Wholesale Mobile Voice call termination

Annexes

1. Legal Analysis

2. Market Research

3. Full critique of the cost model

4. Proposed detailed amendments to the charge control

Annex 1

Legal Analysis

1. Introduction and summary

1.1 If Ofcom were to proceed to adopt its provisional approach to the regulation of wholesale mobile voice call termination in the form of a final statement, that decision would be vitiated through:

(i) its failure to provide clear and credible reasons for the approach that it has adopted to deriving the appropriate charge controls as it is obliged to do pursuant to well-established jurisprudence;

(ii) its failure to demonstrate that its decision is compliant with its primary statutory duties to ensure that its actions promote the interests of competition and consumers;

(iii) its failure to comply with its statutory duty to ensure that its actions are proportionate and in accordance with the principles of best regulatory practice.

1.2 The proposed charge controls for terminating calls on a mobile network have been generated through the use of a Long Run Incremental Cost ("LRIC") methodology. Vodafone has been unable to discern any justification for the use of such a methodology other than the fact that the European Commission has, through a non-binding Recommendation[1], proposed that such a methodology should be used by National Regulatory Authorities ("NRAs") in the regulation of mobile call termination.

1.3 As is explained in further detail below, Ofcom has been unable to demonstrate in its consultation document that its decision to adopt the LRIC methodology in deriving charge controls is consistent with its primary duties set out in the pan-European Common Regulatory Framework ("CRF") governing the telecommunications industry. Specifically, Ofcom's current approach is not compatible with Article 8 of the Framework Directive[2] and Article 13 of the Access Directive (which govern the setting of price controls to be imposed on operators in a position of Significant Market Power)[3].

[1] Commission Recommendation of 7 May 2009 on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU (the "Commission Recommendation") [2009] OJ L 124/67

[2] Directive 2002/21/EC on a common regulatory framework for electronic communications networks and services (the "Framework Directive") [2002] OJ L 108/33

[3] Directive 2002/19/EC on access to, and interconnection of, electronic communications networks and associated facilities (the "Access Directive")

1.4 In spite of Ofcom's previous publicly articulated concerns about the use of a LRIC methodology, no credible evidence has been adduced in the consultation document to show that these concerns have been properly resolved. In light of the fact that the obligations imposed upon Ofcom by the Directives ultimately take precedence over non-binding guidance from the Commission about the adoption of a particular cost methodology, Ofcom must be satisfied that its proposed course of action is compatible with these primary duties. Ofcom's simple reliance on an erroneous assumption that it must follow the approach proposed by the Recommendation does not constitute a credible justification for its current course of action, particularly when the approach proposed by the Recommendation is inconsistent with Ofcom's obligations when setting price controls. Accordingly, any decision to move to a final statement on the current basis will be flawed and invalid.

2. No justification for the use of a LRIC approach to setting MTRs

Ofcom must provide clear and credible reasons for its actions

2.1 As a regulator, Ofcom is obliged, pursuant to well established principles of administrative law, to provide clear reasons for the decisions that it adopts.[4] But, as well as being clear, Ofcom's reasoning must be credible and robust as has been confirmed by the Competition Appeal Tribunal:

"It is the duty of a responsible regulator to ensure that the important decisions it takes, with potentially wide-ranging impact on industry, should be sufficiently convincing to withstand industry, public and judicial scrutiny."[5]

This obligation is further reinforced by Article 5 of the Access Directive, governing the setting of access conditions, requiring Ofcom to ensure that:

"obligations and conditions imposed [in respect of access and interconnection] *shall be objective, transparent, proportionate and non-discriminatory…*[emphasis added]*"*[6]

In the context of the regulation of wholesale mobile voice call termination, Ofcom has acknowledged the need for a compelling justification for a change to the methodology that it has used to date when setting charge controls:

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[4] For example, *R v Secretary for Trade and Industry ex p. Lonrho plc* [1989] 1 WLR 525 per Lord Keith, *"the decision-maker who has given no reasons, cannot complain if the court draws the inference that he had no rational reason for his decision."*
[5] *Vodafone and others v Ofcom* [2008] CAT 22, paragraph 47
[6] Access Directive, Article 5(3)

“*it is important that any such reductions* [in termination rates] *are achieved on the basis of* *__evidence-based regulation__*, *including proper assessment of the impact of any change in methodology, both on market players and consumers.*”[7]

Vodafone endorses this statement. However, as is considered below, Ofcom has clearly failed to demonstrate that it has discharged its responsibilities in this respect.

2.2 The proposed charge controls set out in Ofcom’s consultation document flow from its assumption that it must not only take into account but *also* follow the Commission Recommendation in respect of the methodology to be used by NRAs when setting price controls for operators in a position of SMP for the termination of calls on fixed or mobile networks.[8] As far as can be discerned from the consultation document, this is the sole reason cited for the use of a LRIC cost standard. As we explain in further detail below, the Commission Recommendation does not in its own right provide Ofcom with the justification for its proposed course of action. This is because Ofcom must first be satisfied that its actions in respect of setting price controls (including the adoption of the LRIC approach proposed in the Recommendation) is compatible with its primary obligations under the Framework Directive and the Access Directive. Critically, as can be seen in the analysis below, the approach proposed by the Recommendation and currently espoused by Ofcom is in fact highly likely to be inconsistent with Ofcom’s primary obligations.

The Commission Recommendation is not binding

2.3 The Commission Recommendation has been issued pursuant to Article 19(1) of the Framework Directive enabling the Commission to promulgate measures designed to encourage the harmonised application of the provisions of the CRF. Ofcom has stated that it is required to take “utmost account” of the Recommendation and in this case, importance must be attached to the harmonising objective of the Recommendation.

2.4 In the first instance, it is worth noting that any Recommendation issued by Community institutions does not bind Member States. This is clear on the face of Article 288 (ex Article 249) of the Treaty on the Functioning of the European Union (“TFEU”).

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[7] Joint response of the Department for Business, Enterprise and Regulatory Reform and Ofcom of 2009 to the Draft European Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU.

[8] Ofcom, *Wholesale mobile voice call termination. Market Review*, 1 April 2010, paragraph 7.102-7.103

"To exercise the Union's competences, the institutions shall adopt regulations, directives, decisions, recommendations and opinions…

Recommendations and opinions shall have no binding force. [emphasis added]"

2.5 Thus, it is clear that the Commission Recommendation cannot require Ofcom to adopt the methodology that is proposed in the Recommendation. Whilst Ofcom places reliance on the fact that Article 19(1) of the Framework Directive requires it to take "utmost account" of Recommendations issued by the Commission, that term does not deny Ofcom the flexibility to adopt the regulatory remedy that it considers to be most appropriate in the context of its market review. This has been clearly confirmed by the Court of First Instance ("CFI") in the context of Article 7(5) of the Framework Directive, which also requires NRAs to take "utmost account" of the views of the Commission and other NRAs when conducting a review of relevant markets and imposing regulatory remedies on an ex ante basis. The CFI stated, when providing guidance, as to the meaning of this term:

"*in a case where the comments of an NRA and of the Commission are contradictory, the notifying NRA would not infringe Article 7(5) by following, after careful review of the various comments, the approach proposed by the other NRA and not that proposed by the Commission….Even though, in accordance with Article 7(5), the CMT* [the Spanish NRA] *must take 'the utmost account of comments of other [NRAs] and the Commission', it has some leeway to determine the content of the final measure...it is for that* [national regulatory] *authority alone to adopt that measure and to determine its content."*[9] [emphasis added]

2.6 Such an interpretation of the status of the Recommendation is clearly consistent with the ethos and the objectives of the CRF, which seeks to remove divergences in the approaches of national regulators in respect of when regulatory intervention is justifiable, whilst crucially leaving the form and the method of any regulatory remedy to be imposed to the discretion of the NRAs. There is accordingly a clear distinction to be drawn between the harmonisation of approaches to identifying where markets are not effectively competitive and the uniform adoption of specific remedies across the EU. This principle is given effect by the provisions of Article 15(4) of the Framework Directive:

[9] *Case T-106/09, Vodafone Espana and Vodafone Group plc v Commission*, paragraphs 93 and 160-161. As is discussed at Footnote 10, the Commission can only bind the conduct of the NRA in respect of its definition of the relevant market and its assessment of whether the relevant market is or is not effectively competitive.

"Where a national regulatory authority determines that a relevant market is not effectively competitive, it shall identify undertakings with significant market power on that market…and the national regulatory authority shall on such undertakings impose appropriate [emphasis added] *specific regulatory obligations referred to in paragraph 2 of this Article or maintain or amend such obligations where they already exist."*[10]

The fact that NRAs active in different markets may each adopt different remedies or set charge controls that vary across the EU is entirely consistent with the CRF which clearly recognises that there are national markets and it is appropriate for NRAs to adopt the regulatory measure that is suitable for these national markets[11].

2.7 Accordingly, to the extent that the Recommendation were actually construed to be a measure capable of producing binding effects[12], that measure would be inconsistent with the principles of the CRF since it would, at a stroke, remove the ability of NRAs to determine the remedies to be adopted in a situation where a relevant market has been found not to be effectively competitive. Indeed, Ofcom appears to share this view. In 2009, it advised the Commission that:

"the draft Recommendation embraces a prescriptive solution for the termination regime beyond 2011. If followed, it would make it difficult for NRAs such as Ofcom to consider the advantages and disadvantages of a range of options for addressing the consumer and competition issues specific to their national markets."[13]

Moreover, for reasons that are explained below in sections 2.8-2.14, if the Recommendation were a measure capable of producing binding effects, that measure would potentially be at odds with the

[10] Article 7 of the Framework Directive makes clear that the Commission's ability to ensure harmonised approaches to regulation across the EU is limited to the definition of the relevant market and the finding of SMP (or absence thereof) in respect of one or more undertakings by an NRA where it may open an investigation and exercise a veto where appropriate. By contrast, NRAs are afforded more latitude in the remedies that they adopt in so far as the Commission has no power to exercise any veto over the remedies adopted by the NRA.

[11] Once again, it is worth noting the view of the CFI in respect of Article 7 of the Framework Directive, which provides for the Commission to provide guidance to NRAs in the context of the imposition of regulatory remedies (following an ex ante market review) for the purpose of ensuring "*the harmonised application of the regulatory framework throughout the Community*". The CFI noted, *"that does not mean that the Commission's comments under Article 7(3) of Directive 2002/21 produce binding legal effects."* See Case T-109/06, *Vodafone v Commission*, paragraph 91.

[12] Case C-322/88, *Salvatore Grimaldi v Fonds des maladies professionnelles*, paragraph 14 notes that it is necessary to determine whether "the content of a measure is wholly consistent with the form attributed to it".

[13] Technical Annex to the Joint response of the Department for Business, Enterprise and Regulatory Reform and Ofcom of 2009 to the Draft European Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU, paragraph 2.3

provisions of Article 8 of the Framework Directive and Article 13 of the Access Directive.

2.8 Article 19(1) of the Framework Directive makes clear that Ofcom has the freedom not to follow the approach by a Recommendation provided that it gives reasons for so doing. It does not, as Ofcom appears to believe, require Ofcom to be able to demonstrate that there is a particular characteristic of the UK market that justifies a departure from the approach proposed by the Recommendation. This is plainly wrong based on an interpretation of the wording of Article 19(1) of the Framework Directive.[14] In fact, as is outlined below, there are compelling reasons why the approach proposed by the Commission Recommendation is inappropriate for determining the charge controls and therefore inconsistent with the CRF. Thus, the mere existence of the Recommendation does not provide Ofcom with a reason for the adoption of the LRIC standard, as it now appears to contemplate. Indeed, Vodafone notes Ofcom's view on the weight to be attached to the Commission Recommendation in 2009:

"The fact that the Commission has recommended a particular approach does not of itself provide sufficient justification for adopting it, especially in the absence of adequate supporting analysis of rationale and impact"[15]

2.9 Accordingly, until and unless the concerns identified by Vodafone in connection with the use of a LRIC methodology are fully addressed by Ofcom, any decision to adopt the proposed approach in the consultation document would be deficient in terms of its reasoning and therefore flawed.

Ofcom's failure to demonstrate that it has fulfilled its primary duties

2.10 Whilst the Commission Recommendation is non-binding, Ofcom is subject to a number of formal and binding obligations pursuant to the provisions of the Framework Directive and the Access Directive when adopting access remedies, and in particular, setting price controls. Article 8(2) of the Framework Directive requires Ofcom to promote competition in electronic communications markets by:

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[14] Article 19(1) simply states *"where a national regulatory authority chooses not to follow a recommendation, it shall inform the Commission, giving the reasoning for its position."*

[15] Joint response of the Department for Business, Enterprise and Regulatory Reform and Ofcom of 2009 to the Draft European Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU

"(a) ensuring that users, including disabled users, derive maximum benefit in terms of choice, price and quality;

(b) ensuring that there is no distortion or restriction of competition in the electronic communications sector;

(c) encouraging efficient investment in infrastructure, and promoting innovation; and

(d) encouraging efficient use and ensuring the effective management of radio frequencies and numbering resources."

Article 13(2) and (3) of the Access Directive, which stipulates the way in which price controls should be determined in respect of operators with SMP, elaborates on how the objectives described above are to be achieved and requires that NRAs must:

"*take into account the investment made by the operator and allow him a reasonable rate of return on adequate capital employed, taking into account the risks involved…[and] shall ensure that any cost recovery mechanism or pricing methodology that is mandated serves to promote efficiency and sustainable competition and maximise consumer benefits*."

The above obligations have been transposed into UK law through the enactment of sections 4 and 88 of the Communications Act 2003. To the extent that Ofcom considers that under the TFEU it has a duty to fulfil its obligations under the Treaty or those determined by Community institutions, the obligations set out above are those to which Ofcom must, in the first, instance seek to give effect.

More generally, Ofcom is, pursuant to section 3(3) of the Communications Act 2003, required to comply with an over-arching obligation to ensure that it has regard to

"(a) *the principles under which regulatory activities should be transparent, accountable, proportionate, consistent and targeted only at cases in which action is needed; and*
(b) any other principles appearing to OFCOM to represent the best regulatory practice."

2.11 It is far from clear that the use of a LRIC cost standard by Ofcom in deriving charge controls would be consistent with the obligations that are set out above.[16] Indeed, Vodafone would note that Ofcom itself has previously expressed serious reservations about the adoption of such a cost standard at the time when the Commission first proposed

[16] Vodafone has previously provided Ofcom with submissions from Compass Lexecon to the effect that it is only in exceptional circumstances that the use of a LRIC cost standard will be efficient and maximise benefits for consumers.

introducing the Recommendation, precisely because it did not appear to serve the interests of consumers. Specifically, Ofcom was concerned about the potential consequences of an approach that denied mobile operators the ability to recover their fixed and common costs. It noted, for instance, that the potential existed for recovery of these costs through higher subscription charges that might not operate in the interests of low-usage customers.[17] This statement alone reveals Ofcom's own concerns that the adoption of a LRIC cost standard, as proposed by the Recommendation, would not be compatible with its duties under Article 8 of the Framework Directive or Article 13 of the Access Directive.[18]

2.12 Having expressed concerns of the type described above about the LRIC methodology proposed by the Commission, it was incumbent upon Ofcom to investigate them thoroughly before subsequently adopting it. Indeed, given that the setting of SMP conditions is done on an ex ante or prospective basis, there is a clear burden upon Ofcom to conduct a rigorous assessment when deriving the proposed charge control that will apply on a forward-looking basis. This is a proposition that has previously been endorsed by the Competition Appeal Tribunal and the Irish Electronic Communications Panel in cases involving ex ante analysis carried out pursuant to the CRF.[19]

2.13 In this case, there is no credible evidence to demonstrate that the forward-looking analysis required to justify the use of LRIC has been sufficiently robust. Vodafone would refer to the following examples of these evidential failures:

- In undertaking its competitive impact assessment, Ofcom appears to have reached the conclusion that the use of LRIC resulting in lower charge controls may reduce the risk of competitive distortions between fixed and mobile services. Even though Ofcom states that there is currently limited substitutability between these services, it claims that "there is likely to be increasing convergence [between the two services] in the

[17] Technical Annex to the Joint response of the Department for Business, Enterprise and Regulatory Reform and Ofcom of 2009 to the Draft European Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU, paragraphs 3.13-3.14

[18] Even if the use of the LRIC methodology could be deemed to be consistent with Ofcom's obligations in the Access Directive – a proposition that would Vodafone would reject – the model that Ofcom has used cannot be relied upon to generate accurate charge controls on a pure LRIC basis. The model used in the consultation document is largely unchanged from that used in the last review of mobile call termination in 2007 and Ofcom has expressed its doubts about whether common costs can be isolated or marginal costs estimated with any degree of accuracy. It is therefore highly questionable whether this model is fit for purpose since the derivation of charge controls on a pure LRIC basis is dependent on the ability of any model to separate incremental and common costs. See Ofcom, *Mobile call termination. Statement*, 22 March 2007, Annex 5.18 and Annex 17.43-17.45

[19] *Hutchison 3G Ltd v Ofcom* [2005] CAT 39 citing Case C-12/03 *Tetra Laval*; Decision of the Irish Electronic Communications Panel 02/05

future."[20] At no point does Ofcom provide the justification for or the economic evidence underpinning such a statement.

- In assessing the impact on consumers resulting from the use of a LRIC cost standard, Ofcom elects not to carry out an assessment of "who would gain and who would lose" on the basis that it is "complex and resource-intensive".[21] Annex 13, which contains the details of Ofcom's distributional analysis fails to provide any compelling evidence that the use of LRIC is consistent with Article 13 of the Access Directive. Given that Ofcom had previously identified: (i) that there was a risk of low-usage mobile customers being adversely affected by the move to a LRIC cost standard; and (ii) that the adoption of a LRIC cost standard required a thorough assessment of the impact on consumers, it is clearly incumbent upon it to undertake that analysis now.

- Specifically, when considering the impact of the adoption of a LRIC methodology on levels of mobile subscriptions and ownership by consumers, Ofcom concludes that the impact on ownership is likely to be *"more muted than anticipated"*.[22] A number of points should be highlighted about this claim:

    - This conclusion is based, in part, on the claim that the majority of consumers terminating their subscriptions would be those who currently use more than one SIM for the provision of mobile telephony services. Yet Ofcom has provided no evidence to substantiate its claim, and, as can be seen by the research provided by Vodafone, a significant majority of consumers terminating their mobile airtime subscriptions would be those who currently only use one SIM.[23]

    - Nor has Ofcom investigated the extent to which limited fixed fees for low usage customers will result in lower revenue streams for mobile operators that will need to be recovered in the form of price rises. As can be seen elsewhere in Vodafone's submission, in a competitive market it is simply not possible for revenues from more

[20] Ofcom, *Wholesale mobile voice call termination. Market Review*, 1 April 2010, paragraph 7.122
[21] Ofcom, *Wholesale mobile voice call termination. Market Review*, 1 April 2010, paragraph 9.181
[22] Ofcom, *Wholesale mobile voice call termination. Market Review*, 1 April 2010, Annex 13.75
[23] So far as Vodafone has been able to discern from Ofcom's distributional analysis, Ofcom simply asserts that *" it is possible, and perhaps likely, that it will be customers with multiple subscriptions who would give up only one of several phones or SIM cards in response to higher prices for ownership.*" Ofcom, *Wholesale mobile voice call termination. Market Review*, 1 April 2010, Annex 13.78

profitable customers to be used to fund lower receipts obtained from low-use customers.

- o Whilst Ofcom is eager to discount or highlight the limitations of consumer research and statistical analysis that it has previously commissioned (such as that undertaken by CEG) indicating potentially adverse effects on mobile subscriptions resulting from lower mobile termination rates, it adduces no significant evidence of its own to demonstrate that it can safely rule out the risk of reduced mobile subscription if lower termination rates were to be imposed.

2.14 In these circumstances, it is difficult to see how Ofcom is able to satisfy itself and industry stakeholders that it has acted in a way that it is compliant with the provisions of Article 8 of the Framework Directive and Article 13 of the Access Directive. As such, Ofcom must also be deemed to be in breach of its duty under the Communications Act 2003 to ensure that its actions are in accordance with the "principles of best regulatory practice."[24]

3. Further action

3.1 In light of the above arguments, the only available option to Ofcom is to revisit the analysis that it has conducted to-date and undertake the rigorous forward-looking competition and consumer assessment that is necessary to determine that the adoption of a LRIC methodology is consistent with its obligations under the CRF. Failure to take such action would result in the adoption of an insufficiently reasoned decision that would place Ofcom in clear breach of its primary duties under the CRF (as transposed into UK law by the Communications Act) and therefore leave its decision vulnerable to legal challenge.

[24] Communications Act 2003, section 3(3)(a) and (b)

Annex 2

Market Research

[Confidential]

Annex 3

Vodafone review of the Ofcom 2010 LRIC+ and pure LRIC model

Vodafone's review of the 2010 model addresses in turn the various elements of that model: traffic inputs, network build parameters, cost allocation principles, and unit costs, before considering the newly introduced incremental model methodology. Whilst every effort has been made by Vodafone to review the model in as comprehensive a way as possible, inevitably given the near 100MB of its size, and the single-shot approach of this consultation process, no doubt not all model components and potential issues have been spotted and addressed by Vodafone in this document. Some potential changes that improve the fidelity of the model have been considered by Vodafone but are not included in this document since they do not appear to change the output values sufficiently to be worthy of implementation in the model. There may well be other material errors and issues that persist in the model but that have not as yet been spotted by Vodafone. The absence of any discussion in this document of any particular area of the model does not therefore necessarily mean that Vodafone is now, or will be, content with it.

In due course we will obviously have sight of other consultation responses: arising from this we may have the need, having considered the arguments made therein, to write to Ofcom again.

Given that the model that accompanies the termination consultation is not a new model, but a revision of the previous 2007 edition, that was itself derived from the 2005 2G model and other earlier generations, Vodafone's review of this new version has focussed on the areas of difference, paying particular attention not only to the specific changes made by Ofcom, but also to the implications for voice termination cost modelling of the very significant data volume increase over the 2007 model. This annex does not consider the issue of the weighted average cost of capital used in the model: this is the subject of Section 5 of the main body of our response. All amendments to the model are thus individually examined in this annex at Ofcom's cost of capital of 7.6%, down from the 11.5% of the 2007 model version. Only at the end of this annex do we evaluate the implications of using our preferred cost of capital in the cost model, for both the original Ofcom version and that resulting from the modifications described below.

Before considering the model in any detail however, as a preliminary step it is appropriate to consider whether in its present form it is fit for purpose, in the degree to which it resembles the real world in the size of the operator it constructs, the structure of charges it derives and whether the model can derive a meaningful pure LRIC output.

Vodafone's conclusion is that on all of these counts, the model is flawed: substantial revisions to it are necessary to address the first two defects, but it is less clear that the third issue, that of producing a meaningful pure LRIC output, is capable of resolution. The detailed review that is thus required suggests appropriate areas of revision and derives improved termination cost outputs for both LRIC+ and pure LRIC, although concerns persist that any pure LRIC output of the model can be made sufficiently robust to be usable.

Is the model fit for purpose?

A fundamental question that must be raised is whether the Ofcom 2010 model as issued is fit for purpose, i.e. does the model in terms of the network it builds and the cost recovery structure it proposes sufficiently resemble a real 2G/3G operator so that it can validly be used to suggest an appropriate level of voice termination pricing, and can its newly derived pure LRIC output be considered reasonable? To Vodafone there are thus at least three avenues of exploration:

- the size and cost of the network "built" by the model when compared against actual operator values, i.e. the success of the model's calibration;
- the structure of prices that the model suggests, between voice and data;
- even if the model can be improved on these two counts, is it capable of producing a reliable incremental cost as the pure LRIC output implies?

These issues are examined in turn. The 2010 model itself is not a new model, but a relatively simple update and refresh of the version presented with the 2007 Statement, in that:

- some parameters and inputs have been revised, partially as a response to two detailed information requests made to the operators in 2009 in an attempt to improve the ability of the model to replicate the costs of the average efficient 2G/3G operator;
- the ability of the model to calculate costs for hypothetical operators using 900 MHz spectrum has been removed;
- the model has been amended with respect to volumes and additional network elements to take account of the considerable increase in data traffic since the 2007 version was published, by adding the more efficient (and enabling) technology of HSPA to the model and related other assets;
- inter-operator network cell site sharing has been introduced;
- the model has also been amended to additionally generate a pure LRIC output. It can now be run with and without voice termination volumes, in order to collect the cost differences between these two outcomes, and then to push the resulting net values through the economic depreciation cost recovery algorithm and recover them against voice termination volumes in order to produce a purely incremental cost recovery output.

Vodafone's assessment is that some of these changes have in fact reduced the fidelity of the model, in that it less and less resembles the real world position of a 2G/3G operator, and hence the model in its present state cannot be held to be a usable guide to the real costs of voice termination, either on the traditional LRIC+ approach or on the newly introduced basis of only the incremental cost of voice termination (pure LRIC).

The 2010 model – development and review process

There is a very significant distinction between the current consultation process and the process adopted by Ofcom in the previous charge control review. In the previous process the cost model was the subject of two consultations prior to the final statement. Thus the operators had the opportunity to review the model on a constructive feedback loop. We were able to proffer a practical critique to Ofcom, receive Ofcom's feedback together with an amended model, and review this second version, continuing arguments on particular matters, spotting new issues, examining issues in more depth, together with being able to be aware of, and to comment on, points raised by other operators and so forth. All of this was done *before* Ofcom produced the final version as part of the Statement[25]. This gave both Ofcom and the operators the opportunity over several stages collectively to weed out errors, resolve particular issues etc and derive some form of confidence that the model was functioning correctly (even though obviously issues relating to particular parameter values and calculations continued beyond the Statement).

By approaching the present termination review process on a much more abbreviated timetable, eliminating both the early sight of the model and the second formal model review, Ofcom has given itself and the operators much less opportunity to review, discuss and correct the model. Further, the operators no longer have the opportunity to see and comment on the views of each other. These problems are exacerbated by the fact that Ofcom has failed to implement the changes from the 2007 model correctly. There are some pretty obvious errors in the pre-final model (as evidenced in the case of one particular error by the email to the operators from Dr Manimohan of Ofcom's Competition Policy team).

The final model that will in due course accompany the Statement represents Ofcom's only opportunity to absorb all the operators' feedback, correctly revise and re-calibrate the model, and reach an appropriate and satisfactory output. Given the complexity of the model and the difficulties Ofcom has had to date this is a challenging task. The risks of producing a flawed final version, with incorrect or unreasonable outputs, are quite high. To Vodafone this issue that Ofcom has created for itself suggests that Ofcom should favour a conservative rather than an aggressive set of inputs to ensure that costs do not inadvertently come out too low.

[25] In fact the operators were supplied with a version of the model on which their comments were sought even before the first consultation, so the model in practical terms went through three review stages before the final statement in 2007

Model calibration

Irrespective of whichever cost recovery methodology is being applied, at the heart of the Ofcom 2010 termination model is an assumption that it is representative of an average efficient 2G/3G operator, by being calibrated against current and historic real operator averages, in terms of both network operator financial measures and network build quantities, when fed with real average traffic volumes. In this respect the approach is very similar to the 2007 termination model[26].

In 2007 annexes 6 and 12 of the March 2007 statement Ofcom reported on and made comparisons between the model and actual MNO averages[27] with respect to the gross book value of network fixed assets (GBV), net book value (NBV) and network operating costs (opex) for 2002, 2003, 2004, and 2005 and also compared several different measures of network build in 2004/05 between the model and MNO actual average values[28]. Broadly speaking, the 2007 model's outputs corresponded fairly well with the reported actual values for both financial and operational measures, and Ofcom concluded from this that the model was reasonably calibrated.

In 2010, Ofcom has similarly concluded that the revised model is acceptably calibrated, but this is not a justifiable position to take, primarily because of a simple error. The error that has been made is that when extracting financial measures from workbook 5 – HCA/CCA of the 2010 model[29] Ofcom has inadvertently included the cost of handsets in the total values for network GBV and NBV[30]. Whether the model should be including any costs for handsets in the model at all is a subject considered below, but certainly handset cost should not have been (and was not in 2007) included in any calibration exercise to compare with MNO actual network average values, since the MNOs do not hold any element of handset costs in their network fixed assets.

In the April 2010 consultation, Ofcom has published in annex 10, figures 26 to 28, model output and MNO actual values for GBV, NBV and opex respectively for 2006, 2007, and 2008. On examination of the model, it was obvious that the values that Ofcom has reported in annex 10 as GBV and NBV model outputs can only be obtained by including handset costs within the total. For example for the calendar year of 2007 Ofcom quotes a model GBV of £3,833m, compared with the supplied 2G/3G MNO average of £3,969m. The £3,833m can be duplicated from the model by taking the March 2007 total

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26 With the difference that the current model does not include the option of modelling operators with 900MHz spectrum

27 Figures A6.2 and A12.2 of the March 07 Statement

28 Figure A12.1 of the March 07 Statement

29 As in 2007 this workbook is only used for calibration (it also produces redundant HCA and CCA costs) and was not initially released by Ofcom in the belief that "it was not used in the new modelling exercise" – when on discussion it became clear that the calibration was still done in this workbook Vodafone had to specifically request it to be placed on the website to enable the calibration to be reviewed by us.

30 The model generates no opex for handsets, so there is no such problem with this measure.

GBV from the HCA worksheet of workbook 5 of £4,324.1m, removing the 3G licence GBV of £520.0m to give a total of £3,804.1m, and weighting it with the March 2008 cost of £4,439.3m, or £3,919.3m net of licence cost to give a mid calendar 2007 cost of £3,832.9m, a result duly reported by Ofcom as £3,833m. However these totals include handset costs of £385.5m in March 2007 and £430.2m in March 2008, or a weighted average of £396.7m. Stripping the handset cost out produces a significantly lower result of £3,436m that represents the real model output of network GBV that is prepared on a basis comparable with actual operator values. But this result in no way is aligned to the average MNO actual GBV of £3,969m. Ofcom is similarly wrong in its interpretation of model outputs of GBV and NBV for the other reported years, as shown in table 3.1 below:

Year	GBV Model outputs			NBV Model outputs		
	Reported by Ofcom	Actual result from model	Difference	Reported by Ofcom	Actual result from model	Difference
2006	£3,695m	£3,330m	-£365m	£1,749m	£1,656m	-£93m
2007	£3,833m	£3,436m	-£397m	£1,676m	£1,570m	-£106m
2008	£3,920m	£3,479m	-£441m	£1,558m	£1,443m	-£115m

Table 3.1 – GBV and NBV outputs of the 2010 model

The 2010 consultation supplies actual MNO average values for 2006 to 2008 for GBV, NBV and opex and the 2007 Statement supplied MNO averages for 2002 to 2005. Given that the HCA workbook of the 2010 model outputs the same measures for all these years it is possible to see how well the 2010 model predicts the past for an extensive period from 2002 to 2008, using the values that the model actually generates, and also to compare the level of accuracy of calibration between the 2007[31] and 2010 models. The results are not encouraging. Table 3.2 below shows the lack of accuracy of the GBV outputs in 2010 and the superiority of the 2007 version:

[31] 2007 output values are taken from the March 2007 Statement in this and subsequent tables.

Year	MNO Actual	2010 model		2007 model (per Ofcom)	
		Output	Difference	Output	Difference
2002	£3,092m	£2,546m	-£546m	£2,906m	-£186m
2003	£3,311m	£2,683m	-£628m	£3,158m	-£153m
2004	£3,629m	£2,884m	-£745m	£3,534m	-£95m
2005	£3,850m	£3,135m	-£715m	£3,887m	+£37m
2006	£3,843m	£3,330m	-£513m		
2007	£3,969m	£3,436m	-£533m		
2008	£4,088m	£3,479m	-£609m		

Table 3.2 - GBV model outputs compared with MNO actual values

Extraordinarily the model appears to be up to 20% light on accumulated capital expenditure. The fit to reality is very significantly worse than the 2007 model, in both the 2002 - 2005 period, and in relative terms for the 2006 - 2008 period. The only possible conclusion from this observation is that the model is currently significantly underestimating the necessary capital expenditure to operate a network with the modelled volumes, which apparently are representative of the average 2G/3G operator. (As we return to later, this assumption that the volumes are representative would appear to be reasonable for voice services, but is less correct for data services.) It is possible to do a similar evaluation for NBV, presented in table 3.3 below.

Year	MNO Actual	2010 model		2007 model (per Ofcom)	
		Output	Difference	Output	Difference
2002	£1,828m	£1,415m	-£413m	£1,869m	+£41m
2003	£1,803m	£1,514m	-£289m	£1,821m	+£18m
2004	£1,810m	£1,627m	-£183m	£1,811m	+£1m
2005	£1,802m	£1,674m	-£128m		
2006	£1,693m	£1,656m	-£37m		
2007	£1,633m	£1,570m	-£63m		
2008	£1,549m	£1,443m	-£106m		

Table 3.3 - NBV model outputs compared with MNO actual values

NBV is also not correct, again to a degree of error much greater than the 2007 model. The NBV comparison however is of less significance than the GBV, since it is the latter that reflects the actual cash capital outflows of the operator that are recovered in the economic depreciation calculation – NBV is an artefact that is significantly overlaid with accounting assumptions of depreciation that the model does not really make use of.

On capital outflows the only possible conclusion therefore is that the 2010 model is a long way from being properly calibrated; moreover whatever adjustments have been made to “improve” the 2007 version of the model have very considerably undermined the historic calibration for 2002 – 2005.

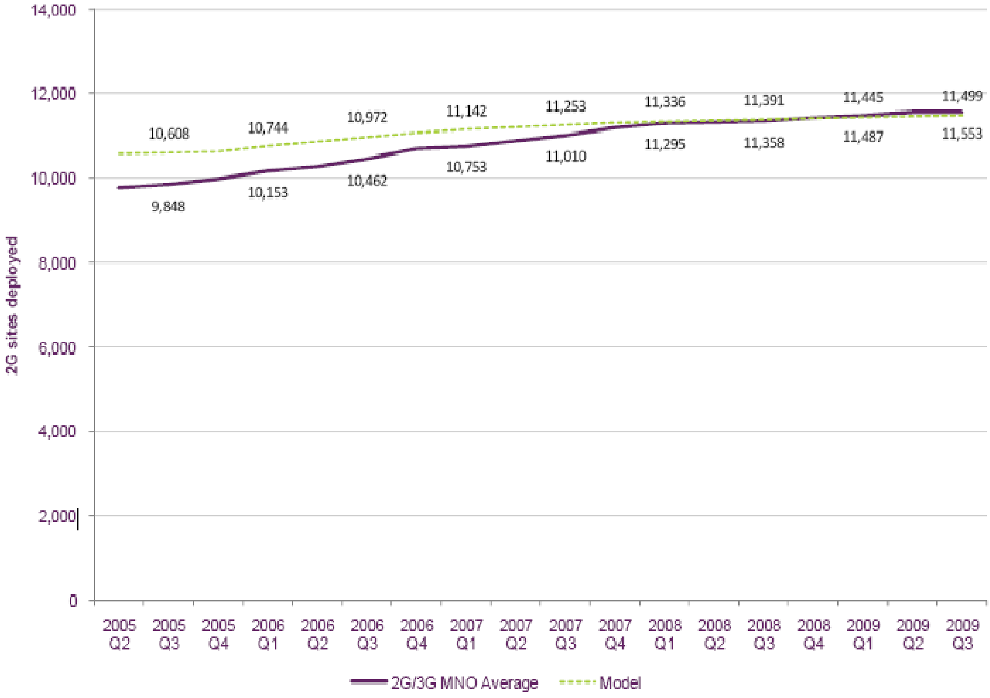
By contrast operating costs, or opex would appear to not be that far wrong in the 2010 model for the 2006 – 2008 period, but somehow the fidelity of the 2002 – 2005 calibration has been also substantially reduced from the 2007 model, with an under-shoot of expenditure as table 3.4 below shows. Again the values reported as 2010 model outputs would appear to be not quite correct. Since in its table 17 of the consultation Ofcom reports 2008 actual MNO calendar opex of £376m, but only £360m in figure 28, Vodafone assumes that in figure 28 (where model outputs are compared with MNO actual values) Ofcom is using network opex excluding AIP, which amounts to £16m. Therefore the 2010 model outputs on a calendar basis have also been adjusted by us to exclude AIP.

Year	MNO Actual	2010 model		2007 model (per Ofcom)	
		Output	Difference	Output	Difference
2002	£324m	£313m	-£11m	£348m	+£24m
2003	£326m	£308m	-£7m	£356m	+£30m
2004	£324m	£297m	-£34m	£353m	+£29m
2005	£334m	£298m	-£36m	£364m	+£30m
2006	£319m	£314m	-£5m		
2007	£336m	£341m	+£5m		
2008	£360m	£356m	-£4m		

Table 3.4 – Opex: model outputs compared with MNO actual values

Financial calibration however is only one part of the assessment of the fidelity of the model. The other area of review relates to network build quantities. Here the 2007 statement reports on a wider range of asset types than the 2010 consultation, which limits itself to site numbers (in figures 22 to 25) and shows a reasonable correspondence over the period 2006 – 2009 although it is noteworthy that the model appears to build too many 2G sites from mid 2005 onward, despite as table 3.2 above shows being rather light on overall GBV at the time. Figure 22 is reproduced below.

Figure 22: Comparison of total 2G sites between model output and 2G/3G MCP data



This comparison in itself is not reassuring, as the calculation of pure LRIC requires the model accurately to capture the relationship between reductions in demand and changes in network dimension around the level of current demand. The chart suggests that while the model has been calibrated so that the model reflects the current network dimensioning at the current level of demand it does not accurately model the network dimensioning in earlier periods when demand was lower than the current level. This provides evidence that the model is unlikely to be able accurately to estimate the reduction in cost associated with a reduction in demand and hence that any estimates of pure LRIC will be inaccurate.

The total number of cell sites, although important, is only one possible network measure for comparison – it is not clear why Ofcom has only used this measure in 2010, when a much wider range of measures were compared in 2007. It is instructive to reproduce the values in figure A12.1 from the 2007 Statement, which compares 2007 model and MNO actual build in 2004/05, but also to add in the network quantities that the 2010 model now builds in 2004/05, as in table 3.5 below.

Asset type	MNO Actual	2010 model		2007 model	
		Output	Difference	Output	Difference
2G macro cells	7,770	8,576	+806	8,077	+232
2G micro and pico cells	2,217	1,967	-250	2,597	+148
3G node Bs	3,330	2,506	-824	3,439	+109
TRXs (2G)	67,350	58,879	-8,471	63,481	-3,869
BSCs (2G)	221	146	-75	159	-62
RNCs (3G)	24	20	-4	20	-4
MSC and MSC servers	68	28	-40	77	+9

Table 3.5 – Network quantities 2004/05, actual and modelled

As observed for the financial comparison, the quality of calibration in 2004/05 would appear to be much worse for the 2010 model than for the 2007 model. As noted above for 2006 - 2008 it builds too many cell sites in total, but in 2004/05 (and presumably also subsequently) it was a little light in micro and pico cells. For some reason it is now significantly behind the deployment curve on node B deployment. Surprisingly the TRX deployment, already light in the 2007 model, has fallen off by a further 4,600 TRXs in the 2010 model. The 2010 model thus appears to build too many 2G macro cells but populate them with far too few TRXs: possibly the balance between 2G coverage and 2G capacity has been altered. The number of BSCs is also a long way light: one must question whether there is a mismatch between the model and reality on BSC capacity and cost – it may be that the unit cost of a BSC in the model reflects the apparently lower capacity of a BSC that requires 50% more to be built in reality than in the model. A similar issue may apply in the case of MSCs where the number built in the model has dropped dramatically from 2007 – it may very well be that a higher capacity has been assumed without any commensurate adjustment in cost.

The types of differences seen above not only reinforce the conclusion that the 2010 model's calibration is somewhat off, but also give suggestions as to where in the model attention may be focused in order to improve the calibration, i.e. to ensure as far as possible that the model actually builds a network that is representative in summary and in some degree of detail with an average 2G/3G operator. George Box's dictum that "all models are wrong, but some are useful" comes to mind – at the moment the model is so wrong that it is not useable, so Vodafone's effort must be directed to ensure that the model is sufficiently less wrong that it can become useful. These points give focus to Vodafone's review of the model in the sections below.

Further, it is a key pre-requisite for checking calibration that the model is fed with accurate historic traffic volumes, in order to make sure that the model adequately "predicts the past". There is however some doubt that this has been done in the case of data traffic, where it appears that the model is being required to handle more than the real historic share of data of a 2G/3G operator, and hence potentially is building a bigger network than is warranted. This point is returned to in the traffic section below.

Calibration is fundamentally a final process in model design. There is no benefit in Vodafone attempting to re-calibrate the model at this stage. Only after the model's other inputs that affect the number of the assets that are required (grouped here into the categories of traffic inputs and network dimensioning) have been reviewed and any necessary changes to the model been made can calibration be properly attempted. At the penultimate stage in our review, therefore, we approach the conjoined issues of asset unit costs and financial calibration, where an assessment of unit cost levels can be combined with a review of how well the model is calibrated at this point, and corrections to both applied.

The structure of prices suggested by the model

The Ofcom model shows a result for LRIC+ in 2014/15 of a weighted average termination rate of 1.54 ppm, in 2008/09 prices, and 0.51 ppm in pure LRIC. But obviously the model also outputs costs for all services, for all years. For data for example, the following costs are produced by the model, as shown in table 3.6 below:

Data charges in pence per MB	2010/11	2014/15
2G (GPRS)	26.282	26.426
3G packet data (R99)	2.366	2.036
3G packet data (HSPA)	2.366	2.036
Weighted average	2.705	2.173

Table 3.6 – Data recoveries from the 2010 model

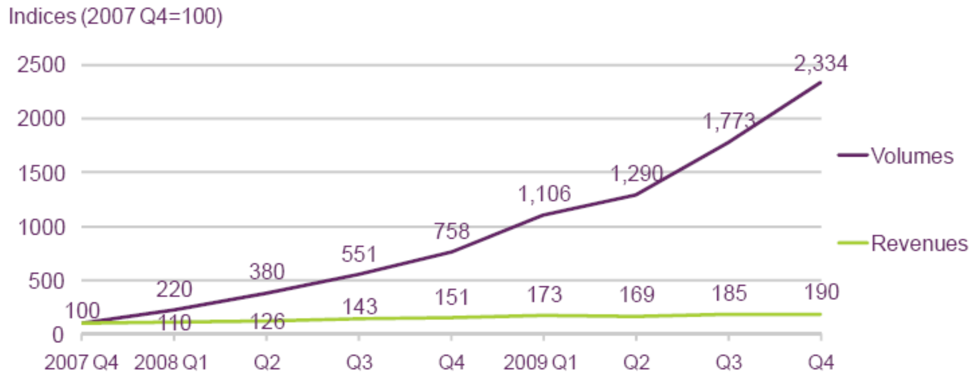
The weighted average data recovery of 2.71 p per MB for 2010/11 produced by the model above represents a necessary £13.55 network recovery for 500MB per month, or £81.30 for 3GB. But data on the handset of 500MB per month can currently be purchased for £5, or £4.26 net of VAT. For mobile broadband on a dongle or datacard, 3GB can be obtained for £15, or £12.77 excluding VAT, but this is including recovery of retail costs as well as supply of a free dongle. This suggests that the model's prices represent an uplift of somewhere between three and seven times on current actual data retail rates, even before considering retail and device cost recoveries.

In a similar vein, looking at total modelled revenue recoveries in each year, i.e. the sum of the modelled rate for each service multiplied by its forecast volume in that year, the total proportion of modelled revenue in 2014/15 that relates to data is calculated at 36%. However included in the total is the proportion of network recovery relating to handsets of 14%. Excluding the latter, this means that the model is forecasting that 43% of total network revenue is being recovered from data services. In the event of adopting a pure LRIC charging basis for voice termination, and assuming that all other service prices increase on a pro-rata basis to compensate for the resulting shortfall of fixed and common costs recovery, then data revenue would constitute more than 50% of the total service revenue. At its peak data recovery is forecast to be more than half of the total annual recovery even on a LRIC+ basis. This cannot be right.

This charging structure suggested by the model just looks wrong in comparison with the structure of prices in the real world. A further illustration of this can be found in the recent "Traffic Management and net neutrality" discussion document where Ofcom shows the growth in mobile data volumes and the matching mobile data revenues, reporting that: "*in the two years since Q4 2007 mobile internet volumes have increased by over 2300 per cent but revenues have not even doubled*"[32]

We reproduce below Ofcom's figure 4 from this document that shows this.

Figure 4: Growth in mobile data volumes and revenues



Furthermore if data were being sold at the rates output by the model, i.e. at a level very significantly higher than in reality, (even before any retail costs recovery), then the volumes of data sold on mobile networks would be much lower. The demand for mobile data does not exist in isolation – the price and speed of fixed broadband and its availability has a considerable impact on mobile data volumes. It is a conundrum that one of the reasons that voice termination rates are being driven so low in the model is the fact that the model is assuming an inconsistent pair of volumes and costs for data – inputting the lower data volumes that would result from the higher data charges into the model would in fact give a higher voice rate.

[32] Net neutrality, June 2010, at 3.9

This suggests that the way that the model is recovering costs is not reflective of the real world. This issue is one that is in large part new to the 2010 version of the model, in that in 2007 the forecast volumes of data were not so large and the retail prices of data were not so low, so that the stark contrast between the real world and the model was not so evident or important. This problem can be addressed in two ways:

- by examining the model's cost allocation algorithms to review the appropriateness of the division of costs between voice and data services;

- by considering an approach where as in the real world, data services are charged at an incremental cost, with no mark-up of fixed and common costs.

Both of these potential resolutions are examined in the sections below, in particular in the section on cost allocation and recovery.

We note also from table 3.6 above that the model's output of the appropriate level of charge for the two types of 3G packet data, i.e. Release 99 and the more efficient and effective HSDPA, are identical when they in reality and in the model use a different volume of RAN resources per bit transmitted. This suggests the existence of a pretty obvious error in the model on how data costs are being recovered – this particular problem is addressed in the section below.

From this brief review we can conclude that the model is not an adequate reflection of the real world, both in the overall size of the predicted network operator, and in how cost recovery is allocated. The rest of this annex considers how this deficiency can be addressed, but first a fundamental question needs to be asked in relation to the modelling of pure LRIC.

Can the model produce a reliable pure LRIC output?

Clearly one of the biggest changes made to the 2010 model has been the introduction of the additional method of cost recovery, that of a pure incremental result. It is necessary to consider whether the model is really up to this task.

Incremental costs are incurred in the support of the increment of demand, assuming that other increments of demand remain unchanged. Put another way, the incremental cost can also be calculated as the avoidable costs of not supporting the increment.

In essence the calculation of the pure LRIC output has been achieved by Ofcom by running the model through twice, once including voice termination, and once excluding it, and finding the differences between the two scenarios with respect to network build and capital and opex outflows for every year of the model. These differences, representing the model's view of the extra capital expenditure and opex required for the voice termination traffic element, are then fed into the economic depreciation calculation and recovered in the usual way, against the volume of voice termination.

It has been clear from previous charge control reviews that the model used by Ofcom to set mobile termination rates would not, in the absence of operator data, accurately model the absolute network dimensioning and level of costs of the actual operators or of a hypothetical efficient operator. When the model was first introduced, the results did not closely match the size of network or level of costs reported by the operators. This fundamental lack of accuracy was addressed by 'calibrating' the model to the actual size of network and level of costs for the network operators by adjusting a range of input parameters until overall cost levels from the model were in line with the operators' actual costs. As a result Ofcom could have reasonable confidence in 2007 in the level of the resulting average costs even if the model itself did not accurately capture cost volume relationships.

Effectively when used to set 'LRIC+' termination rates, the model was used to transform the level of costs reported by the operators to the appropriate cost base for the purposes of setting the price control, through:

- re-setting actual costs levels to the level of a hypothetical efficient operator;
- allocating costs across services; and
- applying economic depreciation.

As such, the underlying inaccuracy of the algorithms used within the model was not in itself a critical factor in calculating charges, as the inaccuracies in the modelling of cost volume relationships within the model only had second order effects on the resulting termination rates.

Under Ofcom's current proposals for pure LRIC, this is no longer the case:

- The level of 'pure LRIC' termination rates is largely dependent on the model's cost volume algorithms but these cannot be directly calibrated against external data;
- The calibration exercise, which attempts to align overall model costs with that of actual operators does not disentangle incremental from fixed and common costs and yet this is what is required to estimate pure LRIC.

In view of this fundamental change in the importance of the model algorithms we would have expected Ofcom to have:

- fundamentally examined the accuracy of the model and its fitness for the purpose of estimating 'pure LRIC' estimates;

- conducted a thorough review process with the operators to ensure that the cost volume relationships within the model were accurate; and

- where there was still remaining uncertainty over the accuracy of the model results, to set mobile termination rates conservatively taking account of this uncertainty.

However Ofcom has not carried out any of these steps but has instead relied on an updated version of the model used in previous charge control reviews. To the extent that changes have been made to the model methodology, these have tended to reduce the fidelity of the results in terms of overall costs and do not appear to have increased the accuracy of the underlying algorithms.

Even if the existing model were to be altered to better calibrate the overall cost results with the costs reported by the operators as Vodafone does below, this does not imply that any pure LRIC estimates produced by the model are accurate as the calibration exercise can only be carried out by changing the overall total level of costs, rather than by separately distinguishing incremental costs from fixed and common costs.

What is obvious however is that the model has not been designed from the ground up to deliver this methodology: the pure LRIC calculation is an overlay on the existing all services model, in an effort to establish on a hypothetical basis how much smaller a network the model would build when faced with lower traffic volumes than those that exist in the real world. Since it is not possible in the real world to assume that inbound voice termination traffic can disappear (particularly whilst assuming that outbound voice traffic to other mobile operators is unchanged) the removal of this traffic is simply a conceptual exercise, not a real one.

Given that the measurement of pure LRIC requires modelling a purely hypothetical situation, that of an operator not providing termination services, it is not possible directly to calibrate the model or to check the results against empirical data. As such Ofcom should exercise caution when interpreting the results of any model.

Clearly it has been possible to construct for desktop analysis purposes a spreadsheet that will produce sets of network volumes and costs with and without a particular traffic flow, but the reliability of this exercise and its relevance to the real world must always be questioned. The purpose of this specific task is to ensure that only the incremental costs that would occur as a direct consequence of the incremental traffic of voice termination are recovered from that traffic, and that fixed and common network costs are not recovered. However in order to achieve this on a meaningful basis that can be related to and applied in the real world, one has to believe that the model accurately "knows" the specific asset quantities of each asset element which are incremental and which are fixed and common. But this is an untested and unlikely belief.

In fact the problem with the existing model goes rather deeper than that. It is a polite fiction that the model truly is a LRIC+ EPMU model:

- What it actually <u>does</u> is to allocate all costs directly to services pro-rata to resource utilisation in a single step.

- What the model <u>does not</u> do is to calculate the incremental costs of each service and to these costs, as a second step then allocate on a simple pro-rata basis the remaining fixed and common costs, as the LRIC+ EPMU designation would imply.

- We accept that it is legitimate to interpret the former as achieving a result similar to the latter, but <u>only</u> where an all-service EPMU mark-up applies.

The initial briefing on the first draft of the 2007 model supplied to operators explicitly said this. *"It does not attempt to calculate common or incremental costs, but rather provides a service cost based entirely on service routing factors"*[33]. Later documentation referred to the cost recovery method as "FAC". The LRIC+ designation is potentially misleading and appears to have led Ofcom in 2010 to an inference that the model splits costs between incremental and fixed and common costs on a basis that is consistent with the real world.

Ofcom in 2007 were under no such illusions. In the 2007 Statement Ofcom actually said:

> *"A5.18 Service costs are arrived at by allocating all the costs identified to different services according to service routing factors. To the extent that common costs exist, these are allocated to service increments according to routing factors. <u>The model does not explicitly identify or estimate the level of common costs</u>. The outputs of the model are unit costs that exhaustively include all network costs. Therefore the model output, and in particular the cost of termination, is an incremental cost and an implicit mark-up for an allocation of any potential common costs. This is a particular form of network common cost allocation. Allocation of common costs is discussed in more detail in Annex 17."*
>
> *"A17.43 The derivation of welfare-optimal termination charges requires also the specification of costs. <u>Despite Ofcom's development of a detailed cost model, however, the estimation of the marginal and of the common network costs is also subject to significant uncertainties</u>[34].*

[33] Analysys, new mobile LRIC model, October 2005.
[34] Vodafone emphasis

A17.44 Ofcom's cost model does not explicitly identify and estimate the level of network common costs. Three potential sources of network common cost have been identified in principle: (i) fixed costs (e.g. network management in the core of the network); (ii) marginal cost economies (e.g. arising in backhaul due to statistical multiplexing); and (iii) modularities in capacity. However, estimating the level of network common costs robustly is not straightforward and the third potential source, modularities in capacity, raises particular difficulties, both conceptually and empirically. The analysis of common costs depends on whether modularities in network deployment give rise to excess capacity and from a long run perspective whether the opportunity cost of traffic in some parts of the network is zero.

A17.45 The initial deployment of assets will often exhibit periods where full capacity is not exploited. If the same assets (with the same capacity) are deployed across all geotypes this may be particularly the case in rural areas where traffic demand is less. Over time as demand increases, assets whose capacity was not fully exploited may become fully utilised and it will become necessary to deploy further assets. However, it may remain the case that in some areas and for some assets the initial deployment is never added to. This is due to the modularity of the initial deployment. In Ofcom's view, whether or not this excess capacity caused by the modularity of initial deployment should be considered a real common cost or the result of short to medium term equipment build constraints and/or modelling simplification is not clear. If MNOs were able to efficiently deploy assets with lower capacity or to charge for traffic services on a geographic basis in order to exploit excess capacity the identification of excess capacity in Ofcom's cost model would not be a real network common cost."

Ofcom in 2007 was thus very sceptical of the model's ability to separate incremental costs from fixed and common costs, as well as being of the opinion that costs that initially appeared to be fixed and common could very well be incremental. It is not clear why Ofcom has changed its mind, particularly as Vodafone can see no evidence in the recent consultation of any attempt to debate this matter or uncover whether the model correctly identifies the relative size of incremental and common costs. There must be considerable doubt therefore as to whether the model even if properly calibrated, can be made fit for the purpose of producing a pure LRIC cost that is sufficiently reliable. We return to this matter at the end of this annex.

Detailed review of the 2010 model

Vodafone's review of the 2010 model in this annex addresses in turn the various elements of that model: traffic inputs, network build parameters, cost allocation principles, and unit costs, before considering the newly introduced incremental model methodology. All of these adjustments are considered in the course of this annex using Ofcom's very low value for the cost of capital – Vodafone's correction to this is discussed in Section 5 of the main body of our response. At the end of the annex we evaluate the outputs from this model, for both the original version and after Vodafone's revision, using our preferred cost of capital from Section 5.

But prior to this thematic approach, the first section below addresses several disparate issues that have been identified that are all obvious mechanical errors of the model. While the impact of these errors individually and collectively is relatively small in terms of the mobile termination rates output by the model, they are relevant in that they also impact on network deployment volumes and costs, potentially improving the calibration of the model. A common theme amongst these errors is that generally they have emerged as a result of the amendments that Ofcom has made to the model, for the purposes of this 2010 revision.

Model - errors of construction

Several individual errors have been found to date that are fundamentally mechanical errors of model construction:

- Ethernet backhaul links are incorrectly transferred from one workbook to another;
- 2G/3G shared site numbers do not agree to the source calculation;
- The use of network handset costs is incorrect;
- Main switch sites are not being dimensioned properly;
- R99 and HSDPA weighting show no differentiation in cost recovery;
- 2G and 3G traffic volumes used in deriving a weighted average cost for termination are incorrect.

Most of these appear to have emerged as a result of the changes that have been made in the 2010 version of the model. These matters are dealt with below. Each change is overlaid on the previous ones, and the cumulative result in terms of termination values output by the model for both LRIC+ and pure LRIC in 2014/15 shown on the relevant table.

Ethernet backhaul mis-modelling

Examination of the network volumes in service of each asset type on workbook 4 – economic[35] reveals that strangely, certain unidentified asset types have been dimensioned with quantities of assets. For example asset number 90 (described as spare) has 4,169 units in 2010/11 and adds more subsequently, rising to a peak of 4,846 units. Similar events occur in the case of assets 91 and 97. However workbook 2 – network[36] builds no such asset types. Neither are costs collected for these assets, nor a cost driver selected: these quantities are simply unattached and thus obviously in error. Tracing this problem back from workbook 4 towards workbook 2 reveals a discontinuity in workbook 3. This workbook, which is devoted to building up the cash outflows required by the network build, holds the error.

The problem relates to the worksheet that consolidates assets that have been dimensioned in workbook 2 on an individual geotype basis, i.e. at a detailed level, back down to a total volume for the whole network for the purpose of costing. In fact the volumes recorded in assets 90, 91 and 97 on workbooks 3 and 4 are in reality all sub-components of asset 89, Ethernet microwave backhaul links. This asset category has been newly added in the 2010 model, but its implementation is obviously not totally correct. The only volume of these links that is actually being picked up in asset 89 on workbook 3 relates to those links that are dimensioned for the urban geotype: what the model is not properly aggregating into asset 89 are the quantities of Ethernet links for all the other geotypes, so the suburban 1 geotype quantities are inadvertently dropped into asset 90, suburban 2 quantities into asset 91 and railway geotype quantities into asset 97. (There are no values inserted into assets 92 to 96 merely because no Ethernet assets are dimensioned for the four rural and the highway geotypes that are sequenced between the suburban 2 and railway geotypes.) Since this error occurs in the front part of the costing workbook, the model is thus not counting and costing most of the actually dimensioned Ethernet assets; accordingly it is light on costs incurred and costs recovered for both the LRIC+ and the pure LRIC model outputs.

The correction to the error is relatively straightforward if slightly laborious to accomplish in that the linked inputs worksheet of workbook 3 needs to be modified in rows 353 and beyond for nine rows so that in column A they all relate to asset 89, and in column B they have the geotype numbers 1 through to 10 in successive rows. The same exercise, ensuring that all Ethernet assets are picked up by geotype must be completed several times on the asset demand for costs worksheet starting at rows 353, 819, 1180, 1541, 1645, 2008, 2367, 2726, 3085, 3447, 3459, and 3914. Once this is successfully done the same total number of Ethernet links dimensioned in workbook 2 on a geotype basis is carried through into workbooks 3, 4, and 5 on an aggregate basis, and the phantom quantities on assets 90 and above

[35] As shown in the array entitled number of elements in operation on the linked input worksheet
[36] This is the workbook where network assets are dimensioned

have as a result disappeared. Hence all the dimensioned Ethernet backhaul links are now being costed, and are having their costs recovered through the economic depreciation calculation.

This correction changes the basic result for both LRIC+ and pure LRIC (as well as increasing GBV, NBV and opex) as shown in table 3.7 below, which compares the original model output with the corrected result for the relevant year of 2014/15, for both the 2G and 3G voice termination rate and the weighted average or blended rate.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
Original model output LRIC+	2.1508	0.7801	1.5428
LRIC+ corrected for Ethernet asset costing	2.1662	0.7966	1.5587
Original model output pure LRIC	0.5835	0.4127	0.5077
Pure LRIC corrected for Ethernet asset costing	0.6426	0.4643	0.5635

Table 3.7 – Correction of Ethernet backhaul links

Discovery of this mechanical error, clearly new to the 2010 version, suggested to Vodafone that there would be merit in a more general review comparing the final dimensioned network quantities in the economic workbook (in the linked inputs worksheet) and the original dimensioned quantities built up in the detailed workings of the network workbook to ensure that a clear and accurate trail existed from the latter to the former. In the event three other errors were uncovered by Vodafone as a result of this review, relating to site upgrades, 2G handsets and site sharing: the first two of these are discussed in the next sections below. The third issue that emerged relates to the newly introduced feature of the quantities of sites being shared between operators, where for some sites neither a shared site nor a transformation site event was being invoked; this error however is addressed in the broader discussion of operator site sharing in the network design section further below.

Share site upgrade numbers are calculated incorrectly

Every 2G cell site that is converted into a shared 2G/3G site triggers in the model a site upgrade event and a resulting asset. However these, as was discovered in the course of the end to end quantity verification described above, are not being accumulated correctly. The problem relates to an error in the network design other worksheet of the network workbook, in that the numbers carried into the summary on rows 180 to 206 are not correctly linked back to the underlying calculation. For example macro site rural 4 geotype upgrades, micro site suburban 1 upgrades and pico site urban upgrades are all referencing the same row, when they should be pointing to three different rows. As a result the numbers of site upgrades are shown in subsequent workbooks at too high a level, so the model is over-dimensioning and over-costing the asset element. Correcting for this error which reduces the modelled costs is minor in impact, as table 3.8 below demonstrates:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.7 above re Ethernet	2.1662	0.7966	1.5587
LRIC+ additionally corrected re site sharing numbers	2.1664	0.7943	1.5578
Pure LRIC corrected as table 3.7 above re Ethernet	0.6426	0.4643	0.5635
Pure LRIC additionally corrected re site sharing numbers	0.6426	0.4641	0.5635

Table 3.8 – Site sharing adjustment

Handset costs are included in the model

A further problem that came out of the end to end quantity review is that 2G handset numbers recorded and costed in the economic workbook are not always the same as forecast customer numbers generated in the traffic workbook. This appears to be the product of the smoothing factor at the front of workbook 3, the costs module, in the worksheet “asset demand for costs”. The smoothing factor is intended to apply to declining or fluctuating network assets, but its use here generates more modelled 2G handsets in use than 2G customers – this clearly cannot be right. To Vodafone this points to the wider absurdity of recording and recovering a network cost for handsets in the model.

Vodafone accepts that handset or more accurately subscription volumes are relevant to the dimensioning of the HLR, and to a lesser extent also for the dimensioning of the MSC. However Ofcom’s model uses handsets not only as a dimensioning factor but also as a costed network asset *and* a service that should recover network costs. But handsets are not a network asset of the network operator, but rather the property of the individual customers of the network. As noted in the calibration section above, this has already led Ofcom to an incorrect inference of reliable model calibration, since the handset cost produced by the model has been included in error in comparing model GBV with actual operator GBV; in the real world no operator capitalises handset costs and treats them as a network asset.

As long as handset costs are a standalone cost in the model, and isolated from network GBV calculations, and only recovering their own hypothetical cost in the cost recovery algorithms, Vodafone has no problem with Ofcom continuing to assume, as it does, a strangely constant handset network cost of exactly £26.02 for all years, or any other unit cost it cares to assume. The problem for Vodafone new to the 2010 model, where Ofcom also assumes as before that handsets are a network service, is that Ofcom not only recovers all the accumulated "network handset expenditure" (via the routing factors and cost drivers set out in the network element output worksheet of workbook 2) but also newly recovers against handsets some proportion of the overall administration costs that it has assessed in Annex 8, (from paragraph A8.135) as appropriate to be recovered from network costs. The administration cost recovery is new to the 2010 model at least in the form of an endogenous calculation. The recovery was previously via a standalone calculation of 0.3 ppm in every relevant year but is now one that has been embedded in the model in workbook 4 on a constant total cost basis. The model now recovers this total annual cost as a simple mark-up pro-rata to overall cost recovery per year by service and the volume of that service, in the worksheet "service costing". As a result the non-network cost recovery is no longer a constant per inbound voice minute across all years but a variable dependant on the mix in the year of service volumes and recoveries.

Since the handset cost recovery is included in this calculation, with handsets recovering some 15% or so of total "network" costs (but all of this 15% in fact relates to the dubious network handset cost of £26.02 per handset) this means that some 15% or so of the administration costs appropriately recoverable through network services are being siphoned off into handset costs. Whilst Vodafone agrees that some *retail* costs and some non-network retail costs are incurred in relation to handset sales, we see no reason whatever why it is appropriate that any of the quantum of administration costs that relate to network activity should be recovered against some hypothetical network handset cost that does not in fact exist.

The easiest way to resolve this in the model is to set the network handset cost at zero. This has the added advantage of simplifying the GBV and NBV calibration exercise by removing handset costs from the calculated totals of GBV and NBV in workbook 5. The result of this change on the termination recovery in 2014/15 is shown in table 3.9 below.

Model outputs in ppm	2G 14/15	3G 14/15	Blended 14/15
LRIC+ corrected re Ethernet and site sharing numbers, as table 3.8 above	2.1664	0.7943	1.5578
LRIC+ additionally corrected re handset costs	2.1945	0.8046	1.5780
Pure LRIC corrected re Ethernet and site sharing numbers, as table 3.8 above	0.6426	0.4641	0.5635
Pure LRIC additionally corrected re handset costs	0.6426	0.4641	0.5635

Table 3.9 – Impact of removal of handset costs

Since non-network costs are only being recovered in the LRIC+ methodology, this change as would be expected has no impact on pure LRIC in Ofcom's model.

Switch sites are not being dimensioned properly

The end to end network quantity review also showed that the number of main switch sites dimensioned by the model, although consistently carried in all the model's workbooks, did not appear reasonable, or in any way similar to the outputs from the 2007 model. In the 2007 model the number of sites rises slowly to 6 in 1998/99, 11 in 2000/01, up to 20 in 05/06, and then keeps at about that level to 2020/21, at which point 23 sites are in use. By contrast the 2010 model has 3 main switch sites in 1992/93 through to 1999/00, 4 in 2000/01, and then jumps in one year to 30 and retains this number from 2001/02 onwards through to 2039/40. Clearly there is some degree of unrealism in the modelling here.

Examination of the dimensioning calculation for this asset that is in the "network design other" worksheet of workbook 2 shows that changes between the 2007 and 2010 versions of the model have not been carried out with adequate care. What appears to have happened is that to solve an apparent dimensioning problem with SGSNs (to force them into being dimensioned by attached subscribers rather than by data throughput) these platforms have been given a nearly infinite capacity in terms of mbit/s throughput. However the main switching site dimensioning rule uses the value of relative mbit/s throughput to derive a simple equivalence of an SGSN to a 2G MSC in order to include SGSNs as a dimensioning element for switch sites. As a result of the change each SGSN built is now equivalent in the model to an almost infinite number of 2G MSCs and hence bizarrely an almost infinite number of main switch sites are required as the immediate result of needing one SGSN in 2001/02! It is only the presence of a maximum limit on the number of switch sites of 30[37] that has prevented a really absurd result. As it is, in 2000/01 the model requires fifteen 2G MSCs and no 2G SGSNs, and happily accommodates these in four switch sites. In the next year, 2001/02, the model builds three more MSCs, and the first SGSN, but "squeezes" these extra four platforms into twenty-six new switch sites! All subsequent SGSN and MSC builds then make no further difference to the number of switch sites.

The problem can be resolved relatively straightforwardly by abandoning the mbit/s equivalence approach currently employed in the model and considering switch building dimensioning more as a response to floorspace requirements. This however needs recognition that MSCs and SGSNs are not the only platforms that require accommodation in switch sites – in particular those RNCs and BSCs not being placed in remote switching sites in the model will also need to be given room to exist.

It is therefore necessary to amend the model to include floorspace for BSCs and RNCs. For simplicity, BSCs, RNCs and SGSNs can all be set at say one-third of the footprint requirement of an MSC, and all of these then converted into MSC equivalents to derive a notional requirement per year, that can then be used to create the appropriate switch site number. Once this has been implemented, then like the 2007 model the 2010 version gives a switch requirement always less than the maximum of 30, with 6 in 1998/99, 11 in 2000/01, 17 in 2005/06, with between 20 and 30 in the next decade. (All network build and traffic parameters are frozen from 2020/21.)

This adjustment gives revised costs as per table 3.10 below:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.9 above	2.1945	0.8046	1.5780
LRIC+ additionally corrected with main switch sites re-dimensioned	2.1949	0.8050	1.5784
Pure LRIC corrected as table 3.9 above	0.6426	0.4641	0.5635
Pure LRIC additionally corrected with main switch sites re-dimensioned	0.6681	0.4863	0.5875

Table 3.10 – Main switch sites dimensioning correction

HSPA's superior performance to Release 99 is not reflected in the cost recovery

[37] This maximum level was also present in the 2007 model, but was not required to be invoked.

It was noted in the overall review of the model outputs above that both 3G data technologies i.e. the original Release 99 and the more recent HSPA gave the same unit cost per megabyte. The latter technology is a newly introduced feature of the 2010 model, whose absence from the 2007 model was criticised by Vodafone in its 2006 critique of that edition of the model. It was obvious even then that the adoption of HSPA technology, with its more efficient use of resources in the radio access network was imminent, and was likely in the near future to become the preponderant method of mobile data transmission by volume. In reality HSPA has represented a necessary enabler to the increase in data volumes, and its modelling is thus vital.

We welcome therefore the belated introduction of modelling for HSPA and are broadly in agreement with the assumption that HSDPA of 14.4 mbps gives a "data downlift" of 6 rather than the 3 of Release 99 when making a bit per bit comparison with 3G voice traffic. But whilst this parameter has been included in the model for dimensioning purposes, the model's output cost recoveries for Release 99 and HSPA are identical as can be seen in table 3.6 above, with both Release 99 and HSPA giving a cost per megabyte in 2014/15 of 2.306 p: this is counter-intuitive.

Tracking this point through the model shows that the problem is that although the greater efficiency of HSPA is used for network dimensioning purposes via the "hspa.efficiency multiplier" named range, it is not being used for cost recovery purposes. Hence there is a mismatch between network dimensioning and cost recovery principles. The key issue is that on the "cost drivers" worksheet of workbook 2, both Release 99 and HSPA use in error the same data downlift factor of 3, rather than HSPA using the more appropriate value of 6[38]. To address this without double counting the difference between the two technologies, the hspa.efficiency multiplier range needs to be amended so that it is always has a value of 1 (i.e. is effectively rendered non-functional) and a new factor of HSPA downlift over Release 99 with a value of 2 needs to be added as a divisor to the cost driver worksheet, so that the weighting of HSPA over Release 99 is halved for cost drivers that relate to the radio access network, i.e. the 3G radio interface traffic driver and the all radio traffic driver[39]. (The drivers relating to backhaul obviously should not be modified.)

The results of this change to the 2014/15 termination output are shown in the table below:

[38] Vodafone were informed of this error by Ofcom on 4th June in an email from Dr Manimohan, but we had in fact already spotted it.

[39] In fact HSDPA is phased in at rising speeds and efficiencies over an initial three year period – but as for the remaining thirty years of the model the downlift of 6 applies (and with significantly higher volumes than in the initial period) this is a reasonable working calculation.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.10 above	2.1949	0.8050	1.5784
LRIC+ additionally corrected for HSPA cost recovery	2.2751	1.0282	1.7221
Pure LRIC corrected as table 3.10 above	0.6681	0.4863	0.5875
Pure LRIC additionally corrected for HSPA cost recovery	0.6680	0.4862	0.5874

Table 3.11 – HSPA cost recovery correction

Weighting of 2G and 3G inbound traffic

Aside from any issues relating to a "2G cap" methodology it is entirely appropriate for the termination charge set in the charge control to be the weighted average of inbound calls terminated on 2G networks and inbound calls terminated on 3G networks. However this is not in fact what the model is actually doing in its current method of calculation.

Given that the average 2G/3G operator will obviously deploy two network technologies, i.e. 2G and 3G, and the resultant possibility that an intra network call could in fact be made on an inter technology basis, the model not unreasonably makes an adjustment to accommodate this to allow for the different costs of 2G and 3G. For costing purposes therefore on-net traffic, i.e. a call from one customer to another on the same mobile network has been broken down in the traffic workbook on a probability basis into four possible call categories:

- From a customer on the 2G network to another customer on the 2G network – treated as a 2G on-net voice call;

- From a customer on the 3G network to another customer on the 3G network – treated as a 3G on-net voice call;

- From a customer on the 2G network to another customer on the 3G network – first leg treated as a 2G outgoing voice call and the second leg as a 3G incoming voice call;

- From a customer on the 3G network to another customer on the 3G network – first leg treated as a 3G outgoing voice call and the second leg as a 2G incoming voice call.

The volume of incoming traffic used for network dimensioning in the model quite reasonably therefore includes some traffic that in reality is the second leg of an on-net call. This traffic however has not originated off-net and is being treated as "incoming" purely to reflect the network technology over which the call is being conveyed in order to approximately reflect the appropriate costs of the set of on-net call cases[40], so 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.

These second call legs of on-net traffic can be fairly easily identified and isolated since they form the traffic rebalancing components of the traffic forecast worksheet of workbook 1 of the model. Vodafone has collected them for each period and then deducted their total from the model's present totals of 2G and 3G inbound volumes, and used the resulting "inbound volumes from off-net" purely for the purposes of producing a revised weighting between 2G and 3G inbound traffic (in a new section of workbook 4) that can then be used to weight the unit costs of 2G and 3G termination produced by the model. The relevant components are those in the categories "changes to 2G network traffic", "changes to 3G network traffic" and "change to 3G incoming network traffic for 3G onnet calls". (It is possible to check that the right total of genuinely incoming traffic has been arrived at by this adjustment by a comparison with the total incoming traffic volumes at the head of the same worksheet in the area entitled "total demand calculation".[41]) The resulting changes for 2014/15 are shown in table 3.12 below:

	Total incoming volume – original (million minutes)	**Of which incoming from external (million minutes)**
2G traffic	11,968.6	10,273.7
3G traffic	9,539.8	6,632.2
Total traffic	21,508.4	16,905.9
2G %	55.6%	60.77%
3G %	44.4%	39.23%

Table 3.12 – Adjustment of incoming minutes 2014/15[42]

Applying these corrected relative traffic weights to the individual 2G and 3G incoming costs from the model gives a different weighted average rate, as shown in table 3.13 below:

[40] To avoid this confusion it would perhaps have been preferable, if less efficient in the model, to have recorded these individual legs of an on-net call not as inbound or offnet traffic but as individual services separate from genuine inbound traffic.
[41] This particular section gives the right traffic total but cannot be used for weighting as it does not give the right mix of traffic between 2G and 3G since some calls to what are nominally 3G customers, i.e. customers with 3G and 2G capable handsets are actually terminated on the 2G network rather than the 3G network.
[42] These are not in fact the final weightings between 2G and 3G – some of the changes Vodafone makes below, particularly in relation to 3G coverage, change these proportions, but the model and the reported outputs adjust for this

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.11 above	2.2751	1.0282	1.7221
LRIC+ additionally corrected for traffic weighting	2.2751	1.0282	1.7860
Pure LRIC corrected as table 3.11 above	0.6680	0.4862	0.5874
Pure LRIC additionally corrected for traffic weighting	0.6680	0.4862	0.5967

Table 3.13 – Re-weighting for genuinely inbound traffic

Following on from these simple corrections to eliminate the model's mechanistic errors (at least those that have been detected to date) a more detailed review can be made of the model's operation and its parameters, inputs and outputs. The first area to be considered is that of the model's traffic inputs, looking in particular at how they have been amended since the 2007 version.

Traffic inputs to the model

Vodafone accepts that any traffic forecast, no matter how carefully developed, is inevitably conjectural. This obvious difficulty, however, should not absolve Ofcom's forecast from criticism. Every effort should be made to establish as reasonable a forecast as possible of traffic of all services of the average 2G/3G operator and 2G and 3G technologies. Vodafone sees that there are several areas for improvement of the values used, with respect to both voice and data traffic volumes.

The starting point for this evaluation is the model incorporating the correction of the errors from the section above, as per table 3.14 below:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected for simple errors as table 3.13 above	2.2751	1.0282	1.7860
Pure LRIC corrected for simple errors as table 3.13 above	0.6680	0.4862	0.5967

Table 3.14 – Outputs from model incorporating corrections to date

Ringing time on voice

Ofcom made two very detailed requests for information to the mobile operators during the course of 2009, to provide inputs to populate the model. Whilst completing these requests Vodafone ✂[43].

It was obvious from this exercise that a simple conversion of recorded minutes to erlangs led to an underestimation of the actual observed erlangs, as demonstrated in table 3.15 below:

[43] This latter was the sum of all traffic recorded at each cell site, i.e. it was a measure of radio access network activity

	Quarter to:		
	Mar-09	**Jun-09**	**Sep-09**
Total voice traffic (million minutes)	✂	✂	✂
Less to voicemail	✂	✂	✂
Onnet to count twice	✂	✂	✂
Total radio access legs (million minutes)	✂	✂	✂
Convert to kErlangs (*1000/60)	✂	✂	✂
Actually recorded network kE	✂	✂	✂
Required uplift to minutes to reach network kE	✂	✂	✂

Table 3.15 – Vodafone actual recorded voice minutes and voice erlangs

Clearly it is the actual volume of network traffic, in erlangs, that constitutes the volume relevant for dimensioning (or at least that for the busy hour traffic). If it appears that the billed/measured minutes is an inadequate proxy for this measure, then an adjustment is warranted to the model. On investigation, the culprit appeared to be call set-up time, i.e. the period that a voice circuit was occupied whilst setting up the call and waiting for the call to be answered, before the actual billing event of an active call began. We identified to Ofcom in our Section 135 response in 2009 that "*as part of its network dimensioning for forecasting purposes Vodafone* ✂[44]."

We are a little disappointed to discover that Ofcom has taken no account of this point, particularly as it appears from internal discussion that the LRIC model in use in the Netherlands specifically includes an uplift of over 12% for "ringing time". On reflection an adjustment for ringing time appears to be a reasonable one to make. We suspect from the evidence above that ✂. (The value used in the Netherlands model is in fact 17 seconds per call.) Using voice call durations from the model, an uplift of 6 seconds increases voice volumes by 8.5% on inbound, and 6.5% on outbound, whilst an uplift of 10 seconds increase inbound by 14.2% and outbound by 10.8%. We suggest therefore an intermediate uplift of 8 seconds: this gives an increase in inbound Erlangs by 11.4% and in outbound Erlangs by 8.7%, an average of a little less than 10% - this is still a conservative uplift, ✂.

[44] Vodafone response to first S135 request, page 4 of main Word document

Running this amendment through the model[45] gives the following changes, when building on the corrections made in the previous sections, as shown in table 3.16 below:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected for simple errors as table 3.14 above	2.2751	1.0282	1.7860
LRIC+ additionally corrected for ringing time	2.3806	1.1076	1.8812
Pure LRIC corrected for simple errors as table 3.14 above	0.6680	0.4862	0.5967
Pure LRIC additionally corrected for ringing time	0.7380	0.5312	0.6569

Table 3.16 – Ringing time correction

Voice traffic volumes

As shown in figures 5 and 8 in annex 8 of the consultation, it is clear that Ofcom is continuing to increase both the number of customers in the mobile market and usage per customer from present levels all the way through to 2020/21[46]. So for example the model assumes in the first quarter of 2010/11 423 outbound minutes per customer, rising to 504 minutes per customer in the last quarter of 2014/15, and to 535 minutes per customer in the last quarter of 2020/21. At the same time the total active mobile customers is forecast to rise from 74.0m in the first quarter of 2010/11 to 77.6m in the last quarter of 2014/15 to 81.1m in the last quarter of 2020/21. This is not a prudent set of assumptions, particularly in view of the dampening impact of the recession.

We observe that the voice termination result in the model is naturally somewhat sensitive to voice traffic volumes – running the model after the changes above with the Ofcom alternative low and high voice volume scenarios gives the results shown in table 3.17 below:

[45] Most easily achieved near the head of the cost drivers worksheet of workbook 2
[46] Although the model is run forward to 2039/40, all input values of traffic, network build, cost etc are frozen at 2020/21 levels. This is a feature of the 2007 model that has remained unchanged in the 2010 version.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.16 above	2.3806	1.1076	1.8812
LRIC+ as above with Ofcom low voice volume scenario	2.5305	1.1419	1.9858
LRIC+ as above with Ofcom high voice volume scenario	2.1408	1.0516	1.7135
Pure LRIC corrected as table 3.16 above	0.7380	0.5312	0.6569
Pure LRIC as above with Ofcom low voice volume scenario	0.7364	0.5207	0.6518
Pure LRIC as above with Ofcom high voice volume scenario	0.7496	0.5623	0.6761

Table 3.17 – Sensitivity to future voice volume changes

We are not suggesting that there is sufficient evidence to require the low voice volume scenario, but that the medium scenario that Ofcom adopts is not conservative, and runs the risk of overstating the actual volumes in the future, and hence understating the appropriate cost recovery.

Data traffic volumes

Clearly there has been a significant increase in data usage in the 2007 – 2010 period over and above that forecast in the 2007 model. As discussed above, one of the reasons for and enablers of this has been the wide implementation in both operator networks and customer devices of HSPA technologies, which allow faster data transfer rates at a device level and higher throughput for given resource consumption in the radio access network. As a result the customer is able to have a reasonable data experience despite the rapidly rising data traffic volumes – without the implementation of HSPA this would not have been possible from both the network and the customer points of view. Despite Vodafone suggesting it in 2006, HSPA was not recognized in the 2007 model.

The 2010 model implements HSPA up to 14.4 mbps, i.e. is no more than a reflection of the current best speed. However looking forward, the model is forecasting a very significant increase in data traffic volumes, from 2,853 GB in the 2010/11 first quarter for the average 2G/3G operator to 8,665 GB in the last quarter of 2014/15 and then up to 14,531 GB in the last quarter of 2020/21. It is hard to see that this volume increase is likely to occur when data throughput is at a ceiling of 14.4 mbps under HSPA, from either a user or a network viewpoint, particularly given the expectation of rising broadband speeds (and demand for speed) in the fixed world. Furthermore it is hard to see how this traffic volume increase will be possible with the forecast number of 3G sites, which fundamentally are providing only outdoor rather than indoor coverage; this is an issue that is returned to in the network design section below. From a technology point of view, at least two developments are likely in mobile: either an increase in speed and efficiency under HSPA beyond 14.4 mbps, and/or the deployment of an alternative technology such as LTE, which could siphon from 3G much of the high speed data demand created in the dongle/PC market.

We consider below the implications of these on the data traffic forecast and the model in general. But first, one point that needs to be examined is whether the model actually "forecasts" the historic data traffic volumes of the average 2G/3G operator.

Efficient operator historic datacard market share

The model newly for 2010 forecasts data traffic generated by the handset separately from data traffic generated by the dongle/PC market (described by Ofcom as datacard subscribers). Vodafone entirely supports this approach – indeed it is one that we have previously advocated. The model forecasts the total market number of customers for handsets and datacards, and usage per individual customer, and then assesses the market share for a 2G/3G operator: the product of all three gives total traffic for each service for the operator.

Unexceptionally, for handset subscribers the model starts with a 25% market share for the average operator in the years prior to H3G's launch, and then slowly drops the percentage down towards 20% as H3G grew (and grow in the future) their base. In the 2007 model a stable 20% market share proportion for the average operator was eventually reached. However the advent of network consolidation means that the 2010 model now assumes a low point of 21.55% market share (H3G implied market share thus 13.8%[47]) in quarter two of 2010/11 – from this point the market share proportion rises back up towards 25% in the last quarter of 2020/21.

Although they are both ultimately linked to UK population and penetration assumptions, a totally separate forecast is made of datacard subscribers, so that in the first quarter of 2010/11 there are assumed to be 74.0m handset subscribers and 4.3m datacard subscribers. Somewhat lazily however the model takes the same average 2G/3G operator market share proportion for data as for voice. This is simply not correct. Whilst H3G may be a voice laggard, historically they have since 2008 been a datacard leader, at least in terms of sales volumes, with a variable level of active participation in the datacard market over time by the other four operators. Market information suggests that for an extended period from March 2008 H3G's share of new

[47] Although this is modelled as a per subscriber basis, in fact the real relevance to the model is on a total traffic basis, and here H3G's higher than average usage per customer (arising from a focus on post-pay) is of importance.

datacard connections was in excess of 40%[48], leaving at best therefore 15% of the market as an average for each 2G/3G operator. This is very different from the market share of the 2G/3G operator in handsets. It is necessary therefore to separate the datacard market share from the handset market share for the 2G/3G operator.

It is straightforward to detach this linkage and create a new independent average operator market share proportion over time for the datacard market, a range that can then be selected on the scenario worksheet of the traffic workbook. Here the 2G/3G operator market share of the datacard market can be allowed to drop below 20% once H3G aggressively launched its datacard product in 2007/08, and then slowly climb back up to 25% with network consolidation.

The use of this datacard market share for the 2G/3G operator in the model[49] will somewhat reduce the historic overall data traffic volume of the average 2G/3G operator – this seems a reasonable and appropriate adjustment in the light of historical experience, and the result in terms of 2014/15 voice termination impact is shown in table 3.18 below.

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected for ringing time as table 3.16 above	2.3806	1.1076	1.8812
LRIC+ additionally corrected for historic datacard market share	2.3937	1.1486	1.9052
Pure LRIC corrected as table 3.16 above	0.7380	0.5312	0.6569
Pure LRIC additionally corrected for historic datacard market share	0.7481	0.5390	0.6661

Table 3.18 – Revision to reflect more accurate historic datacard market share

GPRS

The model's understanding of 2G data traffic (GPRS) is poor. It assumes that GPRS is solely generated by data activity on handsets that are only 2G capable. This is not correct – whilst some GPRS data traffic is clearly generated in this way, a considerable proportion is from 3G devices, both datacards and handsets, when outside their 3G coverage area. Obviously to some extent demand when outside the HSPA coverage area is choked off as

48 And was over 30% for some months prior to this date – H3G's quoted date for their mobile broadband launch was September 2007

49 Vodafone can supply details of the values it has used to Ofcom if required

a result of the lower speed and reduced customer experience under GPRS, in particular for datacard users, but overall it would appear that the model is underestimating the current volumes of GPRS traffic. The model therefore, to improve fidelity, needs to reflect a shift of data traffic demanded from HSPA to GPRS. It is relatively easy to do this by creating new traffic scenarios on the new data worksheet of the traffic workbook that modify in a matched (but opposite) manner the data usage per 2G and 3G handset, and then selecting these scenarios on the inputs worksheet.

In addition the transfer rate of 2G packet data, modelled at 9.1 kbps per channel, is too low, particular given the fact that some operators have implemented EDGE on 2G, which gives a significantly faster throughput per channel used. It is suggested that the data rate could be restored to that of 2G voice traffic, i.e. 14 kbps.

Vodafone has modelled these changes, but collectively however, the impact of them, whilst improving the ability of the model to mimic a real 2G/3G operator, makes little real difference to the model outputs, either in 2014/15 MTR or in 2007/08 modelled GBV, as table 3.19 below shows:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.18 above	2.3937	1.1486	1.9052
LRIC+ additionally corrected for the set of GPRS traffic and throughput changes	2.4036	1.1533	1.9131
Pure LRIC corrected as table 3.18 above	0.7481	0.5390	0.6661
Pure LRIC additionally corrected for the set of GPRS traffic and throughput changes	0.7402	0.5325	0.6587

Table 3.19 – Possible 2G data traffic adjustments

Vodafone considers that the complexity of the set of adjustments required on GPRS is greater than the resulting improvement in modelling quality and at this stage therefore it is a topic probably not worth proceeding with in the model.

HSPDA throughput speed is too slow

It was noted above that the throughput of HSDPA is modelled in the future at no greater speed than the existing best practice of 14.4 mbps. It was also pointed out that one of the deficiencies of the 2007 model was its failure to model HSPA, even though its practical implementation was imminent. In a similar vein faster speeds than 14.4 mbps are on the horizon, particularly with datacards, using the HSPA+ family of enhancements. An increase in speed will generally result in a more efficient use of radio access network resources by data services, particularly in comparison with voice services. It is wrong to ignore this prospect in a model that projects services forward through to 2039/40.

Given that this faster speed will give an improved "data downlift" over the vast bulk of the period to 2039/40 it is reasonable to approximate this impact through using higher values than the 6 used in the model. The table (3.20) below experiments with the use of both 7 and 8, in comparison with the voice value of 1, and the release 99 data value of 3.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.18 above for historic datacard market share	2.3937	1.1486	1.9052
LRIC+ additionally corrected with HSPA data downlift at 7 not 6	2.4094	1.1930	1.9322
LRIC+ additionally corrected with HSPA data downlift at 8 not 6	2.4216	1.2305	1.9543
Pure LRIC corrected as table 3.18 above for historic datacard market share	0.7481	0.5390	0.6661
Pure LRIC additionally corrected with HSPA data downlift at 7 not 6	0.7773	0.5517	0.6888
Pure LRIC additionally corrected with HSPA data downlift at 8 not 6	0.7797	0.5610	0.6939

Table 3.20 – Impact of improving rising data efficiency

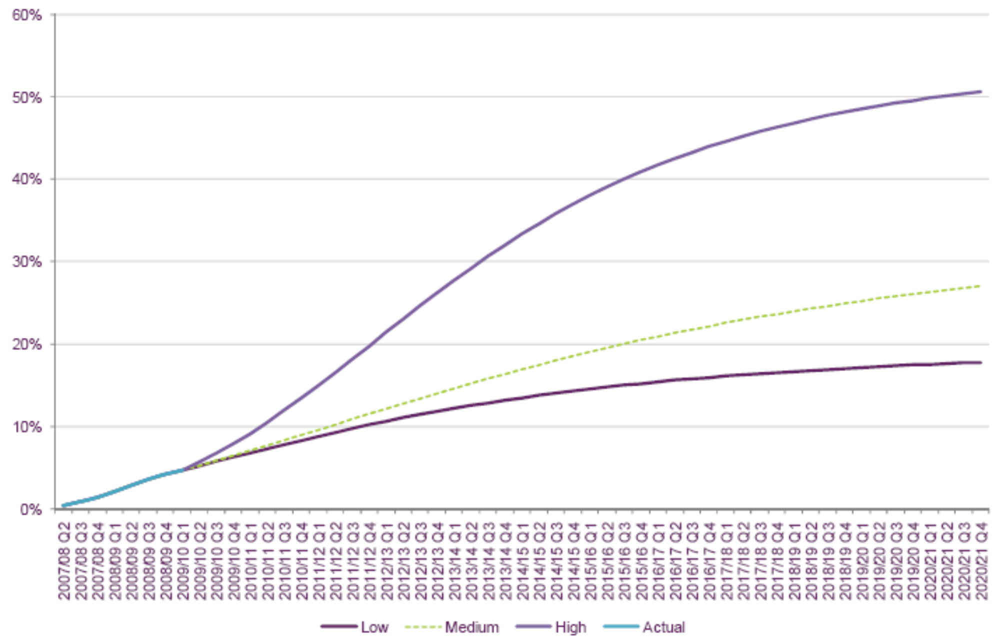
Vodafone considers that it is reasonable to expect some future performance improvement in data throughput speeds and resource efficiency and that from a conservative point of view an adjustment of 7 should be adopted.

HSPA: datacard penetration

Ofcom's market forecast of datacard penetration shows a continued increase up to 2020/21 (after this point all inputs are frozen and the model merely runs with constant inputs). From 4.74% of the population in Q1 2009/10, a value which appears from the new inputs worksheet of the traffic workbook to be an "actual" rather than a forecast, to 9.60% in Q1 2011/12, to 14.64% in Q1 2013/14, to 19.04% in Q1 2015/16, to 25.24% in Q1 2019/20 to 27.04% at the end of 2020/21, the proportion never stops rising, so that by this date the model is assuming that there are 17.25m active datacards in the UK. To be clear this is not 17.25m active data users on handsets, this is 17.25m separate subscriptions of customers using datacards or dongles to access mobile data on their PC.

Ofcom positions this as a medium assumption, as it posits a low closing penetration of 17.80%, or 11.35m devices, and a high penetration of 50.59%, or 32.26m devices. We reproduce below Ofcom's figure 12 from annex 8 of the consultation.

Figure 12: Forecasts for datacard take-up



Vodafone considers that in fact all three Ofcom scenarios are excessive in the context of a model that is only considering data on 3G.

One forecast that is relevant is that of Enders. In their report entitled UK Residential Broadband market, trends and projections to 2014, November 2009, they review total datacard net additions per year, and report an actual in use at December 2008 of 2.3m (Ofcom has 2.2m for the quarter), and a forecast at December 2009 of 3.5m (Ofcom has 3.6m). But Enders reports:

> *"We estimate that total datacard/dongle mobile broadband additions in 2009 will be around 1.2m, a shade below the 2008 figure of 1.3m. Net additions in the second half of the year were strongly supported by prepay purchases, with dongles now available for as little as £20, and strongly appealing to the itinerant target market. We expect the net additions of dongles "in-use" to continue to drop off over the next few years, as the target markets saturate, although the preponderance of occasional-use prepay may distort reported/quoted figures. There continues to be little evidence of significant direct substitution of fixed broadband, with the popularity of prepay packages suggesting that many dongle purchases were never interested in the long term commitment of a fixed service. We*

continue to view datacards /dongles as a strong product for itinerants who do not have a fixed line, mobile workers and gadget geeks who want mobile broadband in addition to fixed, but it is a poor substitute for fixed line broadband."

Whilst not necessarily endorsing all of these sentiments, certainly Enders is right both in that the net growth rate has slowed and in that the bulk of the gross connections in the total market are now prepay rather than contract. The rate of gross connections for contract datacards is about half that of the peak in 2008, and below the levels experienced in 2009. Prepay gross connections are in 2010 somewhere below the peak experienced in autumn 2009, as in the graph of consumer sales (for the total market) shown below.

✂

Figure 3.1 – Consumer datacard sales

Similar points were expressed by Analysys Mason in December 2009[50]. They report survey results (on page 26) that "most of the respondents who have not (yet) taken up mobile broadband services are not interested in doing so – in the UK 69% would not consider taking the service". They also report on page 27 of the same document that:

"Consumers show little interest in migrating fully from fixed to mobile broadband: most will retain their fixed-line service and use mobile services as a complement for the foreseeable future. More than 70% of respondents that have fixed and mobile broadband subscriptions plan to retain both, which indicates that consumers prefer to use each service type for specific applications. 13% of respondents intend to drop fixed

[50] The connected consumer: a survey of telecoms and media usage, Analysys Mason research report, Dec 09

broadband and switch to using only a mobile service. A further 13% plan to abandon mobile broadband and switch or return to DSL- or cable-based services only, indicating that there could be substantial mobile broadband churn."

We note also that Ofcom is in accord with these points:

> "*Despite initial optimism about the potential of mobile broadband to offer a competitive proposition to fixed broadband, many recent surveys have highlighted the relatively slow speeds delivered (compared to fixed broadband) and a generally low level of user satisfaction. 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, mobile broadband is largely used as a complement to fixed broadband, and only to a limited extent as a substitute. We anticipate that this situation will remain unchanged, and have assumed that under all demand forecasts, mobile broadband will largely remain a complement to fixed broadband."*[51]

Given the maturing market and the likelihood of accompanying rising churn all of this evidence suggests a considerable slowing down in the growth of active customers, together with a dilution in average usage arising from the change in mix between contract and prepay users. Ofcom's expectation of virtually straight-line growth looks somewhat unrealistic.

Comparing Enders' and Ofcom's forward looking forecast of datacard customers in table 3.21 below brings out this point. It is hard to see how Ofcom's assumption of continual growth can be realistic or reasonable.

[51] Consultation at A8.52

Active datacard users in millions per year	Enders		Ofcom	
	Year end	Growth	Year end	Growth
2008	2.3	+1.3	2.2	+1.3
2009	3.5	+1.2	3.6	+1.4
2010	4.6	+1.1	5.1	+1.5
2011	5.4	+0.8	6.7	+1.6
2012	5.9	+0.5	8.3	+1.6
2013			9.8	+1.4
2014			11.2	+1.4
2015			12.5	+1.3
2016			13.6	+1.1
2017			14.7	+1.1
2018			15.6	+0.9
2019			16.4	+0.8
2020			17.1	+0.7

Table 3.21 – Ofcom and Enders forecasts of active datacard users

There are two relevant considerations here. In the first place, Ofcom's forecast simply looks too high at an absolute level, particularly in the context of slowing gross additions, rising churn and the change in mix towards prepay users. But in the second, it could be argued that the advent of LTE in the relatively near future will mean that a large proportion of the high volume data users will spend the majority of their time on a network that is not being modelled at all. At the extreme, it is not impossible that virtually all datacard traffic could be on LTE (at least whilst in LTE coverage areas), and data usage on 3G primarily limited to smartphones, and thus at much smaller volumes (the Ofcom volume assumptions mean that in 2020/21 82% of 3G data activity is on datacards).

It is probably simpler to ignore the latter suggestion, at least in the implication that LTE might need to be modelled as well, (or possibly any shared assets that might arise from this), but rather on a compromise basis that acknowledges both points revise the forecast so as not to allow active datacard volumes on 3G to grow anything like as fast as Ofcom has modelled. Vodafone suggests adoption of the Enders market forecast to the end of 2012, and then to grow the market at just over 0.5m annually to reach 10m datacards at the end of 2020 (still a penetration rate against the whole UK population of over 15.5%). Since Ofcom has left spare growth scenarios in the datacard penetration section of the new data worksheet this is straightforward to implement in the model.

The result of this on the termination rate in 2014/15 can be seen in table 3.22 below.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.20 above, data downlift of 7	2.4094	1.1930	1.9322
LRIC+ additionally corrected with lower future datacard penetration	2.4836	1.3205	2.0273
Pure LRIC corrected as table 3.20 above, data downlift of 7	0.7773	0.5517	0.6888
Pure LRIC additionally corrected with lower future datacard penetration	0.7679	0.5346	0.6764

Table 3.22 – Correction for lower future datacard penetration

<u>Network design inputs to the model</u>

We noted in the calibration section above that the original Ofcom model built too many sites too early, but was a little light on micro site quantities and very light on 2G TRX volumes. These differences between the model and historic reality should be borne in mind as part of the review of the network design elements of the model. Vodafone in its review uncovered several topics worthy of revision, including operator site sharing, 2G and 3G coverage proportions and radii, TRX quantities and the spread of traffic across a geotype. However these topics only skim the surface: there are other areas of concern that have been ignored as having little impact, and others that Vodafone has not as yet had the time to investigate.

The starting point for the review of the network design inputs is the Vodafone amended version incorporating the mechanistic model corrections and the traffic input assumption changes, as discussed in the preceding two sections. This gives a revised set of cost recoveries as per the table below:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.22 above	2.4836	1.3205	2.0273
Pure LRIC corrected as table 3.22 above	0.7679	0.5346	0.6764

Table 3.23 – Result of model corrections to date

Site sharing between operators

The 2010 version of the model unlike that of 2007 incorporates the emerging practice of sharing of sites between network operators. Vodafone has some specific criticisms as to how this change has been implemented in the model. The model assumes that site sharing starts for macro sites (micro and pico sites are not shared between operators) in the first quarter of 2007/08 and that the proportion of sites actually shared grows at 12.5% annually, so that by the end of 2014/15 100% of the operator's macro sites are shared.

Rather than creating a new asset type of a shared site, what has been done is (fairly reasonably) to adjust the future costs of the existing site build asset. From a capital point of view the model assumes that *all* new macro site builds from 2007/08 will be shared sites, and that the cost of such a site is half that of a non-shared site, so the unit capital cost of a site build is halved between 2006/07 and 2007/08 from £91,089 to £45,545. From an operating cost point of view it is also assumed that costs will be halved by sharing, so that the effective average operating cost falls in relation to this factor together with the rising penetration of site sharing across the base of macro sites over the period from 2007/08 to 2014/15. Finally the model assumes that for each operator 50% of their sites in existence will be shared, and the remaining 50% abandoned. For each site that is shared, there is an additional capital cost of £17,000 for the upgrade. For each site that is abandoned, there is a site transformation or decommissioning cost of £20,000 (these are described in A8.72 of the consultation). Two additional capex only asset types are modelled to accommodate these changes, named shared sites and transformation sites. The final change as a result of this site sharing is that the model assumes an increase in 3G population coverage from the 90% of the 2007 model to 92.4%, since it is presumed that the smaller cost of site build will increase the depth of 3G coverage.

There are several issues that Vodafone can see with how these changes have been implemented. The most obvious relates to the new asset types of transformation sites and shared sites. The sum of these two should exactly match the total number of macro sites. However in 2014/15 the model (as currently amended) is showing 9,712 macro sites, presumably all of them shared, but only 2,428 shared sites and 2,428 transformation sites, a total of 4,856 – the model is obviously building exactly half the number required. The problem appears to lie on the asset demand for costs worksheet of workbook 2, where these sites are being dimensioned – a 50% scalar is being applied twice to each of the two asset types, not once. This is easily adjusted for, but this in our view is not the best way to model operator site sharing.

Vodafone does not agree with the 50% capex price cut imposed in 2007/08 – in reality the need to spend either £17,000 or £20,000 on a site to allow it to be shared means that the unit cost of new site build falls not from £91,089 to £45,545 but to £45,545 plus the average of £18,500, or £72,589, a price reduction of 20.3%, not 50%. Setting this price reduction in the parameters worksheet of workbook "0 – scenario control" and removing the cost of the shared sites and the transformation sites from the same worksheet gives the following results:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.23 above	2.4836	1.3205	2.0273
LRIC+ additionally corrected for site sharing unit capex costs	2.4935	1.3296	2.0369
Pure LRIC corrected as table 3.23 above	0.7679	0.5346	0.6764
Pure LRIC additionally corrected for site sharing unit capex costs	0.7715	0.5378	0.6798

Table 3.24 – Site sharing unit capex costs correction

The next issue relates to the timing and extent of site sharing. There is a considerable time lag on the construction of cell sites – it is not reasonable to start site sharing site builds as early as April 2007. In reality it would take time even for the hypothetical average efficient operator to start sharing sites, following on from a sharing decision. There are effectively two different types of sharing that could be undertaken: sharing of new sites, and sharing of existing sites. The former is probably much easier to achieve than the latter, but the model is not in fact building many new sites a year in 2007/08 onwards, so the scope of this sharing is somewhat limited. Taking a common view between operators on which existing sites to abandon and which to consolidate, and then actually implementing this would take rather longer. Nor is it reasonable for the model to assume that 100% of sites will be shared – a lesser proportion, say 90% is a more realistic expectation. These considerations are easily modelled in the same worksheet as above by delaying the site sharing rollout by 12 months (still leaving a very aggressive timetable) and reducing the cost reductions in capex and opex by 10%, to allow for a mix of shared and non-shared sites in the future. This gives the following results as shown in table 3.25:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.24 above	2.4935	1.3296	2.0369
LRIC+ additionally corrected for site sharing deployment timetable and depth	2.5153	1.3496	2.0580
Pure LRIC corrected as table 3.24 above	0.7715	0.5378	0.6798
Pure LRIC additionally corrected for site sharing deployment timetable and depth	0.7777	0.5432	0.6857

Table 3.25 – Site sharing deployment correction

We also have issues with the interaction proposed by Ofcom between site sharing and the resulting changes in area coverage by geotype and coverage cell radii for both 2G and 3G, but these are problems best dealt with in the context of overall 2G and 3G coverage, in the sections below.

2G coverage and coverage radii

2G parameters and input values have generally been preserved unchanged in the 2010 edition of the model from the 2007 version, but oddly one particular area that has changed is the coverage radii by geotype, that determines the area over which coverage can be attained by each cell site (from its location at the centre of each hexagon). These have been reduced with respect to their initial value at the launch of 2G in 1992/93, thus increasing the number of coverage sites required to be built by the model. Also, the coverage radii have been further reduced slightly in the period 2007 to 2011: it is presumed that this is some form of response to site sharing, in that overall area coverage is being improved by mixing and matching the best sites of each participating operator, but this will involve an overall increase in sites built. The values used by the 2007 and 2010 models for radii in km are shown in table 3.26 below.

Cell radii by geotype: 2G	2007 model	2010 original values	2010 model in 11/12
Urban	1.1	1.0	0.961
Suburban 1	2.1	1.85	1.777
Suburban 2	2.1	1.95	1.873
Rural 1	4.0	3.5	3.362
Rural 2	4.33	4.33	4.163
Rural 3	5.33	5.33	5.123
Rural 4	8.33	8.33	8.005
Highways	5.33	5.33	5.123
Railways	4.33	4.33	4.163

Table 3.26 – 2G Cell radii by geotype 2007 and 2010 model versions

What this means is that the model is building more 2G coverage sites in the 2010 version than in the 2007 model, and then adding yet more between 2007 and 2010. Strangely, the 2007 version made no such change from the cell radii values it inherited from previous versions[52], yet the 2007 model as has been seen offered a superior calibration to the 2010 version. It is hard to see why this change have been made at this time, given that 2G coverage was basically established in the last decade of the last century, and the observation from the calibration exercise that the 2010 model appeared to be building sites too early, an indication of a problem with coverage rather than capacity. If the previous coverage radii were acceptable for the previous two charge control cycles, it is difficult to see why they should be changed now. Ofcom has made no sort of case as to why the change between the versions is correct: table 6 on page 95 of annex 8 of the consultation merely reports the change, rather than explaining it. Given the superior calibration performance of the old model, it is more reasonable to revert to the old coverage radii.

It is noticeable that the geotypes where Ofcom has reduced the coverage radii are in fact those that are the most populous and traffic intense. It may be that the model is in fact under-building sites in these areas, but there is nothing to say that these are coverage sites – it is more likely that any additional site required is in fact being established for capacity reasons. The adjustment therefore to maintain site build calibration in 2009/10 needs to be a two stage correction – reverting to the old cell radii but also changing an utilisation

[52] In fact the 2007 model changed very few 2G parameters from the previous version

assumption to increase the number of capacity sites. The most obvious place to adjust for the latter is on the 2G cell site scorched utilisation allowance which can be changed on the utilisation worksheet of workbook 2 from 90% to 85%. This gets back to a similar number of sites built in 2009/10, but with lower volumes built in earlier years, thus improving the overall calibration.

One area where Vodafone does agree with Ofcom is that in geotypes where the sites are dimensioned for coverage, not capacity, the impact of the operator site sharing will be to increase the number of cell sites as sites are jointly selected to improve the overall coverage of the network[53]. This is best reflected in a gradual reduction in cell site radii between 2010/11 and 2015/16, the end date for operator site sharing implementation. In the 2G part of the model, only the urban and suburban 1 geotypes are capacity dimensioned: therefore it is appropriate to expect a small reduction in cell radii for the remaining geotypes over the 2010 – 2016 period. This can be modelled for these geotypes at the same rate adopted by Ofcom in its radius reduction for 2007 to 2011, i.e. 1% per annum.

The overall impact of these three changes gives the following outputs in 2014/15:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.25 above	2.5153	1.3496	2.0580
LRIC+ additionally corrected for 2G cell radii & utilisation	2.5134	1.3495	2.0575
Pure LRIC corrected as table 3.25 above	0.7777	0.5432	0.6857
Pure LRIC additionally corrected for 2G cell radii & utilisation	0.8075	0.5595	0.7104

Table 3.27 – 2G cell radii and cell utilisation correction

2G TRX numbers

It was established in the calibration section above that the model is a long way behind the actual number of TRXs deployed in the average real world network in 2004/05. The actual reported MNO volume from table 3.5 above was 67,530, the 2007 model output was 63,481, and the 2010 original output was 58,879. Currently after the Vodafone changes above, the model is building 63,516 TRXs so the calibration is a good deal better, but the volume is still a little light.

[53] This principle is unlikely to apply where there are already more sites than those required for coverage, i.e. where the sites are now being dimensioned for capacity

The most obvious lever to push to increase the number of TRXs without impacting cell site numbers at all is to increase the minimum number of TRXs per macrosite above the current modelled value of one. A value of 1.5 (i.e. assuming the half the sites built for coverage only have one TRX per sector, and half have two) would appear to be a reasonable result, since this gives 67,141 TRXs, very close to the actual reported operator number. This changes the cost outputs as follows:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.27 above	2.5134	1.3495	2.0575
LRIC+ additionally corrected for TRX calibration	2.5323	1.3495	2.0689
Pure LRIC corrected as table 3.27 above	0.8075	0.5595	0.7104
Pure LRIC additionally corrected for TRX calibration	0.7957	0.5581	0.7027

Table 3.28 – TRX calibration improvement

3G coverage and coverage radii

Whilst we appreciate that Ofcom has increased the population coverage for 3G as a result of operator site sharing to 92.4% from 90%, we question whether this goes far enough, in a world where Ofcom envisages 100% (reduced by Vodafone to 90%) of all macro sites are shared. This 92.4% population coverage represents an area coverage of 42.4% (per the inputs worksheet of the traffic workbook). By contrast the 2G population coverage of 99.0% gives an area coverage of 96.8%. This implies therefore that some 54% of the UK by area will be covered by sites newly shared between two operators that only have had 2G equipment installed. It is hard to see that this is all that likely – it is more reasonable to expect that where an operator has to go to a newly shared site it will install both 2G and 3G equipment. As a consequence rather more of these sites will be equipped with 3G equipment as well as 2G equipment than Ofcom is forecasting. On a very conservative basis Vodafone has assumed a 3G area coverage of just under 55% by the end of the decade: this increases the population coverage by only one percentage point, to 93.4%. (This adjustment also obviously increases the proportion of 3G terminated voice traffic and hence changes the relative weighting of 2G and 3G in the overall blended termination rate.)

On a minor point we noted in the calibration review section that the model was a little behind the curve on 3G node B deployment – it currently shows 2,506 in service compared with the MNO reported average of 3,439 at 2004/05.

This is easily corrected by bringing forward the 3G coverage percentage rollout slightly in the middle of the last decade.

These two changes give a result that is shown in table 3.29 below:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.28 above	2.5323	1.3495	2.0689
LRIC+ additionally corrected for 3G coverage deployment	2.5389	1.3662	2.0773
Pure LRIC corrected as table 3.28 above	0.7957	0.5581	0.7027
Pure LRIC additionally corrected for 3G coverage deployment	0.7936	0.5580	0.7008

Table 3.29 – 3G coverage deployment revised

Ofcom have also adjusted slightly the 3G coverage radii from the 2007 model version, as per table 3.30 below.

Coverage radii in km: 3G	2007 model	2010 model
Urban	0.5	0.5
Suburban 1	0.85	1.05
Suburban 2	1.4	1.70
Rural 1	3.64	3.64
Rural 2	3.94	4.20
Rural 3	4.85	4.85
Rural 4	7.58	7.58
Highway	4.85	4.85
Railway	3.94	3.94

Table 3.30 – 2007 and 2010 3G coverage radii

It is not really clear why this has been done: the consultation merely says on page 97 that these changes result from the calibration process: but given the degree of coverage established to date, and the fact that geotypes are not homogeneous, and that there are likely to be rather more coverage gaps at present on 3G than 2G, it may be premature to judge that these increases in coverage radii and hence reductions in the number of coverage sites should be imposed. There is insufficient data to be certain, however.

Comparing 2G and 3G coverage radii, for the urban and suburban 1 geotypes, the 3G cell radii are very much less than the 2G values: it is presumed that this is a product of deeper indoor coverage and cell breathing/interference issues (but if the latter then these are potentially more capacity than coverage related). However for rural 1 and rural 2 geotypes, the area coverage of 3G is assumed to be greater than 2G; this cannot be right. It may be, given the current low level of 3G deployment in the rural 1 and rural 2 geotypes that these large radii values are presently correct for those few sites that have as yet been built, but they might be expected to fall as area coverage in these geotypes becomes more widespread. The logical solution to this is progressively to reduce the 3G radii for these geotypes on a prospective basis, to bring them down to say 95% of the 2G values, i.e. 3.14km for rural 1 and 3.88km for rural 2.

But there is a larger issue with 3G that needs to be addressed instead. The model is currently building by 2020/21 only 8,072 3G macro sites, 686 3G micro sites, and 54 3G pico sites, a total of 8,812 sites. Given the high traffic volumes anticipated and the consequent need for indoor coverage, there is considerable doubt as to whether this is enough. By comparison, Ofcom in the spectrum review consultation of 2009[54] was of the opinion that according to table 25 of annex 13[55] approximately 9,000 sites at outdoor coverage or 12,700 sites at indoor coverage would be required to support a reasonable data volume, but this was only for coverage and traffic capacity out to the 80% population coverage level. Vodafone by contrast argued in our response to the spectrum consultation that approximately ✂ sites at 2100MHz would give reasonable coverage/capacity to 80%, but that a further ✂ sites would be required to add a further 15% population coverage. Furthermore a presentation by the CEO of H3G UK suggested a target of 13,000 3G sites, giving 98.5% "mobile broadband population coverage"[56]. This indicates that perhaps 10,000 macro sites might be required to be modelled as an absolute minimum to achieve respectable coverage of the 94.4% currently in the model. With only 8,072 3G macro sites and 8,812 3G sites in total being built by the model even by 2020/21, it is some way short of the likely necessary total.

Clearly these sites have not yet been built in the real world, so they need to be added in the future into the model (the additional future sites should not impact the historic financial calibration). The logical place to start adjusting the model is in the suburban 2, and rural 1 geotypes, since these represent the bulk of the 80% coverage area, and the urban and suburban 1 geotypes already contain a significant number of sites, at 1 site per 0.65sq km for urban, and 1 site for every 2.3sq km in the suburban 1 geotype, whereas in the suburban 2 geotype there is only 1 site for every 7.53 sq km, and 1 site for every 37 sq km in the rural 1 geotype. An increase in site numbers can be

[54] Application of spectrum liberalisation and trading to the mobile sector – a further consultation, Ofcom February 2009
[55] Page 108
[56] Kevin Russell, Embracing the Internet, 2009

achieved by progressively reducing the cell site radii, down to close to that for suburban 1 for the suburban 2 geotype, say to 1.2km by 2014/15. Similarly the rural 1 geotype radius can be reduced a little, from 3.64 to a little below the 2G's value of 3.30 km, or say 3.15 km.

There is a slightly different problem with rural 2, where the cell radius for 3G is currently set at 4.20 km, i.e. rather more than the 2G value of 4.08 km. There is a certain implausibility to these values. The 2G radius relates to coverage at 1800MHz, and the 3G radius to coverage at 2100MHz. Distance attenuation rises with spectrum frequency, so one would expect that the 3G radius would be consistently a little below their 2G equivalents (or at very best equal to it, as it the case for the rural 3, rural 4, highway and railway geotypes). So the 3G radius for rural 2 can be adjusted down to around 3.90 km over the same time period as the rural 1 and suburban 2 adjustments.

Unfortunately the 3G part of the model, unlike the 2G component, cannot properly cope with shrinking cell radii, since it only builds additional coverage sites in the year that are related to the incremental area produced by any change in area coverage. The workbook needs a little modification to permit geotypes to be dimensioned from a coverage point of view in a similar manner to 2G, i.e. cumulative sites to cumulative area. Having achieved this, then the adjustments to the cell radii described above increase the number of 3G macro sites in 2020/21 to 10,061, a total that appears in line with the minimum expectation of 10,000 3G macro sites to achieve 94% population coverage.

The impact of these changes on the model's outputs is shown in table 3.31 below:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.29 above	2.5389	1.3662	2.0773
LRIC+ additionally corrected for 3G coverage radii and 3G site numbers	2.5501	1.4286	2.1086
Pure LRIC corrected as table 3.29 above	0.7936	0.5580	0.7008
Pure LRIC additionally corrected for 3G coverage radii and 3G site numbers	0.7868	0.5522	0.6945

Table 3.31 – 3G coverage radii corrections

Utilisation and non-homogeneity

Ofcom reports in A8.82 that it has eliminated the 3G non-homogeneity adjustment as being complicated and different from that used by the 2G network dimensioning. It claims to have replaced it with a method that matches that of 2G, i.e. using utilisation adjustments only, and in fact appears to use the same utilisation values as 2G, i.e. 80% for the carrier/TRX and 90% for the cell. However this is not entirely correct, since in fact the 2G model *also* includes a 0.5 TRX non-homogeneity adjustment[57], which is aimed at representing in some way the fact that traffic is not evenly distributed across each geotype and that this fact will lead to a larger equipment requirement than that resulting from traffic that is totally uniformly distributed across the geotype. Vodafone cannot see that Ofcom has retained or introduced a similar adjustment in the case of the 3G dimensioning rules. One might reasonably expect therefore that in the absence of this specific factor for 3G, it would be sensible to reflect it by applying a utilisation factor that is lower than the 2G value.

In fact the reverse position is inadvertently true in the model, since there is a range addressing failure in the utilisation worksheet of workbook 2, so that although the 3G cell utilisation value is given as 90%, in reality a value of 95% is picked up in error from an adjacent row. This can be verified on the network design 3G worksheet, where the macrocell utilisation factor, the product of the cell and equipment factors is given as 76%, i.e. 80% * 95%, rather than the 72% that should result if the desired value of 90% was actually being applied. Vodafone has corrected this addressing issue, and considers that a lower value than 90% to account for the absence of a non-homogeneity factor for 3G is in order. Given that the 2G non-homogeneity factor effectively reduces average 2G capacity from 4.5 to 4.0 TRXs, or some 11%, a utilisation factor for 3G of the original value of 90% * (100% - 11%), or 80% would appear reasonable.

The effect of this change is shown in table 3.32 below.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.31 above	2.5501	1.4286	2.1086
LRIC+ additionally corrected for 3G cell utilisation	2.5517	1.4371	2.1130
Pure LRIC corrected as table 3.31 above	0.7868	0.5522	0.6945
Pure LRIC additionally corrected for 3G cell utilisation	0.7908	0.5739	0.7055

Table 3.32 – 3G non-homogenisation correction

[57] Used in the capacity section of the network design 2G worksheet of workbook 2

Cost allocation rules in the model

The model generally follows the sensible principle of matching the cost recovery to the dimensioning method, i.e. whatever is causing the cost, in relation to the demanded resources per unit multiplied by the unit volume, is also used to recover that cost. But this principle is not always applied. There are several areas of the model over which Vodafone has some concern that the cost recovery is not following the underlying cost causation, such as the network busy hour, the voicemail adjustment, voice erlangs, and the switch site driver. Most of these concerns arise from the changed circumstances of the 2010 model over the 2007 model, particularly in relation to the increased importance of data in the current version. Some occur where a particular asset is being dimensioned indirectly, i.e. is in fact dimensioned not directly from a particular traffic volume, but from the quantities of another asset, but its cost is being directly recovered from a particular traffic/cost driver. It is easy here for a disconnect between dimensioning and recovery principles to arise. For example the number of backhaul links required is not in the first instance determined by the total backhaul traffic, but by the number of cell sites built which in turn results from separate 2G and 3G dimensioning rules. The cost of the backhaul links however is directly recovered via a single driver – the test therefore is how closely this driver resembles the underlying dimensioning principles.

The starting point for this section of the analysis is the 2014/15 termination rates from the final table from the network design inputs section above, as table 3.33 below.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.32 above	2.5517	1.4371	2.1130
Pure LRIC corrected as table 3.32 above	0.7908	0.5739	0.7055

Table 3.33 – Brought forward adjusted outputs from the model

Data network busy hour adjustment

In the 2007 and prior versions of the model, all services have been assumed to have the same busy hour profile, in that they bear a constant relationship between the peak level used for network dimensioning, and the total volume in the period. Given that it is the total traffic volume rather than the peak volume that is used for cost recovery calculations (in the network element output array from workbook 2) this congruence is important. It has been possible in the past for the model to sum the peak levels of each service (when converted to a consistent unit and weighted for resource consumption) and use the overall peak to determine the volume of the particular asset element required, but to subsequently recover the costs of that asset with reference to the *annual* traffic volume weighted by the same resource consumption assumptions.

But this strong link between peak and annual traffic volumes is compromised where different services have different peak proportions. Vodafone identified this point to Ofcom in 2006: at that time it appeared that GPRS packet data on 2G was showing a flatter profile than voice services, in that demand for data was more evenly spread across the day, and the week, than voice. Vodafone suggested that this was likely to also apply to 3G packet data, although there was at the time insufficient information to be certain of this.

This issue obviously becomes more relevant as the volume of data rises. Ofcom in its information requests in 2009 specifically asked for data on this point, looking for the busy hour/month proportion for each service family (i.e. voice and data) and also the *network* busy hour/month for a service where that was different from the *service* busy hour/month for that service. The information that Vodafone supplied to Ofcom (on the basis of busiest hour in the month, not the average of the busy hours in the month, as was requested by Ofcom) suggested that data usage was approximately ✂% flatter than voice. To a very limited effect this differentiation has been reflected in the model. In fact in the model Ofcom has assumed a BH/day proportion of 8% for voice services, and 7.5% for data services, a discount of 6.25%. We welcome this differentiation, even though we believe it is insufficient.

But what this change has meant however is that there is now a mismatch between cost dimensioning and cost recovery, since the latter is being done on annual volumes, where the lower impact of data on peak dimensioning as a result of its flatter usage profile is not being recognised. In the same way that data, when considering the dimensioning of assets in the radio access network is adjusted in the cost recovery for the data downlift factor (that acknowledges that a bit of data uses less resources than a bit of voice), the different time of day profiles should be similarly recognised to down-scale the contribution of data to the busy hour network dimensioning.

The fact that the model is currently faulty can be demonstrated by varying the busy hour proportions of data. At present the model is showing from 2006/07 onwards a BH/day proportion of 8% for voice services and 7.5% for data. If we assume for example that data has a very flat profile, of 3.75%, what this means is that the volume of data in the busy hour has been halved, but the annual total is unchanged. What one would expect to see from this in the model's outputs is a significant shift of cost recovery away from data to voice, with a falling data cost and a rising voice cost. But what actually happens in the model output if peak data loads are halved is a small reduction in the data cost per MB in 2014/15 from 2.349 p to 2.291 p but one that is coupled with a small *reduction* in the voice termination cost per minute from 2.113 ppm to

2.090 ppm. The disconnection between cost causation at the busy hour and cost recovery on annual volumes is apparent.

The solution is straightforward: as was discussed above, what needs to be done is to reflect the lower relative resource usage arising from the flatter time of day profile into the cost drivers that are on the cost driver worksheet of workbook 2. Since these cost drivers are also used in dimensioning, it is important that this adjustment is not double counted, so as a first step the data busy hour proportion must be set to the same level as voice, and then data is “diluted” in the traffic cost driver section in the same worksheet with respect to degree to which data exhibits a flatter profile than voice. The 7.5% to 8% BH/day ratios used by Ofcom for data and voice imply a data dilution factor of 0.9375. Vodafone however believes that this is conservative, given the rising datacard demand and the likelihood that increasing mobile internet activity will be at the weekend or very late in the evening, tending to flatten further the data busy hour/month ratio. Vodafone suggests that a data dilution factor of 0.9 is a more appropriate value to use, but one that is still conservative.

Table 3.34 below shows the result of this change.

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.33 above	2.5517	1.4371	2.1130
LRIC+ additionally corrected for data busy hour dilution, using a 0.9375 factor, as Ofcom	2.5688	1.4717	2.1369
LRIC+ additionally corrected for data busy hour dilution, using a 0.9 factor	2.5774	1.4893	2.1491
Pure LRIC corrected as table 3.33 above	0.7908	0.5739	0.7055
Pure LRIC additionally corrected for data busy hour dilution, using a 0.9375 factor, as Ofcom	0.7908	0.5739	0.7054
Pure LRIC additionally corrected for data busy hour dilution, using a 0.9 factor	0.7917	0.5645	0.7022

Table 3.34 – Correction for data busy hour dilution

Voicemail adjustment

Another adjustment that is new to the 2010 version of the model is a cost driver adjustment relating to voicemail. Ofcom has taken the view that 4% of voice calls terminate on voicemail, not on a handset, and thus the volume of voice calls should be reduced by 4% in the radio access network when dimensioning (and recovering cost). Accordingly voice traffic is discounted by 4% on the following drivers:

- 2G total traffic. This is used to recover the costs of 2G cell site equipment, TRXs and BSCs, 2G licence fees and network management systems costs;

- 2G circuit switched traffic, used to recover MSC RAN facing port costs;

- 3G total traffic, used to recover 3G RNCs and network management systems costs;

- 3G radio interface traffic, used to recover 3G cell site costs, and 3G licence fees;

- All traffic, used to recover backhaul and main switch site costs;

- All radio traffic, used to recover cell sites and remote switching site costs.

In Vodafone's view, this 4% discount, whilst superficially attractive, does not stand scrutiny. By including it in all these cost drivers that recover the costs of all these network assets, the model is assuming that calls that terminate on voicemail do not use any of the above assets. This is simply not correct. There are several reasons why a call goes to voicemail: for example the phone is switched off, the phone is busy, the phone is not answered, or the phone cannot be found – in only the first will no RAN resource be required for the call itself. In all the other call cases some use of the radio network will be made to attempt to complete the call before diverting the call to voicemail, so if Ofcom's assumption 4% of all calls going to voicemail is the correct proportion, a lesser proportion, say 2% should be used for dimensioning and cost recovery.

But the other issue is that Ofcom has failed to cost the voicemail calls properly – the model is in effect assuming that such calls arrive at an MSC and simply disappear. No other cost of an inbound call that terminates on voicemail is included. This is totally inadequate. If Ofcom is going to distinguish calls to voicemail separately from calls to handsets, then a separate service for such calls should have been created, and all relevant costs attached to these particular volumes, and a weighted average termination cost then created for voicemail and handset terminated calls.

Clearly in the first instance these calls are passed to a voicemail platform, where the calls are recorded. This is not costed in the model, but should have been. But furthermore a call to voicemail is of negative customer benefit unless the customer is notified that a voicemail has been left and picks it up. The normal sequence is that this is automatically done when the handset is next detected as available, or failing which a text message is sent to the handset inviting a call by the customer to the voicemail platform. In practice therefore either approach involves a call leg on the radio access network between the handset and the voicemail platform that should also be considered to be a cost arising from voicemail, on top of the cost of the voicemail platform itself. Thus it is therefore reasonable to assume that the voicemail service costs the network operator more than a call that terminates on the handset, not much less, as the model is currently assuming.

The other defect of the approach is that the model is recovering the costs of terminating the call, at either the handset or the voicemail platform across the total volume of inbound traffic. If the intention was to recover only the costs of calls terminating at the handset, then these costs should have been recovered from a smaller volume, not from the volume including voicemail calls. If in the alternative the cost of all terminated calls is being sought, then the model should have developed a weighted average of calls terminated on the handset and calls terminated on voicemail.

In Vodafone's view therefore this 4% discount is erroneous. We are not arguing that a voicemail call should be treated as being more costly than a "normal" call, given the difficulty of modelling, but just that to avoid the complication of separately modelling the costs of voicemail terminated calls (and potentially also the calls terminated abroad through international roaming) and then weighting the result, the call category and volume adjustment should be disregarded altogether, by setting the 4% adjustment on the scenario worksheet of workbook 2 to zero. This has the following impact on cost recovery, as shown in table 3.35:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.34 above, data dilution factor 0.9	2.5774	1.4893	2.1491
LRIC+ additionally corrected by eliminating voicemail discount	2.6145	1.5209	2.1841
Pure LRIC corrected as table 3.34 above, data dilution factor 0.9	0.7917	0.5645	0.7022
Pure LRIC additionally corrected by eliminating voicemail discount	0.8162	0.5818	0.7239

Table 3.35 – Voicemail cost adjustment corrected

Erlangs rather than voice bits

Another problem on cost recovery that has become relevant as a result of the growth of data services is the differential way that data and voice are dimensioned. The crucial distinction here is between 2G which is circuit switched and 3G which is both circuit switched and packet switched. Circuit switched services, i.e. voice on 2G and 3G, and data on 2G require the availability of a discrete channel – effectively therefore in the radio end of the network they are dimensioned on an erlangs basis, not a simple billed minutes/bytes basis, to ensure that sufficient capacity is made available to support the anticipated peak load at a given QoS. So in the 2G dimensioning, the "network design – 2G" worksheet takes the 2G total BH traffic in mbit/s and converts it to Erlangs by simple multiplication. However when assessing this traffic against the number of TRXs required, the model takes account of Erlang theory, in that it discounts the channel availability to take account of the effectively achievable throughput measured in erlangs of those channels. So for example in the urban geotype an availability of 30 channels gives rise to a throughput of only 21.93 Erlangs. Effectively therefore the dimensioning rule is grossing up the traffic volume by 30/21.93 or 1.37 to take account of the channel reservation issue, when dimensioning 2G radio equipment. This is all perfectly unexceptional, and largely irrelevant to cost recovery by service when all services are circuit switched; however in a mixed circuit switched and packet switched world where the volumes of the latter are large, it becomes relevant.

At least one significant cost group, the cell site[58], is being recovered through the all radio traffic driver, on the basis of all the traffic, 2G and 3G combined, that passes through the sites. This driver however merely sums voice and data together on the basis of mbit/s, and fails to take account of the Erlangs uplift required for voice traffic. It would thus appear that although the voice dimensioning, in terms of number of TRXs and hence the number of sites etc is being done on the basis of the Erlangs/capacity uplift, the cost recovery for the resulting number of sites is not. The recovery method is thus not giving the proper resource weight to voice services. A similar situation exists for backhaul, where the number of channels required in the backhaul link for voice services is equivalent to the number of channels of the TRX, rather than the simple Erlangs or minutes throughput. It is thus necessary to modify some of the cost drivers that recover the costs of these shared 2G and 3G assets to account for this problem.

The simplest way to do this is to create an Erlangs weighted version of the all traffic and the all radio traffic drivers, up-scaling voice traffic by the 30/21.93 factor from the paragraph above. These revised drivers can then be used in the model for cost recovery: the modified all radio traffic driver can be swapped in for recovery of the costs of the cell site assets and remote switching sites, and the modified all traffic driver for the recovery of the costs of the backhaul asset group[59] by selecting them in the routeing factors section of the element output worksheet of workbook 2. Since neither of these drivers are used for dimensioning this change has no impact on the size of the network that is built, it is just that the cost recovery of the relevant assets is as a result of the change achieved in a manner that more closely resembles the way these assets are dimensioned.

[58] As indicated by the "lists" worksheet of most workbooks, this cost group contains the individual asset elements of the macrocell, microcell and picocell site acquisition and lease, plus the transformation and shared sites.

[59] The base unit, the 2-32 mbit/s microwave links and the Ethernet microwave link.

There is one further change to cost drivers that is necessary. At present cost recovery of the main switch sites is achieved through the "all traffic" driver, whereas the principal driver of their costs is the number of MSCs required. The costs of this asset should thus be recovered by the all MSC processing driver that is already in existence[60].

The impact of these three changes improving the relationship between cost dimensioning and cost recovery is as follows:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.35 above	2.6145	1.5209	2.1841
LRIC+ additionally corrected by swapping in the modified all radio traffic driver	2.6410	1.5439	2.2091
LRIC+ as above plus swapping in the modified all traffic driver	2.6598	1.5600	2.2269
LRIC+ as above plus using the all MSC processing driver for main switch sites	2.7039	1.6056	2.2716
Pure LRIC corrected as table 3.35 above	0.8162	0.5818	0.7239
Pure LRIC additionally corrected by swapping in the modified all radio traffic driver	0.8162	0.5818	0.7239
Pure LRIC as above plus swapping in the modified all traffic driver	0.8162	0.5818	0.7239
Pure LRIC as above plus using the all MSC processing driver for main switch sites	0.8153	0.5844	0.7244

Table 3.36 – Aligning cost recovery to dimensioning

All of these adjustments above continue to use a simple basis for recovery of fixed and common costs, where all services are given an equal weighting in terms of their peak throughput and modelled resource usage. But this is not necessarily correct. There are two related considerations: the different nature of voice and data services, and as discussed above whether it is appropriate in this context for data services to recover any quantum of fixed and common costs, given the charging structure that exists in the real world, with data services only recovering their marginal costs.

[60] Strictly speaking the costs of the main switch sites should be recovered on the basis of the weighted average of the dimensioning rules used for each of the asset elements, by technology, located at these sites, weighted by relative numbers/space use – this would be rather complex, so the all MSC driver is a reasonable proxy for this.

The different nature of voice and data services

We raised in one of our responses in the previous consultation cycle[61] the fact that voice and data services were rather different and that this should be reflected in the modelling. Given the significant increase in data volumes since the 2007 model these issues are much more relevant to the 2010 version.

> *"Quality of service and delay tolerance:*
>
> *Circuit switched services such as voice and VT are full on real time services. Either there are sufficient dedicated resources available at call set-up and during the duration of the call, in which case the call will go through and be successfully completed, or there are not, in which case the call will be blocked or dropped. Erlang theory applies to the dimensioning of the network in terms of providing sufficient channels in order to satisfy circuit switch demand to a given QoS.*
>
> *Data services are rather different:*
>
> - *They are not blocked but are queued, and*
> - *They can share resources in several ways*
> - *Multiple data card users could be running sessions simultaneously in the same cell site using significant resources only when uploading or downloading.*
> - *Multiple users who are downloading simultaneously can share resources: this will result in slowing the throughput to each user. Whether this is perceptible to the user will depend on the nature of actual service, its degree of delay tolerance (streaming vs. downloading etc), the buffering on the device and so forth.*
> - *Voice services are dimensioned on a defined QoS/blocking rate – data services are delivered on a best effort basis only[62]."*
> - *"It is likely that all data sessions will be initiated at the mobile end, i.e. the data card will declare itself to the network, rather than have to be found by the location update process. Voice is a full two way mobile service, involving a substantial mobility management process to pass calls from one cell to another as the customer moves and also to find the customer in the UK, or abroad, to*

[61] Vodafone – comments on Ofcom 17th March 2006 LRIC model, May 2006
[62] Ibid, page 72

deliver an incoming call. There is a significant proportion of network resource consumed on this problem of mobility management. A data only network which by contrast generally only has a nomadic requirement could be built much cheaper, and with a higher throughput than a mixed or voice only network.[63]"

All of these points suggest that there are both explicit and implicit prioritisations as well as a mobility management cost premium attached to circuit switched voice services over packet data services in a mobile network. This prioritisation and premium is at present not reflected at all in the model's cost recovery, but should be, particularly in relation to the recovery of fixed and common costs.

On different grounds we made a similar point on the relative weighting of voice and data in our response to the preliminary consultation in 2009, in our discussion on relative voice and data price elasticities[64]. Rather than EPMU, therefore, a stronger weighting of fixed and common costs towards voice and away from data would be a much more reasonable result.

But as discussed above there are sound arguments, based on current pricing structures that data services should only be recovered on an incremental cost basis, with all other services recovering fixed and common costs on an equi-proportional basis.

As discussed in the section below on incremental costing, the current LRIC model is not really suitable to determine an incremental cost outcome, so only a rough indication of the implications of recovering all fixed and common costs from non-data services can be obtained. The best approach is to simply run the model with all data traffic removed, i.e. on a voice and messaging only basis and observe the results. The outputs from this exercise in terms of the LRIC+ of voice termination are shown in table 3.37 below.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.36 above	2.7039	1.6056	2.2716
LRIC+ when run with all data traffic removed	2.8918	2.3754	2.6885

Table 3.37 – Running LRIC+ with no data traffic

This suggests that an uplift on the order of 0.41 ppm to voice termination is necessary if data traffic recovers no fixed and common costs. If in the alternative data were to recover a lower proportionate mark-up of fixed and

[63] Ibid, page 71
[64] Vodafone response to wholesale mobile voice call termination: preliminary consultation on future regulation, July 2009, from page 35

common costs on the grounds discussed above, then the LRIC+ of voice might lie somewhere between 2.27 ppm and 2.69 ppm. This calculation needs to be re-run however, once further adjustments to the model as outlined in the section below have been made.

Costs and financial calibration in the model

One of the major areas adjusted by Ofcom in the 2010 version of the model is that of unit costs, and the related area of price trends. Clearly the level of unit costs over the past and present is a very significant element in any financial calibration – as noted above the 2010 model is very deficient in this regard. The changes made by Vodafone in the sections above have improved it somewhat, as table 3.38 below shows:

Year	MNO Actual	2010 model (originally)		2010 model (now)	
		Output	Difference	Output	Difference
2002	£3,092m	£2,546m	-£546m	£2,731m	-£361m
2003	£3,311m	£2,683m	-£628m	£2,882m	-£429m
2004	£3,629m	£2,884m	-£745m	£3,104m	-£525m
2005	£3,850m	£3,135m	-£715m	£3,400m	-£450m
2006	£3,843m	£3,330m	-£513m	£3,490m	-£353m
2007	£3,969m	£3,436m	-£533m	£3,592m	-£377m
2008	£4,088m	£3,479m	-£609m	£3,602m	-£486m

Table 3.38 – GBV calibration to date

When faced with a capital cost calibration failure, the CC in 2002 made a simple percentage uplift to the output termination value. But this is too crude an approach: it is much preferable to alter the input values of the model so that it outputs something approaching the right GBV and opex totals. The starting point for such an exercise is evaluate the reliability of the 2010 model changes, with a view to lessening their effect in order to restore the quality of the calibration at least back to the level achieved in 2007.

One feature of the 2010 version is that a significant drop in the unit prices for cell site equipment, both 2G and 3G has been engineered. Over the three year period of 2005/06 to 2007/08 unit costs drop at either 35% or 30% per annum in the model. Vodafone is not sure that this change is justified given that the result is a pretty poor calibration between model and reality. The probable problem is that Ofcom have taken too literally the unit price of an asset as being representative of the cost of bringing it and all associated assets into service. The wraparound capital costs can be quite extensive – potentially therefore although these additional costs were implicitly recognised in the 2007 model, they have not been brought into consideration in the closing prices for the 2010 model, and thus the extent of the required price reduction has been exaggerated. We suspect therefore that this adjustment is too steep, and has taken Ofcom further from calibration than is warranted.

It is not only the cost of cell site equipment that has been adjusted. Ofcom has also reduced the cost of the RNC and BSC in line with the cell site equipment and the model is now building too few of them, in comparison with the 2007 model's 2004/05 calibration. The simplest way to address this is to set the BSC and RNC price reductions on line with those of the MSC, to which they more closely resemble, rather than the costs of the cell site equipment. The test of this change is whether it improves the financial calibration.

As table 3.39 below shows, there is a small but visible improvement in the calibration in terms of GBV, but the model is still consistently light in GBV from 2002 onwards however.

Year	MNO Actual	2010 model (before)		2010 model (after)	
		Output	Difference	Output	Difference
2002	£3,092m	£2,731m	-£361m	£2,731m	-£361m
2003	£3,311m	£2,882m	-£429m	£2,882m	-£429m
2004	£3,629m	£3,104m	-£525m	£3,104m	-£525m
2005	£3,850m	£3,400m	-£450m	£3,401m	-£449m
2006	£3,843m	£3,490m	-£353m	£3,495m	-£348m
2007	£3,969m	£3,592m	-£377m	£3,609m	-£360m
2008	£4,088m	£3,602m	-£486m	£3,635m	-£453m

Table 3.39 – Impact of slowing BSC and RNC price reduction

The impact of these changes on the termination outputs for 2014/15 is as follows:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.36 above	2.7039	1.6056	2.2716
LRIC+ additionally corrected by slowing the BSC rate reductions	2.7868	1.6028	2.3208
LRIC+ as above plus slowing the RNC rate reductions as well	2.7817	1.6234	2.3258
Pure LRIC corrected as table 3.36 above	0.8153	0.5844	0.7244
Pure LRIC additionally corrected by slowing the BSC rate reductions	0.8601	0.5844	0.7516
Pure LRIC as above plus slowing the RNC rate reductions as well	0.8601	0.5970	0.7565

Table 3.40 – Impact of slowing down BSC and RNC price reductions

The next step should be to slow the rate of decline of 2G and 3G cell site equipment as discussed above – at present the capital costs are declining by 30-35% per annum. Reducing this to 20% gives the following results on GBV, considerably improving the overall calibration to the MNO actual values:

Year	MNO Actual	2010 model (before)		2010 model (after)	
		Output	Difference	Output	Difference
2002	£3,092m	£2,731m	-£361m	£2,731m	-£361m
2003	£3,311m	£2,882m	-£429m	£2,882m	-£429m
2004	£3,629m	£3,104m	-£525m	£3,104m	-£525m
2005	£3,850m	£3,401m	-£449m	£3,401m	-£449m
2006	£3,843m	£3,495m	-£348m	£3,503m	-£340m
2007	£3,969m	£3,609m	-£360m	£3,649m	-£320m
2008	£4,088m	£3,635m	-£453m	£3,715m	-£373m

Table 3.41 – Impact on GBV of slowing cell site price reductions

The 2014/15 termination costs have changed as per table 3.42 below.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.40 above	2.7817	1.6234	2.3258
LRIC+ additionally corrected by slowing the 2G cell site capex reductions	2.9309	1.6186	2.4144
LRIC+ as above plus slowing the 3G cell site capex reductions as well	2.9254	1.7041	2.4446
Pure LRIC corrected as table 3.40 above	0.8601	0.5970	0.7565
Pure LRIC additionally corrected by slowing the 2G cell site capex reductions	0.9123	0.5970	0.7882
Pure LRIC as above plus slowing the 3G cell site capex reductions as well	0.9123	0.6175	0.7962

Table 3.42 – Impact of slowing down cell site price reductions

The model is now something like £350m light on GBV consistently across the period 2002 to 2008. It would be of benefit therefore as a next stage in the analysis to compare 2002 GBVs between the 2007 and 2010 models to attempt to identify where they are different, and to see whether the model changes that produce the difference in GBV are correct. Analysing these 2007 and 2010 model GBV outputs, and comparing the differences[65] reveals that much of the change would appear to be in the core network, as table 3.43 below shows:

Model year	Total GBV		Difference		
	2007	2010	Total	Core	Radio
2001/02	£2,884m	£2,695m	-£189m	-£211m	+£22m
2002/03	£3,087m	£2,839m	-£249m	-£231m	-£18m
2003/04	£3,319m	£3,011m	-£308m	-£256m	-£52m
2004/05	£3,717m	£3,381m	-£336m	-£279m	-£57m
2005/06	£4,043m	£3,462m	-£580m	-£299m	-£282m
2006/07	£4,231m	£3,626m	-£605m	-£313m	-£292m
2007/08	£4,419m	£3,718m	-£699m	-£346m	-£353m

Table 3.43 – GBV comparison between model versions[66]

(These numbers are different from those in table 3.41 above since the latter shows values that have been converted to calendar year midpoints for

[65] Between the 2007 model and the 2010 version as amended by Vodafone
[66] With any modelled handset and spectrum capital costs excluded

comparison with MNO data whilst for simplicity table 3.43 merely shows the results of each financial year taken directly from the model.) Tentatively therefore the failure of calibration against MNO actual values of the 2010 model versus the 2007 model can be ascribed to issues more with the core network rather than the radio network. Looking into the detail of the 2007 to 2010 cost variation on an asset by asset basis, the biggest changes relate to a fall in GBV of the MSCs, the transit switches, and the HLRs.

The 2010 model has increased the throughput of each MSC without changing its unit costs. This has significantly reduced the numbers of MSCs required by the model and hence the overall costs of the MSC asset element. Since the number of transits is linked to the number of MSCs, these suffer a commensurate decline. Similarly to the MSC, the capacity of the HLR has been increased, by a factor of more than three, without any change to the unit costs – hence the total expenditure on HLRs has been considerably reduced.

Each of these changes on an individual basis may or may not be correct; however their overall impact in reducing the quality of the calibration is unquestionably not helpful. If they are correct, then they have revealed a prior cost calibration failure in the radio network previously concealed by over-costing in the core. If they are not correct, then it is the core that is over-costed. The issue is regrettably indeterminable from the data available.

Furthermore the problem appears to be that there is a consistent level of difference across all years, rather than either a falling or rising difference. If either of the latter positions applied, then one might perhaps assume that there was a problem with the slope of the overall price trends. A consistent difference suggests rather that the problem is a general unit price difference, that somehow the whole total of the network costs in the real world is greater than the sum of the individual parts that are being modelled. This is not an unreasonable expectation, given the fact that the individual assets modelled are not the whole of the network expenditure, just the principal elements – if the unit cost of purchase of an asset is used, rather than the cost of bringing it and all the associated elements not specifically modelled into service, then it is not impossible that the model will undershoot the overall GBV in the real world. It appears simplest therefore to follow the approach adopted by Ofcom in 2003/04, when faced with the considered view of the CC that the 2002 model did not adequately reflect the capital costs of an average MNO. The solution adopted by Ofcom was to uplift all capital unit costs by a consistent amount. Applying this principle here would suggest that something like a 7.5% uplift might be required. Such an uplift has the following impact on GBV:

Year	MNO Actual	2010 model (before)		2010 model (after)	
		Output	Difference	Output	Difference
2002	£3,092m	£2,731m	-£361m	£2,886m	-£206m
2003	£3,311m	£2,882m	-£429m	£3,044m	-£267m
2004	£3,629m	£3,104m	-£525m	£3,281m	-£349m
2005	£3,850m	£3,401m	-£449m	£3,596m	-£254m
2006	£3,843m	£3,503m	-£340m	£3,703m	-£140m
2007	£3,969m	£3,649m	-£320m	£3,854m	-£115m
2008	£4,088m	£3,715m	-£373m	£3,921m	-£167m

Table 3.44 – Impact on GBV of unit price change of 7.5%

This result, whilst still under-predicting the actual GBV, is much closer than before, and incidentally for the last three years produces a level of difference very similar to that accepted as reasonable by Ofcom in the April consultation document, as can be seen from table 3.1 above, where Ofcom considered that the model was producing a GBV for the last years of £3,695m, £3,833m and £3,920m respectively.

There is obviously a risk that this change to capital expenditure has pushed network opex unacceptably high. The opex values output by the model at this point can be compared with the MNO actual values, and the outputs of the 2007 model, as in table 3.45 below.

Year	MNO Actual	2010 model (currently)		2007 model (per Ofcom)	
		Output	Difference	Output	Difference
2002	£324m	£335m	+£11m	£348m	+£24m
2003	£326m	£329m	+£3m	£356m	+£30m
2004	£324m	£317m	-£7m	£353m	+£29m
2005	£334m	£320m	-£14m	£364m	+£30m
2006	£319m	£339m	+£20m		
2007	£336m	£369m	+£33m		
2008	£360m	£388m	+£28m		

Table 3.45 – Opex comparison

This would suggest that the opex values of the model are no higher than they were in the 2007 calibration, but in the latter it must be remembered that the

GBV values of the model were very close to the MNO actual values, as table 3.46 below shows.

Year	MNO Actual	2010 model (current revision)		2007 model (per Ofcom)	
		Output	Difference	Output	Difference
2002	£3,092m	£2,886m	-£206m	£2,906m	-£186m
2003	£3,311m	£3,044m	-£267m	£3,158m	-£153m
2004	£3,629m	£3,281m	-£349m	£3,534m	-£95m
2005	£3,850m	£3,596m	-£254m	£3,887m	+£37m
2006	£3,843m	£3,703m	-£140m		
2007	£3,969m	£3,854m	-£115m		
2008	£4,088m	£3,921m	-£167m		

Table 3.46 – GBV comparison

There is thus still some remaining scope for increasing the capital costs produced by the model to improve the fidelity of the model. As it is, the termination costs for 2014/15 output by the model after this capital cost change are shown in table 3.47 below:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.42 above	2.9254	1.7041	2.4446
LRIC+ additionally corrected by unit capital cost change	2.9684	1.7586	2.4922
Pure LRIC corrected as table 3.42 above	0.9123	0.6175	0.7962
Pure LRIC additionally corrected by unit capital cost change	0.9337	0.6321	0.8150

Table 3.47 – Adjustment for unit capital cost change

This adjustment and the resulting cost increase must therefore be considered to be conservative.

Finally it is necessary to examine again the implication of not allocating any fixed and common costs to data services by, as in the section above, running the model with no data traffic, and observing the results. Table 3.48 below shows the impact of this:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.47 above	2.9684	1.7586	2.4922
LRIC+ when run with all data traffic removed	3.1599	2.6912	2.9754

Table 3.48 – LRIC+ outputs with no data traffic

The model is therefore suggesting that an uplift of approximately 0.48 ppm is required when data traffic recovers only its incremental costs, rather than any fixed and common costs.

Administration costs

As in the 2007 model, an additional cost recovery is made of operator administration costs related to the network. The total of the network related administration costs has been calculated by Ofcom on a very similar basis to 2007, but the cost is slightly higher in 2010. The 2007 cost was £148m in 2006/07 terms, equating to approximately £158m in 2008/09 terms: on the same basis the 2010 cost is now assessed at £170m[67]. The allocation of total administration costs between network and retail is influenced by the cost of capital – at the 2007 WACC the 2010 output would have been approximately £183m in 2008/09 terms, an increase over the 2007 calculation of approximately 15%. There is some suggestion therefore that the level of administration costs is not a constant, but varies with volume.

In the model however, a constant £170m is recovered every year. In particular an observation of administration costs based on 2008 operator data is applied in the potentially rather different circumstances of 2014/15. There is the possibility therefore that the total of network administration costs used in the 2014/15 recovery calculation is on the low side.

Where the method differs from 2007 is that previously the administration cost calculation was exogenously conducted – a value of 0.3 ppm was derived, and applied in every year. The calculation is now endogenous to the model, and is a simple mark-up to the service recovery in each year[68] assuming a constant cost of £170m that is to be recovered across all services. The mark-up thus varies by year dependant on the total service recoveries and the volumes of all services. In 2014/15 it is approximately 10%, so for voice termination it amounts to about 0.21 ppm of the 2.49 ppm recovery in table 3.48 above.

[67] £166m on 2008 calendar basis, converted by Ofcom in the LRIC model to 2008/09 as £169.6m
[68] In fact this is the only component of the LRIC+ cost in the model that is modelled as a mark-up

Spectrum costs

Ofcom's approach to setting the cost of spectrum in the model is far from rigorous. However a rigorous estimation of spectrum costs is necessary for two reasons:

- Ofcom's belief that spectrum costs have no impact on pure LRIC estimates are based on a mis-specification of the calculation of pure LRIC;

- When making the policy decision whether to base MTRs on LRIC+ or pure LRIC, both must be accurately estimated.

Ofcom assumes that spectrum costs are fixed with respect to traffic and hence have no impact on pure LRIC costs. However it is obvious that as traffic tends to zero the minimum amount of spectrum required for a basic coverage network is required, and hence for an efficient operator only this element of spectrum is a fixed cost with respect to traffic and all spectrum additional to this must by incremental to traffic. While Ofcom's model does not identify any spectrum as being incremental to traffic, this is an artifact of the model.

When estimating spectrum costs, Ofcom uses a wide range of evidence but places particular weight on the benchmark results of spectrum auctions. However the results of auctions show significant variation both between auctions, with valuations being dependent on a wide range of factors. However rather than attempting to control for these factors, Ofcom calculates simple averages of the results. Ofcom also appears to believe that the results show some trend over time as the highest valuations have not been repeated recently and thus more weight should be given to more recent results. But this analysis is based on the raw data, uncontrolled for the factors that Ofcom note will affect prices paid in auction. Thus it is not clear that the recent lower valuations are due to a downward trend in valuations or simply differences in the value of spectrum arising from auctions most recently conducted.

It is not clear why Ofcom has not sought to reproduce estimates of spectrum costs endogenously from the cost model using methodologies similar to those used by the CC. Consistency between spectrum cost assumptions and the opportunity cost for spectrum is likely to be particularly important when calculating pure LRIC as an accurate estimate would require modelling the trade off between the amount of spectrum available and the cost of additional network roll out.

The pure LRIC outputs of the model

We pointed out in an earlier section of this annex that there is very considerable doubt as to whether the model can give a meaningful pure LRIC result for voice termination, given that:

- the model merely recovers all costs on a service routing basis rather than in a two stage incremental plus EPMU basis (the only exception to this is administrative costs);
- no attempt is made to calibrate the model at any level other than total operator;
- thus the assumption that the model "knows" which costs are fixed and common and which are incremental is an untested belief;
- this is reinforced by Ofcom's 2007 statements that: *"the model does not explicitly identify or estimate the level of common costs. The outputs of the model are unit costs that exhaustively include all network costs"*[69]. "*The estimation of the marginal and of the common network costs is also subject to significant uncertainties*[70]*"*

Obviously it is relatively straightforward to amend the model in the way that Ofcom has, to run the model through twice, once including voice termination, and once excluding it, and find the differences between the two scenarios with respect to network build and capital and opex outflows for every year of the model. These differences, representing the model's view of the extra capital expenditure and opex required for the voice termination traffic element, are then fed into the economic depreciation calculation and recovered in the usual way, against the volume of voice termination. It is also possible to repeat the exercise and remove other services, such as all data, all voice, or all messaging, and subtract each of these from the total cost recovery and presume that the remainder represents fixed and common costs. But this is no more than a set of inherently un-testable Excel calculations, rather than any real world result. We are reminded of the fact that Oftel in 2001 was certain that the fixed and common costs were very low ("the MCP network") and that Ofcom in 2007 as seen above was suggesting that many costs that appeared to be fixed and common might very well not be in reality.

Vodafone can see no evidence in the recent consultation of any attempt to uncover whether the model correctly identifies the relative size of incremental and common costs: there are very good grounds, not just the authority of Ofcom in 2007, to believe that it cannot.

[69] March 2007 statement at A5.18
[70] March 2007 statement, at A17.43

Identification in the model of fixed common and incremental costs

Whilst any allocation made by the model between incremental and fixed and common costs might appear to be both straightforward and correct with some asset elements, it is not really that easy.

So at its simplest for example the model has an asset element called network management systems, of which there is only one ever used, invoked at service commencement: thus clearly this is treated in the model as a fixed cost and not in any way incremental to voice termination, or any other service. But is this really true, or just an abstraction of the model? A network management system must be an amalgam of hardware, software and people costs: some of these must relate to specific inbound traffic routes, and the complexity of the network management system must expand with the complexity of the network, which in considerable part is traffic related. It is very unlikely therefore, although convenient for modelling purposes, that it is wholly correct to assume that the costs of any network management system are totally fixed and that there is no variable element. As Ofcom somewhat strangely puts it, whether the "*excess capacity caused by the modularity of initial deployment should be considered a real common cost or the result of short to medium term equipment build constraints and/or modelling simplification is not clear*[71]" even in the simple case of a network management system. When producing results on a total traffic basis, as in 2007, or in this model on a "LRIC+" basis, this model simplification is largely irrelevant – however it becomes potentially important when any split between fixed and variable, or coverage and capacity is demanded from the model.

In a much more complex vein, there is the cell site, the asset element at the heart of the radio access network. The model functions here by building a mix of coverage sites which as traffic rises are overlaid with capacity sites. Coverage sites are dimensioned in the model by three input values: the coverage radius of a site in a particular geotype, the proportion of that geotype in a given year that has coverage and the total area of that geotype, set in an assumption that the UK can be divided into nine discrete but individually homogeneous geotypes. A capacity site build occurs in the model when the density of traffic in a particular geotype, based on an assumption of how the total UK traffic is split across geotypes, and then on an assumption that the traffic inside that geotype is virtually evenly spread[72], exceeds the traffic carrying capacity of the coverage sites that have as yet been built. Obviously all of these are necessary simplifications of the model to keep its size down to a reasonable level, yet none of the assumptions are correct in the real world: geotypes are not either contiguous or real, the spread of traffic per sq km is much more varied, the reach of a cell is not a regular and uniform hexagon but related to local topography and adjacent cells, and so forth. But the only check that the overall impact of all of these assumptions is collectively correct is whether the model builds roughly the right *total* number

[71] March 2007 statement, at A17.45

[72] A very limited assumption is made on traffic non-homogeneity

of sites across the UK, and at a higher level whether the total capex and opex of the whole network is about the same as the MNO average.

As a result of its methodology, capacity sites only occur in the model in particular geotypes. For 3G it is only the suburban 1 geotype that is assumed to be capacity dimensioned – the area coverage of the urban sites is set at a sufficiently low value that the model appears to believe that capacity sites will never be needed. For 2G by contrast, the model assumes that both the urban and suburban 1 geotypes require some capacity sites. For both technologies however, the majority of sites built are assumed in the model to be purely for coverage purposes.

In the real world however this distinction is not so simple. Whilst it is quite clear at one extreme that the first site built on the Isle of Skye must be a coverage site, and at the other the most recently built site in central London, must be primarily for capacity even though it might also fill in the odd coverage hole, or improve indoor coverage in some buildings, but this improvement is only a by-product of the capacity requirement. In between however it is not so unambiguous: a second site built at the edge of a small town might address for some sectors a capacity issue in that town, at the same time as providing/improving coverage in the surrounding rural area. Similarly filling in small coverage holes, and hence reducing the effective average cell radius in a given area, may only be justifiable when traffic has risen sufficiently in the general area to support the build. Is such a build for capacity or coverage reasons?

In the real world any such distinction is of no value: in the model it is very important for the pure LRIC calculation. Yet in order to believe that the model is correctly splitting these sites (and all other assets) into coverage sites and capacity sites one has to believe that all of the assumptions identified above are individually correct: this is a much more stringent requirement than the directly allocating "LRIC+" methodology requires, and one that has not been considered by Ofcom. Clearly Ofcom in 2007 was of the opinion that the model was not able to distinguish between incremental and common. But in 2010 there has been an implicit assumption that since at total level the model is roughly right[73], at a much more detailed level it must be exactly right. This is untenable – there must be a much lower degree of confidence that the pure LRIC result can be reliable than can be attached to any outcome of the LRIC+ method.

There has not been, and cannot be any objective testing as to whether the model builds even approximately the right number of sites (and all other assets that would be required) for a coverage network only. It is not possible therefore to have much confidence that the division in the model between the number of sites that it considers to be coverage and those that it considers to be capacity is correct, on either a full service or termination minus basis. But clearly this assessment is a crucial prerequisite in order to be able to calculate

[73] Or at least can be made to be so on proper calibration

a pure incremental cost that can be construed as having some objective validity.

A related issue is the inclusion of spectrum costs. A minimum amount of spectrum is necessary to provide a coverage network but additional spectrum above this minimum level would increase costs, while providing no benefits. Thus the minimum amount of spectrum can be considered to be a fixed cost with respect to traffic. However as traffic increases there will be a trade off between the amount of spectrum and the amount of sites required, with additional spectrum allowing extra capacity to be added to existing sites instead building additional sites. For any given level of traffic and cost of spectrum, there will be an optimum level of spectrum that will minimise the overall level of costs.

Another related issue is cell breathing. 2G functions with a number of individual 200kHz channels; the network works on the principle that adjacent sites cannot for interference reasons share the same channel, so careful network planning of individual channels is required to ensure that this does not happen. 3G by contrast uses the same 5MHz carrier at every adjacent site: interference with the neighbouring site is a major determinant of the area coverage of each site. However interference rises with traffic load – so if the traffic density per sq km rises, the coverage area shrinks. This is the phenomenon known as “cell breathing”. But in the model the coverage radii have been set on some expectation or emulation of real world experience (but only indirectly given that calibration is only at the total network level), i.e. on the basis of the traffic load including voice termination. It follows therefore that in a world without voice termination, the coverage radii would have been a little larger, and fewer total sites thus required for the coverage network. Thus one would expect the model’s coverage assumptions to flex between the full traffic scenario and the termination traffic minus scenario, but they do not and cannot.

Similarly the pure incremental methodology in the model does not recover any element of administration costs, whereas the LRIC+ full service has an administration mark-up of around 10%. But is it really true that network related administration costs are fixed? It might be more reasonable to see these costs (£166m per A8.139) as representing an overall level of expenditure that operators have found necessary to support the size of the network and network traffic encountered on a full service basis: it follows that in the absence of termination traffic, a lower level of administration costs might be incurred[74]. Thus some administration costs might reasonably be seen to be incremental to termination traffic. There are two ways in which this argument is supported by Ofcom’s work:

- The logic of Ofcom’s allocation of administration costs between network and retail in table 17 of annex 8. The size of the network capex and opex shrinks without termination – this would reduce the

[74] We note that the network administration cost calculated in 2010 is rather larger than that in 2007, suggesting that the cost does vary with network size and traffic volume

quantum of administration costs allocated to the remaining network services. The difference must presumably relate to termination.

- The observations made in 2007 by Ofcom that the smaller operator, H3G, had a lower level of network administration costs than the larger MNOs and that there was a potential for H3G's administration costs "to rise between now and 2010/11 as its business increases in size[75]"

It is interesting also that Ofcom has linked operator site sharing with increasing network coverage, in that as the cost of site build is modelled to fall it considers it justifiable, given the level of traffic in marginal areas, to extend the coverage network further. One might run the same argument the other way round, and question whether if a significant element of the revenue stream, i.e. that from inbound traffic, were not to exist, the resulting loss in revenue would make some marginal coverage sites not economic, and thus reduce the number of rural sites. The wide area extent of rural coverage might perhaps thus also be considered sensitive to traffic revenues and volumes.

Any calculation of pure LRIC by the existing LRIC+ costing model must therefore be treated with a considerable degree of scepticism. Even if it were to be accepted that the 2010 model can be reliably used in this way, and Vodafone sees little evidence that it can, one must err towards a very conservative set of assumptions in order not to run the risk of setting a rate that is less than the real marginal cost. Under-estimation of the real marginal cost will make investment in incremental long run capacity no longer commercially justified and hence lead to an inefficient outcome.

Pure LRIC and WACC

Another suggestion that the costing model is deficient is the fact that the pure LRIC result that it outputs is very sensitive and erratically responsive to the cost of capital assumption that is used.

In fact it would appear that the cost of capital that Ofcom has erroneously selected, 7.6 %, is one that gives very close to the minimum result under pure LRIC. Figure 3.2 below shows the possible pure LRIC outputs from the Ofcom version of the model when run under varying cost of capital inputs.

[75] March 2007 Statement A 15.109

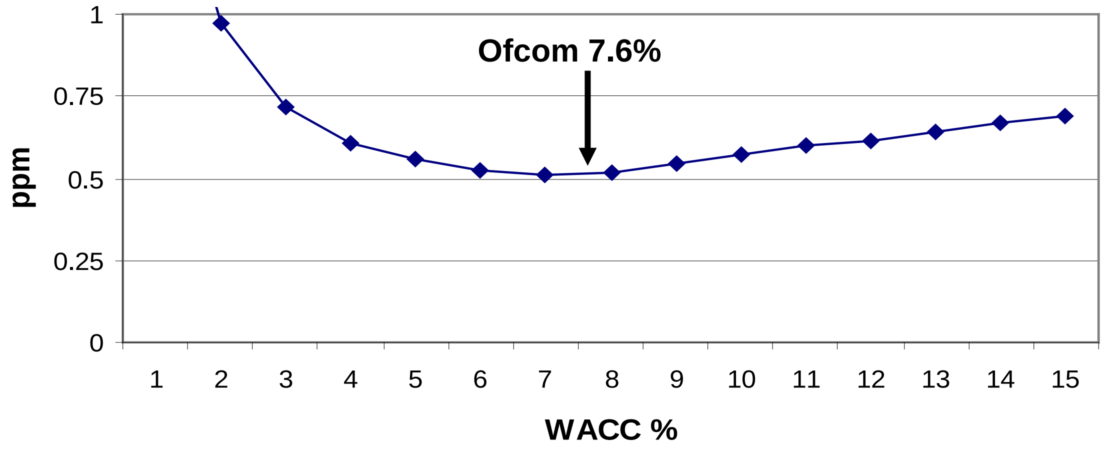


Figure 3.2 – ppm outputs from Ofcom model 2014/15, pure LRIC

The Ofcom value of 7.6 % gives 0.5077 ppm – the lowest possible value from the model as supplied by Ofcom appears to be only very slightly less than this, at around 0.5069 ppm, achieved at 7.4 %. A WACC of higher than 8% or lower than 7 % would have given a larger pure LRIC output. A similar curve under pure LRIC is exhibited by the Vodafone corrected version of the model. (By contrast the lowest value under LRIC+ is achieved with a much lower WACC, of around 4.8%.)

But this is not the only issue that needs to be addressed. It would appear that the pure LRIC result is irregularly sensitive to the WACC, at least between 11 % and 12 %. Figure 3.2 above shows a smooth curve. But in reality the results between 11 % and 12 % are more varied, with a low value encountered at 11.1 %, as table 3.49 below shows:

Cost of capital input	Pure LRIC output ppm
11%	0.6004
11.05%	0.6013
11.1%	0.5311
11.2%	0.5794
11.5%	0.6002
12%	0.6160

Table 3.49 – Pure LRIC outputs

No such irregularity occurs under LRIC+, which exhibits a regular increase in ppm output as the cost of capital is varied between 11 % and 12 %. This rather bizarre result represents another signal that the model is in some way not reliably producing a pure LRIC result[76]. The problem may relate to the choice of economic depreciation method and the way recoveries are in detail calculated by asset element, where various different values are adopted for the cost of capital over the period 1990 - 2008 but a flat rate thereafter. It may be fruitful to consider alternative economic depreciation methods, particularly in the case of pure LRIC cost calculations.

Cost recovery – practical issues

It is workbook 4 that holds the results of the incremental exercise; the worksheet entitled "linked inputs" shows (when the pure LRIC macro is run) network volumes and costs that are the product of "inputs with incoming" less "inputs without incoming". Examination of these net values, that represent the change in network volume and cost as a result of the removal of the termination traffic increment, reveals some strange quirks.

In terms of network asset quantities, some asset types across some years produce negative asset numbers. What this appears to mean is that the model when run with all traffic volumes requires fewer of an asset than when run with less traffic. This rather strange position appears to occur plausibly in the case of assets that are upgraded from one type to another with volume, so that as volumes rise, one backhaul link may be swapped out for a larger one. But strangely the model shows a negative number of NodeB facing ports at the RNC from 2020/21 onward. Other asset elements that should co-vary do not appear to fully do so. For example the model builds in 2011/12 1,022 incremental cell sites but has 1,027 incremental 2G sites. In the same year the model has 46 incremental 3G microsites and 31 microsite upgrades, implying 15 3G only microsites. There are also 528 incremental 2G sites, implying a total of 543 site builds, but the model only actually builds 526. The incremental backhaul link numbers fluctuate extensively from 2,658 in 05/06, to 1,863 in 2006/07, to 1,740 in 2012/13, to 5,364 in 2013/14 to 149 in 2014/15. Other assets appear to fluctuate in demanded numbers, on a regular basis: this may be a product of the values being smoothed in the full traffic network versions – the increment between two such versions can potentially then produce fluctuations.

These anomalies serve to suggest that the model is being asked to produce results for which it has not been fully designed. There can be little confidence therefore on this "full network minus" approach that the model is actually correctly recording the incremental assets and their associated costs that might arise from the alternative approach of a bespoke model building a

[76] Vodafone has not checked all possible WACC values at a similar level of granularity to uncover whether other anomalies exist in the model at different WACC levels.

network without termination and then overlaying termination traffic on top of this, and observing the incremental build that results.

Much more seriously however, the model also gives no thought to how our hypothetical network planners, faced with designing a network in a world without termination traffic, would actually have built their networks on a least cost basis. But this is a question that is explicitly asked by the EC Recommendation:

> "*Avoidable costs are the difference between the identified total long-run costs of an operator providing its full range of services and the identified long-rum costs of that operator providing its full range of services except for the wholesale call termination service supplied to third parties.*"[77] "*The cost allocated to the wholesale call termination service should thus be equal only to the additional cost incurred to provide the service*".[78]

The model however is simply assuming that the network design rules that were appropriate for a full traffic world would have been applied unchanged on a "termination traffic minus" basis. There is absolutely no reason to believe that this would have been so; indeed it seems highly unlikely.

We can considered above possible issues relating to cell breathing and area coverage, but another point relates to micro and pico sites. The full traffic model makes significant use of micro and pico cells in the urban and suburban areas. In 2014/15 it has the following number of micro and pico sites:

No of sites	Micro	Pico	Total
Site builds	2,145	455	2,600
With 2G equipment	1,987	444	2,431
With 3G equipment	478	36	514

Table 3.50 – Micro and pico site volumes 2014/15

These sites are thus being built primarily for 2G and hence, as a result of the 2G traffic load these will be almost entirely for voice. The principal purpose of these sites is to address local hot-spots of traffic peaks: however these sites are considerably less cost effective from a cost per erlang of capacity than a macro site. In the model, these sites are dimensioned by an input assumption of a fixed proportion of total traffic in the geotype that is passed to them and the number built related to the capacity of each site. But in the absence of inbound voice and hence considerably reduced hot-spot volumes (roughly one-third of 2G voice traffic is inbound) a rational network planner would very

[77] Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU, May 2009, paragraph 14
[78] Ibid

probably have needed to build significantly less of them, and would thus have expected them to handle a lower proportion of the traffic in the relevant geotypes. Since the model does not allow the proportion of traffic sent to micro and pico sites to fluctuate with demand, it is likely that the "termination traffic minus" scenario in the model is building too many of these sites. It might be therefore reasonable to expect that in the "real world" our network planner would have significantly reduced the proportion of network traffic that micro and pico sites would have been expected to have handled, say from the 7% assumed in the urban geotype and the 6.5% assumed in the suburban 1 geotype for micro sites and 0.4% – 0.5% for pico sites, to values of exactly half.

Unfortunately the model is not capable of flexing design assumptions between the pure LRIC and the LRIC+ versions and gaining a meaningful result. What can be established however is that when running the model on a LRIC+ basis with the assumption of halving the total proportion of traffic sent to micro and pico sites, the total quantum of the recoveries against all services in 2014/15 (rates multiplied by volume) sinks by approximately £30m from the unaltered version. The recoveries in 2014/15 for pure LRIC, using the unchanged micro and pico traffic assumptions are approximately £138m. Therefore if one assumes that without termination volumes the network that would have been built would have had only half the proportion of traffic going to micro and pico sites than in a full service network, then this additional £30m recovery relating to the costs of building the additional network resulting from the changed network build assumptions between the "termination traffic minus" scenario and the full service scenario in 2014/15 must also properly be considered incremental to termination. This suggests an uplift to the unit rates of £30m/£138m, or 22%[79]. Given that the rate arrived at in Vodafone's revision to date as per table 3.47 above for pure LRIC is 0.8150 ppm, this would give an adjusted recovery of 0.9943 ppm.

This would mean therefore an output in 2014/15 as table 3.51 below:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
LRIC+ corrected as table 3.47 above	2.9684	1.7586	2.4922
LRIC+ when run with all data traffic removed (table 3.48)	3.1599	2.6912	2.9754
Pure LRIC corrected as table 3.47 above	0.9337	0.6321	0.8150
Pure LRIC additionally uplifted by micro and pico site build increment (22%)	1.1391	0.7712	0.9943

Table 3.51 – Suggested outcomes at Ofcom's cost of capital

[79] A similar proportion can be obtained from examining the PV of all recoveries (and thus of costs) rather than just from the 2014/15 recovery

Since this is the only such calculated increment, despite the likelihood that there should be others, this adjustment must be seen as being likely to understate the real pure LRIC cost.

Vodafone's overall conclusion is that the pure incremental method is inherently much less reliable than the LRIC+ result output by the model, given the lack of examination as to whether the model adequately splits assets and costs between the incremental and common categories, and since it is very difficult to establish how network design parameters might differ between the full service world that we know and a world without termination. One might reasonably question whether a pure LRIC output from the existing LRIC+ model is fit for purpose at all: at the very least it is quite clear that Ofcom's approach, by neglecting the likelihood of different network design parameters in a world without termination is always going to underestimate the real incremental cost that arises from termination.

Summary of outcomes of Vodafone modelling adjustments

Table 3.52 below summarises the adjustments that we have made to the LRIC+ model and the outputs that it produces in 2014/15.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
Original model output LRIC+	2.1508	0.7801	1.5428
Corrected for mechanical errors	2.2751	1.0282	1.7860
Further corrected for traffic issues	2.4836	1.3205	2.0273
Further corrected for network design issues	2.5517	1.4371	2.1130
Further corrected for cost recovery issues	2.7039	1.6056	2.2716
Further corrected for unit cost and calibration issues	2.9684	1.7586	2.4922
LRIC+ when run with all data traffic removed	3.1599	2.6912	2.9754

Table 3.52 – Correction of the model: LRIC+

So, on an LRIC+ EPMU basis a charge of 2.49 ppm is indicated, whereas if data services only recover their incremental costs, the LRIC+ charge should be 2.98 ppm. Similarly, table 3.53 below summarises the adjustments for the pure LRIC output of the model.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
Original model output pure LRIC	0.5835	0.4127	0.5077
Corrected for mechanical errors	0.6680	0.4862	0.5967
Further corrected for traffic issues	0.7679	0.5346	0.6764
Further corrected for network design issues	0.7908	0.5739	0.7055
Further corrected for cost recovery issues	0.8153	0.5844	0.7244
Further corrected for unit cost and calibration issues	0.9337	0.6321	0.8150
Pure LRIC additionally uplifted by micro and pico site build increment (22%)	1.1391	0.7712	0.9943

Table 3.53 – Correction of the model: pure LRIC

A minimum recovery of 0.99 ppm under pure LRIC is thus suggested by the model. But all of these have been conducted at Ofcom's cost of capital. Section 5 of the main body of Vodafone's response considered more appropriate alternatives. In the final section of this annex we consider the cost model outcomes that thus arise.

Model results under varied WACC

Section 5 of the main body of this response examines the validity of Ofcom's assumption of 7.6 % as the benchmark cost of capital from 2009/10. We consider there that the most appropriate rates to use are 9.4% for LRIC+ and a higher rate of 11.0 % for pure LRIC (to account for the asymmetric nature of the risk).

Inputting these revised WACC values into the original Ofcom version of the costing model gives the following results shown in 3.54:

Model outputs in ppm	**2G 14/15**	**3G 14/15**	**Blend 14/15**
Original model output LRIC+	2.1508	0.7801	1.5428
LRIC+ at 9.4%	2.3871	0.8157	1.6901
Original model output pure LRIC	0.5835	0.4127	0.5077
Pure LRIC at 9.4%	0.6531	0.4396	0.5584
Pure LRIC at 11.0%	0.7055	0.4685	0.6004

Table 3.54 – Ofcom's original model under different WACC

Applying the same costs of capital to the Vodafone revised version of the model will give the following result:

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.47 at 7.6% WACC	2.9684	1.7586	2.4922
LRIC+ corrected as table 3.47 but at 9.4% WACC	3.3372	1.8799	2.7636
Pure LRIC corrected as annex 3 at 7.6% WACC	0.9337	0.6321	0.8150
Pure LRIC corrected as annex 3 at 9.4% WACC	0.9915	0.6311	0.8497
Pure LRIC corrected as annex 3 at 11.0% WACC	1.0589	0.6609	0.9023

Table 3.55 – Outputs from the Vodafone version of the model at varying WACC

But there remain two further necessary adjustments:

- on LRIC+ to examine the result at 9.4% WACC when data volumes are removed, similarly to table 3.48 above, i.e. on a basis that approximates the position where no fixed and common costs are being recovered from data. The result of this is shown in table 3.56 below.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ when run with all data traffic removed (table 3.48) at 7.6% WACC	3.1599	2.6912	2.9754
LRIC+ when run with all data traffic removed at 9.4% WACC	3.5844	2.9169	3.3217

Table 3.56 – LRIC+ without data at varying WACC

- On pure LRIC to examine the result at 11.0% WACC when the incremental build relating to the design assumption change on micro and pico sites discussed above is included into the incremental cost of voice termination. At this cost of capital this increment represents £25.3m, on a “simple termination traffic minus” increment of £152.5m, or 16.6%. This is shown in table 3.57 below.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
Pure LRIC corrected as table 3.55 at 11.0% WACC	1.0589	0.6609	0.9023
Pure LRIC additionally uplifted by micro and pico site build increment at 11.0% WACC (17%)	1.2342	0.7703	1.0517

Table 3.57 – Outputs from the Vodafone version of the model at varying WACC

The overall results of these changes give the following results at the Vodafone preferred cost of capital, comparable with table 3.51 above.

Model outputs in ppm	2G 14/15	3G 14/15	Blend 14/15
LRIC+ corrected as table 3.55 above	3.3372	1.8799	2.7636
LRIC+ when run with all data traffic removed table 3.54	3.5844	2.9169	3.3217
Pure LRIC corrected as table 3.55 above	1.0589	0.6609	0.9023
Pure LRIC additionally uplifted by micro and pico site build increment (22%)	1.2342	0.7703	1.0517

Table 3.58 – Suggested outcomes at Vodafone's cost of capital

Thus under LRIC+ a cost of approximately 3.32 ppm is indicated, and under pure LRIC a minimum level of 1.05 ppm.

Annex 4

Proposed amendments to the charge control

Irrespective of the level of charge that is adopted in 2014/15, there are three further issues that Ofcom raises, two of which are new to this consultation:

- How to get there from here (the shape of the glidepath and operator symmetry);
- What traffic is in scope;
- Detailed new charge control compliance rules.

Each of these is addressed in this annex.

The glidepath and operator symmetry

In 2010/11 H3G has a termination rate that is 0.3 ppm higher than the other operators, arising primarily from the 2G cap methodology of the CC and H3G's smaller historic voice market share. Ofcom is proposing to eliminate this asymmetry with H3G moving on to the glidepath of the other operators with effect from 1st April 2012, one year into the next charge control period, with a 2G/3G average efficient operator providing the benchmark for all.

It is worth examining what the model suggests might be an appropriate rate for a 3G only operator. The model is no longer set up to produce an output for the 3G only operator, but by using market share proportions derived from those that the model uses for the 2G/3G operator, and 2007 coverage assumptions, it is possible to derive an estimate. Even assuming that the 3G only operator has administration costs that are the same as the benchmark operator (an assumption which appears to give, obviously erroneously, an administration mark-up of over 25%, compared with the just under 10% of the 2G/3G operator[80]) the model suggests a 3G only operator cost that is significantly below the value produced by the Vodafone corrected model of 2.49p for the 2G/3G operator. A similar relative position occurs when using pure LRIC.

This suggests that simply from a cost point of view H3G's termination rate should be set at some discount to the rate of the other operators. Nevertheless Vodafone continues to support the view that a single termination rate for all operators is appropriate and that an average 2G/3G average efficient operator provides an appropriate benchmark.

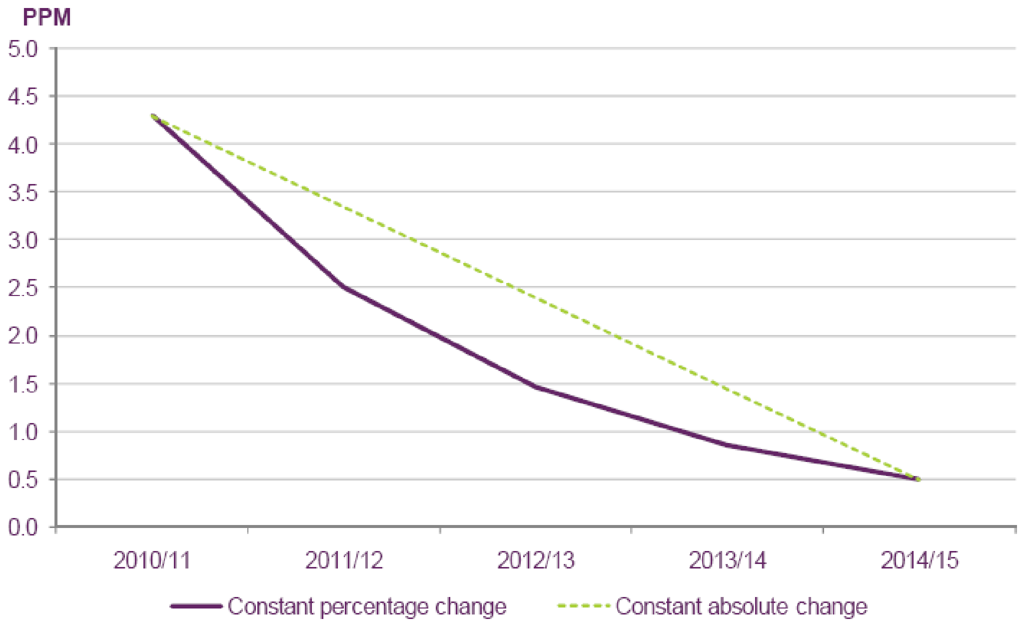
[80] By analogy with the 2007 Statement an uplift of 13% might be considered

The other question that Ofcom asks on the glidepath relates to its shape, i.e. how to get from the 2010/11 starting point of 4.3 ppm[81] to the target rate in 2014/15. In the consultation this latter rate is 0.5 ppm: Ofcom lays out two methods of reaching this point:

- Option 1 – use a constant yearly percentage decrease in charges
- Option 2 – use a constant absolute decrease in charges

We reproduce below Ofcom's figure 12 from chapter 9 showing these two options.

Figure 12 – Glide path options for 2G/3G MCP (2008/09 prices)[206]



Under option 1, the value of X calculated by is 42.7%. Options 1 and 2 would give the following TACs, in 2008/09 prices for the 2G/3G operators:

	Option 1	Option 2
2010/11	4.3 ppm	4.3 ppm
2011/12	2.5 ppm	3.4 ppm
2012/13	1.4 ppm	2.4 ppm
2013/14	0.8 ppm	1.5 ppm
2014/15	0.5 ppm	0.5 ppm

[81] This, as with all other values in the consultation is quoted in 2008/09 prices – the actual 2010/11 TAC for the 2G/3G operators in 2010/11 prices is approximately 4.42 ppm

Table 4.1 – TACs under Ofcom's options 1 and 2

There are material differences between the two in the first three years of the proposed charge control. The points that we have made elsewhere in our response on the appropriateness of a low target rate in 2014/15 can also be related to the intervening steps between the present rate and the endpoint.

- Ofcom's proposed reduction of 42% per year must be one of the largest Xs proposed by any regulator in any industry, in any country in the history of price regulation. It represents a more than four-fold increase in the rate of reductions previously applied to mobile termination rates in the UK.

- The impact of this change will lead to a rebalancing of mobile prices. This will result in a significant number of existing customers exiting the mobile market.

It follows therefore that the least worst way of reaching a very low 2014/15 target would be in a manner that allowed the maximum possible time for rebalancing of mobile prices and thus also the maximum possible time for customers to adjust to these changes. A constant absolute rate reduction as Ofcom's option 2 is thus to be preferred in the event of a low 2014/15 target.

What traffic is in scope

Ofcom has slightly revised the market definition of what termination traffic is in scope to tidy up some anomalies uncovered by recent charge control compliance reviews. We welcome the decision that traffic that terminates on a voicemail platform or on an overseas network are to be considered as in scope in the future. This should eliminate the present administrative effort for both operator and Ofcom of calculating and considering this traffic. However as we discuss in Annex 3, if Ofcom considers that this traffic has a different cost from handset terminated traffic, it should be separately and properly modelled: this Ofcom has failed to do. Logic suggests that the cost of providing voicemail and international roaming services is greater than the cost of handset termination. For costing purposes the pragmatic solution is to treat all terminated traffic in the model as if it terminated on a handset in the UK.

The other scope change that Ofcom is contemplating is the inclusion of ported out traffic, which is currently priced with termination, but not treated as in scope. We cannot see the point of this change. The idea that ported out traffic might be in scope is new – hitherto there has been some degree of discussion as to whether ported *in* calls should be considered to be within the scope of the charge control, but there is very little evidence of any prior view that ported *out* calls might be in scope.

The key feature of ported out traffic is that whilst it is priced at an operator's termination rate, it is not delivered to its own customers. Rather, ported out traffic represents calls to a particular set of former customers of the network, i.e. those former customers of the donor operator who still retain a number that is within the number range of the network. (Obviously these do not represent the total of former customers of the network. There will be others who have not kept the donor operator's number - there is presumably no suggestion that calls to these customers might be considered in scope.)

It is hard to see how calls to these customers are in any way within the influence of the donor operator, and therefore why the traffic to them should be treated as relevant to the termination charge of the operator, merely because they have chosen to retain rather than change their number. Certainly these calls are not modelled within the volume of terminated traffic of the operator. But more significantly unlike the other two adjustments above, i.e. voicemail and international roaming traffic, which are both made to *current* customers of the network, (even if they are not terminated on handsets within the UK), as ported out traffic is to *former* customers of the network, the revenue for this traffic is not retained by the donor operator but passed in full (less a donor conveyance charge) to the recipient operator.

This consideration might be largely irrelevant where ported out traffic has an identical time of day mix to terminated traffic that is otherwise in scope, i.e. calls to current customers of the operator, or where a single annual flat rate for termination were to be mandated. But in the absence of either of these conditions we fail to see why it is sensible to include this traffic within the scope of the charge control and of the charge control compliance assessment as A15 suggests – their inclusion has the potential to lead to a distorted set of time of day rates being applied to termination. We suggest that Ofcom reconsiders this change.

Detailed charge control compliance rules

Ofcom discusses in chapter 9, from paragraph 9.110, the possibility of reducing the degree of flexibility to price by time of day, to eliminate the practice of frequent changes in termination rates and their time of day structure, referred to as flip-flopping. Vodafone supports this objective, as long as the price of obtaining it is not too high. We accept that flip-flopping, with its almost monthly rate changes is an administrative nuisance, and have previously suggested to Ofcom several ways in which it could be eliminated. We are reluctant late participants, merely to protect our own position.

However it is easy to exaggerate the significance of the practice. The views of Colt quoted in the consultation are simply wrong.

> "*the practical effect of monthly rate swings is that originating CPs have to set retail rates to cover the highest expected charges. This is necessary to ensure that losses are not incurred through an adverse combination of traffic and MCT profile*"[82]

[82] Consultation at 9.122

CPs know that each MNO has to comply with its TAC and that, at most, flip-flopping will achieve a small mark-up on the TAC. CPs will therefore not 'lose money' on F2M calls in aggregate.

In paragraph 9.123 Ofcom quotes C&W: "*frequent price changes make it difficult for CPs to assess whether the MCP is complying with the charge control*". It is our understanding that this responsibility is Ofcom's not that of an individual CP. Only Ofcom can have the overall view of an MNO's time of day profile to be able to make such a judgement. The CP however based on the mix of traffic it sends to an MNO on an annual basis and the resulting interconnection cost, could easily assess the overall impact on its future interconnection costs of the next year's change of TAC in order to set a retail rate that ignores the peaks and troughs of a flip-flopping termination rate. But whilst it is no more than a matter of a few seconds work for a CP to calculate the TAC, we welcome Ofcom's proposal in A15.5 that it publishes TAC levels prior to the beginning of each year (a suggestion we have made previously).

To address the issue of flip-flopping Ofcom puts up four options:

- Option 1 - Leave the charge controls as they are;
- Option 2 - Restrict the frequency and size of rate changes;
- Option 3 - Impose a constant time of day ratio;
- Option 4 - Impose a single flat rate for each year.

Ofcom expresses a preference for option 2. This is not an exhaustive list of possibilities. For example Vodafone has previously suggested to Ofcom the idea of re-basing the traffic on which compliance is being assessed to eliminate the revenue opportunity.

In Vodafone's view it is important to retain some degree of flexibility in the termination charge control whilst eliminating as far as possible the opportunity for flip-flopping. The fundamental problem is that there are opposing forces in the design of the charge control:

- a need for regulatory certainty that forces the use of last year's rather than this year's traffic;
- the need to allow flexibility in charging to permit optimum use of the network.

So is it possible to consider the use of current year traffic rather than last year? Unfortunately it is not: the use of current year traffic, given the 60 day notice period required by BT would either mean that operators would have to settle for rates that allowed some form of headroom/shortfall below the TAC (i.e. the operators would not be able to recover their TAC in full) or the rules would have to be changed to permit a subsequent year TAC adjustment to allow for any undershoot/overshoot. The latter possibility would be an unhelpful complication. Also the use of current year traffic without any carry over ability would make frequent rate changes towards the end of the year very likely, perhaps significantly more frequently than monthly.

But is it worth keeping any flexibility at all, rather than a simple flat rate across the whole year? In our opinion flexibility is definitely useful since it does allow the operators the possibility of optimising the use of their network through encouraging traffic at low usage times. However in order for this "traffic steering" to have any real impact, it must be sustained for a relatively prolonged period in order for originating operators to be able to react in a way that might encourage traffic at times of low usage. In other words, any time of day rate structure that an operator desires is unlikely to be useful if it is only short term in duration.

A single rate allowed in the year appears to be too prescriptive a measure for a regulatory charge control. We therefore reject as do Ofcom, their options 1 and 4 above. We believe that some degree of flexibility in termination rates is necessary, so that different time of day rates can be set at different times of the charge year, but in a way that substantially eliminates the flip-flopping opportunity. Another objective is not to make the charge control unnecessarily complex, or difficult to understand, or ambiguous for compliance assessment, or requiring excessive bureaucratic intervention.

Eliminating flip-flopping – possible methods

So in what ways is it possible to retain a reasonable degree of rate flexibility whilst preventing flip-flopping? There are two distinguishing features of flip-flopping:

- a large number of changes occur in the year, typically virtually one per month (although in principle more could be employed, since rate changes might not be at the first of any month, but on any other date as well), and;

- each change significantly varies the relative weights of day, evening and weekend charges, typically reversing or at least varying the direction of relative weighting.

Curbing both these elements is not difficult, but the trick is to achieve this with a minimum of bureaucratic intervention.

Ofcom suggests two basic proposals, option 2 to reduce the frequency and size of rate changes, and option 3, to impose a constant time of day ratio across the year.

Option 2 - Restrict the frequency and size of rate changes

Option 2 in detail is not quite as advertised. In reality the proposal is very prescriptive (and proscriptive):

- Operators can only change their rates on 1st April, 1st July, 1st October, and 1st January each year;

- At the 1st April change, there is no restriction on rate changes, so in effect the structure of termination prices can be reset at this point;

- Apart from the change at 1st April, each subsequent rate change can only vary upwards each time of day rate by no more than 20% from the previous change, but there is no restriction on the size of the downward adjustment;

- All rate changes must be pre-notified to Ofcom.

This option as presently designed is far too restrictive.

Ofcom's justification for the pre-notification imposition 5 days before BT is that it "*will allow us to check whether the new rates will comply with the rules*"[83]. "*If we found that any of these rules were breached we could then write to the MCPs informally to explain this and ask them to change their rate notifications so that they did comply with these rules.*[84]" It is difficult to see the point of this – the proposed rules are not so complex that operators themselves will not be able to assess their own compliance, or the compliance of interconnecting operators. Ofcom is not proposing to give its opinion within the pre-notification window, and adds in footnote 242 "*we expect that it would not get that far as currently BT are in the position to reject new rates notified by the MCPs*".

Pre-notification might be a solution to a problem - operator non-compliance with TACs - that Ofcom has not suggested exists, but is certainly not necessary to eliminate flip-flopping. It will only add to Ofcom's costs.

The second problem with Option 2 is the idea that changes will only be allowed on four specific dates per year, with a reset to the structure of rates only allowed at 1st April each year. But this neglects certain practical problems:

- assessment of compliance is made on the previous year's traffic volumes, which are not finally known until early April;

[83] Consultation A15.20
[84] Consultation, A15.21

- the annual TAC is not known until publication of the RPI data, which can be as late as 20th January;

- pre-notification to Ofcom would require 1st April rates to be supplied by about 25th January.

It is hard to see therefore how operators could in practice reset the structure of rates at 1st April, based on data they will not have, and even how if they estimate the traffic profile, they could run any change through their own internal approval processes in a few days in January. Certainly Vodafone's development of a proposal for a more rigid structure of prices that is similar to Ofcom's option 3 was based on the expectation that, in the absence of flip-flopping, termination rates will only be reset several months into the charge year, once both the TAC and the prior year's traffic profile are known. (The expectation therefore was that rates would continue unchanged from the previous year until this resetting point.)

It is not difficult also to see that an over-rigid adherence to specific rate change dates might actually cause non-compliance. What would happen, for example if for good reasons, an operator missed the last, i.e. 1St January window, and were non-compliant as a result? One can imagine a necessary exceptions process having to be developed, further adding to the cost and complexity. Again, in our option 3 proposal, we were suggesting a restriction on the number of changes that could be made in every year, without prescribing the specific dates on which changes had to be made.

Vodafone's revised suggestion for an improved option 2 type of process to take account of these practical problems would therefore be:

- four rate changes allowed in each year, only at the first of a month, but which month is not specified – each change, apart from in the last quarter must be at least three months after the previous one, but only one change is allowed in the last quarter;

- the structure of rates can change freely in the first change made in the year, whenever it happens;

- subsequent rate changes should abide by Ofcom's proposal – individual rates can go up by no more than 20%, but any amount downwards;

- no pre-notification requirement.

This would be practical for the operators to implement, and substantially eliminate the benefit from flip-flopping whilst still allowing flexibility and also not require substantial bureaucracy.

The flip-flopping opportunity still remains, to some limited extent in this option as operators are still able to change the structure of prices to some degree.

In order to completely eliminate it, some form of an option 3 approach would be required, imposing a more rigid structure of rates.

Option 3 – Impose a rigid time of day ratio

Vodafone's view on the need for flexibility is that it does allow the operators the possibility of optimising the use of their network through encouraging traffic at low usage times. However in order for wholesale rates to have any real impact on traffic mix, there must be some form of predictable continuity in order for originating operators to be able to react in a way that might encourage traffic at times of low usage.

One way to address this is to have a rigid time of day ratio, imposed from the first rate change made in the year, as Vodafone outlined in a proposal to Ofcom in January this year. All subsequent changes must then preserve the ratio between the three times of day rates created by this change.

So for example if operator X had rates in March 2013 of 6 ppm 5 ppm 4 ppm (day, evening & weekend) these rates would continue into year 2013/14 until changed. The first rate change the operator made in 2013/14, e.g. to 6 ppm 4 ppm 2 ppm would then fix the ratio to be used for the rest of the year, so that in this case the 3:2:1 ratio of the three rates would have to be observed for all subsequent rate changes in that year, e.g. 7 ppm, 4.67 ppm, 2.33 ppm would be permitted, but 2 ppm, 4 ppm and 6 ppm would not. (This relative ratio would have to be subject to rounding to say 2 or 3 decimal places.)

This would allow operators to take advantage of any long term time of day weighting that they desire whilst eliminating the opportunity for flip-flopping. Similarly if the first rates change of the operator was to a lower daytime and higher weekend set of rates, such as 3 ppm 4 ppm 5 ppm day evening weekend, then this 3:4:5 ratio would have to be maintained across the rest of the year.

Ofcom's suggested version of this option however bears the similar excessive restrictions of its version of option 2:

- rate changes are only allowed at 1st April, 1st July, 1st October and 1st December;

- rates are frozen in structure at the 1st April change;

- pre-notification to Ofcom is required.

The same concerns we expressed about practicality, excessive proscription and bureaucracy apply here as well. Vodafone suggests that these draconian restrictions be similarly relaxed:

- four rate changes allowed in each year, only at the first of a month, but which month is not specified – each change, apart from in the last quarter must be at least three months after the previous one, but only one change is allowed in the last quarter;

- the structure of rates can change freely in the first change made in the year, whenever it happens;

- subsequent rate changes should then follow precisely the same relative ratio established in this first change;

- no pre-notification requirement.

Option 3 is thus simpler to understand and review than option 2, but the difference is marginal. Ofcom's preference for option 2 over 3 is that:

> "*the downside of this option (3) is that it is inflexible to any changes in traffic profiles or behaviour outside the MCP's control that might require an in-year change to the rate structure. However the rate structure that the MCP had set would only have to remain in place for one year. In practice we have seen minimal evidence of the need for this flexibility.*"

Vodafone does not understand what these external changes might represent. In practice we followed something very similar to a fixed time of day structure for many years, up to 2007.

Option 4 – flat rate

Ofcom have suggested the most limited version of option 4, i.e. a single flat rate throughout the year. Clearly this is not the only possibility: whilst a flat rate across the time of day eliminates the flip-flopping opportunity, it is not necessary for that flat rate to be maintained unchanged through the year. In the alternative allowing the rate to continue to change across the year will still achieve this objective as long as each new rate is extended across all times of day. So for example if an operator continued with their previous flat rate, from the prior charge control year, and then made one or more changes to this rate, as long as they retained each time a single flat rate across all times of day, this would be permissible. This would permit a rather more considered approach to rate setting than the very rushed method imposed by a 1st April change with 60 days notice based on a rate that can only be calculated at around 20th January.

Option 5 – an alternative approach

An alternative approach might be to eliminate the year on year differences caused by weekend/weekday fluctuations. This is the method suggested by

Vodafone to Ofcom in January 2009, and would involve restating last year's traffic into this year's terms (by adjusting for the different mix year on year of weekdays and weekends for each month). It is straightforward to calculate and implement and its effect would be to substantially damp down the opportunities from flipping, without totally eliminating the practice. As such the method is slightly less effective than option 3.

Vodafone view of options 1 to 4

In Vodafone's view none of the Ofcom options 1 to 4 are presently fit for purpose. Option 1, the no change option is at least known to be practical but will not address the practice of flip-flopping. Option 4 is unreasonably restrictive. However both options 2 and 3 as defined in the consultation response are impractical and unnecessarily limited. Vodafone suggests above some necessary minimum modifications to both methods that will make them more functional and practical without imposing unnecessary extra work on Ofcom. We believe that once these changes are made, option 3 more firmly shuts down the possibility of flip-flopping – but since clearly it would be possible for a particular operator to implement a rigid or semi-rigid structure of prices as per option 3, under option 2, we would be content with Ofcom's preference of option 2, but only provided the onerous and unnecessary restrictions to it are first removed.

It may be worthwhile to ensure that Ofcom are not replacing one charge control problem with another, that a separate consultation takes place on the detail of the charge control, once the 2014/15 target number is determined, so that a sensible and practical outcome can be derived.