Wholesale mobile voice call termination

Modelling Annexes

Non Confidential version

✂ indicates passages that have been redacted

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Contents

Annex 6

Network cost modelling

Introduction

A6.1 This Annex outlines the development and functionality of the 2011 cost model, including assumptions that have changed since the development of the 2007 cost model and the publication of the April 2010 cost model. The 2011 cost model is also being published with this Statement.

A6.2 A bottom-up MCT cost model has been used by Ofcom (and its predecessor Oftel) for a number of years. The MCT cost models used in previous proceedings have been twice reviewed by the Competition Commission (CC) (the 2002 CC report and the 2009 CC determination).[1] The charge controls on MCT set in 2007 were set using the 2007 cost model.[2]

A6.3 The 2009 CC determination reviewed a number of aspects of the model – such as 3G spectrum costs, administration costs, the path of unit costs (i.e. the depreciation approach), and market share forecasts for a 3G-only operator. However, the mechanics of network cost modelling were not fundamentally altered from Ofcom's 2007 MCT cost model.

A6.4 In July 2009, we commissioned Analysys Mason to assist us in updating the 2007 cost model.

A6.5 On 3 August 2009 we issued an information request to the (then five) national MCPs in order to gather data on the scale of their networks and volumes of network traffic carried.

A6.6 On 26 October 2009, we ran a stakeholder workshop on cost modelling issues which we considered likely to be important following the 2006/07 market review and the 2009 CC determination. The workshop covered scenarios around traffic forecasts (based on the data we had collected), technology choice, spectrum valuation, the approach to depreciation, implementing pure LRIC, and dealing with site sharing.[3]

A6.7 Following the preparatory work for the workshop, industry discussion at the workshop and further information requests (issued on 5 November 2009), we revised the 2007 cost model, to produce the April 2010 cost model which supported

[1] See Competition Commission (2002), http://www.competition-commission.org.uk/rep_pub/reports/2003/475mobilephones.htm, and Competition Commission (2009), http://www.competition-commission.org.uk/appeals/communications_act/mobile_phones_determination.pdf

[2] There were two variants of the 2007 cost model: one based on a hypothetical efficient national MCP using 2G and 3G technology and the other based on a hypothetical efficient national MCP using 3G technology only. The former was used to set the target charges in 2010/11 for the 2G/3G MCPs (i.e. then Vodafone, O2, T-Mobile and Orange) and the latter to set the target efficient charges for H3G.

[3] For the slides accompanying the workshop see http://stakeholders.ofcom.org.uk/consultations/mobilecallterm/workshop/

the glide-path proposed in the April 2010 consultation. The cost model was published as part of the April 2010 consultation.[4]

A6.8 We received a number of detailed responses to the April 2010 consultation relating to the April 2010 cost model. Those submissions which relate to our estimate of the unit cost of MCT using pure LRIC (and are therefore relevant to the maximum charges set for MCT), or are common to the assessment of both the pure LRIC and the LRIC+ of MCT are dealt with in this annex. Those issues which affect only our estimate of the unit costs of MCT using LRIC+ (relevant to the question of assessing the impact of our decision to adopt pure LRIC) are dealt with in Annex 9.

A6.9 On 30 July 2010 and 17 September 2010 we issued further information requests to the 4 national MCPs. The MCT cost model accompanying this Statement and used to set efficient cost benchmarks for MCT in 2014/15 (the 2011 cost model) therefore reflects our views after considering submissions received from stakeholders and traffic and cost information up to and including Q1 2010/11[5] obtained in July and September.

A6.10 The main changes in the 2011 cost model, compared to the 2007 cost model, are that the 2011 cost model:

- calculates MCT costs based on pure LRIC (as well as LRIC+);
- is based on updated traffic demand forecasts;
- is based on updated data concerning network equipment capacity, prices and other cost inputs; and
- is based on more recent information about network developments, such as the deployment of HSPA (high speed packet access).

A6.11 This Annex is structured in the following way:

- A summary of major changes since the April 2007 cost model;
- an overview of the 2011 cost model and its five constituent modules:
  - "scenario control" module;
  - "traffic" module;
  - "network" module;
  - "cost" module; and
  - "economic" module. ; and
- A detailed discussion of each of the five modules of the 2011 cost model and the stakeholder reponses to the April 2010 consultation.

[4] As well as publishing that model as part of the April 2010 consultation, the model was described in summary form in Section 9 of that consultation and more fully in Annex 8, Annex 9, Annex 10 and Annex 11 to the consultation.
[5] April, May and June of 2010.

Summary of major changes to the model

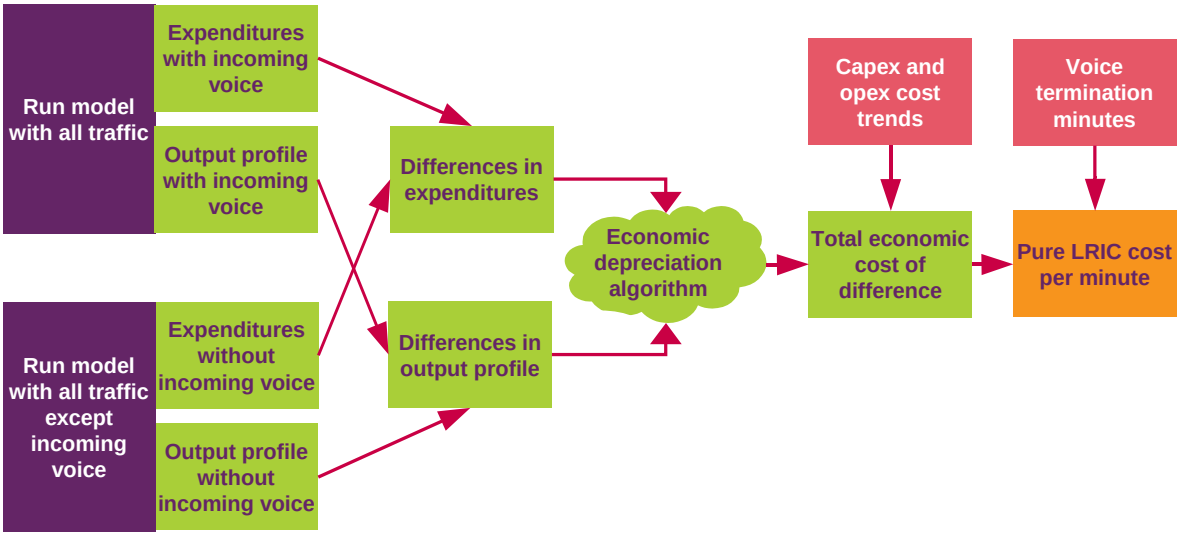
Inclusion of ability to calculate costs based on pure LRIC

A6.12 The model has been amended to enable calculation of pure LRIC, in addition to LRIC+.

A6.13 In a LRIC+ approach we calculate the incremental costs of traffic using a large increment approach (i.e. all voice and data traffic). Common costs are allocated across all services using service specific routing factors. For common costs where no routing factors exist (such as administration costs), the allocation is on an EPMU (equi-proportionate mark-up) basis.

A6.14 In contrast, when using a pure *LRIC* approach incoming voice traffic is considered as a 'final increment' with *no* common costs (such as the common costs of a 'coverage network')[6] being allocated to the wholesale voice termination service. The incremental costs associated with incoming voice traffic are calculated by separately calculating the model outputs (cashflows, service demand, asset volumes for each network element), first, with incoming voice traffic and, second, without incoming voice traffic. The calculation flow used to determine pure LRIC is shown in Figure A6.1 below.

Figure A6.1: How pure LRIC values are determined



A6.15 The incremental cashflows, service demand and asset volumes for each network element are used as inputs to the economic depreciation (ED) algorithm. The output of this algorithm is the pure LRIC of an incoming minute of voice traffic. The same ED algorithm is used for both LRIC+ and pure LRIC, albeit with different asset volumes, outputs and cash flows.

Updates to demand forecasts

A6.16 All demand forecasts in the 2011 cost model have been updated to reflect the best available data on previous and current usage patterns. The updated demand forecasts are based upon data on subscriber numbers, voice traffic, messaging

[6] This is consistent with the approach in the 2009 EC Recommendation recital 14 and paragraph 6.

traffic and data traffic from all four national MCPs from Q1 2005/06 until Q1 2010/11.[7] Forecasts have also been provided by the national MCPs until Q4 2011. Comments made by stakeholders at the modelling workshop on 26 October 2009 and in their responses to the April 2010 consultation were also taken into account. The main forecasts that have been updated include:

- Subscriber numbers for both handsets and datacards (also known as dongles).
- Incoming, outgoing and on-net voice call volumes.
- SMS and MMS volumes.
- Usage of data services on mobile handsets.
- Usage of data services on datacards.

A6.17 These forecasts are inputs to the model, and are used to establish the dimensions of the network. As there are more subscribers, and greater use of data services (both on handsets and datacards) than was predicted in the 2007 cost model, the 2011 cost model has significantly higher demand forecasts (discussed in the description of the traffic module later in this annex). Other changes have been made in response to points raised by operators during the April 2010 consultation. These are discussed in the relevant sections below and Annexes 7 to 10.

Updates to reflect network developments since the 2007 cost model

Deployment of HSPA

A6.18 When the 2007 cost model was constructed, 3G networks were relatively new. As demand for 3G services provided using these networks has matured, there have been changes to their capabilities in a number of areas, and the April 2010 and 2011 cost models have been updated to reflect these changes. For example, HSPA technologies (which are widely deployed by all national MCPs) are now included in the 2011 cost model.[8]

Sharing of network elements between operators

A6.19 Mobile operators may share the passive elements on sites, or the active components of the network such as radio equipment and backhaul.

A6.20 Passive network elements include items such as the physical space and any masts (and sometimes includes non-telecoms related facilities like power or air-conditioning). All of the mobile operators in the UK currently use passive network element sharing to some extent (known as 'site sharing'), and we believe that an efficient operator would continue to extend the amount of site sharing in its network. Functionality has therefore been added to the model to assess the effects of a move by operators to increase the amount of site sharing. This action leads to a reduction in operating costs, though it is also accompanied by the additional one-off costs of moving from dedicated sites to shared sites. These costs cover

[7] Data collected in the August 2009, October 2009, and July 2010 S135 data requests.
[8] HSPA is a mobile data protocol that extends and improves the existing WCDMA protocols, allowing more efficient transfer of data. The model has been modified to allow both HSPA and Release 99 traffic to be carried on a shared carrier.

decommissioning old sites, moving equipment and any necessary upgrades to the shared sites.

A6.21 Mobile operators are also able to share active network elements. This is commonly referred to as active RAN sharing, and has the potential to deliver greater cost savings than site sharing. However, there are significant technical and operational challenges with active RAN sharing, and only one pair of UK mobile operators (EE and H3G) are currently deploying active RAN sharing. We have therefore modelled a hypothetical average efficient operator with passive site sharing but without active RAN sharing.

Updates to network element unit costs and capacities

A6.22 We have updated network equipment capacities and prices based on information submitted by the national MCPs.[9]

A6.23 The costs of 2G and 3G base station equipment have both declined significantly since 2007 and the asset price trends were revised accordingly in the April 2010 cost model. In light of more information and following the calibration exercise for the 2011 cost model, we have further adjusted these prices, resulting in a smoother decline of equipment prices, which are now similar to the price trends in the 2007 cost model.

A6.24 As part of the 2011 cost model calibration exercise, significant changes in equipment capacity have been necessary for some network assets. We have taken into account these capacity adjustments when updating historic MEA prices. For example, even if the replacement cost of assets is unchanged, the MEA price will trend downwards if the capacity of replacement assets increases.

[9] Submissions in response to the August 2009, October 2009 and July 2010 S135 data requests.

Model overview

A6.25 The 2011 cost model estimates the costs of a hypothetical average efficient operator in the UK, and is therefore based on the use of technologies and spectrum bands that have been, or are currently being, deployed in the UK. Specifically it includes:

- 2G in the 1800 MHz band; and
- 3G (including HSPA) in the 2.1 GHz band.

A6.26 The model calculates the capital and operating cost of network equipment, from the radio network to the core network, up to and including gateway switches and interconnect ports. It therefore includes:

- the radio network (including base station sites and equipment);
- backhaul (i.e. links from the base stations to the core network);
- the backbone network (i.e. links between core network sites); and
- core network switching equipment and other assets.

A6.27 Estimated costs are driven by three main factors: (a) the number of subscribers; (b) coverage requirements; and (c) the total traffic generated by subscribers. The number of subscribers drives a relatively small number of network assets e.g. Home Location Registers (HLRs), whereas coverage requirements and service demand (traffic) drive the majority of costs.

A6.28 Service demand from all traffic services (including but not limited to MCT) is aggregated to estimate total traffic. Since certain traffic services use different network resources more or less intensively, specific aggregation factors are applied. These cost drivers are used to calculate the required deployment of 2G, 3G and HSPA networks (where appropriate) to meet demanded capacity and coverage. This is in line with the approach taken in the 2007 cost model.

A6.29 The 2011 cost model calculates service costs by allocating all network costs according to service routing factors. Under LRIC+, any common costs are allocated to service increments according to routing factors. The LRIC+ model does not identify or estimate the level of common costs. The outputs of the LRIC+ model are unit costs that include all network costs. Therefore, the model output, for a LRIC+ cost benchmark, is an incremental cost plus an implicit contribution to common costs.

A6.30 Under pure LRIC, no common costs are recovered from voice termination services. The only costs allocated to voice termination are the incremental costs of providing voice termination on a hypothetical network built to provide all services except voice termination.

A6.31 The model calculates the network costs for the period 1990/91 to 2039/40 with a perpetuity-based terminal value thereafter, although forecasts for all inputs are constrained to be constant from 2020/21 onwards.

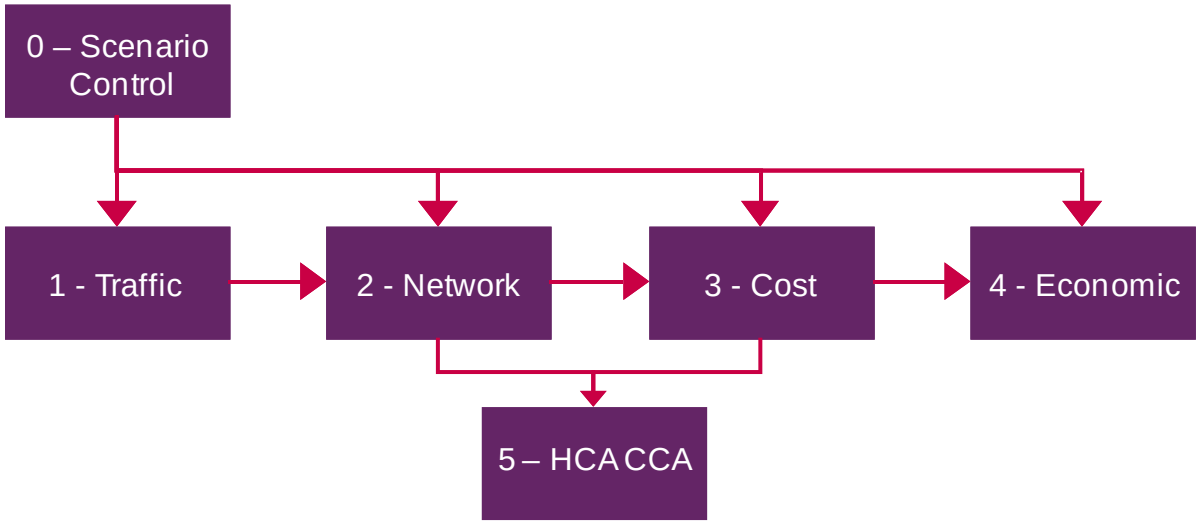
A6.32 The model recovers capital and operating costs over time using a path for unit costs known as original economic depreciation (Original ED). This approach was used in

the 2007 cost model and the use of original ED was considered by the 2002 CC report[10] and the 2009 CC determination.[11]

Model structure

A6.33 In addition to the module used to control the model and present the model outputs, the 2011 cost model comprises five distinct modules, as shown in Figure A6.2.

Figure A6.2: Overall model structure



- **The scenario control module** is used to set the chosen parameters that are used to define the different scenarios and sensitivity analyses that have been considered. It also contains a summary of the main results.
- **The traffic module** contains the demand forecasts and network coverage assumptions.
- **The network module** forecasts the 2G and 3G network deployment required to support the input level of demand and network coverage over time.
- **The cost module** produces the network costs, based on asset costs (both capital and operating) and projected network deployment.
- **The economic depreciation module** calculates service costs from the forecast network costs, based on economic depreciation.
- **The HCA/CCA module** calculates gross book value (GBV) and net book value (NBV) for each asset. These metrics have been used only for the purpose of model calibration.[12]

[10] See Competition Commission 2003 Report paragraph 2.283 http://www.competition-commission.org.uk/rep_pub/reports/2003/fulltext/475c2.pdf and
[11] See Competition Commission, Mobile call termination: reference to the CC made by the CAT on 18 March 2008 in the consolidated appeals from H3G UK Limited v Office of Communications (1083/3/3/07) and British Telecommunications plc v Office of Communications (1085/3/3/07), Section 7 at http://www.competition-commission.org.uk/appeals/communications_act/mobile_phones_determination.pdf

Model outputs

A6.34 The outputs of the 2011 cost model are unit costs (either pure LRIC or LRIC+) in each year for voice call termination. The model works in real terms, indexed to 2008/09 prices, and all outputs are stated on this basis.

0. Scenario control module

A6.35 The scenario control module contains the main parameters that affect the cost of termination, which then feed through to all the other relevant modules.

A6.36 The scenario worksheet contains the parameters which are most important to the output of the model. The sheet is constructed to allow the user to quickly swap between different scenarios, with a macro enabling the calculation of either LRIC+ or pure LRIC results for these scenarios.

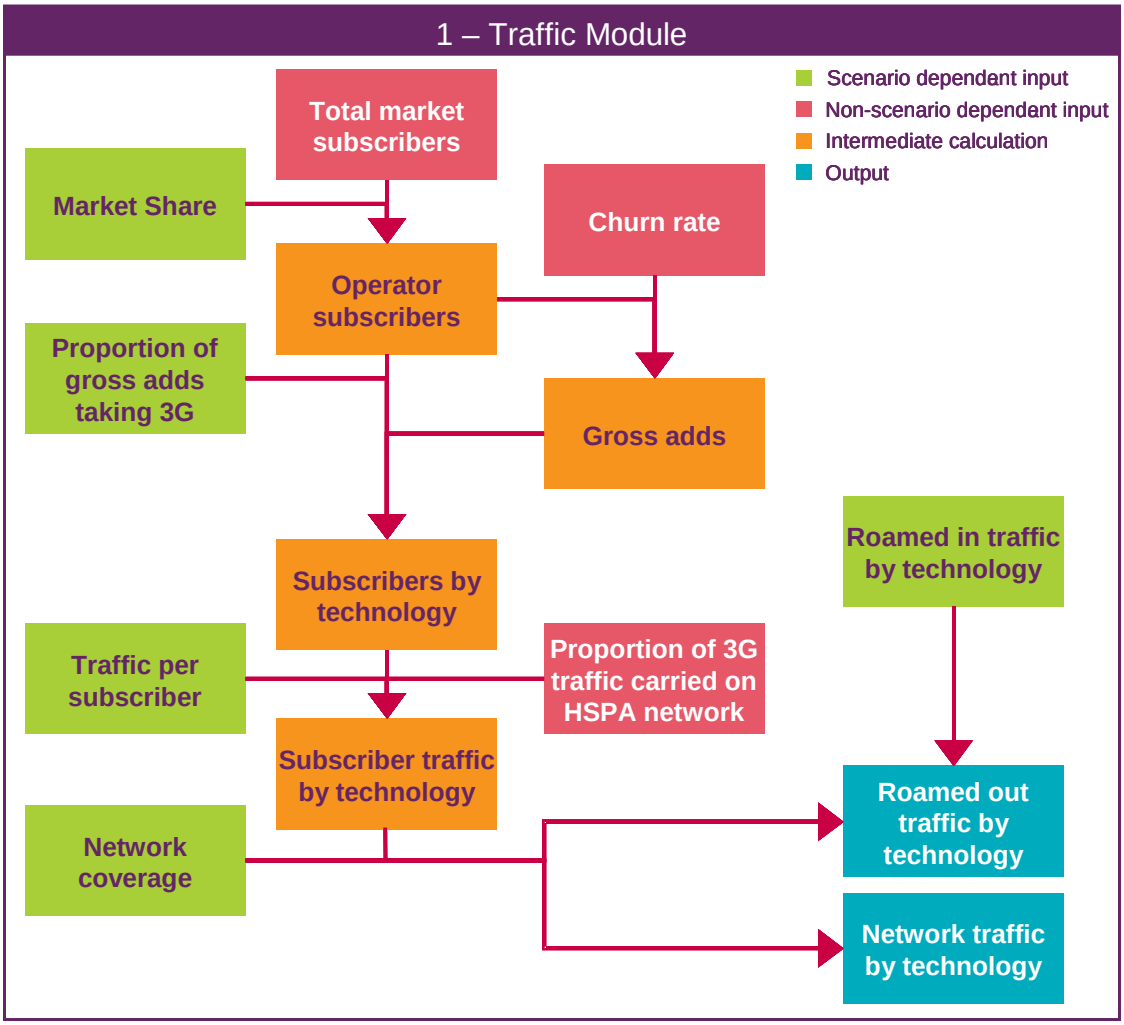
A6.37 The Outputs worksheet contains the most important results from the model. These include the cost of termination for each technology (i.e. 2G and 3G) over time, the blended cost of termination over time and the number of sites constructed over time.

1. Traffic module

A6.38 This module converts demand and coverage assumptions into aggregate traffic levels, which can then be used to dimension the 2G and 3G (including HSPA) networks. This subsection describes in detail the demand forecasts that are used to develop the network traffic forecasts. These traffic forecasts are used in the rest of the 2011 cost model. Figure A6.3 shows the overall logical flow for forecasts of subscribers and service demand on the 2G and 3G/HSPA networks.

[12] The HCA CCA module was designed in previous reviews to be able to calculate the results based upon Historical Cost Accounting (HCA) or Current Cost Accounting (CCA). These two cost recovery methods have not been used to estimate efficient unit costs in this review.

Figure A6.3: Calculation flow in the traffic module



A6.39 Traffic is modelled based on a forecast of subscribers, plus a forecast for the demand per subscriber. Demand for each service is based on past data combined with forecasts for future periods. The forecasts in the 2011 cost model were generated with reference to forecasts from the national MCPs, as well as Analysys Mason mobile market research. “High”, “Medium” and “Low” forecasts have been generated for each of the services below:

- 2G incoming, outgoing and on-net voice calls.
- 2G SMS and MMS.
- 2G packet data.
- 3G incoming, outgoing and on-net voice calls.
- 3G SMS and MMS.
- 3G handset packet data.
- 3G datacard packet data.

A6.40 In the 2011 cost model (and in the April 2010 cost model), 3G/HSPA datacard and handset packet data services have been treated as two separate services. This is because we believe these services have different drivers for usage.

Subscribers for handset-based services

Mobile subscriber penetration (2011 cost model)

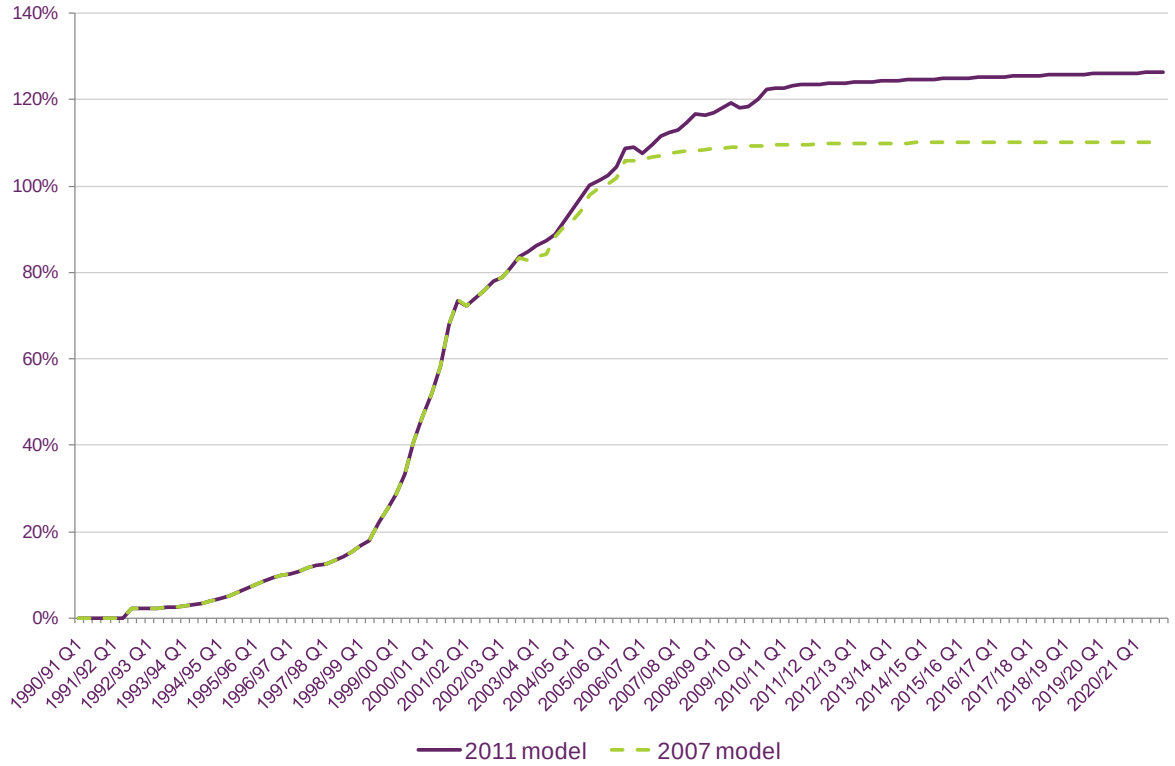
A6.41 The number of subscribers for the hypothetical average efficient operator is calculated according to the total number of mobile subscribers in the market. The forecast for the total number of subscribers assumes that mobile penetration will saturate at 1.32 SIMs per person.[13] We have assumed that the population will grow at around 0.7% per annum.[14] The number of subscribers for each network is then calculated using an assumed market share profile over time.

A6.42 The penetration of mobile services assumed in the 2011 cost model is higher than in the 2007 cost model (shown in Figure A6.4). The number of mobile subscribers using mobile handsets (excluding datacards[15]) has grown more than was forecast in the 2007 cost model: there were a total of 73 million subscribers at the end of June 2009, which is the same as assumed in the April 2010 cost model. The updated forecast is that this will reach 84.4 million by the end of 2020/21.[16]

A6.43 There were no specific responses to the April 2010 consultation on mobile subscriber penetration.

[13] Assumption guided by advice from Analysys Mason Research and Ofcom 2010 CMR (http://www.ofcom.org.uk/static/cmr-10/UKCM-5.1.html - which gives 1.317). We have increased this value from the 1.27 SIMs per person in the April 2010 cost model.
[14] Based on data from the Economist Intelligence Unit, August 2010. This has been updated from the 0.4% used in the April 2010 cost model.
[15] The take-up of mobile broadband datacards is discussed later.
[16] This has increased from 83.8 million in the April 2010 cost model.

Figure A6.4: Mobile subscriber penetration



Source: AnalysysMason

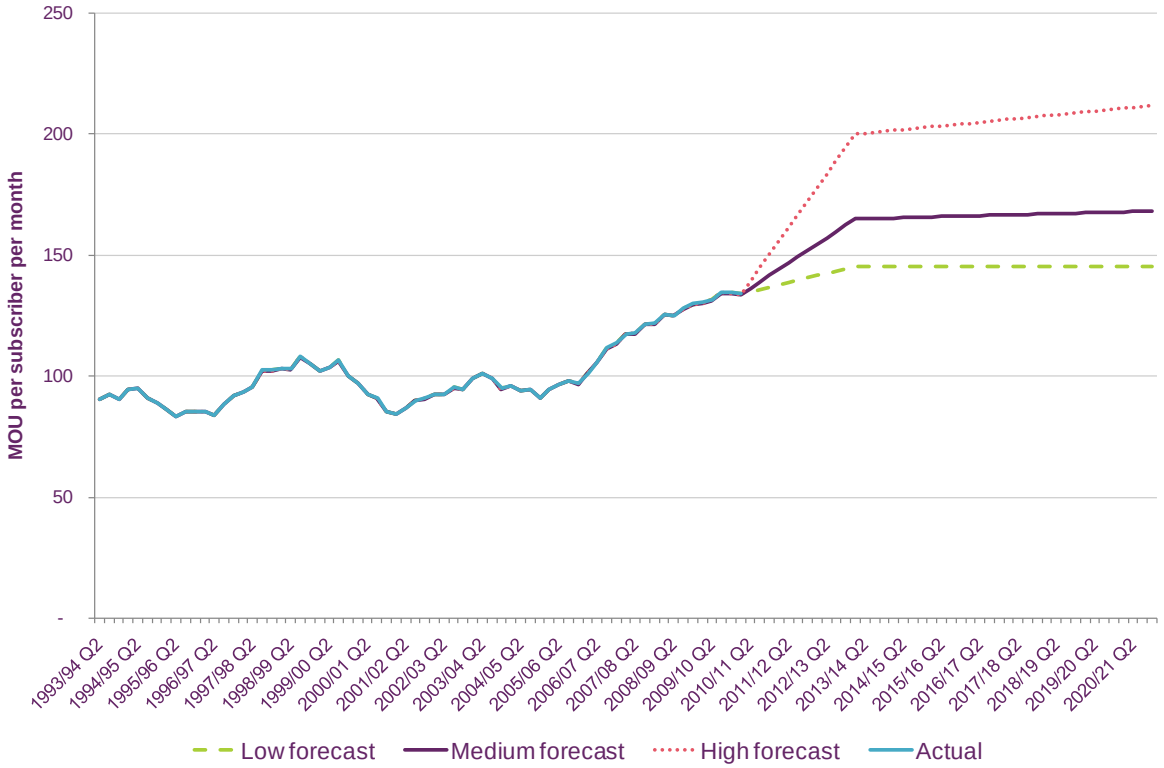
Handset usage forecasts

Voice services in the 2011 cost model

A6.44 The 2007 cost model assumed that subscribers with 3G-capable handsets made more voice calls than subscribers with only 2G-capable handsets. However, the data provided by the national MCPs for this review was not sufficient to determine reliably whether there is in fact any significant difference in voice usage by 3G subscribers. We have therefore decided to use the same values for average per-subscriber voice usage for both 2G and 3G subscribers.

A6.45 Based on actual figures for the period Q1 2005/06 to Q1 2010/11, we have revised the forecasts for minutes of use per subscriber, as shown in Figure A6.5 below.

Figure A6.5: Forecasts for monthly outgoing MOU per subscriber



Source: Analysys Mason

A6.46 The updated Low forecast reaches 145 outgoing minutes per subscriber per month by 2013/14, after which time it remains constant. The Medium demand forecast reaches 165 minutes per month by 2013/14 and 168 minutes by the end of 2020/21. This compares with 165 minutes and 178 minutes in the April 2010 cost model for the medium scenario. The minutes of use per subscriber in the High demand forecast reaches 212 minutes in 2020/21 (and remains constant at this level thereafter). This is lower than the April 2010 consultation value of 252 minutes in the high scenario.

A6.47 To ensure that the proportion of incoming calls from fixed lines is consistent with historical data, we have adjusted a single parameter which affects all years of the model. This parameter determines the number of incoming calls from fixed lines in the MCT cost model based on the number of outgoing calls to fixed lines. Reducing this parameter means that there are relatively fewer incoming calls from fixed lines. We reduced this parameter from 0.75 to 0.50 between the 2007 cost model and the April 2010 cost model and have maintained this value for the 2011 cost model.

Responses to the April 2010 Consultation

Vodafone

A6.48 Vodafone raised a concern regarding the handling of incoming traffic. In order to properly dimension both the 2G and 3G network, the model takes into account that a certain percentage of on-net calls are in fact inter-technology calls (i.e. calls from a 3G subscriber to a 2G subscriber or vice versa). These calls drive network deployment in a similar way as incoming (inter-operator) calls do. For this reason,

the model considers four categories of on-net calls: 2G on-net calls, 3G on-net calls, 2G to 3G on-net calls, and 3G to 2G on-net calls. The volume of incoming traffic used for network dimensioning in the model then includes some traffic that in reality is the second leg of an on-net call. From the perspective of network dimensioning, Vodafone found this a reasonable approach. Vodafone, however, stated that this traffic has not in fact originated off-net. Therefore, according to Vodafone, when producing the weighted average of genuinely incoming traffic for charge control purposes, all this out of scope traffic should be removed from the modelled volume of 2G and 3G inbound traffic.[17]

A6.49 Vodafone also raised a concern that the voice traffic forecasts were too high because the forecasts assumed that both the total number of mobile subscribers and their usage will be increasing. Vodafone found this "not a prudent set of assumptions, particularly in view of the dampening impact of the recession".[18]

O2

A6.50 O2 argued that given the recent volatility in voice volumes, our estimates of network traffic appeared high. It also indicated that given that the price elasticity of demand for voice traffic was low, it would not expect to see any noticeable increase in the volume of traffic as the termination rate was reduced. It also argued that as handset subsidies would be lower, there would be a lower uptake of data enabled phones and so our data traffic forecasts were too high.[19]

Everything Everywhere

A6.51 EE argued that our voice forecasts per subscriber were based on projecting forward a growth rate from only a few recent observations. It suggested that we should look at the long term growth in per subscriber use. Although EE believed that [✂].[20]

H3G

A6.52 H3G argued that data volumes will continue to grow and supported this with evidence from a Vodafone presentation and its own forecasts. H3G generally agreed with our voice forecasts.[21]

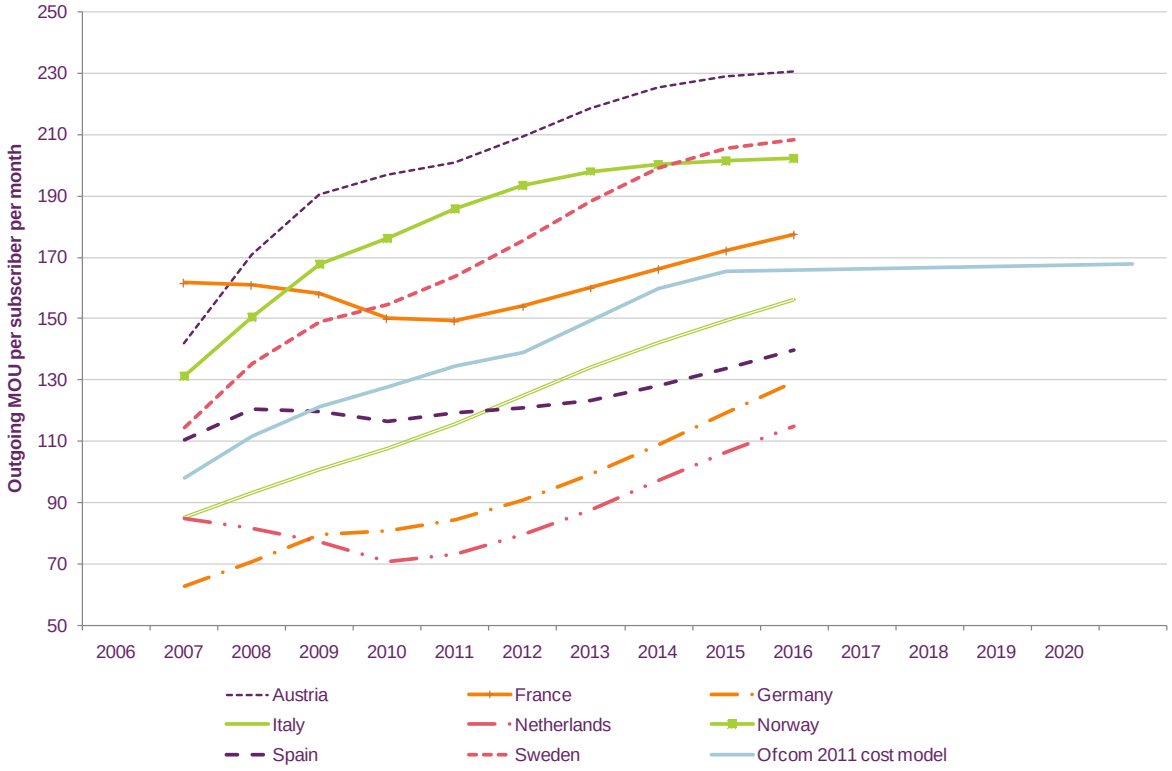
Ofcom's response to specific points raised by stakeholders

A6.53 We accept Vodafone's submission that we should rectify the treatment of on-net inter-technology calls for the purposes of the cost-recovery calculations. As a result, 2G costs get a higher weight in the blended average of the incoming voice call costs.

[17] Vodafone response to the April 2010 consultation, Annex 3 pages 51-53. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[18] Vodafone response to the April 2010 consultation, Annex 3 page 56. Ibid
[19] O2 response to the April 2010 consultation, Section F page 63. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf
[20] EE response to the April 2010 consultation, pages 29-30 and Annex D page 88-91. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Everything_Everywhere.pdf
[21] H3G response to the April 2010 consultation, Annex G page 147-161. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf . H3G did make a comment in this annex about the way traffic volumes were converted into busy hour volumes. This issue is dealt with later when we discuss our definition of the busy hour.

A6.54 We note submissions by Vodafone, O2 and EE suggesting that our demand forecasts are too high. Our demand forecasts are based on recently observed trends in traffic growth. As part of our post-consultation updates for the 2011 cost model, we collected more recent data on traffic trends.[22] In addition to basing the forecasts on historical trends for mobile voice traffic in the UK, we have also compared our forecasts to a range of forecasts from other European countries as shown in Figure A6.6 below. These comparisons show that the long term value we have assumed sits comfortably within the range used by regulators in other countries.

Figure A6.6: Comparisons of monthly outgoing MOU per subscriber



Source: Fixed and mobile voice services in Western Europe: forecasts and analysis, 2010–2015, Analysys Mason

A6.55 We do not agree with O2 or EE that recent volatility in per subscriber traffic means our forecast is too high. While there has been volatility in average MoU per subscriber, since the end of 2004/05 the average MoU has been steadily increasing (see Figure A6.5). We do not believe that the most recent observation represents a cyclical high. Although there would seem to be a ceratin amount of evidence that MoU per subscriber followed a cyclical pattern, this has not been the case since 2005/06. It is unclear to us what cycle average MoU per subscriber could be following given the steady increase for the last 5 years. During this period there have been a number of structural changes to the mobile market. The following factors could have contributed to a structural change and thus caused constant growth in the average MoU per subscriber:

- additional competition from a new national operator (H3G);

[22] As part of the July 2010 S135 data request.

- increasing availability (and take-up) of tariff plans with larger bundled minutes;[23] and

- decreases in mobile and fixed termination rates.

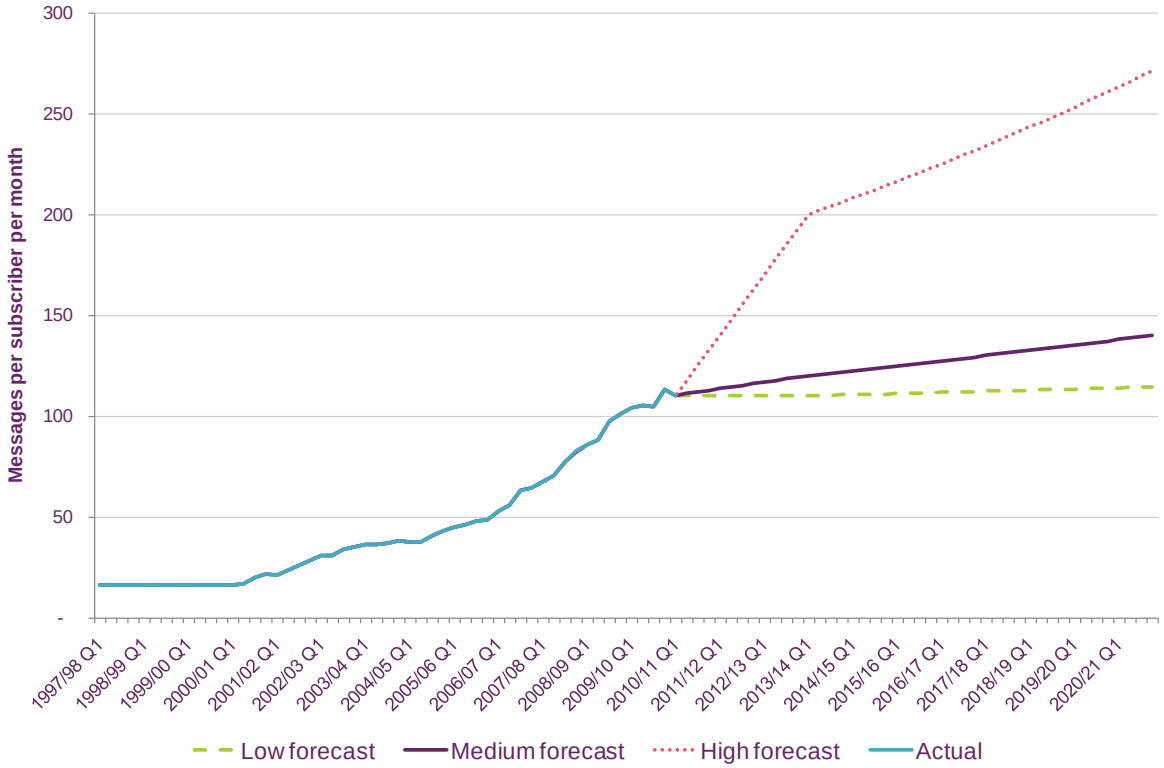
Messaging services

SMS traffic in the 2011 cost model

A6.56 The growth in messaging services since the end of 2004/5 has been significantly greater than was previously forecast, reaching almost 113 messages per subscriber per month by Q4 2009/10, compared to a previous forecast of around 66 messages per month in the 2007 model high demand forecast. Our updated demand forecasts reflect an expected continued growth in messaging (see Figure A6.7 below). The updated Low forecast assumes that messaging usage will plateau at around 114 messages per subscriber per month, the Medium forecast approaches 140 messages per month by 2020/21, and the High demand forecast exceeds 271 messages per month in 2020/21. These values are very similar to the low and medium scenarios used in the April 2010 consultation where messages in the low scenario were assumed to plateau around 110 messages per month, the medium scenario approached 140 messages a month, and the high scenario reached 271 messages per month.

[23] See the discussion in the 2010 Communications Market Report of increased bundled minutes within mobile access charges – Sections 5.1.2, 5.2.4 and 5.2.6. http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr10/

Figure A6.7: Forecasts for monthly outgoing messages per subscriber



Source: Analysys Mason

A6.57 The 2007 cost model forecast the expected proportion of total messages that were MMS to increase to 5.1% for 2G and 6.1% for 3G by 2020/21. However, historical data from the MCPs shows that by Q1 2010/11 the proportion of MMS had fallen from a peak in early 2006/7 of 0.84% for 2G and 1.76% for 3G, to 0.45% for 2G and 0.55% for 3G. Taking this into account, we have assumed that the proportion of messages which are MMS will remain at 0.5% for 2G, and for 3G will drop from 0.8% to 0.6% by 2020/21. The 2G assumption is the same as the April 2010 cost model. The terminal value for 3G is slightly higher than the April 2010 cost model, and is now forecast to plateaued at 0.5%.[24]

A6.58 There were no specific responses to the April 2010 consultation on SMS and MMS traffic.

Handset-based data services

2011 cost model

A6.59 The national MCPs were not able to accurately report the split of handset-based data traffic carried over either 2G or 3G handsets in past years. However, reliable national MCP information is available on the amount of data traffic usage by technology, and the proportion of total data traffic generated by datacards usage. By combining all this information we have estimated the amount of data traffic carried over 2G handsets and 3G handsets. Our revised forecasts for handset-

[24] The average sizes of SMS and MMS messages are unchanged in the model at 0.15kbytes per SMS and 50kbytes per MMS.

based 2G data usage are shown in Figure A6.8 below, while those for 3G are shown in Figure A6.9.

A6.60 Since 2007, 2G handset data usage has grown strongly, and by the end of 2009 average usage was just over 1Mbyte per month. Our Medium and High forecasts assume that this growth will continue, in varying degrees, so that by 2020/21 average usage per subscriber per month reaches 1.4, 2.35 and 5.85 Mbytes in the low, medium and high scenarios respectively. The Low forecast assumes that growth levels off as forecast we used in the subscribers interested in data services migrate to 3G. These are the same as the April 2010 cost model.

A6.61 Regarding 3G data usage, there was relatively little consumer demand for 3G data services on handsets until the recent emergence of devices such as smartphones. Widely observed behaviour in a variety of consumer markets where data services have become available suggests that demand for these data services is likely to grow.[25] Such devices are likely to lead to increasing demand for data services on handsets in the future, and we have revised the model assumptions to take this into account (Figure A6.9 below).

A6.62 The iPhone (made by Apple) exemplifies this trend. There is some evidence from T-Mobile in Germany that iPhone users currently generate over 100Mbytes per month of data traffic per subscriber.[26] Orange has also stated that, in countries where its customers have access to an iPhone, average iPhone usage is around 200Mbytes per month.[27] It is not completely clear whether this usage is all over the mobile network, or over a combination of mobile and WiFi networks – but either way, it is likely that a substantial amount is carried over the mobile network. Our High demand forecast reaches 100Mbytes per month for 3G handsets during 2017/18. This forecast therefore appears to be consistent with a scenario where, within 10 years, the average 3G subscriber consumes a similar amount of data to a heavy user today.

A6.63 Taken together, Figure A6.8 and Figure A6.9 show that data usage on 3G handsets is much higher than data usage on 2G handsets. Recently there has been high growth in data usage on 3G handsets and because of this we are forecasting higher data traffic than in the April 2010 cost model.[28]

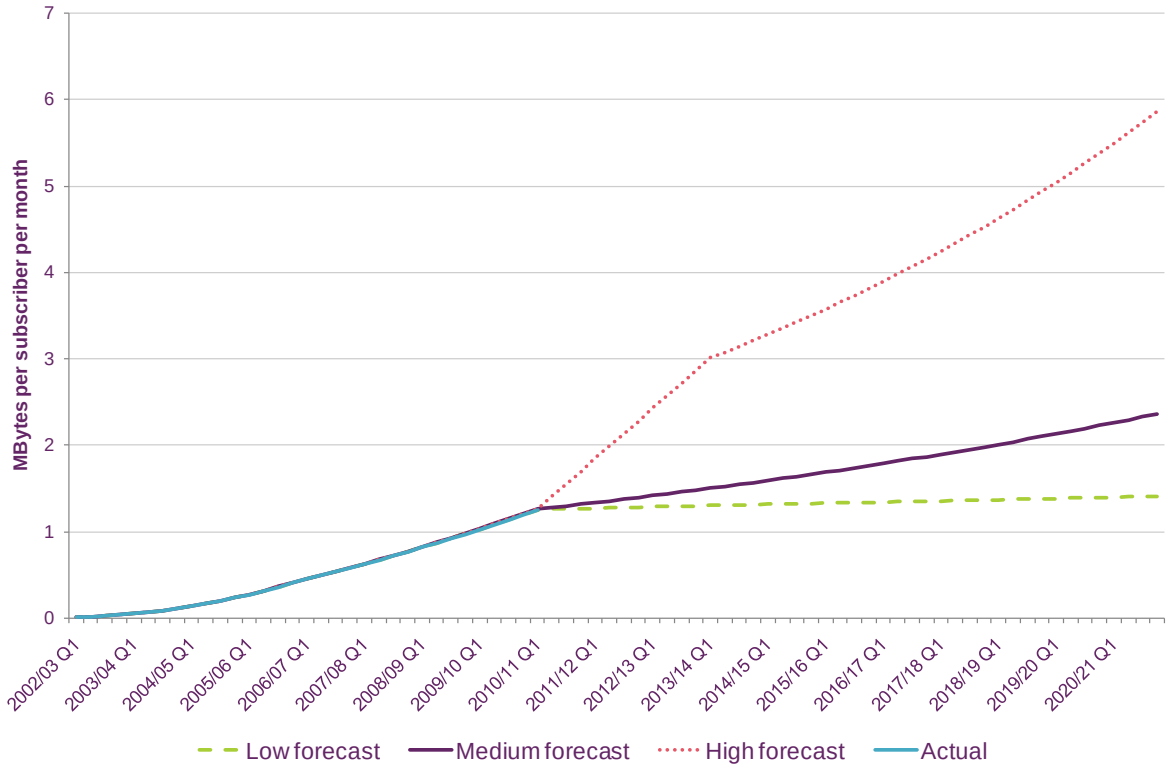
[25] See Section 5.1.3 of the Ofcom Communications Market Report2010. http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr10/

[26] See http://www.unstrung.com/document.asp?doc_id=144563&f_src=unstrung_gnews

[27] See http://www.macworld.co.uk/ipod-itunes/news/index.cfm?newsid=27643

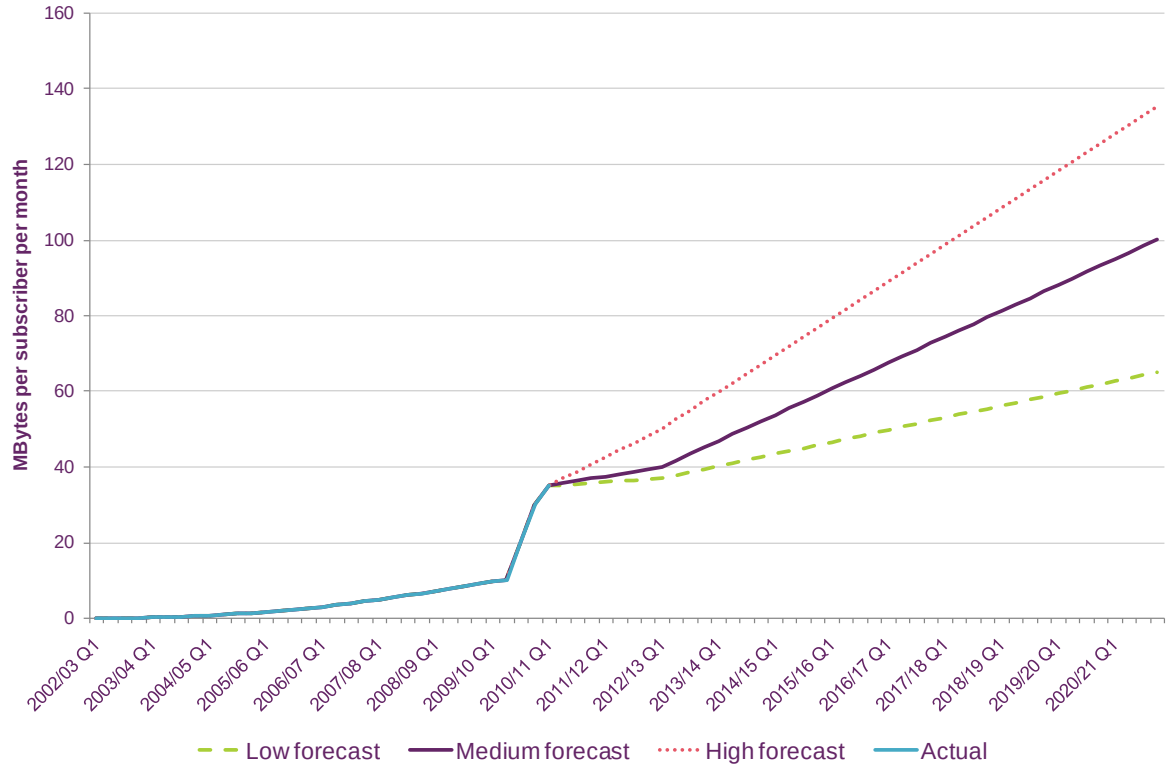
[28] In the April 2010 cost model the low, medium and high scenarios for 3G handset data usage had values in 2020/21 of 25Mbytes, 60Mbytes and 135Mbytes respectively.

Figure A6.8: Forecasts for monthly 2G handset data usage per subscriber



Source: Analysys Mason

Figure A6.9: Forecasts for monthly 3G handset data usage per subscriber



Source: Analysys Mason

Responses to the April 2010 Consultation

Vodafone

A6.64 Vodafone submitted that the April 2010 cost model underestimated GPRS data volumes and the peak throughput for GPRS by not taking into account 3G traffic being carried on 2G due to lack of coverage. Vodafone suggested that we should correct for this by creating a new traffic scenario to shift data traffic demanded from HSPA to GPRS.[29]

Ofcom's response to specific points raised by stakeholders

A6.65 We agree in part with Vodafone's comments. Contrary to Vodafone's submission, the MCT cost model does rebalance 3G data to 2G data. However the rebalancing applies a downlift factor of 90% which results in some traffic being 'lost'. In theory, it would be better to correct that effect, for example, by rebalancing the lost data traffic towards the geotypes where there is 3G coverage. However the effect is minor (as acknowledged by Vodafone) and we consider that the additional modelling complexity and resources required to male this change is not warranted.

Datacard take-up and usage

2011 cost model

A6.66 Mobile broadband datacards have emerged as a significant driver of network traffic; by the end of Q1 2009/10 there were more than [✂] mobile broadband datacards in the UK, from a base of just [✂] at the end of 2006/7.[30] Despite initial optimism about the potential of mobile broadband to offer a competitive alternative to fixed broadband, recent surveys have highlighted the relatively slow speeds delivered (compared to fixed broadband) and a generally low level of user satisfaction.[31] It is therefore not clear if mobile broadband will continue its very fast growth and become ubiquitous, or reach a plateau at a lower level of take-up. At present, it appears that mobile broadband is largely used as a *complement* to fixed broadband, and only to a limited extent as a *substitute* in the UK. However, the percentage of households that have mobile broadband as their only form of broadband access doubled between Q1 2009 and Q1 2010 (from 3% to 6%).[32] Although mobile broadband only households are increasing they still represent a small proportion of the total. As such, we have assumed that under all demand forecasts, mobile broadband will largely remain a complement to fixed broadband.

A6.67 Nevertheless, we expect mobile broadband to continue growing: a report by Analysys Mason Research in February 2009[33] forecast that mobile broadband will reach a penetration of around 27% of the UK population by the end of 2014.[34] However, historical growth appears to be a little below the forecasts in that report.

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[29] Vodafone response Annex 3 pages 59-60. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf

[30] Source: Operator data from Section 135 data requests.

[31] Ofcom Communications Market Report 2010, page 356. http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr10/

[32] Communications Market Report 2010, page 348. http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr10/

[33] http://www.analysysmason.com/Research/Content/Reports/RDMM0-Mobile-broadband-Europe-2009-2014-Feb2009/

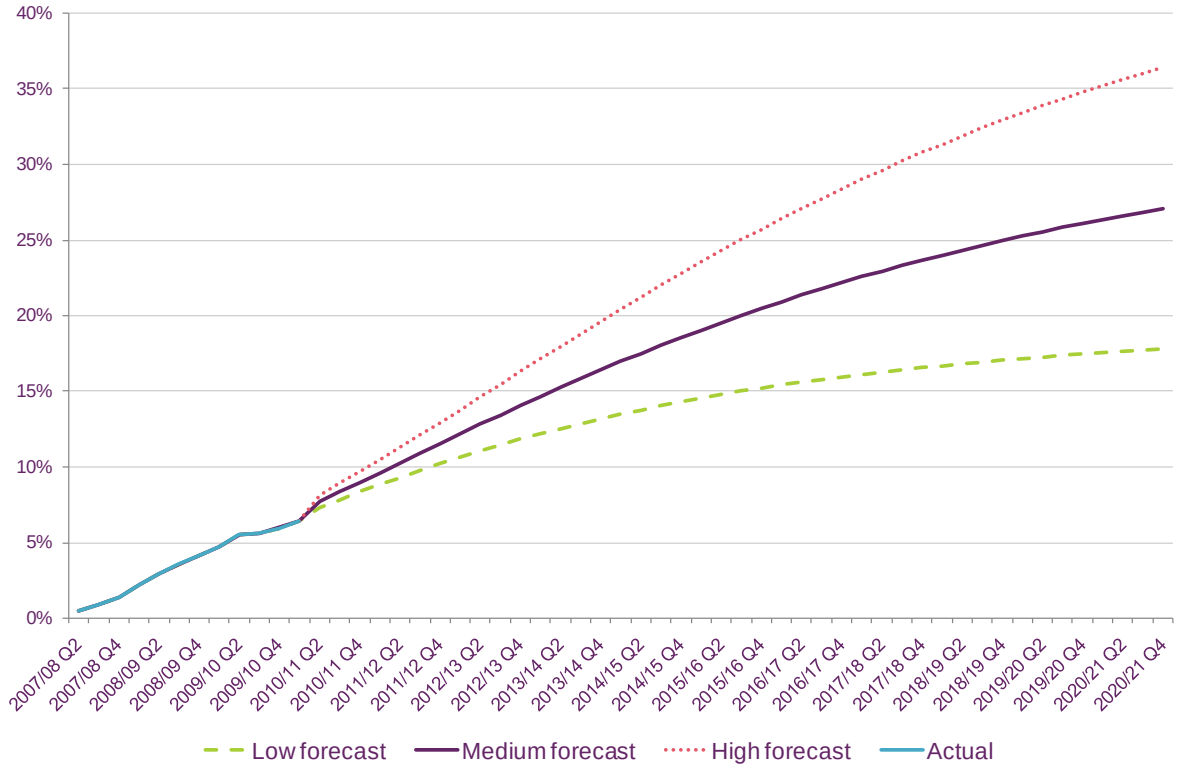
[34] We expect the datacard market to be given a significant boost by the nascent tablet market, which can access fixed networks through WiFi and mobile networks through a SIM card.

For example, at the end of 2008 the report forecast a penetration of 4.3% whereas actual penetration was around 3.6% (noting that the forecast did not have access to actual subscriber numbers for the end of 2008). Taking these figures into account, we have developed a Medium demand forecast that is more conservative than the 2009 Analysys Mason study. Our Medium forecast reaches 19% penetration at the end of 2014/15, and 27% by the end of 2020/21 (see Figure A6.10 below). The Low demand forecast reaches 18% by 2020/21, and the High forecast reaches 36% by the end of 2020/21.[35]

A6.68 Information obtained from the national MCPs[36] suggests that prior to the rapid growth in mobile broadband (which also occurred at a similar point in time to the deployment of HSPA), usage per datacard was lower than at present, at around 100Mbytes per month. However, with the rapid growth in subscribers, lower pricing, and the availability of HSPA, the usage per datacard rapidly rose to around 900Mbytes per month by the end of 2008/09. Since then growth appears to have moderated. Based on this recent data, we have revised the forecasts in the 2011 cost model (see Figure A6.11 below). Our Medium demand scenario assumes that usage per device will decrease from about 1050 Mbytes in Q1 2010/11 to 1000 Mbytes over the model period. This is in contrast to constant 900Mbytes per month in the April 2010 cost model medium scenario. However, mobile broadband is still in its early stages and historical trends may not be a good predictor for the future. The Low demand forecast is to capture a scenario where new users have lower levels of usage, which dilutes the average usage. The low demand forecast has a similar value to the April 2010 cost model, however the higher demand scenario is higher at 1750MB per month rather than 1500MB per month in 2020/21.

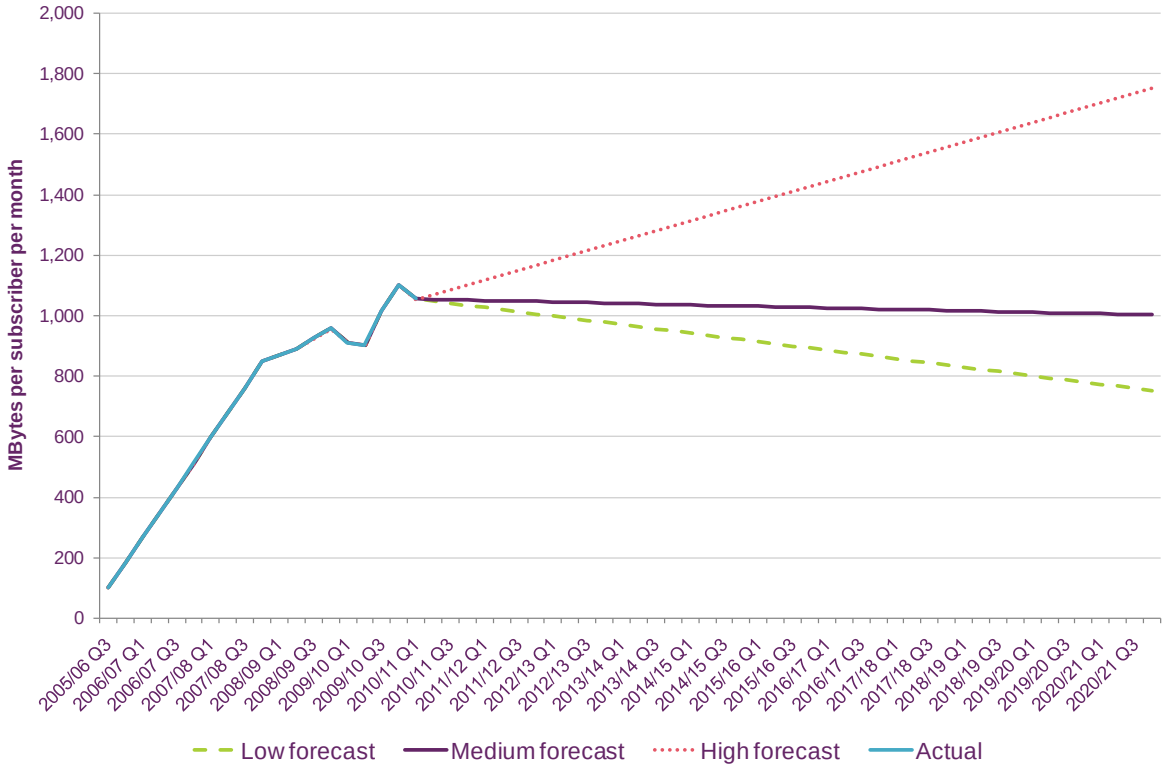
[35] The Low and Medium terminal forecasts are the same as the April 2010 cost model, however we have reduced the high scenario which was 51% in 2020/21.
[36] Source: Operator data from Section 135 data requests.

Figure A6.10:Forecasts for datacard take-up



Source: Analysys Mason

Figure A6.11: Forecasts for monthly 3G data usage per datacard



Source: Analysys Mason

Responses to the April 2010 Consultation

Vodafone

A6.69 Vodafone, in its response to the consultation, raised a concern that the datacard forecast in the April 2010 cost model was too optimistic in all three Ofcom scenarios in the context of a MCT cost model that was only considering data on 3G. It compared those scenarios with analyst reports and concluded by suggesting a new forecast based on the forecast by Enders Analysis until the end of 2012 and on projecting that value to 10m datacards at the end of 2020.[37] [38]

A6.70 Vodafone also argued that it was not appropriate to use the same market share value for handsets and datacards. It used the example of H3G which has a low voice market share but a very high datacard market share. Vodafone believed that we should use different market shares for handsets and datacards. It suggested that the market share for a 2G/3G operator should drop below 20% after H3G began its aggressive datacard offering.[39]

[✂]

A6.71 [✂][40]

A6.72 [✂][41]

Ofcom's response to specific points raised by stakeholders

A6.73 We do not agree with Vodafone regarding the datacard forecasts for three reasons.

A6.74 First, the forecast for future datacard adoption is uncertain. The Enders Analysis report used by Vodafone does not try to forecast datacards beyond 2012 and the 10m figure for the number of datacards is a Vodafone assumption. In fact the most recent edition of that report does not include any forecasts.[42] Additionally there are signs that datacard adoption is increasing. As discussed previously, Ofcom's Communications Market Report indicated that the percentage of households that have mobile broadband as their only form of broadband doubled between Q1 2009 and Q1 2010.

A6.75 Secondly, Vodafone stated that the datacard forecast was too optimistic in all three Ofcom scenarios in the context of a model that is only considering data on 3G. However we do not believe that the absence of the modelling of a 4G network constrains the forecasts of the number of datacard subscribers. Not modelling 4G means that there is no 4G spectrum, no 4G network modelled and that the data usage projected on our 2G/3G cost model is likely to be lower than it would be with a 2G/3G/4G. This does not however preclude the number of datacards (rather than usage) being similar with or without a 4G network.

[37] When comparing with the MCT cost model outputs we take Vodafone's reference to 2020 to mean financial year 2020/21.
[38] Vodafone response to April 2010 consultation, Annex 3 pages 61-66. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[39] Vodafone response to April 2010 consultation, Annex 3 pages 58-59. Ibid
[40] [✂].
[41] [✂].
[42] Enders Analysis, UK residential broadband market 2010, http://www.endersanalysis.com/content/publication/uk-residential-broadband-market-2010

A6.76 Third, the number of datacards suggested by Vodafone (10 m) is very close to the low case sensitivity analysis we already use (i.e. 18% penetration is close to 10m) - so our analysis includes a scenario similar to the future Vodafone describes in its response. In any event, as can be seen in Annex 10 - and as noted further below – using this scenario makes very little difference to the pure LRIC output.

A6.77 We do not agree with Vodafone that we should use a different market share for handsets and datacards. Vodafone is correct to state that MCP market shares do differ between handsets and datacards. Indeed, the smallest of the national MCPs (H3G) holds a large share of the datacard market. However, we are attempting to model a hypothetical average efficient national MCP; we are not attempting to model a specific business case. We believe that keeping the market share identical for both handsets and datacards best reflects a hypothetical average efficient operator.

A6.78 We do not agree with [✂] that [✂].

A6.79 In respect of the concern raised by [✂] and Vodafone that our data demand projections are too high, it should first be noted that the pure LRIC estimate in our 2011 cost model that is used to set the benchmark for efficient costs of MCT exhibits very low sensitivity to data traffic projections.

A6.80 In so far as [✂] is concerned that an increase in prices for data services would reduce data demand and hence traffic, this issue is linked not only to whether current data pricing is realistic (for our discussion on this point see further below in this section and Annex 9) but also to various non-price factors which might influence data service demand.

A6.81 Therefore, apart from updating our traffic forecasts using the most recent data available from the MCPs (i.e. Q1 2010/11), we have not made any significant changes to our traffic forecasting approach.

Proportion of data traffic on the 2G and 3G networks for 3G subscribers and migration of subscribers to 3G handsets

A6.82 It is our understanding that even though a subscriber may use a 3G-capable handset, a significant proportion of that user's voice traffic is still routed via the 2G network. This situation could be the operator choosing to route voice traffic over the 2G network, or the user disabling the 3G functionality of their handset. To allow for this possibility, we have assumed that a proportion of all voice traffic originated and terminated by a 3G handset user is routed over the 2G network. In the April 2010 cost model this proportion was held at 40% for the entire modelling period.

A6.83 In the 2011 cost model, the rate of migration from 2G-only to 3G-enabled handsets is based on an assumption that the proportion of handsets that are 3G-enabled will reach 78% by 2020/21, up from 33% in Q4 2009/10. The terminal value is the same as that used in the April 2010 cost model, but the Q4 2009/10 value is slightly higher than the 32% used by the April 2010 cost model given the height of more recent actual data. The calculation of the number of new handsets requires an assumption on the market (average) rate of subscriber (i.e. handsets) churn. In the 2011 cost model, this assumption remains unchanged from the April 2010 (and 2007) cost model at 10% per quarter.

A6.84 The forecast migration from 2G to 3G services is much slower than the 2007 cost model, which forecast that 3G subscribers would represent 99.6% of total

subscribers by 2020/21. As noted above, the 2011 cost model now assumes this figure to be 78% (see Figure A6.12 below). This slower rate of migration is supported by data which show that 29% of handsets were 3G-capable in Q1 2009/10 compared to a forecast of 44% in the 2007 cost model.[43]

Responses to the April 2010 consultation

H3G

A6.85 H3G agreed with us that 2G/3G operators currently route a proportion of 3G traffic onto 2G networks. However, H3G argued that in the April 2010 cost model there was an inefficiently large proportion of traffic routed over the 2G network and that routing any traffic over the 2G network would not be efficient in the longer term. H3G believed that 2G/3G operators only route 3G traffic onto the 2G network due to existing sunk 2G costs. As 3G network costs are lower than 2G network costs, in the future 2G/3G operators would replace 2G capacity with 3G capacity meaning there would be no need for such routing behaviour. H3G suggested that the proportion of 3G traffic routed onto 2G networks should decrease over time to reflect the lower cost of the 3G network.

A6.86 H3G also argued that the 3G handset migration assumption used in the April 2010 cost model was too conservative. H3G accepted that the 2007 cost model had forecast higher migration than actually occurred, but it argued that the April 2010 cost model was not aggressive enough in its new migration assumptions. H3G argued that the rate of migration was to a large extent under the control of the 2G/3G MCPs. As the 3G network is lower cost than the 2G network, 2G/3G MCPs should be accelerating migration via greater handset subsidies.[44]

Virgin Media

A6.87 Virgin Media argued that the level of traffic carried over the 3G network in the April 2010 cost model was too high. Virgin Media argued that we allowed a faster migration to 3G handsets than observed in reality.[45]

Ofcom's response on 3G/2G traffic proportions

A6.88 In response to H3G's comments on the routing of 3G user traffic onto the 2G network, we consider that the proportion modelled is reasonable for the period to date, as this is informed by the data from the national MCPs with both 2G and 3G networks – which forms the technology mix of our hypothetical efficient national network. We accept that assuming that this value stays constant over time until 2020/21 or beyond might not seem reasonable. With MCPs continuing to expand their 3G coverage and subscribers continuing to acquire 3G capable handsets, one would expect an efficient operator to increasingly migrate its network traffic to the 3G layer.[46]

[43] Data collected from the responses to the August 2009, October 2009 and July 2010 S135 data requests.
[44] H3G response to the April 2010 consultation, Section 5 pages 60-62. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf
[45] Virgin Media based this argument on the proportion of 3G handsets in Figure 7 in Annex 8 of the April 2010 Consultation. Virgin response to the April 2010 consultation, pages 10. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Virgin.pdf
[46] Indeed the calibration exercise described in Annex 7 showed that it was necessary to let the parameter 'Proportion of traffic generated by a 3G sub that is deliberately originated by operators on

A6.89 We agree with H3G that the proportion of traffic for 3G users that is routed onto the 2G network will decline over time. Given 3G is the more efficient technology it is rational for a 2G/3G network to run ever more of the 3G handset generated traffic over the 3G network. We have changed our assumption for this proportion so that it declines gradually from 40% in Q4 2009/10 to 0% by Q4 2020/21 (as opposed to remaining at 40% as in the April 2010 cost model).

Ofcom's response on migration from 2G-only to 3G handsets

A6.90 We accept Virgin Media's observation that Figure 7 in Annex 8 of the April 2010 consultation does not correspond with our statement on the forecast 3G migration path. There was not an error in the number of handsets being 3G capable in 2009/10 Q4 in the model; the data in the model indicated that 31.7% of subscribers were 3G capable in 2009/10 Q4. However, the chart in the April 2010 consultation document was mis-labelled and, in fact, showed the proportion of gross additions that took a 3G handsets (rather than the proportion of total handsets that were 3G). We have now only included the chart showing the 3G migration profile (Figure A6.12).

A6.91 We do not agree with H3G that our assumption for the speed of migration from 2G to 3G is inappropriate. Although it is true in the 2011 and April 2010 cost model that 3G unit costs are lower than 2G unit costs, we cannot be certain that this would necessarily accelerate the migration from 2G to 3G handsets compared to the base case. This migration depends on a number of factors, including the relative wholesale cost of 3G and 2G handsets and the profile of future handset churn. As the migration from 2G to 3G involves a cost being incurred by the MCP and/or subscriber, we do not believe that H3G's suggestion necessarily holds. Since our forecasts are based on observed trends we prefer to rely on these to project the rate of migration from 2G to 3G. The path of migration to 3G handset in the 2011 cost model is shown below in Figure A6.12.

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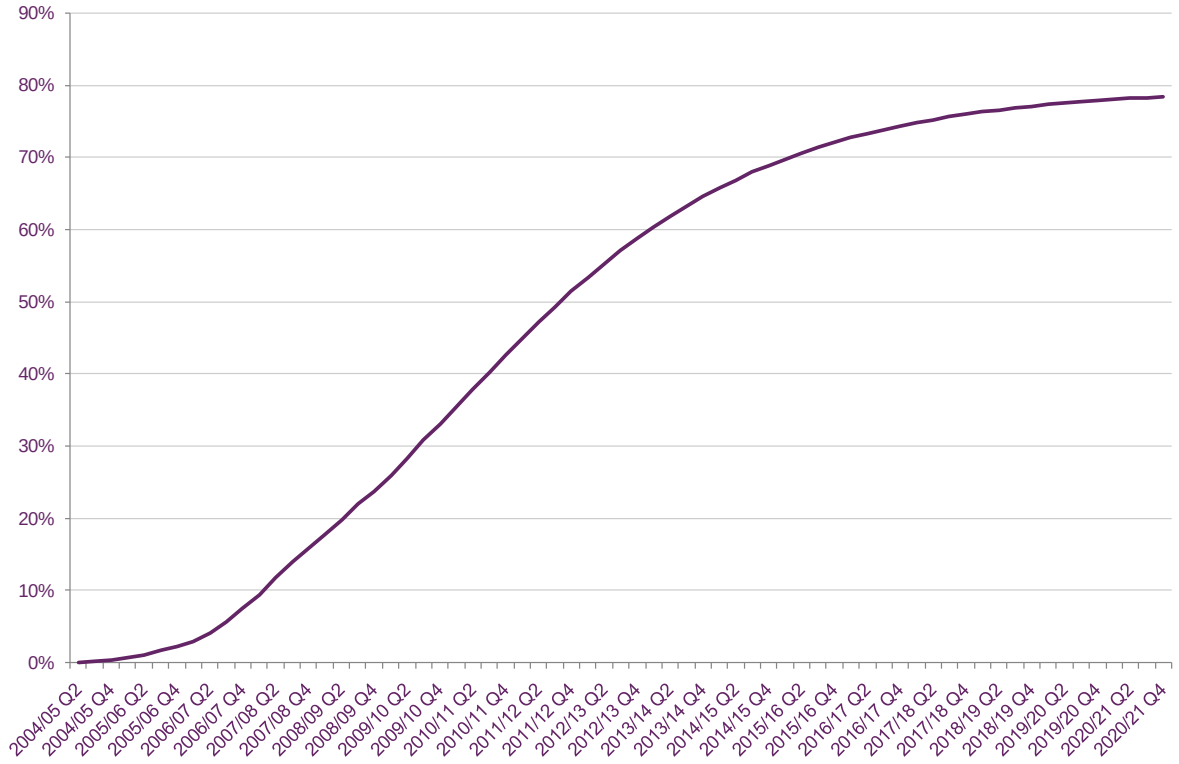
the 2G network (additional to coverage limitations)' fall from 40% to 0% by 2020/21 in order to meet the required number of 3G sites forecast by MCPs.

Figure A6.12: Forecast migration to 3G-capable handsets



Source: AnalysysMason[47]

Market Share Profiles

2011 cost model

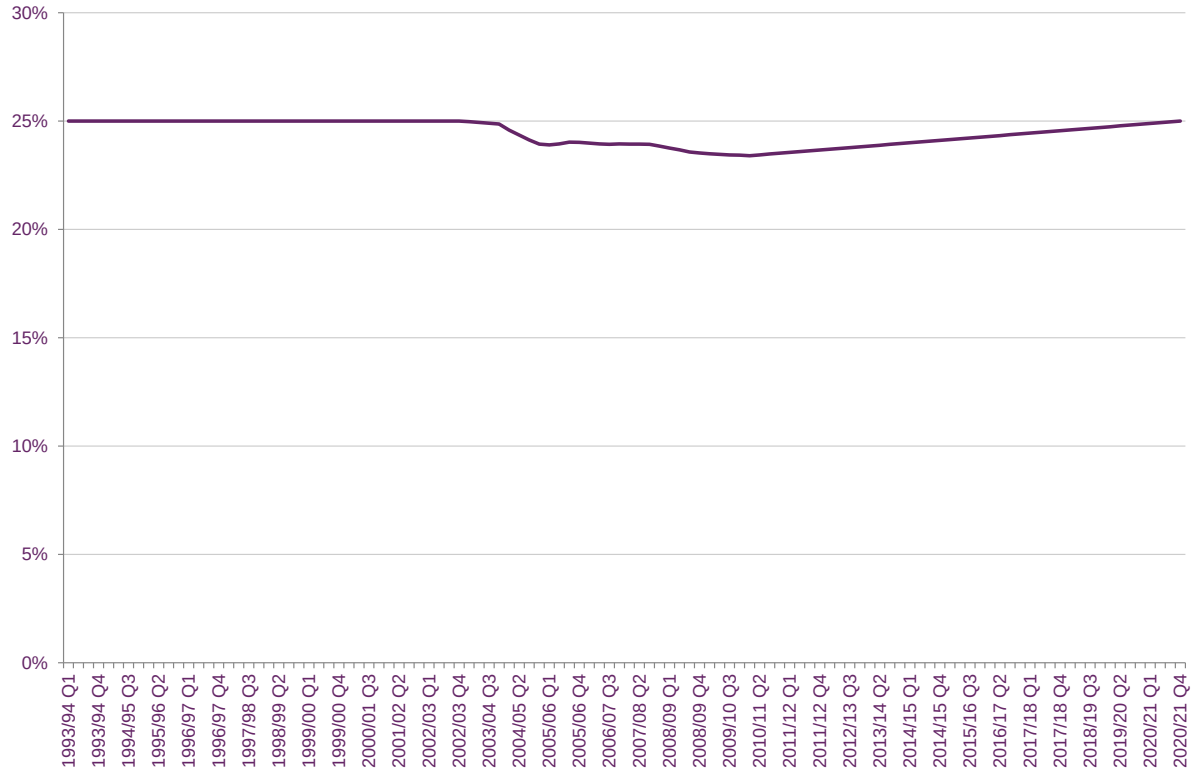
A6.92 The market share profile is based on that used in the 2007 cost model. In the 2007 cost model the market share was declining from 25% to reach 20% in 2020/21. In the 2011 cost model, between 2003/04 and Q1 2010/11 market share declines from 25% prior to the entry of the 3G-only operator to 23.40%. Due to the merger (via a joint venture) between Orange and T-Mobile we explained in the April 2010 consultation that we considered it more appropriate to move towards a 25% market share (corresponding to four players).[48] Accordingly, from Q2 2010/11 onwards the market share in the 2011 cost model increases towards 25%. As part of the calibration, in the 2011 cost model, we have slightly smoothed the decline and increase in the market share profile relative to that seen in the April 2010 cost model.

[47] We are aware that the migration to 3G in this chart differs slightly from the migration path assumed in Ofcom's 2G liberalisation consultation (2009) Annex 9 Figure 10.
http://www.ofcom.org.uk/consult/condocs/spectrumlib/annex9.pdf
However, the modelling in these two projects is seeking to answer different questions and is based on different assumptions. The MCT cost model seeks to model a hypothetical efficient operator given currently available technology. The 2G liberalisation project considers changes in the types of technology used to deliver mobile services. For instance, the 2G liberalisation looked at the migration of 3G from 2.1GHz spectrum to "fast 900MHz", however, the MCT cost model is only considering an operator using 2.1GHz and 1800MHz spectrum.

[48] April 2010 consultation, paragraph 9.54 and A8.37-A8.38.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf

A6.93 This market share profile is shown in Figure A6.13 below. As discussed below, we believe that a 25% market share is consistent with the 2009 EC Recommendation and reflects an appropriate efficient scale benchmark for our average efficient operator.

Figure A6.13: Market share evolution in the model



Source: Analysys Mason

Responses to the April 2010 Consultation

O2

A6.94 In response to the April 2010 Consultation, O2 argued that we had not provided sufficient evidence for a change in market share from 20% to 25% and that we had not demonstrated why the UK should have a different minimum scale from that in the 2009 EC Recommendation (20%). O2 noted that as a result of the Orange and T-Mobile merger, we stated that asymmetries between the UK market and other EU markets had reduced. O2 also suggested that we should estimate the minimum efficient scale as the point in the average total cost curve beyond which no significant economies of scale can be achieved.[49]

[49] O2 response to the April 2010 consultation, Section F page 62.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf

Everything Everywhere

A6.95 EE commented that our assumption of a 25% market share was inconsistent with our market definition. It argued that because we defined the market by number range rather than by network we should include all operators that hold a number range in our 1/n calculation of market share, where n is the number of national operators.[50]

Ofcom's response to specific points raised by stakeholders

A6.96 In the April 2010 consultation, we discussed how the use of a 25% market share was a simplification. Nevertheless, we considered that this simplification fitted the facts reasonably well and was consistent with the 2009 EC Recommendation.[51] The 2009 EC Recommendation states that NRAs should "...*prove that the market conditions in the territory of that Member State would imply a higher minimum efficient scale*".[52]

A6.97 Setting the efficient scale as 1/n is a well established principle in MCT reviews. In both the 2007 and the 2004 MCT reviews, the market share assumption was set as 1/n (25% in 2004 and 20% in 2007). It should also be noted that the April 2010 cost model was not set at 25% for the entire life of the model. Rather, 25% was assumed to be the terminal value that a hypothetical efficient network would reach in 2020/21.

A6.98 As noted above, O2 has stated that we should estimate the minimum efficient scale as the point in the average total cost curve beyond which no significant economies of scale can be achieved. In economic theory the concept of minimum efficient scale is indeed the minimum level of output at which average total costs are minimised. However, the concept is based on a single product. In the context of multi-product industries (e.g. mobile networks) with multiple cost drivers (i.e. coverage, subscribers, traffic) and outputs, estimating the minimum efficient scale would be a complex and disproportionate exercise.

A6.99 Even if it were reasonably easy to identify the minimum efficient scale, we do not believe this would be the conceptually correct approach to determining the level of unit costs for charge control setting. That is, the purpose of regulation is to mimic the outcome of a competitive market. While minimum efficient scale may be a useful indicator of the degree of contestability of a market, it is not the sole determinant of the equilibrium number of firms in a competitive market. Since 1994, there have been at least four – and from 2003 to 2009, five – national MCPs. Therefore, in the context of a hypothetical efficient network cost model built around 2G and 3G/HSPA infrastructure on a national scale, a choice between 20% or 25% is the appropriate range to consider for market shares. Since the consolidation of Orange and T-Mobile, we consider that for the 2011 cost model.

A6.100 Moreover, simply because we are assuming a market share of 25%, it does not mean that we exclude the possibility that a firm could have a different market share

[50] EE response to the April 2010 consultation, Section 5 page 49.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Everything_Everywhere.pdf
[51] See 2009 EC Recommendation :
http://www.cableeurope.eu/uploads/090507_COM_Recommendation%20TR.pdf
[52] 2009 EC Recommendation – Explanatory Note: page 26.
http://ec.europa.eu/information_society/policy/ecomm/doc/implementation_enforcement/eu_consultation_procedures/explanatory_note.pdf

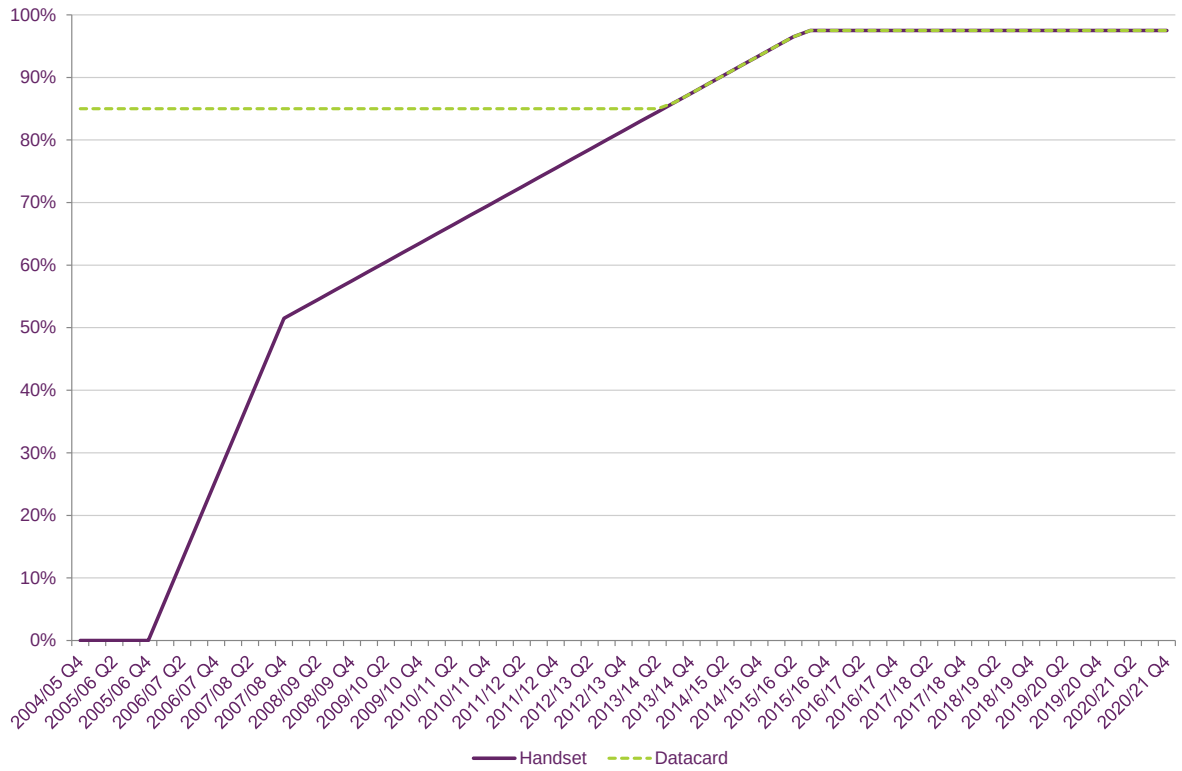
and operate viably. In fact, given the range of business models we would expect different market shares just as we expect different operators to use different technologies. However, for a MCP which operates its own national network (on which the cost model is based), we consider that a 25% wholesale market share is reasonable.

Technology mix for 3G services

2011 cost model

A6.101 Datacards and newer 3G handsets are generally enabled with HSPA functionality, but there is still a base of 3G handsets that cannot utilise the HSPA network. As a result, separate assumptions for the proportion of traffic carried over the HSPA network are used for 3G handsets and datacards. The cost model needs to estimate the split of data usage on 3G networks between Release 99 and HSPA services. It is therefore necessary to forecast the proportion of 3G data services that will be carried over the HSPA network. Our forecast (Figure A6.14, below) has been designed to be in line with the HSPA deployment by the four national MCPs. The inter-relationship between 3G, Release 99 and HSPA is explained in the section on the network module of the 2011 cost model below (paragraph A6.108).

Figure A6.14: Proportion of 3G data traffic carried across the HSPA network



Source: Analysys Mason

A6.102 There were no responses to the April 2010 Consultation regarding the 3G technology mix assumptions (i.e. the split between HSPA and Release 99 data carried on handsets and datacards).

Geotypes and network coverage

2011 cost model

A6.103 'Geotypes' are a means of classifying different geographical segments of the UK according to the likely density of traffic and building clutter that is experienced in those segments.[53] These factors have a direct influence on the number of sites that are required to provide: (a) network coverage and (b) sufficient network capacity to carry all of the traffic in the busy hour. The geotype definitions used in the 2011 cost model are an attempt to capture these geographical factors, and are defined on the basis of population density (as a proxy for variations in traffic density and building clutter). The model includes a total of nine geotypes, which have not changed since the 2007 cost model.

A6.104 The proportion of the UK within each geotype has been estimated using geographical analysis of the postal sector areas in the UK. Demand is then distributed by geotype.

Table A6.1: Distribution of population, area and traffic by genotype

Geotype	Minimum population density (people per km^2)	Percentage of population in geotype	Percentage of area in geotype	Percentage of traffic in geotype
Urban	7959	6.0%	0.1%	12.8%
Suburban 1	3119	30.0%	1.6%	59%
Suburban 2	782	32.8%	4.8%	14.0%
Rural 1	112	21.2%	19.4%	5.9%
Rural 2	47	7.0%	23.3%	1.7%
Rural 3	25	2.0%	13.7%	0.4%
Rural 4	0	1.0%	37.0%	0.2%
Highways	N/A	0.0%	0%	3.0%
Railways	N/A	0.0%	0%	3.0%

Source: Analysys Mason

A6.105 There were no responses to the April 2010 Consultation regarding the geotype assumptions.

[53] For example, city centres with high traffic density and high building clutter versus rural areas with low traffic density and low building clutter.

A6.106 We have kept the definition of geotypes used in the April 2010 cost model in the 2011 cost model. For a 2G/3G operator we believe that long-term 2G coverage of just below 99% and 3G coverage of just below 92% is appropriate for a hypothetical average efficient operator. 3G coverage has been increased slightly from the 2007 cost model. This is due to assumed implementation of site sharing, which makes coverage viable in some previously uneconomic areas. Once site sharing is introduced (see A6.134) 3G coverage increases to 97.6% As part of the calibration process for the 2011 cost model, we have very slightly reduced the long term coverage from that used in April 2010 cost model. For sensitivity analyses involving a 3G-only operator 99% coverage levels are assumed. The population coverage in 2020/21 by geotype for our base-case scenario is given in Table A6.2 below.

Table A6.2: Population coverage assumptions in the Base Case (2020/21)

Geotype	2G population coverage for an average efficient operator	3G population coverage for an average efficient operator
Urban	100.0%	100.0%
Suburban 1	99.0%	99.0%
Suburban 2	99.0%	99.0%
Rural 1	99.0%	98.0%
Rural 2	97.0%	95.0%
Rural 3	80.0%	64%
Rural 4	84.0%	67%
Highways	100.0%	93.0%
Railways	100.0%	93.0%
Overall	**98.4%**	**97.6%**

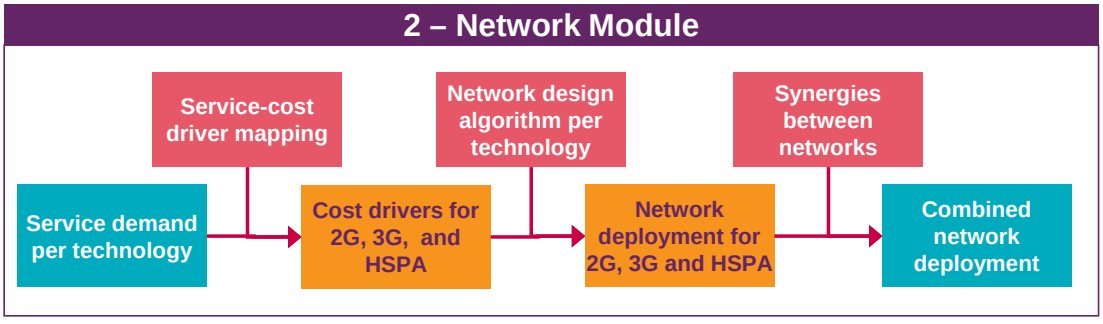
Source: Analysys Mason

Network module

Overview

A6.107 The network module calculates the deployment of each type of 2G and 3G network asset which is required to meet the forecast levels of service demand and coverage in each year. The flow of calculation in this module is illustrated below:

Figure A6.15:Calculation flow of the network module



* The detailed calculation flows in the Network workbook are too numerous and complex to show in a diagram

- Non-scenario dependent input
- Intermediate calculation
- Output or Input

A6.108 The network module has been designed to model an operator with both 2G and 3G/HSPA. For an operator with both 2G and 3G/HSPA networks, certain assets (e.g. cell sites) may be shared between the 2G and 3G/HSPA networks. HSPA technology has been modelled as an additional feature on the 3G network with

HSPA traffic sharing a 3G carrier with Release 99 traffic. We discuss below the comments received on the network module of the April 2010 cost model and the changes we have implemented. We also corrected a number of computational errors identified by stakeholders and by us during the 2011 cost model review process. These corrections include:

- correction of the error in summing shared sites and transformation sites;[54]
- 2G inter-switch and 3G inter-switch circuit-switched traffic have been uplifted to fix an incorrect voice data rate used in inter-switch port calculations;[55]
- the reference to the 3G microcell utilization value has been corrected to use 90%;[56]
- correction of the error when aggregating asset quantities dimensioned in each geotype;[57] and
- correction of MMS and SMS routing factors.[58]

Network traffic demand

Responses to the April 2010 Consultation

Vodafone

A6.109 Vodafone commented that the number of 2G handsets recorded in the economic workbook is not the same as that recorded in the traffic workbook. It suggested that this mismatch was caused by the application of a smoothing factor in the cost workbook.[59]

A6.110 Vodafone also claimed that the differentiation between the level of the voice busy hour (8%) and the data busy hour (7.5%) created a mismatch between cost dimensioning and cost recovery, since the former is calculated based on the busy hour and the latter on annual volumes, where the lower contribution of data on busy hour dimensioning is not being recognised. To correct this discrepancy in cost recovery between voice and data services, Vodafone suggested diluting data traffic by a ratio of 0.9375 (=7.5%/8%), reflecting its more even use throughout the day and therefore its lower impact on the costs associated with network dimensioning. It also suggested, that the difference between the voice busy hour and the data busy

[54] The April 2010 model showed 2,428 shared sites and 2,428 transformation sites but 9,712 total shared sites.
[55] The port calculations were using a value of 14.4 kbit/s for 2G and 12.2 kbit/s for 3G instead of 64 kbit/s in the April 2010 cost model.
[56] The incorrect reference in the April 2010 cost model resulted in using a value of 95%.
[57] In the April 2010 cost model, the asset quantities were not aggregated together correctly when carried over from one workbook to another.
[58] In the April 2010 cost model, MMS was incorrectly treated as voice traffic for the purpose of calculating cost drivers. We have corrected this and MMS is now considered as a data service. The routing factor for the SMS service was incorrectly adjusted for the additional efficiency of 3G data compared to 3G voice in the April 2010 cost model.
[59] Vodafone response to the April 2010 consultation, Annex 3 page 46. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf

hour should be higher, and that a data dilution ratio of 0.9 would be more appropriate, but emphasised that this would still be a conservative value. [60]

H3G

A6.111 H3G observed that the busy hour calculations did not exclude traffic on weekends when converting annual traffic to busy hour traffic. It suggested using a grossed up "weekday equivalent" instead of the 250 busy days a year used in the April 2010 cost model.[61]

Ofcom's response to specific points raised by stakeholders

A6.112 We do not agree with Vodafone's assertions that there is a mismatch between the 2G handset numbers and the forecast customer numbers. For all years, the (year-average) 2G handset numbers are an average of the corresponding quarterly forecast subscriber numbers. The smoothing factor that Vodafone refers to as the possible source of the alleged error is in fact not impacting the 2G handset numbers. We agree that it would be more appropriate to use an average of quarterly mid-points, rather than quarterly end-points when dimensioning the network and have changed this calculation accordingly to use quarterly mid-points.

A6.113 We agree with H3G that traffic falling on a weekend should be taken into account in estimating the busy hour traffic for network dimensioning. An adjustment for weekend traffic was included in our cost-benefit model used in the 2009-10 review of the routing of calls to ported numbers.[62] We asked MCPs for additional data on traffic in the busy hour.[63] Based on this evidence we have added a 'share of traffic in weekdays' ratio, which is equivalent to the grossed up 'weekday equivalent' approach suggested by H3G. The data provided by the MCPs indicated that the 'share of traffic in weekdays' ratio was about 80% for voice and data services.

A6.114 We agree with Vodafone that the difference in the busy hour proportions for voice and data needs to be taken into account in cost allocation and cost recovery. This is because as costs are recovered over annual volumes, an inappropriately low proportion of costs will be recovered from voice services when the voice busy hour is greater than that for data (with the corollary that too much cost is recovered from data traffic). We have therefore included a data dilution factor, that mirrors the implementation of the HSPA efficiency factor, to account for the difference in the proportions of voice and data traffic in the busy hour when allocating asset costs to voice and data services.[64]

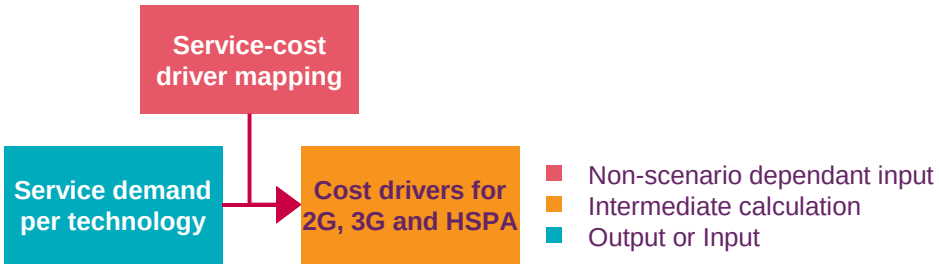
Cost drivers

A6.115 In order to dimension 2G and 3G/HSPA networks on the basis of cost causation relationships, the network module first converts the demand for each service (incoming calls, outgoing calls, SMS, data, etc.) under the selected input scenario

[60] Vodafone response to the April 2010 consultation, Annex 3 pages 77-79. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[61] H3G response to the April 2010 consultation, Section 5 pages 58-59. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf
[62] For the treatment of this issue in the review of routing of calls to ported numbers, see the Routing calls to ported telephone numbers statement, available at: http://stakeholders.ofcom.org.uk/consultations/gc18_routing/
[63] As part of the July 2010 S135 data request.
[64] The data dilution factor accounts for the difference in busy hour traffic proportions for voice and data in cost recovery.

into a number of specific cost drivers, each of which drives the deployment of certain network assets. A common measure of traffic output is required so that demand from multiple services can be aggregated appropriately. Traffic for each service is therefore converted into voice-equivalent busy-hour Mbit/s. A matrix of routing factors is then applied in order to map the services onto a full set of network cost drivers. This approach is shown in Figure A6.16.

Figure A6.16:Cost driver calculation flow



A6.116 An important issue when converting services into cost drivers is the relative efficiency with which circuit-switched (i.e. voice) and packet-switched (i.e. data) services are carried on the 3G radio network. The 2007 cost model concluded that packet-switched traffic is transmitted on average three times as efficiently as the transmission of circuit-switched voice traffic over 3G (Release 99). We have reviewed this assumption and believe that it is still valid.[65]

Responses to the April 2010 Consultation

Vodafone

A6.117 Vodafone identified a discrepancy between the number of billed voice minutes and the Erlang load observed on its network and was of the view that billed minutes was an inadequate proxy for the actual volume of network traffic used in network dimensioning. It commented that this might be caused by the unbilled minutes related to the call set-up time and suggested using a ring time uplift factor to account for that discrepancy. Vodafone suggested a ring time duration of 8 seconds per call.[66]

A6.118 Vodafone also suggested that the costs of the main switch sites should not be recovered using the total throughput cost driver but instead should have used the cost driver based on MSC processing. Vodafone also suggested that a floor space cost driver may be theoretically better but concluded that the MSC processing driver would be a reasonable and simple proxy.[67]

A6.119 Vodafone also suggested that the cost drivers used for allocating backhaul and site costs should be modified to take into account the fact that circuit-switched services require over-provisioning of capacity while packet-switched services do not require

[65] The resulting voice-equivalent capacity of a 3G carrier is therefore 0.36Mbit/s for voice services and 1.07Mbit/s for Release 99 data services. Assuming an average bit rate of 12.2kbit/s for voice services, this equates to a maximum of 29 Erlangs per carrier.
[66] Vodafone response to the April 2010 consultation, Annex 3 pages 54-55. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[67] Vodafone response to the April 2010 consultation, Annex 3 page 83. Ibid.

any over-provisioning of network capacity. Vodafone suggested scaling up the voice allocation in the cost drivers by 137%.[68]

A6.120 Vodafone also raised a concern on the modelling of incoming calls terminating on voicemail. In the April 2010 cost model, the voicemail terminated traffic was not included in dimensioning the radio access network, but was included in the voice minutes used for cost recovery in calculating the unit costs of termination. Vodafone argued this was incorrect and suggested either to recover costs over all incoming voice volumes minus the ones terminated on voicemail or not to discard voicemail traffic in the cost drivers.[69]

H3G

A6.121 H3G in its response to other operator comments agreed with Vodafone's suggestion on the discrepancy between the number of billed voice minutes and the Erlang load on the network but indicated that a longer call duration should be used that would reduce the impact of a ring time uplift on unit costs of termination.[70]

A6.122 H3G argued that the use of 'all radio traffic' (a cost allocation driver based on service demand) for cell sites was not appropriate because it did not take into account the different demands placed by 2G traffic and 3G traffic on cell site capacity. H3G commented that the typical cell site capacity for 3G traffic is much higher than that for 2G traffic and this was not reflected in the 'all radio traffic' cost driver. H3G noted that an effect of this was that that the pure LRIC cost of 3G call termination was higher in the case of a 2G/3G operator than in the case of a 3G-only operator (with similar coverage and demand). H3G therefore suggested either to model 2G and 3G elements separately or to adjust the 'all radio traffic' driver so that each 3G output unit was a quarter of each 2G output unit.[71]

Ofcom's response to specific points raised by stakeholders

A6.123 We agree with Vodafone and H3G on the need to uplift the billed voice minutes to account for the ring time associated with each call. We have introduced a ring time uplift corresponding to 8 seconds per call based on information submitted by the national MCPs and as suggested by Vodafone.[72]

A6.124 In addition to the introduction of the ring time uplift factor, we have also modified call durations in accordance with the latest information provided by the MCPs. For incoming calls the duration has been set to 1.70 minutes per call. This compares with the April 2010 cost model call duration of 1.17 minutes per incoming call.[73]

A6.125 We do not agree with Vodafone's suggestion of using the 'MSC processing' cost driver to allocate the costs of main switch buildings. We note that this would recover all main switch sites from voice and video services, but not data services. Indeed main switch sites also house other network assets (i.e. BSC, RNC, SGSN, GGSN,

[68] The scale factor of 137% corresponds to the case where 30 voice channels provide a capacity of 21.93 Erlangs. Vodafone response to the April 2010 consultation, Annex 3 pages 81-83. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[69] Vodafone response to the April 2010 consultation, Annex 3 pages 79-81. Ibid
[70] H3G's response to other operator comments is available at: http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/three.pdf
[71] H3G response to the April 2010 consultation, Section 5 pages 62-64. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf
[72] Based on responses to the July 2010 S135 data request.
[73] Ibid

etc.) which support both voice and data services. Therefore, we have used a floorspace based cost driver to allocate the costs of the main switch buildings in the 2011 cost model.

A6.126 The new approach splits the existing main switch building assets into assets allocated to voice services, assets allocated to data services and assets shared between voice and data services. The assets allocated to voice services are recovered based on the 'all voice traffic' cost driver. The assets allocated to data services are recovered based on the 'all data traffic' cost driver. The assets shared between voice and data services are split according to the circuit-switched and packet-switched cost drivers. The share of floor space used by voice-related equipment is calculated based on the floor space weights used to dimension the number of main switch sites as described in paragraph A6.165.

A6.127 We recognise Vodafone's comment that in the April 2010 cost model the Erlang over-provisioning for voice in network dimensioning was not fully reflected in the allocation of costs of some network assets. We have adjusted the cost drivers related to some radio network assets to account for this over-provisioning for voice traffic. We do not consider that a similar adjustment is necessary for the allocation of cell site costs, since the number of cell sites is driven both by coverage requirements and network capacity demand and therefore the impact of Erlang over-provisioning for voice traffic might not be a significant cost driver of cell site costs. We consider that it would be significantly more complex to carry out a more detailed assessment of the impact and, given the time and resource required to do so, we concluded this would be disproportionate to the likely change in the model outputs. Therefore, we have reflected the Erlang over-provisioning for voice traffic in capacity driven radio network assets such as cell site equipment, 2G TRXs, 2G BSCs, 3G RNCs and backhaul, but have not applied any adjustments to the cell site cost drivers where the relationship with Erlang over-provisioning is less clear.

A6.128 New cost drivers, reflecting the Erlang over-provisioning for voice, are used in the 2011 cost model to allocate the costs of relevant assets. These new cost drivers are derived from traffic cost drivers by uplifting for 2G and 3G over-provisioning for voice traffic. In order to estimate the 2G Erlang uplift value for voice traffic that should be used in the 2011 cost model, we calculated the additional channel capacity due to Erlang over-provisioning by comparing the number of TRXs that would be required with and without the Erlang over-provisioning. The 2G Erlang uplift fluctuates slightly over time before converging to a value close to 137% as suggested by Vodafone.[74] The 3G Erlang uplift value starts at 130% when voice dominates the first carrier and increases with the share of data traffic to a value of approximately 175% by 2014/15. Based on this analysis, we have used a value of 137% for the 2G Erlang uplift factor and a value of 175% for 3G. These values are are held constant over time in the 2011 cost model.

A6.129 We agree with Vodafone that the separation of voicemail traffic in the April 2010 cost model was not reflected in the relationship between cost causation and cost allocation and cost recovery. However, we do not agree with Vodafone's suggested approaches to correct for this. Neither of Vodafone's suggestions take into account that voicemail terminated calls and handset-terminated calls do not incur the same level of termination costs. Therefore, we have added the costs of the voicemail platform in the 2011 cost model (by adding a new asset, the voicemail server) and recovered a proportion of the costs through incoming voice minutes terminating on

[74] This corresponds to 30 voice channels and Erlang capacity of 21.93 Erlangs resulting in a ratio of 137%.

voicemail.[75] The net effect is that the cost of voice termination is a blend of the costs of the respective voicemail terminated calls and handset-terminated calls.[76]

A6.130 We do not agree with H3G's comments on the cell site cost allocation for the following reasons.

- Firstly, although the all radio traffic cost driver did not make a distinction between 2G voice and 3G voice, it took into account the different demands placed by 3G data traffic. It considered a unit of 3G Release 99 data traffic to be equivalent to one third of a unit of voice traffic and this ratio was increased to one sixth of a unit of voice traffic with the deployment of HSPA.[77]

- Secondly, the vast majority of sites of 2G/3G operators are shared between the two technologies, so the impact of any changes to the modelling of cell sites to reflect the 2G and 3G costs separately would not significantly change the unit costs of termination. Attempting to account for the number of 2G-only, 3G-only and 2G/3G-sites and the traffic associated with them would add a significant level of complexity, especially given that the technologies deployed on a site changes over time and the change would also interact with other parts of the model such as the smoothing algorithm (which prevents the decommissioning of sites that will be needed in the near future). We considered it would be disproportionate and unduly time consuming to change the structure of the 2011 cost model by adding the complexity necessary to capture the effects of 2G-only and 3G-only sites.

Network dimensioning

A6.131 A number of technical parameters are required in order to establish quantifiable relationships between cost drivers and network deployment. The parameters which affect the dimensioning of 2G and 3G/HSPA networks in the model are (a) the cell radii, (b) the traffic demand per cell, and (c) equipment capacities (including the radio, backhaul, backbone and core network assets).

A6.132 In order to derive a realistic assessment of cost structures for our hypothetically efficient national MCP, the 2011 and April 2010 cost models use a bottom-up approach that calculates the quantities of each type of network asset required. The approach for dimensioning 2G and 3G/HSPA networks is the same as in the 2007 cost model. Under this approach the radio network is dimensioned for whichever is the greater of coverage and capacity requirements within each geotype.

Site sharing

A6.133 In the April 2010 cost model, we modelled site sharing between a pair of operators recognising the existence of site sharing arrangements between national MCPs. We included two types of transformation costs, sharing costs and decommissioning costs, to capture the unit investment costs involved in sharing a site between two MCPs. The following capex assumptions were used based on information provided by the four national MCPs:[78]

- cost of sharing a site: £17,000

[75] The costs of the voicemail server are allocated to incoming and outgoing voice traffic.
[76] This is the case for both pure LRIC and LRIC+.
[77] The factor of 3 is applied in the routing factors table of the 'Cost drivers' sheet and the factor evolving from 1 to 2 is applied in the 'Network traffic section' of the 'Element output' sheet.
[78] Based on data received in response to the August 2009 and October 2009 S135 data request.

- cost of decommissioning a site: £20,000.

A6.134 We assumed in the April 2010 cost model that site sharing began in Q1 2007/08, and that all macrocell sites were shared by the end of Q1 2014/15. Sites existing before the start of the agreement were upgraded for sharing or were decommissioned evenly over this period. In the April 2010 cost model the opex of a shared site was 50% of that of a non-shared site. The investment costs of sites constructed after the agreement began were also reduced by 50%.

Responses to the April 2010 Consultation

Vodafone

A6.135 Vodafone commented that the 50% capex reduction was not appropriate as it failed to take into account the capex for upgrading or decommissioning sites.[79]

A6.136 [✂].[80]

A6.137 Vodafone commented that assuming that site sharing started in April 2007 was not reasonable, given the time it would take for the sharing operators to agree on the way forward. It then suggested introducing a delay of 12 months.[81]

A6.138 Vodafone commented on the extent of site sharing and argued that it would be more reasonable to assume that up to 90% of sites could be shared rather than all macrocell sites.[82]

A6.139 Vodafone also commented that the April 2010 cost model was not consistent in its treatment of the impact of site sharing on 2G and 3G coverage. Vodafone observed that the modelled operator would have 2G area coverage of 96.8% and a 3G area coverage of 42.4% at the end of the sharing period. Vodafone submitted that sharing operators would equip new shared sites with both 2G and 3G equipment and concluded that 3G area coverage would increase to just under 55% by the end of the decade.

Ofcom's response to specific points raised by stakeholders

A6.140 We do not agree with Vodafone's comment on the amount of capex savings for shared sites in the model. In the first stage of costing shared sites, capex savings are indeed set at 50%, to split the cost of a cell site operated by a single operator between two operators. However, the additional costs associated with making a site shareable are accounted for separately, which results in less than 50% capex savings overall. More specifically, additional capex is incurred to transform a site or share a new site. Both the April 2010 and 2011 cost models assume that 50% of incremental shared sites are transformation sites and that the remainder are new sites. The net effect is to reduce capex savings from 50% to 30%.

A6.141 [✂][83,84]

[79] Vodafone response to the April 2010 consultation, Annex 3 pages 67-69. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[80] Vodafone's confidential response to S135 information request of 30 July 2010.
[81] Vodafone response to the April 2010 consultation, Annex 3 page 67-69. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[82] Vodafone response to the April 2010 consultation, Annex 3 Page 69. Ibid

A6.142 We do not agree with Vodafone's comment on the timing of site sharing. We are modelling a hypothetical efficient operator and continue to believe that the assumed start date of April 2007 is appropriate. The information we received from national MCPs in response to S135 information requests indicated that site sharing existed in 2007.[85]

A6.143 We have revised the extent of site sharing in the 2011 cost model. For technical and geographical reasons we believe that it would not be possible to share all macrocell sites. We believe that 90% of macrocell sites being shared, as suggested by Vodafone, is a more appropriate reflection of network deployment by a hypothetical efficient national MCP.

A6.144 The extent of 3G area coverage in the April 2010 cost model at end of the sharing period was 43%. We have increased the long-term 3G area coverage to 81.2% by 2020/21 (i.e. 90% of the 2G coverage) taking into consideration Vodafone's comment on the likelihood of 3G equipment being deployed at all new sites and information on [✂] forecast 3G area coverage.[86]

A6.145 Table A6.3 below shows how the site sharing parameters have evolved between the April 2010 cost model and the 2011 cost model.

[83] Based on responses to the July 2009 and August 2009 S135 data requests.
[84] As noted above opex saving of 50% was used in the April 2010 cost model.
[85] August 2009 and October 2009 S135 data requests.
[86] This confidential information was provided by [✂] as part of their S135 submission.

Table A6.3:Site sharing parameters

Parameter	April 2010 cost model	2011 cost model
Cost of sharing a site	£17,000	£17,000
Cost of decommissioning a site	£20,000	£20,000
Sharing begins	Q1 2007/08	Q1 2007/08
Sharing ends	Q1 2014/15	Q1 2014/15
Proportion of sites shared at the end	100%	90%
Opex of shared sites as % of non-shared site	50%	57.5%
Capex of new shared sites after new site sharing agreements signed	50%	50%
Pop 3G coverage at the end (Q1 2014/15)	90%	97.4%
Area 3G coverage at the end (Q1 2014/15)	43%	80.3%

Source: AnalysysMason

2G-specific network dimensioning

A6.146 A series of network design algorithms are applied to create asset requirement projections for the 2G network. The 2G algorithms in the April 2010 cost model were identical to those in the 2007 cost model, though a few changes have been made to some of the parameters which drive these algorithms. These changes have all been influenced by the data submitted by the national MCPs,[87] advice from Analysys Mason, or as part of the calibration process. These changes are listed in Table A6.4 below.

[87] Based on responses to the August 2009 and October 2009 S135 data requests.

Table A6.4: 2G network dimensioning parameters in the 2011 cost model

Parameter changed	Details of change
Number of 2G sites deployed	When our demand forecasts were entered into the 2G network dimensioning worksheet we found that 2G site numbers started to decrease from 2008/09 and then increase again in later years of the model. To solve this problem a "look ahead" function has been added to the model. This look ahead ensures that 2G sites are not removed, only to be added again in later years.
Proportion of data traffic in the downlink	75% (this is unchanged from the April 2010 cost model)
Proportion of traffic carried over macro, micro and pico cells	Proportions are kept constant at 2001/02 values for each year thereafter. This assumption is unchanged from the April 2010 cost model.
Average 2G cell radii for 1800MHz spectrum in different geotypes	These parameters have the same values as the 2007 cost model.[88] In addition there is a 1% decrease in cell radii in each geotype between 2007/08 and 2010/11. This has been added as part of the 2011 cost model calibration process.
BSC unit capacity	The number of TRXs that can be supported by a BSC is 400.[89]
MSC unit capacity	The CPU capacity of a 2G MSC is 15 million busy-hour milliseconds.[90]

Responses to the April 2010 Consultation

Vodafone

A6.147 Vodafone commented that the calibration of 2G cell sites in the April 2010 cost model was not as good as the calibration in the 2007 cost model.[91] It explained that one of the key reasons was that the 2G cell radii had been reduced resulting in a greater number of 2G sites being deployed early for coverage reasons and suggested reverting to the values used in the 2007 cost model. Vodafone provided additional suggestions on how to improve 2G calibration. Those comments are discussed in the calibration annex (Annex 7).

[88] We decreased the 2G cell radii in the April 2010 cost model and have reverted to using the values from the 2007 cost model in the 2011 cost model
[89] We used a value of 512 TRXs in the April 2010 cost model. This value has been changed as a result of the calibration process.
[90] We used a value of 30 million busy-hour milliseconds in the April 2010 cost model. This value has been decreased as a result of the calibration process.
[91] Vodafone response to the April 2010 consultation, Annex 3 Page 70

Ofcom's response to specific points raised by stakeholders

A6.148 We consider that Vodafone's comment regarding 2G cell radii is reasonable and, in a first step towards re-calibration, we have reset the 2G cell radii to the values used in the 2007 cost model. The 2G cell radii are then decreased slightly between 2007/08 and 2010/11 to improve calibration of the 2011 cost model. This has resulted in a better alignment of the 2G site numbers with the average number of deployed 2G cell sites in the 2011 cost model compared to the April 2010 cost model.

3G-specific network dimensioning

A6.149 As with 2G network dimensioning, a series of design algorithms are applied to create asset requirement projections for the 3G/HSPA network. Although many of these algorithms are identical to those implemented in the 2007 cost model, a number of changes were made in the April 2010 cost model to include HSPA modelling. The parameters that are used in the 2011 cost model are shown below in Table A6.5.

Table A6.5: 3G network dimensioning parameters in the 2011 cost model

Parameter changed	Details of change
Maximum sectors per site	The maximum number of sectors per macro site has been reduced from four to three. This is unchanged from the April 2010 cost model.
Proportion of data traffic in the downlink	75% (unchanged from the April 2010 cost model)
HSPA deployment	HSPA 3.6 Mbit/s deployed between 2006/07 and 2007/08. HSPA 7.2 Mbit/s deployed between 2007/08 and 2008/09. HSPA 14.4 Mbit/s deployed between 2009/10 and 2011/12. These parameter are unchanged from the April 2010 cost model.
Base station unit capacity	Voice capacity of 0.36 Mbit/s. Data (Release 99) capacity of 1.07 Mbit/s. Data (HSPA) capacity of 2.14 Mbit/s.
RNC unit capacity	Voice Erlang capacity of 6000 Erlangs.[92] Mbit/s capacity has the same value it had in the 2007 cost model.[93]
Changes to 3G average cell radii for 2100MHz spectrum in	Suburban 1: increased from 0.85km to 1.45km Suburban 2: increased from 1.4km to 1.80km[94] Rural 2: increased from 3.94km to 4.20km

[92] We used a value of 15,000 Erlangs in the April 2010 cost model
[93] We used 400 Mbit/s in the April 2010 cost model
[94] We used a value of 1.7 km in the April 2010 cost model

different geotypes	

Responses to the April 2010 Consultation

Vodafone

A6.150 Vodafone commented that the April 2010 cost model did not take into account the cell breathing effect with lower volumes of traffic under the 'without termination' scenario and did not reduce the number of micro and pico cells sufficiently for the 'without termination' scenario. Vodafone then inferred that the model was not able to flex the assumptions in the pure LRIC approach.[95]

A6.151 Vodafone claimed that the 3G non-homogeneity allowance (which captures the fact that demand for mobile services is not constant across all sites within a geotype) had been erroneously eliminated the April 2010 cost model and argued that it should be either retained or replaced with a similar adjustment.[96]

A6.152 Vodafone raised concerns that some asset types in some years produced negative quantities with the removal of termination traffic and identified Node-B facing RNC ports as an example of such an asset type.[97] Vodafone also commented that incremental backhaul links fluctuated extensively in some time periods.[98] Vodafone was of the view that the forecast data volumes would only be possible with more advanced technologies than currently modelled. Vodafone suggested using a HSPA data down-lift factor of 7 rather than 6 to reflect future HSPA performance improvements.[99]

A6.153 Vodafone[100] and other stakeholders, including H3G[101], [✂][102] and Virgin Media[103], commented, based on their practical experience, that the forecast 3G cell site numbers in the April 2010 model were too low to meet the expected traffic volumes.

Ofcom's response to specific points raised by stakeholders

A6.154 We note that H3G provided a counter argument to Vodafone's general comment that the April 2010 cost model was not suitable for pure LRIC, specifically that removing voice termination traffic was similar to a time-shift in volumes. Section 10 discusses the pure LRIC estimation approach including the comments by Vodafone.

A6.155 We agree with Vodafone's comment on the non-homogeneity allowance. This non-homogeneity of demand within a geotype is captured in network dimensioning in the 2011 cost model through a 3G non-homogeneity factor. This factor is similar to the one used for 2G. It is set at 0.5 for macrocells and 0.0 for microcells and picocells

[95] Vodafone response to the April 2010 consultation, Annex 3 Pages 100, 105-106. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[96] Vodafone response to the April 2010 consultation, Annex 3 page 76. Ibid.
[97] Vodafone response to the April 2010 consultation, Annex 3 page 103. Ibid
[98] Vodafone response to the April 2010 consultation, Annex 3 page 103. Ibid
[99] Vodafone response to the April 2010 consultation, Annex 3 pages 60-61. Ibid.
[100] Vodafone response to the April 2010 consultation, Annex 3 pages 74-75. Ibid.
[101] H3G's response to the April 2010 consultation, Section 5 pages 65-66.
[102] [✂]
[103] Virgin Media's response to the April 2010 consultation, page 10

as the factor is inappropriate for modelling the deployment of microcells and picocells.[104]

A6.156 We agree with Vodafone that the model could indicate negative assets (and hence costs) for some asset types when termination traffic is removed from the model; for example, Vodafone identified that Node B-facing RNC ports increased during some years when termination was removed. We agree that the model could show negative quantities for some assets. This is caused by the swapping of asset types on the basis of traffic volumes, for example, the swapping of TDM links with Ethernet backhaul (as explained in A6.164). When termination traffic is removed, the number of sites and the number of backhaul links decrease, but not in the same proportion. This results in a different TDM links per site ratio impacting the timing of the Ethernet backhaul deployment in a geotype. Asset types, such as Node-B facing RNC ports, that are linked to the swapped assets could also show negative quantities. We are satisfied that the 2011 cost model is behaving correctly.

A6.157 We do not agree with Vodafone's suggestion to use a value of 7 for the HSPA data downlift factor as a proxy for modelling advanced HSPA technologies. As far as we are aware, HSPA+ is not yet deployed at a significant level in any of the UK mobile networks and there is no clear indication of planned deployments. Therefore we consider the exclusion of future HSPA+ enhancements to be an appropriate reflection of the choices that would be made by a hypothetical efficient MCP today and as noted in Section 10 is consistent with our technology neutral approach in this and other recent charge controls.

A6.158 In respect of the comments from Vodafone and other respondents regarding 3G cell site numbers being too low, we have addressed this point through our calibration exercise for the 2011 cost model. The changes to cell radii and the proportion of 3G sites shared with 2G, together with inclusion of a 3G non-homogeneity factor, have increased the number of forecast 3G cell sites in the 2011 cost model. The 2011 costs model forecasts a total of 17,865 cell sites in 2020/21.[105]

[104]The non-homogeneity allowance is not appropriate for microcells and picocells because microcells and picocells are more homogeneous than macrocells as they are deployed to meet demand in traffic hotspots.

[105] The April 2010 cost model forecast for total cell sites was approximately 14,000 in 2020/21.

3G/2G shared network dimensioning

A6.159 The 2G and 3G network dimensioning algorithms in the MCT cost model separately calculate the site requirements for each network. These requirements are then passed to a 2G/3G site-sharing algorithm to capture the use of shared assets to carry 2G and 3G traffic. The 2G/3G shared network dimensioning establishes how many of the 3G sites can be shared with 2G sites rather than purchased as standalone sites. The proportion of incremental 3G sites (additional 3G sites for that year) which will be shared with 2G sites is used as an input to this calculation and is listed in Table A6.6. These values were adjusted from the values used in the April 2010 cost model to aid the calibration of the 2011 cost model.

Table A6.6: Proportion of incremental 3G sites shared with 2G

	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09 onwards
2007 cost model	100%	85%	80%	80%	75%	70%	65%	65%
April 2010 cost model	100%	95%	92%	87%	77%	72%	67%	67%
2011 cost model	100%	100%	100%	100%	100%	50%	50%	40%

Source: Analysys Mason

A6.160 In order to model the effects of backhaul sharing, we calculated the total backhaul capacity that would be required in a geotype for both the 2G and 3G network cell sites. Backhaul is then deployed to accommodate the implied average traffic per site. Two types of backhaul are provisioned: TDM microwave and Ethernet. By default TDM microwave backhaul is deployed, and this is later replaced by Ethernet links. In the April 2010 cost model, Ethernet backhaul deployment was triggered when more than four 2Mbit/s TDM microwave links per site would be required. However, no Ethernet links were deployed before 2009/10 regardless of capacity needs.

Responses to the April 2010 Consultation

Vodafone

A6.161 Vodafone noted there was an issue with the dimensioning of main switching sites based on the number of 2G MSCs, 3G MSC servers and SGSNs in the April 2010 cost model. The use of a capacity driver to estimate the equivalence between SGSNs and 2G MSCs resulted in the number of main switch sites jumping to 30, the maximum allowed, as soon as a single SGSN was deployed instead of a more gradual increase in the number of switch sites. Vodafone suggested using a floor space driver to calculate equivalences between 2G MSCs, 3G MSC servers, SGSNs, non-remote RNCs and non-remote BSCs.[106]

[106] Vodafone response to the April 2010 consultation, Annex 3 pages 48-49. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf

Ofcom's response to specific points raised by stakeholders

A6.162 We agree with Vodafone's comment on switch site dimensioning and have modified the algorithm calculating the number of main switch sites to be based on a floor space driver. We have therefore introduced a floor space cost driver for allocating the costs of switch sites between voice and data services in the 2011 cost model. The floor space ratios for different asset types, relative to a MSC-Server, have been used to estimate these cost drivers.[107]

A6.163 While investigating Vodafone's comments on Erlang over-provisioning for voice (presented in paragraph A6.120), we identified that the April 2010 cost model incorrectly applied the Erlang uplift to backhaul data traffic. This was the case for both 2G and 3G but more of a problem for 3G data (because 2G data is about 5% of 2G traffic while 3G data is above 85% of 3G traffic from 2008/09). We have therefore removed the Erlang uplift from 3G data traffic.

A6.164 During the model update process, we identified that under a specific scenario (with a busy hour value for data higher than for voice), the pure LRIC total costs to recover for certain assets could become negative. A negative cost recovery profile was caused by Ethernet backhaul links, under the "no incoming traffic" case, being deployed earlier than under the "with incoming" scenario. The change in Ethernet deployment timing between the two scenarios was caused by the TDM link per site reaching the Ethernet deployment trigger threshold earlier in the 'no incoming' scenario. We have reduced this threshold to 3.5 TDM links per cell site, recognizing that cell sites within a geotype would gradually migrate to Ethernet backhaul.

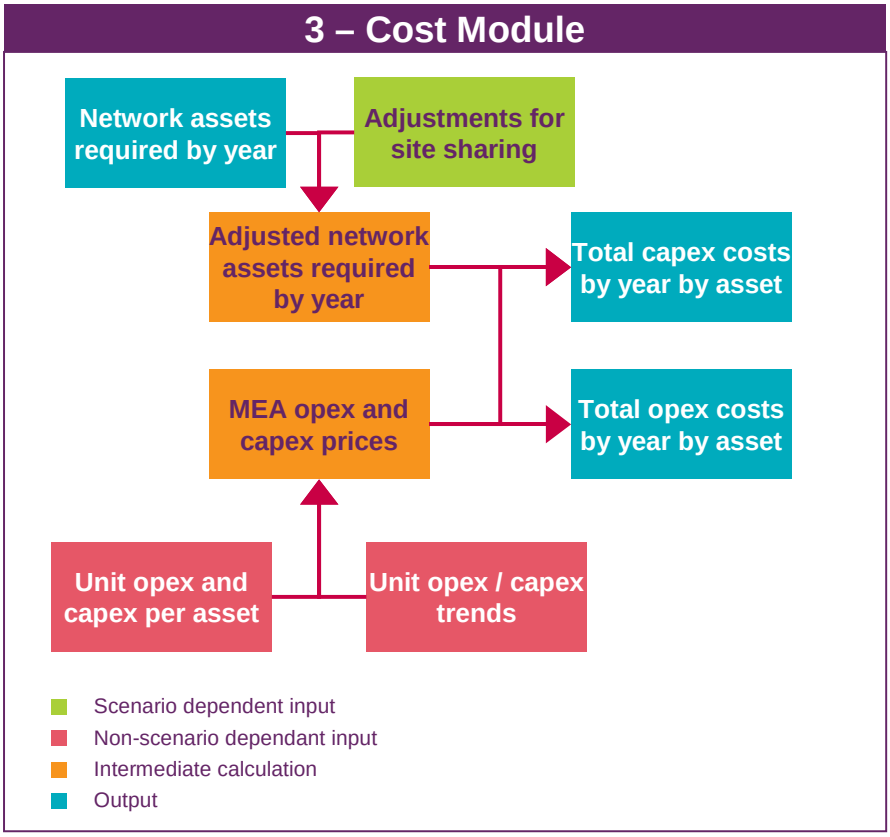
A6.165 In the April 2010 cost model, all 2G traffic was still handled by 2G monolithic MSCs until 2020/21.[108] In the 2011 cost model, part of this traffic is diverted to combined 2G/3G MSCSs/MGWs from 2007/08, with 80% of 2G traffic processed by 2G monolithic MSCs in 2007/08 down to 0% in 2011/12. These values have been chosen based on the latest inventory data provided by the four national MCPs.[109]

3. Cost module

A6.166 The cost module forecasts the total cash flows (i.e. investment and operational expenses) that would be incurred in each year to purchase, renew and maintain the required level of deployment of each type of network asset, as calculated by the network module. An overview of the calculation flow of the cost module is given in Figure A6.17 below.

[107] The footprint requirement of 2G MSCs is assumed to be similar to the one used by the equivalent capacity in layered architecture (i.e. 2G/3G MSC-S + MGWs).
[108] A monolitihic MSC refers to an MSC architecture that does not differentiate between the user data and the signalling information
[109] Based on responses to the August 2009, October 2009 and July 2010 S135 data requests.

Figure A6.17:Calculation flow of the cost module



A6.167 In the 2011 cost model (and the April 2010 cost model), we have based these calculations on a Modern Equivalent Asset (MEA) approach, which takes into account changes in the investment and maintenance costs associated with each asset type, as well as technological developments that improve asset productivity. For example, an asset which is expected to halve in price and double its effective capacity over a given period of time would have an MEA investment price at the end of that period equal to a quarter of the original price. This approach has not changed since the 2007 cost model.

Responses to the April 2010 Consultation

H3G

A6.168 H3G identified that the April 2010 cost model assumed that MSC capacity was fixed over time. In effect, the model determines an on-going decreasing cost per unit of MSC capacity by reducing the MSC unit price over time. Compared to the 2007 cost model, the April 2010 cost model assumed a threefold increase in the MSC unit capacity, from 10 million BH ms[110] to 30 million BH ms. Although H3G found this a reasonable approach, it pointed out that, in order for the historic costs per unit of MSC capacity to remain consistent with the 2007 cost model, the historic unit cost needed to be adjusted in line with the assumed increase in MSC unit capacity. This

[110] Busy hour milliseconds

would imply that the historic MSC unit costs, before similarly priced higher capacity MSCs became available, need to be multiplied by the same factor of three.[111]

Vodafone

A6.169 Vodafone criticised the treatment of handset costs as a costed network asset and a service that should recover network costs. According to Vodafone, this caused two problems. First, the inclusion of handsets in the model Gross Book Value (GBV) leads to an error in calibrating the model against actual operator GBV, since this actual operator GBV does not include handset costs. As a result, the calibrated model underestimated the network GBV when compared on a like-for-like basis. Second, the handset service recovers some of the overall administration costs, as these costs are recovered as a mark-up pro-rated to overall cost recovery by service and the volume of that service. Vodafone suggested resolving this issue by setting the handset costs at zero.[112]

Ofcom's response to specific points raised by stakeholders

A6.170 We accept H3G's comment (see A6.171) and have corrected certain price trends to reflect changes in the capacity of core elements where modelled capacity cannot be changed over time.[113]

A6.171 We agree with Vodafone's comments on the treatment of handset costs (see). As stated in the April 2010 consultation, handset costs are in fact considered part of the customer acquisition, retention and service (CARS) costs, a cost category separate from network costs.[114] As set out in that same document, the administration costs that are put into the cost model only capture the share of administration costs allocated to network activities under the LRIC+ cost standard, not pure LRIC.[115] Annex 8 of the April 2010 consultation shows the calculation of the share of total administration costs to be allocated to network activities. These costs should indeed only be allocated to network services and not to handsets. We have therefore adopted the suggestion to set the (2G and 3G) handset unit costs at zero to resolve the issue of removing handset costs. As handset costs represented 14.8% of total GBV, the model was also then significantly out of calibration as regards matching the historic GBV. This has been corrected as part of the model recalibration (see Annex 7 of this statement). This correction has led to a less steep decline in the MEA prices of many assets as outlined below.

2011 Model Investment costs

A6.172 The investment costs calculated in each year take into account increases in the required quantity of each network asset, and the replacement of assets that have reached the end of their economic life, as well as MEA investment costs per unit for each asset type. In addition to the changes made in response to the above MCP comments, we have also made adjustments to reflect the most recent data provided

[111] Response from H3G to the General Condition 18:Donor Conveyance Charge investigation, which it also asked to be considered in the MCT market review.
[112] Vodafone response to the April 2010 consultation, Annex 3 pages 30-31 and 46-47. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[113] The 'unit Investment' worksheet of the 3-Cost workbook has been changed accordingly. Following our investigation of H3G's comments, we have applied amendments to the following assets: 2G MSCs, 3G MSC Servers, MGWs, SGSNs, GGSNs, BSCs and RNCs.
[114] April 2010 consultation document paragraph A8.135.
[115] Ibid parargraph A8.137.

to us by the national MCPs[116] and as a result of the calibration process (discussed in Annex 7).

A6.173 The MCT cost model calculates the number of assets purchased as the number of incremental assets required in that year, plus the number of assets whose economic lifetime has expired and therefore need replacement. Incremental asset deployment in the cost module is smoothed, to avoid over-purchasing in relation to equipment which declines in quantity but then recovers in later years in response to changes in demand. Typically, the required level of deployment of an asset climbs to a peak before declining over its lifetime. A smoothing algorithm ensures that up until the lifetime peak requirement is reached, the required deployment of that asset can only increase or remain constant in any year, while after the peak requirement has been reached, the required deployment must always decrease or remain constant. This smoothing is intended to reflect the fact that in reality it would be inefficient for an operator to remove a network asset in response to a transitory fall in demand for that asset.

A6.174 The MCT cost model does not assume any payment for assets in advance of deployment – this is consistent with information supplied by the national MCPs.[117] MEA unit investment costs are extrapolated from historical and forecast MEA trends for 2G and 3G networks. Parameters have been built into the model so that unit investments are adjusted to take into account the extent of site sharing.

A6.175 3G licences were purchased in the 2000/01 financial year. However, the MCT cost model does not deploy a 3G spectrum asset until the first year of demand on the 3G network. The value to be inserted into the MCT cost model, therefore requires a holding (or gestation) period uplift – in line with the CC's conclusion on the use of gestation periods.[118] The valuation of both 2.1GHz and 1800MHz spectrum is discussed in more detail in Annex 9.

A6.176 We have reviewed all the asset unit investment costs. This review took into account advice from Analysys Mason, the opinion of the national MCPs, and the model calibration process. All changes from the April 2010 cost model are indicated in Table A6.7 below.

Table A6.7: Unit investment costs in the 2011 cost model

Asset	Details of assumptions and changes
Macro, micro and pico cell unit investment costs	We have inputed the following 2009/10 unit prices (in 2008/09 terms) into the model: Macro cell sites: £46000 (with two operators sharing the site) Micro cell sites: £65000 Pico cell sites: £45000 Unit investment costs are kept constant until the end of 2008/09.

[116] Based on responses to the August 2009, October 2009 and July 2010 S135 data request.
[117] Ibid.
[118] The CC also referred to the same concept as the "holding cost". 2009 CC determination, paragraph 2.6.59, http://www.competition-commission.org.uk/appeals/communications_act/mobile_phones_determination.pdf

	An investment trend of +1% is assumed from 2009/10 onwards. These are the same values as used in the April 2010 cost model.
2G macro and pico cell equipment unit investment costs	The MEA unit investment trends between 2005/06 and 2007/08 have been restored to -5% per annum, the value used in the 2007 cost model (see paragraph A6.22 for more detail). In the April 2010 cost model we had set this value to -35% per annum.
2G micro cell and all other 2G cell equipment unit investment costs	An investment trend of –5% per annum in the investment cost of micro cells between 2005/06 and 2007/08 has been assumed, restoring the value of the 2007 cost model (see paragraph A6.22 for more detail). In the April 2010 cost model we had set this value to -30% per annum.
3G macro, micro and pico cell equipment unit investment costs	The unit investment trends between 2005/06 and 2007/08 have been restored to -5% per annum, the value used in the 2007 cost model (see paragraph A6.22 for more detail). In the April 2010 model we had set this value to -40% per annum.
BSC unit costs	The input unit investment cost has been multiplied by 400/512 (= 0.78) corresponding to a reduction in BSC TRX capacity from 512 to 400 in order to normalise the unit cost for the capacity adjustment. Unit investment trends have also been altered: the value of -4% per annum for 2004/05 to 2007/08 (used in the 2007 cost model) has been corrected by an additional cost factor correcting for the change in capacity. In the April 2010 model we multiplied the unit investment by 300/512 as a normalisation factor.
SMSC unit investment costs	We have used unit investment trends of -20% per annum for each year between 2010/11 and 2013/14. This was the same value that we used in the April 2010 cost model.
RNC unit investment costs	We have restored the unit cost trend between 2005/06 and 2008/09 to -5% per annum, the value used in the 2007 cost model (see paragraph A6.22 for more detail). In the April 2010 cost model, we used a cost trend of -30% per annum.
TDM Microwave backhaul	TDM Microwave backhaul costs were found to be too low historically. Accordingly, we have increased the cost trend between 1996/97 and 2006/07 from -10% per annum to -2%. We have also increased the cost trend between 2007/08 and 2009/10 from -5% to -2%. We have used the following 2009/10 unit prices (in 2008/09 terms) into the model: 8Mbit/s backhaul links: £3,000 16Mbit/s backhaul links: £3,500 32Mbit/s backhaul links: £4,000.

	These are the same values as those used in the April 2010 cost model.
HSPA upgrades	These are a new asset since the 2007 cost model. We have set the unit cost in 2009/10 (in 2008/09 prices) for each upgrade as follows: HSPA 3.6Mbit/s: £4000 per site HSPA 7.2Mbit/s: £2500 per site HSPA 14.4Mbit/s: £2500 per site The unit investment cost is trended at -5% per annum thereafter. This trend is in line with the majority of electronic equipment. These are the same values as those used in the April 2010 cost model.
Ethernet backhaul	We have set the price in 2009/10 (in 2008/09 prices) to £12000 per link. The unit investment cost is trended at -2% per annum thereafter. These are the same assumptions as in the April 2010 cost model.
Shared site	As noted in Table A6.3 above, we have set the price in 2009/10 (in 2008/09 terms) to £17000 per site upgrade. The unit investment cost is trended at +1% per annum thereafter.[119] This trend is in line with other civil work events. These assumptions are the same as those used in the April 2010 cost model.
Site transformation	We have set price in 2009/10 (in 2008/09 terms) to £20000 per site upgrade which is the same as the April 2010 cost model. The unit investment cost is trended at +1% per annum thereafter.[120] These assumptions are the same as those used in the April 2010 cost model.

A6.177 As discussed above, certain assets have had their capacity changed and fixed for the life of the model. In response to H3G's comment above (paragraph A6.168), we agreed that these capacity adjustments should be reflected in the MEA price trend. The final MEA price trend for the assets that have this capacity adjustment are shown in Table A6.8, alongside the MEA price trend used in the 2010 April cost model.

[119] This trend is in line with other civil work events.
[120] This trend is in line with other civil work events.

Table A6.8: Capacity adjusted MEA investment trends

Asset	Model version	2004/05	2005/06	2006/07	2007/08
2G BSC Base unit	2011 cost model	2%	2%	2%	2%
	April 2010 costs model	-30%	-30%	-30%	-30%
2G MSC Processor	2011 cost model	-13%	-13%	-13%	-13%
	April 2010 cost model	-4%	-4%	-4%	-4%
2G MSC Software	2011 cost model	-14%	-14%	-14%	-14%
	April 2010 cost model	-5%	-5%	-5%	-5%
MSC Server	2011 cost model	-28%	-28%	-28%	-28%
	April 2010 costs model	-5%	-5%	-5%	-5%
MGW	2011 cost model	-25%	-25%	-25%	-25%
	April 2010 costs model	-5%	-5%	-5%	-5%
HLR	2011 cost model	-29%	-29%	-29%	-29%
	April 2010 costs model	-4%	-4%	-4%	-4%
2G SGSN	2011 cost model	-50%	-50%	-50%	-50%
	April 2010 costs model	-4%	-4%	-4%	-4%
2G GGSN	2011 cost model	-50%	-50%	-50%	-50%
	April 2010 costs model	-4%	-4%	-4%	-4%
3G SGSN	2011 cost model	-50%	-50%	-50%	-50%
	April 2010 costs model	-5%	-5%	-5%	-5%
SMSC	2011 cost model	-9%	-9%	-9%	-9%
	April 2010 costs model	-4%	-4%	-4%	-4%

Operating costs

A6.178 As with every past version of the MCT cost model, we model operating costs for each type of network asset included in the model. We take into account the costs that would be incurred in maintaining the deployed 2G and 3G/HSPA network assets. These are calculated based on the deployment of each network asset multiplied by an MEA operating cost per unit specific to that asset. In years where asset deployment is decreasing (due to decommissioning), the the MCT cost model assumes that there will be a lag between the point when the asset is no longer required in the network and the point when it will no longer incur operating expenses. This is the same approach as adopted in the 2007 and April 2010 cost models.

A6.179 As with the capital costs, our updated operating costs are in response to the above MCP comments,[121] additional data collected from MCPs and the calibration process described in Annex 7.

A6.180 The approach that has been taken on MEA operating cost trends over time is similar to that described above for capital costs. However, for asset types where less information is available on levels of operating costs, greater reliance has been placed on the calibration process.

[121] See paragraphs A6.168 to A6.169.

A6.181 All asset unit operating costs have been reviewed. This review took into account advice from Analysys Mason, information from the four national MCPs,[122] and the model calibration process. All changes are listed in Table A6.9 below.

[122] Based on responses to the August 2009, October 2009 and July 2010 S135 responses.

Table A6.9: Unit operating costs (in the 2011 cost modela and changes since the April 2010 cost model).

Opex asset class	Details of assumptions and changes
3G site upgrade opex	The purpose of the 3G site upgrade asset is to allow for the reduced cost of maintaining 2G and 3G equipment on a shared site. This asset is set to be 20% of the 3G cell equipment opex for macrosites and 10% for microsites and picosites. This is the same value as the April 2010 cost model for macrosites. The April 2010 cost model used a value of 20% for microsites and picosites.
3G microcell equipment unit opex	We have restored the unit operating trends between 2005/06 and 2007/08 to -15%, -8% and -4% per annum, the values used in the 2007 cost model. In the April 2010 cost model we used -25%, -30% and -30% per annum respectively.
BSC/PCU unit costs	We have set the unit operating cost trends to be consistent with those of unit investment trends for all years (i.e. -4%). This is the same approach taken in the 2010 cost model.
TDM Microwave backhaul	Between 2000/01 and 2009/10 the cost trend has been set to -2% per annum (annual trends used in the 2007 cost model ranged from -15% to -3% over this period). The following 2009/10 unit prices have been inputed into the model: 8Mbit/s backhaul links: £700 16Mbit/s backhaul links: £750 32Mbit/s backhaul links: £800. These are the same values as those used in the April 2010 cost model.
HSPA upgrades	HSPA is a software upgrade and therefore any operating cost is taken into account in the 3G cell equipment opex. This is the same approach as taken in the 2010 cost model.
Ethernet backhaul	The price in 2009/10 is set to £5000 per link. The unit operating cost is trended at -2% per annum thereafter. These are the same values as used in the April 2010 cost model.
Shared site and site transformation	These assets are one-off events and therefore have no operating costs.

A6.182 As with the capital costs, some of these elements require a capacity adjustment to produce the MEA opex trend. The below capacity adjusted MEA opex trends for these assets are shown in Table A6.10 alongside the MEA opex trends used in the April 2010 cost model.

Table A6.10: MEA operating cost trends

Asset	Model version	2004/05	2005/06	2006/07	2007/08
2G BSC Base unit	2011 cost model	2%	2%	2%	2%
	April 2010 costs model	-30%	-30%	-30%	-30%
2G MSC Processor	2011 cost model	-17%	-12%	-12%	-12%
	April 2010 cost model	-8%	-3%	-3%	-3%
2G MSC Software	2011 cost model	-17%	-12%	-12%	-12%
	April 2010 cost model	-8%	-3%	-3%	-3%
MSC Server	2011 cost model	-35%	-35%	-30%	-27%
	April 2010 costs model	-15%	-15%	-8%	-4%
MGW	2011 cost model	-33%	-33%	-27%	-24%
	April 2010 costs model	-15%	-15%	-8%	-4%
HLR	2011 cost model	-32%	-28%	-28%	-28%
	April 2010 costs model	-8%	-3%	-3%	-3%
2G SGSN	2011 cost model	-52%	-49%	-49%	-49%
	April 2010 costs model	-8%	-3%	-3%	-3%
2G GGSN	2011 cost model	-52%	-50%	-50%	-50%
	April 2010 costs model	-8%	-3%	-3%	-3%
3G SGSN	2011 cost model	-56%	-56%	-52%	-50%
	April 2010 costs model	-15%	-15%	-8%	-4%
SMSC	2011 cost model	-13%	-8%	-8%	-8%
	April 2010 costs model	-8%	-3%	-3%	-3%

Asset lifetimes

A6.183 We have reviewed all asset lifetimes from the 2007 cost model. This review took into account Analysys Mason's industry experience, information from the four national MCPs, and the model calibration process. All changes to asset lifetimes are shown in Table A6.11 below. The values in the 2011 cost model are the same as those we used in the April 2010 cost model.

Table A6.11: Changes to asset lifetimes

Asset	2007 cost model	2010 and 2011 cost model
Site acquisition, preparation and lease	20	18
Cell equipment	10	8
BSC equipment	10	9
RNC equipment	10	8

Source: Analysys Mason

A6.184 Due to the introduction of site sharing and HSPA functionality there are a number of additional assets requiring lifetimes to be set. Table A6.10 shows the rationale for the lifetimes chosen for these new assets.

Table A6.10: Lifetimes of new assets

Asset	Lifetime	Rationale
Site sharing: transformation sites	Indefinite[123]	A "transformation site" is essentially a site decommissioning. It is a one-off event and therefore has a lifetime longer than that of the model.
Site sharing: shared sites	Indefinite	A "shared site" is a site adapted to host a second MCP. It is also a one-off event and therefore has a lifetime longer than that of the model.
HSPA upgrades (3.6 Mbit/s, 7.2 Mbit/s, 14.4 Mbit/s)	8	The lifetime is consistent with that of other active cell site equipment.
Ethernet link	10	The lifetime is consistent with that of other backhaul products. In the April 2010 cost model we used an 8 year lifetime.

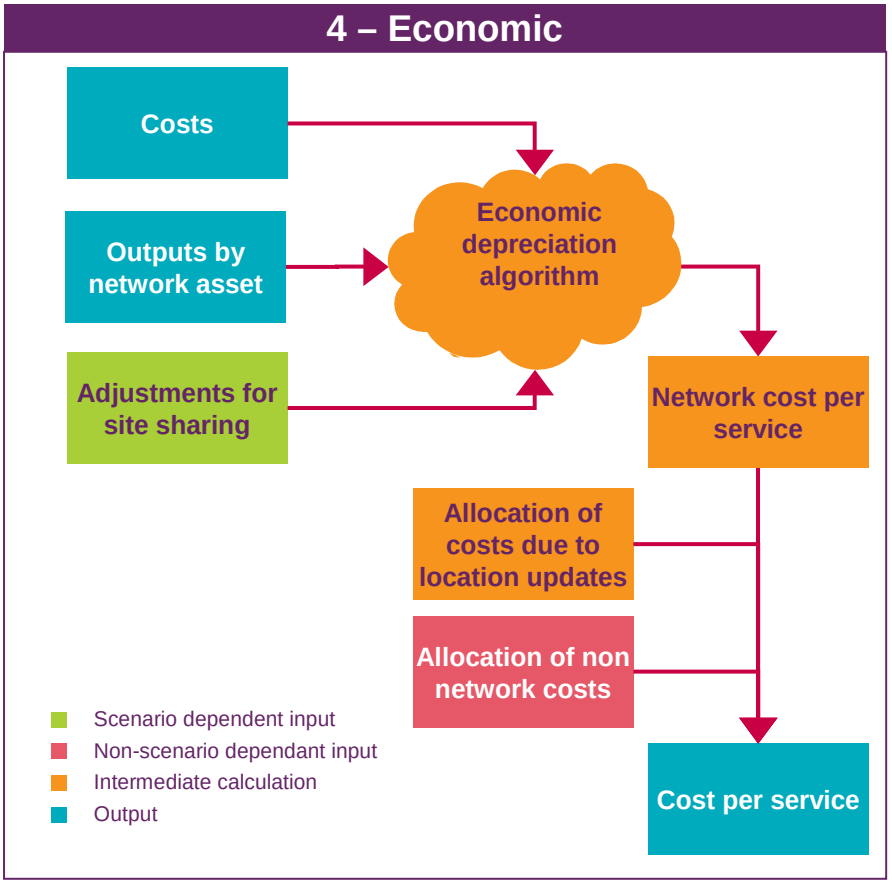
[123] Indefinite lifetimes are set to be 100 in the 2011 cost model to avoid asset replacement.

4. Economic module

Overview

A6.185 The Economic module implements Original Economic Depreciation (Original ED) to calculate a cost per unit of output in each year for every asset in the model. Although Original ED was used in the 2007 cost model, the original ED algorithm has been revised slightly in light of responses to the April 2010 consultation. Those changes are documented and explained below. The main calculation flow in the economic module is shown in Figure A6.18.

Figure A6.18:Calculation flow of the economic module



A6.186 We have adapted the economic module in order to determine the unit costs using a pure LRIC cost standard. We have added three new worksheets: (a) *Active inputs*, (b) *Inputs with incoming*, and (c) *Inputs no incoming*. These worksheets all contain network cost information (from the cost module), network element count, network element output and service demand (all from the network module). The following worksheets have their values determined by the *pure LRIC macro.*

- The *active inputs* worksheet contains the information required to determine unit costs in the live version.
- The *inputs with incoming* worksheet contains the information required to determine unit costs when incoming traffic is included (for the parameters active when the pure LRIC macro was last run).

- The *inputs no incoming* worksheet contains the information required to determine unit costs when no incoming traffic is included (for the parameters active when the pure LRIC macro was last run).

A6.187 Values in the *inputs no incoming* worksheet are subtracted from values in the *Inputs with incoming* worksheet. This calculation produces the hypothetical cost and number of network elements needed to build additional network capacity to transport incoming traffic. This information is then fed through the Original ED algorithm to produce a cost recovery profile for these costs.

A6.188 We have two primary objectives when determining the optimal path of cost recovery. First, the profile of cost recovery should not deny operators the opportunity to recover their efficiently incurred costs, including a reasonable return on their investment. Second, the profile of cost recovery should aim to give efficient pricing signals for consumption and investment.

A6.189 Economic depreciation is the change in the economic value of an asset during the year. Economic value is the asset's earning power, i.e. the discounted present value of expected future revenues from the output produced by the asset, less the present value of associated future operating costs.

A6.190 In the April 2010 cost model, we implemented a form of economic depreciation as the mechanism for recovering network costs over the lifetime of the network. Economic depreciation seeks to set the optimal path of cost recovery over time by mimicking the outcomes of a benchmark competitive market. In this hypothetical competitive market, we assume that unit prices in a given year do not depend on the level of utilisation at that point in time, but on the level of utilisation achieved over the lifetime of the network. It is also assumed that a new entrant has the same utilisation profile over time as incumbents, rather than achieving long run utilisation more rapidly. If there were no changes in input costs (including the cost of capital), this results in a constant level of unit cost recovery over the lifetime of the network.

A6.191 Original ED was used by Ofcom in the previous two MCT cost models and was approved by the Competition Commission in 2002 and again in 2009.[124]

A6.192 The Original ED calculation is performed in three stages:

- **Stage 1**: The theoretical constant unit cost recovery level is calculated as if the final year utilisation and input costs applied over the entire lifetime of the network.

- **Stage 2**: A second component is added to recover the additional costs caused by earlier under-utilisation of the network compared to the final level. This step is also applied as a constant unit price for all time.

- **Stage 3**: A third component is added to recover the remaining un-recovered (or over-recovered) costs due to input costs being above (or below) the final level. The shape of this component is determined by the arithmetic difference between in-year and final-year input costs, and is therefore zero in the final year (or any year that shares the same level of input cost as the final year). More costs are

[124] See Competition Commission 2002 Report paragraph 2.283 http://www.competition-commission.org.uk/rep_pub/reports/2003/fulltext/475c2.pdf and Competition Commission 2009 Determination paragraph 7.103 http://www.competition-commission.org.uk/appeals/communications_act/mobile_phones_determination.pdf

recovered in years when asset prices and the WACC are higher than the final year.

A6.193 This approach to depreciation matches the cost of equipment to its actual and forecast usage over the long term. Consequently, there is relatively little depreciation in years when utilisation is low and relatively high depreciation in years of full, or almost full, equipment utilisation.

Consultation Responses

Everything Everywhere

A6.194 EE criticised our use of Original ED in the model. Its particular criticism of the Original ED algorithm was linked to the change in the WACC in 2009/10. EE claimed that the combination of Original ED and a lower WACC caused an inappropriate cost recovery path. EE objected to a step change in the WACC and claimed that a more stable WACC should be used. EE believed that the impact of the change in the WACC undermined the objectives of Original ED. In particular EE referred to our stated goal of smoothing network costs based on longer-term forecasts of network utilisation.[125]

A6.195 [✂].[126]

Vodafone

A6.196 Vodafone did not make any explicit criticism of Original ED, however, it did raise concerns about the relationship between the pure LRIC output and the WACC. It identified that the pure LRIC output of the April 2010 cost model had a U-shaped relationship with the WACC. In the April 2010 cost model, the low point for the pure LRIC occured when the value of the WACC was around 7.3%. Vodafone also identified instability in the relationship between the WACC and the pure LRIC outputs when the value of the WACC was between 11% and 11.5% (pre-tax real).

A6.197 Vodafone cited the above as a reason for why the model was not appropriate for calculating termination rates using pure LRIC. Vodafone considered that it may be 'fruitful' to consider using a different depreciation approach.[127]

O2

A6.198 O2 criticised the path of unit costs produced by the Original ED algorithm. O2 was concerned by the algorithm's low and ambiguous sensitivity to the WACC.[128] It also identified that the HCA/CCA module produced a more typical relationship between WACC and unit costs (i.e. as WACC goes down the unit cost decreases).

A6.199 O2 was also concerned with our explanation of the step change when the WACC and MEA unit costs were updated. In particular, O2 identified that different values

[125] EE response to the April 2010 consultation, page 28-29 and Annex B paragraph 71-72. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Everything_Everywhere.pdf (quoting from paragraph 9.25 of the April 2010 consultation)
[126] EE response to the April 2010 consultation, page 29 and Annex B page 77-78. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Everything_Everywhere.pdf
[127] Vodafone response to the April 2010 consultation Annex 3 page 101-103. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[128] As can be seen from Figure 46 of Annex 11 to the April 2010 consultation, the pure LRIC value did not change across the values of the WACC used in the sensitivity analysis.

for the WACC made very little difference to the path of unit costs after the input updates in 2008/09, even when using LRIC+. O2 was particularly concerned by the insensitivity of the path of 3G unit costs to changes in the value of the WACC.[129]

A6.200 O2 also stated that although it believed it was appropriate to assume the WACC changes over time, making this change carries a risk that the new cost recovery profile does not match the charges the operators were allowed to charge historically.[130]

H3G

A6.201 H3G generally agreed with our use of Original ED. H3G identified one issue which it believed to be an error in the algorithm. That is, the present value of terminal investment was discounted at the terminal discount rate rather than the average discount rate over the lifetime of the network to that point. H3G believed that an adjustment factor should be used so that the terminal investment value was discounted correctly.[131]

A6.202 H3G also commented on the responses of the other MCPs to the April 2010 consultation. It considered that even though the Original ED algorithm produced some unexpected results these results were not anomalous.[132]

A6.203 In its comments on other operators' responses, H3G was also critical of EE's claim that Ofcom should not use a step change in the WACC and should use a higher WACC instead. H3G argued that, assuming Ofcom's calculation of the WACC was correct, the fact that a step change in the value of the WACC was required meant that the WACC during the last charge control was overstated and the operators were benefitting from that overstatement. As such, this did not justify a higher WACC from 2009/10 onwards.[133]

A6.204 H3G also disagreed that the relationship identified by O2 between the WACC and pure LRIC meant that the model produced anomalous results. It argued that given the complexities in the Original ED algorithm and the modularity that exists in the pure LRIC calculation it could mean that costs were recovered before the relevant cash flows were incurred for some elements. This a feature of the Original ED algorithm and did not necessarily mean that there was a problem with using Original ED.[134]

Ofcom's Assessment

A6.205 As noted above, the Original ED algorithm has been used for Ofcom's (and Oftel's) previous MCT cost modelling and the Competition Commission has accepted its validity during previous appeals.[135] We have recognised both in this and previous

[129] O2 response to the April 2010 consultation, Section F pages 57-61. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf
[130] O2 response to the April 2010 consultation, Section F page 61.
[131] H3G response to the April 2010 consultation, Section 5 pages 64-65. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf
[132] H3G additional response page 21. [http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/three.pdf
[133] H3G additional response page 2 and pages 15-16. Ibid
[134] H3G additional response page 21. Ibid
[135] There have been minor revisions to the algorithm to improve stability, however, its broad structure has remained the same.

market reviews that the Original ED algorithm can produce occasional instability. For instance in the 2007 MCT statement we indicated that:

A6.206 "Ofcom acknowledges that the Original ED approach is more complex to implement that Simplified ED, and can exhibit unusual behaviour in some specific cases."[136]

A6.207 We consider Original ED to be a better form of depreciation than accounting forms because it smoothes the path of unit costs. We also consider Original ED to be a better depreciation approach than other simpler forms of economic depreciation because we think that it better mimics a competitive market. For example, other forms of economic depreciation, such as "Simplified ED", do not explicitly calculate the terminal price based on mimicking a hypothetical competitive market, rather the terminal price is a by-product of scaling the shape of the cost recovery profile to achieve full cost recovery.

A6.208 In assessing whether we should make changes to the Original ED algorithm (or use a different approach) we have examined the following three questions:

i) Are there any errors in the Original ED algorithm that require correction?

ii) Why does the WACC have a U-shaped relationship with the unit cost of termination when using pure LRIC?

iii) Why do we see a drop in the unit cost of MCT in the year after the parameter updates (i.e. 2009/10) and some negative unit cost values for the outpit of certain network elements in certain years?

A6.209 In the responses mentioned above, a number of respondents referred to the level of the WACC being too low. Although we address the interaction between the Original ED calculation and the WACC in this section, we do not consider here the level of the WACC (which is dealt with further in Annex 8). Nevertheless, we would emphasise that our choice for the value of the WACC is based on our best analytical view of the value of the WACC parameters and is not in any way driven by the influence the WACC might have on the mechanics of the ED algorithm or the model more generally.

Correction to the ED algorithm

A6.210 The first part of the Original ED algorithm converts all the volumes and costs into a present value in 1990/91.[137] These costs and volumes are then used to calculate the network element cost per unit of output (i.e. traffic).

A6.211 H3G identified an error in the way the terminal investment value is discounted. We agree that the terminal investment should be discounted differently from how it was done in the 2007 and April 2010 cost models. Previously, the terminal investment value was calculated in the first part of the Original ED algorithm where the unit costs are calculated with utilisation, MEA prices and the WACC constant at their terminal value.

A6.212 H3G identified that the above approach would mean the terminal investment value had been discounted back to 1990/91 using the terminal discount factor for all periods, rather than the actual discount rate in each year. The terminal investment

[136] See 2007 MCT statement para A5.215.
[137] The model uses end of year discounting meaning the base period is actually April 1990.

value needs to be adjusted to reflect higher discount rates in earlier periods. In order to correct for this error we have applied an adjustment factor to the terminal investment value of each network element as follows:[138]

$$\frac{(1 + WACC_{50})^{50}}{\prod_{t=1}^{50}(1 + WACC_t)}$$

A6.213 This adjustment has the effect of reducing the terminal investment value for all elements (since the WACC in earlier periods is higher than that projected from 2009/10 so the average WACC used to discount the terminal investment is higher, and the discount factor lower). The adjustment factor reduces these terminal investment values by 79%. This error was present in the 2007 cost model. It acted in the MCPs' favour by increasing the total costs to be recovered. If it had been identified in the previous MCT charge control we estimate that it would have reduced the target charge by approximately 0.1ppm. Correcting the error in the 2011 cost model has a slightly larger[139] impact due to the lower terminal WACC in the 2011 cost model. The change causes the pure LRIC output to decrease by 0.15ppm.

The relationship between the WACC and the pure LRIC unit costs

A6.214 A number of responses to the April 2010 consultation indentified the counter-intuitive relationship between the value for pure LRIC and the WACC as a reason why the model was not fit for purpose. Respondents noted that as the WACC decreased below 7.3% the value produced by the pure LRIC calculation began to increase.

A6.215 At values for the WACC between 11.5% and 7.3% pre-tax real the pure LRIC value decreases as WACC decreases. Once the WACC moves below 7.3%, the pure LRIC unit cost increases as WACC decreases.

A6.216 Although counter-intuitive, it is possible for a decrease in the WACC to cause an increase in unit costs. This phenomenon occurs when there are differences in the relative timings of investment costs and cost recovery. Unit costs in the MCT model are essentially the ratio of the present value of costs to the present value of volumes (shaped by the MEA profile and path for the WACC). If there are a stream of costs and volumes, decreasing the WACC will increase the present value of both the costs and the volumes. However, the decrease in the value of the WACC will have a proportionally greater impact on those costs and volumes that are incurred further into the future. If a greater proportion of volumes are in early periods and costs are in later periods, then a decrease in WACC could cause an increase in unit costs.

A6.217 The model calculates pure LRIC by taking the difference between the LRIC+ investments and volumes for all network traffic and the LRIC+ investments and volumes when there is no off-net termination. There will be some spare capacity that remains from the coverage infrastructure and so in the early stages of network development we have incoming termination volumes but very little cost. Costs only start to be incurred when the network begins to become capacity constrained. For some network elements early cash outlays will be low, but traffic significant, thereby

[138] Where (WACC) is the yearly discount rate (real terms) and (t) is the time period in the model with period 1 = 1990/91 and period 50 = 2039/40 (i.e. $WACC_t$ is the cost of capital in year t).
[139] This change is between 0.3 and 0.4 for LRIC+ (the appropriate cost standard to compare with the 2007 cost model outputs).

yielding the pattern of cash flows which could result in an inverse relationship between the WACC and unit costs for some values of the WACC.

A6.218 While this cash flow timing effect is only present in a subset of the network elements, such that the overall pure LRIC of MCT remains positive for all periods, in the April 2010 cost model, the effect was sufficient to cause a small reduction in the overall unit cost of MCT under pure LRIC.

A6.219 Although this explains why we may see a negative relationship between WACC and the unit cost of MCT, it does not explain why we might have a U-shaped relationship. This occurs because the Original ED algorithm tilts the cost recovery path so that in periods when input costs are higher, more costs are recovered (i.e. the unit costs are higher for such periods). When we update the WACC in the MCT cost model we do so on a forward looking basis. When we reduce the value of the WACC in the model we cause more of the network costs to be recovered in earlier periods. All other things being equal, a reduction in WACC would cause unit costs in the future to be lower. So the MEA trend and cash flow timing effect (described above) can act in different directions. In the April 2010 cost model, the low point for pure LRIC (when varying the WACC) occurs at a WACC of around 7.3% (pre-tax real). At this point the effect of the MEA trend within the ED algorithm dominates the cash flow timing effect.

A6.220 These two effects (MEA trend and cash flow timing) explain why there could be a counter-intuitive relationship between the WACC and the unit cost of pure-LRIC. However, we do not see this relationship when using the HCA/CCA module or the Simplified ED algorithm that we implemented in the 2007 cost model as a check against Original ED. Although the cash flow timing effect is present in some network elements, when using Simplified ED it is so small that it is dominated by the normal relationship between the WACC and unit costs for other network elements. The reason the Original ED algorithm is particularly affected by the cash flow timing effect is because of the terminal value used in that formulation. Simplified ED does not include a terminal value calculation and so does not suffer from the same problem.

A6.221 Finally, as identified by H3G, the terminal value of network elements was not being discounted correctly in earlier versions of the MCT cost model. Once we correct this discounting error, the terminal value is greatly reduced. In fact, the reduction in terminal values is such that the cash flow timing effect under Original ED is reduced and is now dominated by the normal relationship between the WACC and unit costs for all network elements. Therefore, in the 2011 cost model, the pure LRIC of MCT moves in the same direction as the WACC. The correction to the terminal value calculation also removes the irregular sensitivity that was identified by Vodafone when the WACC was moved between 11% and 11.5%.

The Drop in Unit Costs after the parameter updates

A6.222 The April 2010 cost model and the 2011 cost model have focussed on calculating the unit cost of MCT in 2014/15. Updates to the model have not been performed with the objective of achieving the smoothest possible path of unit costs. For instance, the WACC is updated in a single year, rather than over a number of years. Reductions in the MEA price of assets and the WACC cause unit costs to fall. The result of a step change in the value of the WACC is a sudden reduction in the unit cost of MCT in the year the change is implemented (i.e. 2009/10). For other

updates, such as MSC capacity, the update for the input cost assumption is applied over the entire life of the model – i.e. the effect of the change is smoothed.[140]

A6.223 EE's submission that changing the WACC causes an unrealistic path of unit costs is not strictly correct. It is the combination of asset prices and the reduction in the value of the WACC that causes the steep decline in unit costs.

A6.224 While we could smooth the change in the value of the WACC, we believe that the way EE has suggested making this adjustment is inappropriate. EE suggested using a constant WACC from 1997/98 onwards. Using this approach would mean historically the WACC used in the model would be below the correct estimate of a WACC and, on a forward looking basis the model WACC would be above the correct estimate of WACC (given the WACC is falling steadily over successive charge control reviews).

A6.225 We do not believe that it is appropriate to set the WACC in order to get the MCT model to behave in a certain way. The WACC should be an exogenously determined model parameter. It is likely that the WACC has been too high for at least the latter part of the current charge control. We see no reason to allow this overestimate of the WACC to continue into the forecast period for the 2011 cost model.

A6.226 [✂] and Vodafone also identified that after the step change in the value of the WACC, some network elements started producing negative unit cost values (although it should be noted that these did not persist until 2014/15). Such negative unit costs occur for network elements that have an increase in the MEA price after 2008/09 (i.e. due to the combined effect of the increasing MEA price trend in the Original ED algorithm and the decline in the WACC). If the element has an increasing MEA price trend, then 2009/10 will represent the low point for the combined input costs (i.e. the increasing MEA price and the falling WACC).

A6.227 While one of the reasons for updating model inputs in a single period is to allow such anomalies to be smoothed out before the period of interest for modelling purposes – i.e. 2014/15 – it should be noted that when the Original ED algorithm produces a negative unit cost for an element it is (mathematically) behaving correctly. The Original ED algorithm will always set unit costs so that the present value of efficiently incurred costs are recovered over the life of the network. If in the future the hypothetical firm is able to charge more because the investment costs faced by entrants (and incumbents) are higher (i.e. the competitive constraint is reduced), it will optimally recover less cost in the present period. Inprinciple, this can occur to such an extent that the cost recovered in the present period turns negative.

A6.228 Although the negative unit costs for the output of some network elements produced by the April 2010 cost model are conceptually consistent with the way Original ED operates, we accept that this is counter-intuitive. As such, we have sought to introduce a fix to prevent unit costs for network elements turning negative. This fix has been applied to the small number of network elements that have increasing MEA price trends. The fix introduces an iterative element to the final stage of the Original ED algorithm that shifts the cost recovery profile weighting factor upwards until no unit costs for the output of that element are negative.

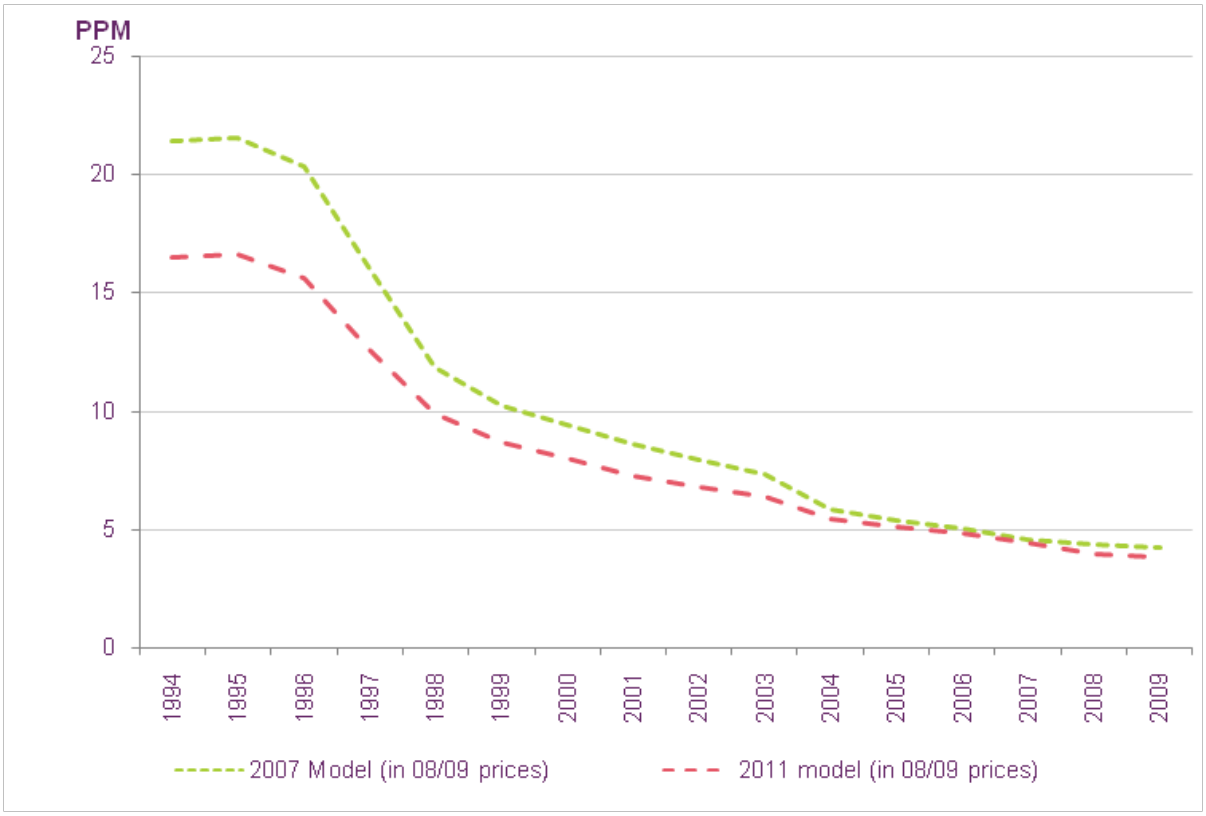
[140] It is smoothed via the capacity adjusted MEA price and operating cost discussed earlier in this annex.

A6.229 The consequence of introducing this iterative fix is to increase the pure LRIC in 2014/15 from 0.68ppm to 0.69ppm

Historic charges lower than modelled charges

A6.230 O2 is correct that changing the WACC could lead to a cost recovery profile that does not match the charges that operators were allowed to set under previous caps. However, the empirical evidence does not support this assertion.

Figure A6.19: Comparison of historic MTR estimates[141]



A6.231 Figure A6.19 charts the outputs from the 2007 cost model and the 2011 cost model. At all times, the unit costs from the 2011 cost model are below the costs from the 2007 model.

A6.232 Even if there was evidence that the historic charges were below the new cost-recovery profile, this does not necessarily mean we would change our approach. As discussed in above, we consider that updating the path of unit costs is desirable, since the objective of ED is to mimic the path of unit cost recovery arising from (hypothetical) competitive entry into MCT. If entrants face a lower cost of capital (or other lower input prices) this would allow them to undercut incumbents. We emphasise that in so far as our measurement of the WACC or other parameters might result in higher input costs at a new market review, our approach would be consistent – i.e. if updated parameter values implied a higher path of unit costs than previously our approach would be to set charges to align with that higher cost path. In other words our approach on updating unit cost estimates and applying glide paths up or down to the revised cost estimate is designed to give MCPs at least a "fair bet".

[141] Source: 2011 MCT model. Note that these values exclude a contribution from the administration cost and HLR update cost.

Conclusion

A6.233 The Original ED algorithm is a complex part of the MCT cost model. As explained above, we believe that Original ED is conceptually the most appropriate depreciation approach and was accepted by the CC in its 2002 and 2009 determinations. We have made some changes to the algorithm to fix an identified error (in respect of the treatment of the terminal value) and to remove the possibility that unit costs turn negative for the output of certain network elements.

A6.234 The unit cost path produced by the 2011 cost model nevertheless displays a step change, but this is a natural consequence from updating the parameter values in a single year (which would apply whether an economic or an accounting approach is taken).

A6.235 In conclusion, having considered the issues raised in responses to the April 2010 consultation, we remain of the view that Original ED is the most appropriate approach to the timing of efficient cost recovery for MCT.

Annex 7

Calibration of the cost model

Overview

A7.1 Cost models can be constructed in both 'top-down' and 'bottom-up' forms. In a top-down approach, relationships between outputs and costs are estimated from historical accounting information, and costs are projected forward on the basis of output forecasts. In a bottom-up approach, the components of cost are identified at a more granular level. Cost causation relationships are then defined to link the quantity of each of these cost components with output and other cost drivers, based on practical and theoretical evidence.

A7.2 In this charge control, as in previous MCT cost modelling, we are using a hybrid approach, with the intention of capturing the strengths of both top-down and bottom-up approaches. The model has been developed as a bottom-up cost model, but it has also been calibrated by adjusting the unit replacement cost levels and cost causality relationships of different cost components, so as to ensure the model is reasonably in line with the national 2G/ 3G MCPs' actual costs in historical years. The purpose of this annex is to describe the methodology we have applied to calibrate the model to accounting and technical data and to summarise the results of the calibration (to the extent that confidentiality of national MCP data allows this information to be disclosed).

A7.3 All the results presented in Annex 10 and the changes to the model structure described in Annex 6 take into account this calibration of the model to an average efficient national 2G/3G MCP.

Calibration benchmarks

A7.4 The calibration exercise for the 2011 cost model is very similar to the calibration we performed for the April 2010 cost model.[142]

A7.5 The 2011 cost model has been calibrated according to two different types of high-level benchmarks obtained from the national MCPs: counts of different types of network equipment (e.g. cell sites, MSCs) and accounting costs based on data from management accounts.

A7.6 We requested actual and forecast equipment inventories from operators for the period 2000/01 to 2014/15. These counts relate to equipment at all levels of the 2G and 3G networks, ranging from 2G and 3G cell sites through to backhaul and BSCs and RNCs to equipment in the core network. Although none of the national MCPs were able to provide complete responses to this detailed request. We regard the information received as sufficiently comprehensive for calibrating the bottom-up cost model. Cell site counts are of particular significance, because the deployment of many other network components is driven (directly or indirectly) by the number of cell sites. All MCPs provided data that could be used for the calibration of these assets.

[142] See April 2010 consultation Annex 10.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf

A7.7 We have also obtained updated figures from each of the national MCPs for network gross book value (GBV), network net book value (NBV) and network operating costs. The information provided by the national MCPs enabled calibration to be made for the years 2006, 2007, 2008 and 2009.

A7.8 We consider that GBV is a more appropriate calibration benchmark than actual in-year capital investment: GBV provides a snapshot of the total value of assets for a national MCP, and is therefore less sensitive to year-on-year fluctuations in investment. Network operating costs, on the other hand, are likely to fluctuate less than capital costs on a year-to-year basis since these represent ongoing network maintenance and operating activities. Hence network operating costs have been used directly as a calibration benchmark. However, we note that there are still likely to be year-to-year fluctuations in these cost benchmarks which are not explainable solely in terms of factors included within the 2011 cost model.

A7.9 We requested accounting data from the national MCPs in the most granular form available. Given the variation in the granularity between submissions, and the scope for inconsistent cost definitions, we have only made comparisons at a high level. A detailed calibration has been made based on overall totals, and a further, more approximate, calibration has been conducted to ensure that the relative spend on access, backhaul and core is correct.

Model inputs

A7.10 The objective of the cost modelling exercise is to establish the unit cost benchmarks for voice termination of an efficient average national MCP, rather than operator-specific unit cost benchmarks. The asset count and cost benchmarks discussed previously for each of the national MCPs have therefore informed the values of the input parameters and the network dimensioning rules for the efficient operator. We believe these factors are similar across the industry and reasonable for an average efficient operator (e.g. design utilisation). Calibration of these key inputs has therefore resulted in a configuration of the MCT cost model such that high-level asset count and cost outputs (specifically GBV and opex) are in line with historically observed industry values.

A7.11 This process can be summarised in terms of adjusting a number of non-operator-specific inputs in order to produce the closest calibration of the model to that of an average efficient national MCP. These inputs are as follows:

- 1800MHz GSM cell radii by geotype;
- 2.1GHz UMTS cell radii by geotype;
- proportion of traffic generated by 2G/3G handset that is carried on the 2G network (in addition to coverage limitations);
- distribution of traffic by cell type (e.g. macro, micro, pico cells);
- utilisation factors;
- the proportion of cell sites which are shared between 2G and 3G networks;
- unit capacities of core network elements;
- MEA investment costs per unit over time; and

- MEA operating costs per unit over time.

A7.12 In addition, we adjusted certain key inputs from the 2007 cost model for the 2011 cost model in order to reflect better the reality of the national 2G/3G MCPs:

- share of traffic in the busy hour (BH);
- market share of the operator;
- 2G coverage;
- 3G coverage; and
- 3G coverage achieved when site sharing is complete

A7.13 While the input parameters from the April 2010 cost model formed the starting point for the inputs to the 2011 cost model, some of these parameters have subsequently been adjusted during the calibration process. With the assistance of Analysys Mason we have made these adjustments after taking into account: the MCPs' submissions; more detailed and up-to-date data in relation to the benchmarks described above; and other technical and unit replacement cost data received from the national MCPs.

Asset count calibration

A7.14 The aim of the asset count calibration exercise has been to ensure that the high-level asset counts produced by the model are consistent with those of national MCPs.

A7.15 The general principle is that the count of the most important assets (e.g. macro sites) should be close to the average of the national 2G/3G MCPs, and as a minimum always between the minimum and maximum values seen across all of the national 2G/3G MCPs. We have adopted the same approach as in the April 2010 consultation, which was itself broadly similar to that used in the 2007 cost model. This involves calibrating the overall levels in the model to averaged data for all 2G/3G MCPs, since the averaged data is more likely to give reliable estimates of overall industry figures rather than those which reflect specific operator strategies.

A7.16 In assessing the deployment of 2G-specific, 3G-specific and shared 2G/3G network equipment, we have taken account of the modelled and actual equipment levels of the 2G/3G network operators. The information for the 3G-only operator was used as an additional point of comparison.

A7.17 The asset count calibration focussed on adjusting the parameters listed in paragraph; except the last two (MEA capex and MEA opex) which are used for the financial calibration.

Responses to the April 2010 Consultation

Vodafone

A7.18 Vodafone expressed concern that we have only used the total number of cell sites as a network measure for comparison and questioned why the other assets

included in the 2007 calibration had not been used for calibrating the April 2010 cost model.[143]

A7.19 Vodafone also claimed that the model was building too many 2G cell sites from mid 2005 onward and suggested that the 2G cell site calibration could be improved by taking a number of steps, including reversing the changes in 2G cell radii, and altering the scorched node[144] utilisation for some geotypes.[145]

A7.20 Vodafone also claimed that the model was building too few TRXs and suggested that the TRX calibration could be improved by increasing the number of TRXs per macro-site.[146]

A7.21 Vodafone commented that the April 2010 cost model estimated too many macro sites compared to the calibration data for 2006-2008.[147]

A7.22 Vodafone also expressed concern that the model was building too few BSCs and MSCs and suggested that it was due to higher capacity adjustments .[148]

O2

A7.23 O2 commented that total macro site counts in the model were below calibration data (initially) before then increasing faster than actual data. O2 also drew attention to the change in busy hour assumptions over time and suggested the revision may not be appropriate.[149]

Virgin Media

A7.24 Virgin Media commented that the growth in macro sites was too low for the period 2005 to 2009. Virgin Media stated that this would mean that the model would underestimate sites in the future.[150]

Ofcom's response to specific points raised by stakeholders

A7.25 As a general response to comments on cell site calibration, we note that the April 2010 cost model was also calibrated against network asset counts other than just cell sites. Indeed, as explained at paragraph A10.12 of the April 2010 consultation, cell sites were not the only asset type used to calibrate the model – even though for other assets the approach was more high-level.

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[143] Vodafone response to the April 2010 consultation, Annex 3 page 34. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[144] A scorched-node deployment is one that evolves over time and is constrained by the history of deployments. Conversely, a scorched-earth deployment is one which has no historic constraints, and can be deployed in an optimal fashion.
[145] Ibid
[146] Vodafone response to the April 2010 consultation, Annex 3 page 35. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[147] Ibid
[148] Ibid
[149] O2 response to the April 2010 consultation, page 58. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf
[150] Virgin response to the April 2010 consultation, pages 10-11. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Virgin.pdf

A7.26 Table A7.1 below shows the count of key network equipment in the model compared to the average operator benchmark after complete calibration of the 2011 cost model. This is shown on an average basis for the national 2G/3G MCPs.

Table A7.1: Comparison of asset count of key network equipment between model output and 2G/3G MCP data in 2009/10[151]

Asset type	MCP average	Model
2G macrocells	9,398	9,421
2G micro and picocells	1,989	2,171
3G macrocells	7,247	7,206
3G micro and picocells	409	415
Total macro sites	10,921	11,373
Total micro and pico sites	2,042	2,376
TRXs	65,626	67,481
BSCs	224	211
3G carriers	20,693	23,224
RNCs	49	59
2G MSC	30	29
2G/3G MSC Server	18	17
2G/3G MGW	30	31
SMSC	17	17
HLR	30	31
SGSN	14	16
GGSN	7	8

Source: Analysys Mason

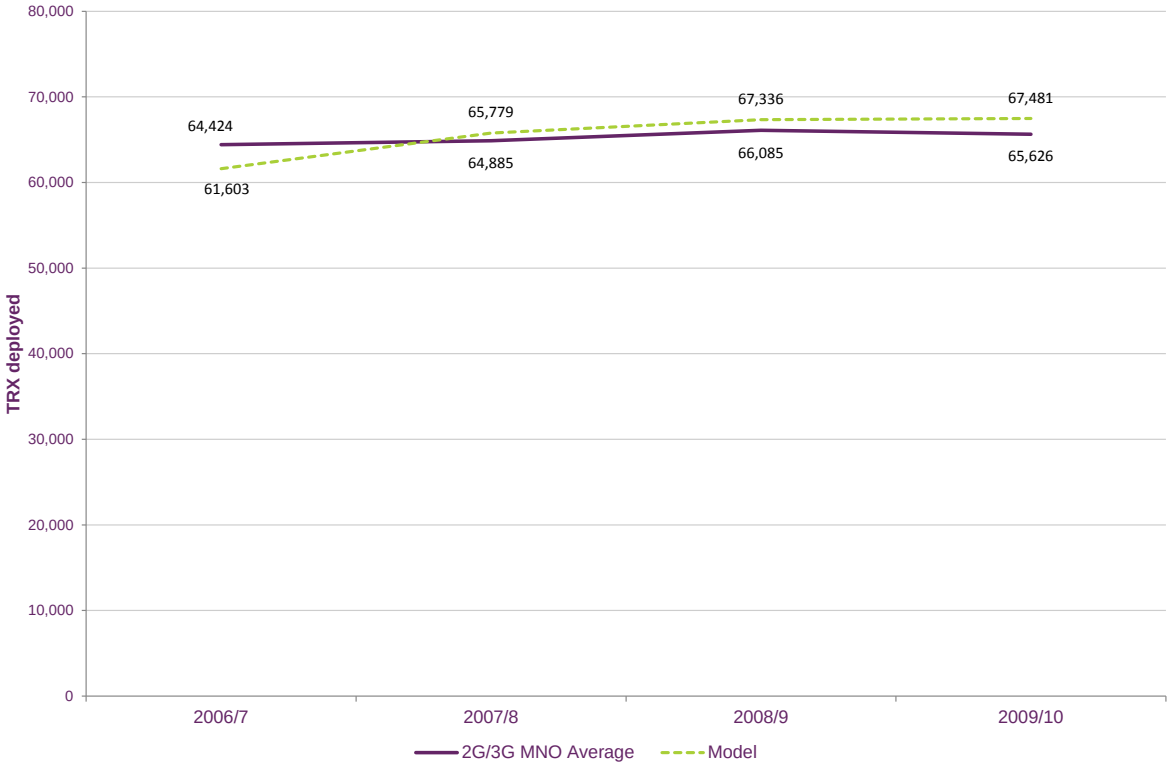
A7.27 We have accepted Vodafone's comments on the 2G cell sites calibration and have taken steps to improve it. As a first step prior to calibration, we have reverted to using the 2G cell radii values from the 2007 cost model.

A7.28 We agree with Vodafone's observation on the misalignment of TRX calibration and have examined the TRX calibration more closely. Figure A7.1 below shows the counts of TRX in the model compared to the operator benchmarks after complete calibration of the new model. We did not find it necessary to increase the minimum

[151] The calibration of data assets (RNCs, SGSN, GGSN) is not as accurate due to the inclusion of H3G data in our data traffic forecasts.

TRX per site, instead changing other parameters resulted in an acceptable calibration.

Figure A7.1: Comparison of TRX between model output and 2G/3G MCP data

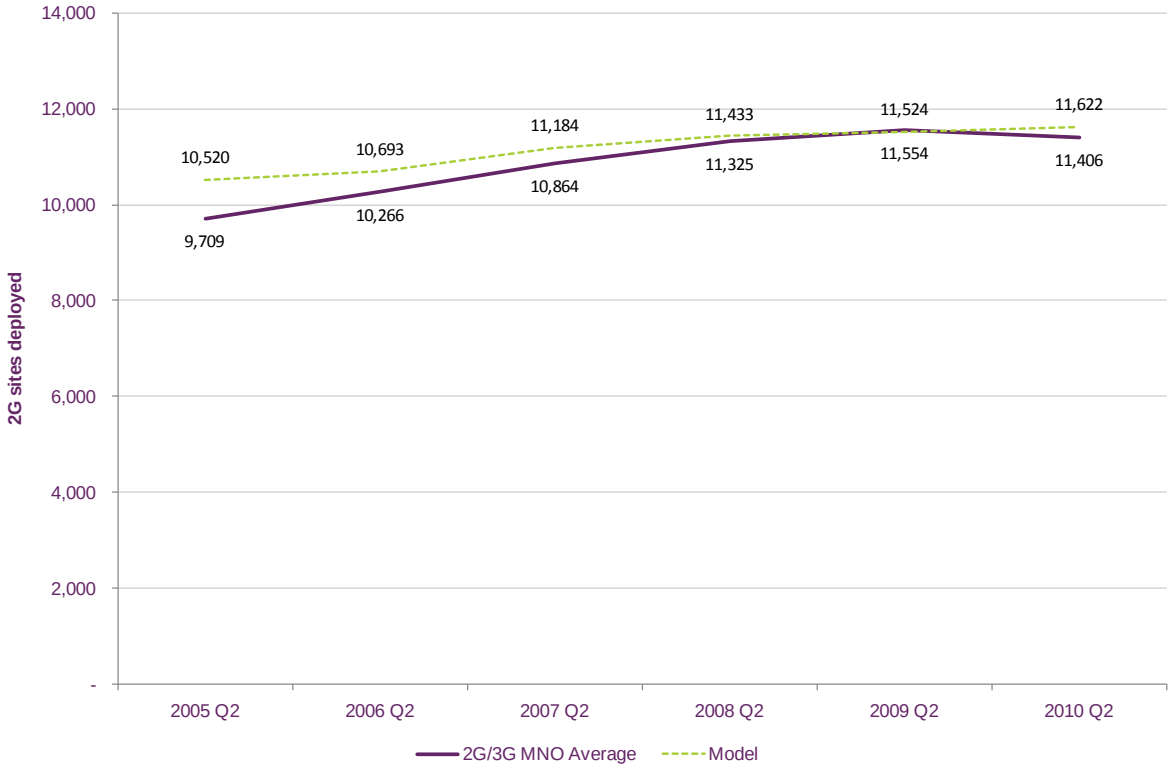


Source: Analysys Mason

A7.29 In light of Vodafone's comments in respect of BSC and MSC calibration, we have taken steps to refine the calibration for these assets, including changing the equipment capacity. We have also put in place a corresponding systematic adjustment to equipment unit costs for these assets. This is described in greater detail in paragraph A7.41 below.

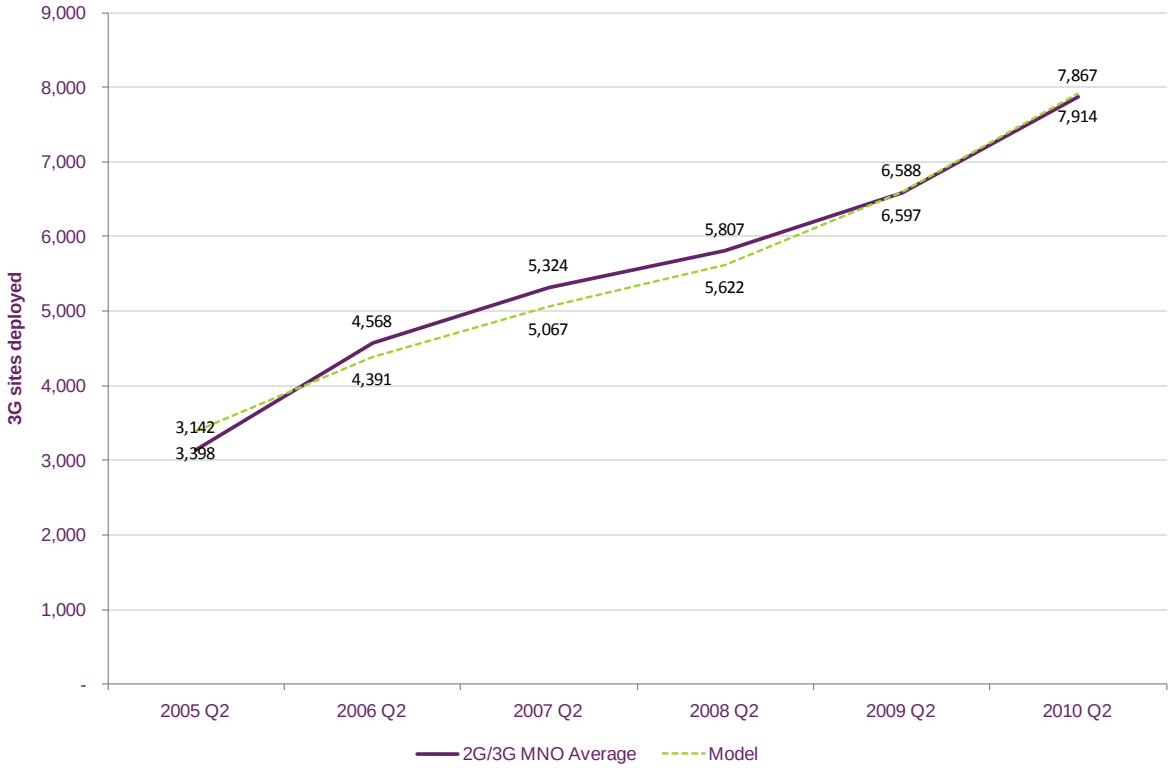
A7.30 We also accept the comments from Vodafone, O2 and Virgin Media that total macro cell sites could be improved from the April 2010 version of the model. The four figures on the following pages (Figure A7.2 to Figure A7.5) show the counts of sites in the model compared to the operator benchmarks after complete calibration of the 2011 cost model. As can be seen, the new "total macro sites" matches more closely the average operator level while the gradient of the "total 3G sites" is much closer to the one for the average operator.

Figure A7.2: Comparison of total 2G sites between model output and 2G/3G MCP data



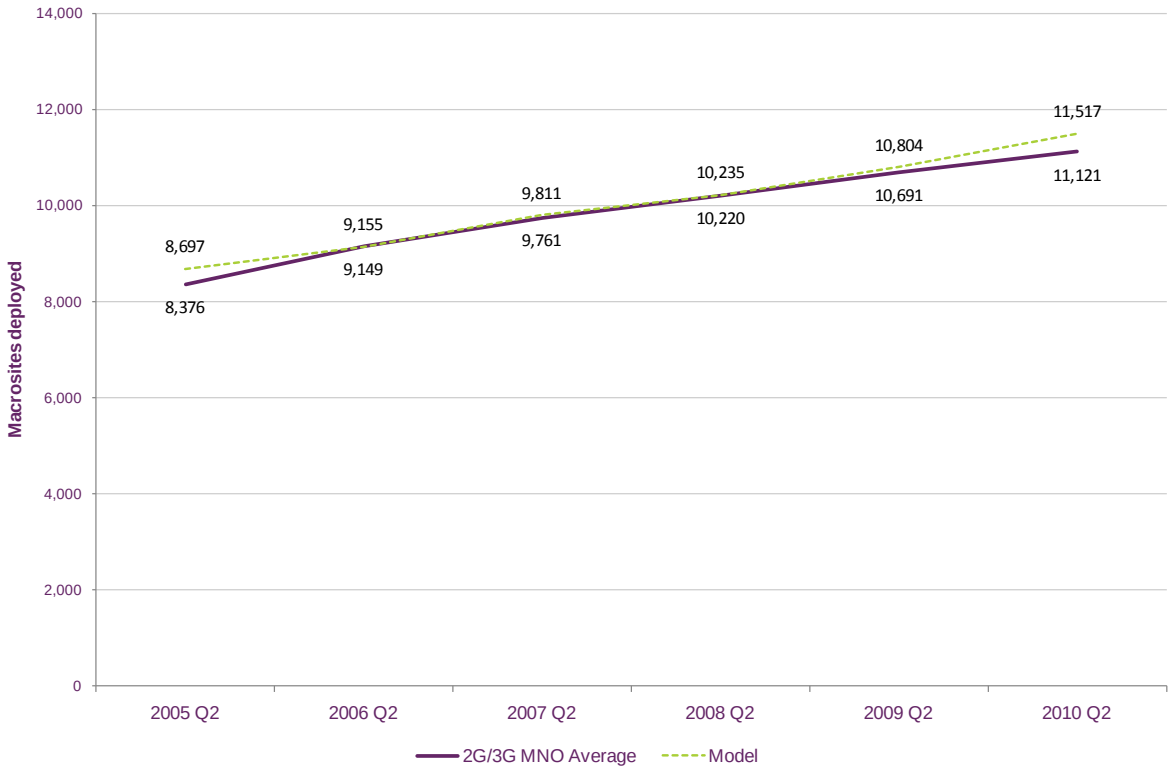
Source: Analysys Mason

Figure A7.3: Comparison of total 3G sites between model output and 2G/3G MCP data



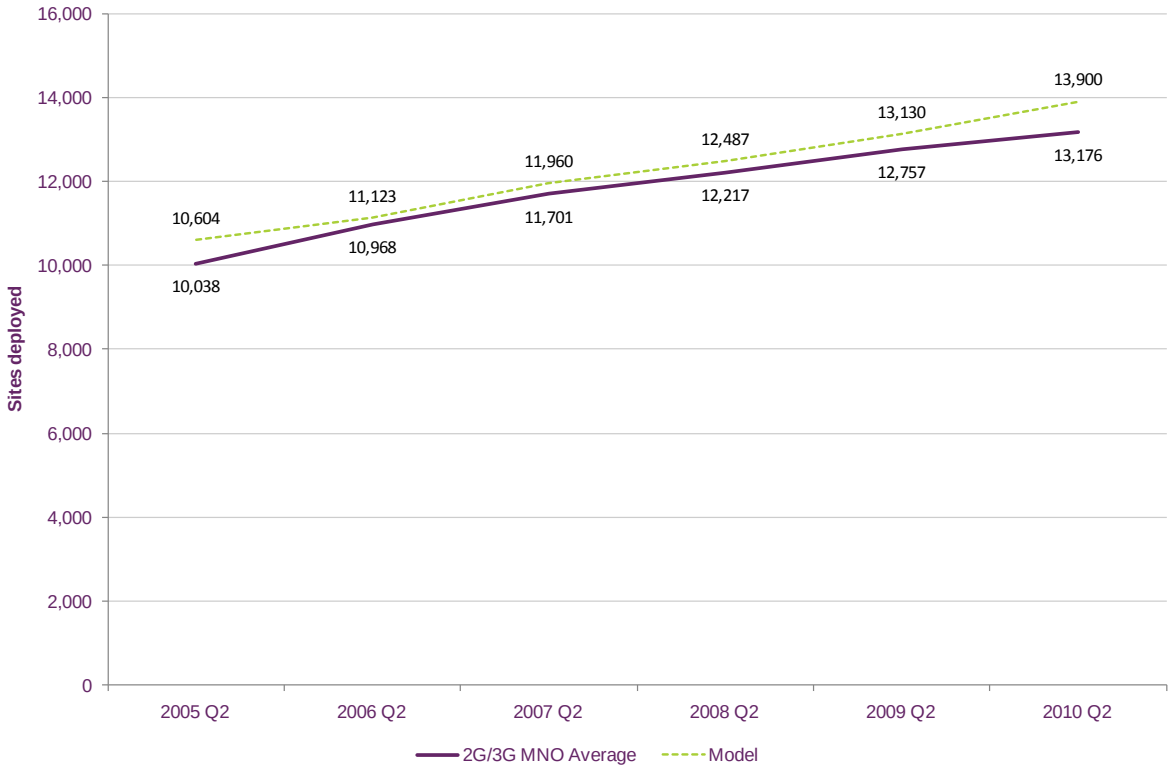
Source: Analysys Mason

Figure A7.4: Comparison of total macro sites between model output and 2G/3G MCP data



Source: Analysys Mason

Figure A7.5: Comparison of total macro, micro and pico sites between model output and 2G/3G MCP data



Source: Analysys Mason

A7.31 Extensive calibration exercises have been carried out for the major asset types. For assets where capacity changes over time (e.g. RNC, HLR), we have approached this calibration in two steps. The first step was to calibrate the actual equipment in 2009/2010 as seen in Table A7.1 by changing the equipment capacity and/or utilisation parameters from the values used in the April 2010 cost model. As a result, the model then calculated too few units in the past (because equipment had lower capacity historically) and too many in the future (because equipment has greater capacity in the future). This effect arises because equipment capacity does not evolve over time in the MCT cost model. The second step compensates for this by adjusting the unit replacement cost and the price trends to ensure that the replacement cost per unit of capacity changes over over time in line with the MEA price trends. This calculation is explained in more detail in paragraph A7.41 below.

Cost calibration

A7.32 Similarly to the calibration of asset counts, the aim of the cost calibration exercise has been to adjust model inputs so that the levels of GBV, NBV and operating costs produced by the model are broadly consistent with average operator data. The model was calibrated so that the GBV, NBV and operating expense outputs for 2006, 2007, 2008 and 2009 should be close to the average of the 2G/3G MCPs, but as a minimum always in between the minimum and maximum values seen across all of the operators. The cost benchmarks obtained from the national MCPs could not be split consistently between 2G-specific, 3G-specific and shared costs, so total network costs for each operator have been considered for the purpose of calibration. The cost calibration has focussed on adjusting MEA levels for investment and operating unit costs over time.

Responses to the April 2010 Consultation

Vodafone

A7.33 Vodafone claimed that there was an error caused by the mistaken inclusion of handset costs in the GBV and NBV calculation.[152]

A7.34 Vodafone also expressed concern that the adjustments for increased core network equipment capacity may not have been reflected in the replacement unit cost of equipment.[153]

A7.35 Vodafone finally claimed that declines in the MEA equipment prices between 2005/06 and 2007/08 were too steep.[154]

O2

A7.36 O2 also claimed that the costs and capacity changes in the April 2010 cost model were not consistent.[155]

A7.37 O2 claimed that declines in the MEA equipment prices for some radio network assets were too large between 2004/05 and 2008/09.[156]

Virgin Media

A7.38 Virgin Media noted a shortfall of 2% in opex relative to outturn values.[157]

H3G

A7.39 H3G claimed that historic equipment prices had not been changed when historic equipment capacity had been adjusted.[158]

Ofcom's response to specific points raised by stakeholders

A7.40 We agree that the inclusion of handset costs in the GBV and NBV calculation was incorrect. This has been now been amended.

A7.41 We agree with Vodafone, O2 and H3G that changes in historic equipment prices should be consistent with changes in historic equipment capacity. New calculations have been added to produce an adjustment factor reflecting capacity changes between the 2007 cost model and the 2011 cost model.[159] The effect is that the cost per unit of capacity reduces in line with the base MEA price trend even if there is a large change in equipment capacity between models.

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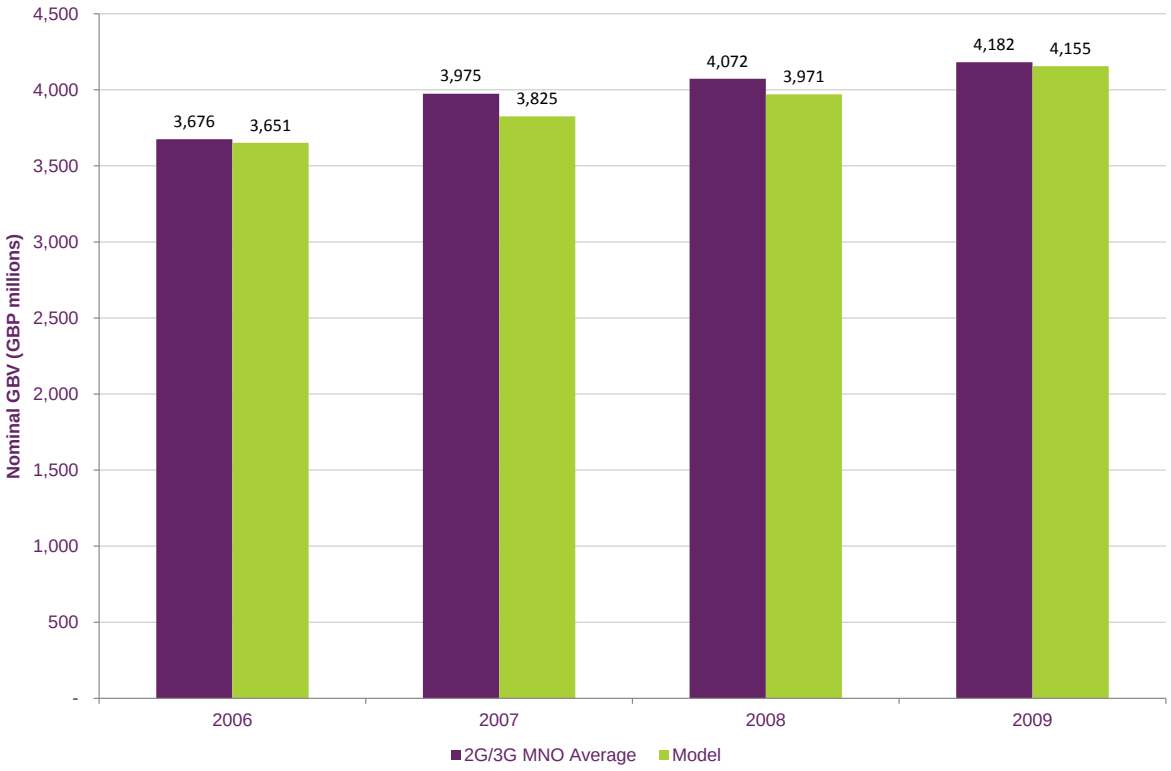
[152] Vodafone response to the April 2010 consultation, Annex 3 pages 30-31. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[153] Vodafone response to the April 2010 consultation, Annex 3 page 35. Ibid
[154] Vodafone response to the April 2010 consultation, Annex 3 pages 88-94. Ibid
[155] O2 response to the April 2010 consultation, page 59. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf
[156] Ibid.
[157] Virgin response to the April 2010 consultation, page 11. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Virgin.pdf
[158] H3G additional response to the April 2010 consultation, page 7. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/three.pdf
[159] This adjustment is applied to the equipment price in addition to the 'Base MEA investment price trend'.

A7.42 We agree with Vodafone and O2 that the changes in equipment costs between 2005 and 2008 were too large, and note that this was mainly due to seeking calibration (and hence due to the incorrect inclusion of handset GBV). Following completion of the new calibration process, these large price declines have now been reduced and are more consistent with the price trends in the 2007 cost model.

A7.43 We do not consider that the opex shortfall reported by Virgin Media is material enough to raise a concern. In addition it should be noted that the calibration exercise implies a level of trade-off between calibrating to various metrics. For instance, if the opex were refined for the small amount identified by Virgin Media, that would likely reduce the accuracy of other calibration metrics.

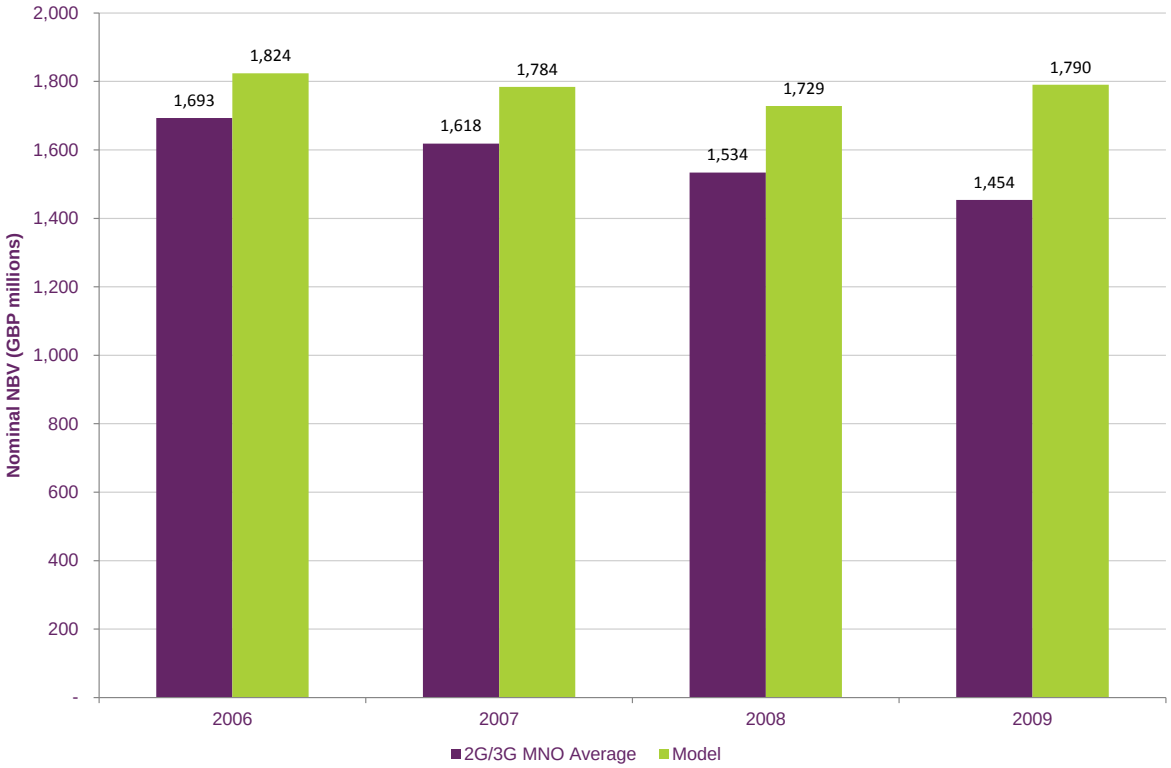
A7.44 The three figures below (Figue A7.6, Figure A7.7 and Figure A7.8) show the levels of GBV, NBV and operating costs from the model in each relevant year compared to the operator benchmarks, after the final calibration of the 2011 model.

Figure A7.6: GBV comparison between model output and 2G/3G MCP data



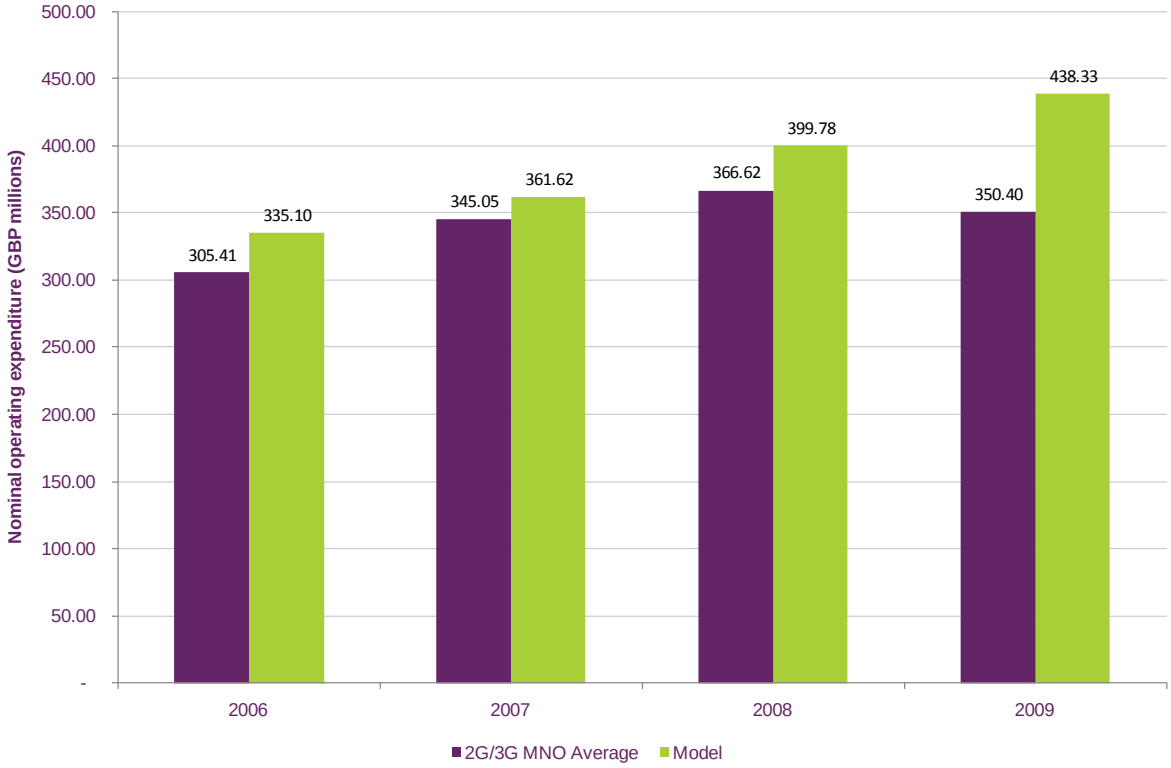
Source: Analysys Mason

Figure A7.7: NBV comparison between model output and 2G/3G MCP data



Source: Analysys Mason

Figure A7.8: Opex comparison between model output and 2G/3G MCP data



Source: Analysys Mason

A7.45 The GBV value calculated by the model is within 1-4% of the *average* GBV and is comfortably within the *range* supplied by the 2G/3G operators. Although the model

overestimates opex and NBV against the average supplied by the national 2G/3G MCPs, the values calculated by the model are comfortably within the range supplied by the national 2G/3G MCPs.

A7.46 Having considered stakeholder responses and further refined key input parameters, we consider the 2011 cost model to be well calibrated to an average efficient national 2G/3G MCP.

Annex 8

Cost of Capital

A8.1 In this annex we cover the following areas:

- A summary of our cost of capital estimate.
- How we estimate and use the cost of capital.
- Updated estimates (and how they compare with previous estimates)
- Why our final estimates are lower than in the April 2010 consultation.
- Key parameter values for the cost of capital:[160]

  i) The risk-free rate,
  ii) Gearing,
  iii) Equity Risk Premium (ERP)
  iv) Beta,
  v) Cost of debt/debt premium
  vi) Corporate tax rates.

- Stakeholder responses and CC precedents on the cost of capital parameters
- Detailed calculations.

Summary

A8.2 We have an established method for estimating the cost of capital. Our method closely reflects that adopted by other UK regulators.

A8.3 Estimating the cost of capital is difficult following the period of unusual capital market instability of late 2008 and early 2009. This has been recognised by Ofcom and by other regulators, including the Competition Commission.

A8.4 Notwithstanding this, certain aspects of our 2009 estimates of the cost of capital for BT were reviewed by the CC in two separate appeals and we were found not to have materially erred on the points raised. Thus we believe that our assessment framework remains appropriate, and that the approach we take to the estimation of the parameters that drive our estimates of the cost of capital is reasonable.

A8.5 For this reason – along with a desire for consistency - we propose to use the same framework to estimate the cost of capital as we have done in the recent past.

A8.6 Our final estimate of the cost of capital for an efficient mobile operator is set out below, alongside our consultation estimate from April 2010, and our previous estimate from 2007.

[160] For each parameter required to estimate an efficient national MCP's cost of capital, we will explain what the parameter represents, how it affects our overall cost of capital estimates, what we have said previously, what respondents to our last consultation said, what the latest evidence says, and what estimate we propose to adopt.

Table A8.1: Cost of capital estimates for a UK mobile network operator

	Pre-tax real WACC (mid-point)
March 2007	11.5%
April 2010 (consultation)	7.6%
March 2011	6.2%

A8.7 The headline estimate of the cost of capital for an efficient UK national MCP shows a reduction of 1.4 percentage points when compared with the mid-point of our consultation range (of 6.5% - 8.8%).

A8.8 This reduction is mostly attributable to macroeconomic changes, but also to mobile operator-specific changes, as follows:

8.8.1 Macroeconomic changes (lower interest rates, and reduced corporate taxes) account for 1 percentage point of the reduction since last year, and

8.8.2 Operator-specific changes (an apparent reduction in the perceived risk of mobile telecom businesses when compared to the general market) account for 0.4 percentage points of the reduction.

How we estimate and use the cost of capital

A8.9 When we refer to the cost of capital we mean the rate of return required by investors that a firm must generate in order to raise money in the capital markets. We usually mean a weighted average cost of capital (WACC).

A8.10 Companies have two basic ways of obtaining funding, through debt or equity. By knowing the proportion of each type of funding, and estimating the cost of each, we can estimate the WACC.

A8.11 The model we have consistently used for estimating the cost of capital is the Capital Asset Pricing Model (CAPM), the preferred model of the Competition Commission[161] and other UK regulators.

[161] Indeed, in its Bristol Water determination in September 2010, the CC said the following:
"*In our 2007 report on Heathrow and Gatwick, we looked at alternatives to CAPM and found that:*
(a) CAPM remains the tool with the strongest theoretical underpinnings;
(b) it is not at all clear from the academic literature that other models have better predictive power, particularly when applied to UK companies; and
(c) none of the alternative models helps to overcome the problems that CAPM has in dealing with limited market data.
We believe that these points remain valid. Hence, we also continue to believe that although the CAPM has its limitations, it is the most robust way for a regulator to measure the returns required by shareholders. Moreover, we have placed considerable weight on the CAPM in previous regulatory inquiries and we see benefits in consistency."

The Capital Asset Pricing Model

A8.12 In its simplest form, the weighted average cost of capital for a firm is derived as follows:

$$WACC = K_e * (1 - g) + K_d * g, \text{ where}$$

[1. K_e = the cost of equity, which is given by reference to the risk-free rate (r_f), the expected return on a basket of equities (the equity risk premium, or ERP), and the perceived riskiness of the asset in question (β), such that $K_e = r_f + \beta$ (ERP).

2. Kd = the cost of debt, which is given by reference to the risk-free rate and the debt premium of the firm, d_p, such that $K_d = r_f + d_p$

3. g = gearing, which is defined as net debt divided by enterprise value. Enterprise value is defined as net debt plus market capitalisation.]

A8.13 In addition to the equations set out above, which are a simplified version of our CAPM calculations, we need to take into account the relative tax treatment of debt and equity, and define a WACC that can be applied at a pre-tax level.

Frequency of Ofcom's reviews of the cost of capital

A8.14 We last estimated the cost of capital for an efficient national MCP in March 2007. This new MCT charge control will come into effect in 2011. When estimating the cost of capital we need to balance:

8.14.1 The need to ensure that cost of capital estimates are not out of date by the end of the period, by using the best available data on a relatively frequent basis; and

8.14.2 The desire for continuity and certainty for investors and stakeholders, which would suggest that longer periods between reviews is appropriate.

Our methodology remains consistent

A8.15 In general we believe that estimates of the WACC based on current and historic data will remain relevant and valid for the period during which the regulated charges will apply.

A8.16 However, it may not always be appropriate to rely solely on current market data. For example, we know that the rate of corporation tax will fall over the next few years, to 24% during the final year of the control. It is appropriate to recognise this in our estimates.

A8.17 In addition, our observations of market data suggest that some parameters have moved significantly in recent months, or currently imply values which need to be carefully interpreted.

A8.18 One such parameter is the risk-free rate, which we observe to be at a historically low level. In this instance, we need to be cautious in selecting values to ensure that they are appropriate and not unduly influenced/distorted by very particular short term events.

A8.19 For example, in the past, in relation to the risk-free rate, we have given significant weight to an observed tendency for mean reversion[162]. We are mindful of departing from this well-understood methodology in an unexpected way which could create regulatory uncertainty.

Our updated estimates

A8.20 In our previous MCT charge control, we estimated the pre-tax real cost of capital to be 11.5%. The parameter values that led to this previous estimate are set out below.

Table A8.2: Cost of capital estimate in previous MCT decision, March 2007

	March 2007
Equity Risk Premium	4.5%
Asset beta (mid-point)	1.18
Equity beta at 10% gearing	*1.0 – 1.6*
Real risk-free rate	2%
Inflation	2.8%
Debt premium	1.5%
Tax rate	30%
Pre-tax real WACC	11.5%

A8.21 In our April 2010 consultation, we estimated the cost of capital for a UK mobile operator to be in a range of 6.5% - 8.8%.

A8.22 Our updated parameter estimates and calculations give a point estimate of 6.2%, as shown below:

Table A8.3: Cost of capital estimates in current MCT consultation

	April 2010	March 2011
Equity Risk Premium	5%	5%
Asset beta (mid-point)	0.62	0.56
Equity beta at 30% gearing	*0.7 – 1.0*	*0.76*
Real risk-free rate	2%	1.5%
Inflation	2.5%	2.5%

[162] Mean reversion describes a general tendency by certain parameters (such as the risk-free rate) to fluctuate around observed average levels. If the parameter value is above or below the average for a period of time, mean reversion suggests that it will trend back towards the average in time.

Debt premium	1% - 2%	1.5%
Tax rate	28%	24%
Pre-tax real WACC	6.5% - 8.8%	6.2%

A8.23 Stakeholders will note that our final estimate is below the range that we identified in the April 2010 consultation. However, it should be noted that the changes to corporate tax rates announced in June 2010 account for a 0.4 percentage point reduction to our estimated cost of capital. Without this change, our final estimate would sit at the bottom of the range identified previously.

Why our new estimates are lower

A8.24 Our approach in this statement, when estimating the cost of capital, is the same as it has been in the past: we observe and take account of relevant market data and exercise judgement in interpreting that data.

A8.25 The changes to our estimates of an efficient national MCP's cost of capital can be considered to be of two types: market-wide changes that affect all companies, and changes that are specific to mobile operators.

A8.26 Our observations highlight three significant changes since the April 2010 consultation:

8.26.1 A reduction in the risk-free rate,

8.26.2 A reduction in the estimated asset beta for an efficient national MCP, and

8.26.3 A progressive, planned reduction in corporate tax rates to 2014/5.

A8.27 Table A8.4 sets out how these changes impact our overall estimates:

Table A8.4: Changes to efficient MCP WACC estimates (mid-points)

	April 2010 cost model (mid-point)	2011 cost model	Change to WACC estimate
Real risk-free rate	2.0%	1.5%	(0.6%)
Tax rate	28%	24%	(0.4%)
ERP	5.0%	5.0%	-
Market-wide changes			*(1.0%)*
Asset beta	0.62	0.56	(0.4%)
Debt premium	1.5%	1.5%	-
Operator-specific			*(0.4%)*
Pre-tax real WACC	7.6%	6.2%	(1.4%)

A8.28 Market-wide changes to our proposed WACC parameters account for 1 percentage point of the reduction in the cost of capital, while company-specific changes account for a 0.4 percentage point reduction.

Key parameter values

A8.29 There are a number of parameters that we have to estimate in order to assess an overall cost of capital for an efficient national MCP, some of which are more material than others. For example, the risk-free rate is the one parameter which affects both the cost of debt and the cost of equity, and therefore our estimation of it is a particularly important part of this process.

A8.30 The following sections of this annex will look at the parameters in turn, and set out the evidence that we rely on in reaching our preliminary view set out here.

The risk-free rate

What are we trying to estimate?

A8.31 The risk-free rate is perhaps the most important parameter when estimating the WACC, since it influences both the cost of equity and the cost of debt.

A8.32 We need to be mindful that this charge control is for a 4 year period, and therefore our rate needs to be relevant for that period.

A8.33 Our approach is to estimate a rate that is based on historic and current data, but which should be relevant for the period covered by the control.

What we have said previously

A8.34 In our second consultation in April 2010, we estimated the real risk-free rate to be 2.0%. This estimate was informed primarily by reference to the average yields on 5 year gilts in the years leading up to our decision.

A8.35 In our statement prior to that in March 2007, we also estimated the real risk-free rate to be 2.0%.

What have respondents said?

A8.36 No respondents commented specifically on our risk-free rate estimates in the second consultation.

Recent evidence

A8.37 The real risk-free rate (as measured by yields on UK 5 year gilts) has been falling since November 2008, when it peaked at over 4%. In the last year the real rate has been between 0.5% and -0.5%, although we do not believe this to be a sustainable long-term level, certainly not at the lower end of that range.

A8.38 The level of demand for UK gilts has been affected by the UK government's programme of quantitative easing as well as from strong investor demand for UK government debt, which is seen as relatively low-risk compared to some other European countries' sovereign debt. The prices (and ultimately the yields) of gilts are determined by supply and demand, just like any other capital market instruments.

A8.39 The currently high levels of demand for UK gilts look unusual when viewed against long-term data, and we are cautious about attaching too much weight to current very low real rates.

A8.40 We note with interest that in its recent determination on Bristol Water, the CC used a real risk-free rate range of 1% – 2%, and chose a point estimate at the top of that range, despite the very low rates observed in the market.

A8.41 We would also note that this decision was based on data up to and including July 2010. We have had the benefit of more recent data, during which time real risk-free rates have persisted at historically low levels.

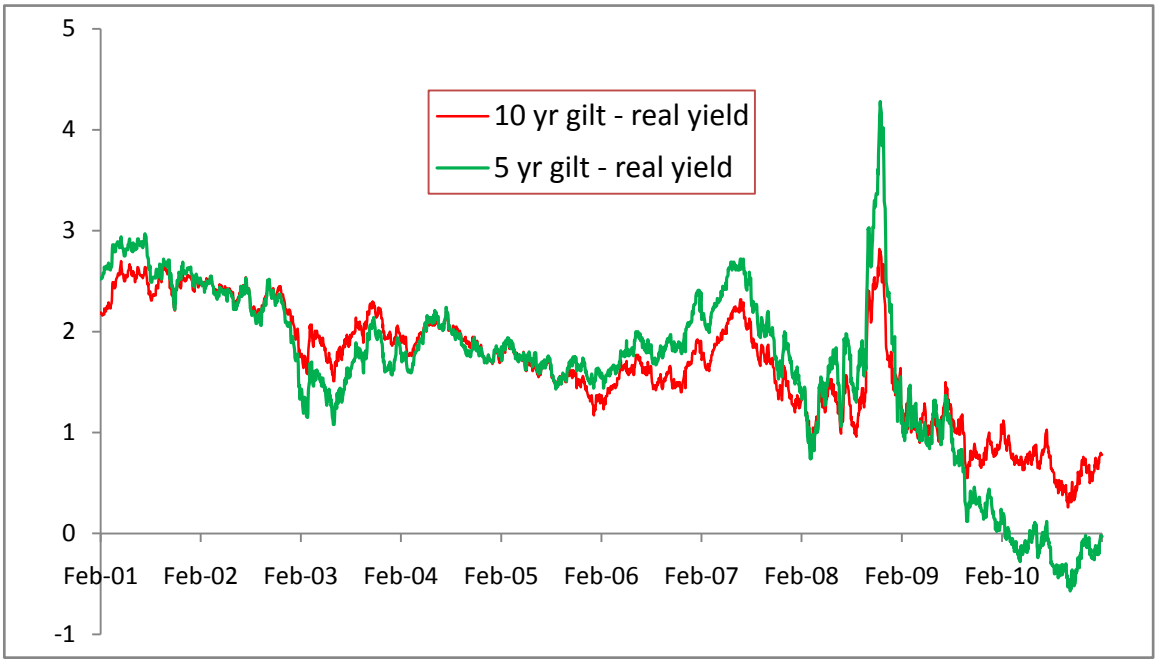
A8.42 We can track real gilt yields over time, using Bank of England data on 5-year and 10-year duration gilts, as shown below. In the past we have tended to rely on 5-year gilts, since these most closely matched the period of the charge controls we were reviewing. However, we note the recent determination from the CC on Bristol Water where it states that:

> "In previous reports in the last ten years, the CC has paid less attention to longer-dated yields because of distortions and more attention to shorter-dated index-linked yields. At present, shorter-dated index-linked yields are affected by action by the authorities to address the credit crunch and recession and are less relevant to estimating the RFR."[163]

A8.43 While we continue to favour the use of 5 year gilt yields when estimating the risk-free rate, we have also considered 10 year gilt yields.

A8.44 From the figure below we can see that real gilt yields have been falling consistently since the beginning of 2009, and are now at, or close to, historically low levels.

Figure A8.1: 5 and 10 year gilt yields since 2001



Source: Bank of England

A8.45 While we would generally tend to give more weight to more recent rates than averages over past years, we are mindful (as in past charge controls) that we do

[163] Competition Commission (2010), page N17. http://www.competition-commission.org.uk/rep_pub/reports/2010/fulltext/558_appendices.pdf

not wish to give too much weight to a rate based on a period of unusual market activity. Therefore we are minded at the present time to give greater weight than usual to longer term averages.

A8.46 Given the likelihood of increasing yields in later years, we give more weight to the 1, 2 and 5 year averages than recent very low rates. We calculate that the 5 year average yield for 5 year real gilts is 1.3%, and the 10 year average for 5 year real gilts is 1.7%.

Table A8.5: Historic averages of Real 5 year and 10 year gilt yields (14 February 2011)

Averaging period	*10 yr gilt - implied inflation*	10 yr gilt - real yield	*5 yr gilt - implied inflation*	5 yr gilt - real yield
1 day	*3.3*	0.8	*2.9*	0.0
1 month	*3.2*	0.7	*2.8*	-0.1
3 months	*3.1*	0.7	*2.6*	-0.2
6 months	*2.9*	0.5	*2.4*	-0.3
1 year	*3.0*	0.7	*2.5*	-0.2
2 years	*2.9*	0.8	*2.3*	0.3
5 years	*3.0*	1.3	*2.5*	1.3
10 years	*2.8*	1.7	*2.5*	1.7

Source: Bank of England data

A8.47 10 year gilts tend to give higher yields than the 5 year equivalents, and are also less volatile. However, even the 10 year gilt yield is at historically low levels.

A8.48 The average yield on the 10 year government gilt over the last 5 years is also 1.3%, the same as that on the 5 year gilt.

What has the CC said?

A8.49 As noted earlier, in its recent Bristol Water decision,[164] the CC used a range of 1% - 2% for the risk-free rate, from which a point estimate of 2% can be inferred. This was based on evidence gathered up to and including July 2010.

A8.50 We view the CC's estimated risk-free rate as a useful reference point, but are also aware that we have 6 months more data.

[164] Competition Commission (2010), http://www.competition-commission.org.uk/rep_pub/reports/2010/fulltext/558_appendices.pdf

Our estimate is 1.5%

A8.51 Taking into account the 5 year and 10 year gilt data, the CC's data, and considering that current yields look unsustainably low, we estimate the real risk-free rate for the purposes of this 4 year charge control to be 1.5%.

A8.52 This is a 0.5% reduction from our previous estimate in April 2010 of 2.0%, and will impact both the cost of equity and the cost of debt materially.

A8.53 We are aware that an estimate of 1.5% is some way above current real risk-free rates. However, we consider that this is reasonable for the following reasons:

8.53.1 The CC's range of 1% - 2% in the Bristol Water determination.

8.53.2 The 5 year and 10 year average yields on 5 year gilts are around 1.5% (1.3% and 1.7% respectively).

8.53.3 When estimating regulatory cost of capital rates, we are mindful of the potential negative effects of making sudden large changes, which could create regulatory uncertainty. We are particularly mindful that current low rates reflect very specific conditions (including the Bank of England's Quantitative Easing programme) and have taken this into account.

Inflation in our risk-free rate assumption

A8.54 We have in the past used a general long-term inflation assumption of 2.5%.

A8.55 For ease of comparison with other modelling assumptions, we use an assumption here that aligns with that long-term figure. We note that the most recent implied inflation on 5 year gilts is 2.8%, and has averaged 2.5% for the last 5 years. Therefore we regard these rates as a useful sense-check of our inflation assumption.

A8.56 In addition, there are a great many inflation forecasts that we could use for the purposes of these charge controls. We believe that 2.5% is within that range of forecasts and is reasonable at this stage.

A8.57 When taken in conjunction with our real risk-free rate assumption of 1.5%, an inflation assumption of 2.5% implies a nominal risk-free rate estimate of 4.0%.

Gearing

A8.58 Debt funding has a lower cost than equity, because debt is less risky. In addition, debt funding is also more tax-efficient than equity funding. So a higher gearing tends to slightly lower the cost of capital. But companies need to balance debt and equity financing, since if the debt level is too high, the risk of default (insolvency) grows.

A8.59 Within the framework of the CAPM, the gearing is the way we measure the level of debt funding, and it is defined as a company's net debt divided by its enterprise value, where the enterprise value is the sum of the net debt and the market capitalisation.

A8.60 In the mechanics of the CAPM calculation, we use the gearing level, in conjunction with the observed equity beta, to determine a company's asset beta.

What we have done previously

A8.61 In the past our approach to gearing has been to assume an optimal level of gearing, which we took to be 10% for an efficient UK national MCP when we last estimated the cost of capital in 2007.

A8.62 In our consultation in April 2010, we proposed a range of 25% - 35%.

Respondents' views

A8.63 O2 suggested that our consultation range of 25% - 35% was too high, as it ignores the impact of the credit crisis. It suggests that "a forward-looking gearing estimate should be lower than the spot gearing."[165]

A8.64 H3G on the other hand, agreed that a range of 25% - 35% is reasonable.[166]

We now base our calculations on actual gearing levels

A8.65 As we explain in the sub-section on betas below, we have a preference for using Vodafone's equity beta and gearing.

A8.66 Vodafone's gearing has been between 25% and 35% in the last 2 years, and currently is around 25 – 30%. We base our calculations of the WACC on a gearing level of 30%, which is the average gearing observed for Vodafone over the last 2 years.

A8.67 This makes our calculations simpler than in the past, and further ensures that our debt premium calculations are consistent with the level of gearing observed during the period in question. Note however that this does not have any material effect on the overall WACC, because the estimation of the asset beta takes into account the gearing level.

[165] O2 response to the April 2010 consultation, paragraph 254, page 55-56, http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf
[166] H3G response to the April 2010 consultation, paragraph 525, page 139, http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf

Equity Risk Premium ("ERP")

A8.68 The ERP is a key component of the estimate of a company's WACC.

A8.69 Under the CAPM the ERP represents the extra return that investors require as a reward for investing in equities rather than a risk-free asset. It is not company-specific.

A8.70 Academics and other users of the CAPM have conducted a large number of investigations into the value of the ERP, using quantitative techniques and surveys. These have produced a range of widely differing estimates.

A8.71 Our approach to choosing an estimate of the ERP is broadly as set out in our 2005 statement entitled "Ofcom's approach to risk in the assessment of the cost of capital."[167]

What we have said previously

A8.72 In our April 2010 consultation we estimated the ERP to be 5.0%, up from an estimate of 4.5% in 2007. Our estimate was informed in particular by the work of Professors Dimson, Marsh and Staunton ("DMS) from the London Business School, which tracks the average premium that investors have earned from equities (as opposed to bonds or gilts) over time.

A8.73 In addition, we believed that the volatility we observed in equity markets at the time suggested that investors required a higher level of return in exchange for holding risky equity assets, and an increase of 0.5 percentage points in our ERP estimate did not seem unreasonable in this context.

What have respondents said?

A8.74 Vodafone[168] stated that our ERP assumption of 5% was too low, and that 6% was a more appropriate value. It said that Ofcom should use a broader range of evidence when assessing the ERP.

A8.75 In addition, Everything Everywhere submitted a paper by CEG in November 2010 which specifically addressed the issue of estimating the cost of capital during a financial crisis. The CEG report focuses on the impact of the credit crisis on the overall equity risk premium for mobile operators (i.e. the ERP multiplied by the equity beta).

A8.76 It suggests that the ERP was elevated during the credit crisis and states that:

> "even if mobile operator's actual risk remained the same during the crisis, there would still have been a dramatic reduction in their observed betas. This is because a stable *absolute* risk for mobile operators, at a time when overall equity market risk was rising

[167] http://stakeholders.ofcom.org.uk/binaries/consultations/cost_capital2/statement/final.pdf
[168] Vodafone response to the April 2010 consultation, Page 55-61. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone.pdf

sharply, implies a falling level of risk for mobile operators *relative* to the market."[169]

Recent data – extrapolating historical risk premia

A8.77 In the past, we have relied heavily on work carried out by DMS[170], which is regarded as being one of the most authoritative sources of historical estimates. DMS measure total returns over a relatively long period, include a large sample of countries and make adjustments for survivorship bias. We continue to believe this is a robust source of data.

A8.78 DMS have suggested an arithmetic mean premium[171] for the world index of around 4.5 – 5.0%.[172] They state that "this is our best estimate of the equity risk premium for use in asset allocation, stock valuation, and corporate capital budgeting applications." In addition, for the UK, DMS's estimated premium of equities over bonds (as measured by the arithmetic mean in the period 1900 – 2009) is 5.2%.[173]

Ex-ante estimation: academic/user surveys

A8.79 In the past we considered surveys of the ERP carried out amongst academics and users of the CAPM. In a consultation that we published in January 2005,[174] in relation to BT's cost of capital, weset out the range of views of academics as being from 3% to 7%, while the views of practitioners ranged from 2% to 4%. A study from 2008 by Pablo Fernandez[175] suggests that UK finance professors used ERP estimates with an arithmetic mean of 5.5%.

A8.80 As in the past, we afford this analysis relatively little weight since participant surveys do not provide the same quality of evidence as market-based measures.

Market commentary

A8.81 Vodafone refers to evidence from some market commentators which suggests that, during periods when equity prices are depressed and average corporate gearing is higher than anticipated, the ERP may be increased, in large part due to the technical effects of leverage. However, to the extent that this is an effect driven by lower equity values we consider that this effect will no longer be relevant once gearing levels revert to longer term norms.

A8.82 This may happen through the recovery of equity prices, or corporate financial management.

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[169] EE response to the April 2010 consultation, paragraph 9, page 3, http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/everything-everywhere-ceg.pdf

[170] Dimson, Marsh and Staunton, "Credit Suisse Global Investment Returns Sourcebook 2010", Credit Suisse Research Institute

[171] These estimates are calculated using arithmetic means from historic data. Arithmetic means are our preferred measure of the historic premia, and we give more weight to arithmetic means than to geometric means from the same data.

[172] DMS 2010, page 34.

[173] DMS 2010, page 158

[174] http://www.ofcom.org.uk/consult/condocs/cost_capital/cost_capital.pdf

[175] Fernandez, Pablo:Market Risk Premium Used in 2008 by Professors: A Survey with 1,400 Answers(April 16, 2009). Available at SSRN: http://ssrn.com/abstract=1344209

A8.83 We need to ensure that we take this effect into account when we estimate asset betas, in order to be consistent between our estimates of betas and the ERP.

Regulatory benchmarks

A8.84 Recent ERP estimates adopted by the UK's economic regulators and competition authorities are in a range of 5% - 5.5%.

Table A8.6: Regulatory benchmarks of ERP

Source/Year	ERP	Comment
Ofcom, 2009	5.0%	LLU Charge control in May 2009. Unchanged after subsequent review by the CC, determination dated August 2010.
CC, Bristol Water 2010[176]	5.0%	CC determination, published September 2010, reversing Ofwat's determination of 5.4% in November 2009
CAA, NATS 2010	5.5%	May 2010 determination

A8.85 We consider the CC's determinations of 5% in the Bristol Water and LLU Appeal to be a relevant consideration in our determination of the ERP. Given how recent these determinations are, and also given the generic, market-wide nature of an ERP assumption, we view this as useful evidence.

A8.86 We would find it difficult to diverge from such a determination without compelling evidence to demonstrate that this value has changed. We are not aware of any such evidence.

Competition Commission view on the market return and ERP

A8.87 In its most recent determination where it discusses cost of capital, i.e. Bristol Water, the CC discusses the market return (i.e. investors' expected return from holding equities, which is given by the ERP plus the risk-free rate) and the implied range for the ERP:

> "We therefore confirm, for our determination, our provisional findings of a range of 5 to 7 per cent for the market return, and implied range of 4 to 5 per cent for the ERP."[177]

A8.88 The CC's point estimate of the risk-free rate can be inferred to be 2%, and combined with their ERP point estimate at the very top of the range of 4% – 5%, it estimates a market return of 7%, again at the very top of its stated range.

[176] Competition Commission (2010). http://www.competition-commission.org.uk/rep_pub/reports/2010/fulltext/558_appendices.pdf
[177] Competition Commission (2010), Paragraph 100, page N27.http://www.competition-commission.org.uk/rep_pub/reports/2010/fulltext/558_appendices.pdf.

Our point estimate for the ERP is 5%

A8.89 We have reviewed evidence from respondents, market commentators, the Bank of England, and the CC, and believe that the high levels of volatility in equity markets suggest that the equity risk premium may have increased in recent years.

A8.90 We maintain our belief that the downside of setting an ERP too low is worse than the downside of setting the ERP too high. We therefore tend to favour setting the ERP towards the upper end of a 4.5% to 5% range.

A8.91 Specifically, our point estimate for the ERP is 5.0%.

A8.92 Our current point estimate of the risk-free rate is 1.5%, which, when combined with our estimate of 5% for the ERP, gives a current estimate of the market return of 6.5%. We note that this is towards the upper end of the CC's range of 5% - 7%.

Beta

What does the equity beta represent?

A8.93 The value of a company's equity beta reflects returns to shareholders relative to returns from the equity market as a whole.

What we said previously

A8.94 In our consultation in April 2010 we set out a preference for using Vodafone's equity beta and gearing levels[178] when considering an efficient national MCP. This was due to its lines of business being predominantly mobile, whereas the parent companies of the other UK MCPs had a broader range of fixed and mobile businesses (and in the case of Hutchison Whampoa - the parent company of H3G - it is a diversified conglomerate).

A8.95 In the April 2010 consultation we proposed an equity beta range of 0.7 to 1.0. This was based in particular on Vodafone's 2 year daily beta against the FTSE All-Share index, which was 0.84 at the time. Vodafone's gearing at the time was around 30%, and we proposed a gearing level of 25% - 35%.

A8.96 Combining the equity beta of 0.84 with a gearing level of 30% gave an assumed asset beta of 0.62 (with a debt beta of 0.1).[179]

A8.97 Our proposed ranges, of 0.7 to 1.0 for the equity beta, and 25% - 35% for the gearing level, were informed by reference to a report prepared for us by the Brattle Group ("Brattle"). We have asked Brattle to update that analysis and their new report is attached as an annex to this statement.

A8.98 Our approach to estimating equity betas in the past has been to give weight to a range of data periods, including 1 year, 2 years and 5 years. We then look at the average gearing, over the period in question, to estimate the asset beta accordingly.

A8.99 Note that in making our estimates we tend to adopt measurement periods that map fairly closely to the duration of the charge control (i.e. 4 years). Over the long run this gives us the chance to capture most of the movements in systematic risk over the period in question, and provides some comfort that in the long run, any potential short-term errors, should be 'smoothed out'.

What have respondents said?

A8.100 Vodafone, Everything Everywhere and O2 all commented on our beta analysis, and suggested that our consultation range for the equity beta was too low.

[178] Rather than using the listed parent companies of any of the other UK MCPs. We have not in the past attempted to disaggregate a Vodafone UK asset beta from the Vodafone Group estimate due to the arbitrary assumptions that would be required to do so. Disaggregation is suggested by O2 in its response to the second consultation. It is an approach we considered, but did not pursue, on the grounds that there is not a robust, widely accepted methodology for such a disaggregation, where it is not even clear whether the UK business of Vodafone has a higher or lower systematic risk than the Group as a whole.

[179] We assume a debt beta of 0.1. This is in line with the CC's estimated debt beta for Bristol Water of 0.1, which we consider is consistent with our estimated debt premium of 1.5% (versus the 1.9% that the CC implied for Bristol Water).

A8.101 Vodafone suggested that we should exclude the period of the credit crisis from our beta analysis. It added that any data after September 2008 should be excluded, and considers that:

> "the evidence between 2006 and 2008 points to an equity beta in the range 0.8 to 1.2."[180]

A8.102 Everything Everywhere stated that we needed to take the financial crisis into account in our analysis. In addition, the report by CEG submitted by Everything Everywhere discusses in some detail beta estimates for MCPs. CEG say:

> "once market conditions have returned to more normal levels, however, we would expect to see…..mobile operators' relative risk (beta) rise back to more normal levels. Ofcom's error has been to set the value of the market risk premium based on an assumption of long run 'normality' but to set the mobile operators' beta based on low estimates from the midst of the crisis."[181]

A8.103 O2 believed that we had placed too much reliance on the Vodafone data, and that we could have made use of additional data by looking at the evidence on other listed international mobile-only companies. O2 also suggested that we might disaggregate the Vodafone Group beta data to estimate a UK-only mobile operator beta[182].

A8.104 H3G supported Ofcom's equity beta ranges, and provided additional evidence about the stability of mobile telephony demand. H3G states that, based on this evidence:

> "it seems to us, from a purely qualitative point of view, that there appear to be sufficient reasons why mobile operators' betas would continue to be relatively low."[183]

Our approach

A8.105 Our approach in this statement is similar to previous charge controls, with a range of estimation periods being used. However, we place emphasis on the 2 year daily equity beta analysis, alongside average gearing during the same 2 year period, in order to derive an asset beta based on 2 years of data points. Our belief is that 2 year daily data affords the best compromise between sufficient datapoints to provide a statistically robust estimate, and the most up to date information.[184]

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[180] Vodafone response to the April 2010 consultation, page 59.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone.pdf
[181] EE response to the April 2010 consultation, paragraph 10, page 3.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/everything-everywhere-ceg.pdf
[182] O2 response to the April 2010 consultation, paragraphs 251 – 253.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf
[183] H3G response to the April 2010 consultation, paragraph 544, page 146
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf
[184] There are different periods that could be considered when looking at betas, which have different merits. Some commentators argue that in the dynamic telecommunications market, one year daily data gives the best snapshot of a firm's systematic risk, while others may argue that a 5 year monthly or weekly statistic is required to provide a robust long-term estimate. We have focused on a 2 year daily statistic in recent years, and we continue to believe this to be appropriate in this context.

A8.106 In this charge control, we are also considering other datasets, including 1 year daily data, and 5 year weekly data. From this information we then derive a plausible range for the asset beta of an efficient national MCP.

A8.107 We consider that the use of a range that includes both the 1 year data (which cannot be said to be from "the midst of the crisis"), and the 5 year data (which is a relatively long-run view of the asset beta), should mitigate the risk of an error such as that suggested by CEG.

A8.108 In addition, we have checked our asset beta range (based on Vodafone data), and the direction of travel of the asset beta, against the asset betas of the other UK national MCP parent companies (France Telecom, Deutsche Telekom and Telefonica), and those of US pure-play wireless operators[185]. This data was provided to us by the Brattle Group (see separate report attached as an annex to this statement).

A8.109 The additional asset beta data supports our view that mobile operators are viewed by investors as exhibiting relatively lower levels of systematic risk now than in the past.

A8.110 For an illustration of this point, see Figure 1 on page 5 of the Brattle report, which shows how Vodafone's 2 year equity beta fell from around 1.4 in January 2004 to below 0.75 by October 2010. In addition, Figure 20 on page 20 of the Brattle report, shows Vodafone's 2 year asset beta falling from around 1.0 at the start of 2005 to below 0.6 by October 2010. The same figure shows asset betas for the other MCP's parent companies being around 0.4 in October 2010, and around 0.6 for US wireless companies.

The evidence

A8.111 The report produced for us by Brattle uses data up to and including October 2010, which means the 2 year data window runs from the beginning of November 2008 to the end of October 2010. With that in mind, in addition to the Brattle analysis, we have updated our own beta and gearing estimates up to and including 14 February 2011. The 2 year window up to this date is likely to be less influenced by the credit crisis.

A8.112 We observe that during the credit crisis, as market capitalisations of companies fell, gearing levels rose. This meant that observed asset betas were depressed even if equity betas were observed to be stable.

A8.113 We use asset beta data which takes account of the crisis, alongside a normal ERP assumption (which will also necessarily include data that relates to both crisis and non-crisis periods). Our intention is to use an ERP estimate that is not adjusted for such short-term crisis effects and to adopt a similarly defined beta.

Vodafone asset beta movement in recent years – Brattle analysis

A8.114 As explained above, we asked Brattle to prepare an updated report on the range of equity betas for an efficient UK national MCP.

[185] We believe this substantially addresses the criticism of O2 that we placed too much weight on the evidence of Vodafone Group, and that we should consider other mobile-only companies.

A8.115 Brattle has concluded from its analysis of Vodafone's equity and asset beta, as well as those of the parent companies of other UK MCPs, and a range of comparator data, that a reasonable estimate of a UK mobile operator's asset beta, based on an equity beta calculated using 2 years worth of daily data, and a debt beta of 0.15, would be around 0.5.

A8.116 Brattle recognised that the recent drop in the 2 year betas might seem surprising. We agree that the scale of the reduction is large. But we consider that any concerns that this may be caused by the inclusion of credit crisis data, has been mitigated by the updating of our analysis to reflect the 2 year period from mid-February 2009 up to mid-February 2011.[186]

A8.117 Brattle's analysis shows estimates of Vodafone's 1 year and 2 year daily equity betas, when measured against the FTSE All-Share index (our preferred comparator index), of 0.73 and 0.68.

A8.118 Brattle's work shows a steady decline in Vodafone's 2 year equity beta since at least 2004, from more than 1.5 in January 2004, down to around 0.7 now. This decline has been associated with rising levels of gearing over the period, and as a result, the asset beta has fallen from above 1 to current levels just above 0.5.

A8.119 We also observe a similar change in the asset betas of France Telecom, Deutsche Telekom and France Telecom (see Figure 20 in the Brattle report), which all now sit between 0.25 and 0.4. The evidence suggests a general downwards movement in asset betas among telecoms operators with significant interests in the provision of mobile services.

A8.120 In addition, Brattle looked at 11 US telecommunications operators, of which 6 were pure-play mobile operators. Obviously we need to exercise caution when considering mobile operators listed on the US market, as they are likely to be subject to somewhat different market characteristics than UK companies. That said, asset betas for the wireless stocks against the S&P500 are at very similar levels to those for Vodafone against the FTSE All-Share Index. In our view, this might be considered to support the view that mobile operators are currently viewed by investors as exhibiting relatively low levels of systematic risk.

A8.121 The table below shows how Vodafone's asset beta has moved since our previous consultation in April 2010. The downward trend observed in April 2010 has been continued since then.

Table A8.7: Equity and asset betas for Vodafone vs FTSE All-share

Data period	2 yrs to April 2010	2 yrs to end October 2010	1yr to end October 2010
Equity beta	0.84	0.73	0.68
Average gearing	30%	31%	30%
Asset beta	0.62	0.53	0.51

Source: Brattle report, Ofcom analysis

[186] Also see paragraphs A8.134 to A8.143 below for further analysis of the impact of the credit crisis on observed asset betas.

Vodafone asset beta movement in recent years – data update

A8.122 As set out above, Brattle's analysis covered the period up to and including the end of October 2010. Adding in more recent data, including the addition of 5 year weekly data and 18 month daily data gives the following table:

Table A8.8: Updated asset betas for Vodafone vs FTSE All-share Index

Data period	*5yrs to 14 Feb 2011*	2 yrs to 14 Feb 2011	*18m to 14 Feb 2011*	1yr to 14 Feb 2011
Equity beta	*0.78*	0.67	*0.67*	0.76
Average gearing	*25%*	30%	*30%*	29%
Asset beta	*0.61*	0.50	*0.50*	0.57

Source: Bloomberg data, Ofcom analysis

A8.123 We are aware that our analysis factors in lower equity and asset betas for Vodafone now than our previous MCT charge control. This raises concerns that we are potentially observing the low point of the asset beta curve for Vodafone, and that this is a temporary, short-term phenomenon.

A8.124 However, in common with previous reviews, this parameter will be reassessed in 4 years time (in the event that there remains a continued requirement for a charge control).

A8.125 In our previous charge control, in 2007, our estimate of the asset beta for an efficient mobile operator was based on an equity beta range of 1.0 – 1.6, with an implied asset beta range of around 0.9 – 1.45. At the time we noted that equity betas and implied asset betas for mobile operators had fallen fairly significantly, and that:

> "there may be reason to revise the top end of Ofcom's previous range of 1.0 – 1.6 down to reflect the change in more recent estimates. However, given that beta estimates are subject to volatility and change it may be appropriate to continue to use the same range as the previous market review. It is not possible to judge whether the lower betas measured today reflect a long term trend or a short term market fluctuation."[187]

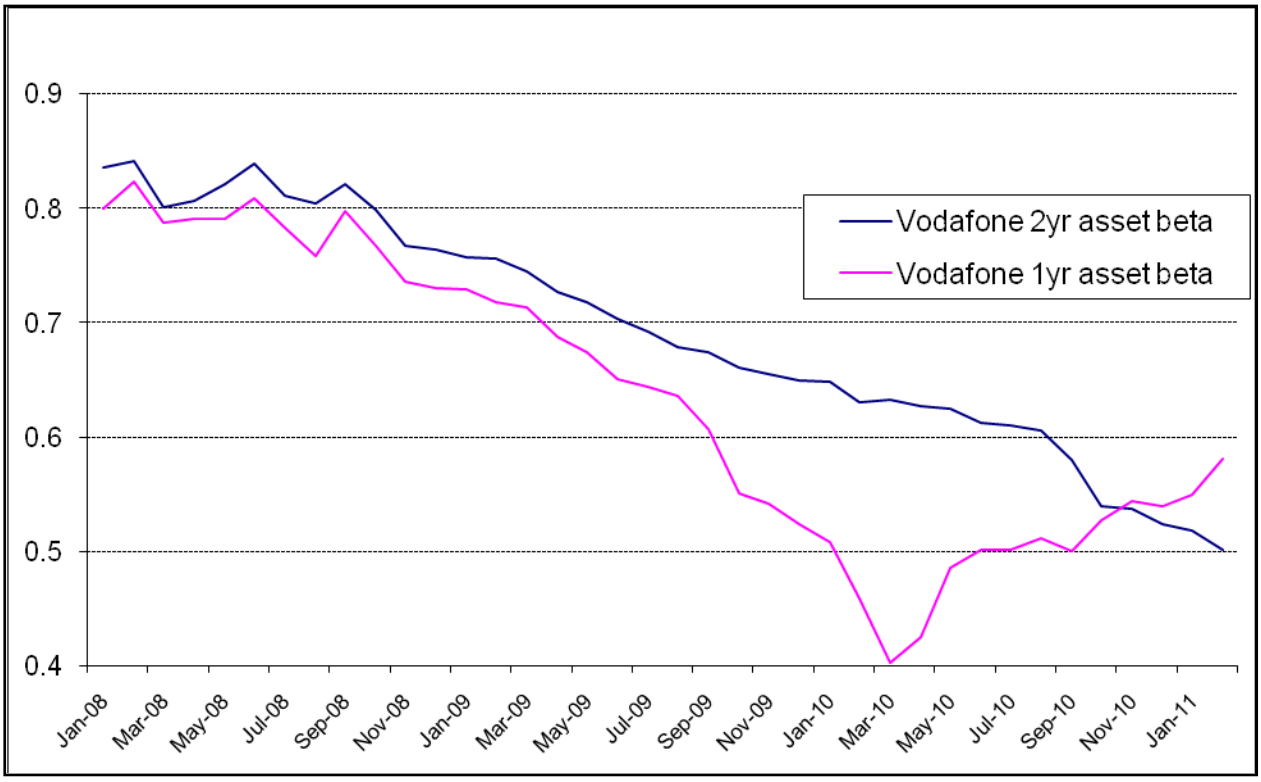
A8.126 We now think that, in the light of the latest evidence, the downward movement of equity and asset betas for mobile operators may be more of a long term trend than a short term market fluctuation. With the benefit of hindsight, our previous beta estimate may have given too much weight to past long run volatility, and not enough weight to more recent data. As a result our asset beta estimate may have been too high.

[187] Ofcom MCT statement (2007), paragraph A8.66. http://stakeholders.ofcom.org.uk/binaries/consultations/mobile_call_term/statement/statement.pdf.

A8.127 Therefore, we believe that the best way to try to mitigate the risk of under or overestimation of this parameter for a forward-looking charge control is to give greater weight to more recent data.

A8.128 The figure below suggests to us that the 2yr asset beta appears to be stabilising at or around 0.5, while we note that the 1yr asset beta has dipped as low as 0.4 in the last year.

Figure A8.2: 2yr and 1yr asset beta for Vodafone over last 3 years



Source: Bloomberg data, Ofcom analysis

Our point estimate of the asset beta is 0.56

A8.129 We believe a range of asset betas of 0.5 – 0.61 would be appropriate, based on the data we have observed. This range incorporates all of the most recent asset beta observations for periods between 1 year and 5 years, as can be seen from the table above. Our point estimate is the mid-point of this range, i.e. 0.56[188].

A8.130 We are acutely aware of the inherent difficulties in making equity and asset beta estimates, particularly when we observe large changes over time. Some stakeholders argue that we should give greater weight to longer term data, while others argue that the most recent data is always the best.

A8.131 We believe that by including asset betas from periods between 1 year and 5 years in our range, we are giving reasonable weight to both long-term data and recent data.

[188] The mid-point of the range is actually 0.555, but we round up to 0.56. Note that the overall pre-tax WACC estimate is 6.2% whether we use 0.555 or 0.56.

A8.132 In these circumstances we are required to use our judgement to arrive at a reasonable estimate that takes account of all available data. We believe a range of 0.5 – 0.61, with a mid-point estimate of 0.56, is a reasonable assessment of the asset beta for an efficient national MCP for the purposes of this charge control. This is equivalent to an equity beta of 0.76 at a gearing of 30%.

A8.133 This estimate should be viewed in conjunction with our equity risk premium estimate of 5%.

'Excluding credit crisis data' from the analysis

A8.134 Vodafone's response suggested we should exclude data from the credit crisis, and should look at pre-2008 data.

A8.135 If the equity and asset beta evidence had been stable over the last 5 years, then we may consider Vodafone's approach to dealing with the credit crisis to be reasonable.

A8.136 However, our belief is that investors' perceive that the systematic risk of telecoms operators in general, and mobile operators in particular, has fallen in recent years. This is evidenced by both our own beta analysis and the work we commissioned from Brattle.

A8.137 As observed equity and asset betas for mobile operators have fallen since at least 2000, taking a view of the beta based on pre-2008 data would involve looking at a period when investors' perceptions of mobile operator systematic risk may have been very different to their views today.

A8.138 There may be benefits from using a "clean" data set, as defined by Vodafone. But we do not believe that the potential benefits would offset the risk of a potentially material overstatement, from using data that is at least 3 years old, and from a period when investor perceptions of risk appear to have been very different to today.

A8.139 Notwithstanding this, it is important to understand the potential effects of the credit crisis. We consider it may be a useful cross-check to try to disaggregate the effects of the crisis, in order to determine whether our 2 year asset beta data (which includes some data from the credit crisis period) is a reasonable reference point. In order to do that we divided up the last 5 years into 3 periods, in relation to the credit crisis:

8.139.1 Pre-crisis, being 1 March 2006 – 31 May 2008 (2.25 years),

8.139.2 Mid-crisis,[189] being 1 June 2008 – 31 May 2009 (1 year), and

8.139.3 Post-crisis, being 1 June 2009 – 28 Feb 2011 (1.75 years).

A8.140 Because ordinary least squares (OLS) regression assumes stability of the parameters, i.e. of beta, we were concerned that if the observed beta during the crisis period was materially higher or lower than that observed before or after it, then any observations including that period would be 'biased' disproportionately.

[189]] It is possible to debate what the exact period of the crisis was, but we believe that the 1 year period we have considered encompasses the most volatile period of equity movements.

A8.141 However, this does not appear to be the case. The asset betas for Vodafone are as follows:

8.141.1 Pre-crisis period ~0.8,

8.141.2 Mid-crisis period ~0.65,

8.141.3 Post-crisis period ~0.5.

A8.142 So it would appear that any concerns, that the inclusion of the major period of the credit crisis in our analysis might be biasing our 2 year beta analysis downwards, appear to be unfounded. In light of this, and the need for caution when considering data from earlier periods (as expressed in paragraphs A8.127 and A8.138), we believe our range of 0.5 – 0.61 to be appropriate.

A8.143 Moreover, as we set out in paragraph A8.99, any short-term potential estimation errors are likely to be ‘smoothed out’ over a number of charge control periods.

Debt premium

Introduction

A8.144 In estimating the cost of debt for a UK mobile operator, we require two inputs.

8.144.1 The risk-free rate; and

8.144.2 the debt premium.

A8.145 We set out above our views on the risk-free rate.

What we said previously

A8.146 We have looked at the yields offered by corporate debt with a redemption date around 5 years hence (in line with our preference for 5 year government gilts).

A8.147 When we consulted in April 2010, we noted that debt yields for the parent companies of all the MCPs were in a range of 1 – 2% above risk-free rates.

The recent evidence is similar

A8.148 We now observe that debt yields for the parent companies of the UK MCPs (i.e. Vodafone, Deutsche Telekom, France Telecom and Telefonica) have narrowed somewhat since April 2010.

A8.149 This narrowing has been broadly in line with yields on government gilts, and the yields on these corporate bonds remain in a range of 1 – 2% above risk-free rates. We use a debt premium point estimate of 1.5% for our final WACC estimate.

A8.150 We note that the yield on Vodafone's 2017 GBP debt as of the middle of February 2011 was approximately 4.5%, around 1.5% above equivalent gilt yields.

A8.151 In addition, we note Vodafone's recent debt issuance on 9th March 2011, in which it issued $600m of 5 year debt at 0.85% premium over equivalent US Treasury bills, and $500m of 10 year debt at 1% premium over Treasuries. Although this debt is in dollars (rather than sterling), it is still a useful reference point for us as it is indicative of the approximate debt premium that Vodafone must pay in order to receive funds from debt investors. It may suggest that our 1.5% point estimate is on the cautious side.

Overall cost of debt

A8.152 Our real risk-free rate estimate of 1.5%, alongside a debt premium of 1.5%, combine to give a real pre-tax cost of debt of 3%, or around 5.5% in nominal terms (assuming 2.5% inflation, the average implied inflation on 5 year gilts over the last year – see Table A8.5 above). This compares with an observed yield on Vodafone's 2017 GBP bond of 3.5% - 5% during the last year.

A8.153 So we may be affording a slightly higher cost of debt than that which is currently observed in the market, but our expectation of a degree of mean reversion in the gilt market suggests that 5.5% is not unreasonable in the medium term.

Corporate tax rate

A8.154 In the Budget of June 2010, the UK government announced its intention to reduce the corporate tax rate from the current 28%, down to 24% by 2014/5.

A8.155 This represents a real saving for businesses that pay tax, and will reduce the (pre-tax) cost of capital accordingly. Companies will be able to deliver lower pre-tax profits in order to deliver the same post-tax returns to shareholders.

A8.156 In the case of this statement, where the charge control incorporates a 4 year glide path to a cost-oriented MTR, we need to incorporate the tax rate in year 4 of the charge control, which in this case is 2014/5. The tax rate in this year, according to the 2010 Budget, will be 24%.

Cost of Capital Calculations

A8.157 The table below sets out our cost of capital estimates for an efficient national MCP based on the estimates outlined in the sections above.

Table A8.9: Pre-tax real WACC for an efficient UK mobile operator

WACC Component	March 2007	April 2010	March 2011
(mid-point estimates where appropriate)	Statement	Consultation	Statement
Real risk-free rate	2%	2%	1.5%
Nominal risk-free rate	4.9%	4.5%	4.0%
Equity Risk Premium	4.5%	5%	5%
Equity Beta	1.3	0.85	0.76
Asset beta	1.18	0.62	0.56
Cost of equity (post tax)	10.7%	8.8%	7.8%
Debt premium	1.5%	1.5%	1.5%
Corporate tax rate	30%	28%	24%
Cost of debt (post tax)	4.6%	4.4%	4.2%
Gearing	10%	30%	30%
WACC (pre-tax nominal)	14.4%	10.4%	8.9%
WACC (pre-tax real)	11.5%	7.6%	6.2%

Stakeholder Responses to the Second Consultation

A8.158 When we published our second consultation in April 2010, four stakeholders responded on the cost of capital assumptions, Vodafone,[190] O2,[191] EE and H3G.[192] In addition, Everything Everywhere submitted a paper by CEG in November 2010 which specifically addressed the issue of estimating the cost of capital during a financial crisis.

A8.159 The issues raised in the responses fell into four areas:

8.159.1 The estimate of ERP

8.159.2 Estimates of the Beta

8.159.3 Gearing

8.159.4 Economic depreciation and the WACC

8.159.5 Pure LRIC and the WACC.

A8.160 The issues raised in relation to the ERP, beta estimates and gearing are dealt with in the specific sub-sections above.

A8.161 In relation to economic depreciation, EE and O2 have pointed out that the way economic depreciation is modelled means that a change in the cost of capital leads to an unusual cost recovery profile. This point is dealt with in detail in Annex 6.

A8.162 Vodafone argued that where a regulated price is set via a pure LRIC approach, there is a greater likelihood that the outturn might be below incremental cost than under a LRIC+ approach. Vodafone submitted that "under estimateion of the WACC (for example adopting a short-term low beta) will make investment in incremental long run capacity no longer commercially justified." [193] Therefore, Vodafone argues that Ofcom should adopt a WACC at the upper end of its range, to mitigate this risk.

A8.163 We consider that the effect that Vodafone refers to is not unique to WACC estimation, but applies in principle to all parameters that affect the incremental costs of MCT. We have discussed the impact of MTRs at pure LRIC on incentives to invest under the heading "dynamic efficiency" in Annex 3 (which discusses the choice between pure LRIC and LRIC+).

A8.164 In the context of the WACC specifically, we would note that in the estimation of certain parameters we have erred on the side of caution. A good example would be the ERP, where we identify a range of 4.5% to 5%, but select a point estimate from the top of that range (as explained in paragraph A8.90 above).

A8.165 Overall our approach to the estimation of the WACC for an efficient national MCP, has been to estimate each parameter accurately based on evidence from financial

[190] Vodafone response to April 2010 consultation, pages 55–61. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone.pdf,
[191] O2 response to the April 2010 consultation, pages 52-56. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf
[192] H3G response to the April 2010 consultation, Annex F, pages 138-146. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf,
[193] Vodafone response to the April 2010 consultation, page 61. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone.pdf

market data. For this reason and those set out in Annex 3, in respect of MTRs set on the basis of pure LRIC and dynamic efficiency, we do not consider that it would be appropriate to apply an upward revision to the WACC as suggested by Vodafone.

Annex 9

Other cost modelling issues: data pricing; administration cost calculations and spectrum valuation

Introduction

A9.1 The purpose of this annex is to explain our reasoning and final conclusions on issues which primarily affect the LRIC+ unit costs of the MCT cost model. We focus on three main issues in this Annex:

- Spectrum value;
- Administration cost calculation and HLR update costs; and
- Data pricing and common cost recovery.

A9.2 The spectrum value section updates our calculation of the value for 2.1GHz and 1800MHz spectrum given international spectrum awards since the April 2010 consultation. This section also discusses the approaches for valuing spectrum that were suggested by respondents to the April 2010 Consultation.

A9.3 The administration cost calculation section updates our calculation of administration costs for the most recently available data. This section also addresses responses on our calculation of administration costs set out in the April 2010 consultation. This section also discusses the exclusion of HLR costs from the pure LRIC calculation.

A9.4 The data pricing and common cost recovery section considers non-voice LRIC+ unit cost outputs from the 2011 cost model. In particular, we consider the criticism that the per megabyte estimate for the cost of data services produced by the MCT cost model is too high when compared to the current retail prices of data services. The suggestion from some MCPs was that because of this difference between the unit cost estimates and the retail price of data, the April 2010 cost model was not correctly calibrated.

A9.5 The reasoning and conclusions set out in this annex are primarily concerned with calculating the unit costs of MCT using the LRIC+ cost standard. As pure LRIC is our preferred cost standard for the charge control, in principle, this would imply not investigating common cost allocation issues further. However, for the purpose of assessing the impact of moving to pure LRIC in this statement, we require a reasonable estimate of unit costs under the LRIC+ alternative. To that end, we have investigated the merits of the arguments advanced by those claiming that there were flaws in the LRIC+ values estimated from our model.

The valuation of spectrum for charge control purposes

A9.6 In the April 2010 consultation, we explained that we considered the way in which we implement the pure LRIC cost modelling implicitly captured the value of spectrum (we discuss the reasons for this further in A9.7 to A9.9 and A9.30 to A9.34 below). Some respondents have questioned our approach to pure LRIC in respect of

spectrum costs. Furthermore, as noted above, for the purpose of assessing the impact of moving to pure LRIC in this statement, we require a reasonable estimate of unit costs under the LRIC + alternative (where spectrum costs need to be explicitly measured). This section of the annex therefore updates the quantitative estimate of the value of spectrum for the purposes of the LRIC+ MCT cost model.

Our views in the April 2010 consultation

Pure LRIC

A9.7 In the April 2010 consultation, we noted that, in principle, pure LRIC could include some contribution to spectrum costs.[194] However, we noted that the implementation of pure LRIC in the MCT cost model meant that we did not have to include an explicit estimate of spectrum costs.

A9.8 The reason pure LRIC could include some contribution to spectrum is that if termination volumes were zero, then this might entail a MCP avoiding having to purchase (or reducing) its current spectrum holdings. For a given amount of spectrum, more capacity can be provided by increasing the size of the network (i.e. increasing the number of base stations and/or traffic-handling capacity at base stations). Alternatively, for a given size of network (i.e. a fixed number of base stations), more capacity can be provided if more spectrum is deployed.

A9.9 However, at the margin, the willingness to pay for additional spectrum required to deliver a given amount of traffic would be no more than the network costs otherwise required (i.e. if network equipment rather than spectrum were used to provide the additional capacity). As our MCT cost model determines pure LRIC based on the network costs with and without termination volumes, it explicitly measures the avoided network costs for the traffic increment in question (i.e. MCT provided to other CPs). Viewed in this way, changes in spectrum value should have no impact on the pure LRIC of MCT.

LRIC +

A9.10 For the LRIC + cost standard, we discussed the approach used by the CC in its 2009 determination[195]. We noted that the CC's approach did not directly estimate spectrum value, but it is possible to infer a value for spectrum based on the CC's use of the so-called 2G-cap.[196] Under the 2G-cap, the value derived from the CC's 2009 calculations would suggest using a £2.5bn value (in 2008/09 prices) for 2 x 10

[194] April 2010 consultation, footnote 100, page 114. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf

[195] http://www.competition-commission.org.uk/appeals/communications_act/mobile_phones_determination.pdf

[196] The CC considered that the 2G cap approach could be used to determine the implied value of 2.1 GHz spectrum used to deliver 3G services. In particular, the value of 3G spectrum could be determined by looking at the network costs of voice termination over the 2G network (at 1800 MHz) plus the value of 2G spectrum established by 2G Administrative Incentive Pricing (AIP). The CC highlighted that the principle underpinning this approach was that for a service supplied in a competitive market, the introduction of a new and more efficient technology (e.g. 3G) delivering existing services should not cause prices for an existing service to rise. Under this approach, the value of 3G spectrum would be the difference between:

- the sum of 2G network unit costs and spectrum unit costs (i.e. a contribution to AIP for 1800 MHz spectrum); and
- the unit network costs associated with voice termination delivered on the 3G network only (i.e. excluding any contribution to the 3G spectrum licence).

MHz paired 2.1 GHz spectrum.[197] Under this approach, the valuation of 1800 MHz spectrum is derived from AIP licence fees and this implies a (capitalised) value of £0.2 bn (for 2 x 30 MHz of 1800 MHz spectrum).

A9.11 We argued in the April 2010 consultation that in principle we could use this £2.5 bn value (2008/09 prices) as a starting point for the value of 2.1GHz spectrum in the MCT cost model.[198] We noted that use of the £2.5 bn valuation at least had the benefit of being a publicly available point of reference and one that was determined following a lengthy appeal in which spectrum costs to be recovered from MCT were explored in depth.

A9.12 We noted that a problem with this approach, among others, was that it did not take into account new information that has come to light since the last review including revised unit cost estimates for 2G and 3G MCT and emerging findings on the value of spectrum at different frequencies.[199] Given our concerns over the 2G cap, we considered how the CC's £2.5bn value compared against alternative benchmarks such as an updated 2G cap calculation based on more recent unit cost estimates and international spectrum awards converted to an "equivalent" UK valuation.[200]

A9.13 Table A9.1 below replicates the results reported in the April 2010 consultation[201] and shows the pence per minute estimates of the value of spectrum based on different benchmarks, including:

- results based on the CC's original estimate of 3G spectrum of £2.5 bn (in 2008/09 prices) based on the 2G cap approach;
- an updated estimate of the value of spectrum using the 2G-cap approach and estimates of unit costs in 2014/15 for the 2G and 3G network from the April 2010 cost model; and
- the range derived, primarily, from information on international awards (£0.3 bn to £1 bn).

[197] Hereafter, all spectrum values are reported on a 2 x 10MHz equivalent basis unless otherwise indicated.
[198] April 2010 consultation, paragraph A9.23. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf
[199] April 2010 consultation, paragraph A9.25 et seq. Ibid
[200] April 2010 consultation, paragraph 9.41 et seq. Ibid
[201] This table has been adapted to include (in column 5) the incremental contribution of spectrum under LRIC +.

Table A9.1: Pence per minute impact of different spectrum valuation options presented in the April 2010 consultation*

Method	2x30MHz at 1800MHz spectrum value(£bn 2008/09 prices)	2x10MHz at 2.1GHz spectrum value (£bn 2008/09 prices)	LRIC+ unit cost benchmark for 2014/15 (ppm in 2008/09 prices)	Contribution of spectrum under LRIC+ (ppm in 2008/09 prices)	Percentage contribution of spectrum under LRIC+
Original 2G cap based values for spectrum	£0.2bn	£2.5bn	1.00	0.14	14%
Updated 2G cap equalised 2014/15 unit costs	£0.2bn	£3.6bn	1.00	0.17	17%
International benchmarks - lower case (£0.3bn)	£0.9bn	£0.3bn	1.20	0.32	27%
International benchmarks - base case (£0.5bn)	£1.5bn	£0.5bn	1.40	0.55	39%
International benchmarks - mid case (£0.7bn)	£2.1bn	£0.7bn	1.60	0.77	48%
International benchmarks - upper case (£1bn)	£3bn	£1bn	2.00	1.14	57%

Source: Annex 9, April 2010 consultation (Ofcom calculations)

* When inserting spectrum values into our LRIC+ cost model we took into account gestation costs.[202]

**We presented unit cost benchmarks with all other model inputs held at their base case values. The LRIC+ figures above exclude the administration cost contribution.

A9.14 In the April 2010 consultation, we selected a base case value of £0.5bn (in 2008/09 prices) from the range £0.3bn to £1bn because we considered that a value towards the bottom of the range was more plausible. We observed, in particular, that for awards post-2001 at the frequencies of interest (i.e. +/- 1GHz of 2GHz), spectrum values were clustered towards the bottom of that range.[203]

A9.15 Selecting a value of £0.5 bn for 2x 10 MHz at 2.1 GHz (and £1.5 bn for 2 x 30 MHz at 1800 MHz) yielded a contribution of 0.55 ppm to LRIC+ unit costs in 2014/15 (in 2008/09 prices excluding administration costs.[204] This was higher than using either the CC's valuation of spectrum at 1800 MHz and 2.1 GHz (see the first row of the above table for the "original 2G cap" calculation) or where the CC's 2G cap was updated and re-run (see the second row of the above table).

[202] The way we have inserted spectrum values into our model is based on the assumption that the spectrum is put into productive use as soon as it is purchased. Since international spectrum awards reflect licence payments in auctions they will be likely to reflect operators' expectations that spectrum will come into use with some delay. In the MCT cost model the cost of 2.1GHz spectrum is put into the model when 3G services are first carried on the network. Therefore, for modelling purposes we have uplifted the values derived from international benchmarks to reflect the fact that the amounts paid will have incorporated an expectation of delay in bringing that spectrum into use. Consistent with the CC's 2009 determination, we have applied a 2 year gestation period and therefore the licence payment is uplifted by a factor of (1+WACC)^2. (For a discussion of the CC's consideration of gestation periods, see the CC's 2009 determination. paragraphs A2.6.5 to A2.6.47).

[203] April 2010 consultation, paragraphs A9.50, A9.63 and A9.66. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf

[204] As discussed below, we now consider appropriate to also exclude the HLR update costs. This would have reduced the values in the table by under 0.02ppm.

Views of respondents

A9.16 Four respondents (H3G, EE, Vodafone and Virgin Media) commented on our approach to spectrum valuation. We discuss in turn their comments, which focus in particular on:

- our proposed approach to modelling pure LRIC and spectrum costs;
- the use of benchmarking, including the results of international awards;
- alternative approaches to spectrum valuation.

Pure LRIC and spectrum costs

A9.17 H3G considered that it was correct to exclude spectrum from pure LRIC calculations.[205] By contrast, Vodafone and Virgin Media considered that any pure LRIC calculation should include an explicit contribution to spectrum costs.

A9.18 Vodafone considered that the view that spectrum costs have no impact on pure LRIC was an artefact of the April 2010 cost model.[206] It noted that a minimum amount of spectrum would be necessary to provide a coverage network, so this minimum amount would not have to vary with additional traffic volumes provided over that network. But any additional spectrum above this level must be incremental to traffic volumes. It was concerned that we had not appropriately considered incremental spectrum costs and the opportunity cost of spectrum – which it thought likely to be particularly important when calculating pure LRIC. It argued that an accurate estimate would require modelling the trade-off between the amount of spectrum used and the cost of additional network roll-out.

A9.19 Virgin Media made a similar point and cited the EC Recommendation in support of its position.[207] It went on to argue (page 10) that "[…] *Ofcom has failed to identify the traffic driven spectrum charges that should be allowed to be recovered under the pure LRIC approach."*[208] Virgin Media argued that *"The opportunity cost in this instance needs to be evaluated as the cost of building more base stations. The opportunity cost is therefore not zero."*

[205] H3G response to the April 2010 consultation, paragraphs 409 and 419. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf

[206] Vodafone response to the April 2010 consultation, Annex 3 page 97. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf

[207] In particular, Virgin Media (at page 9 of its response to the April 2010 consultation) cited section 5.2.2 of the Explanatory Note accompanying the EC Recommendation: *"The costs of spectrum usage (the authorisation to retain and use spectrum frequencies) incurred in providing retail services to network subscribers are initially driven by the number of subscribers, and thus are not traffic-driven and should not be calculated as part of the wholesale call termination service increment. The costs of acquiring additional spectrum to increase capacity (above the initial spectrum necessary to provide retail services to subscribers) for the purposes of carrying additional traffic resulting from the provision of a wholesale voice call termination service should be included on the basis of forward-looking opportunity costs, where possible."* http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Virgin.pdf

[208] Virgin Media suggests that coverage driven spectrum would be about 6 x 200 kHz. In its view, the remaining spectrum would be traffic driven.

The use of benchmark values from international spectrum awards

A9.20 H3G was concerned over our use of international awards and noted that variations of spectrum prices were large and that Ofcom had not carried out a statistical analysis which would control for the factors affecting spectrum awards.[209] H3G argued that where a market value for spectrum from an actual transaction was available that value should be used. Where spectrum was not allocated by auction, there was little point giving it a market value, but where an exercise such as AIP had been undertaken then that exercise should be used to provide a best proxy.[210]

A9.21 H3G also commented[211] on the way 2.1 GHz spectrum licence values should be inserted into our model, given our implied assumption in the April 2010 MCT cost model over the duration of those licences. H3G noted that we appeared to be assuming an indefinite life for our 3G spectrum licences, as the April 2010 MCT model does not allow for spectrum to be renewed within the model's planning horizon. H3G therefore considered that in the economic depreciation calculation, there is no need for a terminal value to be applied in the calculation of the present value of costs.

A9.22 Vodafone considered that Ofcom's benchmarking failed to control for a number of factors that will affect prices paid at auction in different countries. Vodafone argued that it was not clear that the recent lower valuations were due to a downward trend in market valuations. It argued that lower valuations in the most recently conducted auctions could be due to a range of different factors.[212]

A9.23 In the main part of its response,[213] EE submitted that in principle it has no objection to Ofcom's approach to spectrum costs in the April 2010 consultation. However, in the confidential Annex to its submission it made some more detailed points. EE was concerned that [✂].[214,215]

A9.24 [✂].[216,217]

A9.25 [✂].[218]

A9.26 [✂].[219,220]

Alternative approaches to spectrum valuation

A9.27 H3G was also concerned with Ofcom's basis for rejecting AIP valuations of 2G spectrum on the grounds that it was set using conservative principles. It argued that if it was appropriate to set a conservative value for AIP in another context (i.e. for

[209] H3G response to the April 2010 consultation, paragraphs 429 to 430. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf
[210] H3G response to the April 2010 consultation, paragraph 431. Ibid
[211] H3G's response to the April 2010 consultation, Page 69, footnote 125. Ibid
[212] Vodafone response to the April 2010 consultation, Annex 3 page 96. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[213] EE response to the April 2010 consultation, paragraph 115.
[214] EE response to the April 2010 consultation, paragraph 381.
[215] EE response to the April 2010 consultation, paragraph 382.
[216] EE response to the April 2010 consultation, paragraph 385.
[217] EE response to the April 2010 consultation paragraph 380.
[218] EE response to the April 2010 consultation paragraph 383-384.
[219] [✂]
[220] [✂]

operators' licence payments for 2G spectrum) then it should be acceptable to apply the same valuation on a consistent basis across other regulatory decisions. It further argued that our alternative valuation of spectrum made using international benchmarks would discriminate against H3G. H3G noted that it does not hold 2G spectrum, so it would not benefit from conservative AIP policy in other regulatory contexts. It further argued that as implemented in the April 2010 cost model, 3G spectrum costs were adjusted downwards (relative to amounts paid in the 3G spectrum awards in 2000) for all operators, so H3G would not benefit under Ofcom's approach. But applying the value determined for 2 x10 MHz of spectrum at 2.1 GHz also to 2 x 30 MHz of 1800 MHz resulted in an increase in 1800 MHz spectrum costs for the 2G/3G MCPs of 1181% (relative to valuations based on current levels of AIP).[221]

A9.28 H3G proposed a valuation approach based on:

- the use of a suitably adjusted market value of spectrum based on the 3G auctions in 2000 for 2.1 GHz spectrum[222]; and
- the use of AIP-based licence payments for 2x1MHz at 1800MHz of £1.68 m per annum.[223]

A9.29 [✂].[224,225]

A9.30 Vodafone expressed a preference for estimates of spectrum determined endogenously from the MCT cost model.[226]

Our view of consultation responses and further analysis undertaken

Pure LRIC and spectrum costs

A9.31 In relation to pure LRIC, we note that Vodafone and Virgin Media suggested that our approach to pure LRIC did not correctly value incremental spectrum costs associated with MCT. Both suggested that we should estimate the proportion of spectrum that is 'traffic insensitive' (the minimum necessary to achieve national coverage) and by implication, any additional spectrum above this amount should be viewed as 'traffic sensitive'.

A9.32 In responsewe first note that as explained at paragraph 6 and recital 14 of the 2009 EC Recommendation, traffic sensitive costs may arise jointly with other traffic services (e.g. call origination, SMS, MMS etc) and in estimating the pure LRIC of MCT, MCT should be the final service taken into account. This is because many

[221] H3G response to the April 2010 consultation, paragraphs 423-427.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf
[222] It proposed to rely on the 2000 UK 3G spectrum awards to determine 2.1 GHz value. H3G argued that it was possible to deduce a competitive value from the 2000 auction for 3G spectrum based on price paid by H3G. It suggested a value of £2.9 billion for 2 x 10 MHz of spectrum which should enter the MCT cost model in 2000 (H3G response to the April 2010 consultation, paragraph 441). Ibid
[223] It calculated that this was equivalent to an annual fee of £50.4 m for a 2 x 30 MHz licence. It noted that a value double this should be applied from 2011 consistent with any changes to the AIP licence (H3G response paragraph 443-444).
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf
[224]EE response to the April 2010 consultation, paragraph 382-383
[225]EE response to the April 2010 consultation, paragraphs 390-391. [✂].
[226] Vodafone response to the April 2010 consultation, paragraph 97.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone.pdf

traffic sensitive costs are common across a number of traffic services and MCPs will continue to face those costs even if MCT volumes fell to zero.

A9.33 Nevertheless, we accept, in principle, that if MCT traffic volumes were zero then, even when taking account of other services that drive traffic sensitive costs, this might entail a MCP having to purchase (or hold) less spectrum.[227] However, even if it were the case that less spectrum were needed, we would still have to determine a value for the amount of spectrum no longer required.

A9.34 As noted by Virgin Media, the opportunity cost of reducing the amount of spectrum held reflects the trade-off between the amount of spectrum and network capacity needed. If spectrum holdings are reduced, additional network costs (e.g. additional base station sites) would be required to continue to meet forecast demand.[228] However, we remain of the view that our approach to calculating the pure LRIC of MCT captures the opportunity cost of spectrum by considering the avoided network costs associated with reduced termination volumes. Put another way – and as argued at paragraph A9.9 above – the willingness to pay for spectrum needed to provide MCT would not be more than the network costs avoided if MCT were not provided.[229]

Spectrum values for estimating LRIC + unit costs

A9.35 In the absence of recent market-based measures for the value of spectrum in the UK, we continue to consider that there are a number of difficulties in respect of the alternative valuation methods suggested by stakeholders. The alternatives include:

- valuations based on the UK's 3G spectrum awards in 2000;
- AIP estimates; and
- Deriving a value of spectrum endogenously based on unit costs implied by the MCT cost model.

UK 3G spectrum awards

A9.36 H3G considered that the amount it paid in the UK's 3G spectrum awards in 2000 provides a reasonable proxy of a competitive valuation of spectrum. It thought that the use of a value of spectrum (for 2 x 10 MHz) derived from H3G's award for 2 x 15 MHz could overcome some of the particular concerns that the CC expressed regarding the use of the 3G auctions as an appropriate forward-looking value of spectrum.[230] However, as noted in the April 2010 consultation[231], the CC rejected

[227] This point of principle is recognised in the Annex to the EC Recommendation.
[228] There are certain technical constraints that mean that where demand for capacity is very high, in practice, deploying more network capacity on a deployed carrier is not a feasible solution (e.g. it is not possible to continue adding cell sites in a certain location indefinitely as interference between cell-sites may exceed acceptable tolerance thresholds). Thus, at very high levels of demand, concentrated in certain locations, the acquisition of more spectrum might be necessary. We note, however, that such network build constraints will not be an issue over the range of demand we have considered (see Annex 6, paragraph A6.78).
[229] Enders Analysis made a broadly similar point in a paper considering the costs of mobile data provision, where it states that: *"we have shown spectrum costs separately as using new spectrum avoids the need to build more sites, hence including both costs is double counting."* See page 6 of: Enders Analysis, Mobile data economics: the limit of unlimited, 7 September 2010.
[230] This includes for example the possibility that incumbent MCPs participating in the auction may have bid higher amounts for strategic considerations (H3G response to the April 2010 consultation,

scenarios for spectrum values based on the 3G licence auctions. Fundamentally, the CC considered that use of information from 3G auctions was not sufficiently forward-looking as the valuations had not been adjusted for changes in market expectations.[232]

A9.37 We remain of the view that that it is now even more difficult to rely on these past awards. The UK 3G auctions are now over 10 years old and there have been a number of market developments since then. Moreover, there are significant changes on the horizon following the Government's Direction to Ofcom of 20 December 2010 ("The December 2010 Direction"), which paves the way for the auction of further spectrum as well as permitting more flexible use of existing licences. The December 2010 Direction requires us to:

- vary operators' licences to allow for the use of both UMTS and GSM technologies in the 900MHz and 1800MHz frequency bands;
- make the relevant 900MHz, 1800MHz and 2100MHz licences tradable;
- provide for auctions to take place for use of frequencies in the 800MHz and 2.6GHz bands (and any other frequency bands as Ofcom thinks fit); and
- to revise the licence fees for 900 MHz and 1800 MHz licences after completion of the auction for the 800MHz and 2600MHz bands, to reflect the full market value of the frequencies in the 900MHz and 1800MHz bands. [233]

A9.38 On 6 January 2011 we published a statement[234] ("the January 2011 statement") varying the licences to permit the use of UMTS (in addition to GSM) technologies in the 900MHz and 1800MHz frequency bands. In that same statement, we also noted that we will alter the licence fees for the 900MHz and 1800MHz licences after the completion of the 800MHz and 2.6GHz auctions (due to occur in early 2012). On 2 February 2011 we issued a consultation in respect of trading of licences at 900MHz, 1800MHz and 2100MHz; which closes on 17 March 2011.[235] Subject to consultation we intend to make the necessary regulations to allow trading as soon as possible.[236]

AIP estimates

A9.39 In addition to use of the 2000 3G awards as a benchmark for 2.1GHz, H3G argued for the use of AIP fees for valuing 1800MHz. However, we continue to believe that our valuation of spectrum should be based on its forward looking value (i.e.

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paragraphs 432 to 442, http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf).

[231] April 2010 consultation, Annex 9, paragraph A9.44, http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf

[232] 2009 CC determination, paragraph 2.5.43. http://www.competition-commission.org.uk/appeals/communications_act/mobile_phones_determination.pdf

[233] For the Direction, see: http://www.legislation.gov.uk/uksi/2010/3024/contents/madetelegraphy/statement/Statement.pdf

[234] *Statement on variation of 900 MHz and 1800 MHz Wireless Telegraphy Act licences*. See: http://stakeholders.ofcom.org.uk/binaries/consultations/900-1800mhz-wireless-telegraphy/statement/Statement.pdf

[235] http://stakeholders.ofcom.org.uk/binaries/consultations/trading-900-1800-2100/summary/900-1800-2100.pdf

[236] Op cit. Paragraph 6.3.

opportunity cost) and that current AIP fees may understate the true opportunity cost of spectrum for the following reasons:

- Current levels of AIP reflect a conservative policy towards setting AIP fees (i.e. when AIP fees were last set) ;[237]

- The AIP fees for 1800MHz (and 900MHz) only considered the value to an existing user of that spectrum in current unliberalised use (i.e. for GSM). Following the regulatory developments permitting liberalisation and the proposed regulatory changes to allow trading, existing services (at 1800MHz) could be displaced by higher value services that could only be provided using 3G technology; and

- AIP fees will likely be reviewed in 2012 after completion of the auction of spectrum at 800MHz and 2.6GHz.

A9.40 Therefore, we remain of the view that it would be unreliable to base our forward-looking value of spectrum for 1800MHz on AIP. As explained in the April 2010 consultation, the current AIP estimates would imply a 2004/05 capitalised value of spectrum of less than £0.1bn for 2 x 10 MHz (in 2008/09 prices), which is significantly below values derived from other valuation methods.

A9.41 As noted above, H3G was concerned that our basis for costing spectrum would discriminate against it because our approach resulted in setting charges based on a reduction in 2.1GHz spectrum value (which it paid for and holds) but an increase in 1800MHz spectrum (which it does not hold and has not benefited from the conservative setting of AIP).[238]

A9.42 In response to this, the first point to emphasise is that one of our primary objective in setting charge controls on MCT is to address SMP in that market and for regulated charges to give signals for efficient consumption and to facilitate effective competition. In order to achieve these objectives, spectrum should be valued on the basis of its true forward looking opportunity cost. In its 2009 determination the CC argued (paragraph A2.3.71) that it was appropriate to focus on providing signals for efficient consumption as the main objective in relation to 3G spectrum for the purposes of setting regulated MTRs.

A9.43 Second, and following from the preceding point, the 2011 cost model is not designed to capture the actually incurred costs of a given MCP – if it did this would have poor incentive properties (since higher costs would be passed on to rival operators). Where, as in this market review, the policy is one of symmetric MTRs set on the basis of forwarding looking efficient costs – and not incurred costs – H3G is treated no differently from the other MCPs in terms of the relationship between its actually incurred costs (spectrum or otherwise) and the cap on its MTRs.[239]

A9.44 Third, our preferred cost standard is pure LRIC, and as explained above, an explicit measure of spectrum value is therefore not required.

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[237] For example, in Ofcom's 2004 consultation on setting AIP for, inter alia, 900MHz and 1800MHz spectrum, we stated that (paragraph 1.3.6); *"In line with the policy to set AIP fees conservatively so as not to create disincentives for trading, Ofcom intends initially to set AIP fees towards the bottom of the range defined by the value of spectrum in existing uses and its value in alternative uses."*

[238] H3G response to the April 2010 consultation, paragraph 427. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf

[239] On an incurred cost basis there are many ways in which MCPs will differ, both in terms of spectrum assets and other assets or factors driving costs.

Correction to the 2G AIP calculations

A9.45 We note that H3G raised a point over the value of 2G AIP fees used in the April 2010 cost model. In the April 2010 Consultation, we assumed that 1800MHz spectrum had the same per MHz value as 2.1GHz spectrum. However, in the MCT cost model the 1800MHz spectrum is applied as a yearly AIP charge and the 2.1GHz spectrum is applied as a one-off cost in 2004/05 (i.e. when 3G traffic is first carried on the network for a 2G/3G operator). In order to set the per MHz 1800MHz spectrum cost equal to the 2.1GHz spectrum cost we applied an uplift to the 1800MHz AIP. We calculated this uplift as the increase in AIP after 2009/10 required to set the 2003/04 present value (PV) of annual AIP charges equal to the value for 2.1GHz spectrum.

A9.46 In its response to the April 2010 consultation, H3G indentified that when we calculated the present value of the stream of AIP payments, we had not included the terminal value.[240] We agree with H3G that the uplift calculation (to the value of 1800MHz spectrum to reflect its liberalised value) should include the AIP terminal value. In addition, we now consider that the date from which the AIP uplift is applied should be 2011/12.[241]

Deriving a value of spectrum based on the MCT cost model

A9.47 Vodafone favoured estimating spectrum endogenously from the MCT cost model, which would amount to an application of the CC's 2G-cap approach.[242] However, as we noted in our April 2010 consultation (paragraph A9.16), the CC, in its 2009 Determination noted that *"…relying on 2G costs is unlikely to be a long-term regulatory possibility. However, we are concerned with sending efficient price signals for this price control period."* (paragraph 2.9.149). We highlighted that the CC saw this as a short term solution (i.e. in some sense transitional) and an approach that might be less appropriate given market changes. Indeed, as stated in our April 2010 consultation, we are concerned over the reasoning underpinning the 2G cap in a world of liberalised and tradable spectrum – which is now implemented in the case of liberalisation and being consulted on in the case of trading.

A9.48 As set out in Table A9.1 above, the updated 2G-cap analysis, as presented in the April 2010 consultation, suggested a value of 2.1GHz spectrum of £3.6 bn. As set out in paragraphs A9.48 to A9.51 of the April 2010 consultation, we considered a range of benchmarks that called this valuation into question:

- the network costs saved by operating 3G spectrum at 1800MHz compared to 2.1 GHz appear marginal.[243] By contrast, the use of the 2G-cap results in significant differences in valuations of spectrum at 2.1GHz and 1800MHz;

[240] H3G's response to the April 2010 consultation, page 69, footnote 126. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/H3G.pdf

[241] This is for three main reasons:
- 2010/11 AIP is based on existing 2G AIP levels, so this suggests at least moving the date from which the AIP uplift is applied to 2011/12;
- liberalisation of spectrum was enacted with immediate effect on 6 January 2011;
- As noted previously, trading of mobile spectrum is currently being consulted on and, subject to consultation responses, we intend to implement the necessary regulations in 2011/12.

[242] We assume here that this would entail an updated 2G-cap calculation based on the latest MCT unit costs for 2G and 3G as at 2014/15.

[243] April 2010 consultation paragraph A9.31 et seq. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf

- if we consider the valuation of spectrum implied by international awards, no valuation has come close to a value of £3.6bn for 2 x 10 MHz of mobile spectrum in recent years,

- external brokers' and analysts' estimates of the value of spectrum are far more conservative;[244]

- this valuation of spectrum would not pass a "sense check" when compared against indicative market valuations of the mobile operators.[245]

A9.49 As shown in Table 4 below, updating the 2G cap approach with the latest version of the LRIC+ model yields an even more implausible value for 2.1GHz spectrum (i.e. around £7.6bn). The high implied value of spectrum of £7.6 bn reflects, in particular, the lower estimates of 3G unit costs in 2014/15 in our 2011 cost model (and hence the large saving relative to 2G unit costs).

A9.50 As we were (and remain) concerned that the value implied by the CC's original 2G cap (i.e. £2.5 bn) seems high relative to available benchmarks, it follows that we should reject valuations significantly in excess of that original 2G cap value (such as a 2011 cost model update for the 2G cap methodology which yields a value of £7.6bn).

Conclusion on approaches to spectrum valuation suggested by respondents

A9.51 We do not consider that stakeholders have provided sufficiently compelling alternative approaches. On this basis, we continue to consider that a range of estimates derived from international awards provides a reasonable basis from which to identify a range and base case value for UK spectrum holdings at the frequencies of interest.[246]

A9.52 We acknowledge that a more robust approach might be possible, but this would involve making complex assumptions to control for various effects which might also be at play (such as the competitiveness of the auctions, competitiveness of downstream mobile markets in other countries, licence length, mobile ARPU in the country in question and so on[247]). Given that our preferred cost standard is pure

[244] See paragraphs A9.49 to A9.51 of the April 2010 consultation (Ibid) for further discussion of analysts' views. These broker and analyst estimates implied a value of between £0.2 bn to £0.3 bn for 2 x 10 MHz paired spectrum. In paragraphs A9.59 to A9.64 below we discuss more recent reports by brokers and analysts, which value this spectrum at between £0.1 bn to £0.2 bn.

[245] For example, at paragraphs A9.52 to A956 of April 2010 consultation (http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf), we compared the value implied by the 2G-cap to various information on the market valuations of mobile operators. We noted at paragraph A9.52 that media reporting suggested that up to £3.5bn was bid for T-Mobile's UK operations. In so far that any credence could be placed on this information, this would place an upper bound on the value of the spectrum assets used in the UK (not just the value of 2.1 GHz spectrum holdings but all spectrum holdings).

[246] That is, 2x30MHz at 1800MHz and 2x10MHz at 2.1GHz.

[247] These and other factors were identified at paragraph A9.47 of the April 2010 consultation (Ibid). We note that there was also significant discussion of econometric studies submitted by BT and H3G as part of the previous MCT appeal (see for example paragraphs 2.5.44 to 2.5.54 of the CC's 2009 determination). The CC's view was that *"whilst* [the] *analysis does have an intuitive appeal, in our view* […] *the analysis is not sufficiently robust to provide a strong foundation for reaching strong conclusions. In any event, we have not found it necessary to place weight on it."* (Op.cit. paragraph 2.5.50). We do not think that an econometric-based study would be proportionate in the present circumstances (i.e. where we are seeking a reasonable estimate of LRIC+ for the analysis of the different remedies. Moreover, a robust econometric analysis would only be as good as the

LRIC, in which an explicit spectrum value is not required, we consider that significantly more sophisticated analysis than that adopted in the April 2010 consultation would be disproportionate in the circumstances.

Updating our benchmark spectrum valuations using market developments

A9.53 We have updated our analysis to include more recent spectrum awards from those considered in the April 2010 consultation.[248] These results are shown in Table A9.2 and Figure A9.1 below in addition to the data points reported in the April 2010 consultation.

A9.54 Our updated analysis includes the most recent spectrum awards in Austria, Denmark, France, Germany, and the Netherlands in 2010.[249] In addition, we were able to gather more robust per MHz per head of population data on the US from a single consolidated source which we have used in our final analysis.[250] A further small difference from the April 2010 consultation is that we have refined the inflation and exchange rate calculations.[251] We have also updated our estimates of US awards based on a more consistent data set.[252]

parameters used to control for different factors that might explain differences in the amounts paid in auctions (e.g. the degree of competition of each award). While we could devise certain metrics to measure these factors, a sufficiently robust and objective measure may not be available in all cases. We would also have to consider whether such data was available on a consistent basis across countries and whether an econometric study with multiple variables was appropriate given the size of our sample of spectrum award results.

[248] Primarily for reasons of practicality and reasonable comparability, we continue to focus on awards from the main Western European countries and the United States.

[249] We have not included the data from the 800MHz Swedish awards as the auction ended in early March after we had completed the modelling work for this statement.

[250] http://www.spectrumbridge.com/products-services/specex/tools/FCCAuctionData.aspx.

[251] We have rebased the indexation for inflation to the end of 2008/09. The inflation adjustments in the April 2010 consultation were to the mid-point of 2008/09. These changes were made so as to be consistent with the inflation indexation in the MCT cost model. For our exchange rate data, we have used a yearly average exchange rate based on the financial year when the auction occurred.

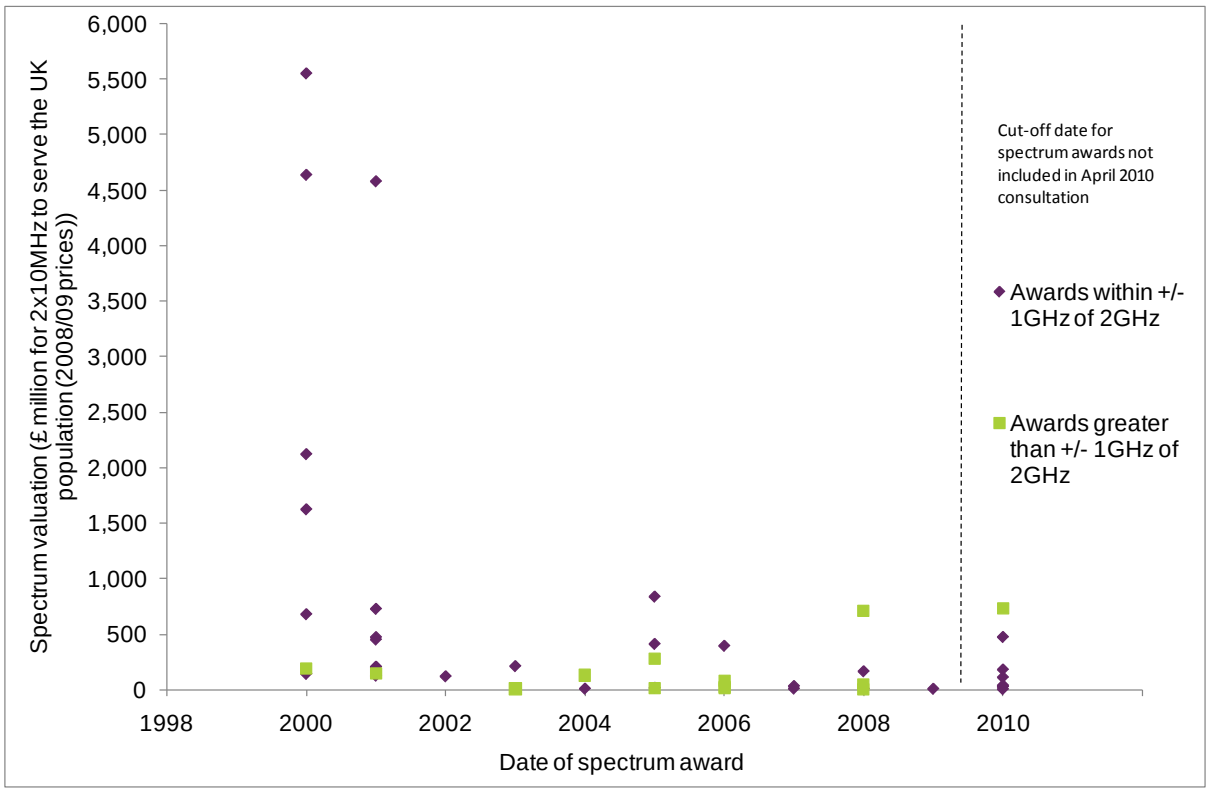
[252] In our April 2010 consultation, we included two data points on 1900MHz spectrum from the US in 2005 of £2.0bn and £1.2bn. On further inspection of the data, we found that these valuations were based on secondary trades between operators rather than spectrum awards – and the focus of our analysis has been on spectrum awards. Moreover, for the data points in question, there is a lack of clarity over the amounts paid and the quantum of spectrum per MHz. We have therefore excluded these two data points from our data set to ensure we have a consistent data set. Had we included these data points, we estimate that the average of all awards post 2001 (at the frequencies of interest) would be around £0.3 bn (rather than around £0.2bn as shown in the table).

Table A9.2: Results from international awards up to and including 2010[253]

Date	Country	Use	Band	GBP/MHZ (paired)/pop (2008/09 prices)	Adjusted values for 2*10 MHz and UK population (£ million) (2008/09 prices)
2000	Austria	UMTS 2 GHz	2100	1.09	676
2000	Germany	3G	2100	8.96	5,553
2000	Italy	3G	2100	3.42	2,120
2000	Netherlands	3G	2100	2.62	1,622
2000	Switzerland	3G spectrum	2100	0.22	138
2000	UK	UMTS	2100	7.48	4,638
2000	US	Mobile	800	0.30	187
2001	Austria	GSM - 1800	1800	0.32	201
2001	Belgium	3G	2100	0.72	448
2001	Denmark	3G	2100	1.17	724
2001	Greece	3G	2100	0.76	469
2001	Greece	2G and 3G	1800	0.33	202
2001	Norway	900 Mhz	900	0.23	145
2001	Norway	GSM 1800 MHz	1800	0.20	122
2001	US	Mobile	1900	7.39	4,580
2002	Austria	GSM	1800	0.19	116
2003	Norway	3G Licence 2	2100	0.34	208
2003	UK	Wireless broadband	3400	0.01	4
2004	Austria	GSM 2004	1800	0.01	5
2004	Norway	450 MHz auction	450	0.20	126
2005	Denmark	UMTS	2100	0.66	408
2005	Ireland	450 MHz	450	0.01	7
2005	Sweden	450 MHz	450	0.44	273
2005	UK	Mobile	1781	0.02	13
2005	US	Mobile	1900	1.35	835
2006	Austria	450 MHz	450	0.12	73
2006	UK	PAMR	412	0.01	8
2006	US	AWS	1900	0.63	391
2006	US	Various	700	0.03	21
2007	NI + ROI	Wireless broadband	1785	0.01	5
2007	Norway	2.6 GHz	2600	0.05	28
2008	Austria	900 MHz	900	0.06	40
2008	Sweden	2.6 GHz	2600	0.26	161
2008	UK	Various	1450	0.01	4
2008	UK	Various	10000	0.00	0
2008	UK	Various	28000	0.00	0
2008	UK	Various	32000	0.00	0
2008	US	Mobile	700	1.14	707
2009	Finland	2.6 GHz	2600	0.01	3
2010	Austria	2.6 GHz	2600	0.06	35
2010	Denmark	2.5 GHz	2500	0.29	177
2010	France	2.1 GHz	2100	0.76	471
2010	Germany	800 MHz	800	1.17	728
2010	Germany	1800 MHz	1800	0.04	25
2010	Germany	2.1 GHz	2100	0.17	107
2010	Germany	2.6 GHz	2600	0.04	22
2010	Netherlands	2.6 GHz	2600	0.00	1

[253] In this Table we have converted the amounts paid in local currencies into a £/MHz (paired)/pop value. For example for 2 x 10 MHz we would divide the amount paid in the spectrum award by 10 (rather than 2 x 10) in order to calculate the value per MHz of paired spectrum. In relation to unpaired spectrum, in some international awards the licence included a bundle of paired and unpaired spectrum. In our per MHz valuation we have not included the unpaired spectrum in obtaining a per MHz value. Because of this, our approach might be expected to yield slightly higher per MHz values of paired spectrum. However, in our view the approach remains appropriate as the situation in the UK is that unpaired spectrum remains largely unused. In this respect, unpaired spectrum is only likely to have contributed minimally to the overall spectrum value. Given the £/MHz/pop value of spectrum, in the last column we calculate the implied value associated with a 2 x 10 MHz holding scaled for the UK population (in 2008/09 prices).

Figure A9.1: Fees paid in international spectrum awards (adjusted to 2 x 10 MHz and the UK population) in 2008/09 prices



Source: Ofcom 2011, based on award data from regulators' websites

A9.55 As in our April 2010 consultation, the equivalent UK value for 2 x 10 MHz of spectrum from different awards shows quite a wide variation. Nevertheless, a clear trend of declining spectrum values is apparent, declining sharply since the awards in 2000 and 2001.

A9.56 Table A9.3 below presents the averages based on the above results and compared to those calculated in the April 2010 consultation.[254]

[254] See Table 21, page 125, of Annex 9 to the April 2010 consultation, http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf.

Table A9.3: Value of spectrum (in 2008/09 prices) based on international spectrum awards since 2000[255]

International benchmarks considered	April 2010 consultation			Updated with latest spectrum results		
	GBP/MHz (paired)/pop (2008/09 prices)	Mean of adjusted values for 2*10 MHz and UK population (£ million) (2008/09 prices)	Median of adjusted values for 2*10 MHz and UK population (£ million) (2008/09 prices)	GBP/MHz (paired)/pop (2008/09 prices)	Mean of adjusted values for 2*10 MHz and UK population (£ million) (2008/09 prices)	Median of adjusted values for 2*10 MHz and UK population (£ million) (2008/09 prices)
Total average (incl. 2000/01)	1.1	669	159	0.9	571	138
UK average (incl. 2000/01)	1.0	598	4	0.9	583	4
Awards within 2GHz (+/- 1GHz) (incl. 2000/01)	1.5	909	353	1.2	766	189
All awards post 2001	0.4	259	37	0.3	156	31
Post 2001 awards within 2GHz (+/- 1GHz)	0.6	364	102	0.3	159	35

Source: Ofcom 2011 and Table 21 of the April 2010 consultation

A9.57 From the above table it can be seen that for awards at the frequencies of interest (i.e. +/-1GHz of 2GHz), over the entire period, the average value has fallen from just over £0.9bn at the time of consultation to under £0.8bn (in 2008/09 prices). Taking out the awards in 2000 and 2001, it can be seen from the above table that the average value for awards around 2GHz has fallen from under £0.4bn at the time of consultation to under £0.2bn (in 2008/09 prices).

A9.58 For awards since those reported in the April 2010 consultation, at frequencies within 1GHz of 2GHz, most of the values observed have been below the range consulted on (i.e. £0.3bn to £1bn) apart from the French award in 2010 (at just under £0.5 bn).[256] Within the last five years for awards within 1GHz of 2 GHz, only the US 1900MHz award in 2006 (which yielded just under £0.4bn) and the French award at 2.1GHz in 2010 have been within the range consulted on.

Consideration of industry analyst reports

A9.59 In the April 2010 consultation (paragraphs A9.49 to A9.50), we also considered broker and analyst reports that sought to estimate the value of spectrum. We noted that these estimates implied a value of £0.2bn to £0.3bn for 2 x 10 MHz. Since the April 2010 consultation we have identified further publications that include attempts to estimate the value of spectrum at different frequencies.

A9.60 Arthur D Little / Exane BNP Paribas[257] estimates a value per MHz (unpaired) of €0.33/MHz/pop and €0.11/MHz/pop for 800 MHz and 2.6 GHz respectively. This would equate to a value around £0.4 bn for 2 x 10 MHz of 800 MHz spectrum

[255] In Table A9.3 the difference in the UK average (incl. 2000/01) reflects updated inflation adjustments (including outturn data on RPI for 2009/10 and the fact that we have adjusted inflation to the end of 2008/09 prices, whereas previous inflation adjustments in the April 2010 consultation were based on prices at the mid-point of 2008/09.

[256] The next highest value appears to be from the Danish 2.5GHz award where the value was around £0.2bn (in 2008/09 prices)

[257] "Mobile internet – blessing or curse?", Arthur D Little**/** Exane BNP Paribas**,** March 2010

(adjusted for the UK population) and around £0.1 bn for the same amount of 2.6 GHz spectrum.

A9.61 Barclays Capital[258] predicts the value of spectrum in forthcoming auctions in France, Italy, Portugal and Spain based on other recent awards. For the 800MHz frequency band it estimates values of between €0.2 to €0.5/MHz/pop for these countries (equivalent to around £0.2bn to £0.5bn of 2 x 10 MHz adjusted for the UK population). For spectrum at 1800 MHz and 2.1 GHz, Barclays Capital estimates values of €0.05 to €0.10/MHz/pop. This range equates to a UK-equivalent figure of around £0.1bn for 2 x 10 MHz for spectrum at 1800 MHz or 2.1 GHz. These estimates from Barclays Capital are lower than their previous estimates for 800MHz and 1800/2100MHz reported in the April 2010 consultation where we noted the 800MHz value to be around £0.5bn (now the top of the Barclays Capital range) and 1800/2100MHz to be around £0.2bn (now around £0.1bn).[259]

A9.62 In a November 2010 note, Barclays Capital[260] considered the outcome of the forthcoming 800 MHz award in the UK. It predicted that the award would be likely to yield around £2.2 bn for 30 MHz of paired spectrum (i.e. around £0.7 bn for 2 x 10 MHz). This is higher than the amounts it predicted for spectrum awards in other European countries at this frequency. But is consistent with a value for UK spectrum at 1800 MHz or 2.1 GHz somewhere in the range of £0.1bn to £0.2bn for 2 x 10 MHz for spectrum.[261]

A9.63 Based on the results of the German award, Execution Noble[262] estimated that the total value of UK awards for the available blocks of 800 MHz and 2.6 GHz spectrum would be around €1.4 bn, i.e. around £1.2 bn. With 2 x 30MHz at 800MHz and 2 x 70MHz at 2.6GHz, that would imply a quantum of 2 x 100MHz of spectrum and hence a value for 2 x10MHz of just over £0.1bn.[263]

A9.64 The above reports and those referred to in the April 2010 consultation suggest that analysts attach significant weight to the results of recent international spectrum awards.

A9.65 Given (a) the general decline in spectrum values seen in international awards; (b) that in the last 5 years values close to the top of the April 2010 consultation range have been only for more valuable lower frequency spectrum[264]; and (c) only the French award in the last 5 years has been close to the April 2010 base case (of £0.5bn), we consider that there are grounds to reduce the upper and lower bounds of the range we consulted on.

[258] "Spectrum – more to come", pages 28-38, Barclays Capital Equity Research 15 October 2010
[259] Paragraph A9.49 of the April 2010 consultation, http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf.
[260] "UK Spectrum – Auction to proceed with Everything Everywhere's blessing", Barclays Capital Equity Research Intraday Commentary, 3 November 2010.
[261] We have inferred this valuation for spectrum at 1800 MHz and 2.1 GHz based Barclay's Capital's relative estimate of spectrum at 1800 MHz and 2.1 GHz in its report of 15 October (Op. cit.). As noted above it values 800 MHz spectrum up to €0.5/MHz/pop relative to spectrum at 1800 MHz and 2.1 GHz of up to €0.1/MHz/pop. Applying this multiple (for 800 MHz) to its valuation of £0.7bn suggests a valuation of spectrum at 1800 MHz and 2.1 GHz of around £0.15bn.
[262] Execution Noble Telecoms Research, 5 July 2010.
[263] Clearly this assumes the same value for 800MHz and 2.6GHz spectrum which is unlikely to be the case, so for 2 x 10MHz at 2.6GHz, the value could be even less than the average £0.1bn derived from the estimates in the Execution Noble note.
[264] Such as in Germany in 2010 for 800 MHz spectrum and in the US in 2008 for 700MHz spectrum.

A9.66 We are mindful to avoid attaching too much weight to the latest observations or industry analyst reports, but the evidence from these sources is consistent with the decline in spectrum values noted at the time of the April 2010 consultation. In that consultation we noted that for awards since 2001, at the frequencies of interest, values were clustered towards the bottom of the consultation range (of £0.3bn to £1bn).[265]

A9.67 In light of the above evidence, and consistent with the approach we adopted in the April 2010 consultation, we consider that a more realistic range for spectrum values at the frequencies of interest would lie between £0.1bn to £0.8bn.

Conclusion on the base case spectrum value for use in the LRIC+ version of the cost model

A9.68 Having revised downwards the plausible range of spectrum values for use in the 2011 LRIC+ cost model we consider that a small reduction to the base case value is appropriate. We have therefore revised the base case value for spectrum in the LRIC+ model from £0.5bn to £0.4bn for 2 x 10MHz (in 2008/09 prices), giving a value for total spectrum holdings of £1.6bn (i.e. £0.4bn for 2 x 10MHz at 2.1GHz and £1.2bn for 2 x 30MHz at 1800MHz).

A9.69 We considered shifting our base case down further (e.g. to a lower value of £0.3bn) but we were concerned that this might yield too low a valuation for UK spectrum bearing in mind the results in France and the fact that brokers' analysis, for example as referred to in paragraphs A9.61 and A9.62 suggests a higher valuation for UK spectrum at 1800 MHz and 2.1 GHz relative to spectrum in some other European countries. Therefore, we have not adjusted our base case down further.

A9.70 The following table summarises the 2011 cost model outputs using the revised range of £0.1bn to £0.8bn, the revised base case of £0.4bn, the consultation base case of £0.5bn, the value from the CC's determination using the 2G cap of £2.5bn and the value from an updated 2G cap calculation using the 2011 LRIC+ model (i.e. £7.6bn). In the table below, we show the contribution of spectrum to LRIC+ under each of the spectrum valuation scenarios. The reported LRIC+ unit cost benchmarks associated with a particular spectrum value exclude the mark-up for both administration costs and HLR updates as these are calculated separately from the main network cost model. When inserting spectrum value in our model we also apply a gestation adjustment. [266]

A9.71 In addition to the gestation adjustment, in the 2011 cost model we have also added the effect of licence renewal outlay. First, the spectrum value we have used is based on international awards for licences of a finite life. Second, the December 2010 Direction requires that from 31 December 2021 (when the current 2.1 GHz licences expire) holders of those licences must pay licence fees reflecting a market based rate (as determined by Ofcom).[267] As we do not have information on those

[265] See paragraph A9.51 of the April 2010 consultation, http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/summary/wmvct_consultation.pdf.
[266] When inputting the chosen spectrum value in our model, consistent with the April 2010 consultation, we have applied a gestation adjustment (see footnote 202 for further explanation of gestation adjustments and the mechanics of this calculation). Applying this adjustment to our base case value of £0.4bn (i.e. non-gestation adjusted) would yield a value of spectrum of £0.45 bn that is then inputted into the MCT model as a licence payment in 2004/05, which is the year in which 3G traffic is first provided by a 2G/3G operator.
[267] Paragraph 5 (3) (d) of the Government Direction to Ofcom dated 20 December 2010. http://www.legislation.gov.uk/uksi/2010/3024/contents/madetelegraphy/statement/Statement.pdf

market based rates, we have assumed a further licence renewal payment in 2021/22 based on our (gestation-adjusted) base case (i.e. £0.45 bn).[268] After 2039/40, similar to our modelling of other asset categories, we apply a terminal value for spectrum based on unit costs at that time.[269]

Table A9.4: Value of spectrum (in 2008/09 prices) based on recent international spectrum awards[270]

Method	2x30MHz at 1800MHz spectrum value (£bn 2008/09 prices)	2x10MHz at 2.1GHz spectrum value (£bn 2008/09 prices)	LRIC+ unit cost benchmark for 2014/15 (ppm in 2008/09 prices)	Contribution of spectrum under LRIC+ (ppm in 2008/09 prices)	Percentage contribution of spectrum under LRIC+
Original 2G cap based values for spectrum	£0.2bn	£2.5bn	1.41	0.14	10%
Updated 2G cap equalised 2014/15 unit costs	£0.2bn	£7.6bn	1.65	0.38	23%
International benchmarks (£0.1bn)	£0.3bn	£0.1bn	1.32	0.05	4%
International benchmarks (£0.4bn)	£1.2bn	£0.4bn	1.44	0.17	12%
International benchmarks (£0.5bn)	£1.5bn	£0.5bn	1.49	0.22	15%
International benchmarks (£0.8bn)	£2.4bn	£0.8bn	1.63	0.36	22%

Source: Ofcom 2011

A9.72 As can be seen from the above table, our revised base case value for spectrum of £0.4bn (for 2 x10MHz in 2008/09 prices) yields a unit cost output for the LRIC+ of MCT in 2014/15 of 1.44ppm (in 2008/09 prices).[271]

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[268] In present value terms this is equivalent to a single licence payment in 2004/05 of £0.58bn (in 2008/09 prices) i.e. a licence payment of £0.45 bn in 2004/05 and a renewal payment in 2021/22 of £0.45, which is discounted back to 2004/05.

[269] In respect of the terminal value calculation, as discussed in paragraph A9.21, we note that in H3G's response (footnote 125), it argued that we should not apply a terminal value because the April 2010 MCT model assumed an indefinite duration for 3G spectrum licences. In light of the adjustments to reflect the Government Direction discussed in paragraph A9.37 above, we have assumed expiry of the spectrum licences in 2021/22 and an additional payment to account for licence payments thereafter. Therefore, as the licence is not treated as having an indefinite life, we think that it is correct to include a terminal value in 2039/40.

[270] The spectrum values shown in column 3 for 2 x 10MHz at 2.1 GHz and in column 2 for 2 x 30 MHz at 1800 MHz exclude a gestation cost adjustment. The LRIC+ values also exclude the mark-up for administration costs and HLR updates.

[271] We note that the same spectrum value of £0.5bn for 2.1GHz of 2x10 MHz implemented in our 2011 and April 2010 cost models yields different results in term a contribution of spectrum under LRIC+. In our 2011 cost model, for a value of £0.5bn, we calculate that spectrum would contribute 0.22 ppm to LRIC+ unit costs (i.e. spectrum would represent 15% of LRIC+ unit costs in 2014/15 (in 2008/09 prices excluding administration and HLR update costs. In our April 2010 cost model, we calculated a contribution of spectrum under LRIC + of 0.55ppm (i.e. spectrum would represent 39% of

A9.73 The revised base case produces a similar overall spectrum contribution to the 2G/3G blended rate as obtained when using the CC's original 2G cap implied valuation for 2.1GHz spectrum value (of £2.5 bn). However, as discussed previously, we remain concerned with the 2G cap approach. Applying the 2G cap approach going forward yields an implausibly high value for 2.1GHz spectrum (i.e. over £7.6bn).

A9.74 Finally, it should be emphasised that the valuation of spectrum undertaken here is solely to provide indicative cost-based charges for MTRs in 2014/15 if LRIC+ were the preferred cost standard – and so provide a benchmark LRIC+ MTR for the analysis of the choice between pure LRIC and LRIC+. The analysis and conclusions made here are not intended to pre-judge (or set down a marker) for Ofcom's future review of AIP in light of the December 2010 Direction.

Administration and HLR Cost Calculation

Calculation in the 2011 cost model

A9.75 Annex 6 set out how the MCT cost model estimates the network costs of MCT – both for the pure LRIC and the LRIC+ cost standard. For the reasons explained in Section 9 we do not consider that the pure LRIC estimate should include a contribution to costs which are not traffic (specifically MCT) driven. In this part of Annex 9 we deal with the non-network costs previously attributed (in part) to MCT under the LRIC+ cost standard and the recovery of other network costs not captured by the main MCT cost model (i.e. HLR update costs).

Non-network costs

A9.76 The non-network costs considered within this and previous MCT reviews[272] can be grouped into three categories:

- Customer acquisition, retention and service costs (CARS) – comprising advertising and marketing, handset costs, discounts and incentives, customer care, billing and bad debts;
- Administration costs – comprising general overheads; and
- Other costs – costs not relating to the running of the UK network nor either of the above two categories.

A9.77 The table below summarises the 2G/3G MCPs' non-network costs in the three categories above, based on the MCPs' average accounting costs as submitted to Ofcom.

LRIC+ unit costs in 2014/15). The main drivers for this difference are the changes to the Original ED algorithm and correction to the spectrum terminal investment value (see A6.185 to A6.235)

[272] See for example, Annex 15 of the 2007 Statement and paragraph C.101 et seq. of Annex C to the 2004 Statement. http://www.ofcom.org.uk/consult/condocs/mobile_call_term/statement/statement.pdf and http://stakeholders.ofcom.org.uk/binaries/consultations/mobile_call_termination/statement/Statement_on_Wholesale_Mobi1.pdf

Table A9.5: Average non-network costs (calendar year 2009)

	Average costs (£ million)
CARS costs	1,822
Administration costs	416
Other	1,204
Total	**3,442**

Source: Ofcom based upon information from national 2G/3G MCPs

A9.78 Of the three categories of non-network costs above, we only include a contribution to administration costs under LRIC+. This is consistent with the 2007 MCT Statement (see Annex 15 thereof) and the CC's 2009 determination (see Section 3 and Section 8 thereof). Administration costs include the overheads for non-network depreciation (IT, furniture and office equipment), property costs, human resources, finance and legal costs, and IT overheads. Because these are common costs – and so by definition not casually related to the provision of MCT – they are not included within our efficient pure LRIC benchmark for MTRs.

A9.79 Table A9.6 below sets out our approach to estimating the share of total administration costs that are allocated to network activities. This table has been created using accounting information for 2009, which is the latest available.[273]

Table A9.6: Allocation of administration costs to network activities based on average costs for 2G/3G operator (calendar year 2009)

Category	Calculation	Average costs (£ million)
Network depreciation	A	318
3G licence amortisation	B	219
Network opex	C	361
NBV of network assets	D	1,446
NBV of 3G licence	E	2,563
Cost of capital[274]	F	8.8%
Cost of capital on network assets	FxD	127
Cost of capital of 3G licences	FxE	226
Cost of capital on network assets and 3G licences	G=(E+D) xF	353
Total annual network costs	H=A+B+C+G	1,252
Annual operating cost of retail activities (CARS)	I	1,822
Annual operating costs of "Other" activities	J	1,204
Annual operating costs of Admin activities	K	416
NBV of non-network assets	L	509

[273] In Table A9.11 the third column contains the data from the 2G/3G national operators and the results of the administration costs calculations. The second column shows how we perform these calculations.
[274] Pre tax nominal assuming 2.5% inflation.

Cost of capital on non-network assets	M=LxF	45
Cost of capital on non-network assets attributable to CARS (Retail)	N=MxI/(I+J+K)	24
Total CARS (Retail) costs	O=I+N	1,846
Cost of capital on non network costs attributable to Admin	P=MxK/(I+J+K)	5
Total Admin costs	Q=K+P	421
Total Network and Retail costs	R=H+O	3,098
% Network costs	S=H/R	40%
Share of administration costs allocated to network activities (2009) terms	T=SxQ	170

Source: Ofcom based upon information from national 2G/3G MCPs

A9.80 Given the above, we estimate that £170m in calendar year 2009 prices (£170.49m in 2008/09 prices) should be allocated to network activities as a share of administration costs for the average efficient operator under the LRIC+ cost standard.

A9.81 The total administration cost allocated to network activities is allocated to network services (e.g. incoming calls, outgoing calls and data) in proportion to their respective shares of network traffic costs. The ppm mark-up for administration costs on termination in 2014/15 is estimated by dividing the termination share of these network traffic costs (in £m) by the number of minutes terminating in that year. For 2014/15 the administration cost contributes 0.16ppm (in 2008/09 prices) to the LRIC+ of MCT.

HLR update costs

A9.82 The HLR (Home Location Register) updates identify the location of subscribers on the network in order to efficiently route mobile services, including incoming voice calls, to them. In the 2011 cost model, as in the April 2010 cost model, HLR costs are driven by the number of subscribers. The costs of HLR updates are then allocated to incoming services based on the proportion of incoming legs attributable to that service. This is added as a mark-up after the model has allocated the other network costs via routing factors. The HLR update costs are not included in the pure LRIC calculation because HLR updates would need to occur even if there are no off-net originated incoming calls.

A9.83 In the 2011 cost model, for 2014/15 the HLR update costs contribute 0.01ppm (2008/09 prices) to the LRIC+ of MCT.

Stakeholder Responses

Vodafone

A9.84 Vodafone argued that rather than keeping the total administration cost constant we should keep a constant ppm contribution for administration costs. Vodafone also noted that the total £m administration cost had increased between the 2007 MCT

modelling exercise and the 2010 modelling exercise.[275] This, it believed, showed that administration costs increased as volumes increased and so were traffic sensitive. Vodafone also asserted that in the 2007 MCT cost model we applied a constant ppm mark-up to termination for administration.

Everything Everywhere

A9.85 EE made no substantive points on the calculation of administration costs. However, EE argued that the pure LRIC calculation should include a contribution to administration costs. It stated that the 2009 CC determination held that a contribution to administration costs was reasonable. EE believed that Ofcom had not offered any new evidence to counter this finding.[276]

A9.86 EE also argued that HLR update costs are mainly incurred to support the supply of termination and so should be included in the pure LRIC estimate of the cost of MCT.[277] EE supports its argument with a quote from the 2002 CC inquiry that refers to incoming calls as a driver of HLR update costs.

O2

A9.87 O2 noted that the WACC was one of the input assumptions used in the calculation of administration costs. But it noted an apparent error in the administration costs part of the April 2010 cost model, the WACC value was fixed at its base case value. Therefore, the sensitivity analysis for different WACC values in the April 2010 cost model should have also been applied to the administration costs calculations. O2 suggested performing the same sensitivity analysis as in the April 2010 consultation, but allowing the WACC to vary in line with the assumptions used the main MCT cost model.[278]

H3G

A9.88 H3G made no substantive points on administration costs in its response to the April 2010 Consultation. However, in a follow-up response, H3G agreed with Ofcom's treatment of administration costs. H3G disagreed with EE and stated that the Competition Commission had previously determined that administration costs should be treated as common costs. As such, administration costs should not be included in the pure LRIC unit cost of termination.[279]

A9.89 H3G also disagreed with EE over the inclusion of HLR update costs in the pure LRIC estimation of MCT costs.[280] H3G argued the HLR updates would continue if there was no incoming off-net termination and so no costs would be avoided if this increment was removed. H3G also quoted the 2002 CC inquiry as stating that:

[275] Vodafone response to the April 2010 consultation, Annex 3 page 96.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[276] EE response to the April 2010 consultation, page 31.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Everything_Everywhere.pdf
[277] EE response to the April 2010 consultation, page 32.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Everything_Everywhere.pdf
[278] O2 response to the April 2010 consultation, page 61.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/O2.pdf
[279] H3G additional response to the April 2010 consultation, page 17-18.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/three.pdf
[280] H3G additional response to the April 2010 consultation, page 18.
http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/three.pdf

A9.90 "[...] the cost of the HLR and updating is not incremental to the volume of incoming calls."

Ofcom's assessment of administration costs

A9.91 In the April 2010 cost model we used an administration cost (in £m) that was fixed in real terms over the modelled period. Because the total administration cost is constant, the contribution of administration costs to the termination unit cost will decrease as volumes increase. Overall, this approach to calculating administration costs was also supported by the CC.[281]

A9.92 We disagree with Vodafone's argument that the ppm contribution to administration costs was held constant for all periods in the 2007 MCT cost modelling[282]. We have therefore continued to keep the total real cost of administration constant in the 2011 cost model. As such, the ppm contribution of administration costs to the LRIC+ of MCT decreases as volumes increase.

A9.93 We accept that administration costs may not stay fixed over time. However, total administration costs do not necessarily increase over time, or with volumes as Vodafone suggests. Indeed, in the 2009 CC determination part of the discussion was focussed on whether total administration costs should decrease over time to reflect efficiency gains, and for the period in question, the CC considered that a real reduction in average administration costs should have been acknowledged and accounted for.[283] However, on the grounds of materiality and because we do not think that a contribution to administration costs is appropriate under pure LRIC, we have not investigated these issues further. For the LRIC+ calculation we have therefore taken the £m quantum of administration costs from the latest accounting information and allocated this to MCT following the same methodology as in the 2007 MCT statement and the April 2010 consultation.

A9.94 One of the reasons that the CC gave in its 2009 determination for not changing Ofcom's approach was the immateriality of any change in the calculation of administration costs to the unit cost of termination.[284] With the current higher volume of MCT the impact of administration costs on the LRIC+ of termination is even smaller.

A9.95 In considering the effect of changes in the WACC in the administration cost calculation, we accept, as suggested by O2, that in principle our sensitivity analysis should vary in line with the WACC assumptions using in the main model. However, in practice our different WACC assumptions do not make a material difference to

[281] 2009 CC Determination, paragraphs 3.83-3.87. http://www.competition-commission.org.uk/appeals/communications_act/mobile_phones_determination.pdf

[282] See paragraph A15.107 of the 2007 statement which states that: *"The ppm mark-up for adminstration costs on termination in 2010/11 [the final year of the 4 year control set in 2007] is estimated by dividing termination's share of this total cost by the number of minutes terminated in that year."* http://www.ofcom.org.uk/consult/condocs/mobile_call_term/statement/statement.pdf

[283] From Table 3.3 and paragraphs 3.67-3.69 of the 2009 CC determination it can be seen that average administration costs had fallen in real terms in the period considered by the CC. From Table A9.11 above and Table 17 from the April 2010 consultation it can be seen that average administration operating costs increased (from £383m to £416m – i.e. a real increase of around 6% given RPI inflation of 2.4% for year to December 2009). However, on the grounds of proportionality we have not investigated the drivers for this increase – e.g. whether they reflect one-off "exceptional" items or changes in cost accounting methodologies – not least since the difference is lost in the rounding of the 2014/15 LRIC+ unit costs, even to 2 decimal places.

[284] 2009 CC determination, paragraphs 3.80 - 3.82.

the outputs of our sensitivity analysis. For changes in the WACC considered in Annex 8, the contribution from administration costs (in ppm) is unchanged to 2 decimal places.[285]

A9.96 In summary, we have updated the administration cost calculation to reflect the most recent accounting information. For the reasons stated above, we have not made any other changes to the way we calculated administration costs under LRIC+ and have not included administration costs in the pure LRIC calculation.

Ofcom's assessment of HLR update costs

A9.97 The 2011 cost model assumes that HLR update costs are driven by subscriber numbers. It is true that if there were no incoming calls there would be no need for HLR updates, so in that sense HLR update costs could be seen as traffic driven. However, we agree with H3G that HLR updates would in any case be needed to support on-net inbound traffic. The off-net termination increment would not cause additional HLR updates and so would not produce incremental costs.

A9.98 We therefore conclude that HLR update costs do not need to be included in the pure LRIC calculation.

Data Pricing and Common Cost Recovery

Introduction

A9.99 As data usage has grown considerably, and is projected to continue growing, it now drives a large part of network costs and will attract more of the fixed and common costs in coming years. The greater the data volumes then, other things equal, the greater the allocation of network costs to data services. This will be for two reasons: first, as data contributes more to total traffic, then more traffic-driven network costs will be allocated to data services (including intra-traffic common costs such as spectrum); second, as data services use network assets more intensively, then network costs driven by coverage or subscribers will be recovered more from data services (i.e. non-traffic common costs).

A9.100 If the cost model directs too many fixed and common costs to data services this will generate problems for the accuracy of the LRIC+ estimates of the costs of MCT, not the pure LRIC. By definition, the pure LRIC of MCT should not include any contribution to costs shared with other services, in this case data.

A9.101 The particular criticism received from certain MCPs is that the output for the per megabyte LRIC+ wholesale cost of data in the MCT cost model is higher than the observed retail prices. In other words, there was concern that the April 2010 cost model seems to allocate too great a proportion of common costs to data services by reference to observed market outcomes for retail data pricing.

A9.102 The MCT April 2010 model allocated shared network costs based on routing (i.e. usage factors). These usage factors were used to determine the number of assets required for a given amount of service traffic. As such, the amount by which a service uses a piece of equipment determines the amount that service contributes to the cost (investment and operating cost) of that piece of equipment.

[285] The change in LRIC+ output when the WACC is changed from the base case to the high or low is approximately 0.003ppm.

Views of respondents

Everywhere Everything

A9.103 EE in its response to the April 2010 consultation[286] argued that the price per megabyte should be consistent with the observed retail prices per megabyte of data. It argued that [✂].

A9.104 [✂].

Vodafone

A9.105 In Vodafone's response to the May 2009 consultation[287] and in its response to the April 2010 consultation[288], it suggested that within the April 2010 cost model a larger amount of the fixed and common costs should be recovered from voice services. Indeed, Vodafone went as far as to argue that the cost of data services should only be calculated on an incremental cost basis. Vodafone noted both that retail data prices were below the LRIC+ cost output of the April 2010 cost model and that revenues from data services were increasing much more slowly than data volumes.

H3G

A9.106 H3G did not make any comments on the unit cost of data output from the April 2010 cost model in its response to the April 2010 Consultation. However, H3G did respond to the other MCPs' comments in a later document. H3G's particular focus was on the linearity of pricing for outputs produced by the April 2010 cost model. It argued that linear unit prices bear no relation to retail prices observed in reality. Instead, fixed charges and non-linear prices are widespread in both the post and pre-paid sector. As such, H3G considered it both difficult and inappropriate to compare outputs from the April 2010 cost model with the retail prices that we currently observe. It argued that observed retail prices did not make a useful calibration point for the model.[289]

Ofcom's Assesment

Snapshot comparison using 2010 retail prices

A9.107 If we assume that the currently observed retail prices represent a long-run equilibrium (which we do not think is an appropriate assumption as discussed below), the available evidence is as follows.

A9.108 Table [A9.5] below shows an estimate for the per megabyte revenue earned from handsets and dongles.[290] It also includes an estimate of cost from the 2011 cost

[286] EE response to the April 2010 consultation, page 29 and Annex C pages 81-84. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Everything_Everywhere.pdf
[287] Vodafone response to the May 2009 consultation, pages 29-30. http://stakeholders.ofcom.org.uk/binaries/consultations/mobilecallterm/responses/Vodafone.pdf
[288] Vodafone response to the April 2010 consultation, Annex 3 pages 85-87. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/Vodafone_annexes.pdf
[289] H3G additional response to the April 2010 consultation, pages 7-10. http://stakeholders.ofcom.org.uk/binaries/consultations/wmctr/responses/three.pdf
[290] In all responses on data pricing, data has been referred to without making any distinction between different data users or data used on different devices. In the 2011 cost model, the data cost is determined by the extent to which a unit of data uses the network and so the "type" of data does not

model. The average monthly usage is from the most recent S135 data (although not all operators were able to provide data in a consistent way so we have not calculated a weighted average across MCPs). The table shows the difference in per megabyte prices and costs when the average subscriber data usage is used instead of the data allowance to determine average revenues (i.e. prices).[291]

Table A9.7: Total data revenue Q2 2010/11 (pence per MB 08/09 prices)[292]

[✂]
Source: Information from MCP s135 responses and Ofcom analysis

A9.109 As we might expect, due to the high volumes and relatively low retail price operators appear to make a loss on dongle data when compared to the LRIC+ output from the MCT model. For data on handsets the majority of operators appear to have retail prices above the LRIC+ produced by the 2011 cost model (with the exception of [✂]). When dongles and handset revenues are taken together, it appears that average revenues are below the LRIC+ produced by the MCT model for four MCPs ([✂][293] and [✂]), but above for [✂].

A9.110 We should note at this point that there was some concern from [✂] on our use of revenue associated with data and the actual volumes that pass over the network. [✂][294]

A9.111 [✂].[295]

A9.112 We agree with [✂] that measuring the revenue received from data is extremely difficult. Indeed, it is for this reason that we consider that retail prices for data make a poor metric by which to calibrate a model. However, in so far as we attempt to compare average revenues with costs, we do not agree that it is appropriate to ignore subscribers that do not use their data allowance. If we were to ignore the [✂] allocated from the access charge to subscribers who do not use their data allowance, then by the same logic we ought to allocate more than [✂] to those who use a large proportion of their data allowance. We are not in a position to try and reallocate retail access charges based on subscriber usage and do not believe it would be appropriate to do so. We have therefore based the comparison in Table A9.7 above on average revenues adjusted for actual usage (since costs in the cost model are also based on actual, and forecast, usage).

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matter. However, this is not the case in the retail market. The price of data can vary depending on the type of device used (dongle or handset) and the way the data is purchased (pre-pay pr post-pay). Moreover, retail data prices and the "fair usage" policies of the operators have been changing since the April 2010 consultation was published.

[291] Responses on data pricing have also not referred to the difference between the retail offering and the actual revenue from data. Where data is sold in bundles, the headline retail price per MB figure does not reflect actual usage. A retail offering of 1GB for £10 would mean a unit price of just under 1 pence per MB. However, if only half of the allowance is used on average across the retail subscribers, then the actual revenue would be around 2 pence per MB (assuming 1024 megabytes to a gigabyte).

[292] We have calculated the ppMB values from data provided by the MCPs. EE reported the data for Orange and T-Mobile separately, so they have been reported in the table in this way. The MCPs were not able to provide the data in a consistent fashion and so we have not calculated a weighted average. [✂] could only provide revenue information on data that was out of bundle. [✂] was only able to provide data up until April 2010. [✂] provided a total data revenue and volume figure for all data on its network, which included data carried from domestic and international roaming.

[293] Although for [✂] this is particularly difficult to infer as it relates to out of bundle usage

[294] [✂].

[295] [✂]

Alternative data sources

A9.113 As part of our assessment of the retail price of data we have also examined estimates produced by other organisations, specifically Enders Analysis (Enders) and Analysis Mason. The Analysys Mason report includes the UK as part of an EU wide study. The Enders report looks at estimates for both the UK and Europe. Our analysis only considers the UK market, so we need to be careful when making direct comparisons between these reports and our own analysis.

A9.114 Enders produced a report in September 2010 that, among other things, sought to estimate the retail price of data and the network cost of a unit of data. Enders calculated what it refers to as the "average cost" and the "incremental cost" of mobile data. It is the average cost of data that we are interested in for comparison with our own LRIC+ costs of MCT. Table A9.8 and Table A9.9 below show the estimates produced by Enders for the average price (and average cost) of data.

Table A9.8: Enders Analysis estimate of network cost of data (pence per MB)[296]

	2008/09	2009/10	2010/11 (estimate)
Vodafone Europe per MB	7.62	4.69	3.03
	2008/09	**2009/10**	**2010 (estimate)**
H3G UK per MB	5.96	2.54	1.27

Table A9.9: Enders Analysis estimate of average revenue (price) by data service[297]

	Revenue per MB	Network cost per MB	
	Average	Average	Incremental
Total (voice, SMS and data)	10p-20p	Around 3p	0.2p to 0.4p per MB
Total data	Around 3p		
Smartphone connectivity	Around 2.5p on average		
PC connectivity	Around 1.5p on average		

A9.115 As can be seen from the above, Enders' estimates of unit costs (at around 3ppMB) are somewhat below our own (3.67ppMB in 2010/11, albeit in 2008/09 prices)[298], although we understand that Enders has excluded a contribution to spectrum costs in its per MB cost estimates. From the average price-cost analysis presented by Enders, it appears that the current average revenues for dongle services may be below "average" costs, but that at the total data level, average revenues may be at

[296] Estimates produced by Enders Analysis, Mobile data economics: the limit of unlimited, 7th September 2010, www.endersanalysis.com/node/3918. Data converted to pence per MB assuming 1024MB to 1GB.
[297] Op cit.
[298] In 2010/11 prices our estimate of average unit costs is 3.89ppMB.

or around average costs. Enders's price-cost comparison also indicates a significant (positive) margin on incremental costs.[299]

A9.116 As part of its work on international mobile roaming, the European Commission on behalf of the Body of European Regulators for Electronic Communications (BEREC) commissioned Analysys Mason to produce retail price estimates for domestic mobile services across the EU. As part of this report Analysys Mason estimated the retail price of data services. The results of this analysis for the UK are shown in Table A9.10. This report has not been published to date.

Table A9.10: Estimate of the average retail revenue of data in the UK (pence per MB)[300]

[✂]

A9.117 The retail revenue estimates produced by Analysys Mason are of similar magnitude to those produced by our own analysis, if not a little below. For the latest period containing actual values it appears that the blended price of data services would be around [✂] from the Analysys Mason study. This compares to a range produced for our analysis of around [✂]ppMB (based on [✂] out of bundle revenues in 2010/11 prices) to around [✂]ppMB (based on the combined dongle and handset average revenues from [✂] in 2010/11 prices). Using the blended price per MB from the Analysys Mason study would imply average revenues [✂] our LRIC+ estimate of unit costs (using 2010 prices and 2010/11 costs).The table also shows that retail prices have [✂] by approximately [✂] year-on-year between 2007 and 2009.

Other caveats to relying on observed retail prices

A9.118 There are a number of caveats to bear in mind in any comparison of observed retail prices with outputs from the 2011 cost model. First, the 2011 cost model is by construction a network cost model and so no analysis is made of the efficient level of retailing costs. In principle, a deduction for retailing costs would be necessary in comparing the derived retail prices with modelled (network-level) costs.

A9.119 Second, even if the model were producing unit cost estimates that appear different to observed retail revenue this does not mean that the model is producing erroneous outputs. This is because the 2011 cost model is an all service model. Even if the LRIC+ unit cost of data were above the unit retail price of data, it is likely that the LRIC+ for other services will be below the observed retail price. Indeed, if we refer back to Table A9.7 we can see that according to the Enders analysis the average revenue per gigabyte for voice and non-voice services combined is at least three times that of the network cost of a gigabyte of network usage (and possibly up to six times greater). For a single service, perhaps the most stark example of revenue being above cost is for SMS. The Enders report calculates that the per gigabyte revenue raised from SMS is at least £100,000.[301]

A9.120 Third, the 2011 cost model estimates the path of long-run prices. Data is still a relatively new service and the current prices are unlikely to reflect long-run stable prices. Indeed, in a response to a S135 data request on data revenues [✂].

[299] Op cit, Figure 8
[300] Estimates produced by Analysis Mason – Average revenue per unit for domestic mobile (1 December 2010).
[301] Enders report Figure 4 (2010/11 prices). Enders Analysis, Mobile data economics: the limit of unlimited, 7th September 2010, www.endersanalysis.com/node/3918

A9.121 [✂].

A9.122 It is in fact typical of product life-cycles with customer acquisition costs for firms to invest in growth by charging low prices initially and then "harvesting" the revenues from the installed customer base in later periods.

A9.123 The criticism from Vodafone was that we should be using the retail price of data as a calibration metric. However, we consider that retail prices make a poor metric for calibration. As noted above, retail prices are difficult to observe and are susceptible to fluctuations and short-term changes. Indeed, as Vodafone explains in its recent submission to the European Commission's review of the functioning of the Roaming Regulation

A9.124 "The Commission faces another challenge with data caps, namely that domestic pricing for data is in a state of flux (in a way not seen with voice or SMS). One of the greatest challenges facing mobile operators today is the challenge of how to price domestic data services so as to better align revenues and costs. Many operators are making radical changes to the way they price mobile data services, with a current trend away from simple 'unlimited' tariffs towards usage-based and application-specific alternatives.

A9.125 Nobody – including the Commission – knows how domestic data pricing will evolve over the next 5 years. This only adds to the difficulty of trying to set caps and structures for data roaming. With domestic prices so volatile and uncertain, attempts to 'anchor' data roaming prices in regulation means that prices will diverge if the former changes in ways not anticipated by the regulator"[302]

A9.126 By contrast, we consider that technical parameters and financial data (i.e. accounting GBV and opex) provide better metrics with which to calibrate the 2011 cost model. These metrics are aggregated, subject to audit scrutiny and in the case of technical parameters (e.g. cell sites) more easily observed. We believe these metrics provide better tools for calibrating the 2011 cost model and our approach thereto is explained at Annex 7.

Conclusion

A9.127 We faced criticism in responses to the April 2010 consultation that the unit costs per megabyte of data from the April 2010 cost model were too high relative to observed retail prices and, as such, the model was not correctly allocating network common costs. To support this proposition, respondents referred to prevailing retail prices for data services and the fact that they considered these to be below the data unit costs produced by the April 2010 cost model.

A9.128 In response to this criticism, we have sought to estimate the actual average retail price of data and find other estimates of the network cost of data (in addition to those produced by the 2011 cost model). We have found that the retail price of data is difficult to estimate robustly due to much data usage being consumed as part of bundles of other services and the fact that data services are still relatively nascent (whereas the 2011 cost model is based on lifetime network costs). While making generalisations or drawing firm conclusions from the above analyses is difficult, we

[302] Vodafone response to the 2011 European Commission's Review of the functioning of the Roaming Regulation, page 13.
http://www.vodafone.com/content/dam/vodafone/about/public_policy/position_papers/vodafone_roaming_jan10.pdf

do not consider the unit costs for data produced by the 2011 cost model to be too far out of line with the utilisation adjusted retail prices.

A9.129 In any event EE and Vodafone themselves recognise that average retail data prices will substantially change over the next few years. This means that any calibration exercise based on current retail prices would be unlikely to be reliable.

Annex 10

Network cost model outputs

Introduction

A10.1 The 2011 cost model has been used to calculate the unit costs of incoming voice traffic using both LRIC+ and pure LRIC. The detailed assumptions underlying the 2011 cost model are set out in Section 9 and Annex 6, Annex 7, Annex 8 and Annex 9. This annex summarises the results of the model under a base case scenario and also under low cost and high cost scenarios, in order to illustrate the range for the benchmark efficient unit costs of MCT.

A10.2 We first describe the assumptions of the base case, and then present the corresponding results (the unit costs of incoming 2G and 3G voice calls). Although pure LRIC is the preferred cost standard for the charge control, we have presented below the MCT cost model outputs for both LRIC+ and pure LRIC. LRIC+ unit costs have been calculated in order to evaluate the impact of moving to pure LRIC (see Section 8, Section 9 and Annex 3) where a reasonable estimate of the level of LRIC+ MTRs is required.

A10.3 We have examined the sensitivity of the unit costs of incoming voice calls to changes in individual model parameters. We have done this by means of sensitivity analyses, which are presented in the next two sub-sections. The first sub-section examines the sensitivity of the results to changes in demand assumptions. The second sub-section examines the sensitivity of the model outputs to other assumptions such as technology, market share, WACC and other cost inputs.

A10.4 Following the sensitivity analyses, we present the results of the model under two combined scenarios: “high cost” and “low cost”. These scenarios vary all the assumptions identified in the individual sensitivity analyses described above.

Model results for the base case

A10.5 This section summarises the base case outputs from the 2011 cost model. It also provides a breakdown of the impact that changes since the April 2010 cost model have had on the unit cost of termination.

A10.6 The base case scenario has the following assumptions:

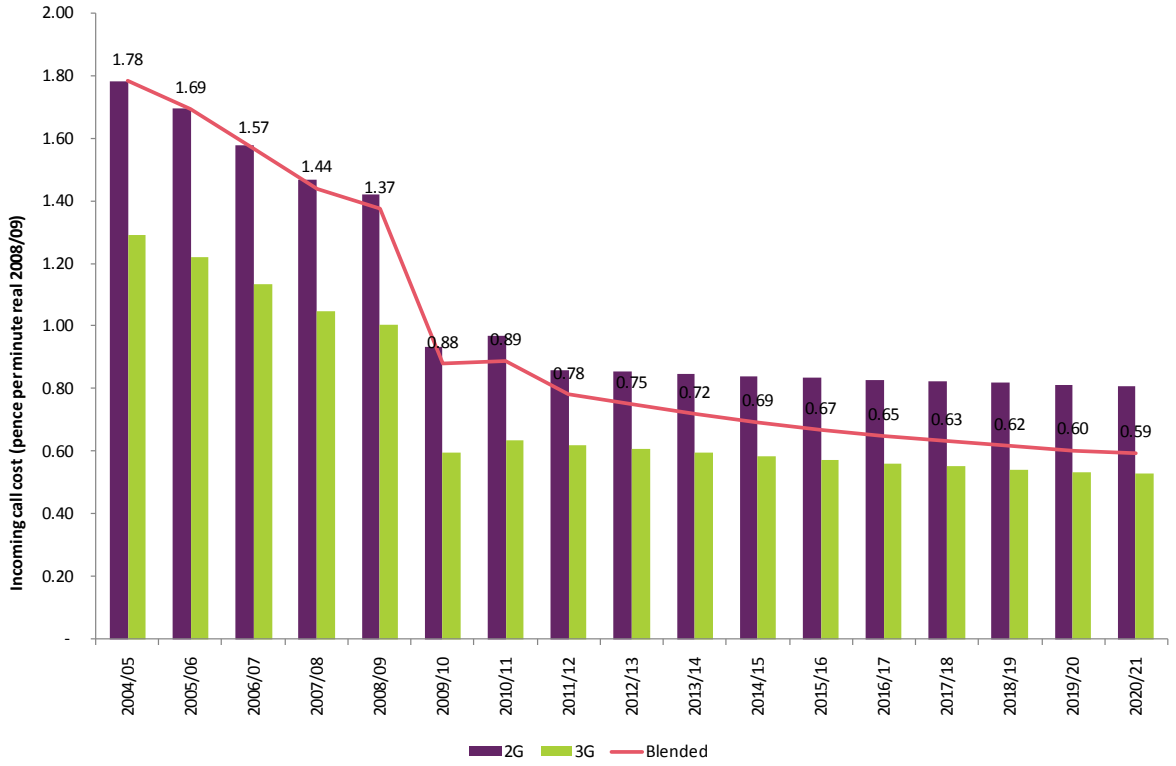
- A hypothetical efficient national MCP deploying 2G and 3G/HSPA technologies.
- The 2.1 GHz spectrum used for 3G has a value of £0.58bn[303] (for 2x10MHz in 2008/09 prices) and the 1800 MHz spectrum used for 2G has a value of £1.75bn (for 2x30MHz in 2008/09 prices).
- Our medium forecasts (as described in Annex 6) are used for all usage and take-up assumptions.
- Long-term market share for the efficient operator is 25%.
- Site sharing begins in Q1 2007/08, and all sharable macrocell sites (90%) are shared by the end of Q1 2014/15.
- Costs are in real terms, expressed in 2008/09 prices.
- All LRIC+ values include a contribution to administration costs.

A10.7 The unit costs for 2G and 3G MCT calculated using pure LRIC are shown in Figure A10.1 below. The pure LRIC unit costs of MCT for 2014/15 are 0.84ppm for 2G and 0.58ppm for 3G. This leads to a blended pure LRIC unit cost for MCT of 0.69ppm in 2014/15.

A10.8 Both 2G and 3G incoming voice calls have declining unit costs over time: this is due to the declining unit costs of modern equivalent assets and the declining WACC which together, when using economic depreciation, lead to a fall in unit costs over time.[304] The significant reduction in the unit costs between 2008/9 and 2009/10 is due to a step change reduction in the value of the WACC[305] for an average efficient national MCP. Although in general the unit cost of MCT is declining, there is an increase in unit costs between 2009/10 and 2010/11 under pure LRIC. As can be seen in Figure A10.1 below, this increase occurs for both the 2G and 3G unit costs. This single year increase is caused by a number of model changes that occur in this year. Certain assets will have an increasing path of unit costs of output due to increasing input costs (e.g. cell sites). Combined with these increasing element costs some additional costs are also introduced in 2010/11, specifically Ethernet backhaul. We have modelled the Ethernet links such that they begin to be put into operation in 2010/11 and from this date make a contribution to unit costs. Although across the life of the network Ethernet links reduce cost, when they are introduced they cause a jump in the unit costs. If Ethernet links are removed then the pure LRIC of MCT decreases between 09/10 and 10/11.[306]

[303] This value includes an uplift for the gestation adjustment and renewal expenditure as described in Annex 9
[304] Traffic demand has a limited effect on the pure LRIC costs.
[305] The WACC for an efficient national MCP is discussed in Annex 9
[306] There is a 0.01ppm increase in the 2G termination rate but this is lost in the blending process.

Figure A10.1: Pure LRIC unit costs of incoming 2G and 3G voice

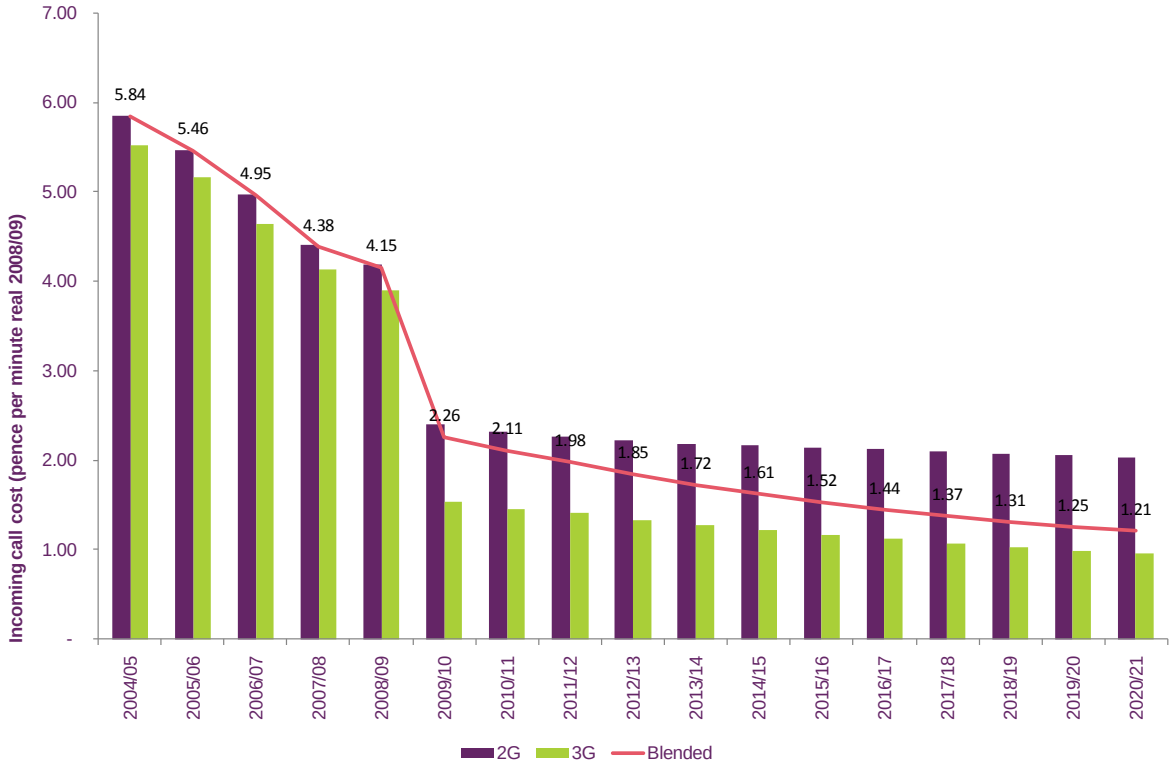


Source: Analysys Mason

A10.9 The LRIC+ unit costs for 2G and 3G MCT over time are shown in Figure A10.2 below. The LRIC+ unit costs of MCT for 2014/15 are 2.16ppm for 2G and 1.22ppm for 3G. This leads to a blended LRIC+ unit cost of incoming voice of 1.61ppm for 2014/15.

A10.10 As for the pure LRIC cost standard, both 2G and 3G incoming voice decline over time under LRIC+ due to the declining replacement costs of modern equivalent assets and the declining WACC. The unit cost path again sees a significant reduction between 2008/9 and 2009/10 due to a step change reduction in the value of the WACC for an average efficient national MCP.

Figure A10.2: LRIC+ unit costs of incoming 2G and 3G voice



Source: Analysys Mason

Changes from the April 2010 cost model

A10.11 Table A10.1 below shows the changes from the values in the April 2010 consultation to the values in this Statement. We have grouped those changes in blocks to make it easier to observe the effect of the changes. The rationale for the changes is discussed in detail in Annex 6, Annex 7 and Annex 8.

Table A10.1: Changes from the values in the April 2010 consultation to the values in the Statement (2014/15 ppm unit cost in 08/09 prices)[307] [308]

	Blended pure LRIC
April 2010 Consultation	0.51
Model corrections	0.54
Changes to demand assumptions	0.36
Changes to network dimensioning	0.48
Changes to site sharing	0.50
Changes to cost drivers	0.53
Changes to asset costs	0.67
Changes to cost recovery profile	0.69
2011 Statement	0.69

A10.12 The group of changes that has the largest effect on the unit cost is the change to demand assumptions. This demand assumption grouping not only includes the forecasts of total network volumes (which have remained largely unchanged) and general updates to reflect recent actual volumes, but also changes to average call duration, the traffic in the busy hour and the quantity of traffic carried on the 2G and 3G parts of the network.[309] Changes to the asset costs also have a significant effect on the pure LRIC unit cost. The changes that we have made to the cost recovery profile (i.e. economic depreciation as described in Annex 6) have a small effect on the pure LRIC unit cost.

Sensitivity analysis: demand assumptions

A10.13 We have carried out a number of sensitivity analyses to explore the impact of varying assumptions on the model results. This section examines the effect of changes in four demand-side parameters, as follows:

- **Voice usage**: the minutes of use per subscriber (with the same number of subscribers as in the base case).
- **3G handset data usage**: Mbytes per handset per month of data services on 3G handsets (with the same number of subscribers as in the base case).

[307] In the April 2010 consultation we rounded the model outputs to 1 decimal place. This table shows the model outputs from the April 2010 cost model to 2 decimal places, consistent with the rounding convention adopted in this statement. We have chosen to round to 2 decimal places for the following reasons: first, given the reduction in MTRs under the charge control rounding to only 1 decimal place has a larger proportionate impact on the ppm charge than previously; second, there are precedents from previous MCT reviews of rounding the cost modelling to 2 decimal places – e.g. the 2002 CC enquiry and the 2004 statement both rounded the MCT cost model outputs to 2 decimal places; third, MCPs are typically able to round to 4 decimal places for billing purposes so are readily able to accommodate rounding to 2 decimal places; and fourth all respondents commenting on cost model outputs reported outputs under their analysis to more than 1 decimal place (i.e. Vodafone, H3G, EE, O2).

[308] Within the table, the changes as a result of the calibration exercise have not been identified as a separate grouping as they are spread across multiple groupings e.g. proportion of traffic in the busy hour (under “demand assumptions”), cell radii, proportion of traffic generated by 2G/3G handset that is carried on 3G network, equipment utilization factors, 2G/3G site sharing factors (under “network dimensioning”), and MEA price changes (under “asset costs”).

[309] All these changes are described in Annex 6, Annex 7 and Annex 8. Note that due to the way the model has been updated these values can not be reproduced with the release version of the model.

- **Datacard take-up**: the penetration of 3G datacards (with the same usage per device as in the base case).

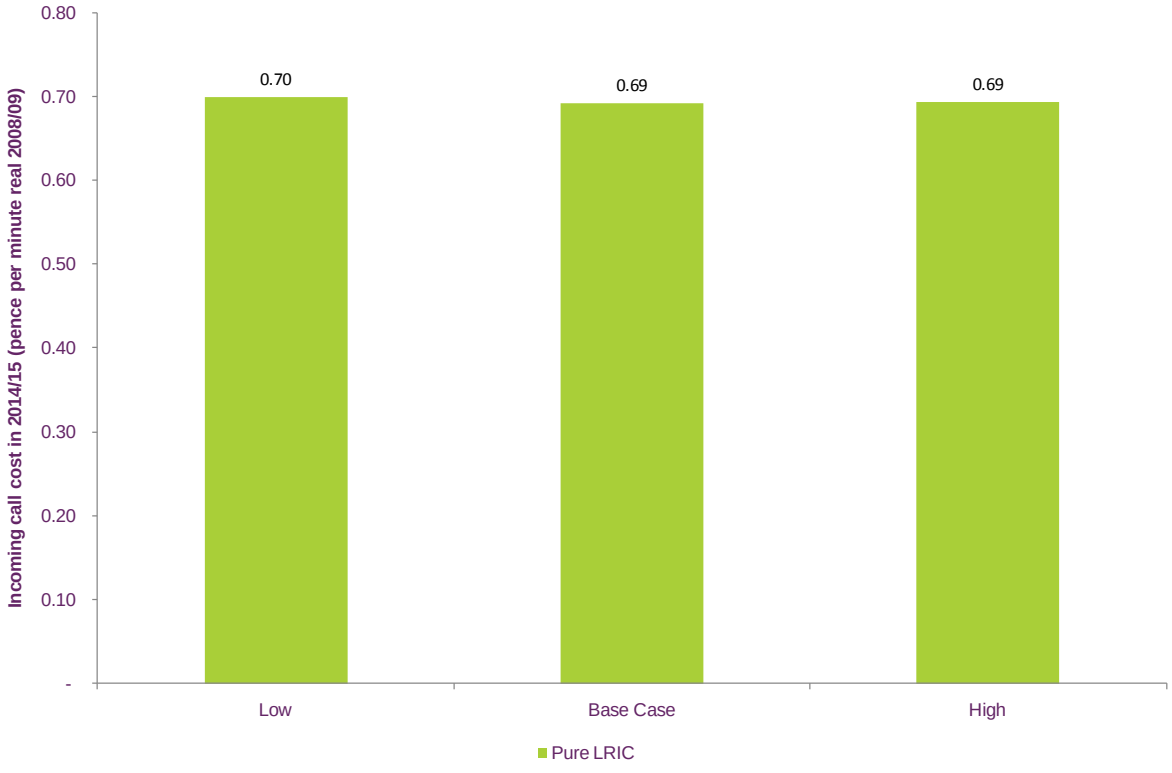
- **Datacard usage**: the average usage (in Mbytes per datacard per month) of datacards (with the same take-up assumptions as in the base case).

A10.14 In the following subsections we consider the impact of changing each of these parameters individually, and then examine changing several (or all) of them at the same time. In all cases we compare the results for the base case (using our medium demand forecasts) with results where the parameter has the value specified in the low or high demand forecasts. These different levels of forecast demand are discussed in more detail in Annex 6.

Voice usage

A10.15 Figure A10.3 below shows the impact on the pure LRIC unit costs of MCT of changing the forecast usage of voice services. Lower levels of voice usage lead to marginally higher unit costs, with an increase from 0.69ppm in the medium demand forecast to 0.70ppm in the low forecast. In the April 2010 cost model the pure LRIC unit cost was shown as unchanged at 0.5ppm for both the low and high voice scenarios.

Figure A10.3: Sensitivity analysis of different voice usage forecasts



Source: Analysys Mason

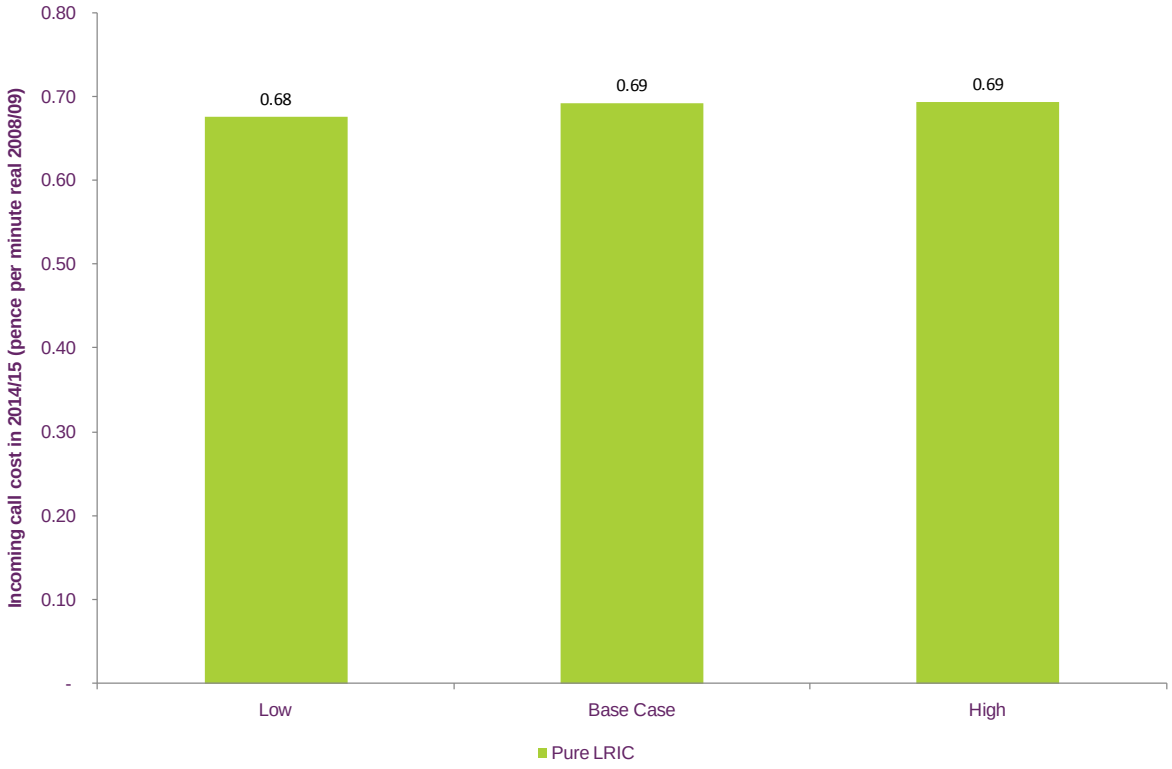
Data usage on 3G handsets

A10.16 The model is not very sensitive to the usage of data on 3G handsets. It can be seen from Figure A10.4 that the pure LRIC unit cost only varies between 0.68ppm and

0.69ppm. We saw similar insensitivity to changes in 3G handset data usage in the April 2010 cost model. The pure LRIC unit cost of MCT was shown as unchanged at 0.5ppm across all 3G handset data usage scenarios.

A10.17 In principle, it might seem counter-intuitive for the pure LRIC of MCT to be sensitive to the volume of data traffic. In a world where network assets were infinitely divisible, more data traffic would not cause the cost of carrying an increment of termination voice traffic to change. However, in practice, we may see some fluctuation in the pure LRIC unit cost due to a modularity effect.[310] That said, as can be seen in Figures A10.4 to A10.7 this modularity effect is small.

Figure A10.4: Sensitivity analysis of different 3G handset data usage forecasts



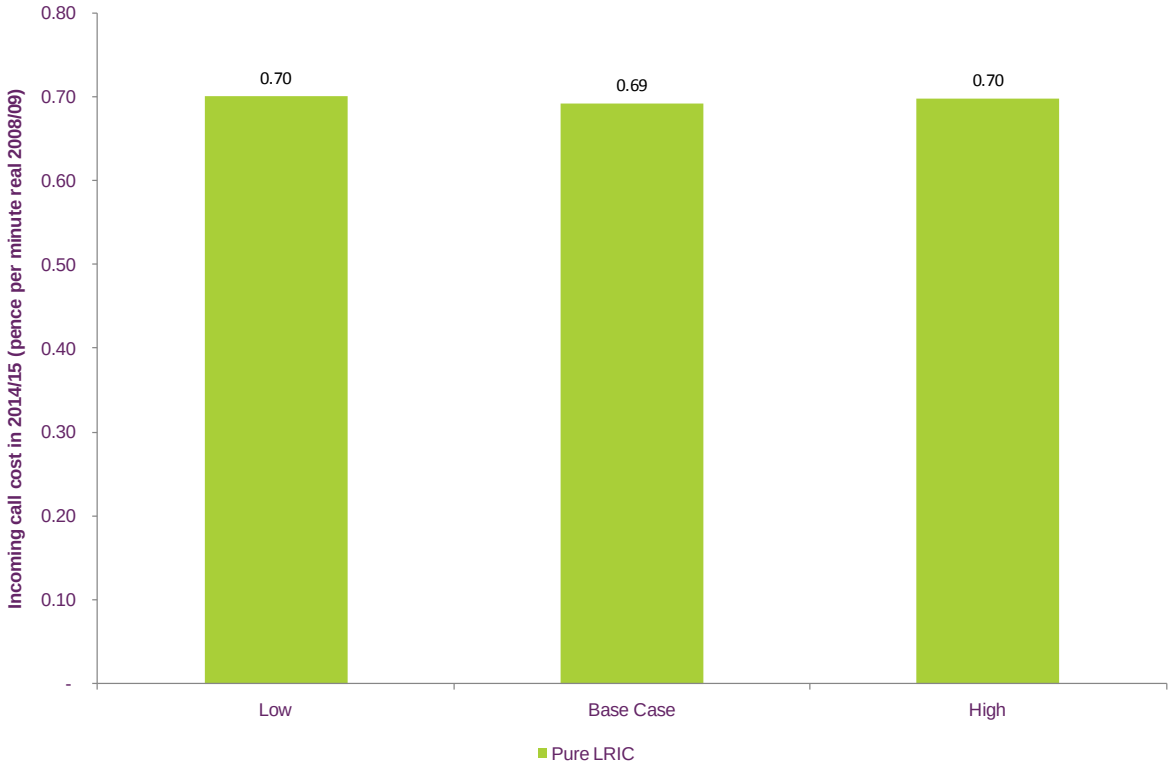
Source: Analysys Mason

Take-up of datacards

A10.18 The pure LRIC unit cost varies very slightly in response to the ranges assumed for datacard take-up (see Figure A10.5A10.5 below). In the April 2010 consultation the pure LRIC unit cost was shown as unchanged at 0.5ppm across all take-up scenarios and it ranges between 0.69ppm and 0.7ppm in the 2011 cost model.

[310] The modularity effect occurs because when a new asset is purchased it may not be fully utilised immediately. If assets are underutilised, when we introduce an increment of traffic the spare capacity will be used before any additional costs are incurred. Likewise, if assets are fully utilised then adding incremental traffic will incur costs immediately.

Figure A10.5: Sensitivity analysis of different datacard take-up forecasts

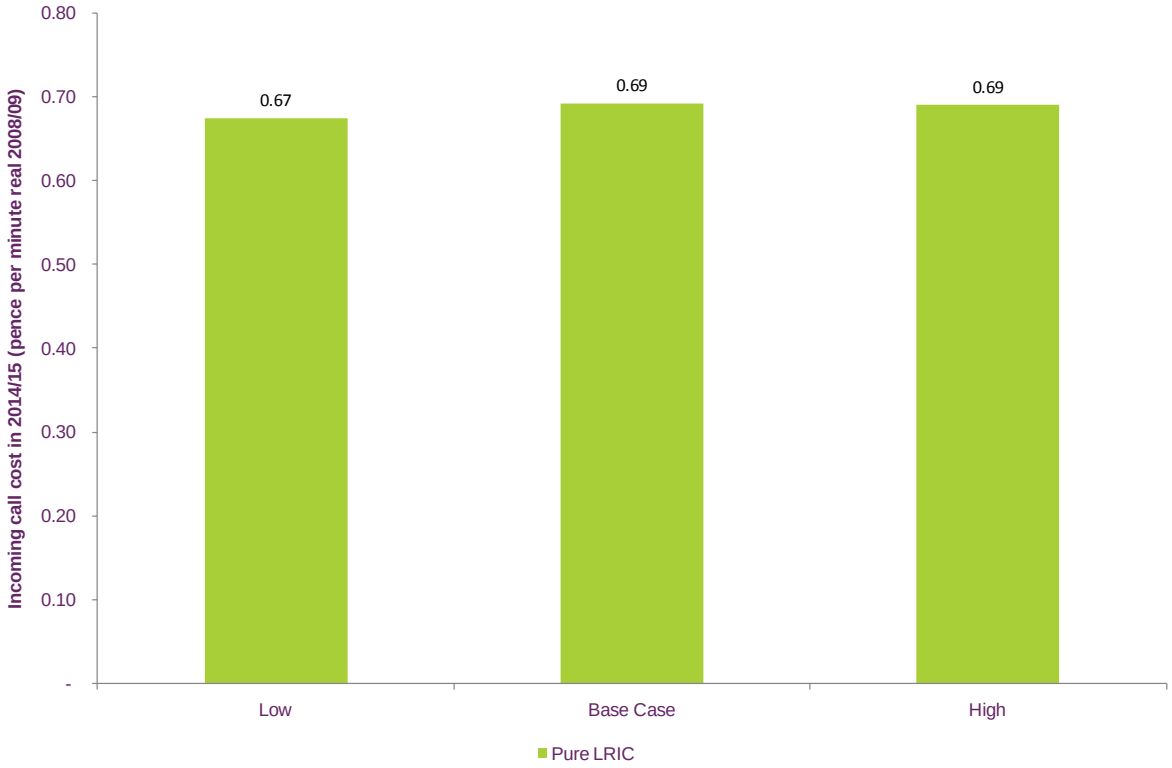


Source: Analysys Mason

Average datacard usage

A10.19 Figure A10.6 below shows the sensitivity of the unit cost to the average usage of a datacard. The results for the pure LRIC unit cost only vary between 0.67ppm and 0.69ppm. (The pure LRIC unit cost in the April 2010 consultation was shown as unchanged in the low and high scenarios at 0.5ppm.)

Figure A10.6: Sensitivity analysis of different datacard usage forecasts



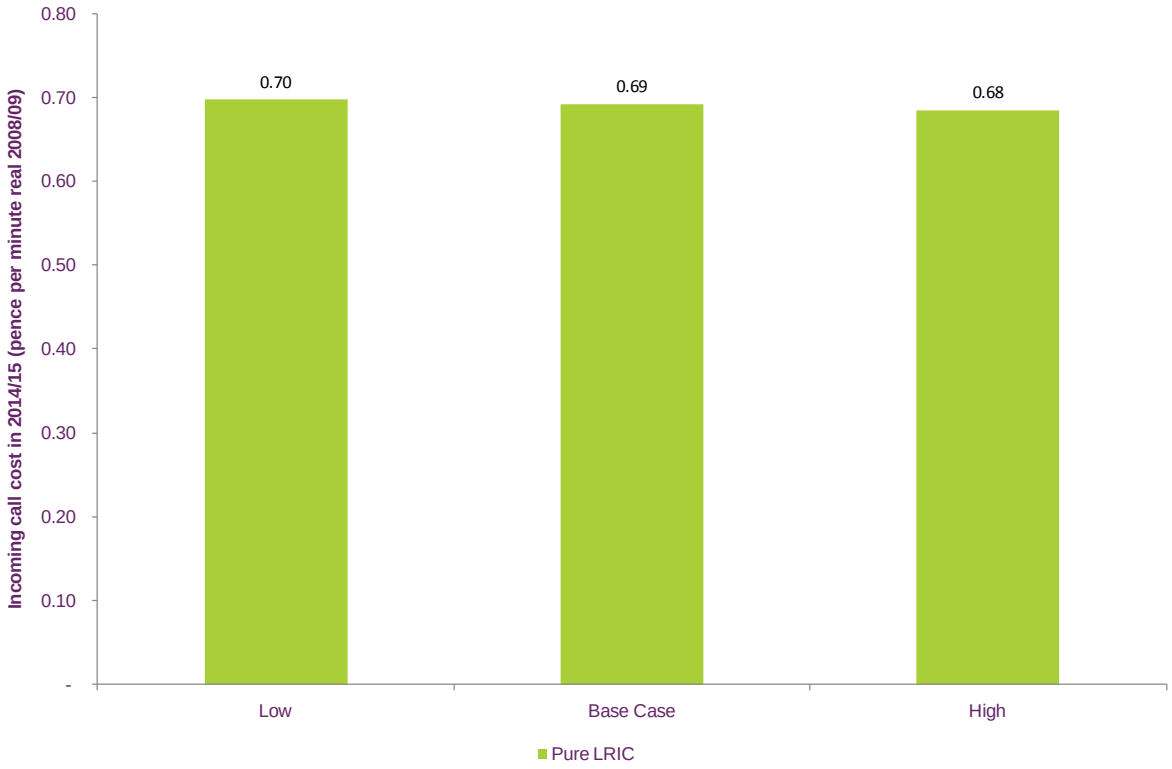
Source: Analysys Mason

Combination of multiple demand assumptions

A10.20 The effect of changing the main demand parameters together is shown in Figure A10.7 below.[311] The pure LRIC unit cost varies between 0.68ppm and 0.70ppm. (In the April 2010 consultation the pure LRIC unit cost was shown as unchanged at 0.5ppm for the combined low and high demand scenarios.)

[311]It should be noted that applying all of the high forecasts at the same time represents an aggressive set of assumptions.

Figure A10.7: Sensitivity analysis of applying combined low and high demand forecasts



Source: Analysys Mason

Sensitivity analysis: technology, market share, WACC and other cost assumptions

A10.21 In this section we study the impact of a number of non-demand-related assumptions on the unit cost of MCT for an average efficient operator. The sensitivies are as follows:

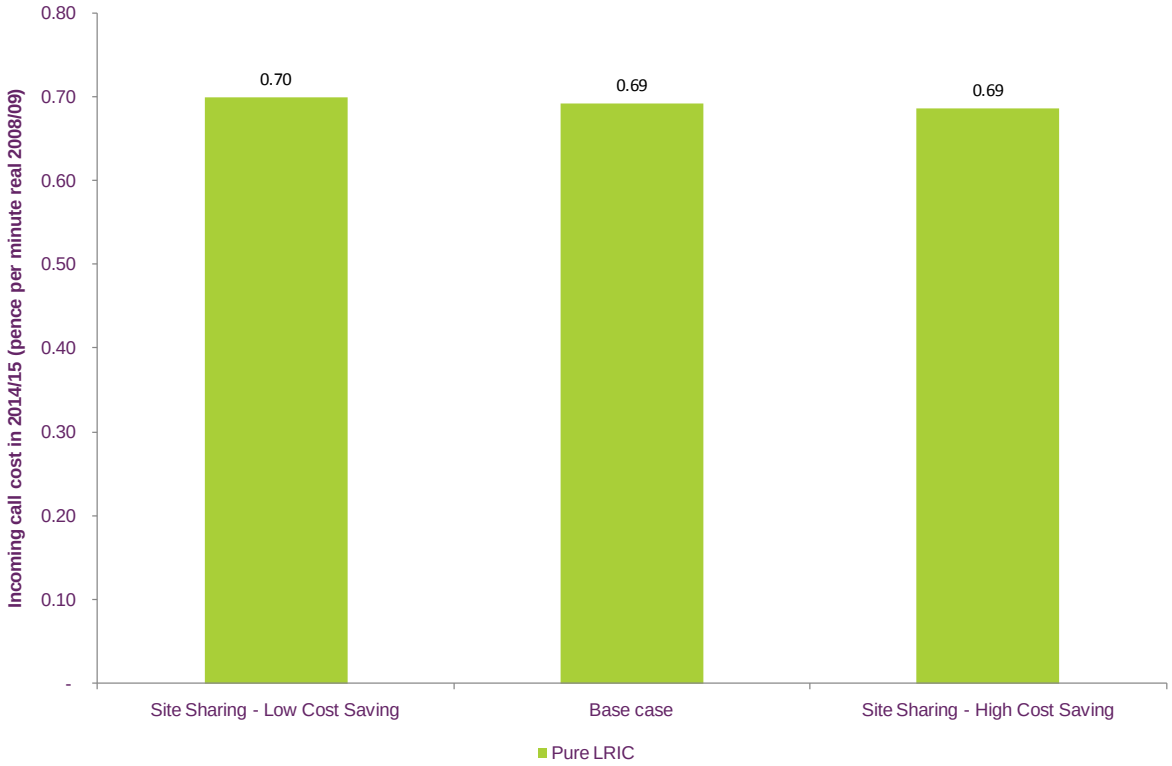
- change in the opex saving from site sharing;
- modelling the hypothetical efficient national MCP as a 3G-only national MCP;
- decreased market share for the hypothetical efficient national MCP;
- changes in the value of the WACC of the hypothetical efficient national MCP.

A10.22 The impact of different spectrum valuation scenarios is discussed in Annex 9.

Site sharing

A10.23 Site sharing is included in our base case scenario. The sensitivity analysis considered is the impact on the cost of MCT depending on the level of site sharing cost saving assumed. In the base case we assume a 42.5% opex saving from site sharing. The low and high cost saving sensitivities assume 35% and 50% opex saving respectively. The pure LRIC unit cost of MCT varies between 0.69ppm and 0.70ppm under the high cost saving and low cost saving scenarios respectively. We did not run this sensitivity in the April 2010 cost model.

Figure A10.8: Sensitivity analysis of site sharing



Source: Analysys Mason

3G-only national MCP

A10.24 From the results in Figure A10.1 and Figure A10.2 it can be seen that the unit cost for a 2G/3G operator to terminate incoming 3G voice services is lower than for incoming 2G voice services in 2014/15 (and all years shown in the charts). However, a new entrant to the market would not be likely to deploy its own 2G network. We have therefore examined the possibility that the modelled average efficient operator is a 3G-only operator. This scenario has different assumptions for market entry, coverage and market share from the case with a 2G/3G operator:

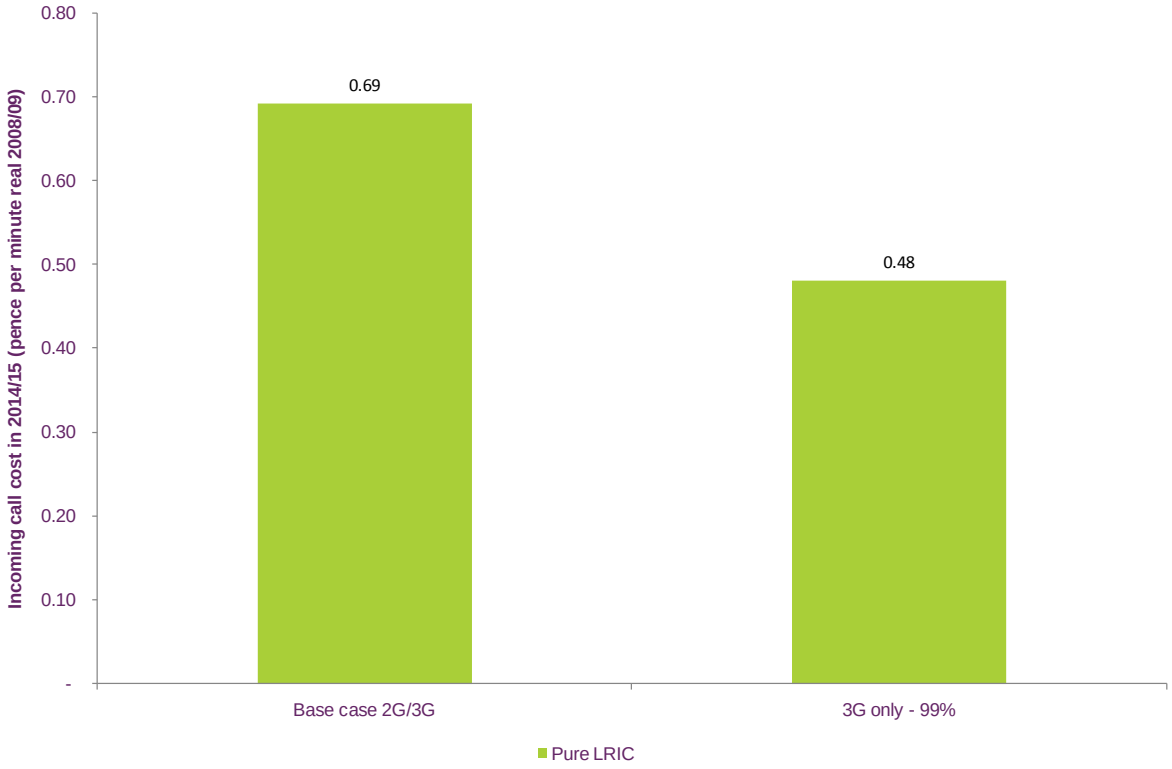
- The 3G-only operator is assumed to enter the market in 2003/4.
- It fully deploys its network by the end of 2012/13 to 99% of the population.[312]
- It grows to reach a market share of 10% by the end of 2009/10 and 25% by the end of 2014/15.

A10.25 The pure LRIC unit cost for a 3G-only operator is lower than the blended unit cost for a 2G/3G operator, at 0.48ppm in the medium demand forecast compared to 0.69ppm (blended) for a 2G/3G operator.[313]

[312] The long-term coverage target is the same as that of the combined 2G/3G national MCP, but the rate of coverage growth is different between the two models

[313] Comparing the 2014/15 pure LRIC 3G unit cost for a 2G/3G national MCP shown in Figure A10.1 above and the pure LRIC 3G unit cost for the 3G only national MCP in Figure A10.9, it can be seen that the 3G unit cost of termination for the 2G/3G national MCP is modelled as higher than the unit cost of termination for the 3G-only national MCP. We consider that the explanation is likely to lie with the different 3G coverage and 3G traffic profiles between the two scenarios and the effect of

Figure A10.9: Sensitivity analysis of assuming a 3G-only operator



Source: Analysys Mason

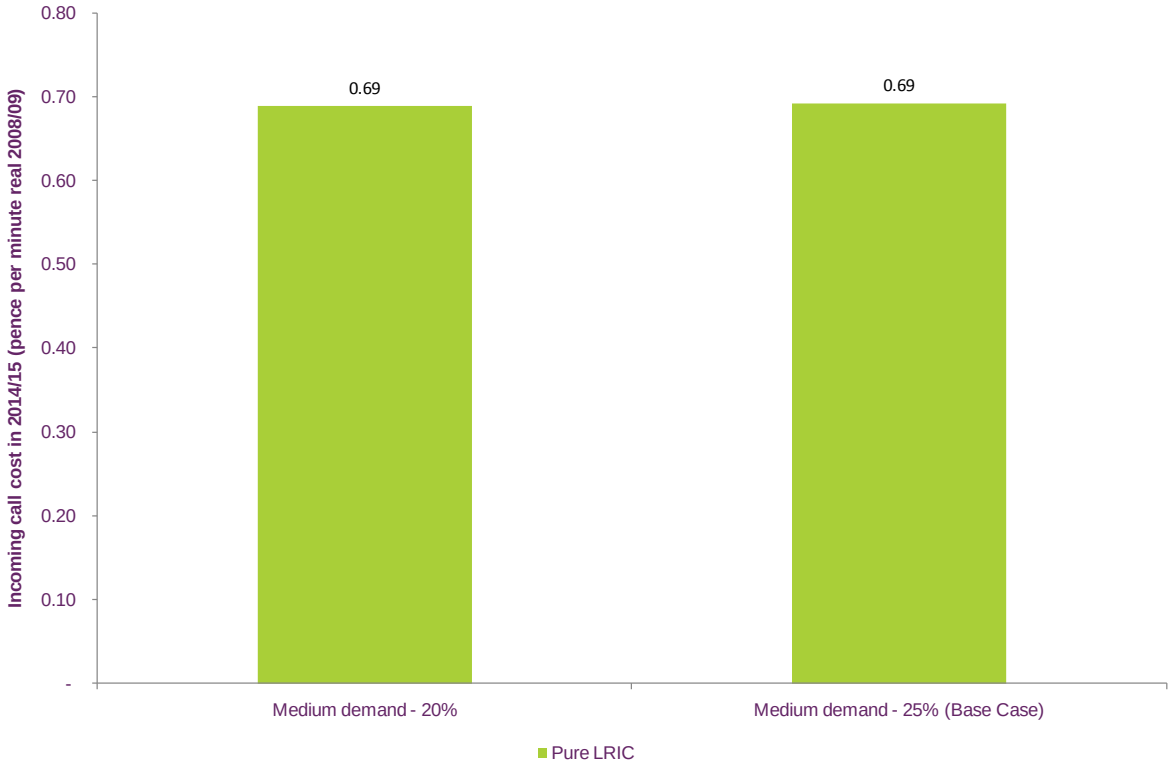
Reduced market share

A10.26 The 2007 cost model specified that the market share of an average efficient national MCP would stabilise at 20% by 2020/21. As explained in Section 9 and Annex 6, we now consider it more appropriate to use a 25% market share (corresponding to four players) in our base case.

A10.27 Figure 10.10 below shows the results if we use a 20% market share (as in the 2007 cost model). As with the other demand sensitivities, we can see that the reduced market share has no impact on the pure LRIC unit cost. (In the April 2010 consultation the pure LRIC unit cost was also unchanged at 0.5ppm).

modularity in network equipment.The modular deployment of 2G/3G shared assets could result in the incremental traffic impacting the network costs differently for the 2G/3G MCP model compared to the 3G only MCP model. The utilization levels of shared assets might be higher in the 2G/3G MCP model than in the 3G-only model in the “all traffic minus termination” case, resulting in a higher 3G unit cost of termination in the 2G/3G scenario.

Figure A10.10: Sensitivity analysis of decreased market share



Source: Analysys Mason

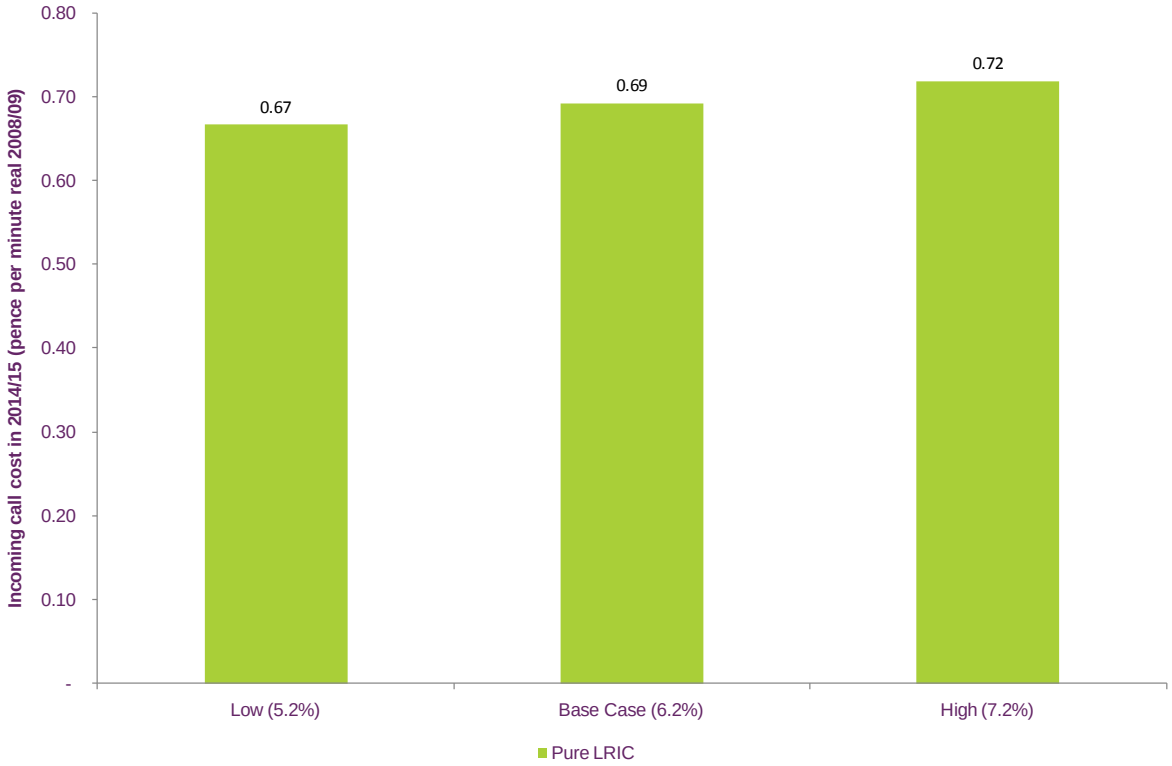
WACC

A10.28 The base case assumes a pre-tax real WACC of 6.2%. We have carried out a sensitivity analysis examining the impact of a higher (7.2%) and a lower WACC (5.2%).

A10.29 The results in Figure 10.11 show that the pure LRIC unit cost increase with the WACC. However, the pure LRIC is not particularly sensitive to the changing WACC, ranging from 0.67ppm to 0.72ppm. The pure LRIC unit cost is now slightly more sensitive to changes in the value of the WACC than in the April 2010 cost model.[314] The greater sensitivity of the pure LRIC to WACC in the 2011 cost model is due to our correction in the discounting of the investment terminal value described in Annex 6.

[314] This holds notwithstanding the fact that the sensitivity range for the WACC in the April 2010 consultation was slightly higher than that used.

Figure A10.11: Sensitivity analysis of changing the WACC



Source: Analysys Mason

Base case, high cost and low cost scenarios

A10.30 To show the sensitivity of the MCT cost model outputs to combined parameter changes, we have defined high cost and low cost scenarios alongside the base case. The different assumptions for the scenarios are summarised below:

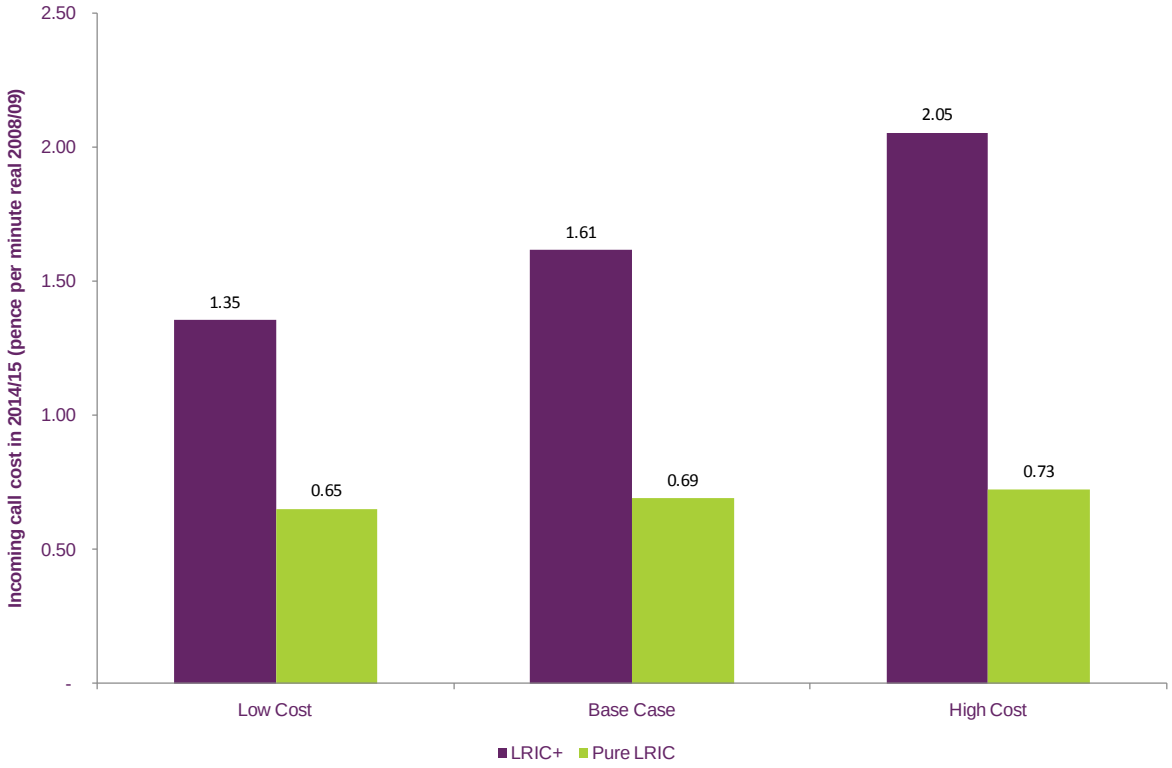
Table A10.2: Summary of assumptions for the three scenarios

	Base case	High cost scenario	Low cost scenario
Demand	Medium	Low	High
Market share	25%	20%	25%
WACC	6.2%	7.2%	5.2%
Site sharing opex saving	42.5%	35%	50%

A10.31 The resulting unit costs for MCT under these three scenarios are shown below for both pure LRIC and LRIC+. The pure LRIC for MCT ranges between 0.65ppm and 0.73ppm and the LRIC+ unit cost of MCT ranges between 1.35ppm and 2.05ppm.

A10.32 In the April 2010 consultation we used fewer parameters in the high and low scenarios (only the demand and market share parameters). In the April 2010 scenarios, the pure LRIC was shown as unchanged at 0.5ppm in those scenarios. The LRIC+ ranged from 1.3ppm in the low scenario and 2.0ppm in the high scenario.

Figure A10.12: Results for base case, low cost and high cost scenarios



Source: Analysys Mason