interworking between technologies wherever convenient and useful.

Hypotheses

Established operators will compete for traded spectrum, trying to control the market and keep out others, by buying up any traded spectrum. They will be able to control the frequencies they have now and will want in the future through political and financial power, even if they have to pay for some that were at virtually no cost, or mandated to them before. Later on, the characters of the 2 markets emerge :

- One slower moving traditional for cellular 2G/2.5G, and also digital broadcast and certain government services, varying by MS

- Second - new services, new technology - based on the unlicensed bands

Key Drivers

- The entrepreneurship opened up by free spectrum availability
- The advance of radio technology with spread spectrum in new ways, cognitive radio based on software defined front ends, MIMO spatial directional multiplexing etc
- Inertia in incumbents to relinquish market control through spectrum
- Demand for new services of a wideband nature compared to 2G and 3G bandwidth

Leverage or tipping points

- The amount of spectrum released for unlicensed bands, compared to that available in the segments of traded spectrum and of managed or government-controlled allocation
- Rate of advances of technology in bandwidth sharing, and in diffusion of that technology into the market

The scenario unfolds

The use of radio services divides into two. The first path encompasses the traditional radio services from the incumbent operators in mobile, broadcast and especially in civil government (ATC etc)/military services. Little moves here in the long term as the key major players either individually or in associations (eg GSM-A) pressurise the EC to allow them to continue and also use arguments such as the digital dividend (the advantages in terms of techno-economics, coverage, reception quality, spectrum utilisation and new markets generation) from terrestrial and satellite digital TV to retain the bands in which they are interested.

This cements a 2-speed Europe in spectrum as on the unlicensed side, the picture is quite different. New entrants and increased R&D efforts on spectrum sharing techniques (new spread spectrum, CR/SDR/MIMO etc) means that the bandwidth stretches available are for communications at the level of WLANs (eg WiFi), and of MANs (eg WiMax, WiBro).

Consequently, linked cellular–like national structures evolve using mesh, WiMax and also a new crop of European AWTs/ERTs that avoid the IPR problems of WiMax. Integrated, they build an alternative communications and media transport infrastructure across Europe. This 4G or B3G grows as a limited WiFi/WiMax voice data services at first, with the start being a mix of current technologies - WiFi +VoIP, with initial growth being dual mode.

Take-off depends on handsets having agile SDR while the next step is an extra layer of distributed operating system mesh products which knits all together. In a second stage – a limited form of 4G appears (after 2008) but a complete native 4G takes some 8 years to arrive (up to 2014). ERTs also seed services for health (eg NFC BANs), elderly care and for industrial applications with both open standards (eg ZigBee) and also proprietary protocols (eg Z-Wave).

New IP services for multimedia accessed over the Internet are transported by the unlicensed wideband carriers as technology advances faster than expensive 3G - which has to pay back its licence costs - and so 3G operators limit services such as Skype on mobile. Such services are only offered over the unlicensed bands, where IPTV also takes off connecting Web TV stations, to serve specialised narrowcast audiences, peer to peer content and increasingly the broadcast content.

With this IP access given by unlicensed bands handsets comes Internet access and new set of social uses. A range of high-dependence lifestyle services grow up in the 4G unlicensed bands, based on the low cost of usage combined with the new accessibility of wider bandwidth. It all tends to drive major new uses in controlling the several worlds of family, work and leisure. This produces the organising tool for the single parent, the nomadic knowledge worker, the socially hyperactive - and many users are all of these at once. High bandwidth allows professional and social videoconferencing email and a host of business services at low cost in the SME user segment, which is the largest and fastest growing business segment as large and medium size corporations continue to downsize, shedding staff as productivity rises.

The unlicensed bands are also for the basis for whole new industry segments. Primary among these is health, followed by social services for the elderly and a range of support services for security, as well as industrial applications including RFID, and telematics for road, rail and air transport, and navigation services, etc.

In contrast, the traded bands preserve the existing players with their traditional services, although entertainment is gradually replaced by digital downloads and streaming via Internet access, at first via fixed line including CATV but increasingly via the IP links of the high-bandwidth unlicensed radio frequencies. Operators of broadcast media, both satellite and terrestrial begin to review their previous need for network dominance in a new light, and realise that a physical network for access ownership is less important than content ownership and access freedom (whereby the user is free to access the content by whatever access path she chooses).

Scenario 2: Radio Drop-outs

Theme

Each MS goes its own way, with multiple allocation methods including trading, administrated command and control, free unlicensed bands and mixes of just two of these, as well as all three, with allocation regimes that only extend to the national boundaries.

Assumptions

- No directions on assignment can be enforced
- No real market in trading exists across the EU as there are only pockets of trading and they cover different bands
- Some MS have restrictions on the applications to which particular bands can be put.

Assertions

- We see a set of smaller mostly national markets arising in both services and products
- Volume pricing for equipment (mobile handsets, network equipment, home media equipment) will not apply as the scale is too small by country so generally equipment for consumers and operators will tend to be more expensive, driving up the prices of both services (telecommunications or media) and of related consumer goods
- There will be a growing range of different standards in protocols to obtain optimal performance at frequencies used, as no single EU standard can really take hold and local proprietary standards may become de facto
- However the major established EU standards will continue for mobile, with GSM, and for European digital TV broadcast.
- Regional similarities will pertain with some countries providing cross-border agreements not only on spectrum usages, but also in forms of allocation.
- Expect to see protectionism for local suppliers of services and especially equipment re-appear as national standards can be served by small specialist local suppliers

Hypotheses

Several MS will join together to allocate frequencies by usage which extend across a region beyond their individual national borders. Slowly a set of national and regional agreements arise with cultural affinities being important for usages - eg television in Baltic states and the Nordic countries are all at same frequencies - while in contrast the major economies may deliberately encourage differences in frequencies and their applications, and even in transmission protocols, to build up national champions while all try to export their technologies.

Local players in government departments, the military and those major industries using spectrum will try to guide government policy for their own objectives, which will tend to be to preserve the status quo. Those that can break this hold and move towards free allocation of spectrum, especially in unlicensed bands will open the market to entrepreneurial development in both services and new technologies.

We will tend to see a division among the states in Europe with a whole range of colourings of allocation, from a frozen state of managed allocation, through to a slightly greater freedom yet highly controlled market among the incumbent players, to open services competition based on unlicensed bands.

Key drivers

- The interests of individual MS in pursuing economic development of both existing services and establishing new innovative radio technology, goals which may be in conflict
- The power of the government services, including the military within each MS to preserve their allocations, and also their attitude to allowing this spectrum to be re-allocated

- The power of the incumbent operators for both telecommunications and broadcast media within each state to control the future forms of allocation of spectrum.

Leverage or tipping points

- The amount of co-ordination between MS, that will allow common forms of allocation to be built up across larger geographic areas and also common agreements on exact bands of spectrum to be traded, or offered as unlicensed or allocated by managed intervention for specific usages such as the emergency services
- The power of the EU to engage MS in a meaningful acceptance of directives and so spread commonality in forms of allocation and bands of specific usage.

The scenario unfolds

Over the years, national priorities will tend to build up national and locally regional enclaves of types of usage, due to specific types of services and products which are frequency dependent. Fractured markets mean no common patterns of economic usage as offerings vary nationally.

However, the major existing EU standards agreements (GSM, Broadcast etc and civilian applications such as air traffic control and navigational aids for ships and aircraft) become far more rigid as they are strictly protected by industry associations lobbying MS governments, and are the only pillars of agreed usage. They come to act as points of reference in a very varied sea of protocol standards and frequencies. The overall affect is to freeze technology as the industry associations protect their territory and tend to restrict innovation as a threat to the cash cow of their traditional technologies, which support the established range of services.

Progress in radio technologies thus tends to slow down, lacking a critical market mass to support emerging products and services, combined with a lack of available spectrum for new entrants, and which when available, is fragmented by national boundaries. This might possibly even affect the 'digital dividend' of digital TV switchover across the EU.

However in contrast, in some MS, or more likely groups of MS, where we see that:
a) there is a large enough subscriber base for advances to be financed as demand is large enough, and
b) there is the freedom to launch alternative services against an incumbent as the frequency bands are available, be they traded, or unlicensed and shared,

then some form of competitive market in certain services arises. However it is likely to be restricted in scope.

Thus the degree of liberalisation and opening to competition will tend to divide Europe, with those governments that open the spectrum moving to new technologies faster and so seeding new markets and employment in products and services. We can expect that some accession states for instance will leapfrog the most advanced of the original EC-15 countries as they welcome open exploitation of the new radio technologies. In contrast many other MS, both accession and earlier members, remain captured by their past, and spectrum availability tends to be controlled by their incumbent players in both the private and public sectors. As radio technologies will tend to be developed and exploited in the more liberal and advanced states, they may then seep back into the rest of Europe, especially if international exports of such radio technologies enable volume manufacture and so lower pricing. This is especially true of unlicensed band technologies (ERTs) and the services they can support, often of a wideband nature, which grow fastest in accession countries where there are fewer restrictions, but grow in an ad hoc manner.

In consequence, we will tend to see an ecosystem of supplier/first-user states and client or purchaser MS. This model is already apparent in radio technologies on an international scale – Korea has developed its domestic version of the IEEE 802.16 standard in a form that is somewhat different but perhaps more robust than the US WiMax form (and avoids some IPR pitfalls) and is selling it globally under the WiBro name to those states seeking wireless broadband, including parts of the USA. It was developed, tested and rolled out at what seemed to traditional European economists as apparently high (even prohibitive) cost – but they had not understood the strategy model of a domestic high technology development as the basis for export. Note that the essential ingredient of this strategy is rapid and if possible first-mover development with concerted efforts to market the technology, in Korea's case supported by government in the form of research funds and to some extent, acting as first client.

Against this are the national interests of local markets with their governments encouraging local players to produce equipment and services for this limited market, with fairly high prices. The spectrum differences act as barriers to entry to such markets, which can only support a limited number of producers. Certification of equipment can also be used by the national regulatory agency as a second barrier to protect local suppliers against imports, whatever the EU rules on commonality may be, as the local spectrum allocations can offer a new set of hurdles. Against this may be technical development for producing equipment in volume for small spectrum markets using programmable front-ends – software defined radio – already in use for such applications as digital audio broadcast (DAB) receivers.

Thus the new concepts for EU-level radio networks for advanced applications, such as a robust tiered radio emergency network for disasters[11] will tend to be ruled out. Other novel applications of radio in health, social services, transport and logistics which depend on unlicensed bands will also tend to be curtailed by lack of accord over their spectrum range, except in those pockets of the European market where agreements greater than national boundaries have been reached.

Long term the concept of pockets of agreements, surrounded by non-agreement states, will tend to expand in geography, so that they control more of the EU - but built up in an ad hoc fashion on an opportunistic basis as MS come to see the advantages of open free usage of the spectrum. The trend in these regions will be to larger swathes of unlicensed bands as this provides more economic payback because the impetus to entrepreneurialism and innovation is far greater. We can expect that in other countries, auctions, held for reasons of government funds will hold sway. In these countries the range of constraints over perfect market operations will pertain as the dominant operators in media and telecommunications snap up available spectrum or buy out those who have won some in the auctions, so secondary trading will be present but not very active.

Scenario 3: Radio Bazaar

Theme

Trading occurs EU-wide, with markets for primary and secondary trading of spectrum, increasingly being used instead of any other form of frequency assignment. Property rights over spectrum ensure it is used only by the owner but also can be sold freely.

Assumptions

- Trading in primary markets (by auctions) and secondary (resale) markets exist unhindered.
- They are completely free markets for those frequencies in the traded bands – there is no administrative control or interference with the market deals, or in ownership or pricing etc
- There is frequency neutrality – any traded piece of spectrum can be put to any use by its new owner. The lack of usage restrictions stretches across broadcast entertainment, telecommunications and radio-based devices.

[11] See for example MEWTAD (Mapping European Wireless Trends and Drivers) a study from JRC/IPTS, Work Packages 2A and 2B – Annex 2 and also Annex 3 of EUR No: 22250 EN Year: 2006 ISBN: 92-79-02035-8 Catalogue (OPOCE): LF-NA-22250-EN-C, available with a synopsis of the whole study from: http://www.jrc.es/home/pages/detail.cfm?prs=1428

- The traded bands are the vastly dominant swathe of spectrum from 10MHz to 100GHz. There are very few bands of reserved usage (eg for civil emergency services or military or ISM) across the EU.
- There is a lack of pricing information available to all potential traders – regulatory authorities see these transactions as commercial and between private parties, hence the market will suffer through imperfect information.
- Transactions costs of trading spectrum are relatively unimportant.

Assertions

- Economic imperatives, not technical, will govern spectrum assignment, ie operators will buy and sell spectrum to gain market access, concentrating on both optimal and sub-optimal areas.
- These imperatives will be driven by not only gaining market access for a particular operator but in preventing others using any part of the spectrum available for a competing offer.
- For trading pieces of spectrum, brokerages and exchanges could appear
- There may need to be a registry agency, noting who is registered to own what, carried out at first by NRAs and later by an EU body.
- The impacts of size of players will be non-linearly increased in a free market as they are the only ones that can act across the EU, and as spectrum is released by MS, act to take it up.
- A 'big bang' spectrum release for trading across the EU (or a series of them) will not stop the above market control trend; it could make it easier.
- Frequency trolls may appear, flower and die, being holding companies for spectrum traded, just like any other futures asset. Once they have sold their spectrum, they may fold if no more frequency is available to trade and their *raison d'etre* disappears.
- Technologies that succeed will be of the 'ownership' variety – that is one frequency band, one owner, one usage - for reasons of interference as the technology is not a frequency sharing type.
- Spectrum will slowly become a scarcer asset as it is progressively concentrated in fewer hands by consolidation because market transactions naturally favour those with deepest pockets. Increasingly, market players will be bought solely for being owners of spectrum assets and a trend that will progress with the degree of consolidation.

Hypotheses

As the emphasis shifts away from managed licensed assignments by regulated authorities, a completely free market will initially pertain in those bands where trading is permitted. But this does not mean it is a perfect market. Following real market experiences, such as the 3G auctions, those with deep pockets will act in terms that may seem, for an expected free market–based strategy, as irrational. In the absence of the steadying hand of regulation, attempts will be made to control the spectrum market. Its price is not the price of access - instead it is the value of market share, mostly for those already in the market. Major operators will not finely gauge the price of spectrum as being worth the sum asked or not – they are assuring their survival in future markets so the price elasticity is far higher than perfect markets theory. Their rational is that they will increase revenues and profits afterwards – overpaying is par for the industry. The only question is the cost of capital against ARPU in an unsaturated market when new services are considered, often through too-optimistic forecasts. In this scenario, risk is reduced through building a store of frequency assets and that includes technologies, so that new technologies tend to be precluded. They are frozen out as upsetting the business.

Key drivers

- The need for the major incumbent players to restrict competition by controlling the spectrum available on the market.
- The balance of power between the various players having different usages – principally those in mobile communications, and those in entertainment media - who have dominant market positions already

Leverage or tipping points

- The number of players
- The rate at which freely traded spectrum dries up
- The degree of market regulation and intervention

The scenario unfolds

Within the changing dynamics of governed spectrum assignment, the amount of spectrum to trade will slowly increase across the EU as MS release it into the EU spectrum market. However this may not mean an increasing supply of spectrum.

Ease of market entry for new entrants will be carefully throttled through spectrum purchases by those whose existing businesses could be threatened. Significant oligopoly, even duopoly power may be retained by the incumbent players, be they in telecommunications or in broadcast, by use of the free market. They are only regulated by competition law, not by spectrum allocation, ie by their control of markets *once they have achieved that control*. Only a subset of relevant demands is therefore met by the marketplace – those that correspond to the offerings of the oligarchs.

Consequently innovation in services and technology tends to be incremental and is a series of gradual improvements over the current state especially in technology – the case of telecommunications industry in the USA and elsewhere between 1925 and 1985. Innovative technology is not needed – the aim is to conserve the current market and this means long-term stability is required to recoup spectrum investments due to the prices paid for spectrum to recoup investments. In an atmosphere of uncertainty over market control, the trend is to offer services based on traditional known demands with known technology, leaving funds available to buy any newly available spectrum, to prevent it entering into a competitive role.

Operators justify the conservation of the status quo – high prices and little innovation – as the need to stabilise the market following their spectrum investments. The fixing of the high market pricing of spectrum (as it is driven higher by the scarcity rent) is given as evidence of their high fixed costs, which must be paid back by high consumer prices and limited services to justify the outlay and its return under stable conditions, long term.

This may also generate tacit agreements, never overtly admitted, between the riders of the two main 'horses for courses' – that is, those in broadcast media agree to stay out of telecommunications, and out of trading any spectrum to those who might enter telecommunications. Moreover the telecommunications players in return reign in convergence plans for IP services and media, perhaps leaving IPTV to the broadcast media players, with revenue sharing. Any such co-operation would be almost impossible to prove in an anti-competitive behaviour action by the competition regulators.

Generally we see a divergence of social value and monetary value in allocation mechanisms[12] as the spectrum is regarded as a simple, owned, economic resource by its owners[13], one that is the key to market control. For instance, any tendency toward broadband wireless services that could serve lifestyle and other applications in health, elderly care, etc will be slow and difficult, as spectrum may not be available, even if the service providers for these types of support do not appear to compete directly with the major players in telecoms and media. There will always be the fear that they might sell it to some enterprise that will compete directly. The sums sunk into the incumbent's networks are such that the risk of this is unlikely to be tolerated. Such concepts of apparently irrational economic behaviour are well known and obviously logical to market pragmatists in business[14]. They were amply illustrated in the examples of the 3G auctions in the UK and Germany in 2000.

---

[12] See Forge, S. 'The radio spectrum and the organisation of the future: new allocation approaches', *Telecommunications Policy*, February 1996, which reviews auction mechanisms – significant in light of 3G auctions in Europe.
[13] Akalu, Rajen, 'EU spectrum reform and the WAPECS concept', *info*, Vol 8, No 6, 2006, p 31.
[14] Such analysis is well-established and well documented – for a popular exposition, see for example J.K. Galbraith, *The New Industrial State*, Pelican Books, USA, I967 on industrial behaviour in imperfect markets

However these principles of market control may not be well understood or even known to the 'economic' designers of 3G auctions, unless they are cynically counting on no progress in telecommunications at the expense of large-scale injections to the government coffers, to pay off public deficits, using a new instrument of confiscatory taxation. The UK and German 3G auctions clearly demonstrated the power of large capital assets to assure spectrum control. Radio frequency's scarcity rent is not considered too high a price to pay - for survival – by such players. Consequently certain governments among the EU's MS are pleased to sell at auction, be it national or EU-wide and to strongly endorse the 'free' market approach. Moreover some large MS (UK, Germany, etc) will certainly see the need to shore up their 3G licence sales, firstly to further justify their original principles of markets for spectrum but secondly to gain reserves in case of demands for recompense from the 3G operators who were given a licence with restricted spectrum usage privileges, and guarantees of no competitors for decades. These assurances could now be flouted by the potential re-use of other ranges of the traded spectrum, for the same purposes.

In this atmosphere of strong competition for spectrum from those with deep pockets, prices will tend to rise – spectrum's value is not that of economic break-even in service but that of corporate survival. Thus there will be an increasing scarcity rent in the pricing of spectrum. Generally, the prices of services might also then rise, especially as service competition could be effectively restricted by market control of the key asset in a technical and market condition of one-frequency-one-usage.

3. Cross scenario assertions

A summary of which technologies are in use in each scenario, in the various categories of spectrum usage can now be given following the description of all the scenarios, although each scenario situation would not be static, but evolving, with the trends as shown in Table 3.1.

Table 3.1. Technologies in use in each scenario

Application	**Mobile radio communication types**				**Broadcast media**			**Other**
Scenario	***2G***	***2.5G***	***3G***	***4G (IMT-Advanced)***	***Analogue &digital terrestrial***	***Digital satellite***	***IPTV via mobile***	***BAN, RFID etc***
1 Radio Europe Mix	***Med***	***Med***	***Low***	***High***	***Med***	***Med***	***Med***	***Med***
23 Radio drop-out	***High***	***High***	***Low***	***Med***	***High***	***High***	***Low***	***Low***
3 Radio Bazaar	***Med***	***High***	***Low***	***V. Low***	***High***	***Med***	***V. Low***	***Low***

Thus the mixed scenario would tend to see high usage of new technologies (4G) but the others would be much more oriented to traditional mobile (2G and 2.5G). There are perhaps some surprises here. For instance, in a situation of many different regimes (Radio drop-out), Europe-wide satellite might hold higher attraction against local programming on a national basis. Other radio applications might not take off without freely available bandwidth (scenarios other than the mixed situation).

4. Initial conditions

These are the input conditions for all scenarios.

Here we examine the outlook for the next five years to see if there are any discontinuities that would radically change their impacts.

- Political – choppy stability with security fears, and disillusionment with 'united states of Europe', or a federal Europe, but the EU continues to host the largest global group with a medium/high level of prosperity, moreover one which is expanding by accession and building greater stability across more of the world.

- Financial – generally more optimistic than pessimistic but major variations in outlook and status by MS eg France and Italy vs. the Nordic states, and fears of inflation in EU due to world energy and commodity prices. High risks of sharp changes due to housing market inflation, derivatives usage and hedge fund collapses

- Economy type – consumerist – dependent on consumer disposable income and increasing dependence on consumer wealth in EU economies with disposable income being a major part of the economic drive and maintaining growth. An increasing proportion of consumer wealth is tied up in property – an potentially unstable situation.

- Social – inclusion problems - varies by MS, and goes with failing services for health, social and elderly care. General slow deterioration in social conditions, in terms of violent crime, rising prison population, and personal security becoming generally worse across EU

- Family structure – slowly changing towards more single parent families and also growth in single occupiers of a home

- Work-life balance – increasing wish to have more free time, and to assert self through accomplishments, both in and outside employment. Increasing convergence of values across Europe with EU accession process.

- Energy – prices generally increasing at high rates while security of supply is far more volatile than the previous decade.

- Environment – accelerating warming with effects on weather, agriculture, settlements, recurrence of natural disasters and their multiple effects on the economy from health, energy costs, building costs to insurance rates and insurance failures. Increasing problems of pollution of all forms – industrial and household low-toxic waste, greenhouse gas emissions, toxic chemical spills, nuclear materials leakages, etc with rising health issues

- Employment – problems at extremities – youth employment and post-50 age-groups. This is generally a major problem for EU economies with high protection for those in work, high employment overheads and inability to create and attract new enterprises

- State support - Pensions, social security, health systems failing

- Demography – aging population, EU slowing population growth, birth rate falling, immigration rising, EU absolute levels rising by accession

- Commodities – world prices rising fast (wheat, coffee, maize, cocoa, etc as well as raw materials - metals, etc)

- Oil and gas - world prices rising fast and staying historically high

- Physical infrastructure – transport, water, energy distribution (electricity, oil, gas) - highly variable across EU dependent on recent history and political agendas followed for investment in infrastructures' renewal.

Technology acceptance – rejection of intrusive technology with growing privacy concerns across EU. Access technologies increasing shown in Internet growth expanding in new accession countries, WiFi hotspots expanding over Europe and DSL spreads.

CHAPTER 4. Findings

1. The importance of the scenarios in our final results

As we have indicated, we found that very few complete datasets were available which restricted our ability to build an accurate baseline picture simulate the future accurately. Hence, our main findings are based on examination of scenarios. These scenarios are by nature *caricatures of reality* – they simplify and extend the strongest features beyond what may happen to ensure that each scenario paints a picture that is clear and well distinguished and contrasts with other scenarios. They thus form the major contribution to the debate.

As part of our analysis we identified what would be useful to have as datasets for measuring and benchmarking for further analysis. The 'wish list of the experts' for the parameters they would ideally like to see is given in our appendix, Questionnaire On Parameters With Responses.

Also, our scenarios set the scene for the quantitative findings in that they define the level of competition. This in turn sets the start pointing for our micro-economic parameters – all depends on competition and its driving power, be it levels of ARPU through pricing, range of services in mass usage, subscriber growth rates or coverage by most advanced services.

The scenarios essentially set the behaviour of the market through the level of competition. This sets all the chosen parameters at a micro level – ARPU, growth of users, range of services and coverage by the most advanced services. And *the levels of competition are set by spectrum allocation* in that it controls:

- The entry of new players who raise the degree of competition in the market; they depend on spectrum being available to operate services
- Pricing of services, through the initial fixed costs of spectrum, be it large, 'reasonable', or free
- Radio technologies used and the costs of the infrastructure for each type – the capex and opex costs for 4G for instance, combined with unlicensed bands make it into a 'cellular killer', especially when competing with the notoriously high costs of 3G cellular, and particularly for a broadband services market

Our results concentrate on a blend of communications services based on a range of technologies (2G, 2.5G, 4G and 3G) and so effectively examine the competition between them, not just a simple co-ordination. As outlined in the scenario assertions, we would expect that the most advanced services and lowest pricing would appear in the 4G segment and this would tend to compete with other technologies, driving down prices in the two scenarios where it is more important, Radio Europe Mix and Radio Drop-outs, where individual MS continue to go their own way.

2. Quantitative results

The Micro-economic level results can be viewed as what is happening at the level of one operator. With more time, we would have perhaps used more sophisticated models for 2G and 2.5G, 3G and 4G. The breadth of detail available for this approach is shown only for 4G, given in the Appendix.

The micro-economic parameters by scenario are given in the figure below and a setting simulating the expected behaviour from the scenarios going forward to 2020. These set the whole process in motion for the three scenarios across the various levels of economic aggregation.

Figure 4.1. Micro-economic simulation for one operator

The profiles have been chosen for descending ARPU in the Radio Europe Mix scenario as competition between low cost 4G (see Appendix for the 4G business model results, which show a very low capex and opex in comparison to cellular). This comparative situation drives up usage as measured beyond by growth of the number of users, the growth rate shown being the number beyond 100% saturation for one operator – we would expect the other scenarios to show lower penetration. Competition also drives the services commonly used and the rates of rollout and coverage by the most advanced services (not the base services of voice and SMS).

These are then used to drive the Meso-economic level through a weighted formula of the type:

L8= K8+(J8*1.05*((L$43*$AB$28+L$46*AB29+L$49*$AB$30+L$52*AB31)/4))*(3/(L$6-$K6))

In which the K variables refer to the Meso-economic time series for one scenario, modulated by the input weighted sums of the four micro-parameters, formed by time series evolution as simple difference equations on preceding values. These are modulated for direction by inspection using a table of values of +1, -1, or 0, as shown below, which refer to the AB28 type variables:

Table 4.1.Matrix of Meso/Micro-economic relations, direct, inverse or zero

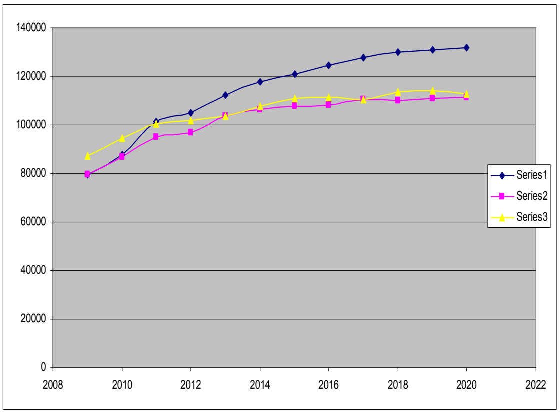
Micro	MESO 1	2	3	4	5
1	-1	-1	0	-1	-1
2	1	1	1	-1	-1
3	1	1	1	**1**	**1**
4	1	1	1	**1**	**1**

Key	
X	= Inverse relation (eg are ARPU goes down, subscribers increase)
D	= only deduced link from Statistics tracking
X	= strong expected relationship

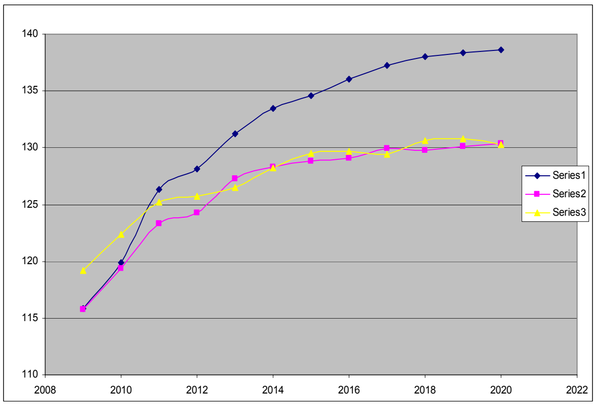
Using the tables of the coefficients with previous samples of the time series for each Meso-economic parameter to give the start values we can extrapolate forwards to simulate possible future values of the time series, as shown below:

Figure 4.2. Time series for Meso-economic parameters to 2020

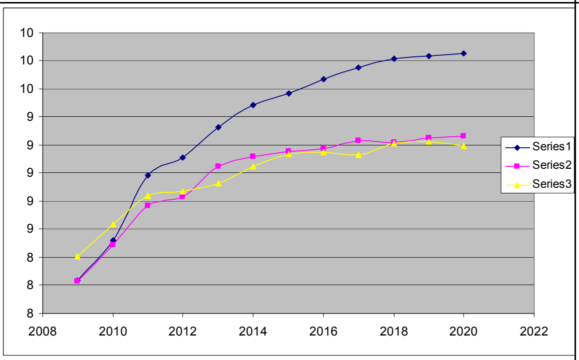
Meso 1 Growth of Wireless industries (as numbers of WiFi hot-spots)



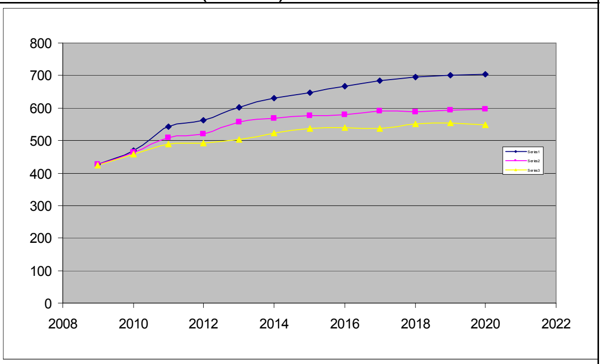
Meso 2 Average mobile subs per 100pop EU-25



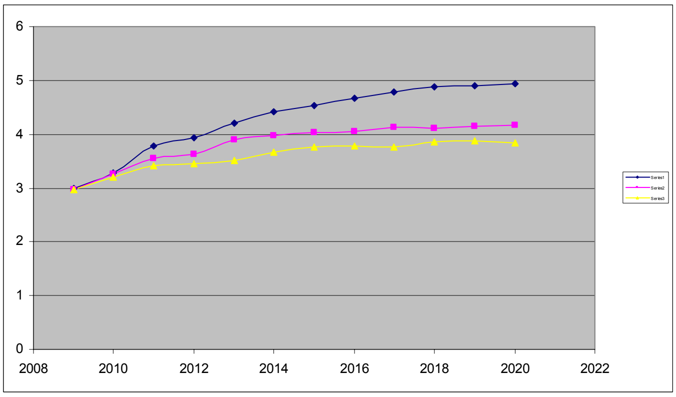
Meso 3 e-Readiness



Meso 4 Consumer expenditure on communications (Euros)



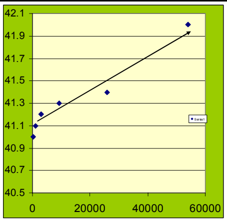
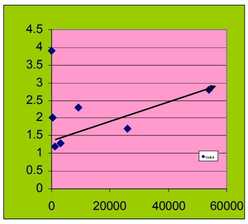
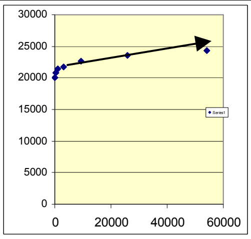
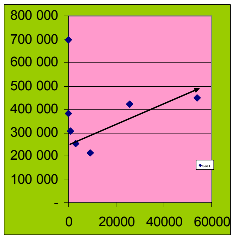
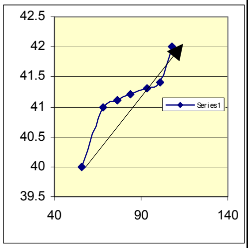
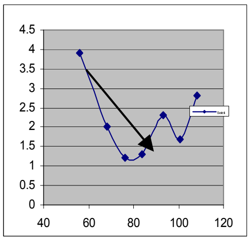
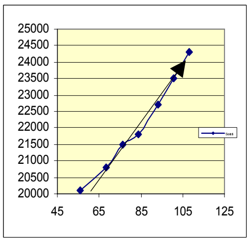
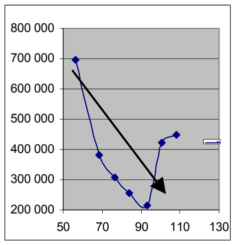
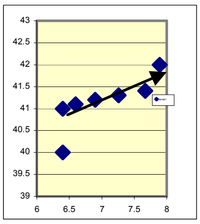
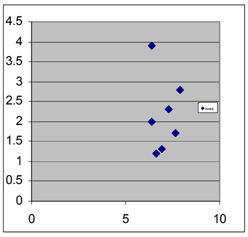
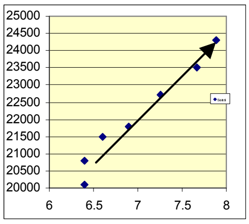
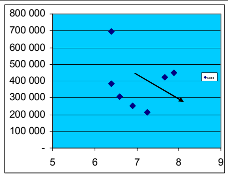
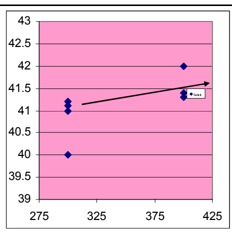
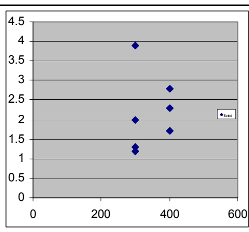
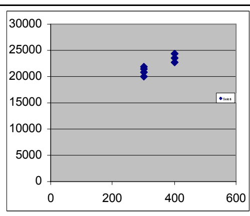
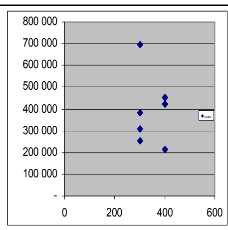
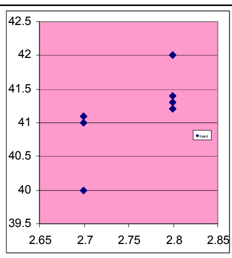
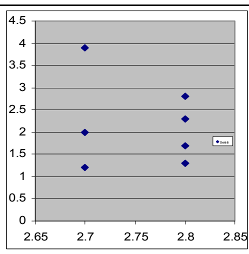
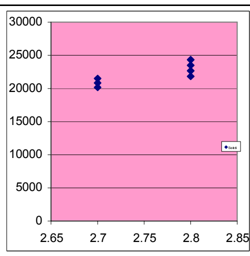
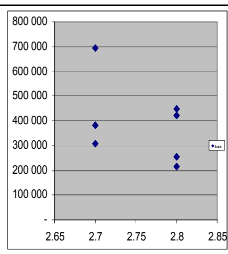
Meso 5 Communications expenditure as % total disposable income



1 Radio mix
2 Radio Bazaar
3 Radio Dropouts

At a meso-economic level we see the co-ordination of the chosen variables with the macro-economic time series for the chosen parameters as follows in the figure of scatter charts of the variance of Macro-economic parameters with Meso-economic below:

Figure 4.3.Co-variance of the Macro- and Meso economic parameters shown as scatter charts

	Macro-Economic 1 EU employment K-inds	Macro-Economic 2 EU GDP growth	Macro-Economic 3 EU GDP/head	Macro-Economic 4 Socio-economic opps thru FDI
Meso 1				
Meso 2				
Meso 3				
Meso 4				
Meso 5				
Key	Some relation – regression line possible	Tentative relation	NO relation or unclear	Possible negative correlation

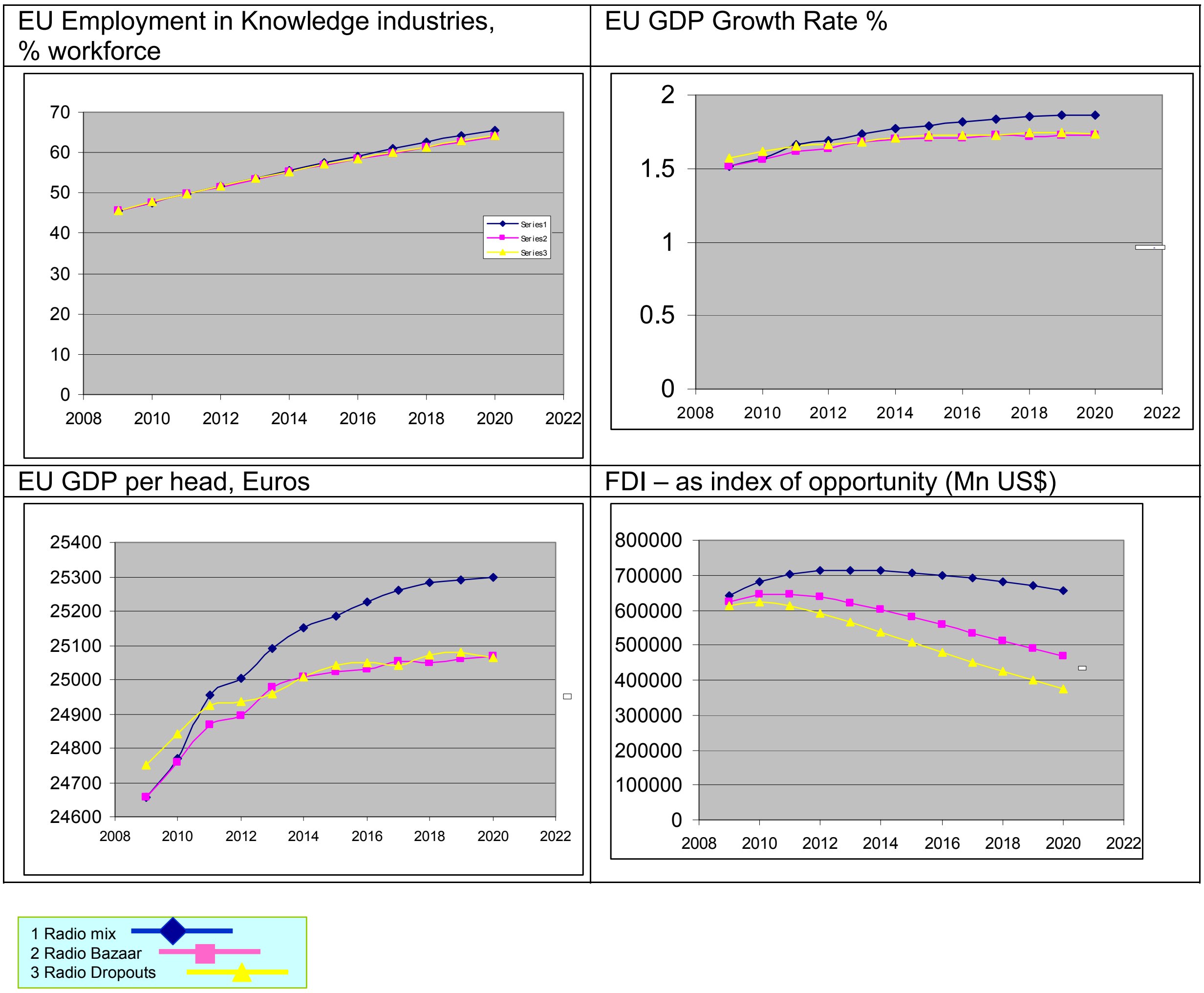
At this point we can also examine the correlation between the time series for Meso and Macro-economic parameters

Table 4.2.Cross correlation

	Cross correlation coefficients				
	MESO 1	MESO 2	MESO 3	MESO 4	MESO 5
MACRO 1 EU employment K-inds	0.7506	0.9182	0.8080	0.6612	0.6909
Macro 2 EU GDP growth	0.1710	-0.2815	-0.0529	0.0943	-0.1933
Macro 3 EU GDP/head	0.8816	0.9912	0.9809	0.8796	0.8168
Macro 4 Socio-economic opp FDI	0.1049	-0.4165	-0.1766	-0.1592	-0.4221

Using the highest cross correlation elements (white background) gives regression lines which can be used simulate the time series of later years. However we would note that this is highly speculative and is not yet robust as many improvements could be made in a larger project. Results for the macro level for the three scenarios are shown below:

Figure 4.4. Results for macro-economic parameters for the 3 scenarios



3. Interpretation of results

The results at a macro-economic level exhibit fairly distinguishable differences in behaviour for each scenario, for most parameters with the Radio Europe Mix showing greater performance in terms of EU opportunity (as measured by FDI), GDP per head, and perhaps in percentage of employment in the knowledge industries. The simple direct linear regression lines against the meso-economic performance for the workforce figures have been augmented by a non-linear time dependent affect, for an S-Curve as has the opportunity index, but by a saturation curve with time.

The scenario and modeling results indicate that, in brief:

- Radio Europe Mix will give higher GDP/head development due to opening the spectrum

- Pure trading (Radio Bazaar) for extensions of property rights will give limited competition due to the market effects and will tend to increase ARPU by the cost of spectrum written off over a number of years for the ‘license’. This will show up in the indicators used as a sub-optimal performance for our scenario behaviours

- For the Radio Dropouts, where no action by the EU to encourage new uses of the spectrum will leave the NRAs to make local decisions, seem to give less advantageous results in our scenarios. Those MS where local forces for national champions are seen as benign and advantageous will go for their own regimes. Regional clustering around common regimes can be expected with advantages in product costs, services costs and media content sharing; the Nordic countries with the Baltic states is one potential example.

We would expect that the directives could have clear and possibly advantageous impacts on the EU economy in certain circumstances, if allocation is addressed in a specific manner. This assumes that the mixing of the three regimes is possible so that trading, unlicensed bands and mandatory command and control administration for some bands as agreed across the EU take on specific roles and characters of operation.

What we envisage by this is a ‘horses for courses’ type of allocation, where functions are to a great extent dictated by the form of allocation and the implicit cost of spectrum that this engenders, with its concomitant effects on the operator’s business model and cost base. Thus we may summarise:-

- Pure trading is likely to have some effects if it can attract otherwise ‘locked up’ spectrum into the public domain for commercial usage but it may not have the macro-economic advantages of other approaches in that it may tend to hold back technology and new services

- Free spectrum is more likely to promote EU development and employment in that it triggers innovation

- Managed administration is likely to be slowly abandoned as a vestige of past economic models of centralised state management that will hold back European development

In any future research using this approach we would emphasise certain areas for experiment and improvements as being:

- Use of multiple parameters for correlation and for simulation of the next level of aggregation rather than the single parameters used in the final stage
- Non-linear regression using multiple parameters for each of the scenarios
- Allowing sufficient weighting for non-linear supplementary effects of saturation, and technology diffusion curves in cross variable analysis
- Use of techniques for detecting signals in noise, both deterministic and non-deterministic.

CHAPTER 5. Policy discussion

1. Impact assessment

1.1. The causal link between economic development and e-communications

It is generally accepted that there is a driving force from the development of communications through to macro-economic measures of global development. Over the past forty years, the discussion has raged over the connection between economic development and electronic communications, as a strong correlation between the two seems evident, be it for the developed[15] or the developing world.[16]

However, correlation is not the same as causality. While better communications networks are strongly associated with higher income, higher income also leads to better communications networks. The problem of this "causality" is how to disentangle the two effects.[17]

Generally, communications networks have helped generate economic growth by enabling firms and individuals to decrease transaction costs, and firms to widen their markets as well as to increase social overhead capital (SOC) for economic growth. Usually, SOC is considered to be expenditures on education, health services and public infrastructure such as roads, water and sewage, ports and the like. Several researchers (eg Roeller and Waverman[18], 2001) have examined the impact on GDP of investment in telecoms infrastructure in the OECD between 1970 and 1990 and how it enhanced economy-wide output while allowing for the demand for telecoms itself being positively related to GDP. Taking the longer view, of going back to 1970, highlights that telecoms penetration was then low in a number of OECD countries – while the US and Canada had near-universal service in 1970, France, Portugal and Italy respectively, had only 8, 6, and 12 phones per 100 inhabitants. The newly connected OECD economies of Europe leapfrogged the analogue systems of the USA, UK and the Nordic states, leaders at the time, with the next generation of digital voice technology. Moreover, digitised telecommunications infrastructure development between 1970 and 1990 generated economic growth over and above the investment in the telecoms networks itself.

More recent work in this area of linking development to telecommunications, for the World Bank and others, has looked specifically at the larger ICT area, to include computing for a prognosis into the 21st Century. It has concluded that there is an economic accelerator, due to ICTs, especially communications. With the formation of a global 'tele-economy', the hypothesis is that we will see an impact equivalent to that of railways on the US economy between 1840 and 1870[19] over the next fifty years.

[15] Hardy, Andrew, "The Role of the Telephone in Economic Development", *Telecommunications Policy*, 1980, 4(4), pp. 278-86

[16] Forge, Simon, *The Consequences of Current Telecommunications Trends for the Competitiveness of Developing Countries*, World Bank, InfoDev Program, working paper, January 1995, available from http://www.infodev.org/library/WorkingPapers/tocforge.html

[17] L. Waverman, presentation: http://arnic.info/workshop05/Waverman.ppt, and Leonard Waverman, Meloria Meschi and Melvyn Fuss, The Impact of Telecoms on Economic Growth in Developing Countries, supported paper sponsored by Vodafone and Leverhulme trust

[18] Roeller, Lars-Hendrik and Waverman, Leonard, "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach," *American Economic Review*, 2001, 91(4), pp.909-23

[19] Forge, Simon, 'The e-factor: the new rules of the tele-economy', Part 1, *foresight*, Vol. 2, No. 1, Feb 2000; Part 2, *Foresight*, Vol. 2, No. 3, June 2000.

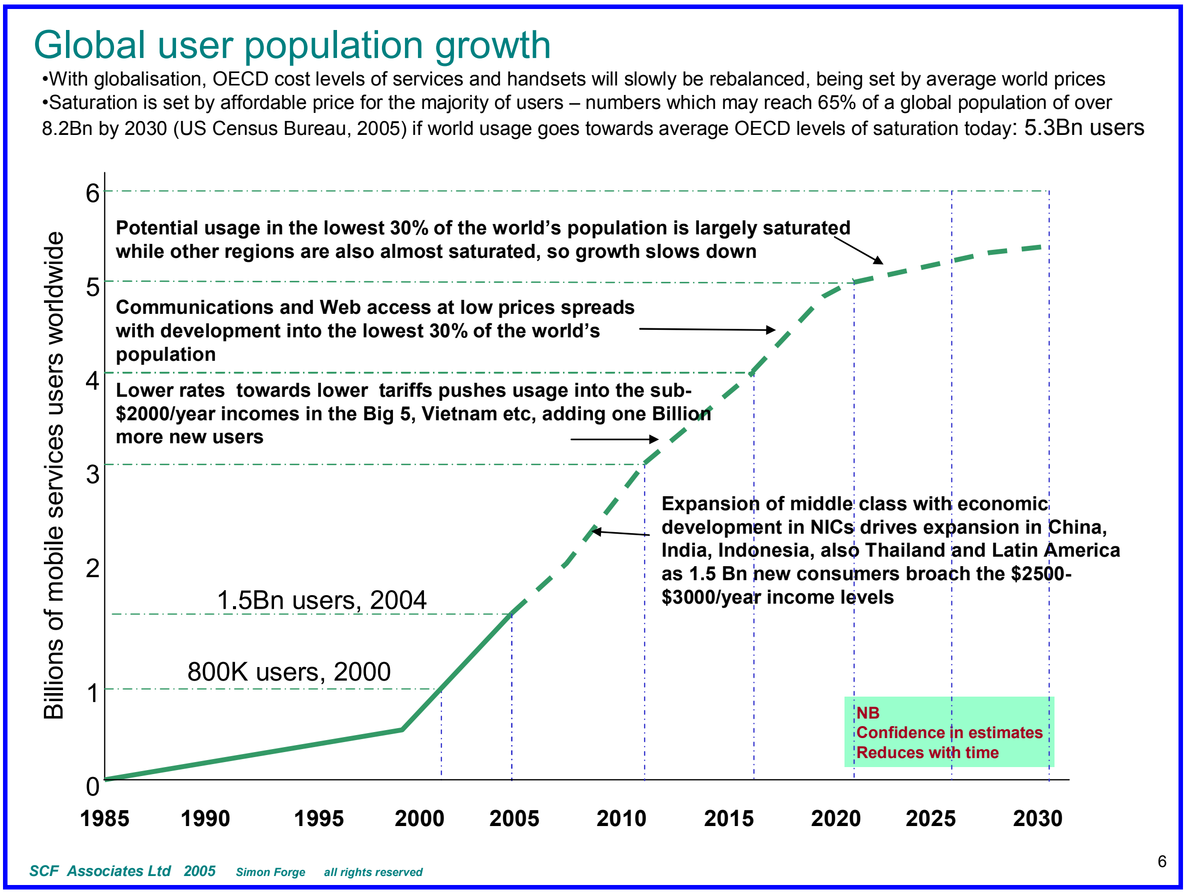
Much of this is due to the importance of SOC to economic growth, for which the telecommunication infrastructure, whether publicly or privately funded, is a crucial element. It enables the ubiquitous, speedy spread of information so that we are now in the throws of the progressive formation of a "tele-economy" whereby information and communications technology enables higher growth but with low inflation. This "New Economy" (as so termed by Alan Greenspan former Chairman of the US Federal Reserve Board) has grown through enabling greater competition and new means of organising production. Its impact has been to change what is of value from the accumulation of capital and the employment of capital–based assets towards intellectual capital and knowledge working.

In the particular case of communications and media by radio, we see radio technology as *the* key sector for e-communications development of all types over the next fifty years. The throttling point is the release of spectrum to allow it to develop freely and at a cost on a level with its returns.

1.2. Growth in radio services usage and specifically mobile communications

Previous work in this area[20] on the significance of radio services of all types has shown the wide variety of services possible, with some 130 services being identified from body area networks (BANs) to location-based services. The opportunity for new services and enterprises in this market is vast: the success of the GSM initiative points the way and needs to be built upon judiciously. Moreover we can expect a global increase in the use of radio services and the demand for its products and services, as highlighted by the analysis of future growth in the user population below:

Figure 5.1. Development of the usage of mobile communications to 2030 in a global market



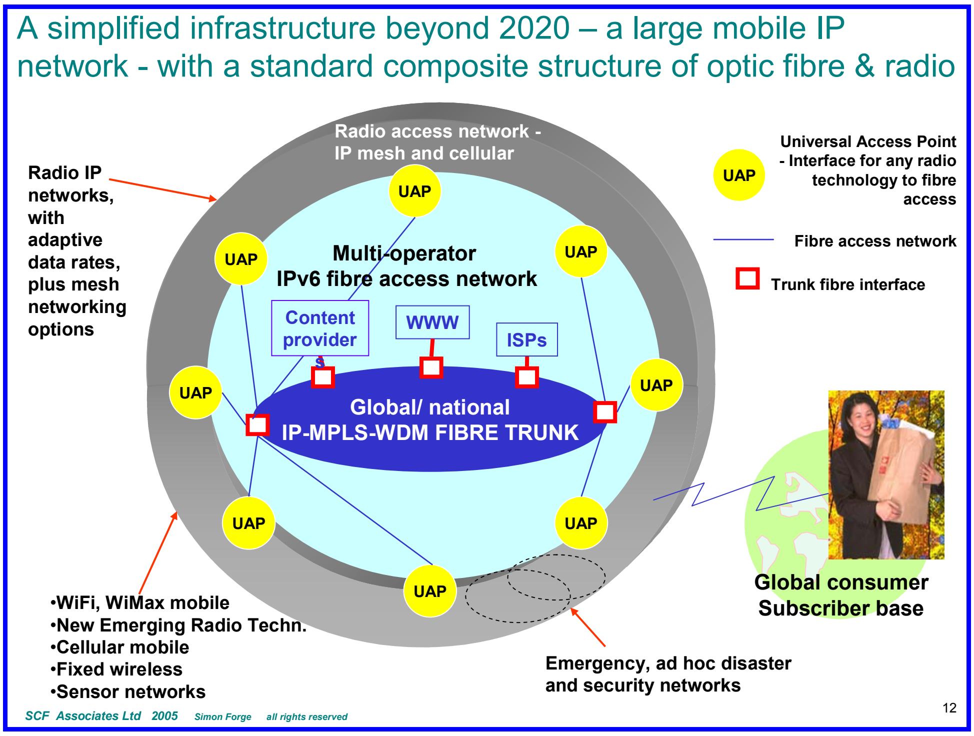
[20] Forge, S., Blackman, C. and Bohlin, E. (2005), *The Demand for Future Mobile Communications Markets and Services in Europe*, Technical Report Series 21673 EN, IPTS, Seville, available at http://www.jrc.es/home/pages/detail.cfm?prs=127

We should also note that this growth curve is only for human users. When we take into account the "Internet of Things" – that is the radio interconnection of inanimate objects, be they RFID tags on railways trucks or articles of clothing, or car tracking devices, down to appliances such as refrigerators and toasters – we may be speaking of a far larger population of users of the radio spectrum, beyond 2015.

Moreover the impacts of spectrum availability are likely to be emphasised by the use of radio communications in future telecommunications infrastructures going forward. The impacts on telecommunications of new network architectures has been analysed by the OECD in its future infrastructures programme[21] to assess needs for future public/private investment, identifying critical issues, including the viability of current models of infrastructure and their funding.

Drawing on this work, we see that new network architectures will appear. First steps in this trend are being realised in the current builds of Next Generation Networks (NGNs) which are oriented to carrying simple aggregations of IP traffic, be it data or voice, integrating mobile and fixed-line minutes. Looking further into the future we can see that our economy will be even more dependent on all kinds of radio communications, particularly at the base level of local loop connection, as shown in the diagram below, drawn from OECD work for a future two-layer architecture:

Figure 5.2. Future dependency on radio in a simplified architecture of 'fibre core and radio tails'



This includes the use of emerging radio technologies (ERTs) in the local loop to replace fixed xDSL technologies for broadband, just as WiMax has often been positioned. The Korean WiBro system based on WiMax IEEE 802.16 is one example here, but it can also be used for mobile communications and also for backhaul for WiFi networks, and the use of the 3.5GHz band for backhaul has been indicated as of interest by the EC.

[21] Bohlin, E., Forge, S., and Blackman, C., 'Telecoms infrastructure to 2030', chapter in *Infrastructure to 2030: Telecoms, Land Transport, Water and Electricity*, OECD, Paris, 2006.

Notice the emphasis on non-cellular radio for the future as well as the entry of non-operator-centric entities running communications services against the established current players. New entrants are both private sector entrants and public sector, as is happening in the USA and Europe as municipalities and local authorities build broadband Internet access services for their communities using WiFi, WiMax and proprietary technologies (eg from IPWireless). We can expect that ERTs will also provide a fruitful source of future technology endeavour and income for Europe as building on the example set by the GSM success for global exports.

Consequently we should realise that spectrum allocation will have strong impacts on economic development at four levels:

- Utilisation of radio as an accelerator of all aspects of the economy and its business processes

- As a catalyst for consumption – for new services and also products; this is the key to jobs and GDP growth in a consumption-based economy

- A major source of new innovation in radio technology products and services with high global export potential, including software, chipsets, and digital media content such as ringtones, music, and entertainment for the 'third screen' (after TV and cinema)

- If judiciously allocated, radio services may act as a driver for competition, in that its ubiquity, low cost of infrastructure and new broadband capabilities can challenge the status quo, not just for the fixed-line telecommunications industry but in the way health, policing, elderly care and social services are carried out, and so improve the social overhead capital (SOC) investments.

1.3. Impacts on media services based on radio distribution

These include broadcast and satellite services. Impacts will tend to be muted for the major services, since we would expect the major bands in use today and expected for digital TV and radio switchover to remain outside the concepts of traded spectrum or unlicensed bands for the next five to ten years. However beyond that it is quite questionable whether these services will be amenable to new spread spectrum and other frequency sharing techniques such as agile cognitive radio and so could be switched over to operate in unlicensed bands and release their current spectrum properties. Trading in peripheral bands may open up local radio services but the impacts are unlikely to be radical as spectrum is not an enormous factor due to the re-use of FM bands geographically.

1.4. Impacts on usages and services other than e-media and communications

The most promising area for new radio exploitation is not perhaps in communications and entertainment per se. It is in new usage of the ether for services such as:

- Location based services – navigation and maps for pedestrians and vehicles, with added points of interest super-imposed – using satellites or base station triangulation
- Tracking and tracing – be it a railway wagon, a road vehicle, a consignment, an article of clothing, or even a child whose whereabouts are always known to its parents, but only the parents
- Health and safety applications, increasingly significant for the aging demography in the EU[22]
- Sensor networks – industry and health applications for monitoring and feedback controls

All of these may used assigned frequencies, but increasingly will tend to use the unlicensed bands as they are often associated with products for consumers (or private or public organisations) which are themselves the emitters of radio signals which would otherwise require a licence to operate.

[22] See MEWTAD study, Work Package 2, Ibid

1.5. Spectrum allocation mechanisms and their impacts

Here we examine the main mechanisms of spectrum management and allocation and assess their impacts. The mechanisms are:

- Command and control
- Markets
- Unlicensed bands which might be taken eventually produce a commons in spectrum[23]
- A combination of some or all of the above

The impacts of each are shown in the table below.

Figure 5.3 Spectrum allocation mechanisms and their impacts

Allocation form	Main Impacts on the EU	In a nutshell
Command and control – the managed administration of allocation, usually by central government	This is the way we have dealt with spectrum, with some few exceptions such as the 3G auctions, for over 100 years. It favours centralised services, usually operated under state organisations. As such, it still has some part to play, for emergency services, for example, and the like. Most MS will try and conserve common bands for existing media broadcast and for the currently accepted ITU bands for mobile cellular service (2G and 2.5G) under this regime.	Cannot be continued with as usages and technologies progress
Markets for spectrum as property	Opening a market for trading will only change the EU economy if today's holders of spectrum are willing to trade and the process of doing so is straightforward. If trading does arise, the natural arrival of a free market in spectrum is unlikely in a situation where spectrum would be viewed as the key to market entry, and a key which is traded and might be bought by (new) rivals, so that incumbents will act to corner the market if any real threats to current cash flows transpired. Prices to the consumer may well go up if spectrum is traded. In some case it could mean progressively fewer customers, so that the operator might be forced to abandon the services. In this case the trading mechanisms lead to restriction of services.	Mixed possible success. Will need careful EU-level regulation to assure a level playing field.
Unlicensed bands	The freeing of spectrum for use in business and by consumers at a product level will change the competitive landscape fundamentally. Services based in these bands will offer major cost advantages handed on via reduced levels of ARPU required to breakeven and so services pricing. This will tend to encourage new services and a pricing that invites take-up. The technologies that will tend to use these bands may also offer far lower infrastructure costs (see Appendix on 4G networks). The combination of low cost services due to zero licence costs combined with lower capital and opex outlays could prove a killer for the current cellular technologies, if allowed to operate. This may only be in the new accession MS, on a large scale. At a macro-economic level, unlicensed bands offer new opportunities for innovative radio products and thus additional employment and GDP growth which would invite increased FDI flows.	Eventual way forward as technologies evolve to more shared ways of spectrum usage
A combination of some or all	Effectively starting from today's situation means a mix of the above for at least a decade, and in practice perhaps several. The interesting point is the balance between them - one compromise might be some restricted traded bands, larger swathes of unlicensed spectrum than currently available and a constant erosion of administered bands by fiat as new technology makes efficiencies in spectrum usage apparent in all technologies. For instance in civilian aviation, digital chirp radars for bandwidth sharing might replace the analogue wideband demands of today while secondary surveillance radars become spread-spectrum-based while even instrument landing systems and navigation beacons move to such technologies, so all can share.	The most likely situation. Will require careful balancing acts by MS and the EU

[23] Kevin Werbach, 'Supercommons: Toward a Unified Theory of Wireless Communication', *Texas Law Review*, Vol. 82, 2004, pp 863 – 971.

1.6. Quality of base information for benchmarking and impact assessment

As an aside we would note that at any quantitative level, benchmarking and forecasting impact assessment has been made far more difficult by two factors:

- The intangibility of parameters that assess progress in advanced technology – the absence of clear and meaningful indicators – although there are many major attempts at this (eg SIBIS, BISER, SEAMATE, B2B Metrics),[24] they do not see to have made a substantial difference to the data that is collected and available. Some initiatives on indicators do look promising, eg the Digital Opportunity Index,[25] but are not yet available as time series data. Moreover, the tendency is for these composite indicators to measure what was important in the past and hence, radio-based data tend to be under-emphasised.
- The incompleteness or absence of basic data for the enlarged European Union beyond the EU-15 Member States. This applies to some basic economic and social data as well as ICT statistics, eg investment in telecoms or radio-based industries, monthly ARPU or on usage of different services or their coverage.

When we look at the higher level studies aimed at B2B usage such as 'e-readiness' their problems include different methods for data collection of very different types of samples with many gaps and different bases of assessment (for example in measuring consumer spend using local currencies rather than common for a twenty year time series, so currency movements must be factored in) with only roughly comparable findings; cross verification is difficult.

Thus we would repeat our health warning in considering the following conclusions section: the study is highly ambitious given:

- Time constraints
- 'Experimental' nature of modelling approach
- Paucity of data on EU-25+, ICTs and mobile/wireless

Thus its conclusions must be considered in this light.

2. Conclusions

Our key conclusion overall is that the forms chosen for spectrum allocation are critical to future economic development in the EU. We would also note that regulation in the EU is moving in the right direction, to assure that Europe will progress by grappling with spectrum allocation issues.

It seems highly likely that 'new radio' will become the crucible in which the major technology advances in mass technology usage will be formed over the next fifty years. This means that more opportunities in working patterns, lifestyles, health and elderly care will opened up by radio technologies than by any other ICT development.

In terms of the scenarios constructed for the purposes of this study, it is perhaps useful to summarise the possible impacts on a variety of stakeholders. Table 5.1 gives some very brief comments summarising the position for a range of stakeholders within each scenario.

[24] For a list of some relevant IST projects, see Appendix.
[25] http://www.itu.int/osg/spu/statistics/DOI/structure.html

Table 5.1. Summary of impacts for stakeholders by scenario

Stakeholder	Radio Europe Mix	Radio Dropouts	Radio Bazaar
Citizens	More choice – more services, lower cost with more offerings (and offerers); more types of k-society use	Same choices as today: few changes in services and product pricing and technologies	Few changes in offerings but expect progressively higher charges, to pay for spectrum
Regulators	More co-ordination, and move to more unlicensed; more market control of traded bands	Same regimes and rules	More market control for traded bands
Incumbent telcos	More challenges from new entrants/service types/technologies	Old rules rule	Must move quickly to maintain position with spectrum acquisition
New service providers (SPs) and new radio product entrants	More opportunities – low cost entry	Varies by national spectrum regime; little difference to today	SPs must bid against the largest for prime cuts of spectrum or take the crumbs
Media and content players	Business opportunities as players expand, especially in mobile content	Same rules and players – may slowly change as mobile media arrives and incumbent telcos follow media convergence (eg BT in UK); limited 3G sales in some MS	Few changes as players are mainly conservative and will not have access to wide swathes of bandwidth for broadband mobile on a one user/one band approach as too expensive; limited 3G market could finally take-off
Broadcasters, terrestrial & satellite	More competition from mobile media	Same rules, few changes	Must move quickly to maintain position with spectrum acquisition. Form tacit alliances with incumbent telcos
Equipment suppliers including networking, handsets, etc	Higher competition from new entrants plus rapid technology introductions demands higher R&D efforts to keep up	Roughly the same technologies, products and pricing; volume production limited ; national champions can flower	Few and slow changes in offerings or prices – conservative market; prices and margins maintained.
Other suppliers – software ISVs, VARs, system integrators etc	More opportunities as new networks, services and technologies	Same relationships and opportunities	Same relationships and opportunities

Thus, our analysis would tend to indicate that the scenario of Radio Europe Mix, with the advent of 4G type technologies powering low-cost infrastructures and new usages, could be the most advantageous scenario from the point of view of EU economic development. However the adoption of the new technology is still nascent and so a gradual approach to its enablement in regulation may be prudent.

A market-based future with trading and extension of property rights, as depicted in Radio Bazaar, might perhaps bring undesirable effects in that the market would:

- Concentrate market power in those with the deepest pockets, who will preserve the status quo both in technology and range of services in order to conserve the 'cash cow'
- Ignore the social needs in usages
- Ignore the requirements of the EU for innovative technologies that will form a platform for new business and economic development both in infrastructures internally and in exports

Thus those Member States who release most spectrum to unlicensed bands are likely to benefit most economically as they will at the same time release two forces:

- New entrepreneurial drives in services at low cost
- New technology developments to share spectrum

At this juncture we should re-emphasise that that scenarios are to some extent caricatures – they may tend to simplify and over stress some points in order to clarify trends and impacts. We now examine each of the above points in more detail.

Throughout the migration to concepts of trading in spectrum, it is important that the ideas of social balance should not be lost.[26] By this we mean that there is a social as well as a commercial value on services and this must be weighed up in choosing applications. Introducing this in an unregulated free market is not possible, unless in addition the social mandate is applied through a managed administration of some allocations. This is important as traditional neo-classical concepts of free markets are unlikely to hold. Against an apparent opening of the spectrum market via trading for new services, supposedly bringing higher competition, the brakes on openness will tend to be applied by the incumbents to preserve the status quo and protect market positions, using the very market mechanism of the traded spectrum itself to halt change.

In consequence we can expect those who already exploit radio services to want to see competition suppressed. Therefore market distortions ay well arise as a result of their actions. Extensions of property rights will be a gift to the incumbents if they are allowed to amass spectrum without hindrance. If left to itself, the radio spectrum market will lead to oligopoly and collusion. Market players may also tend to drive down the price to themselves as there may be very few buyers under these conditions. With various agreements amongst themselves, explicit or tacit, be they in private sales, or in 'rings' at auctions, they will tend to control prices in their favour. Consequently, some form of regulation on cornering spectrum markets is likely to be needed for trading scenarios. This would support the call for a European regulator of telecommunications competition, as current national competition law is unlikely to cope either in jurisdiction, load or in specialist knowledge.

Even with regulatory intervention to prevent it, imperfect markets will reign without some form of information circulation in the trading environments covering both pricing and the identity of owners, in a market that may be fast moving, so ownership must be registered in seconds or minutes via online databases. At a more technical level, with rapid trading, the rules on physical spectrum interference could be difficult to police – so that frequency interference is likely to appear.

Compared to an unlicensed scenario, in a trading situation we can expect costs to the user to be driven up, and this is shown in the Appendix on the 4G case. Previous 3G auctions have shown that sums of up to €650 per subscriber were added to base costs, with numbing effects on both network rollout and

[26] Forge, Simon, 'The radio spectrum and the organisation of the future: new allocation approaches', *Telecommunications Policy*, February 1996.

funding of a technology hobbled by immaturity and lack of adequate R&D funding.[27] This drove up ARPU for the 3G operators and hobbled the success of the services. But we should also note that spectrum is just one of many costs including network build and operational expenses.

While trading will add a scarcity rent to the cost of radio usages of all kinds, be they media or telecommunications, unlicensed bands will offer major economic advantages over the traded bands as ARPU will need to be lifted to repay the added fixed costs of traded spectrum. Unlicensed bands will tend to utilise new spectrum sharing technology[28] and their opening could spur EU research into such technologies.

Novel ways in which tomorrow's technology will be packaged to include radio-enabled features also means spectrum access must be freely given to the user. Many new products will rely on use of spectrum freely and can only flourish with it – the end-user must not need permission to use or to purchase a licence in order to exploit the product. One example is the Centrino chip from Intel. The wireless microprocessor chip market depends on free usage of spectrum – operator licences do not need to be sold with laptops. Such freedoms must be preserved and we may expect the EU market to expand in the future as more products appear like this, for instance, one of the latest being Wibree from Nokia, a Bluetooth-like technology still seeking open public endorsement. So a balance must be sought between trading and unlicensed for industrial product development and its need for free spectrum in radio-enabled products.

When we examine digital media – terrestrial broadcast and satellite – we see that the free growth of radio-based online access to the Internet would indicate a spread usage of IPTV if bandwidth is great enough and charges for data access are in line with willingness to spend. That is, disposable income is matched to the attractiveness of the service. In this case, terrestrial broadcast and satellite media would tend to compete with web-based TV stations and with ubiquity and eventually higher convenience for reception and with the advent of low-cost in broadband, some competition would be possible. However the inertia of this market following early disappointments with IPTV makes the EU market success of this service difficult to gauge. We may also expect that the common broadcast bands will remain sacrosanct for the major TV networks and the trading would only affect the industry marginally at the level of local broadcast stations across the EU, where pockets of spectrum become available, and an advent of trading will not affect the market measurably. Naturally in releasing any spectrum, one should expect Member State governments to want to protect their national media champions, especially in broadcast.

However, we should also recall that all will be tempered by international criteria and agreements in the ITU and the conference forum for the World Radiocommunication Conference (WRC-2007). We may expect more national and industry lobbying and changes of direction in the short term as the dialogue continues. We would also anticipate that national/regional agendas will suddenly demand faster action than the four year intervals of WRC arenas as the pace in radio speeds up over the coming five years. In addition, we can expect competition within EU and outside between the various legal frameworks (specifically the EU, USA and China).

We may expect spectrum management tools to appear, offering far more controls and monitoring of the spectrum in order to: identify who is using what; find gaps; and ensure that users are really not overstepping either their traded bands or that unlicensed band users are not exceeding the boundaries. These will be complemented in a trading market by databases of registry and circulation of pricing information to prepare for a more perfect market.

One other bonus is perhaps possible, that the EU could seize the chance to reduce regulatory bureaucracy through more unlicensed bands – lack of regulation tends to make regulatory services

[27] Forge, Simon, 'Is fourth generation mobile nirvana or …. nothing', *info*, Vol.6, No. 1, 2004

[28] Forge, Simon and Blackman, Colin, 'Spectrum for the next radio revolution: the economic and technical case for collective use', *info*, 2006, Vol. 8, No. 2.

redundant, apart from expansion of the key services of testing and certifying products and services for compliance with spectrum rules and safeguards.

In summary we can see that unlicensed bands might tend to drive EU prosperity in products and new services from new entrants. Unless market costs are very low, traded spectrum on the other hand would tend to encourage the circulation of assets among those who are already users or owners, rather than new entrants, as spectrum costs become a barrier to entry which existing players are able and prepared to pay for in order to assure their future survival.

Moreover we should not underestimate the pressure on some Member States to limit or delay competition because of the legacy affects of the allocation of 3G licences through spectrum auctions. Government finance ministries naturally may perhaps want to avoid any possibility of repaying licence fees in the event that operators argue that spectrum was awarded for exclusive use for the duration of their licences. Whether the conditions of 3G licenses contravened EU competition law remains moot.

Looking at the Radio Dropout scenario, we may conclude that the situation of opting out of a single spectrum framework may not bring the economic benefits expected for the EU in other scenarios and so is not a judicious course for Europe. Moreover one might conclude it indicates a need for two major changes to current regulatory practice in the EU:

1) a legal basis on which to enforce a usage of European regulation for co-ordination, so that spectrum provisions for allocation can be commonly applied and interpreted across all Member States; execution of spectrum policy might not be left to the national regulators to apply in the form and timeframe whereby they alone decide.

2) The above application of an EU framework for spectrum allocation would need a Europe-wide telecommunications regulator. This would initially co-ordinate national regulators and subsequently tend to replace them, perhaps also federating departments of the national regulator where appropriate.

On the Radio Bazaar side one might conclude that the current competition laws should prevail to cover any situation of a non-competitive cornering or control of the market and nothing further is required. However, we would tend to balance this with the observation that in the real EU, competition laws are likely to be less effective in the case of spectrum and so are unlikely to change very much immediately for trading spectrum in the short term, due to the inertia in their application – eg a non-competitive situation has to arise before they are applied. In any case it is highly conceivable that regulatory authorities will act to protect incumbents, as currently seems to be happening in Germany where the new Telecom Bill grants Deutsche Telekom a 'regulatory holiday' while stifling competition in the broadband market.[29]

Moreover the NRAs are unlikely to act quickly, especially where national interests intervene and/or 'regulatory capture' has occurred – that is effective control of the regulator by national operators and /or equipment suppliers. This happens to a greater or lesser degree as *realpolitik* in many of the larger MS. For example:

> Witness the recent letter from the European Commission to the UK regulator[30] Ofcom (which claims to be one of the most open and vigilant NRAs in Europe). The UK mobile operators have been levying an *average* toll on their customers of 1.2p (approximately 0.18 Euro) charge *per minute* to terminate mobile calls to repay their 3G auction outlays of some £22 billion. However the current law only requires NRAs

[29] 'Fury in Germany over DT's regulation vacation', *telecoms.com*, 22 November 2006, http://www.telecoms.com/itmgcontent/tcoms/news/articles/20017387397.html?1=1&mp_articleid=20017387397&mp_pubcode=MTEL&mp_channelid=30000000378&Marlinsource=V2autoMatt&ST=OEM&MarlinViewType=ARTICLEVIEW&siteid=30000000461&from=M@T-TopNews

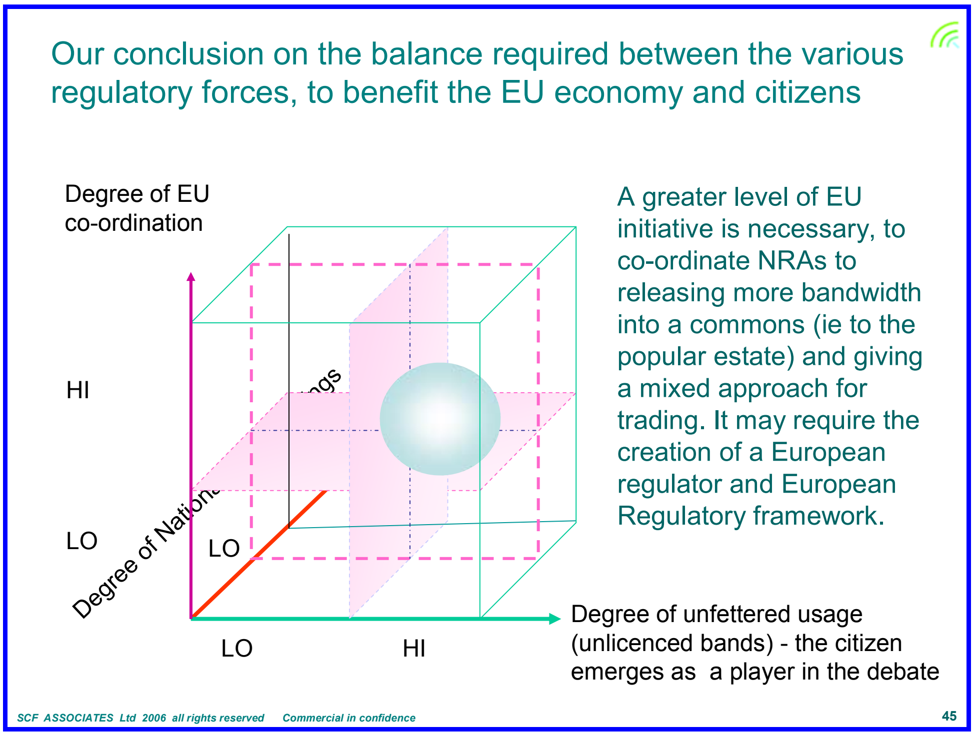
[30] Tobias Buck, 'Brussels reprimands Ofcom over mobile network charges', *Financial Times*, 28 November 2006.

> to take "utmost account" of the EC view but the Commission cannot impose its view except via a (lengthy) court action in the European Court of Justice. This levy situation is not recent – it has been in place for some years, without action until this point. Indeed when any affects of such a letter will be seen is also open to question – Ofcom states it will complete its review of the levies in some four months, reporting in March 2007.

To some extent this also reinforces the case above for an EU- level of regulator who can act on spectrum trading across Europe in a timely and consistent manner in all MS. Thus the EU will perhaps need to have a co-ordinating power over the NRAs on how much spectrum is released where in terms of frequency and geography.

The balance of co-ordination may perhaps be illustrated as shown below, in which the citizen must appear directly, for possibly the first time, as a voice on the usage of the spectrum as a third dimension or force in the co-ordination of spectrum allocation between the national bodies, the NRAs and the European Commission:

Table 5.2. The balance between regulatory forces



In the multi-dimensional space of co-ordination by the EU, the citizen's needs and the degree of NRA decision-making, the ball might be seen to rest squarely in the court of high EU co-ordination to meet the citizen's needs with a lower degree of decision-taking at a national level..

3. Recommendations

3.1. Principles for recommendations

The principles on which our recommendations are based should be clear. These principles are drawn from our scenarios development and subsequent quantitative and qualitative analysis. They are to:

- Provide better use of any newly released spectrum through service neutrality as well as technology neutrality, and, as far as possible, optimal use for the EU economy and its citizens
- Ensure that the inefficiencies of the market approach are addressed

- Assure that spectrum allocation mechanisms and directives are consistent with competition policy and regulation
- Allow, where necessary, the use of multiple regimes at once (trading, mandatory allotment, unlicensed)
- Assure that the regulatory framework be shaped to respond to new technology developments.

All of these attempt to avoid a potentially harmful situation of market dominance through vertical or horizontal integration by use of spectrum assets.

3.2. Our recommendations and the problems they attempt to counter

Our key recommendation is that: the initial assumption should be that regulatory authorities should stipulate the use of spectrum without the need for a licence unless allocation by other means can be justified. Should a market trading approach – alone or in combination with other approaches – be chosen, then several regulatory interventions may be necessary. Key problems are in the competitive aspects of trading, and regulation seems to be the only possible recommended way forward for the following areas of issue:[31]

- Regulatory intervention may be necessary to prevent the cornering of markets, to stop those with deepest pockets effectively halting competition and sitting on all available traded spectrum. Regulatory authorities will need to be vigilant and have appropriate measures planned using either competition regulation or possibly new legal measures for spectrum trading.
- Prevention of tacit divisions of spectrum on a functional services basis will be needed. Such divisions could enhance the market power of the incumbent media broadcasters and MNOs, in that they each would purchase control, or already control, the most appropriate swathes of spectrum and not permit sale to a rival be it in their own sector or in a sister sector.
- Monopoly pricing may become a problem in that those who already hold spectrum, and may be the only source, could attempt to extract excessive pricing. The first problem is to assess what constitutes excessive pricing. The second problem is in selection of appropriate actions. The problem is acute where technologies are closely tied to spectrum and frequency change requires difficult equipment redesign which may be impractical for economic or technical reasons. Regulatory intervention will be needed to counter monopoly pricing owing to technical reasons where it occurs.
- It is possible that excessive trading could provoke fragmentation into non-useful slices of the frequency spectrum, too small for fixed frequency equipment. Moreover having one slot in the midst of an undivided set either side could command premium pricing in some circumstances. Appropriate safeguards to prevent this will be necessary.
- To differentiate between many owners in a heavily fragmented and traded part of the spectrum, it may be necessary to assure interstitial guard bands between assigned slots. These could take up a significant portion of each slot, reducing spectrum efficiency. Regulation would thus have to consider the critical minimum slice to trade for effective use.
- Imperfect knowledge of the market will hinder trading so we recommend that there is a database or register of trades at EU level, so all potential market entrants know who owns

[31] Our views here are not the only ones where observers see issues in the traded spectrum concept – see for instance, Xavier, Patrick and Ypsilanti, Dimitri, 'Policy issues in spectrum trading', *info*, Vol. 8 No. 2, 2006, pp 34-61.

what, where. A register of trades must cover the secondary markets as much or even more so than the primary sale or auction. The same databases could also be used for exchanging information on pricing to help build a more perfect market. Such an arrangement may help to prevent spectrum farming from becoming a costly and protracted bureaucratic process – there is a strong need to control the direct and indirect costs of primary and secondary trading transactions, if adopted

Although difficult to implement and requiring far more study on lightweight EU-wide mechanisms, we would recommend that there must be some form of balance between social needs and trading.

Moreover, consideration of unlicensed bands must be brought to the fore, especially to balance the needs for industrial development and its dependency on free spectrum (the Centrino chip example) as well as to encourage new services and radio technology developments. In all of this there is also the need to assure public emergency services can obtain frequencies needed at reasonable cost or free.

We would also note that the present system of fragmented decision taking is not working so we recommend a more collective and co-ordinated approach as a European objective: the items for further study in order for this to occur are outlined in the final point below.

3.3. Suggestions for further study

We would recommend further study on the legal and managerial implications of:

- Expanding the unlicensed bands progressively with early growth from 2007, in recommended frequency bands
- Amending existing licences as necessary for trading
- The problems of association of IPR with technology standards and a specific frequency for technical reasons – forming entry barriers to new players. Recent developments in this area increase the risks of patents and IPR control[32]
- Encouraging incumbents and public sector owners to relinquish spectrum – eg generous spectrum allowances and either abandon spectrum or use it in far more efficient manner if they are permitted a mandate to retain some spectrum and release the rest
- The need for a single framework of spectrum regulation across the EU, with a single set of rulings on all bands held in common in every MS; this implies the need for a single European spectrum regulator to introduce, manage and enforce this spectrum regime, as well as the need for a legal basis on which to implement all these new directions.

[32] Lynnette Luna, 'Qualcomm buys MIMO', *FierceWireless*, 04 December 2006 (describes Qualcomm's acquisition of Airgo, its patents and IPR).

Appendixes

1. References
2. Project Workplan
3. Cellular Mobile Modeling
4. Model Building – Micro Business Model
5. Questionnaire on Parameters with Responses
6. IST Projects for European ICT usage benchmarking

1. Bibliography

Akalu, Rajen, 'EU spectrum reform and the WAPECS concept', *info*, Vol 8, no 6, 2006.

Björkdahl, J., Bohlin, E., (2003), "Competition Policy and Scenarios for European 3G Markets", *Communications & Strategies*, No. 51, 3rd Quarter, pp. 21-34, 2003.

Björkdahl, J., Bohlin, E., Lindmark, S., (2004), "Financial Assessment of Fourth Generation Mobile Technologies", paper presented to the EURO CPR 2004 Conference, 29-30 March 2004, Barcelona, Spain, published in *Communications & Strategies*, No. 54, 2nd Quarter, pp. 71-96.

Björkdahl, Joakim (2003) "Financial Prospects", in Bohlin, E et al (2003) "Prospects for the Third Generation Mobile Systems", European Commission, Directorate General, Joint Research Center, report no. EUR 20772 EN

Bohlin, E., Ballon, P., Björkdahl, J., Lindmark, S., Weber, A., Wingert, B., (edited by C. Rodriguez Casal, J-C. Burgelman, G. Carat) (2004), "The Future of Mobile Technologies in EU: Assessing 4G Developments," IPTS Technical Report prepared for the European Commission – Joint Research Center, EUR 21192.

Bohlin, E., Burgelman, J-C. (2004) "Mobile Futures Beyond 3G: Special Issue", *info*, Vol. 6, No. 6, pp. 345-398.

Bohlin, E., Forge, S., and Blackman, C., 'Telecoms infrastructure to 2030', chapter in *Infrastructure to 2030: Telecoms, Land Transport, Water and Electricity*, OECD, Paris, 2006.

Bohlin, E., Lindmark, S. Rodríguez, C., and Burgelman, J.-C., *Mapping European Wireless Trends and Drivers*, JRC/IPTS, 2006, http://www.jrc.es/home/pages/detail.cfm?prs=1428

Brinkley, Ian, and Lee, Neil, *The Knowledge Economy in Europe*, The Work Foundation, 2006, http://www.theworkfoundation.com/products/publications/azpublications/knowledgeeconomyineurope.aspx

Dopfer, Kurt, 'The Origins of Meso Economics: Schumpeter's Legacy', Papers on Economics and Evolution, August 2006, https://papers.econ.mpg.de/evo/discussionpapers/2006-10.pdf

Economist (2005) "Face value - Hong Kong's high roller", *The Economist*, January 6 2005

Economist Intelligence Unit, *The 2006 e-readiness rankings*, http://graphics.eiu.com/files/ad_pdfs/2006Ereadiness_Ranking_WP.pdf

Eurobarometer, *E-Communications Household Survey*, Special Eurobarometer, July 2006, http://ec.europa.eu/information_society/policy/ecomm/doc/info_centre/studies_ext_consult/ecomm_household_study/eb_jul06_main_report_en.pdf

European Commission, COM(2002) 655 final, "eEurope 2005: Benchmarking Indicators", 21 November 2002,

European Commission, COM(2005) 400 "A Market based Approach to Spectrum management in the European Union", 14 Sep 2005 http://eur-lex.europa.eu/LexUriServ/site/en/com/2005/com2005_0400en01.pdf

European Commission, COM(2005)411 "A forward-looking radio spectrum policy for the European Union: Second Annual Report", 6 September 2005, http://eur-lex.europa.eu/LexUriServ/site/en/com/2005/com2005_0411en01.pdf

European Commission, COM(2006) 334 on the review of the EU regulatory Framework for electronic communications networks and services. 28 June 2006, http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/com334_en.pdf

European Commission, *Impact Assessment Guidelines*, SEC(2005) 791, June 2005.

Faulhaber, G.R, Farber, D.J. (2002) "Spectrum Management: Property Rights, Markets, and the Commons", Working Paper 02:12, AEI-Brookings Joint Center Publications.

Forge, Simon, *The Consequences of Current Telecommunications Trends for the Competitiveness of Developing Countries*, World Bank, InfoDev Program, working paper, January 1995, available from http://www.infodev.org/library/WorkingPapers/tocforge.html

Forge, S. 'The radio spectrum and the organisation of the future: new allocation approaches', *Telecommunications Policy*, February 1996.

Forge, Simon, 'The e-factor: the new rules of the tele-economy', Part 1, *foresight*, Vol. 2, No. 1, Feb 2000; Part 2, *Foresight*, Vol. 2, No. 3, June 2000.

Forge, S. (2004a), ' 'Is fourth generation mobile-nirvana or . . . nothing?' ', *info*, Vol. 6 No. 1, available at www.emeraldinsight.com/Insight/viewContentItem.do?contentType=Article&contentId=873993

Forge, S., Blackman, C. and Bohlin, E. (2005), *The Demand for Future Mobile Communications Markets and Services in Europe*, Technical Report Series 21673 EN, IPTS, Seville, available at http://www.jrc.es/home/pages/detail.cfm?prs=1278

Forge, Simon and Blackman, Colin, 'Spectrum for the next radio revolution: the economic and technical case for collective use', *info*, 2006, Vol. 8, No. 2.

Galbraith, J.K., *The New Industrial State*, Pelican Books, I967.

Hardy, Andrew P. "The Role of the Telephone in Economic Development." *Telecommunications Policy*, Vol. 4, No. 4, pp. 278-286, December 1980.

Hazlett, T. (2001), 'The wireless craze, the unlimited bandwidth myth, the spectrum auction faux pas, and the punchline to Ronald Coase's 'big joke': an essay on airwave allocation policy', *Harvard Journal of Law & Technology*, Vol. 14 No. 2, pp. 335-545, available at http://jolt.law.harvard.edu/articles/pdf/hazlett.pdf

ITU, *Measuring Digital Opportunity*, BDB-WSIS/06, 23 November 2005, http://www.itu.int/osg/spu/statistics/DOI/linkeddocs/Measuring_Digital_Opp_Revised_31_Oct_2005.pdf

ITU, *World Telecommunication/ICT Development Report 2006: Measuring ICT for social and economic development*, 8th edition, 2006, http://www.itu.int/pub/D-IND-WTDR-2006/en

Liikanen, E (2001) in "*eMobility – Report of the Conference on Mobility in the Knowledge Economy, Göteborg, June 2001"*, Directorate General Information Society, European Commission

Reding, Viviane, Spectrum reforms and the Lisbon strategy, Address to the 7th meeting of the Radio Spectrum Policy Group, Brussels, 16 June 2005, http://rspg.groups.eu.int/doc/documents/meeting/rspg7/rspg_vr_speech.pdf

Roeller, L.-H. and Waverman, L. (2001), 'Telecommunications infrastructure and economic development: a simultaneous approach', *American Economic Review*, Vol. 91 No. 4, pp. 909-23.

Teligen, Telecom Price Developments from 1998 to 2005, Report for DG InfSo, December 2005, http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/studies_ext_consult/price_developments_1998_2005/Infso_tariff_trends_report_1998_2005.pdf

Waverman, L., Meschi, M. and Fuss, M. (2005), ' 'The impact of telecoms on economic growth in developing countries' ', Africa: The Impact of Mobile Phones, *The Vodafone Policy Paper Series*, No. 3, March, available at: www.vodafone.com/assets/files/en/GPP per cent20SIM per cent20paper.pdf

Werbach, Kevin, 'Supercommons: Toward a Unified Theory of Wireless Communication', *Texas Law Review*, Vol. 82, 2004, pp 863 – 971.

World Investment Report, UNCTAD, 2006, http://www.unctad.org/Templates/Page.asp?intItemID=1465

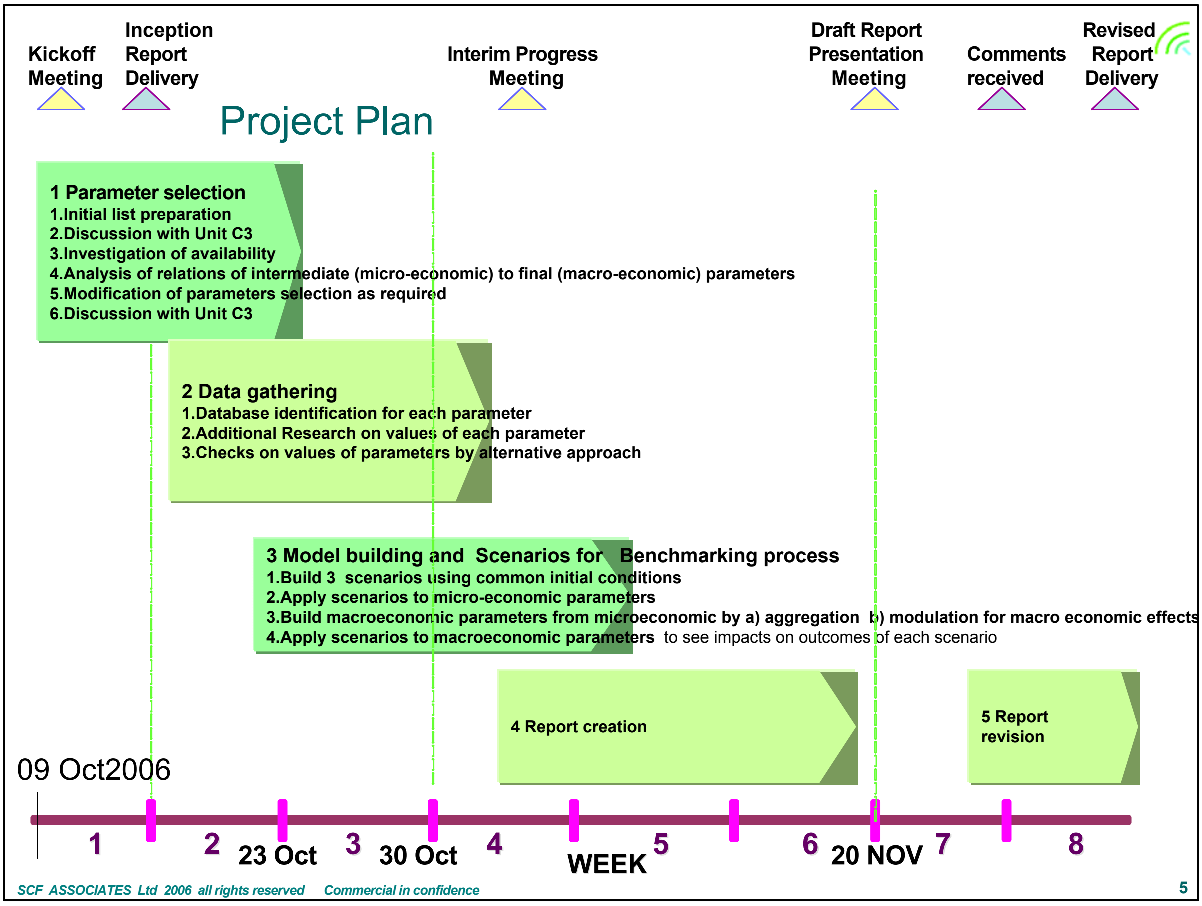
Xavier, Patrick and Ypsilanti, Dimitri, 'Policy issues in spectrum trading', *info*, Vol. 8 No. 2, 2006, pp 34-61.

2. Project workplan

The workplan - design and implementation of the analyses to be performed, with methodology, tools and approach to the key study requirements

The programme of work follows the contract and the approach as laid out in the tender. First we outline the schedule of work and then the management organisation for the series of five workpackages corresponding to each contractual task of the work programme shown in the diagram below (fig.1).

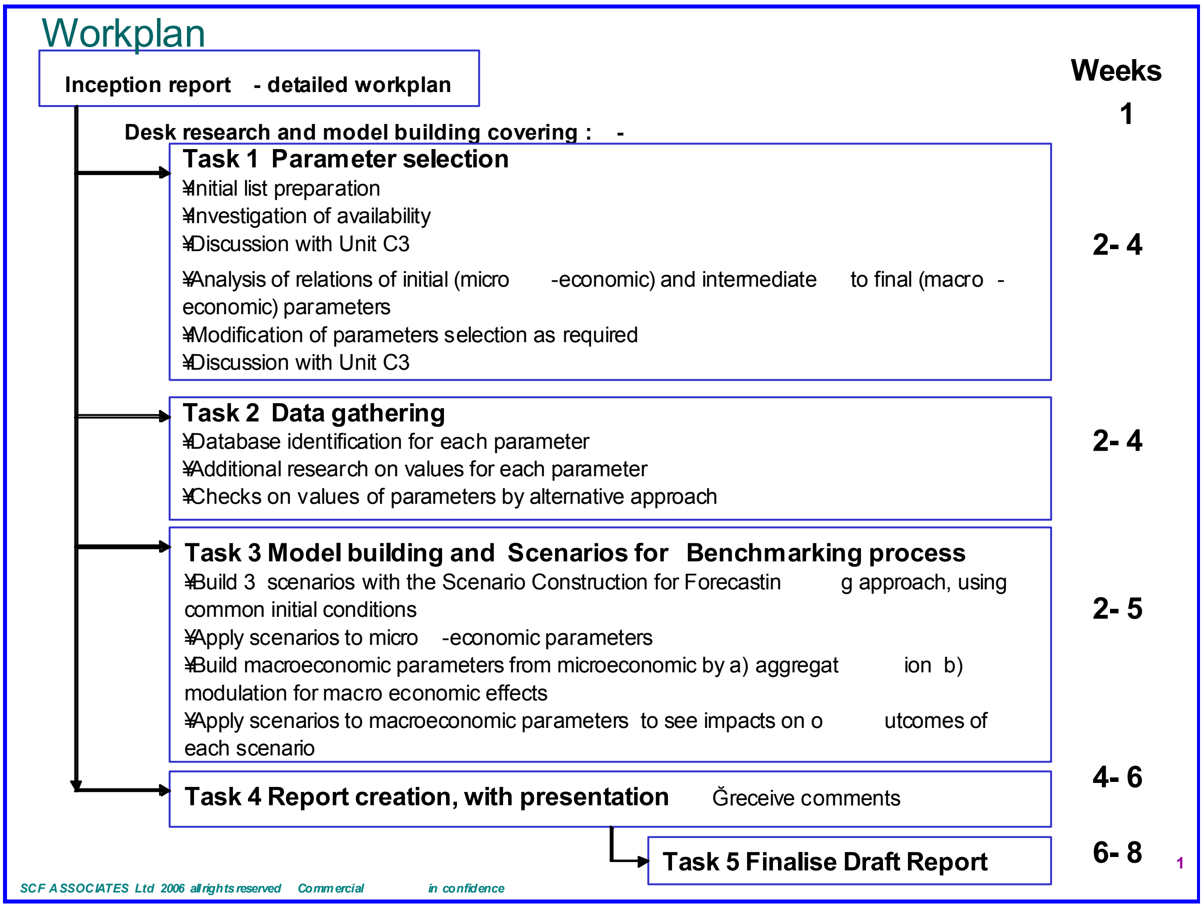
Figure 1 Overview of the work programme as a Project Plan



Breakdown of tasks

The overview of the work programme with breakdown of the key tasks is shown below:

Figure 2 Key tasks of the work programme



3. Cellular mobile modeling

Working paper for Cellular modelling – 2G, 2.5G, 3G

1 A way to use the network unit structure and to translate it to a cellular structure

We can use the cellular structure as the same radius of operation as we use for 4G with different cell sizes and different functional units – BTS (or BST), BSC and MSC

2 To change the model to 2G/2.5G : corresponding inputs to those of 4G on the following tables

For 2G/ 2.5G (with GPRS)

Use assumptions of

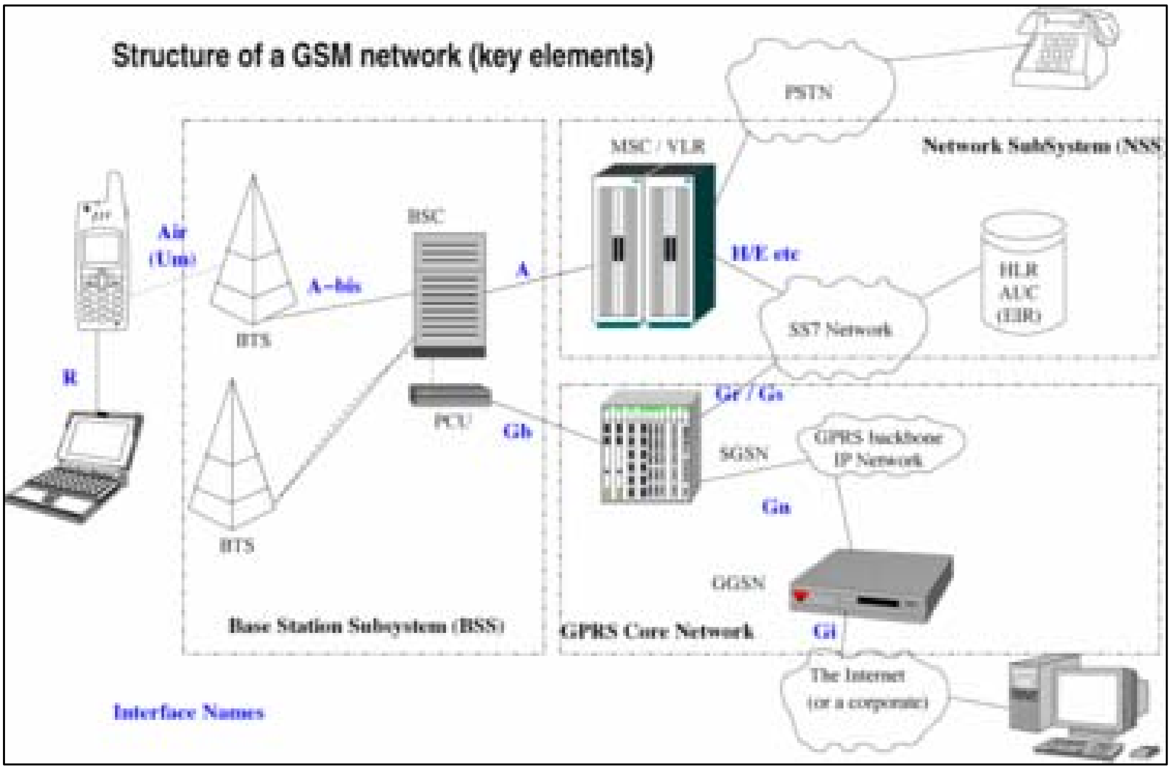
- peak of 10% subscribers have simultaneous calls (in one cell) ie 600 in urban km2
- 4 competing operators, with approximately equal market share, so 25% of subscribers each, ie 150/operator in urban km2
- 20 simultaneous channels per BST
- BSTs as dense as 0.5km distance apart in urban, 2km suburban, up to 10km rural
- One BSC handles up to 50 BSTs
- Multiple BSTs possible per cell site – use a max of 1 per site for simplified model

Area type	SUBs/Km2	Subs/ operator/ km2 for 4 operators	Subs/ n/w unit /operator	Average area reach (km2) of network unit	Network unit radius kms
Urban	6000	1,500	1125	0.75	0.5
Suburban	500	125	1500	12	2
Rural	30	8	1600	200	8

The figures below are based on units/km2 – these can be translated into a Eurolandia city by giving a number of km2 to a city, and similarly estimated for suburbia, or rural coverage

Density of units

Component	Number needed Urban area/km2	Suburban/km2	Rural/km2	National
BST	9 (0.5km spacing)	1	0.1	N/a
BSC	0.2 (for 50 BST)	0.02	0.002	N/a
MSC Mobile switching centre with VLR/HLR (visiting and home location registers)				2



In a more modern 2.5 G GSM network, costs of GPRS for data must be added, at the level of the MSC in density – multiple units nationally.

Cellular range

The working range of a cell site - the range within which mobile devices can connect to it reliably is not a fixed figure but is limited by local geographical or regulatory factors and weather conditions and depends on:-

The type of signal in use (i.e. the underlying technology) and frequency

BST (also BTS – base transceiver station) transmitter's power

Transmitter's height.

Generally, in areas where there are enough cell sites to cover a wide area, the range of each one will be set to:

- Ensure there is enough overlap for "handover" to/from other sites (moving the signal for a mobile device from one cell site to another, for those technologies that can handle it - e.g. making a GSM phone call while in a car or train).
- Ensure that the overlap area is not too large, to minimise interference problems with other sites.

Cell phone traffic through a single cell site is limited by the site's capacity (as there is a finite number of calls that a site can handle at once), and this limitation is another factor affecting the spacing of cell sites. In suburban areas, sites are commonly spaced 2-3 km apart, and in dense urban areas, sites may be as close as 500-1000 meters apart.

The *maximum* range of a site (where it is not limited by interference with other sites nearby) depends on the same circumstances. GSM, has a fixed maximum range of 35 km, which is imposed by technical timing limitations. CDMA and iDEN have no built-in limit, but the real limiting factor is really the ability for a low-powered personal cell phone to transmit back to the cell site. As a rough guide, based on a tall site and flat terrain, it is possible to get between 50 and 70 kilometres but variable reception. When hilly, the maximum distance can vary from as little as 5 to 10 km to about 40 km. In practice, cell sites are grouped in areas of high population density- most potential users - Eg to cover 80% of UK requires only to covering 45% of land mass.

3 Cellular 2G and 2.5G Cost elements for critical equipment aspects

- BST: €20-70 k
- BSC: €175 -525 k
- MSC: ~ €1 million.
- Network interconnections for backhaul etc – fibre optic installation prices per site connection per month: €700
- GPRS units - (General Packet Radio System)
  - SGSN Serving GPRS Support Node: €20k
  - GGSN, Gateway GPRS Support Node: €70k
- Cell site capital cost: from 20,000 Euro/ site to 1Mn Euro/site depending on location and country

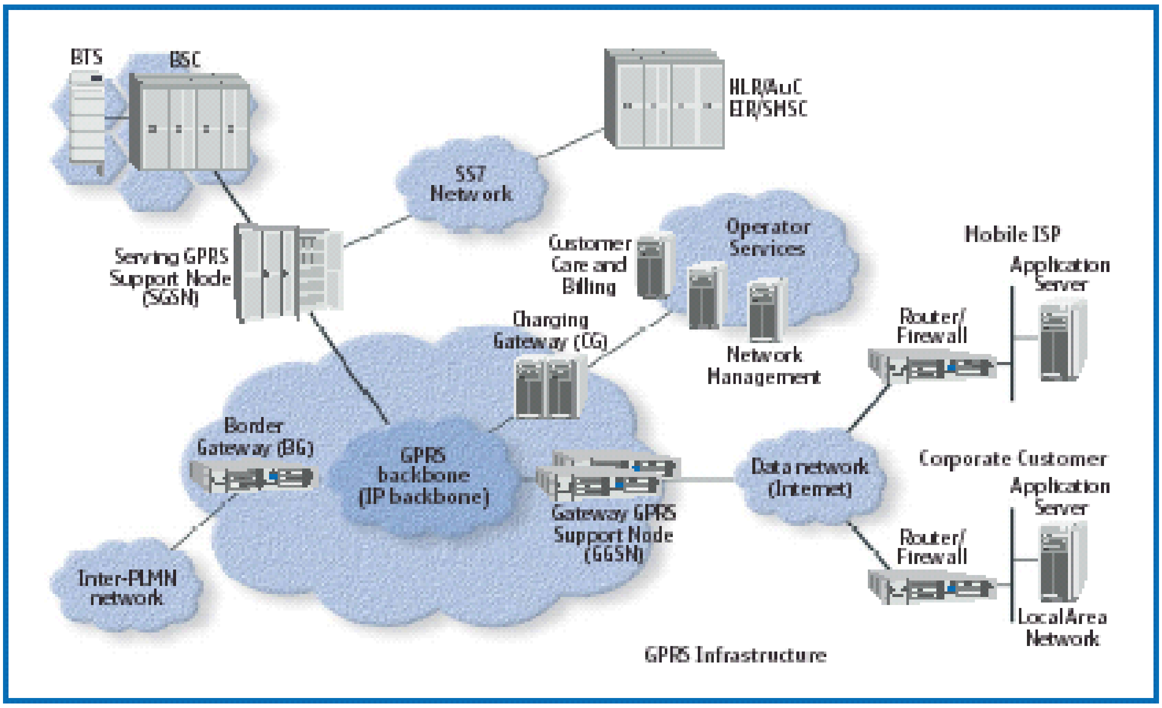
Upgrading GSM radio network to GPRS requires new software be remotely downloaded to base stations - GPRS solutions also supports 3G UMTS (3GPP standards) for interoperability and roaming. GPRS roaming is a key issue and the number of GPRS roaming agreements is expected to expand into the thousands, following the successful path of GSM roaming which currently has about 20,000 roaming agreements in place.

The **Serving GPRS Support Node (SGSN)** provides scalable, modular subscriber management services, matching the demands of the radio network to the IP core. Important functions of the SGSN include mobility management, user authentication, signaling to the mobile switching centre and collection of billing data. Using It uses a multiprocessor-computing platform with built-in redundancy.

In a GPRS network the **Gateway GPRS Support Node (GGSN)** provides secure connections from the GPRS network to the Internet and corporate intranets. In addition to this functionality, the latest evolution is a service aware GGSN (or saGGSN)which may provide a single access point for the user connection while at the same time, giving several access points to serve the operator and third party services. Using this system, the GGSN can detect and analyse both the traffic and content for a simplified user experience - one-click access to all different types of content and services available. It eliminates manually reconfiguring the handset and then reconnecting to access different services, such as picking up email or browsing Internet pages.

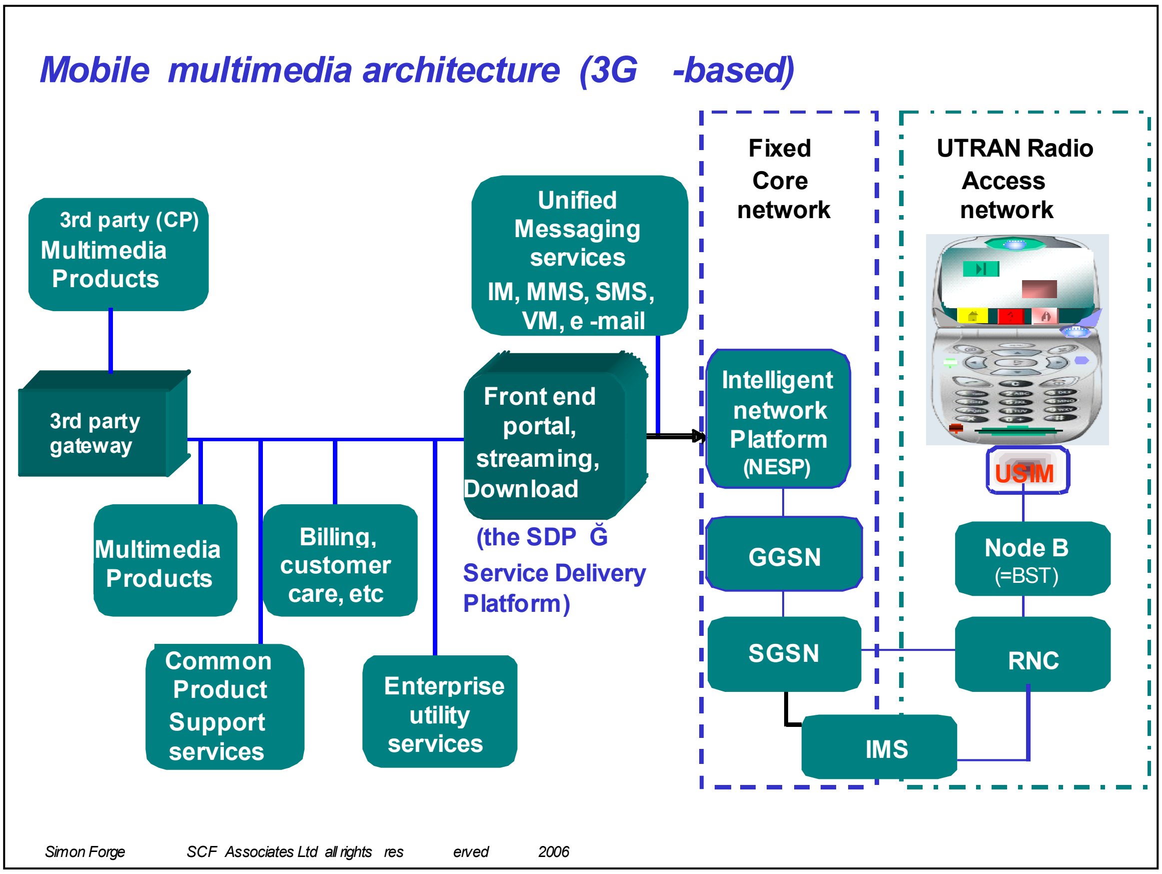
Here is the Nokia Networks solution for GSM/GPRS:

3G UMTS Architecture (3GPP standards group)



Source: Nokia

SDP – service delivery platform



4. Model Building – Micro Business Model

Draft Contribution by

Erik Bohlin, Visiting Researcher, SCF Associates
Permanent affiliation: Chalmers University of Technology, Göteborg, Sweden

Contact: erik.bohlin@chalmers.se
Tel: +46-31-772-1205

Revised version 14 November, 2006

This paper extends and elaborates upon findings presented in the DG JRC-IPTS project Future Mobile Services (http://fms.jrc.es), coordinated by SCF Associates

The usual disclaimer apply - this contribution is of the authors, and does not necessarily reflect the view of the European Commission.

1 Introduction

1.1 Background

Our objective in task 3 is to assess the impacts of the spectrum regulation directives on the economy and the telecommunications environment (its industry and market) by using a model of development based on the parameters selected previously, with multiple scenarios. Our modeling approach consists of:

1 Scenario building

Scenarios will be constructed as outlined in our proposal using the SCF approach of a key theme and initial key drivers, with known initial conditions to yield the assumptions, assertions, leverage points, hypotheses, points of doubt and inaccuracy and finally the scenarios.

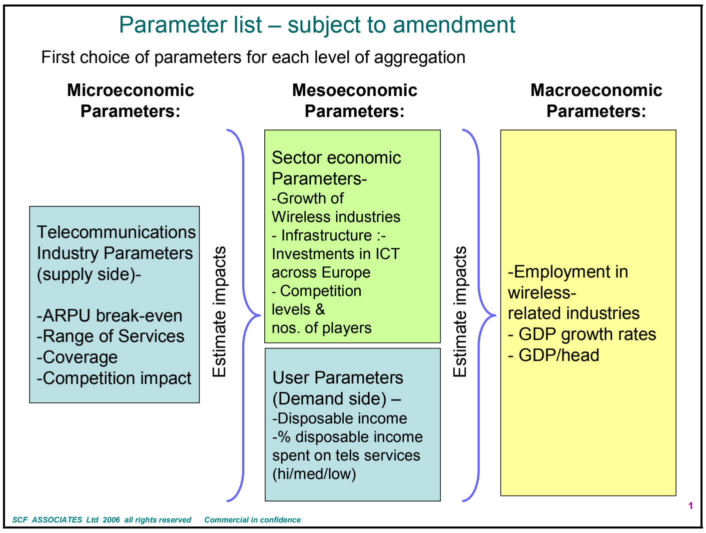
2 Constructing the model

The model is constructed using the Impact Trees approach wherever possible to give the links for a composite structure of dependence, with the three levels of scale. This requires building the model as a set of dependent variables, following the Impact Tree, to which the start data can be applied, then modulated by the scenarios

3 Applying the data and exercising the model

The data gathered to give the status quo acts as a start point. Projection by scenario of the data can then be applied to the parameters. From the scenarios' influence on the key parameters at each stage of the model we can see the outcomes, finally at the macro-economic level.

In this paper, there will be a more limited approach related to business modeling, and the micro economic impact of the scenarios on the financial viability of a future, IMT-Advanced, mobile network. The model will focus on the micro-economic parameters in the figure below.



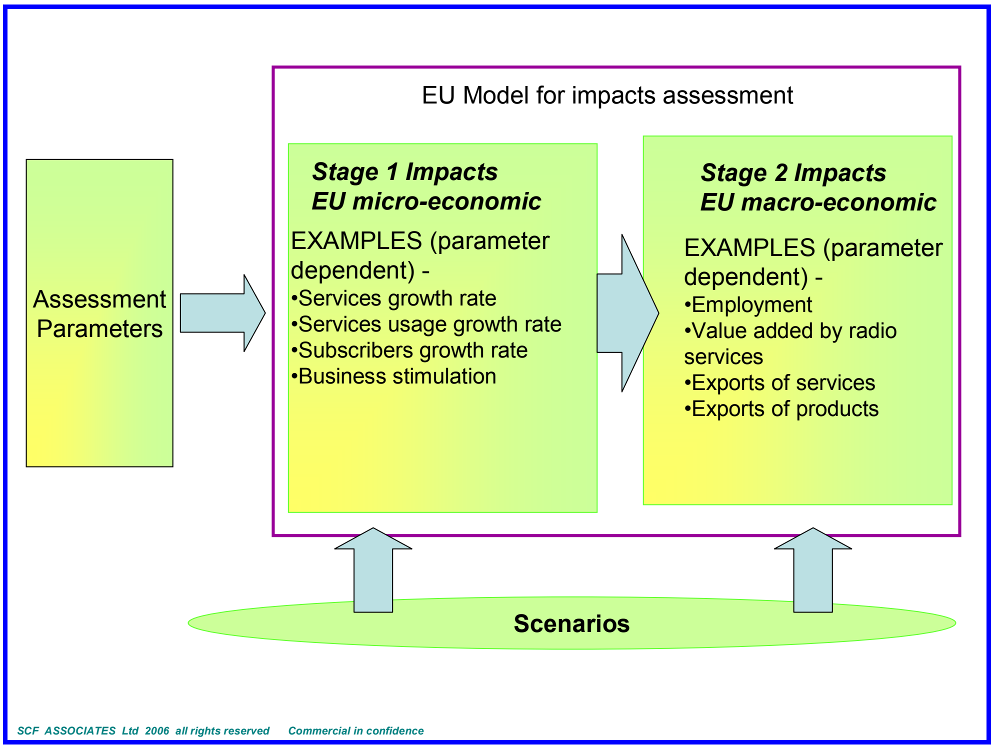
The proposed model will evaluate through a financial assessment various impacts of the scenario-based spectrum regimes. The model will focus on in particular:

- impacts on the internal market
- impacts on market structure and number of players
- investment impacts
- impact on market growth trajectories
- impact on break even levels for prospective operators

The model will be of a cross impact type with possibility of sensitivity analysis. The main data will be costs relating to infrastructure investment, demand, and new services. The model will build on previous work developed in related EC-funded projects, in particular model the financial impacts of new, advanced mobile technologies.[33] Specifically, the model will encapsulate how different spectrum regimes impact the viability and financial bottom-line of prospective operators, and how the different spectrum regimes contribute to indirect effects on selected macro-oriented variables.

The model will contribute towards an macro-oriented assessment of the impacts of the spectrum scenarios on the economy and the telecommunications environment (its industry and market) by using a model of development based on the parameters selected previously, with multiple scenarios.

[33] In particular the Future Mobile Services/FMS and SPORTVIEWS projects (see http://fms.jrc.es and www.sportviews.org).



At this stage we would envisage that the scenarios that the model will take into account would be:

1. Licence-free and free spectrum trading at low prices - with technology, network and service neutrality

2. Diverse positions across Europe by Member State – gaps and centres of different policies as member states do not have a unified policy

3. Free spectrum trading at low prices – with technology, network and service neutrality

The three scenarios will impact the financials of a prospective operator in different ways. A critical contribution is to provide financial metrics on the different spectrum regimes, and to model the impact of the scenarios on the financial viability of an operator (including growth, investments and break-even).

Based on the above, the paper aims to contribute in the following respects:

- investigation of the financial viability of new radio technologies according to three spectrum allocation scenarios
- identification of critical aspects and pitfalls relating to the financial viability of the business model, taking into account technology adoption and regulation frameworks
- exploring consequences on financial metrics and spectrum management
- clarify the conditions for spectrum optimisation from an economic and business perspective

In particular, the paper will address

- an IMT-Advanced network structure containing SDR, relay antenna structure, hopping capabilities, universal access points.
- a financial evaluation of this network structure with appropriate assumptions, allowing for a complete financial evaluation of a national IMT-Advanced system

- various sensitivity analyses of this model, which include a view on market structure and competition, various growth projections, CAPEX and OPEX, cost of licenses.

The paper is structured as follows:

- A brief overview of the IMT-Advanced concept and related technologies
- Approach and methodology of the business model
- Results and sensitivity analysis

2. What is IMT-Advanced[34]?

2.1 A simple network structure

Building on our modeling experience, the following basic characteristics for IMT-Advanced are important:

- Increased data usage
- Multi technology usage
- Decreased cell sizes
- Introduction of ad-hoc (mesh) network capabilities
- Increased bit rates
- Increased importance of software (e.g. SDR)

A simplified IMT-Advanced network to be analyzed in the simulation is depicted in Figure 1 below.

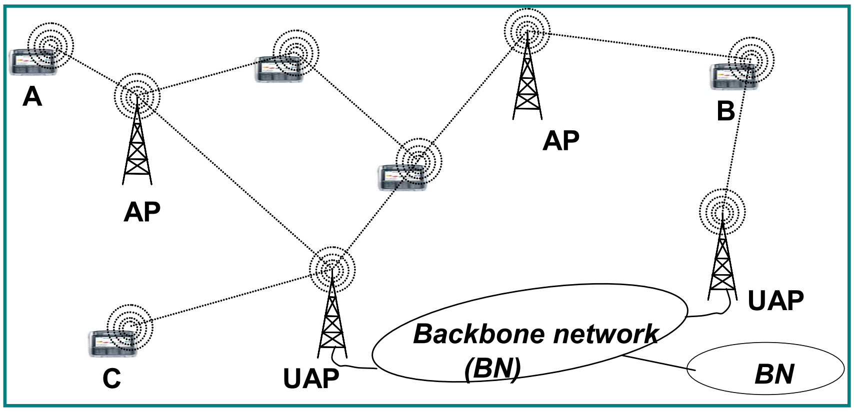


Figure 1: Simplified and schematic description of an IMT-Advanced network

In this simplified network, three main communication components have been introduced: UAPs, APs and SDR capable handsets:

- UAPs (Universal Access Points) function as ordinary base stations with backhaul connections
- APs (Access Points) function as repeaters and signal amplifiers, relaying radio signals to allow extensions of hops.
- SDR (Software Defined Radio) is a technology to increase flexibility of frequency use. SDR allows for more intelligence in the transceiver unit, enabling a function to switch frequency utilisation as required to reduce cost or avoid congestions

The major difference from an existing mobile 2G/3G communications network is the ad-hoc mesh capabilities. In Figure 1, all three communication components are thought to have mesh capabilities,

---

[34] IMT comes from the ITU nomenclature IMT-2000 (International Mobile Telecommunications 2000), also known as UMTS (Universal Mobile Telephony System) or 3G (Third Generation) mobile. IMT-Advanced is the next mobile generation, defined at the last ITU-R WP 8F meeting in Denver (August, 2006) with a process for development of IMT-Advanced, beyond IMT-2000.

while only UAPs are connected to a backhaul network. Therefore, multihop paths between SDR handsets, APs and UAPs are believed to be possible, and redundant paths are often available.

Ad hoc mesh connections, creating multi-hop paths enhance the cost efficiency of IMT-Advanced over previous generations as less need to be spent on:

- 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. 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 here viewed as a possible development track in the next generation of mobile communications solutions.[35]

Recently, the last ITU-R WP 8F meeting in Denver (August, 2006) produced the agreed text of a Draft New Resolution on the Principles for the process toward the development of IMT-Advanced. The objectives of achieving harmonization are recalled as the basis of global operation and economy of scale, and therefore, key factors of success. The new report of ITU-R (Radio Aspects for the Terrestrial Component of IMT-2000 and Systems Beyond IMT-2000) presents some views expressed by manufacturers and operators on the future specifications of IMT-Advanced systems:[36]

- It is predicted that potential new radio interface(s) will need to support data rates of up to approximately 100 Mbit/s for high mobility such as mobile access and up to approximately 1 Gbit/s for low mobility such as nomadic/local wireless access.
- Carrier bandwidth: 20 MHz up to 100 MHz.
- Spectral efficiency: 2 to 10 bit/s/Hz/cell (respectively for mobile profile and fixed nomadic).
- Support of multicast.
- Spatial multiplexing using MIMO systems.

In the on-going evolution towards IMT-Advanced, it is likely that a number of different debates will take place, and that the actual technology deployment can take different forms than envisaged in the business model below. Here we mention two such considerations:

- Decreased cell sizes: It is expected various profiles of IMT-Advanced systems will be developed for addressing various services (data rates) and spectrum bands. It may be envisaged that some profiles, for instance for supporting high data rates will offer lower cell sizes than those encountered currently with IMT-2000 Systems. It seems likely that many operators will certainly continue deploying macro IMT-advanced base stations for coverage issues and cost effectiveness.
- Multi technology usage: as the IMT-Advanced systems will offer Spectrum Flexibility usage (FSU) capability that could encompass SDR technology, it is possible that operators will focus on deploying only IMT-Advanced systems and will avoid to deploy a set of different technologies more or less compatible. The IMT-Advanced will offer a sufficient level of

[35] However, in contrast to the Internet, the mobile context may have adverse incentives. Owners of mobile devices might have an incentive to "free ride" and not to provide relay functions (being a relay has no immediate benefit and drains battery life). On the other hand, new community groups, new markets and pricing schemes may evolve to compensate for such incentives.
[36] Personal communication to the author by a leading mobile communications carrier.

flexibility in order to be able to address many services through different environments and will be dynamically reconfigurable in order to take into account user's profile.

These evolutions may have effects on the future capital investments in mobile networks. For instance, decreasing the number of technologies may enable the operator to optimize the investments. Moreover, the implementation of macro IMT-advanced base stations may also impact investments, as will be shown below.

3 Business Models

3.1 Approach and methodology

There are several types of approaches in discussing and developing business models. One approach is schematic and reasoning, while other approaches seek to address the famous 'bottom-line' by including financial assessments. The latter approach in order to be workable must be quite specific in terms of assumptions and relationships between factors involved. Moreover, the financial assessments often include several simplifications, both in terms of cost and revenue drivers but also in terms of causal structures. It is possible to construct a financial assessment with a high degree of complexity but such a model may loose its usefulness the transparency of the model is limited. A too complex model may 'hide the forest because of too many trees'.

In this contribution, the more specific framework has been chosen. The business model used in this report does not aspire to provide the definitive view of costs and revenues for the future mobile system. The aim is rather to present a viewpoint to enable an open discussion about viability of IMT-Advanced network investment to make economic sense. 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, and each of these aspects will need to be carefully reviewed. The business simulation is limited by the well-known GIGO-principle (garbage in, garbage out). Below, critical assumption of the model will be discussed.

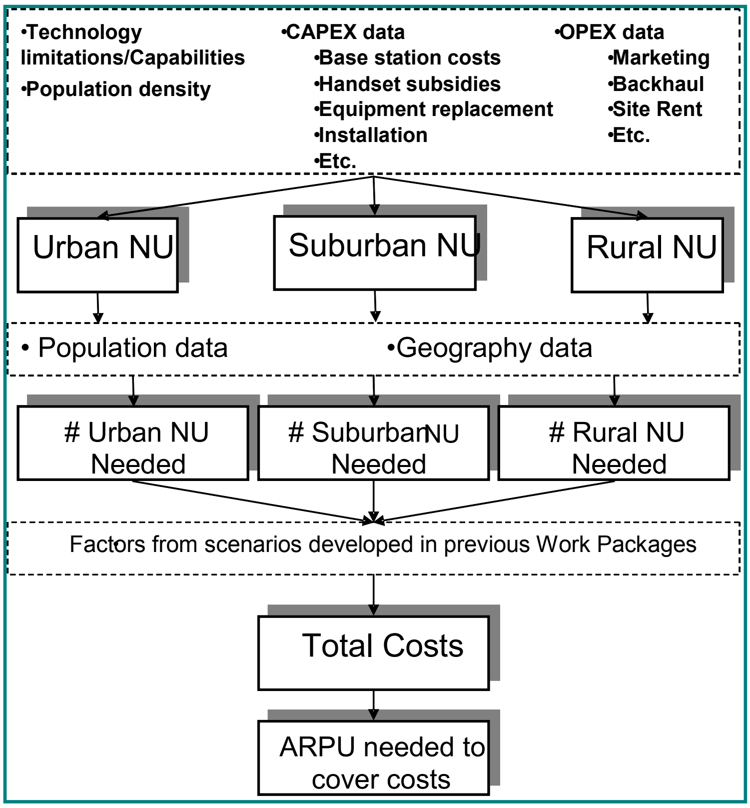


Figure 2: Model characteristics - Schematic overview

Schematically, the business model has been structured according to the model presented in Figure 2. As Figure 2 shows, a number of steps should be fulfilled in order to generate useful results from financial simulations. Firstly, proper definitions of the technological world should be established, including a basic notion of the network structure to be implemented. A simplified network has already been presented in Figure 1 above. Secondly, cost elements of future technologies and components should be analytically estimated. Thirdly, estimations of revenue levels, far off in the future, should be made. And, finally, a geographically defined market, virtual or real, should be constructed. All these elements will be discussed in more detail below.

3.2 Assumptions on spectrum availability and allocation

As a first approximation, it is assumed that spectrum will be available so that the envisaged IMT-Advanced system can be built. For the purposes of this model, the basic condition of spectrum availability is fulfilled – otherwise the network operator would not go ahead because the system would be infeasible from the outset. As a further first approximation, the spectrum is allocated to the prospective operator without any direct license payment. Rather, the operator has fulfilled an implicit beauty contest.[37]

3.3 Assumptions on growth, uptake speed and timing

An important starting point of the business model is a perspective on market growth and uptake. In the following, the three spectrum allocation scenarios are hypothesized to contribute to three different growth uptakes in the wireless markets, and additionally to the general economic environment:

- Licence free and free trading, conferring high IMT-Advanced uptake (Scenario 1, 90% maximum diffusion)

[37] A later section provides some impact analysis of a range of license fees. The rather quick network roll-out scheme can be viewed as part of the implicit beauty contest. The sensitivity analysis provides also alternative roll-out schemes, as a way to model more relaxed beauty conditions.

- Diverse licence conditions, conferring low IMT-Advanced uptake (Scenario 2, 50% maximum diffusion)
- Free spectrum trading, conferring medium IMT-Advanced uptake (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), corresponding to their respective level of optimism and growth. These starting years represent a hypothetical start of the IMT-Advanced system. Without losing the generality of the model, the dates can be moved forward, if it is concluded that a later implementation of the respective scenarios is more likely. See Figure 3 for an overview how these assumptions play out, using a common base line.

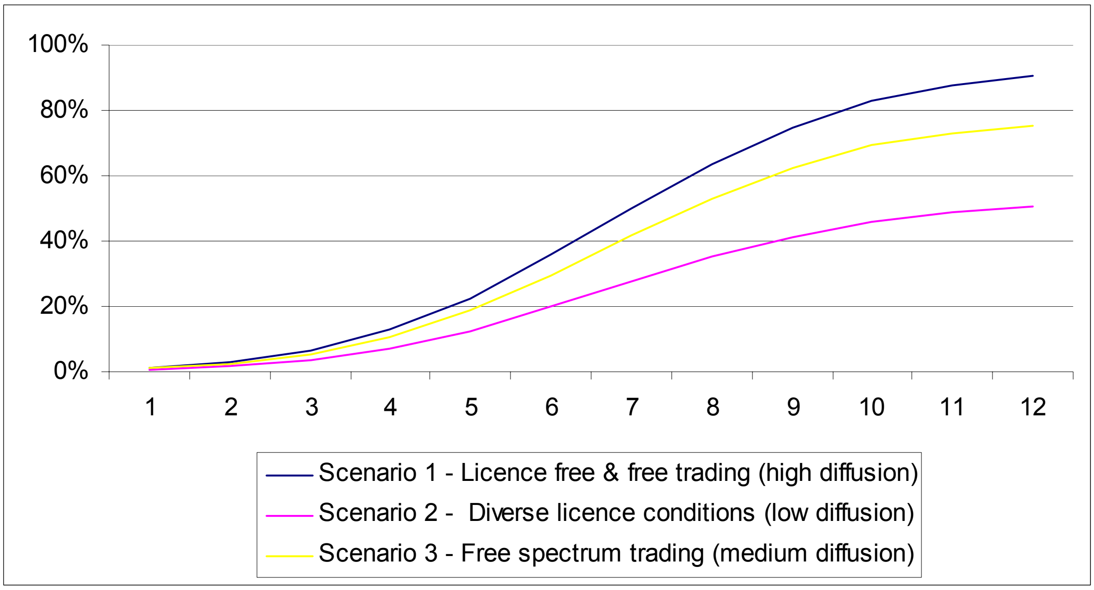


Figure 3: Scenario assumptions of diffusion rate in the financial simulations

3.4 Geographical scope of simulation

Without a geographically defined market to simulate, virtual or real, the financial simulation will not be concrete. 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 is useful as a benchmark. 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 here are based on the latter solution. In order to simulate the financials for covering a country with IMT-Advanced network reach, a fictive geographical area, Eurolandia, has been created for the financial simulations of an IMT-Advanced network. This country is entirely fictive and only used as first possible approximation of a possible country. The population has been assumed to be 46.4 million, the average of a number European countries (France, Germany, Italy, Netherlands, Spain, Sweden & UK populations) – see Table 1 for more data.

Table 1: Network coverage in selected countries

Country	Area (km2) (50% of pop.)	% of total area	50% of pop. (m)	Area (km2)/m pop.
Eurolandia	*63561.1*	*17.6*	*23.2*	*2330.6*
UK	13526	5.6	29.8	454
Netherlands	11148	26.8	8.3	1343
Germany	90002	25.2	42	2143
Italy	64143	21.3	28.1	2283
Spain	60817	12	20.6	2952
France	95852	17.6	29.3	3271
Sweden	43474	9.9	4.5	9661

Source: Based on Björkdahl (2003)

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 2 below.

Table 2: Assumed share of population by area (urban, suburban & rural)

Area	Share of population	# of people
Urban areas:	50%	(23 200 000)
Suburban areas:	35%	(16 240 000)
Rural areas:	15%	(6 960 000)

Urban areas are estimated to have around 6000 inhabitants per km^2, 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 in order to encompass a complete range of possibilities. 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 km^2. Relatively sparsely populated countries as Sweden and Estonia have been used as models for rural areas, estimated to approx. 30 inhabitants per km^2 (see Table 3).

Table 3: Population density in selected countries

	Population	Land area (km2)	Population/ km2
Urban			**6 000**
Singapore	*4 353 893*	*683*	*6 377*
Hong Kong	*6 855 125*	*1 042*	*6 579*
Suburban			**500**
The Netherlands	*16 318 199*	*33 883*	*482*
Rural			**30**
Estonia	*1 341 664*	*43 211*	*31*
Sweden	*8 986 400*	*410 934*	*22*

3.5 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.

The analytical approach used in this business model simulation will be to divide network investments into three groups: 1) urban, 2) suburban, and 3) rural (see Figure 4). By using proxies for number of subscribers handled in each class, the average base station reach, and technology types and costs etc., a kind of "network units" can be created. These network units are then used for a given geographical area, e.g. a region or country, to calculate total investment costs. In the model, only two network radio components, UAPs and APs, have been used for reasons of simplicity. In reality, it could be expected that a number of different technologies, with different reach and bit rates, will be used.

By spreading the network units over a geographical map containing information about populations in different regions, network investments are calculated. Although this model may seem simple at a first glance, complexities are involved in calculating the investment cost element. This element contains estimations about e.g. which technologies will be used, to what extent mesh networking between users' handsets will take place (making it difficult for operators to charge for), and what the installation and civil work costs for each base station will be.

Considering the difficulties associated with calculating the effect of mesh networking on investment levels, and the differences in network architecture needed between rural and urban areas due to use of different technologies, the model tries to divide the network investments into units where the network design and usage will be similar. This way of making generalized assumptions that e.g. all rural areas will have the similar network characteristics and investment costs is of course overly simple. However, it makes the model relatively independent from certain geography and can be used in any geographical area. With only minor adjustments, the model can be used to approximate network investments costs for e.g. any European national network by placing network units like a puzzle over the geography until the whole area is covered.

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 IMT-Advanced business case would probably be impossible if the same technologies are used as in the urban areas. Here is a strong case for using macro-type IMT Advanced base stations (UAPs).

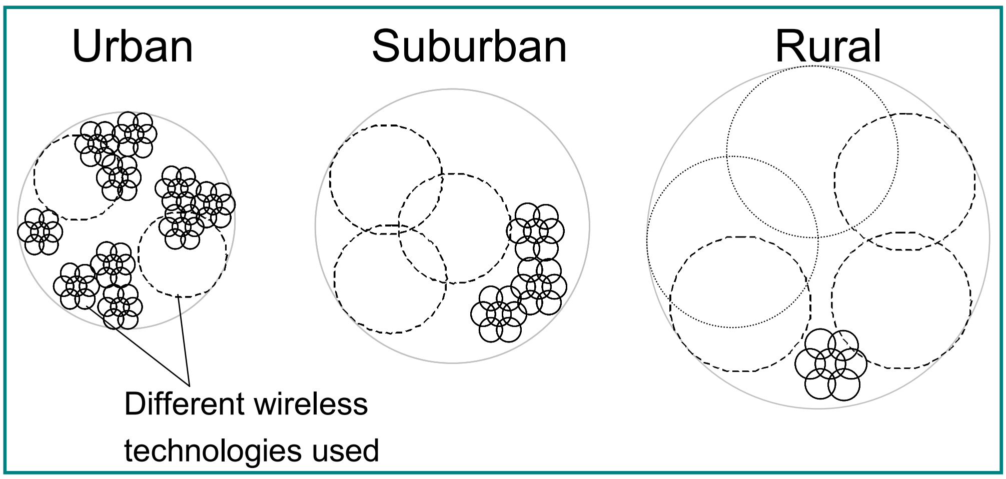


Figure 4: Network unit descriptions

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 4.

Table 4: Network unit characteristics – number of subscribers served

Area type	# Subs./ km2	# Subs./ Network unit	Average area reach (km2)	Network unit Radius (km2)
Urban	6 000	100 000	17	2
Suburban	500	50 000	100	6
Rural	30	25 000	833	16

Note: Rounding errors appear the last column.

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 the average area reach in the different network units. The total number of APs and UAPs needed is presented in Table 5.

Table 5: Network unit characteristics – number of network component needed

Component	# needed		
	Urban	**Suburban**	**Rural**
UAPs	16	96	800
APs	40	240	2000
SDR Handsets (add. inv.)	100 000	50 000	25 000

Source: SCF Associates Ltd.

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.

3.6 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 base line (years 0 to 11). Thus the images shown below are based on the base-line 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, and we provide here an average estimate for the different kinds of equipment possible for AP. and UAPs.

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 5 and 6, 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. In a section below, various aspects of these cost estimates will be reassessed based on a sensitivity analysis. [38]

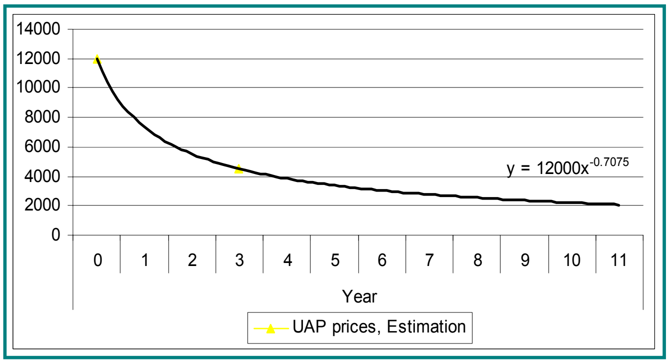


Figure 5: Price for Universal Access Points (UAPs estimates in euros)

Source: SCF Associates Ltd.

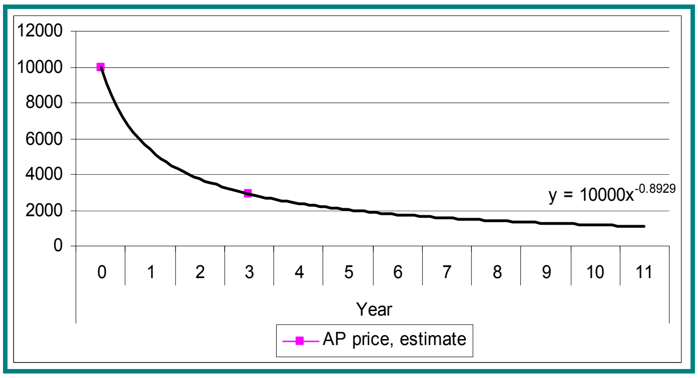


Figure 6: Price for Access Points (APs, estimates in euros)

Source: SCF Associates Ltd.

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 of160€ (in year 0) (see Figure 7). In the model, the

[38] Note that this equipment cost estimate does not include site building costs. It rather assumed that sites can be rented at a market rate, by using available 3G and 2G sites. The new technology is expected to use far less space for sites, and hence there is the possibility that the 2G/3G networks can share sites due to reduced space requirements. In particular, the APs will be very small and compact, and enable new, innovative and cheap site locations (house walls, public lamp posts, etc.) The site rentals are available in the OPEX data below. Below, find also a sensitivity analysis that includes site construction up to 25% of all the UAPs and APs.

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.

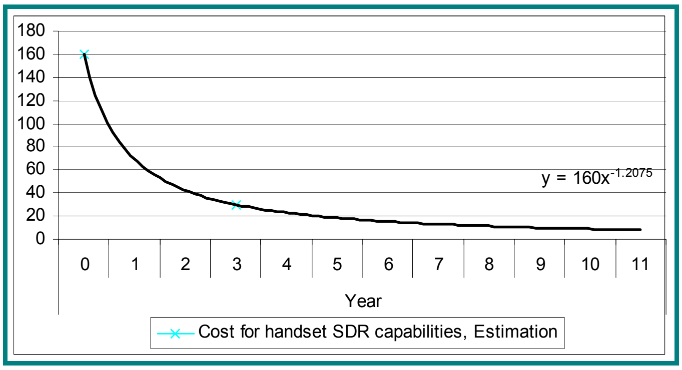


Figure 7: Added price for Software Defined Radio capabilities (in euros, estimates)

Source: SCF Associates Ltd.

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 3G subscribers in 2005 (Economist, 2005).

3.7 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 modeled 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 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.[39]

[39] 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€)

Administrative costs

The administrative costs have been estimated as an addition of 10% on other operational costs.[40]

3.8 Minimum 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

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

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

4 Results

4.1 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 Figures 8-10. The early years are dominated by CAPEX for UAPs and APs. In the middle of the period, the cost relating to SDR handsets CAPEX is most significant (recall that the operator subsidizes each SDR handset with 160€). 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 11. The total CAPEX is naturally highest in Scenario 1 and lowest in Scenario 2 due to the total diffusion levels.

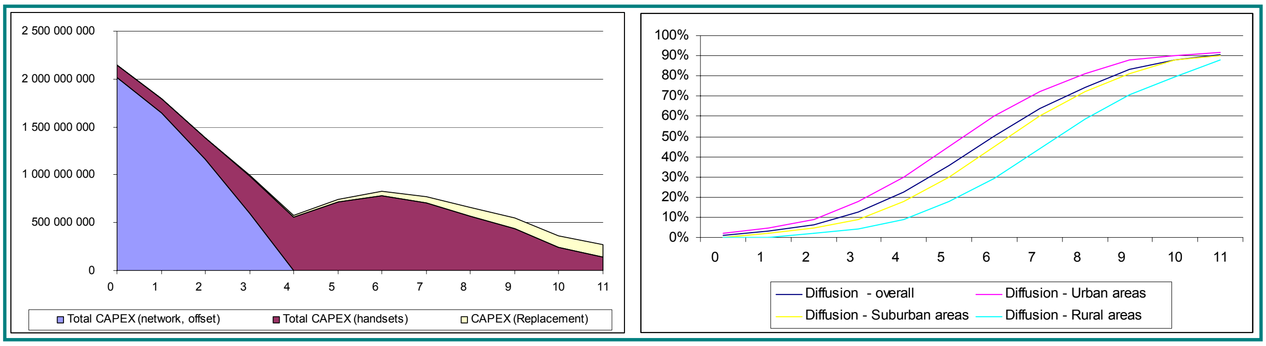


Figure 8: CAPEX and diffusion developments in Scenario 1

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 becomes 7.4/4 = 1.85 € / person / operator.

[40] 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).

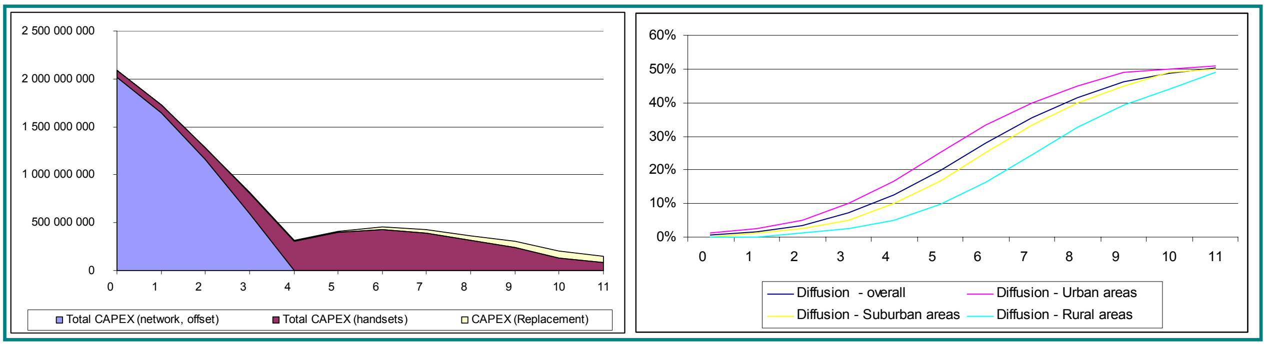


Figure 9: CAPEX and diffusion developments in Scenario 2

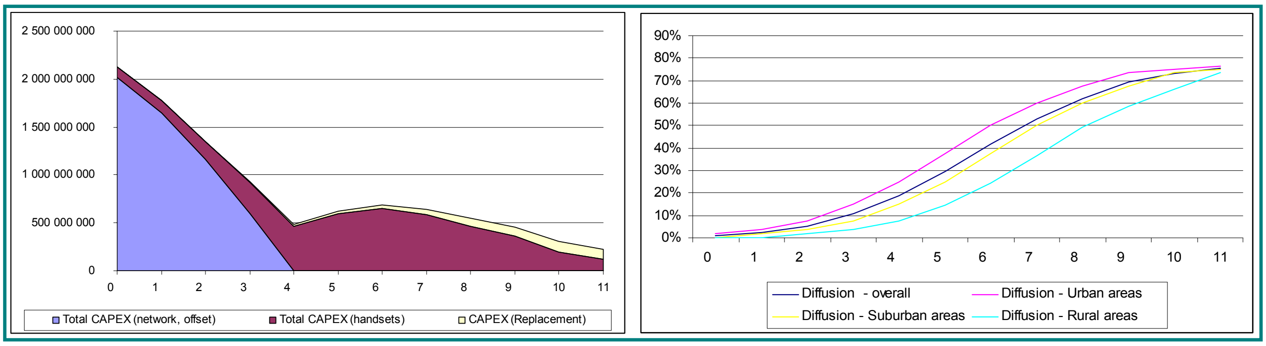


Figure 10: CAPEX and diffusion developments in Scenario 3

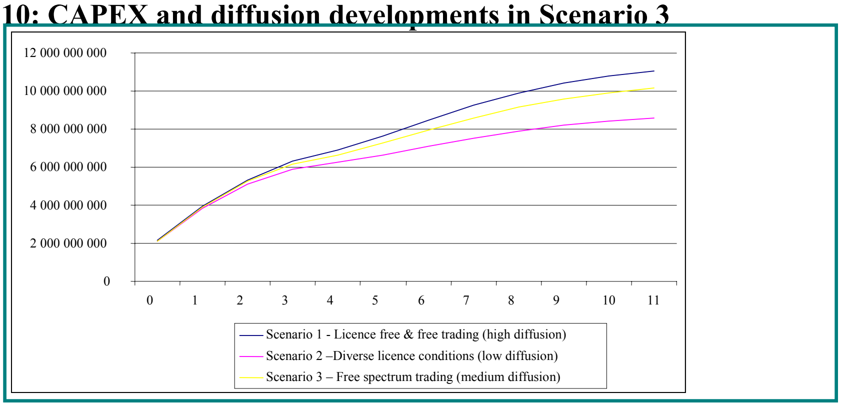


Figure 11: Accumulated CAPEX

4.2 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 12a-12b below. 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.

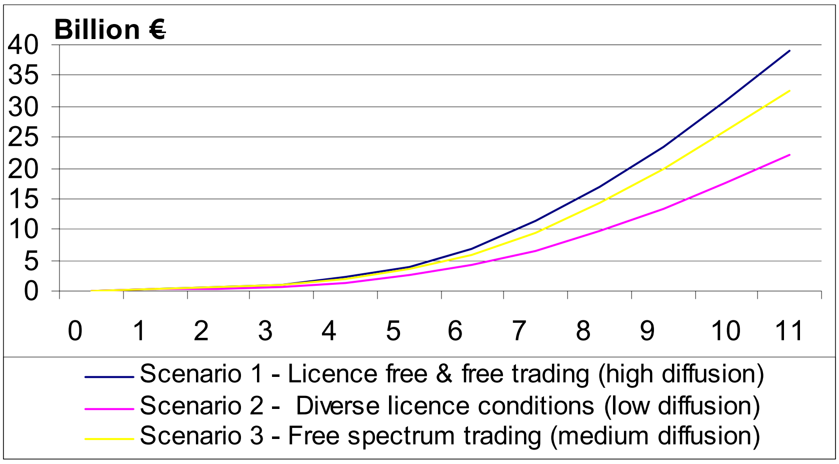


Figure 12a: Accumulated OPEX for each scenario

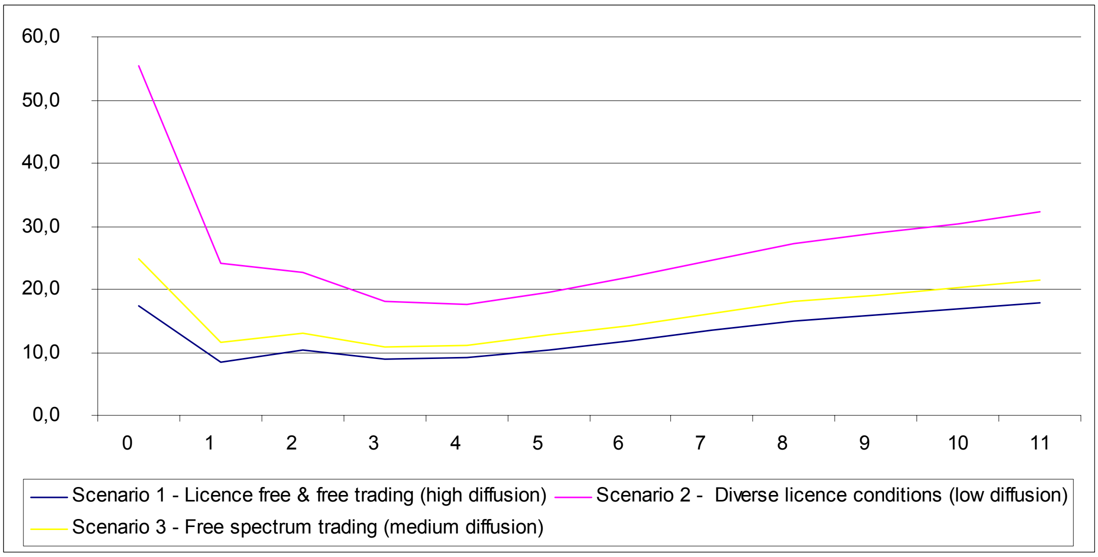


Figure 12b: Monthly OPEX in each scenario

4.3 Minimum 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 an IMT-Advanced network vary between 15 and 19 € according to our simulations (see Figure 13). More exactly, the obtained results for each Scenario are:

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

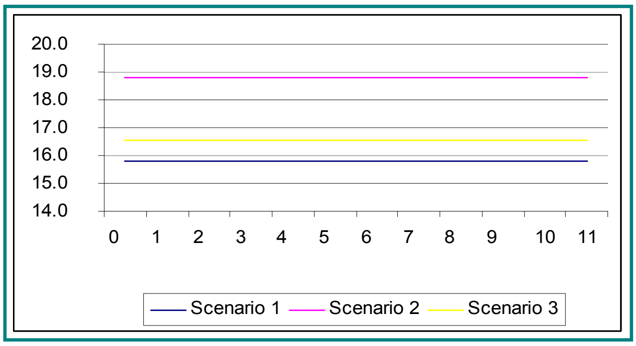


Figure 13: ARPU levels needed in different scenarios

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 2006 (Euroswap, 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.

4.4 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 14, 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.

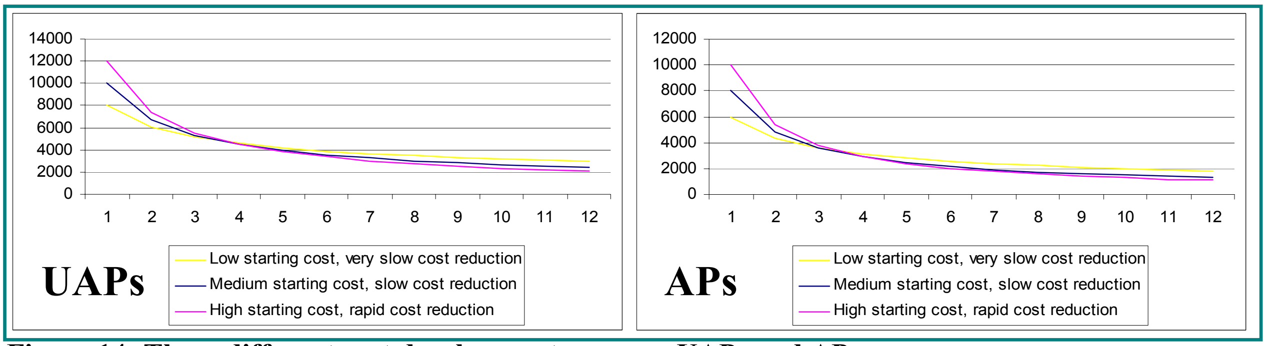


Figure 14: Three different cost development curves – UAPs and APs

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 15.

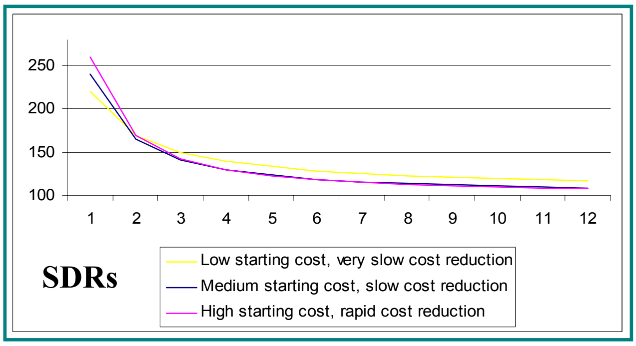


Figure 15: Three different cost development curves – SDR capability for handsets

The impact of the changed cost development curves on the ARPU levels needed is not very high, as indicated in Figure 16. 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.

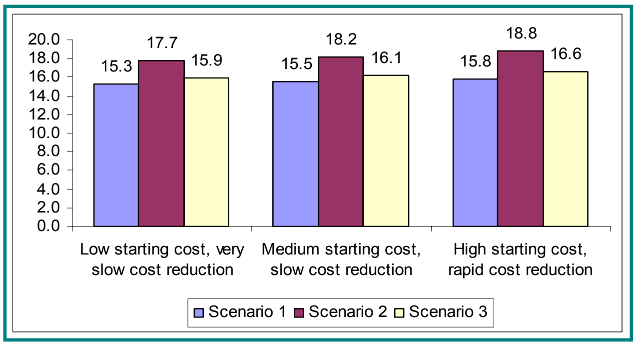


Figure 16: Equipment cost development impact on ARPU levels needed

It would be of interest to further elaborate the equipment cost estimates for APs and UAPs, and if possible, corroborated with available cost estimates for comparable functionality in 3G and other mobile networks. There are some difficulties however in obtaining estimates of relay antennas (e.g. APs) because such are not much used at present.[41]

Further cost impacts: site rentals and site construction costs, roll out speed and replacement cycle

The CAPEX cost estimates above do not include site construction costs. Instead, the assumption has been that that site space can be rented at available 2G and 3G networks at competitive market prices. (Even if there is only one national operator with integrated 2G and 3G networks, the site rentals will have to be competitively priced.) The estimates of site rentals have been included in the OPEX data above.

However, it is desirable to further elaborate impacts of site costs in the model, and to more precisely develop both simple and relevant metrics. The IMT-Advanced technology is expected to use far less space for sites, and hence it has been assumed that IMT-Advanced and 2G/3G networks can share sites due to reduced space requirements. Moreover, for many APs, the site costs can be assumed to be

[41] Another aspect which is of interest is the viability of the proposed network structure, and in particular the engineering of network coverage as suggested in Table 4-5. There is an implicit assumption that the suggested network structure provides sufficient performance in terms of data speed and coverage, and that suitable frequencies are available. These are rather brave engineering assumptions, based on discussions with engineers and network planners. However, it is of interest to elaborate further on the viability and performance of the proposed network structure, and the relationship of the network structure to available frequencies. However, given that these technologies are still in a fluid development phase, there are limits to the publicly available information, and this deliverable has not found contradictory information to the assumptions used in the model.

quite low since will be very small and compact, and enable new, innovative and cheap site locations (house walls, public lamp posts, etc.)

To address the impact of site rentals, we have made a simple calculation on the impact of double, tripe and quadruple rentals, compared with the base case (see Section 3.5 for base case.) Figure 17 shows ARPU levels for site rentals varying from the base case up to four times that assumed cost. Higher site rentals lead to slightly higher ARPU.

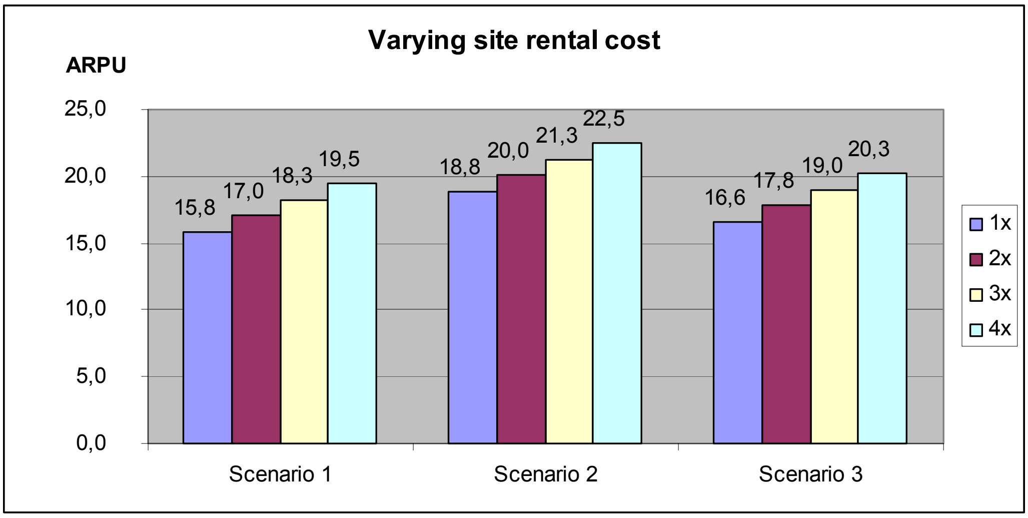


Figure 17: Change in ARPU depending on site rental cost

Apart from site rentals, some operators may lack access to old sites suitable for IMT-Advanced. Therefore, the model should address the cost impact of constructing and acquiring new sites. The construction cost including for example building permits for an UAP site is estimated to be in the same range as a 3G site (100 000 euro) and an AP about 10% of an UAP, thus 10 000 euro. With the assumption that 25% of the sites are new, there is a considerable impact on ARPU levels.

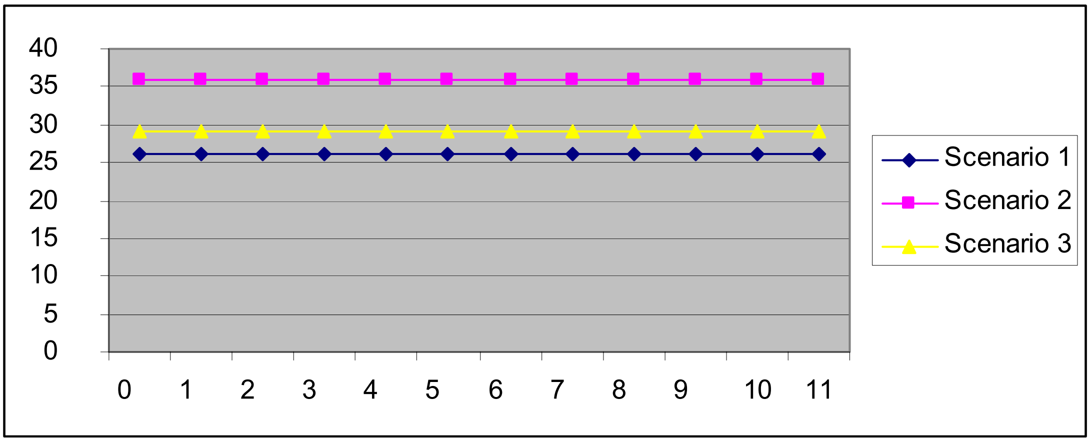


Figure 18: ARPU levels needed with 25% UAP and AP new site acquisition

A further elaboration is the speed of roll-out. In the base case, the roll-out time for completing the network is four years. (One could assume that this roll-out time has been derived from a beauty contest since there are no other spectrum management obligation. .In Figure 19, the ARPU impact of 2, 4 and 6 years roll-out can be viewed.. ARPU needed for a 2 year roll-out is higher than 4 years, however it is only a small difference between 4 and 6 years. (Note also that longer roll-out time than 6 years cause Scenario 1 to have higher diffusion than network capacity during a time period.

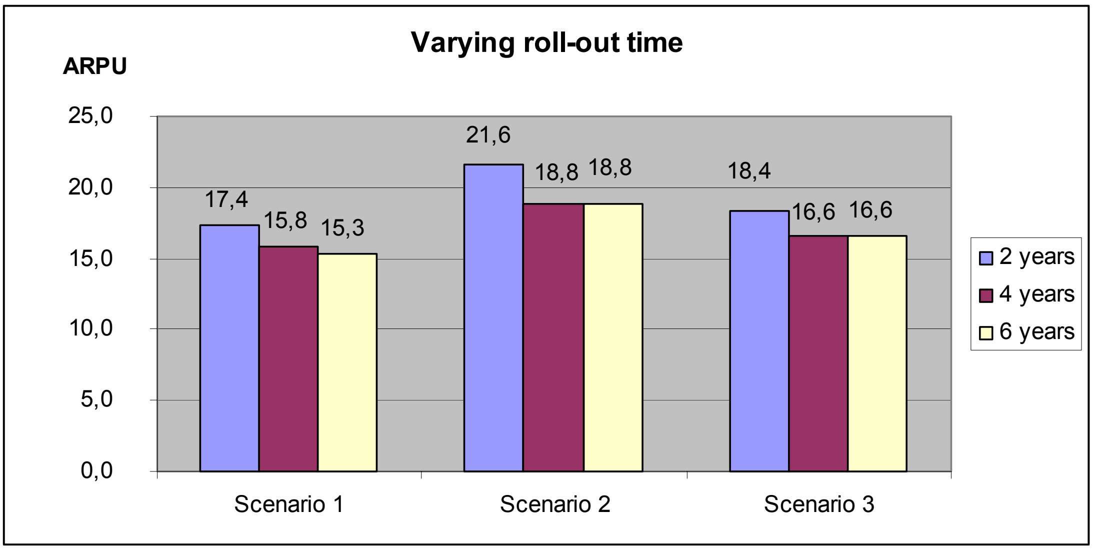


Figure 19: ARPU depending on roll-out time.

A further elaboration is to consider shorter investment renewal horizon, i.e. higher depreciation schemes. In Figure 20, the investment renewal time have been cut in half, from 10 years to 5 years, showing that such a change has a marginal effect on the final ARPU levels.

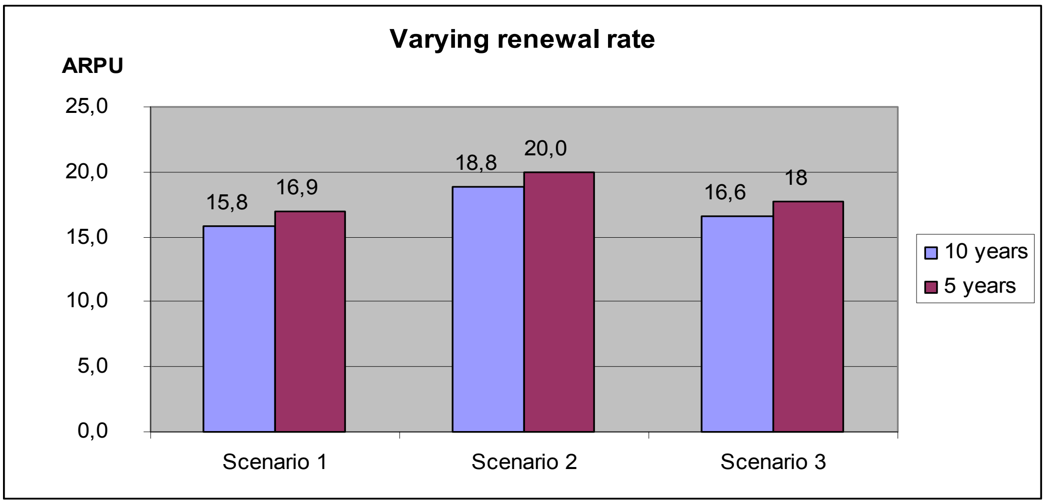


Figure 20: Varying reinvestment horizon

Modelling competition

The model thus far has assumed that a prospective mobile operator builds a nation-wide network but does not face direct competition. The impact of competition on prices is straightforward: competitive prices tend to align with costs. The impact of competition on costs, however, is difficult to model. The industry as a whole incurs extra costs due to network duplication by competing operators. But according the rational of market liberalization, those extra costs are offset by the innovative dynamics provoked by 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 moreover consider competitive impacts from various substituting networks, have a view on pricing strategies, consumer demand and elasticities, 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 nation-wide 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 for each of the market growth scenarios. 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.[42] Figures 21-22 shows the ARPU impact of varying levels of competition on Scenario 2 and 3, showing a considerable impact on minimum ARPU when the market share is low.. (Note that the total market penetration in Scenario 2 and 3 corresponds to 50% and 75 % respectively.)

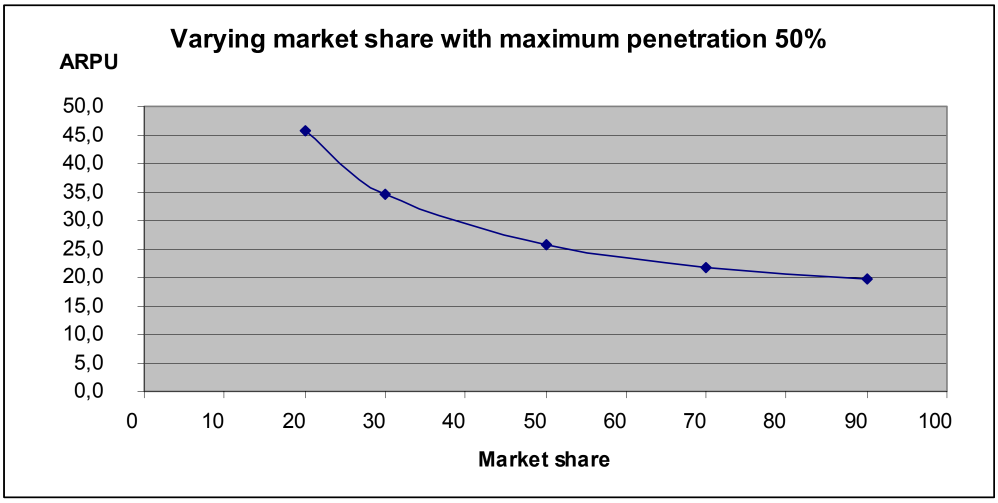


Figure 21: ARPU levels needed in scenario 2 as a function of competitive market share

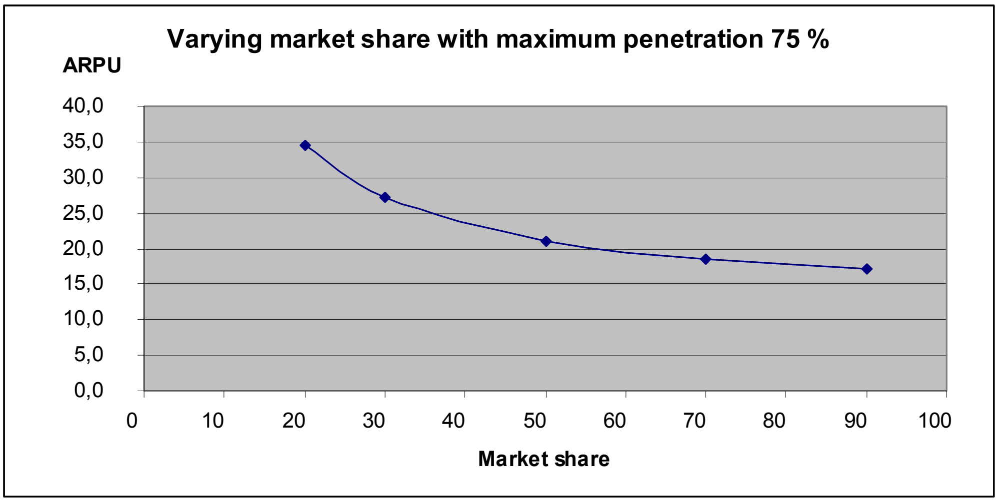


Figure 22: ARPU levels needed in scenario 3 as a function of competitive market share

[42] 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 on the break-even ARPU levels (cf. Figure 13 above) 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.

Network sharing between competitors

It is of interest to elaborate the impact of network sharing for competitors, as this is a regulatory instrument that reduces the need for investments in infrastructure.

Figure 23-25 simulates two competitors with network sharing. Here it is assumed that the competitors have two separate networks with varying degree of collaboration. Naturally, ARPU needed varies between the more successful competitor and the less successful. To illustrate this, the two competitors have respectively 60% and 40% share between the two of them. Also, the two competitors may have captured only part of the total market. Here, we show the impact of both players having combined 90%, 50% and 75% share of the total market share (corresponding to Scenarios 1-3). The figures suggest that the ARPU levels are considerably impacted by a low market share, even if there is a considerable network sharing.

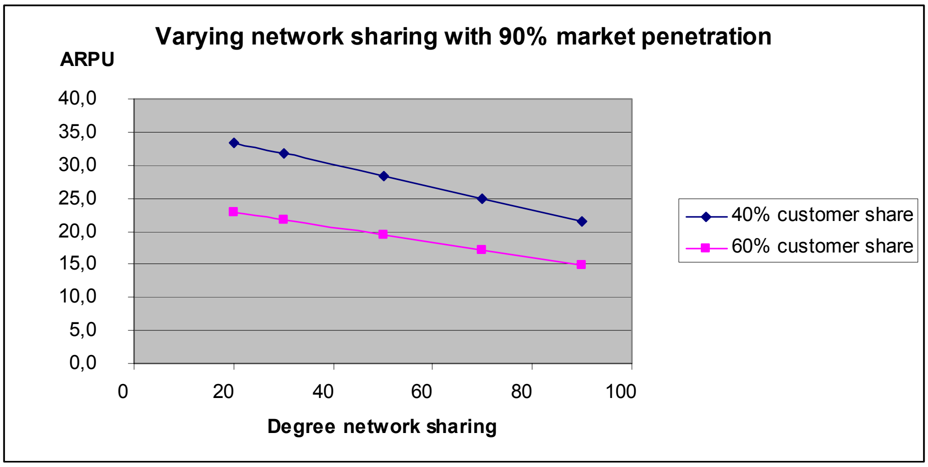


Figure 23: ARPU needed in scenario 1 with network sharing and two competitors.

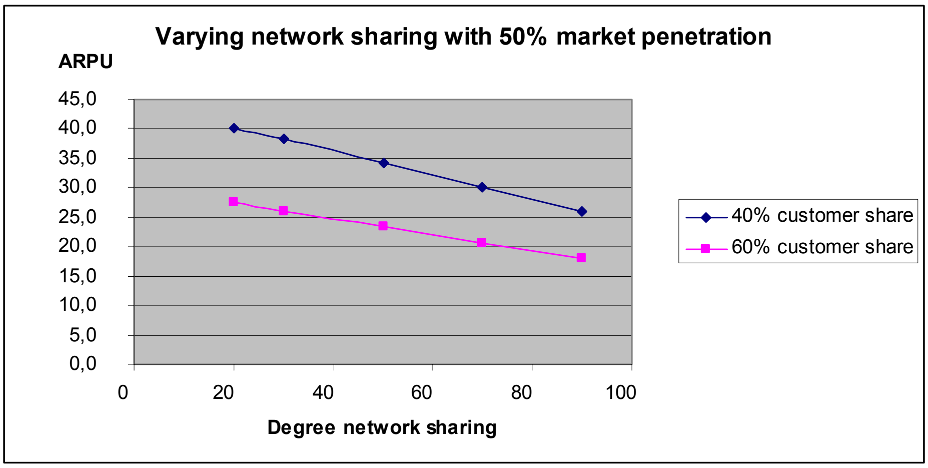


Figure 24 ARPU needed in scenario 2 with network sharing and two competitors.

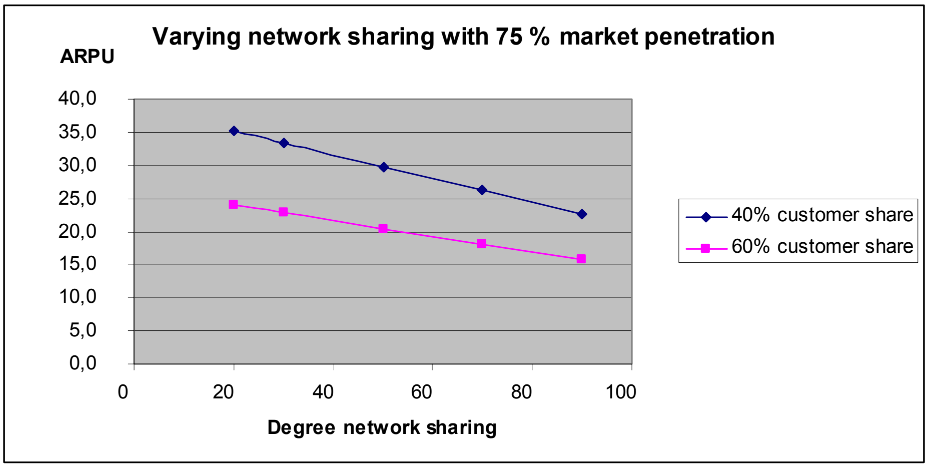


Figure 25: ARPU needed in scenario 3 with network sharing and two competitors.

Introduction of a license fee

The licence fees introduced in the 3G business cases in many countries through spectrum auctions heavily impacted the ARPU levels needed for break even. In order to evaluate the impact of spectrum cost in an IMT-Advanced setting, licence fees ranging from 652€ per capita to zero $ per capita have been added to the ARPU levels needed (Figure 26). (The 652€ per capita was the maximum paid in Europe for 3G licences, in UK, according to Liikanen, 2001.)

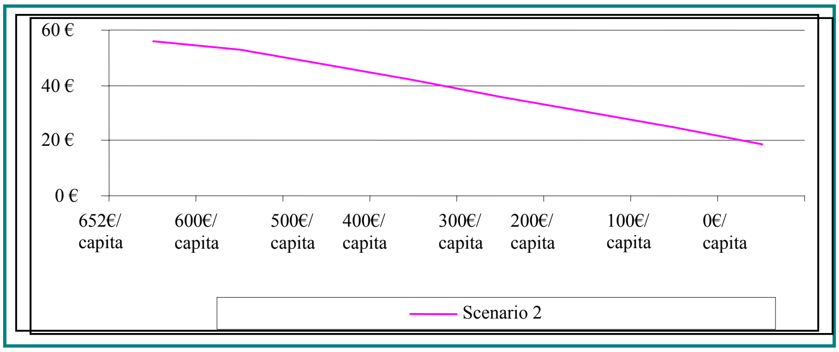


Figure 26: Licence fee impact on ARPU levels needed

Perhaps without any surprise, adding a licence fee has strong effects on ARPU levels needed to recoup investments and cover operational costs. The impact will depend on the total diffusion levels. Scenario 2 suggests that there will be considerable impact on ARPU levels. Overall, the maximum licence fee (652€/capita) raises the ARPU levels needed by 200% in scenario 2.

5 Conclusions

Our base case simulation indicates minimum ARPU levels of 15-19 € monthly will be needed for IMT-Advanced business cases to become viable, depending on the spectrum scenario.

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, site costs, competitive impacts and licence costs. Many more factors could be added, but this model provides a first comprehensive analysis of a future IMT-Advanced network.

The impact analyses regarding certain factors' impact on IMT-Advanced business cases indicate the following degree of importance for ARPU levels needed:

– Equipment cost development curves	Low
– Site rentals	Low
– Roll-out timing	Low
– Replacement cycle	Low
– The IMT-Advanced diffusion levels	Medium
– Site construction costs	Medium to high
– Competitive impacts	Medium to high

The business model provides a viability validation of the costs of the new technology and suggests that the new technologies could offer infrastructure cost advantages, and be a viable business proposition should demand be there. However, the required ARPU levels should be taken with the caveats that e.g. licence costs could intervene to make break-even ARPU cost much higher. In fact, the paper suggests that spectrum management may be the single most important factor for IMT-Advanced business viability (see Scenario 2 with 3G-type licence schemes).

Indeed, the UK and Germany 2000 auctions have been widely criticized as having delayed by years 3G deployment. It is shown in the present report that amounts similar to those reached in the UK and German cases increase the base case breakeven levels for IMT-Advancedby 100%. We should be careful, however, in drawing conclusions. It can also be said that the particular circumstances of these auctions, organized as market islands within a non-market context, has artificially increased the amounts paid. If more spectrum bands had been open to flexible use (technology and service), if trading had been possible, the market mechanisms themselves would have played a more moderate role. It has even been argued by Faulhaber and Farber (2002), that by reducing "artificial" scarcity, meaning scarcity induced by restrictive, non-flexible, management methods, market mechanisms could play a moderating role, or help to provide spectrum for free.

Results of the same nature (low spectrum costs contributing to the diffusion of innovative services) could be achieved by the implementation of the various categories of spectrum sharing management methods, like unlicensed bands or dynamic access technologies. The common result of these management methods is that they aim at providing for real time, potentially optimal and efficient, adjustments in spectrum use, conducive to lower costs.

Finally, considering that Scenario 2 can be expanded into several European countries of Eurolandia style, there is a potential for highly variable licence fees across several such countries, with a strong variable impact on profitability. In turn, such variable internal market landscape will have strong effects on competition and profitability. There will be several challenging effects.

In particular, one of the most challenging effects of such a scenario is the bad feeling between citizens in Member States that will emerge when the public in one country starts to recognize that its own licence bill in effect contributes to tax revenues in another country. This development can contribute to reluctance about European integration, since the costs of European integration come close to the individual mobile users, who arguably will be a sizable portion of many citizens in the respective countries. There are, as well, several multiple secondary effects of the auction schemes on employment and stock markets, where the costs and benefits will be skewed as mentioned above. These secondary effects may also impact the citizen's attitude towards European integration. This ramification of the scenario 2 may be the most costly for Europe over the long term.

Given the uneven cost conditions, due to varying fees in the respective countries, there will be an incentive to shift revenues from one country market to another country market. The size of the contribution from 'cheap countries' (with little or no license fee) will reflect a combination of imperfect competition and the existence of multinational mobile operators. The latter will have an interest in using excess profits from some countries in order to pay debt from the heavy auction burdens. The only way to remedy this kind of transfer will be an active competition policy which ensures that competition is strong in each country. Effective competition will then guarantee that there are no excess profits. With effective competition, pricing will vary within Europe according to the demographics, license fees and other characteristics in each country. However, a strong, consistent and comprehensive competition policy may come into conflict with other pan-European initiatives under way, such as policies to facilitate network sharing. This potential conflict will be played out over the years, since competition policy necessarily acts *ex post*.

References

Björkdahl, J., Bohlin, E., (2003), "Competition Policy and Scenarios for European 3G Markets", *Communications & Strategies*, No. 51, 3rd Quarter, pp. 21-34, 2003.

Björkdahl, J., Bohlin, E., Lindmark, S., (2004), "Financial Assessment of Fourth Generation Mobile Technologies", paper presented to the EURO CPR 2004 Conference, 29-30 March 2004, Barcelona, Spain, published in *Communications & Strategies*, No. 54, 2nd Quarter, pp. 71-96.

Björkdahl, Joakim (2003) "Financial Prospects", in Bohlin, E et al (2003) "Prospects for the Third Generation Mobile Systems", European Commission, Directorate General, Joint Research Center, report no. EUR 20772 EN

Bohlin, E., Ballon, P., Björkdahl, J., Lindmark, S., Weber, A., Wingert, B., (edited by C. Rodriguez Casal, J-C. Burgelman, G. Carat) (2004), "The Future of Mobile Technologies in EU: Assessing 4G Developments," IPTS Technical Report prepared for the European Commission – Joint Research Center, EUR 21192.

Bohlin, E., Burgelman, J-C. (2004) "Mobile Futures Beyond 3G: Special Issue", *info*, Vol. 6, No. 6, pp. 345-398.

Economist (2005) "Face value - Hong Kong's high roller", The Economist, January 6 2005

Faulhaber, G.R, Farber, D.J. (2002) "Spectrum Management: Property Rights, Markets, and the Commons", Working Paper 02:12, AEI-Brookings Joint Center Publications.

Forge, Simon (2004) "Is fourth generation mobile nirvana or… nothing?" *Info*, volume 6, number 1, 2004, pp. 12-23

Forge, S., Blackman, C., Bohlin, E., (2005), Future Mobile Communications Markets and Services (FMS) in Europe, Final Report, submitted to DG JRC-IPTS, European Commission (http://fms.jrc.es).

Liikanen, E (2001) in "*eMobility – Report of the Conference on Mobility in the Knowledge Economy, Göteborg, June 2001"*, Directorate General Information Society, European Commission

5. Questionnaire on parameters with responses

The following questionnaire was sent to:

- Ian Miles, PREST University of Manchester
- Emilio Fontela, Dean of the Faculty of Law, Economics and Business Administration, Universidad de Nebrija, Madrid
- Martin Weiss, University of Pittsburgh
- Lara Srivastava, Strategy and Policy Unit, International Telecommunication Union
- Taylor Reynolds OECD Telecoms economics unit

SCF Associates Ltd
4 Chiltern Close,
Princes Risborough, Bucks, HP 27 0EA, United Kingdom
Tel + 00 44 78 66 60 13 52 **simon.forge@whsmithnet.co.uk**

Commercial in Confidence.

Study on
Benchmarking Impacts of EU Policy - Options for Economically Efficient Management of Radio Spectrum
For DG INFORMATION SOCIETY AND MEDIA
European Commission Directorate C – unit 3
Lisbon Strategy and Policies for the Information Society
Evaluation and Monitoring, unit C3, and Spectrum policy, unit B4

Questionnaire

Background and context:

We are carrying out an impact assessment on new directives for spectrum allocation in Europe following moves to common initiatives as set out in the EC Communication of July 2006.

Impact assessment is moving up the EC agenda and is a key component in the drive for better regulation, particularly for new initiatives under the Lisbon objectives and general social equality. The fundamental aim of such legislation is considered as being - “what is of maximum benefit for the consumer and citizen?”.

In this study we hope to draw out the impacts of different forms of spectrum allocation – market-based, unlicensed, status quo including administered/centrally managed granting. The timeframe for legislative change is envisaged as – proposals 2007, consultation and discussion 2007- 8/9, legislation coming into force 2009/10, transition period to around 2015.

Our approach is to look at the economic impacts at a macro-economic level and our final focus should only be on these high level impacts, social as well as economic – eg how quickly services become available in the recent accession Member States. However we will begin at a micro-economic level – number of subscribers, services, prices of services, numbers of players, costs of services, etc. We intend to base the work on three scenarios of spectrum allocation as a starting point and then examine the affects on the key indicator parameters.

The key question that we wish to ask you is:-
What are the best parameters to assess the impacts of spectrum allocation legislation, using both micro and macro-economic variables as indicators, ones which can be used for benchmarking the status quo against the future?

Our scenarios to be analysed are:

1. Free trading at low prices – with technology, network and service neutrality
2. Licence-free vs. free trading at low price
3. Diverse positions across Europe by Member State – gaps and centres of different policies as member states do not have a unified policy.

We should be most grateful for a reply by email and would also like to call and discuss the parameters briefly with you.

Yours sincerely

Simon Forge, Colin Blackman, Erik Bohlin

Responses

Ian Miles PREST

Micro –
1) Speed of shift to new spectra as opposed to more costly/inefficient old spectra
2) Innovation: speed of introduction and uptake; innovativeness of new services; Roll-out.
3) Growth of services of different types and business models including P2p etc.
4) Effect on digital divides
Meso –
1) Competitiveness (In telecoms sector): extent to which policy shapes competitiveness of EU telecoms players – of different kinds – BEYOND entry-barrier and national-champion type effects
2) Impact on critical services like health, security, disaster management, emergency relief
Macro – -

Emilio Fontela, University of Nebrija
Micro –
1) The number of operators
2) Degree of concentration (of market sales)
3) The product structure (product/ services)
Meso –
1) Output of related advanced service sectors
2) Share of family expenditure on telecoms
Macro –
1) GDP (perhaps more growth rates than levels)

Martin Weiss, University of Pittsburgh

Emphasized the idea of diversity as the most critical impact variable of various spectrum regimes, across micro, meso and macro levels:

- application diversity
- service diversity
- competitive diversity
- innovation diversity

The litmus test of any policy is whether it promotes diversity in innovation and competition.

Lara Srivastava ITU Strategy and Policy Unit
Micro –
1) Number of multi-media downloads/user/country - indicates usage of mobile and radio services by what numbers of subscribers (- and this reflects Family structures)
2) Costs of data downloads against income – reflects needs of people for the service
3) how traffic is growing when the numbers of subscribers has reached country saturation – ie what new services are they using and how much, and also, are they using same services more (eg voice) because it is cheaper?
4) Access to broadband and multi-media – if access is increased do people use it ? – ie what is the impact of new availability (eg via wireless broadband) vs actual usage. Requires use of pricing in PPP terms
Meso –
1) Some measure of the "Degrees of co-ordination of society"
2) Measure of Age/Gender/Income and relation to technologies
Macro –
1) GDP growth

Taylor Reynolds OECD Telecoms economics unit, mobile & wireless
Micro –
1) Prices (PPP)
2) Coverage
3) Numbers of subscribers
Meso –
1)(Ground) Transport services congestion – vs teleworking
2) Data traffic levels (ie Internet Access)
Macro –
1) GDP Growth
2) Employment levels
3) Number of wireless ISPs (as measure of international competivity)
Discussion with OECD–
Result of the Trading Process should be that users pay less (SCF noted – may not be true if free market is driving up prices through scarcity rents and non-free market distortions eg cornering spectrum)
Rely most on spectrum allocation affects on the macro variables – but difficult to see if radio services have a big impact [SCF noted – UK RA study (simplistic) does show employment impacts]
Needs to be service neutrality for spectrum – big problem for the incumbent 3G operators who have paid large sums - and for their MS govts., who have taken the money – opening the door to new competition counteracts sole-usage clauses for wideband services as endorsed by the spectrum award. However non service neutrality hinders market development- eg if fixed wireless only in one band, no mobility allowed so Korea's WIBRO (IEEE802.16e) would be ruled out even for walking mobility

6. IST Projects for European ICT usage benchmarking

BEEP - Best eEurope Practices - Promotes best practice cases in four key business and social areas (domains) that will lead to Europe enhancing its position globally. URL: http://www.beep-eu.org/

BISER - Benchmarking the Information Society in European Regions - defines, develops and pilot a set of statistical indicators for benchmarking the progress of European regions in respect of the eEurope Initiative and the emerging Information Society. URL: http://www.biser-eu.com/

B2B METRICS - Statistical indicators for the information society - will allow for a better understanding of the B2B e-commerce development via the use of innovative frameworks and indicators. URL: http://www.b2b-metrics.de/

DIECOFIS - Development of a System of Indicators on COmpetitiveness and FIScal Impact on Enterprise Performance- covers key and long debated EU issues on indicators, competitiveness and the impact of public policy. URL: http://www.istat.it/diecofis

ECATT - Benchmarking Progress on Electronic Commerce and New Methods of Work - has generated representative information on the prevalence and spread of electronic commerce and new forms of work in Europe. URL: http://www.ecatt.com/

E-LIVING - Life in a Digital Europe - created and co-ordinated a set of pan-European longitudinal household panel studies to generate quantitative data on time-use, uptake of IST's, IST competencies, environmental impact and perceived quality of life. URL: http://www.eurescom.de/

MUTEIS - Macro-Economic and Urban Trends in Europe's Information Society - intends to analyse, explain and understand functional and spatial diversity in Europe's digital economy both from a macro and local/urban perspective. URL: http://muteis.infonomics.nl/

NESIS - New Economy Statistical Information System - was designed to contribute to the continuing elaboration and evaluation of European benchmarking indicators, as successive phases of the Lisbon strategy unfold and are implemented. URL: http://nesis.jrc.it/

NewKind: New Indicators for the Knowledge Based Economy - The project has developed indicators for assessing the significance of changes in the knowledge-base underlying economic, industrial and firm performance. URL: http://www.researchineurope.org/newkind/index.htm

PRISMA - The project has analysed good practice across a range of eGovernment service areas, used scenarios to understand future development requirements, and published a series of strategic guidelines for eGovernment policy makers and practitioners. URL: http://www.prisma-eu.net/

STAR - Socio-economics Trends Assessment for the Digital Evolution- examines the socio-economic impacts of new technologies and services on the nature of work and business enterprise in the next decade. URL: http://www.databank.it/star

SEAMATE - Socio-economic analysis and Macro-modelling of Adapting to Information Technologies in Europe. URL: http://www.seamate.net/

SENIORWATCH - developed a European Observatory and Inventory on the specific IS needs of older and disabled people to guide industry, RTD and policy. URL: http://www.seniorwatch.de/

TERRA - has developed scenarios for the ways in the Networked Society might evolve and their implications for sustainability. URL: http://www.terra-2000.org/