Application of spectrum liberalisation and trading to the mobile sector: A further consultation

Summary

Vodafone welcomes Ofcom's further consultation on the seemingly intractable issues associated with spectrum liberalisation and trading within the mobile sector and it appreciates that Ofcom has taken the time to consider the matter afresh. Vodafone endorses a number of the modifications made to Ofcom's approach from the previous consultation. In particular we support: the abandonment of the precautionary principle; the more sophisticated appreciation of risk and uncertainty; and the acknowledgment that the UHF band will, within a relatively short period, provide an adequate substitute for the 900MHz band. We recognise that these changes have been instrumental in reducing the amount of 900MHz spectrum which Ofcom believes should be released by Vodafone and O2.

That said, Vodafone still believes that there are very material deficiencies within Ofcom's work. Vodafone remains hopeful that, once these are understood and acknowledged, Ofcom will abandon its commitment to requiring the 900MHz operators to release some spectrum, perhaps in favour of a less intrusive intervention.

Ofcom is required, by law, to assess whether the liberalisation of the 900MHz band is likely to distort competition; it discharges this requirement by considering whether the non-900MHz operators could match, at 2100MHz, the number of sites required to offer a comparable service to that provided by the 900MHz operators. Ofcom believes that, under certain demand conditions, the non-900MHz operators would be unable to keep up with the 900MHz operators and that this would lead directly to just such a distortion. However, Ofcom's analysis contains an implicit (but critical) assumption: that if re-farming were permitted then Vodafone and O2 would, except when data demands are low, clear their 900MHz spectrum and use it for mobile broadband and specifically for UMTS 900. ✂.

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Turning to Ofcom's actual analysis, Vodafone finds flaws in both its structure and content which, taken together, eviscerate the case for any intervention, even if Vodafone and O2 were to re-farm.

Despite the Kafkaesque sophistication of Ofcom's new approach there are a large number of inconsistencies between the detailed annexes and the way in which they are used and interpreted in the main body of the scenario analysis. Of particular concern is our observation that Ofcom's method for locating the boundaries between significance scenarios by using the relative deployment of sites at differing frequencies is at odds with its own technical analysis of the different numbers required at 900MHz and 2100MHz frequencies. Moreover, these boundaries, which are crucial to Ofcom's analysis since under different scenarios the operators are judged to behave differently, lack any coherence and do not demarcate points where operators would alter their deployment strategies. In addition, errors in the costing of rollout at UMTS900 versus 2100MHz mean that Ofcom significantly exaggerates the putative

'productivity benefit' enjoyed by the 900 operators by up to 75%. These mistakes, of themselves, must cast doubt on the worth of the whole of Ofcom's scenario analysis.

However, we have also uncovered material deficiencies in the three critical building blocks in Ofcom's case: the cost of clearing spectrum, the benefits of 900MHz versus 2100MHz spectrum for the deployment of mobile data and the competition benefits of more players in the market. In summary:

- Ofcom's desk-top approach of modelling perfectly tessellating 'average sites' appreciably underestimates the number of additional sites required to augment network capacity in order to overcome cell congestion in a real network. In addition, Ofcom makes a puzzlingly incorrect assumption about the number of GSM channels that we dedicate to the micro and pico cell layers in our network and the BCCH channel re-use factors that are achievable. Furthermore, Ofcom's assumptions regarding the implementation of Synthesized Frequency Hopping (SFH) are flawed; this means that Ofcom miscalculates both the numbers of sites which would need to be upgraded under the different spectrum removal scenarios and the costs involved for Vodafone to implement SFH. These errors mean that Ofcom materially underestimates the cost of (for example) a one block release by between £130m and £390m depending on the technical approach adopted.

- Ofcom has made significant errors in its technical analysis of the difference between frequencies. The cell edge speed that it claims is necessary for the high quality data market to emerge (2400kbps) defies the laws of physics and is not physically attainable in loaded HSDPA networks. Once this and other errors are corrected for we show that the difference in the number of sites required for comparable coverage at 2100MHz versus 900MHz is 5,000 rather than the 10,000 that Ofcom computes. This means that, under Ofcom's rollout assumptions, the non 900MHz operators are able to match the quality of coverage of the 900MHz operators before the arrival of the 800MHz band and therefore, as a corollary, there would be no distortion to competition when re-farming is permitted if the 900 operators were to deploy UMTS 900.

- Ofcom uses a Cournot model to calculate the welfare effects of the failure of the non-900MHz operators to 'match' under the high significance scenario. Although Ofcom concedes that the results need careful interpretation, we submit that that it exaggerates the number of customers who will switch to the 900MHz operators and be prepared to pay a premium to do so in the high significance scenario. Once more realistic assumptions are used we estimate that the benefit in welfare arising for the number of 'fully' competing players is reduced from £625m to £150m.

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We further submit that Ofcom has been unduly pessimistic in its assessment of the possibility of two operators striking a bargain for access and the efficacy of any intervention should they fail to do so. These concerns do not appear to be shared by Orange, a prospective purchaser of access, who has *"suggested*

that regulated roaming (with a sunset clause) was a reasonable temporary solution"[1]. Despite this, Ofcom's doubts are manifested in the seemingly arbitrary discounts applied to the benefit associated with regulated access.

In short, ✂ the propagation benefits of 900MHz spectrum are not sufficient to mean the non-900MHz operators would be unable to compete effectively using infrastructure operating in the 2100MHz band. Therefore the costs imposed on the 900MHz operators (which are considerably higher than Ofcom calculates) of requiring a release of spectrum will confer no additional benefits on society and should not be contemplated.

Vodafone respectfully suggests that Ofcom re-works its analysis by taking into account the detailed comments in this submission and corrects for its many technical deficiencies. ✂.

Outline of Vodafone's response

The remainder of our response is organised as follows:

Part 1: Outlines the legal test imposed upon Ofcom by the revised GSM Directive and highlights its failure to consider the critical (prior) question of whether, in practice, Vodafone and O2 would choose to re-farm.

Part 2: Contains a detailed critique of Ofcom's analysis including an assessment of the location of the boundaries between the low, medium and high significance scenarios, an identification of the internal inconsistencies in Ofcom's work, and an explanation of the errors made in identifying the cost differential arising from deploying at 900MHz vs. 2100MHz.

Part 3: Re-assesses the cost of clearance, the number of sites required at different frequencies and the benefits from competition and goes on to re-do Ofcom's scenario analysis with corrected values.

Part 4: Examines shortcomings in Ofcom's analysis with respect to LTE and national roaming.

Part 5: Summarises our conclusions

Annexes 1-7 contain further detail of the topics covered in parts 2 and 3.

[1] Paragraph A7.399

Part 1: Legal Background

What is the test on Ofcom?

1. Ofcom states that:

> *"We must now have regard to the current backdrop of the new draft European legislation. In that regard, we note that previously in the 2007 document Ofcom was seeking, in light of its statutory duties and the draft RSC decision, to promote competition. That test has been altered slightly by the new requirement and wording in the draft Directive which says that Member States shall address distortions of competition where justified and proportionate."*[2] (Emphasis added)

2. It then goes on to assert:

> *"We do not consider that this leads to any difference to the substance of Ofcom's considerations. This is because the 2007 consultation aimed at addressing distortions of competition arising from existing spectrum holdings as part of Ofcom's wider statutory duty to promote competition. Indeed the draft Directive takes the same approach to dealing with existing spectrum holdings as that of the 2007 consultation."*[3]

3. Vodafone does not accept this analysis. There is a clear difference between promoting competition (improving or increasing it from its current state) and addressing distortions of competition (that is, if necessary bringing the state of competition back to where it was prior to this limited exercise in spectrum liberalisation). While Vodafone made it clear in its 2007 response that it considered the key consideration for Ofcom should be to ensure that the current level of competition did not deteriorate to *"safeguard the existing level of competition"*[4], Ofcom stated up-front in its 2007 Consultation that it had *"sought to identify the option which will implement the RSC Decision in a timely way and promote competition; and secure optimal use of the radio spectrum."*[5] These are manifestly different considerations from those imposed upon Ofcom under the revised GSM Directive.

4. Vodafone believes that the new GSM Directive places an obligation upon Ofcom to do a limited and sequential analysis. First, it must decide whether, as a direct result of implementing the Directive, a distortion of competition will arise. If it considers that it is "likely" to do so, it must decide whether and how it is most proportionate and justified for Ofcom to address it.

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[2] Consultation at 2.36
[3] Consultation at 2.37
[4] See for instance paragraphs 1.48, 1.51 and 1.68 of the 2007 Consultation.
[5] Paragraph 1.8 of the 2007 Consultation

5. For a *"distortion of competition"*[6] to be likely, Ofcom must consider that: (i) Vodafone and/or O2 will re-farm their 900MHz spectrum to deliver data services; and (ii) if they do, the other operators will not be able to compete effectively with their own spectrum holdings and/or alternative spectrum which becomes available (such as 800MHz or 2600MHz). Ofcom considers the second of these questions in its consultation and Vodafone comments in detail upon its analysis in Parts 2, 3 and 4. However, more strikingly, Ofcom makes little or no attempt to address the prior question of whether Vodafone and/or O2 will re-farm; the issue is simply assumed away: *"this is a scenario in which 900MHz operators have found it profitable to rollout a high level of coverage at 900MHz, to improve the quality of the mobile broadband services they could offer relative to those they are able to provide through more limited investment in their 2100MHz networks"*.[7] ✂ Vodafone addresses this question in Part 2 below.

6. In fact, Ofcom has wrongly conflated two steps in deciding whether *"some approaches to liberalisation might have the potential to distort competition"*[8]. It has assumed that Vodafone and O2 will re-farm and then considered the risks that the market will not 'deliver' and then alighted upon what it considers to be a 'justified and proportionate' approach. Vodafone believes there is a more fundamental question: 'will the 900MHz operators re-farm in the short to medium term? ✂.

Is a distortion of competition likely?

7. Ofcom correctly acknowledges that there is considerable uncertainty as to how the putative mobile broadband market might develop in the future. In Vodafone's view, the task facing Ofcom is similar to that of merger control- it must consider which of the various possible outcomes is most likely in circumstances where the market(s) are currently competitive. In merger control, the authority must consider whether the concentration in question will, on the balance of probabilities, overturn this competitive situation and lead to a significant impediment to effective competition, in particular the creation of a dominant position. To say that something will happen judged on a balance of probabilities (i.e. it is more likely than not) is fundamentally the same test that Ofcom is required by the GSM Directive to apply here: *"in requiring liberalisation… to examine whether the existing assignment of the 900MHz band to the competing mobile operators in their territory is likely to distort competition in the mobile markets concerned…"* In relation to such a forward-looking analysis, the ECJ has held:

> "*A prospective analysis of the kind necessary in merger control must be carried out with great care since it does not entail the examination of past events – for which often many items of evidence are available which make it possible to understand the causes*

[6] A loss in productive efficiency does not constitute a distortion to competition (it just means that it costs the non 900MHz operators more to compete) and so this test is only relevant, by Ofcom's own analysis, to a subset of the scenarios i.e. the high significance scenarios. As Ofcom acknowledges in A8.111 *"we still consider it unlikely that asymmetric profit shocks will have a direct, material effect on competition".* (Our emphasis)

[7] Paragraph 5.72 of the consultation

[8] Paragraph 2.2 of the consultation

– or of current events, but rather a prediction of events which are more or less likely to occur in future if a decision prohibiting the planned concentration or laying down the conditions for it is not adopted. Thus, the prospective analysis consists of an examination of how a concentration might alter the factors determining the state of competition on a given market in order to establish whether it would give rise to a serious impediment to effective competition. Such an analysis makes it necessary to envisage various chains of cause and effect with a view to ascertaining which of them are the most likely."[9]

8. Vodafone submits that, based upon the evidence it puts forward, there is simply no case to conclude that liberalising 900MHz spectrum will lead to a distortion of competition in any mobile market.

Is it proportionate and justified?

9. Finally, under the terms of the Directive, even if a distortion to competition is identified, Member States must address it only if it is proportionate and justified so to do. Clearly this requires Ofcom to consider the scale of any distortion it might identify and weigh that against the costs placed upon operators to address that distortion. If, as we argue, the costs outweigh the benefits, or Ofcom does not take sufficient account of the inherent uncertainty of those benefits (by ignoring the prior question of whether Vodafone and O2 would actually re-farm) they cannot be proportionate or justified.

[9] Commission v. Tetra Laval Case C-12/03 P at paragraphs 42 and 43

PART 2 – Detailed Review of Ofcom's Scenario Analysis

Introduction

10. Given the central role that Ofcom's scenario analysis plays in shaping its policy proposal Vodafone has devoted considerable time and effort to critiquing this work. We have therefore chosen to include much of the detail of our analysis in the main body of our response rather than relegating it to a series of annexes.

11. Part 2 of Vodafone's response is dedicated to analysing the internal logic and coherence of Ofcom's scenario analysis. In the various sections and accompanying annexes (4 through to 7):

    a) ✂[10]

    b) ✂[11]

    c) ✂.

    d) We expose the internal incoherence and logical inconsistency of Ofcom's scenario analysis and show that:

        i) the boundaries between the significance scenarios do not define points at which operators will behave differently.[12]

        ii) Ofcom's method for locating the boundaries is inconsistent with its own technical analysis of the difference between frequencies.

        iii) there are a large number of other inconsistencies between the detailed annexes and the way in which they are used and interpreted in the main body of the scenario analysis.

        iv) the model Ofcom uses to calculate the cost differences between the frequencies is incorrectly and inconsistently used by Ofcom so that the cost differences are overstated by Ofcom.[13]

12. In Part 3 we go on to examine and re-quantify the three most important components of Ofcom's analysis: the differential site numbers arising from the technical analysis of the differences between 900MHz and 2100MHz, the cost of clearance and release of GSM 900 spectrum and the benefit of competition.

[10] Further detail to that in Part 2 is supplied in Annex 6.
[11] This topic is further explored in Annex 7.
[12] Annex 4 supplies much of the detail of this analysis.
[13] Annex 5 examines this in detail.

Data Markets[14]

✂

Ofcom's scenario analysis

13. Ofcom builds a sophisticated methodology for reviewing the implications of one action, the factual, against the opposite, or counterfactual, all against the background of 900MHz incumbent rollout of UMTS 900 (except in the low significance scenario).

14. Vodafone endorses an analysis of alternatives based on low, medium and high significance scenarios. Our case is that Ofcom has incorrectly assessed the boundaries between the scenarios and the costs and benefits that then arise in each situation and its counterfactual. If the significance scenarios have not been correctly located in terms of the demand for data services, then any assessment of the costs and benefits that relate to each scenario is meaningless. In summary, Vodafone submits that:

    a) The breakpoints are not located in positions which demarcate a change in operators' strategic decisions. We submit that this has happened because there is no sense-check in Ofcom's analysis which translates the breakpoints into either traffic or revenue forecasts, which are a more relevant determinant of operator decision making (of network deployment and/or market entry or "exit"). When Vodafone attempts to locate Ofcom's defined breakpoints along the 'customer' dimensions identified by Ofcom — speed, volume and penetration — it reveals that the positioning of the breakpoints is implausible and incoherent.

    b) The location of the breakpoints is inconsistent with the detail of Ofcom's work in the accompanying annexes.

    c) There are a significant number of inconsistencies and misinterpretations of Ofcom's own detailed work in annexes 9 and upwards which means that the parameters and outputs used in the scenario analysis are not consistent with one another or with what Ofcom has concluded elsewhere.

    d) The scenario analysis is too narrow. It considers UMTS 900 deployment as an end in itself, comparing UMTS 900 against UMTS 2100. Nowhere is there any evaluation of LTE against UMTS, and how as a result of Ofcom's proposed intervention, the five operators might be placed to deploy the (superior) LTE when it arrives. ✂.

15. We substantiate each of these points in the following sections.

[14] This topic is explored in more detail in Vodafone annex 6

Breakpoints[15]

16. One crucial component in Ofcom's analysis is the concept of breakpoints – the levels of demand at which the behaviour of the five mobile operators varies. These breakpoints are established by Ofcom in terms of the relative site numbers required at 900MHz and 2100MHz, which are themselves a product of the anticipated level of demand for data services.

Do the breakpoints correspond to any particular level of demand?

17. One problem with Ofcom's scenario analysis is that it appears to work from a false premise: that operators will choose to compete in, or exit from the market for high speed mobile data depending upon the level of network deployment required. This means that:

    a) If less than 4,000 900 MHz sites are required, nobody will build them.

    b) If 4,001-4,499 900 MHz sites are required, then the two incumbent 900 MHz operators will build them, and the other three operators will each choose to build up to 4,500 extra 2100 MHz sites so that all five operators will compete.

    c) If exactly 4,500 900 MHz sites are required, then the two incumbent operators will build them and the RAN pair of operators will build up to 13,500 sites at 2100 MHz, so that four operators will compete, and the fifth operator will exit the market.

    d) If more than 4,500 900 MHz sites are required, then the two incumbent operators will build them and only these operators will be able to compete – the other three operators will "exit" the high quality mobile data market (or at least they will no longer be able to offer a network that is sufficient to retain customers who are sensitive to high quality data).

18. The breakpoints, to be useful, must mark a genuine point at which operators' behaviour changes. The number of sites is not an objective breakpoint in itself, merely a manifestation of the underlying variables defined by Ofcom (size of market, transmission speed and indoor penetration) and illustrated in the figure below.

[15] This subject is analysed in more detail in Vodafone annex 4

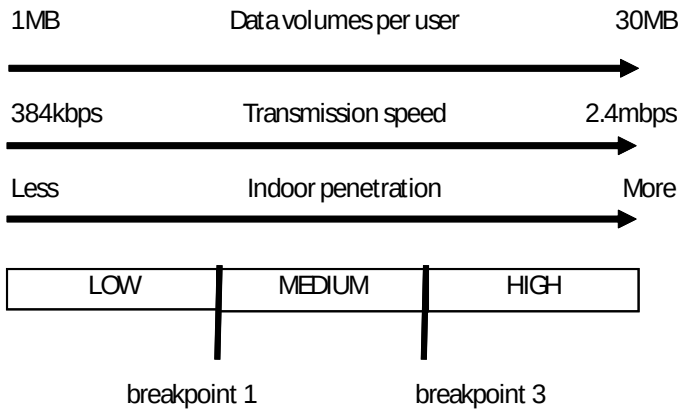

Figure 1: positioning of the significance scenarios along the data dimensions

19. However, at no point does Ofcom sense-check its breakpoints by placing them along these three underlying dimensions. And yet it is the interaction between revenue, traffic volumes, QoS and necessary network deployment that defines more realistically how individual operators will react. Vodafone has attempted to relate Ofcom's breakpoints (shown in the table below) to forecasts of traffic demand to see if they do mark a point at which operators' strategies will differ.

Scenarios	Number of sites required	
	900MHz	2100MHz
Low significance scenario	Below	Below
Breakpoint 1	4,000	10,000
Medium significance scenario, all operators can match	Between	Between
Breakpoint 2	4,500	12,375
Medium significance scenario, only RAN share operators can match	Between??	Between
Breakpoint 3	4,500	13,500
High significance scenario	Between	Between
Breakpoint 4	7,000	21,000

Table 4: Ofcom breakpoint and significance scenario locations

20. In fact the breakpoints are very difficult to place. Two particular difficulties are that Ofcom's own modelling shows that a medium speed of 1.2mbps never requires more sites than the Ofcom base speed of 384kbps, and that the volume of necessary sites at 2100 MHz is virtually flat across all levels of demand, so that capacity of 30MB can be achieved at 2100 MHz for at most 4% more sites than that required for coverage, i.e. with minimal incremental investment.

21. For breakpoint 1, Vodafone calculates (by interpolation) that the point at which 900MHz at 4,000 sites and 2100MHz at 10,000 sites have a common value for the three data dimensions

in figure 1 above is at a depth of around 1.3 i.e. 30% along the range between depths 1 and 2,[16] a speed of 1.2mbps and somewhere around the 17MB daily volume mark.[17]

22. However, if this is so, then breakpoint 1, the top end of the low scenario, and the point at which the incumbent 900MHz operators will find it profitable to switch to UMTS 900, exists at a most peculiar place, where traffic could almost double from 17MB to 30MB with almost no investment at 2100MHz, but any increase in traffic would require considerable further investment at 900 MHz, reducing substantially the productive efficiency differential, i.e. the incentive to invest in 900MHz. The transmission speed is already at a respectable 1.2mbps, and the depth is a reasonable 1.3 (whatever that may mean in practice). Conceptually, therefore the upper end of the low significance scenario should be located further to the right in Figure 1 (see Figure 2 below).

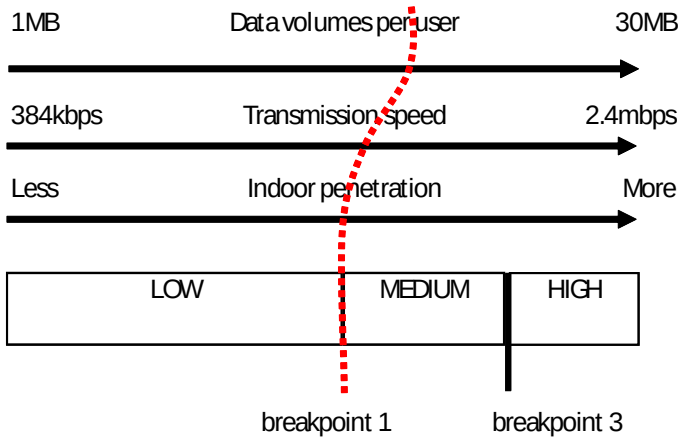

Figure 2: illustrative view of the extent of the low significance scenario

23. So why is this point construed to be a significant one for the 900MHz operators? If above this point volumes are likely to increase above a healthy 17MB per day, it is easier to absorb this at 2100MHz rather than at 900MHz. The 900MHz operators could increase the depth of penetration towards 2, but this will be a relatively subtle improvement, and unless it will increase the traffic volumes substantially (which would then significantly increase the cost of the investment, given the slope of the 900MHz traffic/site curve) or allow them to charge a significant price premium, it is not obviously viable.

24. Equally the 900MHz incumbents could increase the speed from 1.2mbps towards 2.4mbps, but again they would need to be certain that they could capture a significant number of customers and/or charge a substantial premium for this speed. However, above this breakpoint it is assumed by Ofcom that the medium scenario exists, where the 2100MHz operators would anyway be able to compete at 2100MHz, so the option open to the 900 MHz operators of

[16] Respectively Ofcom's lower and higher alternative versions of indoor penetration and coverage
[17] The detailed calculation of this is supplied in Vodafone annex 4

capturing additional customers is not available. The only opportunity therefore available to the 900 MHz incumbents that is cheaper at 900 MHz than at 2100MHz is to increase the depth, not the volume – but how would this bring in extra revenue, as compared to an increase in volume? It is not clear therefore that there is any advantage for the 900MHz operators to commence re-farming at this point. Whilst the logic of the existence of a theoretical breakpoint 1 is sound, it cannot be located where Ofcom has put it!

25. What about breakpoint 3, the point at which the medium significance scenario ends, the 2100MHz only operators "exit" the market,[18] and only the 900MHz incumbents compete? Ofcom has located this at 4,500 900MHz sites and 13,500 2100MHz sites. Its customer characteristics must be towards the right hand side of the volume, speed, and penetration diagram (figure 1). There is no single solution to where breakpoint 3 may sit, since there are a range of solutions where the depth and speed can be varied. So at a 20% speed premium above 1.2mbps, the breakpoint appears to exist at around 9MB per user, at 33% at around 7MB, at 50% at around 3MB, and at 75% there is no intersection point. Some mid-point value of this might be a speed premium of 40% over 1.2mbps, a data volume of 5-6MB and a depth of 1.6[19] This, however, is a very odd place for breakpoint 3 to sit!

26. The location of breakpoint 3 is, under Ofcom's analysis, where the data demands become too great in speed, depth and volume so that the 2100 MHz operators choose not to compete, and "exit" the high quality data market, by choosing not to expand their network above 9,000 2100MHz sites . It is very difficult to see that 4,500 900MHz sites and 13,500 2100MHz sites is the right point for this – if we assume the constraint imposed by the 4,500 sites at 900 MHz of 5-6MB applies to the breakpoint location, a very significant five-fold increase of volume above this could be accommodated with minimal increase in cell site deployment at 2100MHz, so exiting the market would be a very curious decision.

27. The crux of Ofcom's approach is that above breakpoint 3, the data demands of customers sensitive to "high quality data" are such that these customers will all vacate the 2100 MHz operators for the 900 MHz operators. Why would the 2100MHz operators allow this to happen when it is clear that they could increase the throughput of their network by 400% to 30MB with minimal further investment?

28. Comparing breakpoints 1 and 3, breakpoint 1 could be at 17MB, depth 1.3 and speed 1.2mbps, and breakpoint 3 at 5-6MB, (a third of the volume), depth 1.6 (25% deeper), and a 40% or so premium on speed. This would appear to suggest that as one moves across the medium significance scenario from the low end to the high end, the volume of data transmitted

[18] In terms of not being able to attract users sensitive to high quality data
[19] See annex 4 for the underlying calculation

falls by two-thirds, whilst the speed increases by a relatively small 40% and the depth by 25%[20]. These breakpoints are therefore mutually incoherent.

29. Vodafone concludes that the fundamental starting point for Ofcom's scenario analysis, the breakpoints at which operators' actions change from competing at 2100MHz, deploying 900MHz and competing at 2100MHz, and deploying at 900MHz are incoherent with reference to Ofcom's fundamental dimensions of competition: data volumes, speed and depth of penetration. This observation must undermine the whole of Ofcom's scenario analysis.

Ofcom's method for locating the boundaries between the scenarios

30. It is worth reviewing how Ofcom has actually identified and positioned the breakpoints because it turns out that its work is riddled with errors and inconsistencies. This means that their placement is little more than arbitrary.

31. The method that Ofcom has used relies on a few simple balances between disparate cost/benefit elements that are interpreted in a manner inconsistent with Ofcom's own analysis elsewhere in the consultation. In summary the breakpoints between the scenarios are established by Ofcom where:[21]

a) Low to medium – cost of clearance balances the cost of 900MHz operator deployment = £150m: – the value is set by the cost of clearance. This breakpoint is set at 4,000 900MHz sites and 10,000 2100MHz sites.

b) Medium A to medium B – gross profit from Cournot model balances the incremental cost of 2100MHz deployment over 900MHz deployment = £470m: – the value is set by the competition benefits model. This breakpoint is set at 4,500 900MHz sites and 12,375 2100MHz sites.

c) Medium to high – practicality limit of 2100MHz deployment cuts in before gross profit from Cournot model balances the incremental cost of 2100MHz deployment over 900MHz deployment = 13,500 2100MHz sites: – the value is set by the assumption of 1,500 sites built per year. This breakpoint is set at 4,500 900MHz sites and 13,500 2100MHz sites.

32. Between the breakpoint deployment levels, low, base and high site numbers for scenario variants are then derived by simple interpolation – it is these variants that are then assessed

[20] Given that the depth/sites and speed/sites relationship between 1 and 2 and 1.2mbps and 2.4mpbs is probably not a straight line but a rising curve, the gap between the two breakpoints in terms of speed and depth is probably even less than the simple linear comparison suggests.
[21] See the second part of Vodafone Annex 4 for more detail

for costs and benefits in the scenario analysis in annex 7. These breakpoints are therefore not fixed points – they are merely the product of the intersection of four independent sets of values computed or assumed by Ofcom:

a) the level of operator gross profits that vary with the number of operators competing in the market;

b) the cost of clearance of spectrum;

c) the relative number and hence the differential costs of deployment at 900MHz vs. 2100MHz; and

d) the number of new sites that can be built in a year.

33. Changing any or all of these values will obviously move the location of the breakpoints.

34. However, Ofcom's own numbers and analysis are not internally consistent. In the section from A7.110 onwards, Ofcom discusses how it has arrived at the particular set of relative site numbers shown above. It makes the point that "*multiple combinations of 900MHz and 2100MHz site numbers can produce the same cost difference. We have therefore selected site numbers (and ratio of 2100MHz to 900MHz site numbers) that appear reasonable and consistent with a particular outcome*."[22] The starting point for this analysis, as Ofcom makes clear is breakpoint 3, which has 13,500 and 4,500 sites. The site ratios for breakpoints 1 and 2 are then set with reference to the ratio at breakpoint 3. Whilst the 13,500 is an outcome of the practicality constraint (9,000 sites plus 3 years of 1,500 sites per year) A7.50.3 explicitly says "*from the technical analysis (set out in annex 13) we know that a ratio of 3:1 for 2100MHz sites to 900MHz sites is plausible*". So the 4,500 sites result has been created by simple division of 13,500 by 3.

35. The next stage is described in A7.111.2: "*as we move to lower cost differences, low frequency spectrum becomes less significant, so it is intuitive that the ratio of 2100MHz to 900MHz site numbers should fall. The number of sites should also fall. Using these two conditions, we are limited to a few combinations of 2100MHz and 900MHz sites numbers that produce the cost differences at break points 1 and 2*." In 7.111.3 "*using this approach we arrive at the following site numbers (900MHz vs. 2100MHz) at each break point:*

- *Break point 1: 4,000 vs. 10,000 (ratio = 2.5)*
- *Break point 2: 4,500 vs. 12,375 (ratio = 2.75)*
- *Breakpoint 3: 4,500 vs. 13,500 (ratio = 3)"*

[22] A7.111 of the consultation

36. In other words, the entirety of the sophisticated detail of annex 13 to determine the actual difference in site numbers between the frequencies has been condensed into a single ratio of 1:3 where 13,500 2100MHz sites is the independent variable, with its value derived from an estimate that a build of 1,500 new sites per annum is the practical limit for an operator, and then alternative ratios and results derived at lower levels to satisfy the predetermined cost difference required in breakpoints 1 and 2, i.e. £150m and £470m respectively.

37. However, Ofcom does not appear to realise that this ratio gives the somewhat bizarre result that breakpoints 2 and 3 require exactly the same number of 900MHz sites! To recap, inside breakpoints 2 and 3 is the medium B significance scenario, defined as that level of demand where only the RAN share pair will choose to match at 2100MHz. Below breakpoint 2 all 2100MHz operators can match. Above breakpoint 3 the level of demand is too great for any 2100MHz operator to attempt to match. However it is clearly established in the technical annex that as the volume of demand rises, the number of sites required rises. So how is it simultaneously possible for breakpoints 2 and 3 to have the same number of 900MHz sites and for the level of demand to be greater at breakpoint 3 than at breakpoint 2?

38. The only apparent way to resolve this paradox is to assume that 4,500 sites is a minimum coverage number for a particular level of service, so that as demand rises from point 2 to point 3 the number of 900MHz sites does not change – and somehow also assume there is not a matching position on 2100MHz so that the number of 2100MHz sites does increase. Ofcom however has made no such unlikely argument. Vodafone is inclined to the view that Ofcom has simply made an error in logic; its scenario analysis has just become too unwieldy.

39. As explained above, the starting point for all the pairs of site numbers is Ofcom's judgement that a 1:3 ratio applies at 13,500 2100MHz sites. Vodafone is however not as sanguine as Ofcom that a ratio of 1:3 can actually be applied. Ofcom appeals to table 5 of annex 13 for corroboration.[23] This table actually supplies 9 alternative values with individual and average ratios as follows:

[23] In A7.50.3 of the consultation

Scenario				Sites required		Relative ratio
	Data rate	Usage	Depth	900 MHz, 1 carrier	2100MHz, 2 carriers	
A	0.4mbps	1MB	1	2,900	8,600	1:2.97
B	0.4mbps	30MB	1	6,800	9,000	1:1.32
C	0.4mbps	1MB	2	4,000	12,700	1:3.18
D	2.4mbps	30MB	2	7,300	21,100	1:2.89
E	0.4mbps	30MB	2	6,800	13,100	1:1.93
F	2.4mbps	30MB	1	5,900	14,400	1:2.44
G	2.4mbps	40MB	2	7,900	21,200	1:2.68
H	2.4mbps	60MB	2	11,800	21,400	1:1.81
I	2.4mbps	30MB	2	5,900	13,400	1:2.27
Average				6,588	14,989	1:2.27

Table 5: Ofcom view of relative number of sites required under varying demand and supply assumptions

40. Vodafone submits that these results do not support the assumption of a 1:3 ratio. The average of the 9 scenarios is 1:2.27, and the only result that approximates Ofcom's breakpoint 3 is C – but this is a situation with a low transmission speed and a low data volume. Breakpoint 3 is between the medium and high significance scenarios, i.e. both the speed of transmission and the data volumes are reasonably high. The closest option that satisfies this would appear to be option I, where the site numbers are 5,900 and 13,400. This suggests that the 1:3 site ratio of breakpoint 3 is simply wrong. On any reasonable analysis, given that data values[24] must be on the high rather than the low side; when the number of 2100MHz sites is assumed to be 13,500 the number of 900MHz sites should be around 5,900 to 6,100. Correcting this would resolve the anomaly of the 4,500 site number being common to both breakpoints 2 and 3. Looking at the Ofcom cost differences model, a 6,000 to 13,500 sites result would give a 900MHz cost of £627.6m and a 2100MHz cost of £1,270.9m for a single operator, so when comparing on a 145% uplift for the RAN pair the difference is £933m, still comfortably below the other potential breakpoint constraint of affordability, which Ofcom calculated as £1.4bn.[25]

41. Vodafone also notes that Ofcom's statement that "*as we move to lower cost differences, low frequency spectrum becomes less significant, so it is intuitive that the ratio of 2100MHz to 900MHz site numbers should fall*" is the exact opposite of the output from Ofcom's technical analysis. This again points to the lack of coherence between the different strands of Ofcom's case. We contend that more sites are needed for coverage at 2100MHz than at 900MHz but that a greater number of sites gives more capacity, so that as demand rises, the number of additional sites required at 900MHz rises much faster than at 2100MHz, particularly as each operator has at least two carriers available at 2100MHz and there is only one available at

[24] In terms of volume, speed and penetration
[25] But actually slightly above the value calculated by Vodafone of £901.6m in Vodafone annex 4

900MHz. By implication the site ratio is greatest when the number of sites is lowest, and flattens as the number of sites rises. This is a trend that can be seen in the tables of relative deployment above. So, if one assumes that breakpoint 3 is somewhere around scenario I above, with a 1:2.25 ratio, then as traffic and site numbers decrease from this the ratio will rise: the breakpoint 2 ratio might be around 1:2.6, and breakpoint 1 around 1:3, not the 1:2.5 assumed by Ofcom.

42. Given that in Ofcom's analysis breakpoint 2 is where the costs of A - C are around £475m and breakpoint 1 is where A - C is £150m, it is possible to look for solutions in the model[26] where these ratios and results coincide. Breakpoint 2 might be 4,750 and 12,350 sites, and breakpoint 1 3,250 and 9,750 sites. The intervening points between the breakpoints can then be derived by interpolation, as in Ofcom's table 4 of annex 7. Table 6 below also shows possible outputs where breakpoint 3 is constrained to 12,000 sites.

		Ofcom no. of sites, @1,500 new sites pa		Vodafone no. of sites @1,500 new sites pa		Vodafone no. of sites @1,000 new sites pa	
		At 800/900MHz	At 2100 MHz	At 800/900 MHz	At 2100 MHz	At 800/900 MHz	At 2100 MHz
Breakpoint 1		4,000	10,000	3,250	9,750	3,250	9,750
Medium significance scenario, Where all 2100MHz operators can match	Low	4,125	10,594	3,625	10,400	3,750	10,312
	Base	4,250	11,188	4,000	11,050	4,250	10,875
	High	4,375	11,781	4,375	11,700	4,750	11,438
Breakpoint 2		4,500	12,375	4,750	12,350	5,250	12,000
Medium significance scenario, where only the RAN pair can match	Low	4,500	12,656	5,062	12,637	No solution	No solution
	Base	4,500	12,938	5,375	12,925	No solution	No solution
	High	4,500	13,219	5,687	13,212	No solution	No solution
Breakpoint 3		4,500	13,500	6,000	13,500	5,250	12,000
High significance scenario	Low	5,125	15,375	6,250	15,375	6,250	15,375
	Base	5,750	17,250	6,500	17,250	6,500	17,250
	High	6,375	19,125	6,750	19,125	6,750	19,125
Breakpoint 4		7,000	21,000	7,000	21,000	7,000	21,000

Table 6: Ofcom and illustrative Vodafone breakpoint and significance scenario positioning

43. This substantially revised set of scenarios will produce very different costs of deployment for the 6 (or perhaps only 3) alternatives that sit between breakpoints 1 and 3. This means that the values used by Ofcom in the scenario analysis in its annex 7 are unreliable.

44. To round off this section we note a number of other inconsistencies:

[26] Using Ofcom's cost difference model as is, rather than attempting to adjust it for the errors identified by Vodafone in subsequent sections

45. Annex 13 examines the relative site deployment between one carrier at 900MHz and two carriers at 2100MHz. Annex 7 uses this information to generate pairs of site deployment numbers that are then used in the scenario analysis. Careful scrutiny of annexes 12, 15 and most significantly the cost of deployment model makes it clear that what is actually being contemplated is that, not unreasonably, although an operator deploying at 900MHz or 800MHz reduces its stock of 2100MHz equipment, it retains 2100MHz equipment on all sites where UMTS 900 is deployed – this can be readily seen from inspection of the rollout profiles A, B and C in figures 4-6 of annex 7. It is clear that the financial comparison of the cost differences spreadsheet is constructed in the same basis – so the comparison between the deployment profiles is in cost terms between one carrier at 900MHz *plus* two carriers at 2100MHz and two carriers at 2100MHz. All deployment models are therefore considering a 900MHz deployment where 2100MHz is retained, i.e. a deployment of one carrier of 900MHz *plus* two carriers of 2100MHz. However, the two plus one vs. two scenario is not a scenario apparently used in the technical model at all, so whilst it is reasonable to expect the minimum coverage site number to be the same in this situation as for a single carrier of 900MHz, there is no indication in the technical model as to how the site deployment/data demand curve for this will be likely to change above the coverage point – so Ofcom has no basis for using the site numbers for the 900MHz operator that it has adopted.

46. Although Ofcom defines breakpoint 3 with reference to 13,500 2100MHz sites on the basis that this is the maximum that can be built by 2013 from a starting point of 9,000 in 2010 i.e. on the basis of a maximum annual build of 1,500 sites, elsewhere in the cost modelling this restriction of slow growth to 13,500 sites is absent. The cost_difference.xls model, rather than building sites at an even rate of 1,500 per year from 2011 onwards, actually builds all its new sites in 2011, and hence incurs too much opex and capex from the premature build. As a result of this the model is overestimating the costs of profile A (and the productive efficiency costs) compared with the way the breakpoint has been derived.

47. The affordability constraint, used in breakpoints 2 and 3 is constructed from the Cournot model as per annex 9 and predicts that the gross profit each RAN sharing operator can make is around £700m over the 3 year period 2012-2014, assuming immediate and complete service availability at the beginning of 2012. Ofcom also appears to assume that the 2100MHz operators have built all the requisite additional sites in 2011. Where is the logic for the existence of the practicality constraint at all, if Ofcom is conveniently assuming it away in both the benefits model and the cost of deployment model? The artificiality of the location of breakpoint 3 is thrown into sharp relief.

Conclusion

48. Ofcom's breakpoints between the significance scenarios are not placed in a manner consistent with the rest of Ofcom's analysis nor are they located at points that would signify a change in

operator behaviour. The entire edifice of the scenario analysis would appear to be built on foundations of sand.

49. In Part 3 Vodafone re-runs Ofcom's scenario analysis with updated breakpoints and revised cost and benefits.

Inconsistencies in Ofcom's analysis

50. Vodafone has uncovered a large number of inconsistencies between the various strands of Ofcom's analysis which in total are serious enough to undermine its conclusions. In summary:

a) The table below shows the inconsistency between the costs of release and the cost differences between frequencies models. This means that comparing mid-point outputs from the two models is not comparing like with like, with either the productive efficiency costs overstated or the costs of clearance understated.

Costs of release model	"Low"	"Medium"	"High"	
New site cost	£40k	£50k	£60k	
New equipment cost	£15k	£25k	£45k	
Difference between frequencies model		**"Low"**	**"Medium"**	**"High"**
New site cost		£50k	£60k	£75k
New equipment cost		£25k	£45k	£65k

Table 7: Ofcom unit costs, clearance and deployment profile models

b) Ofcom acknowledges, but does not explain, the fact that the cost difference model underlying annex 15 (and the spreadsheet supplied on Ofcom's website) does not use the same set of assumptions or produce the same results as the cost differences that are actually used for decision making in annex 7.

c) Annex 12 walks through a set of GANTT charts giving possible timings of deployment of UMTS 900, LTE 800 etc that make it clear that the likely date for full UMTS 900 deployment for a 900MHz operator is end 2014, yet the cost differences model of annexes 15 and 7 for profile C removes 2100MHz coverage in 2013 and 2014, i.e. it starts two years early, understating the costs of this profile and overstating the productive efficiency costs used in annex 7. Equally the competition benefit model in annex 9 assumes that the benefit of early UMTS relates to the period 2012-2014, whereas annex 12 considers it to be 2015-2017 (the latter produces lower benefits).

d) Annex 15 and its underlying spreadsheet makes it clear that the two contrasting scenarios being built and costed are a 2100MHz operator which subsequently acquires lower

frequency spectrum, and a GSM 900MHz operator allowed to re-farm, yet annex 7 uses the outputs of the latter to generate the costs of a non GSM 900MHz operator given early access to 900MHz. By doing so, it inadvertently claims for profile C a cost discount which annex 15 explains is only applicable for an operator deploying UMTS 900 on a site that is already equipped with both UMTS 2100 and GSM 900. Removal of this discount significantly increases the cost of profiles C and B and reduces the productive efficiency costs.

e) Annex 12 discusses explicitly the belief that the deployment by the 2100MHz operators in 800MHz will be LTE, and suggests that because of its likely superiority LTE will require fewer sites than 900MHz, yet annex 7 talks about 800MHz deployment in a technically neutral manner and uses exactly the same number of sites for 800MHz in 2017 as 900MHz in 2013. This too overstates the productivity costs.

f) Technical annex 13 makes clear the advantage of two carriers at 900MHz over one, when traffic loads are high, yet no account of the fact that LTE at 800MHz will be two carriers against the one carrier at 900MHz is taken in the dimensioning of profiles A and B vs. C.

g) Technical annex 13 appears to function with 16.2m users in the 80% population area per operator, which implies an active market size of 101m in 2011, whereas the Cournot benefit model or annex 9 uses 82m. Neither is grounded in reality.

h) The central thesis of the competition benefits model of annex 9 is that above a certain level (breakpoint 3) all data sensitive customers switch to the two incumbent 900MHz operators, who will be the only providers of UMTS 900. This will create very lopsided traffic loads between the five operators, necessitating substantial further investment by the UMTS 900 operators that is not factored into the scenario analysis.

i) The assumption in annex 7 that adding one roaming partner will involve no additional deployment costs, but adding two will require a whole new UMTS 900 carrier flies in the face of annex 13 (see Part 4).

j) When the costs of deployment are calculated, the model assumes that the RAN pair of operators builds exactly the same number of sites as a single operator, despite the presumption that the traffic is doubled. Technical annex 13 demonstrates that increasing traffic volumes increases the required site numbers, once the capacity limit of the coverage network is exceeded.

51. Vodafone corrects for those errors that it is able to in our re-working of Ofcom's analysis in Part 3.

The calculation of the cost differences between the frequencies[27]

Assessment of the cost implication of the difference in site numbers at different frequencies

52. The next stage of Ofcom's analysis is to derive the alternative cost of deployment at each frequency for each scenario. The difference in site numbers is converted into a NPV cost difference using a set of alternative deployment profiles – the results are then used by Ofcom as the productive efficiency differential cost in certain of the scenarios in annex 7, particularly the medium significance scenarios.

53. Vodafone has identified a series of errors in the way that annex 7 develops and uses the results calculated in the cost difference model in the detailed scenario analysis:

a) The version of the cost differences model as supplied in the consultation is not the one actually used in annex 7.

b) The model develops a profile of UMTS 900 deployment cost for an *incumbent* GSM 900MHz operator that annex 7 interprets as that of an *acquiring* 900MHz operator, i.e. one that does not have GSM 900 deployed, and so incorrectly includes a cost discount and significantly underestimates the cost of UMTS 900 deployment to the non GSM 900 operator by an average of £75-100m, as in table 9 below.

c) The costs for the RAN share pair of operators are incorrectly calculated and exaggerate the nature and extent of the incremental costs that are likely to be shared.

d) Premature decommissioning dates of UMTS 2100 are adopted for early UMTS 900 deployment.

e) The level of unit costs used is different from that in the cost of clearance model, and the low-high scenario range presented by Ofcom allows for site number variation only – unit costs are not flexed.

54. As a result of this Ofcom has substantially overstated the cost differences between the profiles, and hence the costs used in the scenario analysis to identify the breakpoints between significance scenarios and to calculate the productive efficiency benefit of early UMTS 900 deployment are incorrect.

UMTS deployment profiles

55. In annex 7, 12 and 15 Ofcom considers that in 2010 all five operators have a common starting position in the 80% population coverage area; it then posits three scenarios that a 2100MHz

[27] This subject is examined in more detail in Vodafone annex 5

operator might choose to adopt in the face of UMTS 900 deployment by the incumbents.[28] The differences between profiles A and C, and B and C are given in table 8 below:

Total site numbers by year	Profile A	Profile C	A vs. C	Profile B	Profile C	B vs. C
2010	9,000	9,000	0	9,000	9,000	0
2011	12,938	9,000	3,938	9,000	9,000	0
2012	12,938	9,000	3,938	9,000	9,000	0
2013	12,938	6,750	6,188	9,000	6,750	2,250
2014	12,938	4,500	8,438	9,000	4,500	4,500
2015	12,938	4,500	8,438	9,000	4,500	4,500
2016	8,719	4,500	4,219	6,750	4,500	2,250
2017	4,500	4,500	0	4,500	4,500	0
2018	4,500	4,500	0	4,500	4,500	0

Table 8: difference in site numbers between deployment profiles

56. Ofcom's modelling does not remove the 2100MHz equipment from any UMTS sites that remain in service so that in all three profiles there are 4,500 sites with both lower frequency (800MHz or 900MHz) and 2100MHz capability. Strangely however, this is not how Ofcom in annex 13 has evaluated the relative difference between frequencies, where for example in table 25 comparison is made between site numbers required where an average operator has either one carrier at 900MHz, two carriers at 900MHz or two carriers at 2100MHz – the number of sites required where the operator has one carrier at 900MHz together with two carriers at 2100MHz is not evaluated, but is likely to be rather different from the number required where an operator is using only one carrier at 900MHz for its UMTS traffic.[29] So there is no obvious justification for Ofcom using the 900MHz sites numbers that it has adopted.

57. In the case of profiles C and B where the 2100MHz operators do not expand their 2100MHz network, but wait for the arrival of the lower frequency spectrum in 2014, the higher costs of retaining all 9,000 2100MHz sites for a longer period in Profile B than C are offset by the reduction in cost from the delay in lower frequency implementation. But here for both B and C, the model is assuming a 50% discount when the UMTS 900 deployment is on sites that already have GSM 900 and UMTS 2100.

58. Ofcom explains in annex 15 that this saving arises through sharing of common frequency equipment (e.g. antennas) between GSM and UMTS at 900MHz. Vodafone submits that this discount is inappropriate for a GSM 900 operator since ✂[30] The removal of this mistaken

[28] These are assembled in more detail in annex 12
[29] This is a deficiency that Vodafone has addressed in its own modifications to the model underlying annex 13.
[30] The point is discussed in more detail in our annex 5.

discount would increase the cost for the 900MHz operator in profile C by £99.5m.[31] But in any event, it is clear that even in Ofcom's logic, this 50% discount can only apply to the incumbent 900MHz operators, and not to a non GSM 900 operator being awarded 900MHz spectrum, since this operator has no pre-existing 900MHz equipment on its cell sites. It is apparent from the labelling of the cost differences model that was developed for annex 15 that it is the cost of the *incumbent* 900MHz operator that Ofcom was seeking to model in the spreadsheet. By adopting the model's calculated costs for this operator type to stand for Profile C for a 2100MHz operator i.e. an *acquiring* UMTS 900 operator, in the annex 7 analysis, Ofcom has misinterpreted its own model. Thus profile C needs to be reworked with the 50% discount removed.

59. Similarly it appears to Vodafone that Ofcom has misunderstood their model for Profile B (the "wait until 800MHz is available" option) since although the model calculates the cost for both a 900MHz operator at £516m (with the GSM 900/UMTS 900 discount) and for a 2100MHz operator where no GSM 900 discount is applied, £597m, it is the £516m which appears to have been used in table 3 (rounded to £525m). Hence all the results of Profiles C and B shown in table 3 of annex 7, and consequently all the productive efficiency calculations used by Ofcom in the scenario analysis, are wrong.

60. Vodafone supplies in table 9 below for the single 2100MHz operator the rounded values supplied by Ofcom for profiles A, B and C in table 3 of annex 7, the underlying results obtained from the model, and the corrected results when the 50% shared GSM and UMTS 900 frequency discount is removed. The cost of profiles B and C generally increases by £75-100m (and thus the difference between them and A — the productive efficiency cost — declines by a similar sum).

[31] In the medium B base scenario

Scenario for single 2100MHz operator, adopting any of the three alternative profiles		Site numbers		Profile A (match at 2100MHz)		Profile B no match, subsequent deploy of 800MHz			Profile C deploy 900MHz		
		Lower freq	Higher freq	Ofcom table 3	Model result	Ofcom table 3	Model result	Corrected model result	Ofcom table 3	Model result	Corrected model result
		No.	No.	£m	£m	£m	£m	£m	£m	£m	£m
Medium A	Low	4,125	10,594	775	768	500	504	579	525	519	608
Medium A	Base	4,250	11,188	850	851	500	508	585	525	526	619
Medium A	High	4,375	11,781	925	933	500	512	591	525	533	630
Medium B	Low	4,500	12,656	1,100	1,053	525	516	597	550	541	640
Medium B	Base	4,500	12,938	1,100	1,090	525	516	597	550	541	640
Medium B	High	4,500	13,219	1,100	1,126	525	516	597	550	541	640
High	Low	5,125	15,375	1,400	1,435	525	536	627	575	578	693
High	Base	5,750	17,250	1,800	1,753	600	596	696	625	614	745
High	High	6,375	19,125	2,100	2,100	675	682	778	675	668	805

Table 9: Outputs for profiles A-C, removing incorrect discount

RAN sharing

61. Since the particular scenario illustrated in detail above (scenario 5, medium B base) is one where it is assumed by Ofcom that only the RAN shared operators can compete at 2100MHz with the incumbent operators, the scenario analysis developed by Ofcom then assumes that these operators can jointly follow option A but that there is a reduction in each individual operator's costs of 27.5% from the single operator cost of £1,090m shown above, so that the combined costs for the pair of operators are 2*72.5% or 145% of this cost, i.e. £1,580m. Ofcom thus adopts in the scenario analysis the proposition that the difference between the RAN pair securing 900MHz spectrum and deploying at 2100MHz is £1,600m less £800m, or £800m. The value of this cost avoidance can then be seen in (for example table 59 of annex 7) as the major benefit of ensuring that the RAN pair do in fact secure access to 900MHz.

62. This simple application of a 27.5% discount to all the costs incurred under both profiles A and C is not the right way to identify the differential cost between A and C. The difference between the two profiles is almost entirely the £500m or so spent on new 2100MHz only sites (using the medium cost assumption of £60k for the site build and £45k for the electronics). Given that the two RAN sharing operators, T-Mobile and H3G are sharing both sites and 3G radio network equipment[32] there is no reason why a new 2100MHz site that is shared will cost them jointly a premium of 45% over the £105k. It is reasonable to assume in the circumstances where the single operator has a cost of £60k site build and £45k equipment, that the combined unit costs

[32] T-Mobile and H3G, joint press release 18th December 2007

for the RAN pair will be £60k site build and £60k for the equipment. Inputting these into the cost differences model changes the result for Profile A to a joint cost of £1,306m.

63. The costs of Profile C should also change, since what is being envisaged in Profile C by Ofcom is that the RAN pair will jointly use a single carrier at 900MHz – it is appropriate therefore that the upgrade to the existing stock of sites with UMTS 900 equipment should also use the £60k unit cost assumed for the equipment. Equally to maintain comparability between Profiles C and A (and correctly identify the cost difference between them) the costs of the existing stock of 9,000 sites should be consistently calculated. Therefore it is reasonable to recalculate the cost of Profile C using the same £60k site build and £60k electronics cost as Profile A – the result should give the joint cost of operating at 900MHz from an early date as opposed to the joint cost of matching at 2100MHz and then operating at 800MHz subsequently as is assumed in Profile A.

64. It is possible using this form of joint costing to restate the RAN share cost portion of Ofcom's table 3[33], as follows:

Scenario for RAN pair of 2100MHz operators, giving joint costs of adopting any of the three alternative profiles		Site numbers		Profile A (match at 2100MHz)			Profile B no match, subsequent deploy of 800MHz			Profile C deploy 900MHz		
		Lower freq	Higher freq	Ofcom table 3	Model result	Corrected model result	Ofcom table 3	Model result	Corrected model result	Ofcom table 3	Model result	Corrected model result
		No.	No.	£m	£m	£m	£m	£m	£m	£m	£m	£m
Medium A	Low	4,125	10,594	1,100	1,114	946	750	731	735	750	753	768
Medium A	Base	4,250	11,188	1,250	1,234	1,039	750	737	743	750	763	783
Medium A	High	4,375	11,781	1,350	1,353	1,132	750	742	751	750	773	797
Medium B	Low	4,500	12,656	1,550	1,527	1,265	750	748	759	800	784	811
Medium B	Base	4,500	12,938	1,600	1,581	1,306	750	748	759	800	784	811
Medium B	High	4,500	13,219	1,650	1,633	1,346	750	748	759	800	784	811
High	Low	5,125	15,375	2,000	2,081	1,694	800	777	799	850	838	882
High	Base	5,750	17,250	2,600	2,542	2,048	850	864	878	900	890	951
High	High	6,375	19,125	3,000	3,045	2,432	1000	989	972	950	969	1,027

Table 10: RAN share pair, profiles A-C, revised costs

65. The difference between the profiles, particularly A – C has reduced significantly.

66. There is an additional factor which indicates that the productive efficiency calculations above are still too high. Ofcom assumes that the RAN share operator can double traffic demand and use exactly the same number of sites as the single operator at 900MHz. This is completely at

[33] In annex 7

odds with the technical modelling and the scenarios which contend that, as the data demand rises, so does the volume of sites required, particularly at 900MHz (see Ofcom's table 25 of annex 13). Therefore the profile A to profile C comparison for the joint RAN pair should not be made on the basis of comparing one 900MHz carrier to two 2100MHz carriers, but on the basis of a doubled traffic load on one 900MHz carrier to the same load on four or five 2100MHz carriers.[34] This will undoubtedly increase the cost of Profile C, decreasing the productive efficiency cost i.e. C – A by a measurable extent.[35]

Equipment decommissioning

67. The model is very cavalier with equipment and site decommissioning. In the abrupt fall in site numbers, spread across 2013 and 2014 for Profile C, and across 2016 and 2017 for Profiles A and B, several assumptions are made implicitly. Whilst 2100MHz is retained on all lower frequency sites, given that Ofcom is confident that the 2100MHz equipment has a reduced coverage reach, at the edge of every site there will be an area that can only be reached by UMTS 900 (or at least if there is 2100MHz coverage in this marginal area it will be to a reduced indoor penetration and to a lower transmission speed.) It is presumably assumed by Ofcom that there are no remaining UMTS customers who do not have UMTS 900 compatible equipment from the decommissioning date of 2013 for profile C.

68. It is not clear that this will be the case; there is a risk that a significant proportion of customers will still have 2100MHz only devices, and would thus effectively be disenfranchised by early decommissioning. The consequences in terms of poor quality of service for these customers and loss of reputation for the 900MHz incumbents would considerable – unless Ofcom is assuming some form of forced migration to UMTS 900 capable devices (if so, one would expect to see this being costed as part of profile C, and it is not).

69. The decommissioning date of 2013-14 that Ofcom has adopted is apparently derived from annex 12. Table 7 of that annex calculated the decommissioning point as the period 2013 - 2014 on the basis that this is the "*point at which user equipment is in hands of most data users and there is a full level of service*" but in fact concludes that the date for penetration of suitable devices for most data users is *"no later than end 2013"* (and the secondary constraint of full service being mid 2013 and end 2013 in GANTT charts C and D respectively) so the removal of 50% of the decommissioned sites in 2013 for the 900MHz operator might be one year premature. By contrast the timing of profile A for 800MHz deployment in table 8 of annex 12 concludes that the equivalent date for handset deployment is end 2015, and then fairly rationally proceeds to decommission in 2016 and 2017. This suggests to Vodafone that to be consistent between the assumptions for A and C, the model should delay the 2100MHz

[34] Arguably though in the context of annex 7 and the way the cost difference model works, the comparison should actually be between a) one carrier of 900MHz with five carriers of 2100MHz, and b) five carriers of 2100MHz. Vodafone is not aware that Ofcom has attempted such a comparison.

[35] Of course the difficulty of doing this for Ofcom's current set of scenarios is that as seen above they are not linked to any particular volume forecast

decommissioning for the 900MHz incumbent under Profile C by one year from 2013-14 to 2014-15.

70. More significantly however, inspection of the GANTT charts in annex 12 reveals that charts C and D, that give a full service start date of UMTS 900 as end 2013 actually relate to the incumbent 900MHz operators. It is charts E and F that relate to profile C of an acquirer of 900MHz spectrum; whilst the first criterion that of device penetration is unchanged as end 2013, the date of full service is now end 2014. This suggests that for such an operator, decommissioning should not start earlier than 2015, two years later than annex 7 is assuming.

71. It is necessary therefore to redo Profile C for the 2100MHz operator for both the single and RAN sharing operators, delaying the decommissioning by two years, and for the 900MHz operators, delaying decommissioning by one year, as follows:

Scenario for profile C, with the decommissioning of 2100MHz delayed by one year for the incumbent 900MHz operator, and by two years for the acquirer 900MHz operator		Site numbers		Single 2100MHz operator acquiring 900MHz		900MHz incumbent refarming for UMTS		RAN pair 2100MHz operators acquiring 900MHz	
		Lower freq	Higher freq	Previously calc above	Impact of delay	Previously calc above	Impact of delay	Previously calc above	Impact of delay
		No.	No.	£m	£m	£m	£m	£m	£m
Medium A	Low	4,125	10,594	608	679	608	645	768	855
Medium A	Base	4,250	11,188	619	688	619	655	783	867
Medium A	High	4,375	11,781	630	698	630	665	797	880
Medium B	Low	4,500	12,656	640	707	640	675	811	892
Medium B	Base	4,500	12,938	640	707	640	675	811	892
Medium B	High	4,500	13,219	640	707	640	675	811	892
High	Low	5,125	15,375	693	753	693	724	882	954
High	Base	5,750	17,250	745	798	745	773	951	1,014
High	High	6,375	19,125	805	852	805	829	1,027	1,083

Table 11: revised cost of profile C with delayed decommissioning date

Site removal

72. Ofcom is not only decommissioning equipment, but also completely decommissioning some of the stock of sites that only hold 2100MHz equipment, up to 3,000 in the case of profiles B and C, and potentially considerably more than that in the case of profile A. In the case of site removal it is effectively assumed that there is no future use at any frequency for a site at this particular location. This means that Ofcom is presuming on the operators' behalf that sufficient capacity can always be provided in the foreseeable future by a less dense network of sites.

73. In the example of scenario 5, Profile C is assuming that the operator acquiring 900MHz spectrum can remove 2,050 2100MHz only sites, permanently decommissioning not only the 2100MHz equipment but also the cell site itself in the designated years. In practice these sites would only be decommissioned if the operator can be certain that the stock of remaining sites, effectively the total of 6,250 GSM sites, is sufficient to allow for future growth of demand.[36] It is not clear that this is a valid assumption. Looking at the technical annex 13, table 5, it is not difficult to identify Ofcom scenarios where more than 6,000 sites are required for UMTS 900.

74. So, in a real world outcome where data demand continues to rise during the next decade, if one of the 900MHz incumbents decommissions sites when the level of demand is equivalent to the medium significance scenario, it will be forced to acquire further new sites when in due course the level of demand rises towards the high scenario, a potentially very expensive option. Removal of currently surplus sites in the expectation that they will never be needed is therefore an unrealistic assumption. A non GSM 900 incumbent, under either profile B or A will not face this problem until a later date than a GSM 900 operator, since they will continue to have a stock of (as a minimum) 9,000 UMTS sites available for UMTS 900 deployment, and hence would be less exposed to traffic volume increases over time. This point is particularly relevant given the rising cost of site builds and the falling cost of site equipment modelled by Ofcom. In effect therefore, Ofcom's simple profile analysis is assuming both perfect knowledge in 2010 and flat data volumes from 2012 or so.

Summary

75. Correcting for the shortcomings identified above and also allowing for Ofcom's own variation in the unit cost of sites shown in table 7 above significantly reduces the size of the cost difference between profiles A and B, and hence the quantum of the productive efficiency benefit that it is appropriate to use in Ofcom's scenario analysis, as is shown in table 12 below.[37] The productive efficiency differentials calculated by Ofcom are substantially exaggerated by between 25 and 75%.

[36] Given that most of the GSM only sites do not have 2100MHz for technical reasons which probably also will restrict their use for UMTS 900, the real available pool is limited to not much more than 6,000 sites
[37] More details to this table, and the underlying calculation can be found in Vodafone annex 5

Scenario	Costs used	Site volumes		
		Low £m	Base £m	High £m
Single operator, medium significance, all operators can match, difference between profiles A and C	Vodafone max/min	57	163	304
	Ofcom base/high (as previously used)	250	325	400
	Reduction from Ofcom	193	162	96
	% reduction	77%	50%	24%
RAN shared pair, medium significance, where all operators can match, difference between profiles A and C	Vodafone max/min	57	172	327
	Ofcom base/high (as previously used)	350	475	575
	Reduction from Ofcom	293	303	248
	% reduction	84%	64%	43%
RAN shared pair, medium significance, where only the RAN pair can match, difference between profiles A and C	Vodafone max/min	213	414	593
	Ofcom base/high (as previously used)	750	800	850
	Reduction from Ofcom	537	386	257
	% reduction	72%	52%	30%

Table 12: Differential cost A minus C, Ofcom vs. Vodafone

76. As a result of the scenario analysis approach of Ofcom, once the productive efficiency costs of A minus C change, this also means that the breakpoints will change. This is detailed in annex 5, but the most significant change is that breakpoints 2 and 3 appear now to be both governed by the same practicality constraint (since the affordability constraint that previously defined breakpoint 2 now relates to a bigger site build at 2100MHz than the practicality constraint will allow). If breakpoints 2 and 3 are in the same location, then the medium B significance scenario, when only the RAN pair is able to match, which is the outcome that is supposed to exist between breakpoints 2 and 3, would appear to have no viable outcomes. Given that this scenario is a major component of the assessment of the benefit of regulatory intervention[38], this further undermines the robustness of Ofcom's conclusions.

[38] For example the assessment in Ofcom's table 112 of annex 7 of the net benefit of the one block release in the base medium scenario, £450m, is the simple average of table 59 for medium B, £625m, and a much smaller value from table 64 for medium A, £250m – when the medium B solution disappears, the average net benefit, other things being equal falls to £250m. (But as per table 12 above Vodafone believes the gross benefit on table 64 should fall by £303m, the actual result of table 64 becomes negative.)

PART 3 – Review of major inputs to the spectrum scenario analysis – costs of clearance, the difference between the frequencies, and benefits from competition

77. In part 3 Vodafone reviews and revises the key quantitative elements of Ofcom's scenario analysis. We find that:

a) The costs of GSM clearance for the 900MHz incumbents have been substantially understated. This is further detailed in annex 2.

b) Ofcom has made significant errors in its technical analysis of the difference between frequencies; the high cell edge speed that it claims is necessary for the high quality data market to emerge is not physically attainable in loaded UMTS networks and the difference between 900MHz and 2100MHz in terms of cell deployment under rising data volumes is exaggerated. This is examined in detail in annex 1.

c) The benefit of competition, i.e. the increased consumer welfare benefits arising from increasing the number of competitors in the high quality data market through regulatory intervention has been substantially overstated as a consequence of treating the data market as homogeneous and of misunderstanding the likely real and perceived advantage of "fast 900MHz" over "moderate 2100MHz" to the average consumer. (Annex 3 supplies additional detail on this issue).

78. Our revised values for these elements are fed back into Ofcom's own scenario analysis. Vodafone demonstrates that using Ofcom's methodology with corrected inputs the operators never move out of the low significance scenario, ✂.

The cost of clearing and releasing 900MHz spectrum[39]

79. In this section Vodafone summarises its critique of Ofcom's cost of clearance analysis. We use our revised estimates within the framework of Ofcom's scenario analysis to relocate the breakpoints between the significance scenarios and to alter the costs that are an input to the results of the scenario analysis.

80. Ofcom estimates the costs of clearing and releasing different quantities of 2G spectrum. These estimates are based on three different approaches:

i) Approach 1: SFH upgrades and UMTS2100 widening

ii) Approach 2: SFH upgrades plus cell splitting

[39] Vodafone annex 2 covers this subject in more detail

iii) Approach 3: GSM 1800 upgrades plus cell splitting

81. Ofcom's estimates of the costs of clearing and releasing 900MHz spectrum using each of these approaches are summarised below in tables 13 and 14. These costs do not include the costs associated with removal of the interleaving of the current Vodafone and O2 spectrum allocations.

Blocks cleared	Approach 1		Approach 2		Approach 3	
	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)
1 block	30	45	30	45	45	70
2 blocks	60	100	70	110	80	120
3 blocks	260	430	190	290	140	210
4 blocks	520	880	500	770	260	400
5 blocks	880	1,550	1,600	2,400	530	810

Table 13: Ofcom estimated costs of clearance, 10% 2G traffic growth

Blocks released	Approach 1		Approach 2		Approach 3	
	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)
1 block	200	330	120	180	60	90
2 blocks	260	450	310	480	120	190
3 blocks	360	670	1,100	1,630	270	410

Table 14: Ofcom estimated costs of release, 10% 2G traffic growth

82. Vodafone's costs estimates, based on similar methodology to that used by Ofcom, are provided in Table s 15 and 16 below. For the purposes of comparison with Ofcom's cost estimates we have assumed that Vodafone and O2 incur the same costs for spectrum clearance.

Blocks cleared	Approach 1		Approach 2		Approach 3	
	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)
1 block	40	80	100	120	50	60
2 blocks	260	290	240	300	140	160
3 blocks	600	740	700	920	380	450
4 blocks	1,200	1,180	1,250	1,660	720	830
5 blocks	1,790	1,770	2,490	3,520	1,270	1,510

Table 15: Vodafone estimated costs of clearance, 10% 2G traffic growth

Blocks released	Approach 1		Approach 2		Approach 3	
	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)
1 block	340	450	460	620	240	290
2 blocks	940	890	1,010	1,360	580	670
3 blocks	1,530	1,480	2,250	3,220	1,130	1,350

Table 16: Vodafone estimated costs of release, 10% 2G traffic growth

83. The differences between the Ofcom and Vodafone estimates for clearing and releasing spectrum blocks are summarised in tables 17 and 18 respectively.

Blocks cleared	Approach 1		Approach 2		Approach 3	
	Lower	Upper	Lower	Upper	Lower	Upper
1 block	10	35	70	75	5	10
2 blocks	200	190	170	190	60	40
3 blocks	340	310	510	630	240	240
4 blocks	680	300	750	890	460	430
5 blocks	910	220	890	1,120	740	700

Table 17: Differences between Vodafone and Ofcom estimated costs of clearance (positive figure indicates that Vodafone's estimate is higher)

Blocks released	Approach 1		Approach 2		Approach 3	
	Lower	Upper	Lower	Upper	Lower	Upper
1 block	140	120	340	440	180	200
2 blocks	480	110	580	700	400	390
3 blocks	710	30	720	930	680	660

Table 18: Differences between Vodafone and Ofcom estimated costs of release (positive figure indicates that Vodafone's estimate is higher)

84. Ofcom underestimates the costs of a one block release by between £130m (the mid-point of the range for approach 1) and £390m (the mid-point of the range for approach 2).

85. The significant differences between our estimates result from flaws in Ofcom's methodology and assumptions, in particular:

a) ✂.

b) The assumed BCCH channel re-use factors that are achievable outside of urban areas and in all areas, when higher quantities of spectrum are cleared, are overoptimistic.

c) The approach of modelling 'average sites' appreciably underestimates the number of additional sites required to augment network capacity in a 'real world' network in order to overcome cell congestion.

d) Ofcom's assumptions regarding SFH are flawed; this means that Ofcom miscalculates both the numbers of sites which would need to be upgraded under the different spectrum removal scenarios and the costs involved for Vodafone to implement SFH in its GSM network.

e) Ofcom has underestimated the true costs of performing GSM 1800 upgrades to existing 2G sites.

86. Further details of the limitations of Ofcom's analysis are provided in Annex 2.

High spectrum clearance scenarios

87. Vodafone does not believe that it would be possible to clear 10MHz (or more) in the foreseeable future (based on 2G traffic levels) and maintain an acceptable network quality. The risks of customer disruption would be untenable for the following reasons:

✂.

88. For these reasons, the costs provided for these two extreme clearance scenarios are purely theoretical and are only shown for illustrative purposes.

Timing of release

89. Ofcom estimates that spectrum blocks could be cleared in 18 months and assumes that 24 months is adequate for release (i.e. allowing for some contingency). Ofcom also assumes that no delays in release would occur if a GSM 900 operator decided to deploy UMTS 900 in parallel with 2G spectrum clearance. However, many of the vital tasks that an operator clearing spectrum and deploying a UMTS 900 network would have to perform have been ignored. Vodafone estimates that at least 3 years would be required before release is possible:

✂.

Network disruption

90. By confining itself to quantifying only the transient impact of network rearrangements (a small number of dropped calls across a small number of days) Ofcom has overlooked the much

wider and longer term risks to the 900MHz incumbents associated with the loss of GSM spectrum in terms of the uncertainty of the traffic levels at the point of spectrum surrender and the uncertainty of whether all cell sites required will actually be found in the time available: a higher traffic level than forecast or a failure to find important sites could lead to a long term, not a transient issue with GSM QoS.

Critique of Ofcom analysis of UMTS site counts at different operating frequencies[40]

91. Ofcom has revised its approach to estimating the number of sites required to deploy UMTS networks operating at different frequencies. However, the analytical model that Ofcom has developed is seriously flawed in a number of areas and as a result:

a) It overestimates the number of sites required to provide coverage to the more densely populated areas at all frequencies. For example, assuming a user demand of 30MB/user/day, the Ofcom model predicts that between 14,363 and 21,094 sites are required for a UMTS 2100 network. We believe that only 11,100 sites are necessary.

b) When the technical errors are corrected the model underestimates the number of sites required to provide coverage to the more densely populated areas at all frequencies. This is because Ofcom assumes a contiguous coverage area with perfectly tessellated hexagonal cells. The predicted number of 20,761 sites for UMTS 2100 coverage falls to 8,268 sites after the errors in the model have been corrected.

c) It significantly overestimates the capacity of HSDPA cells: predicting capacities greater than 10Mbps/carrier versus the maximum possible theoretical capacity of 4.5Mbps/carrier.[41]

92. Vodafone has used the following methodology to evaluate critically the Ofcom model (more detail is available in annex 1):

a) We analysed the model and corrected any errors that we detected.

b) We modified the model to predict the number of sites required by an operator that has one UMTS 900 carrier together with two UMTS 2100 carriers for different levels of user demand.

c) We assessed the outputs from the corrected model using Ofcom's baseline assumptions for site requirements at 900MHz and 2100MHz.

[40] Vodafone annex 1 considers this issue in more detail

[41] In actual HSDPA networks the capacity will be lower than the theoretical maximum since advanced terminal architectures are necessary, which are not supported by many of today's existing HSDPA terminals.

d) We assessed how the corrected model predicts the site numbers based on Vodafone's current network design assumptions and the number of sites that we expect from our coverage plans.

e) We re-calibrated the corrected model based on our expectations of the upper limit on the UMTS 2100 site numbers required for 80% population coverage.

f) We used the corrected, recalibrated model to predict the site numbers required for differing levels of user demand.

93. The key errors in Ofcom's model are:

a) Ofcom has assumed that a cell edge HSDPA data throughput of 2400kbps is achievable in a loaded HSDPA network, whereas the data speeds achievable at the cell edge will be limited to approximately 500kbps in actual HSDPA networks. Ofcom's link budget calculations for HSDPA do not correctly account for the inter-cell interference found in actual HSDPA networks. When these errors are corrected, the number of sites required for coverage reduces dramatically at all frequencies.

b) With the link budget errors corrected, the model then underestimates the number of sites required for coverage at all frequencies compared to actual HSDPA networks.

c) The assumption that a cell edge HSDPA data throughput of 2400kbps can be achieved results in an overestimate of the HSDPA cell throughput per carrier.

d) ✂.

e) The cell areas used in the model are calculated incorrectly. Ofcom uses the formula $2.6*r^2$ whereas the formula 1.95*r2 should be used for tri-sectored sites (where r is the cell radius). Correcting this error actually increases the number of sites predicted by the model, but this is more than offset by the reduction in the number of sites predicted by the model when the other errors are corrected.

f) The Extended Hata (SE21) propagation model is implemented incorrectly.

94. We have corrected the errors in Ofcom's model. The details of the changes are described in annex 1. Ofcom's estimates of site numbers are shown in Figure 3 below and the impact of our corrections on the site numbers is shown in Figure 4. The curves are produced purely as a result of correcting algorithmic errors in the model and the percentage of power dedicated to the CPICH. We have used Ofcom's baseline planning margins for UMTS 900 and UMTS 2100 networks.

95. The differences between the numbers of sites the original Ofcom model predicts for HSDPA coverage and the numbers the Vodafone corrected model predicts are pronounced. For example, assuming an operator has 2 carriers at 2100 MHz, Ofcom predicts that 20,761 sites are necessary for coverage (for an unachievable, 2400kbps cell edge data rate in a loaded network) whereas the corrected model predicts that this figure is 8,268 sites. We note that Ofcom makes the approximation that an operator which has access to one UMTS 900 carrier and two UMTS 2100 carriers is equivalent to an operator which has access to two UMTS 900 carriers. We have modified Ofcom's model to correctly account for an operator that has one 900MHz carrier and two 2100 MHz carriers.

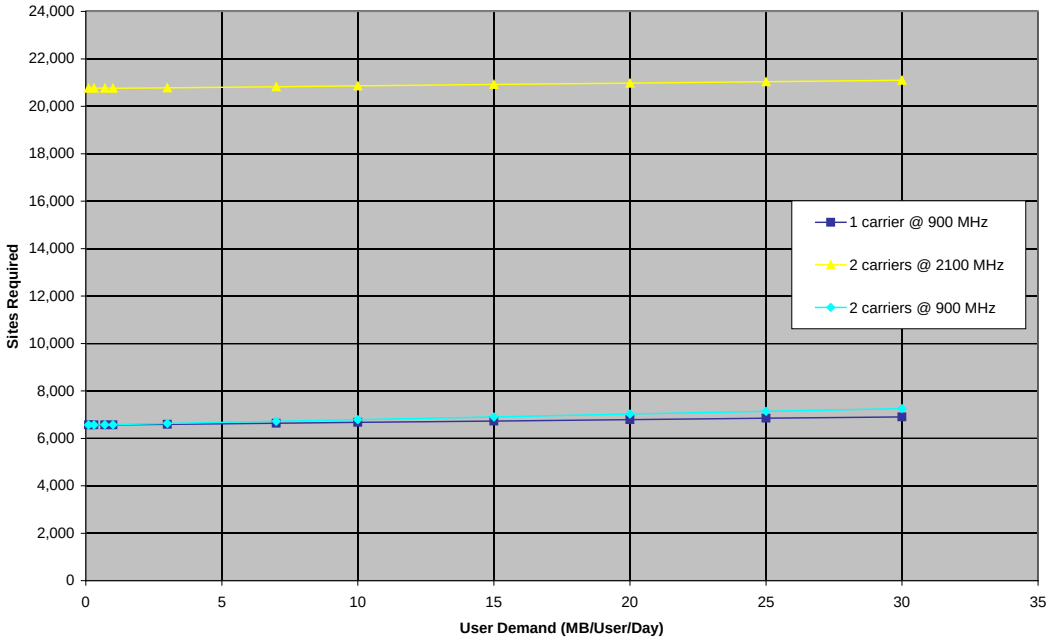

Figure 3: Estimated site counts v User demand (Ofcom estimates).

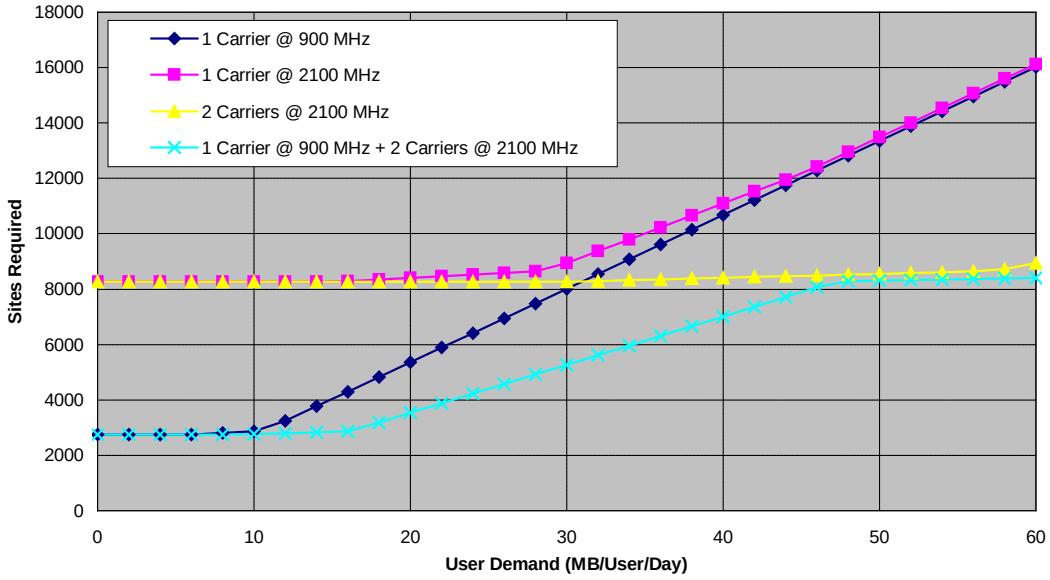

Figure 4: Estimated site counts v User demand (with Vodafone corrections).

96. The site numbers necessary for coverage in Figure 4 are primarily driven by Ofcom's baseline planning assumptions ✂.

97. Using our own coverage planning rules we estimate an upper limit of 11,100 sites will be necessary to provide HSDPA coverage to the 80% population area at 2100MHz ✂. When we apply our planning assumptions to the corrected Ofcom model it significantly under predicts site numbers, ✂. Put simply, the model does not calibrate with the 'real world'. We believe that this is due to the 'edge effects' associated with the fragmented dispersion of population centres; the model implicitly assumes a contiguous coverage area with perfectly tessellated hexagonal cells. This gives the model an inherent "planning efficiency" which is not found in practice.

98. Vodafone has used a recalibrated model with an upper limit of 11,100 UMTS 2100 coverage sites ✂ to estimate the number of UMTS 900 sites required for coverage and the effects of user demand on site numbers at both frequencies. The results are shown in Figure 5 below.

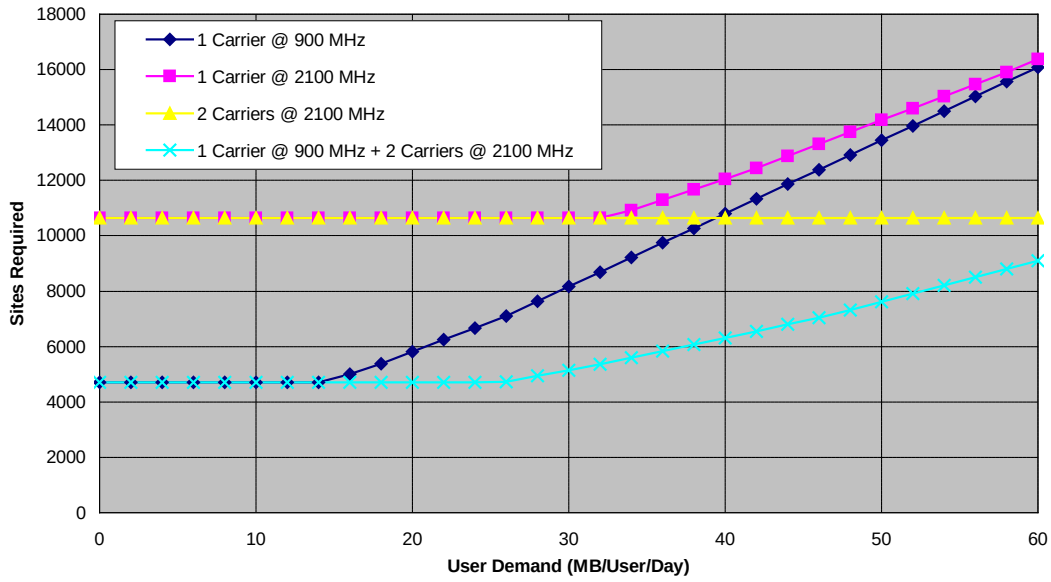

Figure 5: Estimated site counts v User demand based on Vodafone calibrated number of sites for UMTS 2100 coverage.

99. In table 20, the results are tabulated for the scenarios where an operator has two UMTS 2100 carriers or one UMTS 900 carrier together with two UMTS 2100 carriers. The difference is shown in the final row of the table.

		User Demand MB/user/day								
Scenario	Number of carriers	0.1	7	10	15	20	25	30	45	60
A	2 carriers @ 2100MHz	10,648	10,648	10,648	10,648	10,648	10,648	10,648	10,648	10,648
B	1 carrier @ 900MHz + 2 carriers @ 2100MHz	4,699	4,699	4,699	4,699	4,699	4,699	5,147	6,918	9,092
Difference in site numbers		5,949	5,949	5,949	5,949	5,949	5,949	5,501	3,730	1,556

Table 20: Estimated site counts v User demand based on Vodafone calibrated number of sites for UMTS 2100 coverage.

100. We compare the results predicted by our analysis with those predicted by Ofcom assuming its baseline planning assumptions (taken from Ofcom Annex 13, table 26) which are shown in table 21 below.

		User Demand MB/user/day								
Scenario	Number of carriers	0.1	7	10	15	20	25	30	45	60
A (Depth 2)	2 carriers @ 2100MHz	20,761	20,826	20,861	20,919	20,977	21,035	21,094		
B (Depth 2)	2 carriers @ 900MHz	6,566	6,638	6,673	6,731	6,789	6,847	6,905		
Difference in site numbers		14,195	14,188	14,188	14,188	14,188	14,188	14,189		
A (Depth 1)	2 carriers @ 2100MHz	14,031	14,096	14,131	14,189	14,247	14,305	14,363		
B (Depth 1)	2 carriers @ 900MHz	4,738	4,810	4,845	4,903	4,961	5,019	5,077		
Difference in site numbers		9,293	9,286	9,286	9,286	9,286	9,286	9,286		

Table 21: Ofcom estimated site counts with baseline planning assumptions.

101. The Ofcom technical model is limited to assessing a single service and user class at a time so the analysis in annex 1 assumes that all of the capacity of the Radio Access Network is dedicated to HSDPA users. However, in practice, networks will also have to support other services, e.g. Release 99 data and voice services. For example, in the consultation document Ofcom assumes that approximately 308,000 busy hour voice erlangs will also be carried by 3G networks. A requirement for a 3G network to carry significant amounts of voice traffic will reduce the amount of network capacity available for HSDPA traffic. In practice we believe that this will reduce the differences between UMTS 2100 and UMTS 900 site numbers more rapidly than predicted in Figure 5, as user data traffic increases.

102. We conclude:

a) Fewer sites are required at 2100 MHz than Ofcom predicts for coverage. Ofcom predicts that between 14,031 and 20,761 sites are required. We believe that an upper limit of 11,100 sites is required.

b) The difference between the number of sites required by an operator which has access to one UMTS 900 carrier plus two UMTS 2100 carriers and an operator which has access to two UMTS 2100 carriers is less than Ofcom predicts. Ofcom predicts a difference of between 9,293 and 14,195 sites exists for coverage. We believe that an upper limit on the difference is 5,949 sites.

c) This difference in site numbers required converges more quickly than Ofcom predicts as user data volumes increase. For example, assuming a user demand of 30MB/user/day, the difference Ofcom predicts is virtually unchanged. However, the Vodafone predicted difference decreases to 5,501 sites. This figure assumes that *every data user* in the network

uses an advanced Type 3 UE receiver architecture and, therefore, it sets an upper limit on the difference. Since, in reality, many users will have simpler UE receiver designs, the site number difference will be less in real life networks.

d) In practice the Radio Access Network capacity will be shared between HSDPA and Release 99 data and voice services. We believe that the presence of significant volumes of voice traffic will reduce the differences between UMTS 2100 and UMTS 900 site numbers more rapidly as user data traffic increases than the model predicts. However, the Ofcom model is not able to capture this mixed service scenario.

103. Vodafone submits that there are serious deficiencies in Ofcom's assessment of the relative benefit of using 900MHz versus 2100MHz. The revised cell site deployment numbers above can be fed into Ofcom's cost differences model (corrected for errors) to create a revised set of differences between the cost of profiles A, B and C for the breakpoint and scenario analysis – this is discussed below in the final section of Part 3.

The benefit of competition[42]

104. The assessment of the benefits from competition is one of the major building blocks of the scenario analysis. The benefits are calculated on the basis that 25% of the total mobile market revenue is comprised of those sensitive customers who are likely to switch operators to those that can provide high quality data services. There are three key assumptions that influence the welfare calculations: the number of sensitive customers, the value of their sensitive revenue, and the price elasticity.

Elasticity

✂

Number of sensitive customers who will switch and pay a premium

✂

105. The final outputs for the welfare benefit are given in table 24 below:

[42] Vodafone annex 3 considers this subject in more detail

Benefit in welfare, 07/08 NPV arising from the change in the number of players	Ofcom base case	Vodafone revision 2012-2014, 15% of market, elasticity -2.0	Vodafone revision 2015-2017, 15% of market, elasticity -2.0
	£m	£m	£m
From 2 to 3	425	124	103
From 2 to 4	625	182	150
From 2 to 5	750	213	176
From 3 to 5	300	89	73
From 4 to 5	110	31	26

Table 24: Vodafone revised welfare calculations

106. Clearly the welfare benefit has shrunk considerably after the Vodafone corrections. We use below these values and the consequent producer surpluses to revise Ofcom's scenario analysis.

Revising Ofcom's scenario analysis

107. Using the results from all the sections above, we now have enough data to re-do Ofcom's scenario analysis.

108. The first stage is to establish the location of the breakpoints between the scenarios using Ofcom's method for deriving the breakpoints between the low, the medium A and the medium B, and the high significance scenarios, and Vodafone's values for the cost of clearance, the benefit of competition and the productive efficiency benefits of the difference between frequencies.

Breakpoint 1

109. In breakpoint 1, Ofcom actually identifies the cost of clearance as £40-60m, but uses £150m as the profile A-C value for the 900MHz operator, on the grounds that "*although this is significantly higher than the high estimate of the cost of clearing one block, we feel that this takes account of the uncertainty over the level of consumer interest in improved mobile broadband networks under the low significance scenario*[43]" Effectively therefore Ofcom is using a headroom allowance for uncertainty of £100m - Vodafone adopts the same value in its workings.

[43] A7.40 of the consultation

110. Vodafone's equivalent cost of clearance is £160-190m for the pair of operators using the high/medium unit costs of £60k and £45k, and £140-160m from table 15 above for the low/medium unit costs of £50k and £25k, or at mid-point £90m and £75m respectively per operator. After adding the uncertainty headroom of £100m the tipping point of the productive efficiency costs for the 900MHz operator therefore lies at around £190m at high/medium unit costs, and £175m at low/medium.

111. A productive efficiency differential between profile A and profile C of £175m with low/medium unit costs or £190m with high/medium unit costs must thus be sought from the cost differences model, after applying the Vodafone adjustments discussed in Part 2 above, using as relative deployment numbers the results of the Vodafone technical analysis of the differences between the frequencies from table 20 in the section above. For simplicity of exposition, the productive efficiency differences at varying data volumes are shown in table 26 below, comparing the impact of two carriers at 2100MHz, profile A, with one carrier at 900MHz plus two carriers at 2100MHz, profile C. The table shows that at all levels of demand between Ofcom's low and high extremes of 1MB/user/day and 30MB/user/day the difference in costs between profiles A and C is less than the cost of clearance plus the uncertainty headroom.

Single operator results		User demand in MB/user/day								
		0.1	5	10	15	20	25	30	45	60
2100MHz, 2 carriers		10,648	10,648	10,648	10,648	10,648	10,648	10,648	10,648	10,648
900MHz, 1 carrier plus 2100MHz, 2 carriers		4,699	4,699	4,699	4,699	4,699	4,699	5,147	6,918	9,092
At low/medium unit cost, i.e. £50k & £25k	Profile A, i.e. 2100MHz followed by 800MHz	£511m	£511m	£511m	£511m	£511m	£511m	£523m	£659m	£818m
	Profile C, i.e. early use of 900MHz	£423m	£423m	£423m	£423m	£423m	£423m	£442m	£557m	£791m
Target cost difference = £175m	Cost difference	£89m	£89m	£89m	£89m	£89m	£89m	£81m	£101m	£27m
At high/medium unit cost, i.e. £60k & £45k	Profile A, i.e. 2100MHz followed by 800MHz	£801m	£801m	£801m	£801m	£801m	£801m	£822m	£1,015m	£1,203m
	Profile C, i.e. early use of 900MHz	£691m	£691m	£691m	£691m	£691m	£691m	£726m	£909m	£1,264m
Target cost difference = £190m	Cost difference	£110m	£110m	£110m	£110m	£110m	£110m	£96m	£106m	£-62m

Table 26: Vodafone A minus C calculation using corrected calculations of cost and quantity, single operator

112. This analysis suggests that breakpoint 1 is never reached, so the low scenario must always apply.

Breakpoint 3

113. Breakpoint 3, the boundary between the medium and the high scenario, is either at the practicality limit of 13,500 sites, or at the affordability limit, when the gross profitability of the RAN pair is matched with the incremental cost of 2100MHz deployment (profile A), over 900MHz deployment (profile C), for the RAN pair of operators.

114. We can see from table 26 above that the practicality limit of 13,500 sites does not apply within the range of data demand up to 60MB. It can therefore effectively be discounted.

115. Where might the affordability limit lie? Our analysis of the benefits of competition in annex 3 indicates that the value of this affordability limit is £338m for the pair of operators. The table below compares profiles A and C for the RAN pair using the low/medium and the high/medium unit cost rates – it is not clear which of the two should be used, but for the moment it is immaterial, since the limit is never reached.

RAN pair operator results		User demand in MB/user/day								
		0.1	5	10	15	20	25	30	45	60
2100MHz, 2 carriers		10,648	10,648	10,648	10,648	10,648	10,648	10,648	10,648	10,648
900MHz, 1 carrier plus 2100MHz, 2 carriers		4,699	4,699	4,699	4,699	4,699	4,699	5,147	6,918	9,092
At low/medium unit cost, i.e. £50k & £33k	Profile A, i.e. 2100MHz followed by 800MHz	£611m	£611m	£611m	£611m	£611m	£611m	£627m	£778m	£926m
	Profile C, i.e. early use of 900MHz	£544m	£544m	£544m	£544m	£544m	£544m	£569m	£699m	£973m
Target cost difference = £338m	Cost difference	£67m	£67m	£67m	£67m	£67m	£67m	£58m	£79m	£-48m
At high/medium unit cost, i.e. £60k & £45k	Profile A, i.e. 2100MHz followed by 800MHz	£989m	£989m	£989m	£989m	£989m	£989m	£1,017m	£1,239m	£1,454m
	Profile C, i.e. early use of 900MHz	£912m	£912m	£912m	£912m	£912m	£912m	£956m	£1,170m	£1,563m
Target cost difference = £338m	Cost difference	£77m	£77m	£77m	£77m	£77m	£77m	£61m	£70m	£-109m

Table 26: Vodafone A minus C calculation using corrected calculations of cost and quantity, single operator

116. This result is consistent with the previous one – if we never emerge (in the range of outcomes encompassed in the scenario analysis[44]) from the low significance scenario, then it would be incoherent to see the breakpoint between the medium and high scenarios in the same range.

117. The result is also intuitively reasonable; if Ofcom has underestimated the costs of release, and overstated the cost disadvantage and site number disadvantage of deployment at 2100MHz vs. 900MHz and also substantially overstated the benefits of competition, it is not surprising that the scenario analysis has reached the wrong conclusion.

118. In summary, the benefits from competition have fallen, so that the addition of one extra player in the market gives a consumer benefit of only £100m, as per table 27 below (a duplication of table 24 above):

Benefit in welfare, 07/08 NPV arising From the change in the number of players	Ofcom base case	Vodafone revision 2012-2014, 15% of market, elasticity -2.0	Vodafone revision 2015-2017, 15% of market, elasticity -2.0
	£m	£m	£m
From 2 to 3	425	124	103
From 2 to 4	625	182	150
From 2 to 5	750	213	176
From 3 to 5	300	89	73
From 4 to 5	110	31	26

Table 27: Vodafone revised welfare calculations

119. But the cost of clearance has risen as per table 28[45] below, and the difference between the deployment profiles is approximately £100m from the tables above, on a per operator basis.

Blocks cleared	Ofcom		Vodafone	
	Lower (£m)	Upper (£m)	Lower (£m)	Upper (£m)
1 block	45	70	50	60
2 blocks	80	120	140	160
3 blocks	140	210	380	450
4 blocks	260	400	720	830
5 blocks	530	810	1,270	1,510

Table 28: Vodafone estimated costs of clearance, 10% 2G traffic growth

[44] I.e. 1MB to 30MB per user per day
[45] A replication of table 15 above

120. This means that:

a) The step between clearance of two blocks for own use, and release of an additional block is a cost of £240m to £290m, whereas the benefit from competition from increasing the number of players from two to three is significantly less, at £103m.

b) The cost of an additional block's clearance of £340m to £380m contrasts unfavourably with the £47m competition benefit of moving from three players to four.

c) The cost of clearance for the GSM operators' own use, at £140m to £160m plus the uncertainty headroom is more than the saving in network costs that arises from deploying UMTS 900 rather than UMTS 2100.

d) Given that the affordability constraint for the RAN pair of operators is way above the differential cost of deployment of 2100MHz vs. not deploying 2100MHz and waiting for 800MHz (A minus B) there never seems to be a situation where ✂ at least two of the 2100MHz operators could not match at 2100MHz.

In summary, by staying within the framework of Ofcom's scenario analysis but amending its errors, inconsistencies and mis-estimated input assumptions we reach radically different conclusions. Vodafone shows that welfare is not improved by requiring the release of 900 spectrum; ✂ their performance could be matched by the 2100MHz operators.

PART 4 – LTE and national roaming

121. In Part 4 Vodafone discusses two additional deficiencies in Ofcom's analysis:

a) The focus on UMTS deployment as an end in itself, without examining the relative benefits of an alternative technology such as LTE deployment opportunities.

b) The imposition of substantial speculative and unproven discounts to the regulated access option.

UMTS and LTE

✂

Regulated access

122. One of the outcomes that Ofcom entertains, both in the factual and the counterfactual, is national roaming. In the scenario analysis certain material adjustments to the quantified costs and benefits are assumed for national roaming. There are two principal adjustments both of which Vodafone believes are unfounded: a loss of benefit from an operator receiving regulated access rather than a spectrum acquisition and a requirement to clear sufficient GSM 900 spectrum to enable a second UMTS carrier to be used. Eliminating both of these in the scenario analysis gives the result that regulated access confers a benefit above that of a one block release.

Loss of benefit from regulated access

123. There is a key assumption, the argument for which is developed in A7.118 onwards, that under regulated access the benefits are less than under commercially negotiated access or under spectrum acquisition. Ofcom asserts that the *"probability that regulated access fails to provide the efficiency and competition benefits"* varies so that under low benefit/high cost the benefits are multiplied by 30% i.e. a discount of 70%, in the base case by 50% and in the high benefit/low cost version by 70%. This is claimed to arise because of *"asymmetries of information between the regulator and the parties"* and the *"complexity of the regulatory intervention needed when the incentives of the parties to reach an agreement are not well aligned".*[46] Ofcom cross-refers to section 5, table 13, where there is no further discussion, merely a repetition of the same point. Ofcom continues in A7.*120 "these adjustments are illustrative and there is no evidence on which these can be based. However we think these adjustment factors reflect the significance of the concerns we have over the effectiveness of regulated access options. As noted in section 5 commercial access agreements are unlikely to be subject to the same risks"*.

[46] A7.119 of the consultation

124. Vodafone believes that, in practice, these concerns are not material:

a) asymmetries of information: As Ofcom notes, regulated access *"would involve us mandating that when the 900 MHz spectrum is liberalised, if it is used to deploy new networks supporting improved mobile broadband services, the licence holder has to provide wholesale roaming or some other form of access to other mobile operators"*.[47] In the first instance therefore the discussions would be between two operators that are well equipped to handle themselves during the vicissitudes of commercial negotiations about access; each is part of a wider international grouping and will have access to both experience of and information about the cost of re-farming together with local knowledge of the UK market. The operators themselves can reduce the incentive for either party to simply refer the matter to Ofcom to see if they can 'do better' by taking the latest offer from the seller 'off the table' should this occur, in other words each party could suffer by reverting to Ofcom.

b) complexity of the intervention needed: As we pointed out in our previous response *"[a]though the costs associated with UMTS 900MHz may be more uncertain than 2G, Ofcom is used to, and perfectly capable, of forming a view about complex issues that are subject to a degree of uncertainty, for example, in the setting of 3G termination charges. Ofcom can never derive a perfect solution in the face of uncertainty but it can achieve answer that is good enough to achieve an objective of allowing more than two operators the option of rolling out 3G services at 900MHz"*. It would also be open to Ofcom to call for information, under powers, from both the buyer and the seller. No regulator (or operator) will ever have sufficient information to set welfare optimising prices but this rarely deters them from taking a stab. It is not clear to Vodafone how setting a price which deviates from some unknowable optimum undermines the benefits of a regulated access requirement.

c) incentives of the parties not well aligned: If the benefits from using 900MHz spectrum for mobile broadband services are as great as Ofcom suggests then surely there is an incentive on both parties to reach a commercial agreement, particularly if neither party can offer those services until a commercial (or regulated) agreement is reached. Indeed it may also be the case that the 900MHz operators will wish to compete for wholesale data traffic, as they do at the moment for voice.

125. Nevertheless Ofcom applies these speculative and substantial discounts to the benefits of regulated access. Whilst much of the Ofcom scenario analysis is detailed and rigorous, this would appear to be one area where both attributes are seriously lacking, leading to the risks of inferential error. Prima facie, regulated access has the advantage that it always generates a level playing field, in that all five operators are able to compete in the high quality data market – this is not a feature of many of Ofcom's other scenarios, where intervention generally increases the number of players from two to three, or two to four.

[47] Paragraph 5.30

126. It is worth examining the implications of Ofcom's discounts. In the high significance scenario, as can be seen in table 30 of annex 7, the result of regulated access in place of no market solution is an increase in the number of players from two to five. The discounting of the benefits has the following impact:

	High significance scenario variants, £m		
	Low	Base	High
Competition benefit from Ofcom table 2, annex 7 of 2 to 5 players	450	750	1,000
Regulated access discount	70%	50%	30%
Resulting benefit	140	375	700

Table 29: discounting of the competition benefit

127. What in practice does the £375m reduction in benefits mean in the 'base' scenario? The benefit is calculated as that arising from the fact that in a two player market the retail price of high quality data services will be higher and the number of participating customers lower than in a five player market. So by reducing the benefits, presumably Ofcom is implicitly considering that an operator with regulated access would only be able to offer a data service that in some way was inferior to that offered by the 900MHz incumbent on the same network or that which could be offered if the operator had its own 900MHz spectrum on its own network. It is difficult to see how that might be so, at least in relation to the carriage of packet data itself. Of course it is possible that the 900MHz incumbent on whose network a particular operator was roaming might choose not to supply deep coverage in a particular area, but the fact that two or three operators' potential traffic rather than just one is in scope would make any marginal investment more likely, rather than less.

128. In the medium significance scenario the discounts on the productive efficiency benefit give:

	Medium A significance scenario variants, £m		
	Low	Base	High
Benefit from single 2100MHz operator not expanding 2100MHz network, 2011-2015, table 9, annex 7	275	350	425
Ditto for the RAN pair of 2100MHz operators	375	500	600
Total benefit	650	850	1,025
Regulated access discount	70%	50%	30%
Resulting benefit	195	425	718

Table 30: Discounting of the productivity efficiency benefit

129. In the 'base' scenario, Ofcom is concluding that £425m of additional network expenditure is required to accommodate the national roaming. Given that Ofcom has already built in an allowance for the cost of setting up an access agreement, it is hard to see where this expenditure might be incurred.

Additional Infrastructure for roaming traffic

130. This error is further compounded by an assumption that Ofcom makes on additional infrastructure required for roaming traffic. Ofcom states in A7.166 that it assumes that:

> "*one block of 900MHz spectrum is sufficient to carry the traffic of two operators. Therefore a 900MHz operator can provide access to one other operator without any need for further infrastructure investment. But if the 900MHz operator provides access to more than one other operator, then we assume that it would need to invest in additional infrastructure, i.e. invest in an additional carrier. We assume that this cost is only incurred when all 3 non-900MHz operators are relying on access, and that in this case only one of the 900MHz operators will incur this cost*."

131. This is not correct. One block of 900MHz spectrum in the case of national roaming is not going to be required to carry the whole traffic of two or more operators. Each of the participating operators will continue to maintain two carriers of 2100MHz, as Ofcom clearly identifies in its rollout profiles from A7.81 onwards. So using the 4,500 vs. 13,500 sites scenario, the 900MHz operator will have 4,500 sites with two carriers of 2100MHz which it can use for capacity and one carrier of 900MHz which it will use for traffic in the area where 2100MHz will not reach. The UMTS 900 carrier will thus be responsible for only a proportion of the total traffic of this operator.

132. The roaming 2100MHz operators have under profile B 9,000 2100MHz sites, so these will cover more of the area than the UMTS 900's 4,500 sites and also provide more capacity than in the case of the 900MHz operator, so the participating 2100MHz roaming operator's roaming traffic that is actually passed to the recipient operator will be less than that operator's own traffic on the 900MHz carrier, so its load will not double (or treble)[48].

133. But what Ofcom has actually assumed is risible, that the addition of the traffic of one roaming operator will make no difference at all to the deployment costs of the receiving operator, but that the overlay of the traffic of a second roaming operator (as must happen to one of the two 900MHz incumbents) can only be accommodated by the provision of a second UMTS carrier. Neither of these propositions is correct.

134. The notion that the traffic on one 900MHz carrier can be "doubled" without changing the number of required sites for <u>all</u> scenarios must be wrong. The circumstance where this will

[48] In any event, as the sites will probably not generally be co-located, some of the roaming traffic will actually be capable of being accommodated on the 2100MHz carriers of the receiving operator.

apply is where an increase in traffic volumes is insufficient to take it above the point where the capacity provided by the minimum coverage sites is sufficient. Under all other circumstances site numbers will rise when the traffic is doubled. This can be easily seen in table 25 of annex 13, where the required sites rise as traffic volumes increase – but it is obvious that the relationship is not linear. The impact of the roaming overlay would anyway not be a doubling, but some lesser increase.

135. Ofcom is also assuming that although doubling of the traffic volume in a given scenario has no impact at all on the costs of deployment, trebling it can only be accommodated by the provision of an extra carrier at 900MHz. This is simply incoherent. The most obvious solution is not to increase the number of carriers, but the number of sites. Looking at table 25 of annex 13 for example one can see that a trebling of traffic from 1MB to 3MB at depth 2, 1.2mbps increases the site requirement at 900MHz from 4,039 sites to 4,087, i.e. 48 sites. Adding an extra carrier at 900MHz reduces the site requirement to 4,051 sites, a saving of 26 sites. Clearly there is an impact at higher volumes – going from 10MB to 30MB on the same row moves the site requirement from 4,257 to 6,157, whereas the extra carrier drops the requirement to 4,379 – but it is still doubtful whether the extra carrier would be the better investment. In fact, Vodafone's table 20 above shows relatively small increase in site numbers at 900MHz/2100MHz as volumes increase.

136. Ofcom's quantification of the effect is anyway otherwise flawed. It reasonably identifies the cost as being the product of additional spectrum clearance and additional infrastructure deployment (but on no additional sites). For the cost of clearance however, it comes up with £60-90m, being the cost from table 49 of annex 16, of the cost of clearing an additional block over the two already presumed to be cleared for the 900MHz operators' own use. This is incorrect however, since these costs are joint costs for the two 900MHz operators. In reality only one 900MHz operator will be required to clear the additional carrier, so it can hardly be expected that the other 900MHz operator will participate. For an individual 900MHz operator, each "block" represents 2.5MHz, so that for one operator to clear an extra carrier, that operator must clear two blocks. The cost of such clearance, i.e. moving from 2 blocks clearance to 4 blocks, is half the value in table 49, i.e. not the £60-90m assumed by Ofcom, but £90-140m[49]. Apart from the practical problems of clearing such a large amount of GSM spectrum, this higher cost further puts into question Ofcom's assumption of the use of an additional carrier. Vodafone thus rejects Ofcom's calculation of the cost of additional infrastructure for roaming traffic, assessed at £190m to £140m – a much smaller sum arising from incremental 900MHz site equipment deployment is likely. For the purposes of the calculation below only, Vodafone assumes the sum to be a constant £50m, but we expect this sum to be an overestimate.

137. It appears to Vodafone therefore that Ofcom has somewhat stacked the deck against the regulated access solution. Removing the discounts applied to the competition benefit and the productive efficiency benefit significantly changes the results of the three Ofcom regulated

[49] Vodafone's calculated equivalent of this value, from table 16 above, is £290-335m for a single operator

access scenarios in the "no market solution case" from tables 30, 35 and 40 of annex 7. The revised results are shown in the table below, which compares them to the equivalent Ofcom benefits in the preferred case of one block release (from tables 54, 59 and 64):

	High significance			Medium RAN pair only			Medium all operators		
	Low	Base	High	Low	Base	High	Low	Base	High
	£m	£m	£m	£m	£m	£m	£m	£m	£m
Net benefit as Ofcom	-150	160	550	-10	275	575	-160	170	575
Remove discount on competition benefit	310	375	300	50	50	40	-	-	-
Remove discount on productive eff. benefit	-	-	-	535	400	250	460	425	300
Adjust additional infra. to nominal £50m	140	120	90	120	110	90	120	110	90
Result	300	655	940	695	835	955	420	705	965
Ofcom benefit for 1 block clearance	160	425	725	525	625	750	30	250	475

Table 31: Reassessment of benefits from regulated access scenarios by removing the discount

138. In every case, regulated access unequivocally gives a superior benefit. This suggests that in the absence of any objective justification for Ofcom's discounts there is a very good case to be made that Ofcom's scenario analysis should have concluded that regulated access was preferable to one block release.

139. It is also not clear why there should be any delay as a consequence of regulated access. Because access will obviate the need for any spectrum release it could be that the putative benefits of re-farming are shared earlier because the 900MHz operators will need to clear less spectrum. In any case it is difficult to see how any inter-operator spats about the conditions for access could delay matters beyond 2011, the date from which the benefits from spectrum liberalisation are assumed to flow. Furthermore, the costs involving in agreeing access which, at most, should amount to no more than a few hundred thousand pounds can hardly be adduced as a material factor in Ofcom's deliberations over a proportionate policy option.

140. We should remind ourselves also that regulated access is only a short-term solution to bridge the gap between the ability to use liberalised 900MHz spectrum and the availability of the 800MHz band — a period of only a few years (Ofcom notes that it has "*assumed that access is only a short term measure: 2100MHz operators taking up commercial access (and regulated access) will deploy their own low frequency network later (using 800MHz spectrum when it is available)*")[50]. As such the risks of significant effects on dynamic efficiency and the likelihood of the need for further re-negotiation of the agreement[51] seem rather exaggerated given that it is not a permanent solution but merely 'holds the fort' until additional spectrum is available within a few years.

[50] Paragraph A7.29.2
[51] See paragraph 5.85 in bullets 2 and 3

141. In short Vodafone sees no compelling reason for Ofcom to discount materially the benefits of the regulated access option. It is instructive, as Ofcom notes in paragraph A7.399, that one of the potential purchasers of access Orange *"suggested that regulated roaming (with a sunset clause) was a reasonable temporary solution"* (our emphasis).

Part 5: Conclusion

142. Ofcom states in paragraph 5.128:

> *"The evidence in favour of any one policy option is not overwhelming. However at its most basic, the question we need to ask ourselves is what certain costs do we think it is proportionate to impose on stakeholders in order to reduce the risk of uncertain, but potentially very significant lost benefits in the case where the market would fail to achieve wider access. For the choice between liberalisation in the hands of the incumbents and one block release this comes down to a judgement as to whether the risk of the market failing to achieve wider access is sufficient to warrant imposing costs of up to £90m in total on Vodafone and O2. Given our statutory duties to promote the interests of citizens and consumers, and secure efficient use of spectrum, we think that this is a proportionate action given the magnitude of the potential benefits, which if they arise could amount to hundreds of millions of pounds[52]"*

143. In contrast (and despite the considerable effort that Ofcom has devoted to revising its analysis) Vodafone concludes that there is compelling evidence against requiring a release of 900MHz spectrum from Vodafone and O2. We have reached this conclusion via a rigorous exposure of the inadequacies in Ofcom's analysis. It is Vodafone's case that:

a) ✂

b) The location of the breakpoints (which provide a fundamental underpinning to Ofcom's analysis and conclusions) is both inconsistent with Ofcom's analysis and does not correspond in any meaningful way to the critical dimensions of competition that it identifies: data volumes, transition speed and indoor penetration. As a consequence they do not demarcate points at which operators will alter their rollout strategy and should not be used to guide decision making.

c) Errors in the way that Ofcom models the UMTS deployment profiles mean that it exaggerates the alleged productivity benefit enjoyed by the 900MHz operators by as much as 75%.

d) Ofcom seriously underestimates the cost of clearing and releasing 900MHz spectrum, in particular for larger blocks of spectrum. In large part this reflects the fact that Ofcom has failed to appreciate how Vodafone actually deploys its GSM network compounded by its text book approach of assuming 'average sites' - a world of perfectly tessellating sites. These

[52] 5.128 of the consultation

errors mean that Ofcom materially underestimates the cost of (for example) a one block release by between £130 and £390m depending on the technical approach adopted.

e) Ofcom has made significant errors in its technical analysis of the difference between frequencies; the high cell edge speed that it claims is necessary for the high quality data market to emerge is not physically attainable under UMTS and the difference between 900MHz and 2100MHz in terms of cell deployment under rising data volumes is exaggerated. Once these and other errors are corrected for we show that the difference in the number of sites required for comparable coverage at 2100MHz versus 900MHz is 5,000 rather than the 10,000 that Ofcom computes. This means that, under Ofcom's rollout assumptions, the non 900MHz operators are able to match the quality of coverage of the 900MHz operators before the arrival of the 800MHz band and therefore, as a corollary, there will be no distortion to competition when re-farming is permitted and if the 900 operators were to deploy UMTS 900.

f) The increased consumer welfare benefits arising from increasing the number of competitors in the high quality data market through regulatory intervention has been substantially overstated because Ofcom has treated the data market as a homogeneous lump and misunderstood the likely real and perceived advantage of "fast 900MHz" over "moderate 2100MHz" to the average consumer.

144. In summary, by staying within the framework of Ofcom's scenario analysis but amending its errors, inconsistencies and mis-estimated input assumptions we reach radically different conclusions. Vodafone shows that welfare is not improved by requiring the release of 900 spectrum and may indeed be harmed; ✂. There is no case for requiring the release of spectrum.

✂

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