Introducing Analysys Mason

Liberalising 2G spectrum and GSM refarming

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Q1 2010

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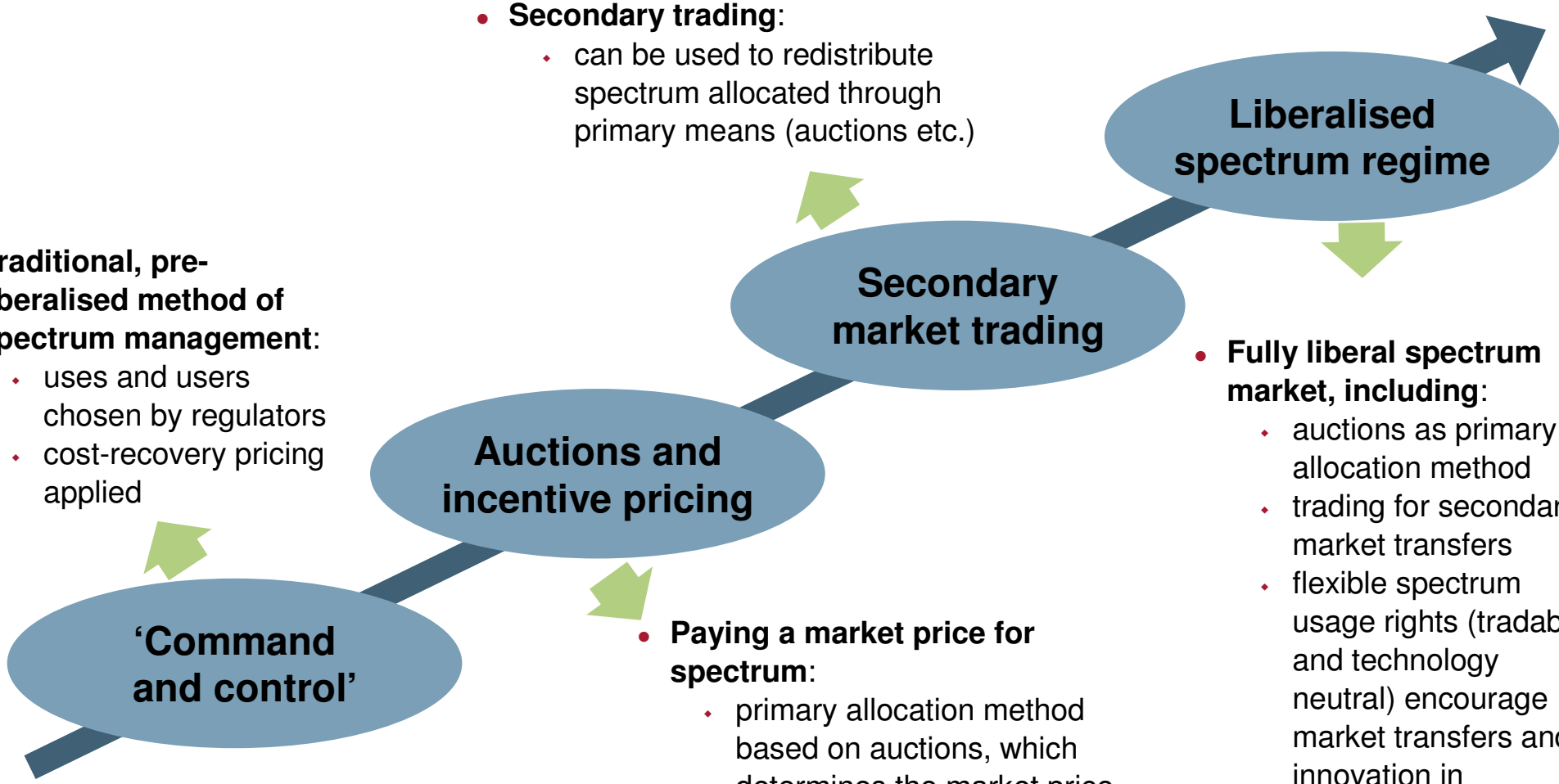
Liberalisation refers to the removal of technology restrictions on spectrum, to enable more flexible use



- **Traditional, pre-liberalised method of spectrum management**:
  - uses and users chosen by regulators
  - cost-recovery pricing applied

- **Secondary trading**:
  - can be used to redistribute spectrum allocated through primary means (auctions etc.)

- **Paying a market price for spectrum**:
  - primary allocation method based on auctions, which determines the market price
  - incentive pricing used where spectrum is not allocated by auction

- **Fully liberal spectrum market, including**:
  - auctions as primary allocation method
  - trading for secondary market transfers
  - flexible spectrum usage rights (tradable and technology neutral) encourage market transfers and innovation in spectrum use

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Liberalising mobile spectrum gives the option to refarm 2G mobile services to 3G, with potential longer-term benefits

- 2G networks typically use frequencies in various bands, which vary by country and region:
  - 800MHz – used in many countries in the Americas
  - 900MHz – typically refers to the 'primary' and 'extended' GSM900 frequency bands
  - 1800MHz – typically refers to spectrum used for GSM services in the 1800 band
  - 1900MHz – used for PCS licences in the Americas
- Many of the original 2G licences were issued using traditional 'command and control' assignment methods:
  - 2G licences are often technology specific (i.e. they can only be used for GSM)
  - Operators with 900MHz licences are often those that entered the market early – with subsequent market entrants holding 1800MHz or 1900MHz spectrum

Since 3G technologies have better capabilities and greater efficiency than GSM, refarming of GSM spectrum will generate more value for operators and consumers

2G networks typically use frequencies below 1GHz, which are very attractive for 3G services

- Frequencies below 1GHz are more attractive for mobile coverage than those above 1GHz, because signals travel further, enabling:
  - greater coverage at lower cost
  - better indoor coverage
- Since sub-1GHz 2G spectrum is typically held by incumbent mobile operators, enabling them to refarm that spectrum to 3G services might give them an unfair advantage:
  - to level the playing field, regulators might require incumbent operators to release some 2G spectrum for reallocation
  - regulators need to think about how much spectrum a mobile operator should be allowed to hold in total for 2G and 3G (spectrum caps)
  - there is a need to consider the coverage obligations that will apply to 800/900MHz spectrum once refarmed to 3G and, for operators, the cost of meeting those obligations in different frequency bands

Impact of frequency on base station densities

Base stations per km²	*UMTS 900*	*UMTS 1800*	*UMTS 2100*
Suburban	0.017	0.027	0.037
Remote/rural	0.008	0.013	0.018

Source: Ofcom mobile liberalisation consultation

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Although it offers consumer benefits through increased 3G availability, refarming presents various challenges

- Since 2G networks still carry large amounts of voice and data traffic, releasing 2G spectrum for 3G services raises various issues for **operators**:
  - how to carry the remaining 2G traffic until 2G networks are fully decommissioned
  - how to migrate the remaining 2G traffic onto 3G networks (device replacement etc.)
  - how to minimise the cost of migration (number of replacement sites required, number of sites needing hardware upgrades, labour costs, etc.)
- For **regulators**, liberalising 2G spectrum also raises a number of issues:
  - there is the potential for 'windfall' effects for incumbent 2G operators who did not acquire the spectrum through an auction
  - various competition issues need to be considered, to ensure operators remain on level spectrum terms
  - should refarming be approached in isolation or alongside other spectrum releases (e.g. 'big bang' auction packages)?

Liberalising and refarming of 2G spectrum raises various issues for regulators to consider

Release of spectrum

Should operators that have been allocated 900MHz and 1800MHz spectrum for 2G retain it after it is liberalised, or are there market or competition reasons to release some of that spectrum for other users?

Distribution of spectrum

Are some operators better positioned to deliver 3G services post-liberalisation, as a result of their 2G spectrum, particularly in bands below 1GHz that are in high demand?

Timescales

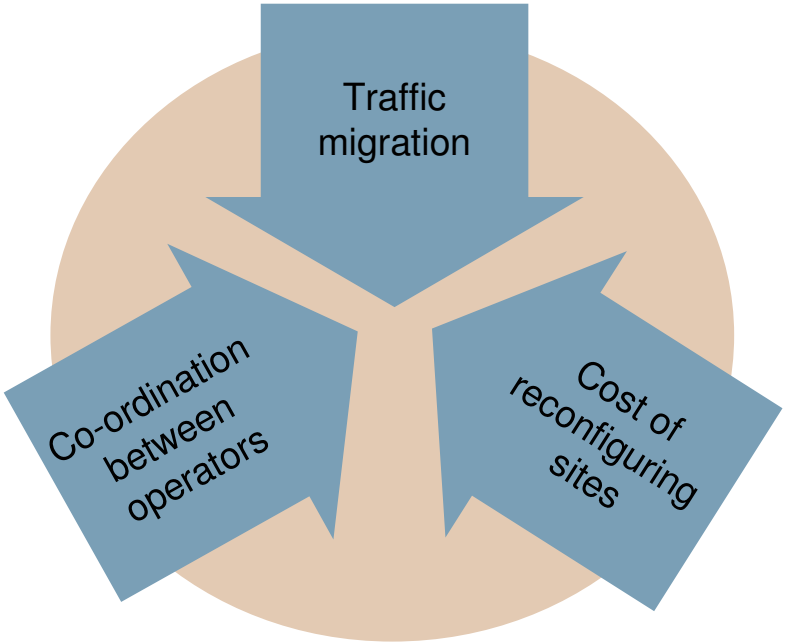
If some 2G spectrum is to be cleared/released to other operators, what are reasonable timescales, and how does this fit with other planned spectrum releases?

Overall approach

What are the implications of new spectrum releases (e.g. 800MHz, 2600MHz) on the mobile market? What are benefits of a 'packaged' approach to refarming? Should spectrum caps be applied?

Operators face a number of challenges in clearing 2G spectrum

- **How to avoid disruption to existing 2G users and encourage migration to new services**:
  - What strategies are available to accelerate 3G handset adoption?
  - Are there more efficient ways to carry 2G traffic in the interim?
  - Planning the most effective means of migration
    - methods to avoid substantial frequency/site replanning



- **How to reconfigure the 900MHz band for 3G use**:
  - Some GSM spectrum allocations are interleaved between operators; to avoid fragmentation, reconfiguration between operators may be required
  - This requires co-ordination and co-operation, and management of interference between operators and networks

- **Reducing the cost of reconfiguring spectrum**:
  - Is frequency reconfiguration necessary?
  - What site optimisation is required (e.g. repeat of drive testing, site location and geographical analysis)?
  - Depending on the age/type of existing equipment across a network, what proportion needs to be upgraded or replaced?

European countries are taking a range of approaches to refarming, with varying impact on incumbent operators

Ireland plans to re-award its entire 2G spectrum

- ComReg plans to re-award 900MHz and 1800MHz frequencies in Ireland, in light of:
  - existing 2G 900MHz licences expiring in 2011, and 1800MHz licences in 2013
  - previously unallocated spectrum in the 900MHz band being available for award
  - the wish to award liberalised licences
- Two options have been proposed:
  - re-awarding the entire 900MHz band in a single auction, in blocks of 2×5MHz (with a maximum of 2×10MHz per operator)
  - making liberalised 900MHz spectrum available in blocks, with timing linked to expiry of current licences

UK will liberalise 2G licences in the hands of existing licence holders

- The UK plans to:
  - liberalise 2G licences and make them technology neutral, and tradable in the hands of existing licence holders
  - hold a single auction of 800MHz frequencies and 2.6GHz frequencies, allowing those operators that do not have 900MHz licences to bid for 800MHz spectrum
  - allow 900MHz licensees to bid for 800MHz spectrum if they return an equivalent amount of 900MHz spectrum for re-award
- Caps would temporarily apply in the 2.6GHz/800MHz combined auction:
  - overall spectrum cap per operator of 2×65MHz
  - no operator may have more than 2×17.5MHz of sub-1GHz spectrum

Swedish 2G operators have agreed a spectrum release to the new 3G player

- Prior to refarming in Sweden, three operators held both 2G 900MHz licences and 3G 2100MHz licences; one operator had 2100MHz only
- The 900MHz licence holders agreed with the Swedish regulator to release spectrum to the new 3G entrant, the only operator in the market without 900MHz spectrum
- The decision will result in all 900MHz spectrum in Sweden being distributed among the four operators, with some holding 2×10MHz and some 2×5MHz
- All licences will be technology and service neutral
- New licences are expected to be issued in 2010

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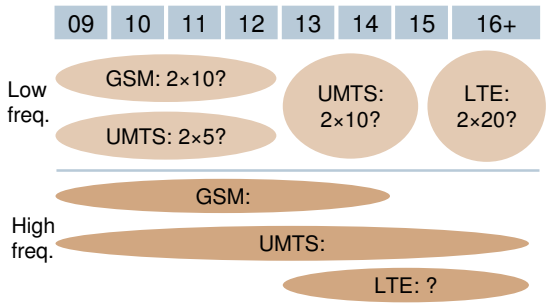
We offer a range of services relevant to liberalisation and 2G to 3G refarming

Spectrum strategy development

- Assessment of spectrum requirements in different bands
- Assessment of competitor requirements
- Assessment of wireless technologies in different bands
- Development of strategy for refarming existing services

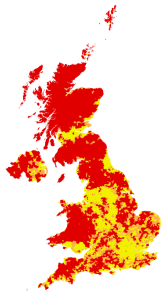
Example output: spectrum demand



Geographical coverage analysis

- Mapping of fixed and mobile coverage levels in different countries
- Comparison of data speeds achieved in different geographical areas
- Comparison of the cost of achieving coverage obligations in different frequency bands
- Interference analysis

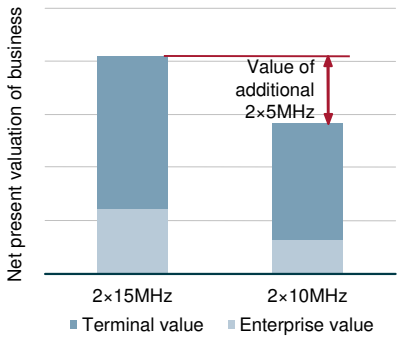
Example output: Predicted UK mobile coverage



Economic valuation

- Economic impact of liberalising mobile spectrum under different regulatory scenarios
- Bidder valuation modelling:
  - relative value of different bands
  - value of different amounts of spectrum
  - how value varies between lots
- Market impact of spectrum caps

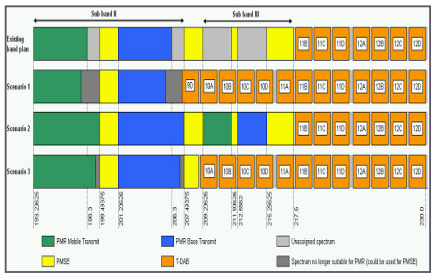
Example output: business case



Consultation process support

- Review of regulator/government refarming proposals
- Assessment of optimal response strategies
- Development of economic arguments to support consultation responses
- Drafting and editing of responses
- Technical assessments (interference analysis, guard bands, migration strategies)

Example output: allocation/assignment options



Source: Analysys Mason

Some of our assignments relating to mobile liberalisation and GSM refarming are presented on the following slides

Case study	*Client type*	*Summary*
Case study 1	UMTS Forum (mobile trade association)	Long-range forecast of spectrum demand in Europe
Case study 2	European mobile operator	Scenarios for future use of 900MHz frequencies
Case study 3	Ofcom	Evaluating the cost of mobile coverage in rural areas
Case study 4	European mobile operator	Benchmarking geographical coverage of fixed and mobile broadband networks in different European countries

Case study: Long-range forecast of spectrum demand in Europe

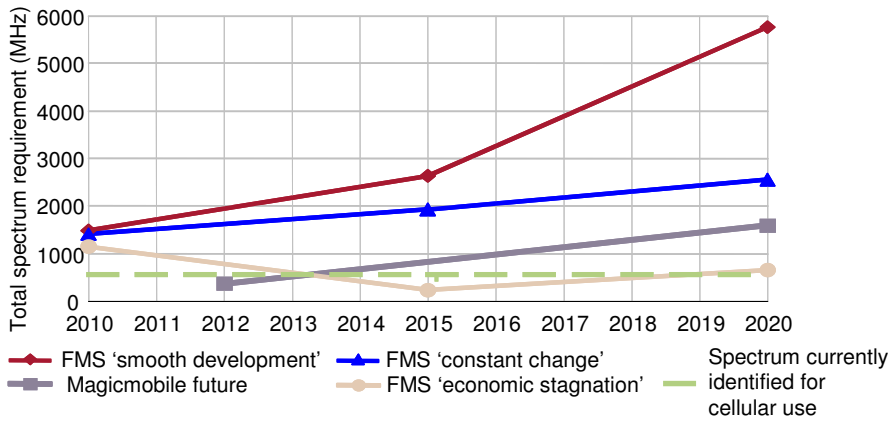
Business challenge

- In preparation for the World Radio Conference (WRC) 2007, the UMTS Forum wished to understand the spectrum that would be required by Western European mobile operators to 2020
- We were asked to calculate this spectrum demand from 2010 to 2020 given existing mobile traffic forecasts (from the UMTS Forum and the European Commission)

Approach

- Our approach was to understand the spectrum requirements from an operator's perspective: operators face a trade-off between the amount of spectrum they have and the number of base stations they need to deploy
- We developed a model to calculate the cost savings that an operator could make by obtaining additional spectrum, through needing to deploy fewer base stations
- If these savings were significant, we assumed that an operator would demand more spectrum
- We included a variety of scenarios regarding the proportion of traffic which occurs during the peak hour, improvements in spectral efficiency, and competing mobile technologies

Spectrum requirements for cellular operators, 2010–20*



Benefits and results

- We concluded that, given the traffic forecasts used, operators may require at least double the spectrum currently identified for mobile use
- The credibility of our results was enhanced by our wide experience in the cost modelling of mobile networks
- The UMTS Forum published the report on its website in order to encourage discussion of spectrum requirements and harmonisation among operators and regulators ahead of the WRC 2007

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** Source: Analysys Mason, 2006*

Case study: Scenarios for future use of 900MHz frequencies

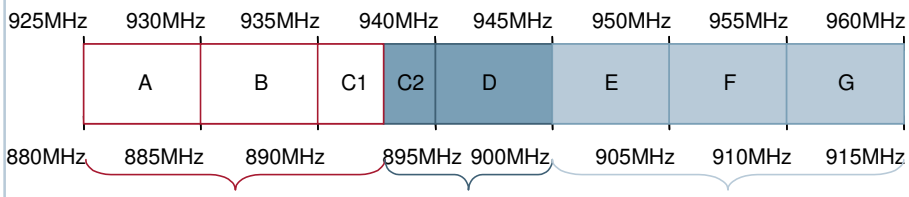
Business challenge

- Following publication of national regulatory proposals for liberalising 900MHz and 1800MHz frequencies, which set out alternative options for re-awarding part of the GSM 900 band, we were asked to advise an incumbent 900MHz operator on the impact of each option on its future business plans
- We were commissioned to assess the alternative options being proposed by the regulator, to assist the operator in responding to the regulator's consultation proposals

Approach

- We assessed the two main options being proposed by the regulator and developed scenarios which the operator might face under each option, to compare their advantages and disadvantages
- We then assessed the financial implications of each option for the operator, and considered what strategies other operators might adopt in response to each option
- Our overall assessment was presented in a workshop to the operator, and we prepared a final report that took account of discussions with the operator at the workshop

Example options



Benefits and results

- Our client benefited from a clear examination of the national regulator's consultation proposals, possible outcomes, and the impact on future capital and operational expenditure

Case study: Analysis of mobile coverage in rural areas

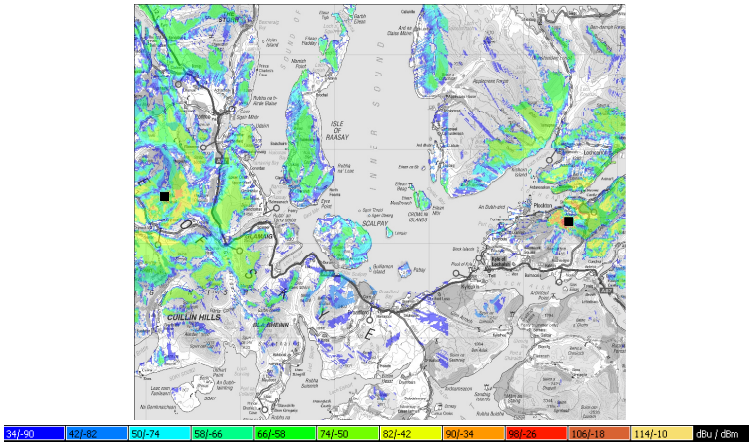
Business challenge

- In 2007, Ofcom wished to investigate reasons for lack of 2G mobile coverage in some rural areas of the UK and to identify possible solutions to improve coverage and network choice
- We were commissioned to measure 2G mobile coverage in selected rural areas, and to use a radio planning tool to assess options to improve upon the measured coverage, and the associated costs to an operator of providing this additional coverage

Approach

- We conducted drive tests using 2G test mobiles to measure coverage along defined routes
- We used MapInfo to map coverage measurements along the defined routes
- We used an RF planning tool to analyse options to improve on measured coverage in the identified areas
- We identified potential barriers to achieving coverage in the selected areas
- We assessed the capital and operational costs of delivering additional coverage in different geographical areas

Example output: mobile sites at 900MHz



Benefits and results

- The client was able to use the report as an indicator of the issues affecting mobile coverage in rural areas, and the additional costs associated with improving coverage in those areas

Case study: Benchmarking the geographical coverage of fixed and mobile broadband networks

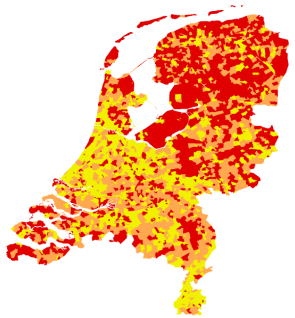
Business challenge

- A major fixed and mobile operator wished to estimate fixed and mobile coverage levels in different European countries
- We were commissioned to map current and future fixed and mobile coverage in different countries, using postcode sector population data for mobile coverage and exchange data for fixed coverage, considering spectrum availability and network technology developments

Approach

- For the mobile coverage, we used MapInfo to rank different geographical areas by their population densities and then map coverage at different speeds
- When examining fixed coverage we included cable, VDSL and ADSL2+
- Coverage was estimated for low, medium and high broadband speeds
- We identified the key drivers for extending coverage and speeds for each service, and modelled their projected evolution to 2015
- We defined thresholds for speed, based upon typical current network performance and likely evolution

Estimated mobile coverage (Netherlands)



Benefits and results

- Our report provided the client with detailed coverage maps for a range of European countries, comparing fixed and mobile coverage levels at the current time and at different points in the future (2011, 2013 and 2015)
- The client was able to use the report as input to its development of broadband strategy and supporting policy discussions

We advise regulators worldwide on a range of other topics

Category	Recent relevant experience	Our achievements
Spectrum framework review	• BIPT spectrum strategy review (2009)	• Assisted the Belgian regulator to review spectrum policies for frequencies between 790MHz and 3400MHz
	• EC spectrum trading study (2004)	• Detailed set of recommendations and action plan for the EC to take forward; raised awareness of spectrum trading and liberalisation issues across the EU
	• Ofcom mobile spectrum liberalisation (2005)	• Assessed the impact of allowing spectrum not currently used for mobile services to be used for mobile services, and the options for liberalising existing 2G spectrum
Spectrum award advice and support	• Ofcom Band III/L-Band award options (2005)	• Developed recommendations on allocation of spectrum to T-DAB, PMR and other uses, based on an assessment of economic benefits and other constraints
	• Ofcom award options for selected bands (2005)	• Study on allocation options for the bands 410–415/420–425MHz, 872–876/917–921MHz, 2010–2025MHz and 2290–2302MHz
	• Latin America mobile licence award (1999)	• Policies and procedures for licensing of new mobile operators
	• Asian 3G assignment options (2003)	• Quantitative economic assessment of approaches to awarding 3G licences
	• Second GSM licence in Middle East (2003)	• Recommendations on number of licences, valuation and supporting regulatory policy
	• Bid evaluation Belgium/Czech Republic (1999)	• Developed a selection procedure; reviewed bids leading to successful licence awards
Spectrum pricing	• AIP for PMSE spectrum for Ofcom (2009)	• Study to calculate the opportunity cost and recommend administered incentive pricing (AIP) levels for PMSE spectrum
	• Opportunity cost for Band I for Ofcom (2009)	• Study to determine opportunity costs for business radio spectrum in VHF Band I
Interference analysis	• Ofcom 2.6GHz interference analysis (2006)	• Impact on mobile network deployment in the 2.6GHz band of radio astronomy usage in adjacent spectrum
	• Ofcom assessment of interference in L-Band (2005)	• Assessed international interference restrictions on future users of the L-Band, as well as identifying mitigating measures
Other spectrum issues	• Review of UWB for Ofcom (2004)	• Economic cost/benefit analysis of potential introduction of UWB
	• Wired vs. wireless technologies for London 2012, for Ofcom (2008)	• Evaluated technology solutions for delivering communications for the London 2012 Olympics; the results were used as input to Ofcom's spectrum plan for the Olympics

In addition, we also regularly advise spectrum users on a wide range of issues

Category	Recent relevant experience	Our achievements
Spectrum acquisition support	• Hong Kong 2.6GHz auction support (2009)	• Supported a bidder in the 2.3/2.6GHz auction on valuation and bidding strategy
	• North African GSM licence application (2009)	• For a fixed and 3G mobile operator in North Africa, assisted in producing an application for a 2G GSM licence
	• Canadian AWS auction support (2008)	• Supported a global telecoms operator with valuation of spectrum and auction strategy
	• Middle East mobile licence applications (2007–2008)	• Supported operators with applications for new mobile licences in Kuwait and Qatar
	• Egyptian mobile licence application (2006)	• Supported a Middle Eastern operator with acquisition of third mobile licence in Egypt, including preparation of technical application and business plan
	• European UMTS beauty contest support (2005)	• Supported a fixed operator managing a beauty contest application for a UMTS mobile licence in a Western European country
	• Asian 3G business plans (2000–2002)	• Developed detailed 3G business plans for operators in Malaysia, Taiwan, Singapore and Hong Kong, and (where relevant) provided support during auctions leading to licence acquisition
	• European 3G licence auction support	• Supported operators bidding for 3G licences in Germany and Switzerland
Valuation of spectrum assets	• Spectrum price benchmarking (2008)	• Reviewed spectrum auction prices worldwide for a major global mobile operator
	• US 220MHz valuation (2008)	• Valued 220MHz spectrum for US rail companies looking to make a purchase
	• WiMAX spectrum valuation (2007)	• Valued spectrum for an East European WiMAX operator looking to raise finance
	• US 220MHz valuation (2006)	• Valued 220MHz spectrum in the USA on behalf of a financial organisation
	• WiMAX spectrum valuation (2005)	• Valued WiMAX spectrum on behalf of a major UK telecoms operator
	• US 800MHz valuation (2003)	• Valued 800MHz spectrum in the USA for a major global organisation
Other spectrum issues	• Global spectrum forecast (2006)	• Forecast cellular spectrum demand over 2010–2020 for the UMTS Forum
	• Review of spectrum trading implications (2005)	• Identified opportunities and threats for a major mobile operator arising from the potential introduction of spectrum trading in a major Western European market

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Industry commentary

900MHz refarming: the effects of delay

The GSM Directive currently stipulates that 900MHz frequencies must be reserved for GSM networks in Europe. It is expected that this legislation will be lifted, which will enable these valuable frequencies to be refarmed for emerging UMTS 900MHz deployments.

The anticipated benefits of using 900MHz for UMTS deployments include lowering the cost of deploying UMTS and mobile broadband services in less populated, rural areas, and improving in-building signals. These benefits could be realised by incumbents, new operators or recent entrants across Europe.

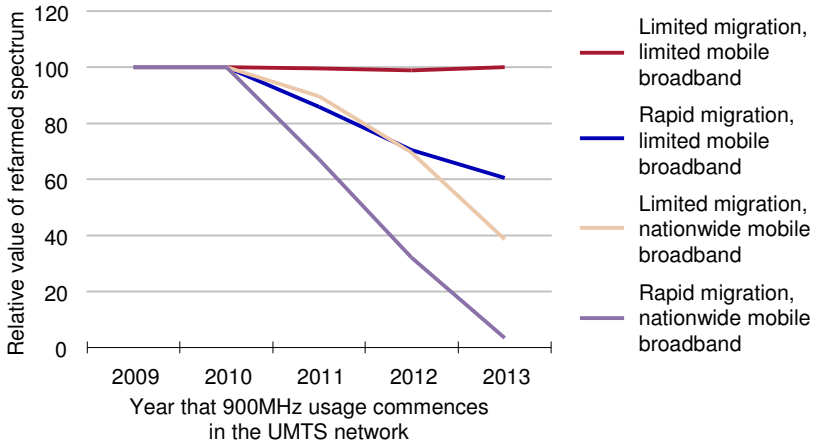
However, there are two aspects of market evolution that will determine the benefits generated from early refarming: whether 3G voice and mobile broadband becomes a nationwide proposition, and whether there is a rapid migration of subscribers, handsets and voice traffic to UMTS networks (and subsequent rationalisation of the old GSM networks).

If refarming is delayed, any gains will be significantly diminished. For mobile operators, this could have an impact in three ways.

- They would be required to make extra investments to deploy their networks at 2100MHz, without being able to rely on long-term access to the more cost-effective, refarmed 900MHz spectrum.
- They would have to limit the extent of mobile broadband deployment, focusing on cities and dense suburban areas and neglecting areas of lower population density.
- They would also have to delay their migration to 3G, and operate overlapping GSM and UMTS networks in parallel for longer.

The figure opposite shows the relative values of refarmed spectrum, estimated using a generic cost model of a mobile operator.

In a situation of rapid migration to 3G combined with the early roll-out of nationwide mobile broadband, delays to 900MHz refarming will be costly. The value of having unrestricted access to this spectrum reduces rapidly by 97% for delays during the three years in which rapid network evolution occurs.



If evolution of the mobile network is slower – with either limited migration or limited availability of mobile broadband service – early refarming will still be important, but delays will result in a smaller reduction in spectrum value (around 40%–60% over three years).

If migration to 3G is slow and mobile broadband services are limited to urban areas, delays in refarming the 900MHz spectrum will not be significant. However, in this situation, the overall development of the mobile market could be significantly impeded.

In order to create the maximum benefit for mobile operators, and to generate the greatest value, GSM restrictions on 900MHz frequencies should be lifted as soon as practical, ready for spectrum refarming.

Consequently, the directors of spectrum policy for regulators and mobile operators should explore the opportunities for early 900MHz refarming within their jurisdiction and consider their options in the context of expected mobile market evolution. As experienced advisors to regulators, policy makers and operators, Analysys Mason is ideally placed to support organisations engaged in the debate on spectrum refarming.

Ian Streule, Senior Manager, December 2008

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