



Application of spectrum liberalisation and trading to the mobile sector

Including implementation of the Radio Spectrum
Committee Decision on 900 MHz and 1800MHz

Consultation

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Section 1

Summary

- 1.1 This consultation document consults on the measures that Ofcom should take to implement the Radio Spectrum Committee Decision ("RSC Decision") relating to the 900 MHz and 1800 MHz bands.¹ ("900 MHz and 1800 MHz spectrum"), a copy of which is provided at Annex 12. This spectrum is that currently used by four mobile network operators ("MNOs") to run their 2G networks. The effect of that Decision will be to liberalise the use of the 900 MHz and 1800 MHz spectrum and so allow the spectrum to be used for 3G and potentially other technologies.
- 1.2 The RSC Decision has been agreed by the Member States of the EU. It is expected that it will be formally adopted when the GSM Directive² (which currently limits use of most of the 900 MHz spectrum to 2G (GSM) use) is repealed by the European Council and Parliament. Ofcom's understanding is that this is likely to occur by the end of 2007, if not before. The RSC Decision requires the UK to designate and make available the 900 MHz and 1800 MHz for GSM systems and designate and subsequently make available those frequency bands for 3G systems. It also allows the UK to designate and make available the bands for other terrestrial systems.
- 1.3 The implementation of the RSC Decision in relation to GSM systems does not require Ofcom to take any action. However, in relation to 3G systems and other systems Ofcom is required to take some action to implement the RSC Decision.
- 1.4 The way in which the RSC Decision is implemented and so liberalisation of the 900 MHz and 1800 MHz spectrum is brought about potentially has major consequences for UK citizens and consumers as it could affect the extent of competition in the mobile market, and the degree to which mobile broadband services are deployed in the UK. The mobile market is a very significant market for the UK. Total revenues in the mobile market in 2006 were £16.5 billion³. Recent research estimated that in 2006 the market generated economic benefits of £21.8 billion, of which £19 billion accrued to consumers.⁴
- 1.5 The focus of this consultation document is on the appropriate method for making the 900 MHz and 1800 MHz spectrum available for 3G in line with the RSC Decision. The document is the result of a significant amount of analysis which Ofcom has undertaken to formulate its current views and to make proposals for the implementation of the RSC decision. The purpose of this consultation is to subject Ofcom analysis to the scrutiny of stakeholders and any other interested parties. In particular, whilst the consultation document contains a number of specific questions, Ofcom is not seeking to limit the comments which respondents may wish to make and respondents are invited to include representations on any issues which they consider to be relevant.

¹ "900 MHz band" means the 880-915 MHz and 925-960 MHz bands.

"1800 MHz band" means the 1710-1785 MHz and 1805-1880 MHz bands

² Council Directive 87/372/EEC of 25 June 1987, OJ L 196, 17.7.1987, p.85 (the GSM Directive)

³ Ofcom report "The UK Communications Market 2007" published 23rd August 2007

⁴ Economic Impact of the use of radio spectrum in the UK, Europe Economics, 2006,
http://www.ofcom.org.uk/research/radiocomms/reports/economic_spectrum_use/

The Consultation Options and Ofcom's Duties

- 1.6 Ofcom has identified a range of alternative approaches which could be adopted to implement the RSC Decision:
- Option A – liberalisation of the spectrum in the hands of the incumbent licensees
 - Option B – liberalisation of the spectrum in the hands of the incumbent licensees, subject to a regulatory obligation to offer roaming to third parties
 - Option C – partial mandatory spectrum release (revocation of part of the spectrum usage rights held by existing licensees and re-award by Ofcom) and liberalisation of the remainder of the spectrum in the hands of the incumbent licensees
 - Option D – full mandatory spectrum release (revocation of all of the spectrum usage rights held by existing licensees for this spectrum and re-award by Ofcom).
- 1.7 One of Ofcom's principal duties under the Communications Act 2003 is to further the interests of consumers, where appropriate by promoting competition. Ofcom's principal spectrum-related duty is to secure the optimal use of the spectrum. These are the key duties which Ofcom considers it must seek to fulfil in implementing the RSC Decision.
- 1.8 Accordingly, Ofcom has 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.
- 1.9 Ofcom considers that the option which best meets these objectives will also meet its overarching duty to further the interests of consumers and citizens in these circumstances. In addition Ofcom must ensure that the option identified is non-discriminatory, proportionate and transparent. Ofcom has accordingly carried out a cost/benefit analysis of each of the options.
- 1.10 In considering the options, Ofcom has taken into account the history of licensing of spectrum which can be used to offer mobile services in the UK which has resulted in significant differences between the existing five Mobile Network Operators ("MNOs") in terms of their current spectrum holdings. In short, Ofcom is not "starting with a blank page". It follows from this that any particular approach to implementing the RSC Decision is likely to have different commercial impacts on individual licensees.
- 1.11 Ofcom has analysed each of these options in light of the above and proposes that:
- for 900 MHz spectrum – some variant of Option C is the most appropriate approach;
 - for 1800 MHz spectrum – Option A is the most appropriate approach.
- 1.12 The rationale for these initial views and some further detail on the relevant variants of Option C are set out below, but before doing that some key background information on the 900 MHz and 1800 MHz spectrum is provided.

Characteristics of the 900 MHz and 1800 MHz spectrum & other background information

1.13 Ofcom has undertaken extensive engineering and cost analysis of the effects of frequency on the deployment of 3G services. Its initial views are that:

- a) evidence exists to suggest that 900 MHz spectrum and possibly 1800 MHz spectrum has advantages relative to other spectrum (e.g. 2.1 GHz or 2.6 GHz) available for deploying 3G services. This is because it is at a lower frequency range which means for technical reasons it has a coverage advantage. Fewer base stations need to be deployed to cover open spaces (rural areas) and provide mobile broadband services in densely populated areas, both outdoors and within buildings;
- b) the evidence suggests that the effects of frequency on quality and costs are likely to be much greater in the case of 3G systems (and indeed those beyond 3G) than they have historically been for 2G systems. This is due to a fundamental difference in the way those technologies use spectrum. In 2G networks the advantage of lower frequency is effectively limited because in densely populated areas operators still need to build a large number of sites to provide sufficient capacity, regardless of the frequency they use. This means they cannot fully realise the potential benefits from the better coverage characteristics of the lower frequency in a mature network. In 3G networks, the coverage of the network, the number of users which can be supported and the data rates which can be offered are all directly linked to the loss which a signal undergoes in reaching the users. This loss is substantially lower at lower frequencies, so 3G operators in densely populated areas realise a benefit from the lower frequencies which tends to increase as more users are served;
- c) the evidence suggests that the advantages are much more significant for 900 MHz spectrum than 1800 MHz spectrum which in practice Ofcom believes is unlikely to offer a material advantage over 2.1 GHz; and that the advantages in relation to densely populated areas are much more significant than those in less densely populated areas;
- d) Ofcom estimates that access to 900 MHz spectrum could mean that in the order of 10,000 fewer sites need to be deployed per operator in densely populated areas compared to 2.1 GHz and in rural areas approximately 2,500 fewer sites per operator are needed in order to achieve a common quality of service;
- e) Ofcom's initial view is that a reasonably conservative estimate of the cost saving per operator of using 900 MHz compared to 2.1 GHz is in the order of £1bn in the case of deployment in densely populated areas and £250m in rural areas (ie a total potential cost saving of £1.25bn)⁵;
- f) Ofcom's analysis suggests that there may be a theoretical cost saving from using 1800 MHz spectrum compared to 2.1 GHz spectrum, albeit significantly smaller than that from using 900 MHz spectrum. However, Ofcom's initial view is that such an advantage is unlikely to be realised in practice due to the likelihood that UMTS 1800 MHz equipment will not be available and even if it were that it would be likely to have a higher cost compared to equipment at other frequency bands.

⁵ All cost numbers quoted in Section 1 represent the costs calculated on a net present value basis in which operating and capital expenditure is discounted over 20 years from 2009/10 using a social discount rate of 3.5%.

- g) Ofcom's analysis also indicates that a 3G operator could obtain most of the cost advantages associated with 900 MHz spectrum with just one block of lower-frequency spectrum (ie 2 x 5 MHz). It would need further spectrum for capacity reasons, but it could use higher-frequency spectrum for that.
- 1.14 The existing spectrum holdings in the mobile sector are asymmetric and are the result of past decisions determining what spectrum bands should be awarded and to whom they should be awarded. In summary the key points to note are:
- The 900 MHz and 1800 MHz spectrum currently used for 2G comprises the equivalent of seven blocks (of 2 x 5 MHz) of 900 MHz⁶ spectrum and fourteen blocks of 1800 MHz,⁷ and was allocated by administrative assignment at various points in time;
 - all the 900 MHz spectrum is licensed to two operators, Vodafone and O2;
 - the 1800 MHz spectrum is licensed to four operators, Vodafone, O2, T-Mobile and Orange; but most is held by T-Mobile and Orange;
 - the licences for 2.1 GHz spectrum, which is currently used to provide 3G services, were awarded following an auction in 2000 and while there are some differences between the five operators the holdings are similar;
 - one of the holders of a licence which authorises use of 2.1 GHz spectrum, H3G, does not hold any rights to use 900 MHz or 1800 MHz spectrum.
- 1.15 The existing mobile market is generally seen as competitive relative to other major economies. There are four operators with roughly equal market shares plus there is a new entrant operator, H3G. In other European markets there are in general either fewer operators, or one or two operators have a much larger share of the market than the other players.
- 1.16 Ofcom has considered whether the availability of other spectrum through its spectrum award programme impacts on the choice of method for implementation of the RSC Decision. The two awards that are most relevant are the 2.6 GHz award and the award of spectrum covered by the Digital Dividend Review (DDR). Ofcom's provisional conclusion is that neither award is likely to have a material impact as they are unlikely to be effective substitutes in practice for the 900 MHz spectrum.
- 1.17 Ofcom's initial view is that the 2.6 GHz spectrum is not likely to give an operator the same advantages as 900 MHz spectrum. The cost advantages associated with 900 MHz in relation to 2.6 GHz are likely to be at least as great as those in relation to 2.1 GHz (see paragraph 1.13) and probably greater.
- 1.18 In relation to the spectrum covered by the DDR the position is more complex. There is potentially 120 MHz of spectrum available between 470 MHz and 862 MHz. Of this, recent international discussions have identified 798-862 MHz (ie a total of 64 MHz) as potentially suitable for mobile use. These frequencies will have very similar propagation characteristics to the 900 MHz spectrum. So it is necessary to consider whether they could be effective substitutes.

⁶ There is actually 2 x 34.4MHz of 900 MHz spectrum but our understanding is that 7 paired 5 MHz carriers could be accommodated in practice.

⁷ The minimum carrier size for 3G / UMTS networks is 2 x 5 MHz so it is helpful to discuss the 900 and 1800 MHz spectrum in terms of 2 x 5 MHz blocks.

- 1.19 Ofcom's provisional conclusion is that this is not likely to be the case, and that within the timescale that is relevant to this decision the DDR spectrum is unlikely to be a substitute for the 900MHz band. While in pure propagation terms the respective frequencies are similar, there are uncertainties over many aspects of the potential use of the DDR band for mobile services. These include the extent to which any mobile use would be on a harmonised basis across Europe, and (related to this) the extent to which equipment might be available to make use of the band, the standards that this equipment would use, the costs of that equipment and the timing of its availability. There is also a difference in the timing of the availability of the two bands, as the DDR spectrum will not be available for nationwide mobile use until the end of 2012, at the earliest.
- 1.20 It is also relevant that the need to meet the UK's international obligations in relation to the DDR spectrum may mean that significant constraints on its use for mobile services are needed.

Liberalisation of 900 MHz and 1800 MHz Spectrum is likely to bring benefits to citizens and consumers

- 1.21 In addition to Ofcom's obligation to implement the RSC Decision, by allowing the deployment of 3G technology in the 900 MHz and 1800 MHz spectrum and also other future technologies, Ofcom in any event considers that liberalisation is likely to lead to significant benefits for consumers and citizens in terms of provision of mobile broadband services. This is due to the characteristics of the spectrum identified above at paragraph 1.13. In particular, liberalisation of the 900 MHz spectrum, and 1800 MHz spectrum, to a lesser degree, should allow:
- improvements in the quality of 3G networks so, for example, higher data rate services (e.g. full mobile web browsing, gaming and music downloads), with good coverage inside buildings, are more likely to be deployed, particularly in main population areas in the UK; and
 - extension of 3G services into rural areas (areas beyond those already served by 3G networks, i.e. the last 10 – 20 % of population).
- 1.22 The extent of these benefits will depend on the growth of mobile broadband services in the future and there is some uncertainty about the level of demand amongst consumers for those services. There are some indicators that suggest that demand for these services could be very significant:
- Ofcom estimates that there are almost eight million 3G mobile subscribers in the UK, and the number has grown at a compound annual growth rate of over 70% in the two years to December 2006.
 - Ofcom's research suggests that UK citizens and consumers consider high speed mobile broadband across the UK, including rural areas, to be of value to society. For example, in the consumer research conducted for the DDR it was found that mobile broadband was valued by people both as consumers and as citizens.
 - More generally there has been very significant growth in fixed broadband services in the last few years.
- 1.23 However, there are other indicators which are less positive about the future development of mobile broadband. The commercial plans of the operators indicate differences of view on this question. Given there is some uncertainty about future

level of interest in mobile broadband services, Ofcom in undertaking its analysis has considered a variety of scenarios to ensure that its proposed approach is appropriate, taking into account that uncertainty.

- 1.24 If, as Ofcom believes is relatively likely, consumers do value mobile broadband services and they become an important part of the mobile market, then the benefits from liberalisation of the 900 MHz and 1800 MHz spectrum are likely to be significant.
- The cost savings associated with 900 MHz spectrum (see paragraph 1.13e above) are likely to mean that without liberalisation it is possible that operators would choose not to invest further in 3G or only do so to a limited extent and on a much slower timescale. Ofcom estimates that on a reasonably conservative basis the cost saving is in the order of £1.25bn for each operator. So the total potential cost saving for the UK which liberalisation could achieve is in the order of £6.25bn if five 900 MHz networks were deployed.
 - Increased chance of innovations by new entrants as well as current operators is a further benefit of liberalisation. Liberalisation also reduces the overall scarcity of spectrum so potentially allowing more providers and / or applications to get access to spectrum in other bands.
 - Reduced environmental cost is also a benefit of liberalisation. Liberalisation reduces the number of sites that need to be built to offer high quality mobile broadband services. We estimate that deploying such services with 900 MHz spectrum is likely to significantly reduce the number of new sites needed.

Distribution of spectrum may affect the realisation of the benefits of liberalisation

- 1.25 In considering what is the most appropriate method to implement the RSC Decision and so liberalise the 900 MHz and 1800 MHz spectrum, it is important to understand how the realisation of the likely benefits of liberalisation identified above are likely to be affected by the distribution of 900 MHz and 1800 MHz spectrum. As noted above at paragraph 1.14, the existing distribution is highly asymmetric in the case of 900 MHz and some asymmetries also exist in relation to 1800 MHz.
- 1.26 Ofcom's analysis of the competition and efficiency impacts of distribution of 900 MHz and 1800 MHz spectrum has reached the following initial views.
- 1.27 In the case of 900 MHz spectrum wider access to the spectrum than exists at present is likely to promote competition and lead to a more optimal use of the spectrum.
- If, following liberalisation of the 900 MHz spectrum, access remained concentrated in the hands of just 2 competitors, then assuming there were 5 networks built only 40% of the cost savings available in deploying 3G services would be realised, a loss to the UK in the order of £3.75bn (NPV).
 - Alternatively, in this situation some operators without 900 MHz spectrum may decide not to roll out. This would be likely to lead to a reduction of competition in the mobile market with adverse consequence for consumers. It could lead to less competitive pressure so that new services may not be developed as quickly, existing services may not be extended into wider geographical areas, and network coverage in core coverage areas in cities and towns may not be deepened. Also the lower intensity of competition would be likely to reduce the

pressure on operators to keep prices close to costs. The consequences for the UK of less competition could be substantial because the mobile market is so large. For example even a small reduction in the intensity of competition which led to just a 1% reduction in consumer benefits for 10 years would represent a total loss to consumers in the order of £1.5 billion (NPV).

- 1.28 Therefore in the case of 900 MHz spectrum the key question is whether, absent regulatory intervention the market would be likely to redistribute the spectrum so it was not concentrated in the hands of just two operators. Ofcom's current view is that the market is not likely to achieve such a re-distribution itself. This is because it seems quite likely, especially if there is significant demand for mobile broadband services, that holding 900 MHz spectrum may provide a competitive advantage for incumbent licensees over their competitors who do not have access to that spectrum. In such circumstances it seems unlikely that the holders of 900 MHz would sell spectrum to those who are not currently licensed to use it.
- 1.29 In the case of 1800 MHz the position appears to be different. Ofcom's preliminary view is that the evidence does not suggest that wider access to 1800 MHz spectrum would significantly promote competition or efficiency of use. It is not clear that there is a material cost advantage associated with 1800 MHz that would be realised in practice, in particular due to the lack of availability and / or cost of UMTS 1800 equipment. No such equipment is being produced or planned in the medium term whereas UMTS 900 MHz equipment is already being produced. Furthermore 1800 MHz spectrum is currently held more widely than 900 MHz spectrum, i.e. by four rather than two operators, so it is far from clear that wider access than this would have a major effect in promoting competition and efficiency of use of the spectrum.

Analysis of options

- 1.30 In the light of the situation regarding the nature of each of the 900 MHz and 1800 MHz spectrum and the likely impact on competition and efficiency of deploying networks using those frequencies, Ofcom has analysed the alternative methods for implementation of the RSC Decision.

Option A – liberalisation of the spectrum in the hands of the incumbent licensees

- 1.31 Under this option Ofcom would implement the RSC Decision by varying the existing licences for 900 MHz and 1800 MHz spectrum to allow the holders to use the spectrum to provide 3G services (and also other services to the extent this is permitted under the Decision). Ofcom would also continue to set AIP (Administered Incentive Pricing) for this spectrum on the basis of the opportunity cost. If the opportunity cost rose as a result of liberalisation, AIP would naturally reflect this.
- 1.32 In other contexts Ofcom has typically adopted this approach as the means of introducing spectrum liberalisation as it is the least interventionist approach and the one likely to bring most benefits to citizens and consumers. However, it is necessary to consider whether in the case of the 900 MHz and 1800 MHz spectrum it is the approach most likely to meet Ofcom's statutory duties and objectives.

900 MHz Spectrum

- 1.33 This option could be used to implement the RSC Decision. It would be a relatively quick and simple approach to take. It would also have low costs as it would not impose new obligations with which the existing licensees would have to comply in the

way that Option B (regulated roaming) or Options C or D (mandatory spectrum release) would do. It would be likely to bring about some efficiency benefits as two operators would have access to 900 MHz spectrum with its associated cost savings.

- 1.34 However, the benefits of this approach are limited unless the market itself ensures wider access to the benefits of 900 MHz spectrum, for example through a redistribution of the spectrum. Ofcom's current view is that it is unlikely that the market itself would deliver wider access to the benefits of 900 MHz spectrum because access to 900 MHz spectrum is likely to provide holders with a competitive advantage relative to non-holders, and so they are unlikely to engage in trades or other transactions which reduce or eliminate that advantage. This gives rise to a particular concern that this option may fail to promote competition. If the 900 MHz spectrum after liberalisation remained concentrated in the hands of just the two existing licensees then there is a significant risk that the level of competition in the mobile market could be reduced from today's position, with adverse consequences for citizens and consumers.
- 1.35 Therefore Ofcom's initial view is that Option A is available as one option for implementation of the RSC Decision. However it is unlikely to promote competition and is likely to fail to realise the full efficiency benefits associated with liberalisation of the spectrum. Accordingly, it is necessary to consider whether there are other options, albeit involving increased degrees of regulatory intervention and cost, that may be more appropriate.

1800 MHz Spectrum

- 1.36 In relation to 1800 MHz spectrum Ofcom's initial view is that the position is different. First, as explained above (see paragraph 1.13f) Ofcom does not consider that changes to the existing distribution of 1800 MHz are likely to be necessary to promote competition or secure efficient use of the spectrum. Second, given that conclusion, if it were the case that some more efficient distribution of the spectrum did exist, it would be reasonable to expect the market to achieve that outcome through trading (or commercially-offered roaming services), because the impact of trading on competitive intensity is likely to be relatively low, given that four operators hold 1800 MHz spectrum. Third, if wider access to 900 MHz spectrum is achieved, then the likelihood of wider access to 1800 MHz spectrum bringing additional competition and efficiency benefits is small.
- 1.37 Accordingly, Ofcom's initial view is that Option A is likely to be an appropriate method for implementing the RSC Decision for 1800 MHz spectrum. There does not seem to be a sufficient case for considering more interventionist options as these would impose higher costs and so are unlikely to be proportionate when a less interventionist approach would appear to meet Ofcom's statutory duties and objectives.

Option B – liberalisation of the spectrum in the hands of the incumbent licensees, subject to a regulatory obligation to offer roaming to third parties

- 1.38 Under this option, in addition to varying the existing licences for 900 MHz spectrum to allow the holders to use the spectrum to provide 3G services and also other services, Ofcom would impose on the holders the requirement to offer roaming on regulated terms and conditions to third parties who did not hold 900 MHz spectrum. This is significantly more interventionist than Option A. It is likely that Ofcom would have to specify the terms and conditions of a roaming service in some detail for it to be effective.

- 1.39 The purpose of the roaming obligation would be to address the competition and efficiency concerns which arise from the 900 MHz spectrum being held by just two of the competitors in the market. Ofcom's provisional view is that this is unlikely to be an attractive option for the following key reasons:
- roaming is a service obligation and so does not go to the root of the concerns identified with the distribution of 900 MHz spectrum, namely access to the spectrum itself;
 - it would be difficult to implement and would run a significant risk of being implemented imperfectly in specifying the scope of the obligation and the price of roaming, and those problems would be of a continuing nature;
 - it would be likely to act as a brake on innovation as the roaming operators would be constrained by the pace of network deployment of 900 MHz operators; and this effect may be amplified since the existence of the roaming obligation might provide a disincentive for network deployment by the 900 MHz operators.
- 1.40 Accordingly, Ofcom's initial view is that Option B is not the most appropriate way to implement the RSC Decision for 900 MHz spectrum.

Option C – partial mandatory spectrum release (revocation of part of the spectrum usage rights held by existing licensees and re-award by Ofcom) and liberalisation of the remainder of spectrum in the hands of the incumbent licensees

- 1.41 This is a significantly more interventionist option compared to Option A as it envisages Ofcom taking back some of the spectrum currently held by the existing 900 MHz licensees, by means of partial licence revocation. However, Ofcom currently considers that if appropriately specified it is likely to be the most appropriate method to implement the RSC Decision for 900 MHz spectrum and so bring about liberalisation of that spectrum. Ofcom's initial view is that it appears to be the approach most likely to meet Ofcom's statutory duties and objectives.
- 1.42 The key rationale for this initial view is that Ofcom believes there is strong evidence to suggest that the existing distribution of 900 MHz spectrum is not likely to be efficient and there is a clear risk of a reduction in efficiency and competition in the mobile market after liberalisation with such a distribution, especially if there is strong growth in the demand in the future for mobile broadband services. In these circumstances, Ofcom believes it needs to take a precautionary approach. As noted above the UK has a relatively competitive mobile market. There are four roughly symmetric MNOs and a fifth, new entrant in H3G; this is a more competitive structure than generally in the rest of the EU and elsewhere. In this context, Ofcom considers that it should seek to protect against the possibility that changes in spectrum policy could upset the balance in the downstream market, as this could have far-reaching adverse effects for competition and consumers. Rather it needs to ensure that its approach to liberalisation of 900 MHz spectrum is likely to ensure that the mobile market continues to be competitive, with the possibility of becoming more competitive and further that cost savings are realised in deploying 3G services to the greatest extent possible.
- 1.43 However, there are costs which would be imposed through a policy requiring spectrum release as the existing licensees would incur some costs in order to clear the spectrum to be released. These are largely the costs of carrying the traffic, which was previously carried on the spectrum that is released but which must now be

carried by some other means. Crucially those costs increase with the quantity required to be released and they increase in a non linear way.

- 1.44 Accordingly, Ofcom has carefully considered different quantities of spectrum release to assess which quantity is appropriate. In doing so, in relation to the benefits Ofcom has taken into account the need to guard against the risk of a significant reduction in competition if there is significant growth in the demand for mobile broadband services, while recognising that such a growth in demand is uncertain. Ofcom has also taken into account the costs which spectrum release would create. Ofcom has recognised that these are much more certain than the benefits, although the extent of those costs is difficult to estimate accurately. This is partly because the costs would be dependent upon what the existing 900 MHz operators chose to do to carry their 2G traffic if this option is implemented. In the analysis below (for reasons explained below) it is assumed that spectrum is released in such a way that each block of spectrum released is acquired by an additional operator.
- 1.45 In assessing the most appropriate quantity of spectrum to be released, it is appropriate to start with the minimum quantity as that would impose the lowest cost. This is a total of one 2 x 5 MHz block (ie release of 2 x 2.5 MHz by each operator). Ofcom estimates that the total costs of release for one block could be around £120m. This needs to be compared against the likely competition and efficiency benefits which might result if there were three networks with access to 900 MHz spectrum rather than just two networks. Ofcom considers that in light of the size of the cost advantages associated with 900 MHz spectrum if there were significant growth in the demand for mobile broadband services it is very likely that the benefits would significantly exceed the costs of releasing one block of spectrum. It is true that if such growth in demand for these services does not materialise then there might be a net cost associated with the approach. However, any such cost would be relatively small when set against the risk of lost competition and efficiency benefits if it did arise. While this analysis suggests that release of one block might be appropriate, as explained below Ofcom also believes that there are greater quantities of release that would be likely to offer greater net benefits and so be more appropriate.
- 1.46 Ofcom has considered whether the further blocks of spectrum should be released by assessing the relative incremental cost and benefits associated with each further block released. The first case to consider is two block release (ie release of 2 x 5 MHz by each operator). Ofcom estimates that the incremental costs (ie the extra cost of releasing two blocks over release of one block) of releasing this amount of spectrum would be in the region of £40-50m. Ofcom considers that it is highly likely that the incremental benefits associated with having four operators with access to 900 MHz spectrum compared to three operators with access to that spectrum could exceed those costs. Accordingly a two block release option is likely to be appropriate and better than a one block release option.
- 1.47 The next case to consider is a three block release option (ie release of 2 x 7.5 MHz by each operator). Ofcom estimates that the incremental costs (ie the extra costs of releasing three blocks over release of two blocks) of clearing the spectrum associated with this release would be in the region of £120-660m. There is clearly a significant increase compared to the two block release and is due to the fact that in the case of three block release the amount of spectrum available to the releasing 900 MHz operators to carry their 2G traffic would be very significantly reduced (by 1/3rd) and this would be likely to require them to undertake extensive investment in order to be able to continue to provide 2G services to their existing (and future) subscribers.

- 1.48 The key question is whether the extra benefits of having five operators with access to 900 MHz compared to four operators would be likely to be greater than these costs. Ofcom considers that it is quite possible that, if that fifth operator did deploy a network at 900 MHz for the provision of mobile broadband services, then the benefits could exceed the costs. It is also the case that, given the uncertainty over future demand for mobile broadband services, it is not certain that these benefits would be realised and if they were not, this approach to implementing liberalisation would have imposed very significant costs. At present there are five operators in the mobile market and the addition of the fifth operator since 2000 has created greater intensity of competition to the benefit of consumers. There is a risk that, unless three blocks are released, the level of competitive intensity in the future might deteriorate from today. Ofcom's judgement on this issue is informed by its estimation of the possible welfare impacts of moving from five to four operators in the mobile market. A simple illustration of that impact suggests it could lead to a total loss in welfare of £1.1bn. It should be noted that this is comprised of a loss to consumers of £4.9bn offset by a gain to producers of £3.8bn. Even if the mobile broadband services represented only a part of the market, this suggests that the incremental benefits to consumers of releasing three blocks could be significantly greater than the incremental costs. There is also potential for dynamic gains from greater competitive intensity, such as faster or greater innovation. Accordingly, Ofcom's initial view is that the need to safeguard competition in the mobile market suggests that a three block release option is preferable to a two block release option.
- 1.49 The next case to consider is the four block release option (ie release of 2 x 10 MHz by each operator). Ofcom's analysis indicates that incremental costs which would be imposed by such an approach would be very significant (around £300 – 650m) and may be higher as it is more difficult to estimate the costs for this amount of release accurately. Ofcom does not believe that it is plausible to believe with sufficient certainty that an additional sixth operator at 900 MHz would be likely to generate additional benefits that would exceed the costs and therefore it does not currently believe that this option is appropriate. Accordingly, it does not currently consider that any higher quantities of spectrum release are likely to be appropriate. The particular case of full spectrum release is considered below.
- 1.50 Ofcom has also considered whether it is possible to improve the option for spectrum release by staggering the timing at which blocks are released. The above discussion has assumed that all release would take place at the same time as soon as practical, which Ofcom at present judges to be in 2010. A particular variant which Ofcom has considered is one in which the 3 block release would take place in the form of 2 initial blocks, in 2010, and 1 further block in 2012. Although it is possible that this approach might reduce the costs of releasing spectrum relative to a simultaneous 3 block release, it is unclear whether the reduction in costs would occur or be material. On the other hand staggering spectrum release reduces the benefits, as the last operator to gain access to 900 MHz spectrum would do so later than all of the others. Ofcom is inclined to regard the net benefits of staggering release as not sufficiently large or clear and therefore favours the simultaneous release of blocks of 900 MHz spectrum.
- 1.51 In summary Ofcom's initial views on the quantity of spectrum release are that the choice is between a two or a three block release. Its current view is that it has a preference for a three block release as the approach most likely to safeguard the existing level of competition in the mobile market and allow the efficiency gains associated with liberalisation to be realised to the greatest extent possible. Of the two identified ways of effecting a three block release Ofcom favours a simultaneous approach over a staggered approach.

- 1.52 Therefore, Ofcom currently regards Option C, requiring partial spectrum release of two or three blocks of 900 MHz spectrum (with a preference for three blocks), as the approach most likely to meet its duties and objectives given the uncertainty regarding the future market development. Some further detail on what might be involved in such an approach is set out below.

Option D – full spectrum release (revocation of all of the spectrum usage rights held by existing licensees for 900 MHz spectrum and re award by Ofcom)

- 1.53 A final alternative approach for implementing the RSC Decision and bringing about liberalisation of the 900 MHz spectrum would be for Ofcom to revoke all licences for all the 900 MHz spectrum and then re-award the spectrum. This would be a significantly more interventionist approach to adopt than the previous options as it would remove the essential input for the two incumbent 900MHz 2G MNOs' businesses.
- 1.54 This approach could be said to promote competition to a significant degree as it could create more opportunities to access 900 MHz spectrum than other options. However, Ofcom does not currently consider it is an appropriate approach to adopt for the following reasons:
- Other less interventionist options appear to be sufficient to address the competition issues identified above. It was noted that the competition and efficiency concerns associated with 900 MHz spectrum can largely be addressed by widening access so that a greater number of operators have access to at least one 2 x 5 MHz block of spectrum each. Consequently it does not appear to be necessary to take back all of the 900MHz spectrum to guard against the risk of a reduction in competition.
 - The analysis of the costs of spectrum release as explained above has shown that it is very unlikely that it would be possible to be confident that the benefits associated with full 900 MHz spectrum release would exceed the cost of releasing all of the spectrum.
 - This option would impose huge costs and risk of disruption to the existing operators which could lead to a lower quality of service and material detriment for consumers.
 - It would be likely to significantly reduce or possibly eliminate most of the benefits associated with liberalisation. This is because, in order to release all of the spectrum whilst continuing to provide a service to their subscribers, the 2G operators would be forced to build out network using other frequencies at higher cost, such as their 2.1 GHz spectrum or potentially 2.6 GHz spectrum. But, once this were done, it is not clear in the medium term whether there would be any material benefits realised through liberalisation of the 900 MHz spectrum.
- 1.55 Therefore, given the availability of less interventionist options, and the substantial costs and disruption which would be likely to be incurred, Ofcom's initial view is that full spectrum release would not be an appropriate means to implement the RSC Decision.

Further Specification of Option C – for 900 MHz spectrum

1.56 As explained above Ofcom currently considers that Option C is likely to be the most appropriate way to implement the RSC Decision for the 900 MHz spectrum. In order to set out a more concrete proposal for comment there are a number of dimensions of this option which need to be specified. These are:

- Quantity of spectrum to be released
- Timing for that release
- Mechanism and participation and acquisition rules associated with the release
- The terms on which the retained spectrum (ie the 900 MHz spectrum not released) is held.

1.57 The next section summarises Ofcom's initial views on each of these issues.

Quantity

- 1.58 As explained above, Ofcom currently considers that the appropriate quantity of 900 MHz spectrum to release is either two or three blocks (with a preference for three blocks).
- 1.59 Ofcom proposes that it would serve a revocation notice on each of the existing holders of the 900 MHz spectrum, O2 and Vodafone, which would require them to release the spectrum (half of the total each) by a specified date.

Timing

- 1.60 Ofcom considers that in order to meet its objectives of reducing the regulatory uncertainty associated with the process for liberalisation of the 900 MHz spectrum and also to ensure timely implementation of the RSC Decision it is likely that it would be appropriate for it to specify the timing for release of the spectrum rather than the market. Ofcom recognises that there is some risk in making this judgement but believes on balance it needs to be made by the regulator.
- 1.61 Ofcom's current view is that spectrum should be released in 2010 as this is likely to be the earliest practical date by which it could be achieved.
- 1.62 This would also be the time when liberalisation of the retained 900 MHz spectrum would occur. This would be to prevent the holders of the spectrum having an advantage over the acquirers of the released spectrum.

Mechanism, participation and acquisition rules associated with the release

- 1.63 Ofcom has considered alternative mechanisms for the award of the released 900 MHz spectrum. The method must be an open, transparent and non-discriminatory. It should also meet other objectives, notably promoting efficient use of the spectrum by helping to ensure that the spectrum reaches its most valuable use and user.
- 1.64 Ofcom's initial view is that an auction is likely to be the best way of meeting these objectives. One option would be to hold that auction in advance of the actual release date. If this approach were followed, Ofcom's current view is that it may be possible to hold such an auction in 2009. Another alternative would be a "beauty contest" or

comparative selection approach. This option could potentially meet the legal requirements, but it is not clear that it will be as effective as an auction in ensuring that the released spectrum is awarded to the most efficient user. A comparative selection process would require the use of qualitative criteria (such as promotion of competition and the efficient use of spectrum) in order to ensure Ofcom's policy objectives were met.

- 1.65 Ofcom has also considered other options that have been suggested, including awarding the spectrum to particular parties through an administrative re-allocation. Ofcom does not consider that such an approach would be lawful as it would fail to ensure that the rights to use the spectrum would be awarded through an open, transparent and non-discriminatory process.
- 1.66 Ofcom proposes that in the award it would offer new licences for the released 900 MHz spectrum which would have terms similar to those established for other newly awarded spectrum. The licences would have an indefinite term with a minimum term of 15 years, be tradable and contain no rollout obligations or similar non spectrum licence conditions. The licences would be technology neutral subject to the restrictions necessary to comply with the RSC Decision.
- 1.67 Given the rationale for requiring spectrum release, it is likely that it would be necessary to put in place some particular rules in relation to the award. These would include the following:
- The existing holders of the 900 MHz spectrum, O2 and Vodafone, would not be allowed to participate in the award for the released 900 MHz spectrum. To do otherwise would be highly likely to frustrate the policy objective of widening access to 900 MHz spectrum (the purpose of which would be to protect against a reduction in competition and allow efficiency gains to be realised).
 - All other parties would be able to participate in the award but they would be limited to acquiring one 2 x 5 MHz block each. Again this would be to ensure that the policy objective of broadening access to the 900 MHz spectrum was achieved.
- 1.68 It is also necessary to consider what rules should apply in the secondary market in relation to the trading of 900 MHz spectrum. There is a case for continuing the same restrictions imposed in the award in the secondary market to safeguard competition. However, Ofcom considers that to establish such a mechanistic rule might create barriers to commercial developments which could bring benefits to citizens and consumers. Accordingly, it would currently propose to introduce trading and make trades of 900 MHz spectrum subject to a competition review before they could be approved.

Retained 900 MHz spectrum

- 1.69 Ofcom proposes that the 900 MHz spectrum not subject to revocation by Ofcom would be liberalised in the hands of the incumbent licensees. This would take place by variation of their licences and would come into effect at the same time as spectrum is released.
- 1.70 The licences would also be made tradable. Ofcom also considers that it would be likely to be appropriate to vary the term of licences for the retained spectrum in a similar way to other licences which had been liberalised and made tradable.

Accordingly, the licences would be made indefinite but subject to 5 years' notice of revocation for spectrum management reasons.

- 1.71 AIP would be payable on this retained spectrum, as for any other spectrum which has not been allocated through an auction, at a level which reflects the opportunity cost of the spectrum. Ofcom would review the existing level of AIP in the future after the award of the released spectrum and take all relevant information into account in determining the appropriate level including the prices paid in any auction of the released 900 MHz spectrum. The application of AIP to the retained spectrum would also help to minimise differential impacts in terms of the prices paid by different competitors for access to 900 MHz spectrum.

Further specification of Option A for 1800 MHz spectrum

- 1.72 As explained above at paragraph 1.35, Ofcom's provisional view is that Option A is likely to be the most appropriate method to use to implement the RSC Decision for 1800 MHz spectrum. In order to set out a more concrete proposal for comment some further detail regarding this Option is set out below.
- 1.73 Option A would be implemented by Ofcom varying the licences for the 1800 MHz spectrum as soon as possible, probably in 2008 or 2009, to remove the restrictions on technology subject to restrictions necessary to comply with the RSC Decision.
- 1.74 Those licences would also be made tradable. Ofcom also considers that it would be likely to be appropriate to vary the term of licences in a similar way to other licences which have been liberalised and made tradable. Accordingly, the licences would be indefinite but subject to 5 years' notice of revocation for spectrum management reasons.
- 1.75 AIP would be payable on this spectrum, as for any other spectrum which has not been allocated through an auction, at a level which reflects the opportunity cost of the spectrum. Ofcom would review the existing level of AIP in the future after the award of the released 900 MHz spectrum and take all relevant information into account in determining the appropriate level.

Trading and liberalisation and the licences for 2.1 GHz spectrum

- 1.76 This consultation document also covers briefly the issue of the introduction of trading and liberalisation to the licences for the 2.1 GHz spectrum ie the 3G licences awarded in the 2000 auction. Ofcom currently believes that these licences should be made tradable and the technology restrictions removed. The complications in relation to the 900 MHz spectrum are unlikely to apply to this spectrum due to its characteristics and therefore a simpler approach for bringing about liberalisation is likely to be appropriate. The consultation invites views on the appropriate method and timing for when trading and liberalisation should be introduced.

Summary of Ofcom's initial views

- 1.77 In summary Ofcom's initial views set out in this consultation are the following.

900 MHz and 1800 MHz spectrum

- a) The RSC Decision should be implemented in the UK in relation to the 900 MHz spectrum by means of a partial spectrum release option (Option C above). Under this option:

- Up to three blocks of 2 x 5 MHz spectrum would be taken back by Ofcom for re-award through an award process as soon as feasible, probably in 2009. Certain restrictions would apply in relation to participation and acquisition of spectrum through the award. Spectrum would be released and made available for 3G and potentially other technologies in 2010.
 - The remainder of the 900 MHz spectrum would be liberalised in the hands of the existing holders at the same time as the rest of the 900 MHz spectrum was released.
 - AIP set at the level of opportunity cost would be applied to the retained spectrum.
 - The new licences for the released spectrum and the varied licences for the retained spectrum would both be made tradable and the tenure made indefinite subject to appropriate terms for revocation.
- b) The RSC Decision should be implemented in the UK in relation to the 1800 MHz spectrum by liberalising the spectrum in the hands of the existing licensees (Option A above). Under this option:
- The existing licences for the 1800 MHz would be liberalised so the spectrum could be used for 3G and other technologies. This would occur as soon as feasible, probably in 2008 or 2009.
 - Those licences would be made tradable and tenure made indefinite subject to appropriate terms for revocation.
 - AIP set at the level of opportunity cost would be applied to the spectrum.

3G Spectrum – 2.1 GHz

- 1.78 The existing licences for this spectrum should be liberalised so that their technology restrictions are removed and they are made tradable

Section 2

Introduction

- 2.1 This document considers the future use of the 900 MHz and 1800 MHz spectrum⁸ which is licensed to four mobile network operators (“MNOs”) Vodafone, O2, T-Mobile and Orange for deployment of 2G or GSM networks. The spectrum is sometimes referred to as the 2G spectrum.
- 2.2 Ofcom now needs to consider the use of this spectrum for other technologies. The European Commission has proposed that the GSM Directive⁹ which currently governs use of some of these frequencies should be repealed and in its place a Radio Spectrum Committee (RSC) Decision be adopted. A copy of the draft RSC Decision is provided in Annex 12. It is expected that this will take place by the end of 2007 if not before. In the light of these changes to the European position the UK will be obliged to liberalise the 900 MHz and 1800 MHz spectrum to allow it to be used for providing 3G services.
- 2.3 The main aim of this consultation is to consider the implementation options for liberalisation of the 900 MHz and 1800 MHz spectrum, in line with the RSC Decision and Ofcom’s statutory duties and objectives. It also considers other issues related to the application of spectrum trading and liberalisation policies in the mobile sector.
- 2.4 This section provides a brief background to these issues and outlines the structure of the rest of the document.

Background

- 2.5 In addition to the legal requirement to liberalise the 900 MHz and 1800 MHz spectrum as a result of the forthcoming RSC Decision, Ofcom believes there is a strong public policy case for liberalising that spectrum as it is likely to bring major benefits to UK citizens and consumers. The mobile communications sector is very significant for the UK, with recent research¹⁰ estimating that it generated economic benefits of £21.8 billion, of which £19 billion accrued to consumers.
- 2.6 In 2005 Ofcom published a consultation on its plan to implement the policies coming out of its Spectrum Framework Review, including the implementation of spectrum trading and liberalisation (the Spectrum Framework Review Implementation Plan - SFRIP). This identified the need to consider the future use of the 900MHz and 1800MHz spectrum. The consultation discussed a number of constraints in relation to 2G liberalisation, including the presence of the GSM Directive which prevented the liberalisation of much of the spectrum, and complications arising from the potential impact on competition as a result of liberalisation. It included an initial discussion of possible approaches to 2G liberalisation including deferring the decision, delaying liberalisation or liberalisation subject to various conditions.
- 2.7 Since publication of the SFRIP, the position has now changed with the expected adoption of the RSC Decision and abrogation of the GSM Directive which will remove

⁸ 900 MHz Spectrum refers to spectrum at 880.1-914.9 MHz paired with 925.1 -959.9 MHz and the 1800 MHz Spectrum refers to spectrum at 1710.1 -1781.7 MHz paired with 1805.1 -1876.7 MHz.

⁹ Council Directive 87/372/EEC of 25 June 1987, OJ L 196, 17.7.1987, p.85 (the GSM Directive)

¹⁰ Economic Impact of the use of radio spectrum in the UK, Europe Economics, 2006, http://www.ofcom.org.uk/research/radiocomms/reports/economic_spectrum_use/

the restrictions limiting some of the spectrum to GSM use and which will require the 900MHz and 1800MHz spectrum to be liberalised for 3G use. In light of this, Ofcom has undertaken considerable work to assess different approaches, including those identified in the SFRIP. This document explains that analysis and sets out Ofcom's preliminary views. A summary of the relevant SFRIP responses is included in Annex 11.

Purpose and structure of this document

2.8 The aim of this consultation is to seek stakeholders' views on the different implementation options for the RSC Decision, in order to narrow the range of options to be considered and to ensure that the approach finally adopted both fulfils Ofcom's obligations under the RSC Decision and is the best fit in the context of Ofcom's statutory duties and objectives. It also considers other liberalisation and spectrum trading issues relevant to the mobile sector.

2.9 At a high level the rest of the document is structured as follows:

- Background to the implementation of the RSC Decision is covered by sections 3-6
- Consideration of the consultation options for implementation of the RSC Decision is covered by sections 7-14.
- Other liberalisation and trading issues relevant to the mobile sector are considered in sections 15-16.

2.10 A more detailed roadmap to the document is set out below.

Table 1: Structure of consultation document

| Section | Scope |
|---|---|
| <i>Background to implementation of the RSC Decision</i> | |
| 3 and 4 | Provide the legal framework relevant to the implementation of the RSC Decision – both the impact of the decision itself and Ofcom's statutory duties. Together, these set out Ofcom's obligations under the RSC Decision and the legal duties and objectives which limit Ofcom's discretion in deciding how to fulfil those obligations. |
| 5 | Important factual background about spectrum and the mobile sector. This includes an overview of the competitiveness and development of the UK mobile sector, the current uneven distribution of mobile spectrum holdings, and Ofcom's current conclusions on the likely advantages of 900MHz and 1800MHz spectrum for providing 3G services compared to higher frequency alternatives. |
| 6 | Considers the implications for competition and efficiency of the findings of section 5. In particular it considers whether the existing distribution of 900MHz and 1800MHz spectrum is likely to meet Ofcom's objectives to promote competition and efficient use of radio spectrum. |
| <i>Assessment of options for implementation of the RSC Decision</i> | |
| 7 | Provides an overview of the options Ofcom has identified for implementing the RSC Decision in light of the legal framework and competition and efficiency concerns. It also explains the framework used for analysing those options in subsequent sections based on the legal framework set out in sections 3 and 4. |

| Section | Scope |
|---|--|
| 8 | Considers whether Option A: Liberalisation in the hands of the incumbents would be an appropriate option for implementing the RSC Decision, with respect to 900MHz and 1800MHz, in light of our statutory duties. |
| 9 | Considers whether Option B: Regulated Roaming would be an appropriate option for implementing the RSC Decision, with respect to 900MHz and 1800MHz, in light of our statutory duties. |
| 10 | <p>Considers whether any form of mandatory spectrum release (options C & D) in principle might be appropriate option for implementing the RSC Decision, with respect to 900MHz and 1800MHz, in light of our statutory duties. Under these options spectrum would be taken back from the existing holders and awarded by Ofcom. It sets out Ofcom's preliminary view that some form of spectrum release may in principle be appropriate for 900MHz but not for 1800MHz spectrum.</p> <p>This section also introduces the costs benefit analysis used to assess spectrum release in more detail in subsequent sections.</p> |
| 11 & 12 | <p>These sections focus on 900MHz and consider Option C: Partial mandatory spectrum release in more detail</p> <p>The quantity of spectrum released and its timing is considered by section 11. It assesses a wide range of different quantity and timing options for mandatory partial release and sets out a narrower range of options that currently appear to best fit Ofcom's statutory duties.</p> <p>The issues in implementing partial mandatory spectrum release are considered in more detail by section 12, including how the released spectrum should be awarded.</p> |
| 13 | Considers in more detail whether Option D: Full Spectrum release would be an appropriate option for implementing the RSC Decision, with respect to 900MHz in light of Ofcom's statutory duties. |
| 14 | Sets out Ofcom's initial views on the preferred option for implementation of the RSC Decision for 900MHz and 1800MHz, drawing on the analysis of individual options in sections 8-13. |
| <i>Other liberalisation and trading issues in the mobile sector</i> | |
| 15 | Considers whether Ofcom should widen the scope liberalisation of 900MHz and 1800MHz spectrum beyond UMTS (as required by the RSC Decision), and the application of spectrum trading to these licences. |
| 16 | Considers application of trading and liberalisation to 2100MHz spectrum. |

Terminology

2.11 Throughout this document the following terms are used as follows:

- 900MHz spectrum means 880.1MHz – 914.9MHz paired with 925.1MHz – 959.9MHz
- 1800MHz spectrum means 1710.1MHz – 1781.7MHz paired with 1805.1MHz – 1876.7MHz

- 2100MHz or 2.1 GHz spectrum means 1920 – 1980 MHz paired with 2110 – 2170 MHz for frequency division duplex (“FDD”) and 1900 – 1920 MHz for time division duplex (“TDD”)
- 2600MHz or 2.6 GHz spectrum means 2500 – 2690 MHz
- 2G spectrum means 900MHz and 1800MHz spectrum
- 3G to refer to UMTS technologies

2.12 The glossary at annex 13 provides a comprehensive list of terms used in this document.

Section 3

The RSC Decision on 900MHz and 1800MHz Spectrum and its implications for the UK

- 3.1 On 22 May 2007 the EU's Radio Spectrum Committee (formed of representatives of the Member States) approved a draft European Commission decision on the harmonisation of the 900MHz and 1800 MHz frequency bands ("the RSC Decision"). The Decision is not yet in force, but it is anticipated that it will come into force by the end of 2007, at the same time as the current GSM Directive¹¹ is abrogated.
- 3.2 The GSM Directive restricts use of the most of the 900 MHz spectrum to GSM.
- 3.3 The draft text of the RSC Decision is set out in Annex 12 and is not expected to change before it comes into force.
- 3.4 As a decision of the European Commission, the RSC Decision will be binding on its addressees (in this case the Member States including the UK), and its implementation is therefore mandatory.
- 3.5 The RSC Decision imposes certain obligations on Member States in relation to the liberalisation of the 900 MHz and 1800 MHz spectrum.
- 3.6 The provisions of the RSC Decision most relevant to this consultation are as follows:
 - 3.6.1 Article 3(1) provides that the 2G spectrum "shall be designated and made available for GSM systems" by the date of entry into force of the directive which will repeal the GSM Directive;
 - 3.6.2 Article 3(2) provides that the 2G spectrum "shall be designated from the date of entry into force of the directive which will repeal the GSM Directive and subsequently made available" for systems as set out in the Annex of the RSC Decision. The systems in the Annex comprise UMTS ("3G") complying with certain standards.
 - 3.6.3 Article 3(3) provides that "Member States may designate and make available the 900 MHz and 1800 MHz bands for other terrestrial systems ... provided that they ensure that such systems can co-exist with GSM systems and systems listed in the Annex on their own territory as well as in neighbouring Member States".

The implications of the RSC Decision for the UK regarding timing and implementation methodology

- 3.7 Article 3(1) imposes a duty on the UK to designate and make available the 2G spectrum for GSM systems. This is intended to protect the current position under the GSM Directive which ensures that the 2G spectrum is available for GSM use across the European Union.

¹¹ Council Directive 87/372/EEC of 25 June 1987, OJ L 196, 17.7.1987, p.85 (the GSM Directive)

- 3.8 Article 3(2) imposes a duty on the UK to designate and subsequently make available the 2G spectrum for 3G use.
- 3.9 Article 3(3) permits the UK also to designate and make available the 2G spectrum for other terrestrial systems.
- 3.10 The RSC Decision does not impose a timetable on Member States in relation to implementation. Recital 15 to the RSC Decision explains that radio spectrum technical management includes the harmonisation and allocation of radio spectrum and that such harmonisation should reflect the requirements of general policy principles identified at Community level. However it clarifies that this does not cover assignment and licensing procedures (including their timing), nor whether to use competitive selection procedures for the assignment of radio frequencies.
- 3.11 Ofcom has considered what the word “subsequently” in Article 3(2) means in this context.
- 3.12 The RSC Decision is a European harmonisation measure aimed at ensuring that the 2G spectrum is designated and made available for 3G use across the Community. Given the supremacy of EC law over national law in cases of conflict and given the overriding harmonisation intention of the RSC Decision it is Ofcom’s current view that a reasonable long-stop date by which implementation must be achieved in order to fulfil the UK’s obligations is implied in the RSC Decision.
- 3.13 In seeking to determine the reasonable long-stop limit for implementation, Ofcom’s current view is that:
 - 3.13.1 an open-ended timescale would not be deemed to be reasonable, as this would not “make available” the 900 MHz and 1800 MHz spectrum for 3G use on similar timescale across the EU and so could frustrate the harmonising objectives of the RSC Decision;
 - 3.13.2 a plain and natural reading of the text suggests however, that the RSC Decision does not require immediate implementation;
 - 3.13.3 a comparison of related prior Community legislative acts relating to radio spectrum harmonisation shows that typical implementation periods tend to be of relatively short duration, usually between six months to just over three years, but in this case account should be taken of the fact that some of the alternative implementation methods may take longer to implement because of their impact on and potential disruption to existing use of the spectrum.
- 3.14 Ofcom’s current view is that the long stop limit implied by the word “subsequently” should be defined taking into account these matters and the longest reasonable implementation period would be in the region of five years.
- 3.15 The RSC Decision is also silent as to the methodology by which Member States should implement the requirements of Articles 3(1) and 3(2) of the RSC Decision. As such, the UK has discretion to determine how best to effect implementation, within the scope of Ofcom’s statutory duties and the general principles of administrative law.
- 3.16 In summary, the RSC Decision imposes an obligation on the UK to designate and make the 2G spectrum available for GSM and 3G use.

- 3.17 In addition, it permits the UK to designate and make the 2G spectrum available for other technologies, provided that they remain available for GSM and 3G use and that any non-GSM or 3G technologies can co-exist with GSM and 3G systems.

Scope of the existing 2G licences

- 3.18 There are currently four licences in force which relate to the use of the 2G spectrum (the “2G licences”).
- 3.19 Each of these 2G licences contains provisions restricting the technology which may be used to transmit and receive over the relevant frequencies. These restrictions currently prevent the use of 3G technology.
- 3.20 As set out above, the RSC Decision imposes an obligation on the UK to make the 2G spectrum available for use by 3G technologies.
- 3.21 Ofcom therefore considers that in order to fulfil the UK’s obligations under the RSC Decision it must take active steps to change the existing licence position. The following section sets out the legal framework of Ofcom’s discretion to change the existing licences, and the legal duties and objectives which set the limits of that discretion.

Question 3.1 Do you have any comments on Ofcom’s interpretation of its obligations under the forthcoming RSC Decision?

Section 4

The legal framework for implementation of the RSC Decision

- 4.1 This section provides an overview of the main UK and European legislative provisions relevant to the exercise of Ofcom's discretion in relation to its implementation of the requirements of the RSC Decision
- 4.2 It does not provide a comprehensive statement of all the legal provisions which may be relevant to Ofcom's functions. Interested parties should seek their own legal advice in relation to legal provisions that are relevant to the issues discussed in this document.

The framework for the exercise of Ofcom's discretion in relation to its implementation of the RSC Decision

- 4.3 The framework for the exercise of Ofcom's discretion in relation to its implementation of the requirements of the RSC Decision is set out in the Wireless Telegraphy Act 2006 (the "2006 Act") and Articles 5 and 7 of the Directive on the authorisation of electronic communications networks and services 2002/20/EC (the "Authorisation Directive"). These set out Ofcom's power to grant, vary and revoke wireless telegraphy licences, and the processes by which rights of use of radio frequencies must be granted.
- 4.4 When exercising its discretion, Ofcom must ensure that it considers a number of key statutory objectives and duties which set the limits of that discretion.
- 4.5 In order to fulfil the UK's obligations under the RSC Decision, as set out in the previous section, Ofcom must take active steps to change the existing licence position. The consultation options set out in this document may require Ofcom to vary and/or revoke the 2G licences, and possibly to grant new licences.

Granting, varying and revoking wireless telegraphy licences

- 4.6 Ofcom's legal power to grant, vary and revoke wireless telegraphy licences is set out in the 2006 Act. Section 8(1) of the 2006 Act makes it unlawful to establish or use a wireless telegraphy station or to install or use wireless telegraphy apparatus except under and in accordance with a licence ("a wireless telegraphy licence") granted by Ofcom under that section.
- 4.7 Section 9(1) of the 2006 Act gives Ofcom the power to grant wireless telegraphy licences subject to such terms, provisions and limitations as Ofcom thinks fit.
- 4.8 However, Ofcom's broad discretion in relation to the terms that can be imposed in a wireless telegraphy licence is subject to the rule that Ofcom must impose only those terms that it is satisfied are objectively justifiable in relation to the networks and services to which they relate, not unduly discriminatory, and proportionate and transparent as to what they are intended to achieve (section 9(7)).
- 4.9 This obligation mirrors obligations imposed by Article 9 of the Framework Directive, which provides that the allocation and assignment of radio frequencies by national

regulatory authorities must be based on objective, transparent, non-discriminatory and proportionate criteria.

- 4.10 Schedule 1 of the 2006 Act sets out the procedure for the grant, variation and revocation of wireless telegraphy licences. Section 10 of the 2006 Act provides that Schedule 1 has effect.
- 4.11 Paragraph 6 of Schedule 1 provides that Ofcom may revoke a wireless telegraphy licence or vary its terms, provisions or limitations by a notice in writing given to the holder of the licence or by a general notice applicable to licences of the class to which the licence belongs, published in such a way as may be specified in the licence.
- 4.12 Paragraph 8(5) of Schedule 1 provides that if it appears to Ofcom to be necessary or expedient to revoke a licence or vary its terms, provisions or limitations for the purposes of securing compliance with an international obligation of the United Kingdom, Ofcom may at any time give the holder of the licence a notice in writing to that effect.

Granting rights through open, transparent and non-discriminatory procedures

- 4.13 Under Article 5(2) of the Authorisation Directive, when granting rights of use of radio frequencies (wireless telegraphy licences in the UK context), Member States must do so through open, transparent and non-discriminatory procedures.
- 4.14 Under Article 7(3) of the Authorisation Directive where the number of rights of use of radio frequencies needs to be limited, Member States' selection criteria must be objective, transparent, non-discriminatory and proportionate. (Section 164 of the 2003 Act requires Ofcom to make an order setting out the criteria.)
- 4.15 Within that context, Ofcom has power under section 14 of the 2006 Act (having regard to the desirability of promoting the optimal use of the electromagnetic spectrum) to make regulations providing that applications for the grant of wireless telegraphy licences must be made in accordance with a procedure which involves the applicants making bids for licences (for example an auction).
- 4.16 Ofcom has broad powers in section 14(3) of the 2006 Act to make provision in regulations for the form of the licences and the auction bidding procedure.

Power to charge licence fees

- 4.17 Section 12 of the 2006 Act provides that a person to whom a wireless telegraphy licence is granted must pay to Ofcom such sums as Ofcom may prescribe by regulations. The provisions of section 12 do not apply in relation to licences granted by auction under section 14 of the 2006 Act.
- 4.18 Section 13 of the 2006 Act provides that Ofcom may, if it thinks fit in light (in particular) of the matters to which it must have regard under section 3 of the 2006 Act (see 4.24 below), prescribe sums greater than those necessary to recover costs incurred in connection with its radio spectrum functions. Charges imposed using this power are referred to as Administrative Incentive Pricing ("AIP"). "Prescribe" is defined as meaning prescribe by regulations or determine in accordance with regulations.

- 4.19 The level of licence fee currently payable under the existing 2G Licences is set out in the Wireless Telegraphy (Licence Charges) Regulations 2005 (SI 2005/1378), as amended by the Wireless Telegraphy (Licence Charges) (Amendment) Regulations 2006 (SI 2006/2894).
- 4.20 The UK statutory provisions implement Article 13 of the Authorisation Directive, which also provides that Member States must ensure that any fees imposed must be objectively justified, transparent, non-discriminatory and proportionate in relation to their intended purpose. Ofcom must take these requirements into account when it prescribes licence fees.

Ofcom's legal objectives and duties

- 4.21 Ofcom's margin of discretion when granting, varying or revoking wireless telegraphy licences is limited by the following legal objectives and duties.
- 4.22 Under section 3(1) of the Communications Act 2003 (the "2003 Act") it is the principal duty of Ofcom in carrying out its functions:

- to further the interests of citizens in relation to communications matters (section 3(1)(a)); and
- to further the interests of consumers in relevant markets, where appropriate by promoting competition (section 3(1)(b)).

In doing so, Ofcom is required to secure:

- the optimal use for wireless telegraphy of the electro-magnetic spectrum (section 3(2)(a));
- the availability throughout the UK of a wide range of electronic communications services (section 3(2)(b));

and to have regard to certain matters which include:

- principles of better regulation – transparency, accountability, proportionality, consistency and necessity (section 3(3));
- the desirability of promoting competition (section 3(4)(b));
- the desirability of encouraging investment and innovation (section 3(4)(d));
- the desirability of encouraging availability and use of high speed data transfer services throughout the UK (section 3(4)(e));
- the different needs and interests, so far as the use of the electro-magnetic spectrum for wireless telegraphy is concerned, of all persons who may wish to make use of it (section 3(4)(f)); and
- the different needs and interests of persons in different parts of the UK (section 3(4)(l)).

- 4.23 As the management of the UK radio spectrum is governed by the European Communications Directives, which aim to harmonise the regulation of electronic communications networks and services throughout the European Union, section 4 of

the 2003 Act requires Ofcom when carrying out its spectrum functions to act in accordance with the “six Community requirements” set out in that section when managing the wireless spectrum in the UK. These comprise:

- the requirement to promote competition (section 4(3));
- the requirement to secure that Ofcom’s activities contribute to the development of the European internal market (section 4(4));
- the requirement to promote the interests of all persons who are citizens of the European Union (section 4(5));
- the requirement to act in a technology neutral way (section 4(6));
- the requirement to encourage to such extent as appropriate the provision of network access and service interoperability (section 4(7)); and
- the requirement to encourage such compliance with international standards as is necessary for: (a) facilitating service interoperability; and (b) securing freedom of choice for the customers of communications providers (sections 4(9) and (10)).

Ofcom’s specific duties and objectives when carrying out spectrum functions

4.24 In carrying out its spectrum functions it is the duty of Ofcom (under section 3 of the 2006 Act) to have regard in particular to:

- the extent to which the electro-magnetic spectrum is available for use, or further use, for wireless telegraphy (section 3(1)(a));
- the demand for use of that spectrum for wireless telegraphy (section 3(1)(b)); and
- the demand that is likely to arise in future for the use of that spectrum for wireless telegraphy (section 3(1)(c)).

It is also the duty of Ofcom to have regard, in particular, to the desirability of promoting:

- the efficient management and use of the spectrum for wireless telegraphy (section 3(2)(a));
- the economic and other benefits that may arise from the use of wireless telegraphy (section 3(2)(b));
- the development of innovative services (section 3(2)(c)); and
- competition in the provision of electronic communications services (section 3(2)(d)).

4.25 Where it appears to Ofcom that any of its duties in section 3 conflict with one or more of its general duties under sections 3 to 6 of the 2003 Act, section 3(5) of the 2006 Act requires that priority must be given to its duties under those sections 3 to 6.

4.26 Section 3(6) of the 2006 Act provides that where it appears to Ofcom that a duty under this section conflicts with another in a particular case, it must secure that the conflict is resolved in the manner it thinks best in the circumstances.

Section 5

Spectrum and the mobile sector

- 5.1 In order to address the task of implementing the RSC Decision described in section 3 it is important to understand the UK background in which the decision must be applied. The effect of the Decision will be to widen considerably the range of frequencies available for 3G systems. Therefore it is important to understand how these bands were assigned, the future importance of services most suited to use on 3G systems and the effect of operating 3G networks at different frequencies.
- 5.2 Accordingly this section will:
- provide an overview of the mobile sector in the UK and discuss the possibilities for the likely development of, and demand for, mobile broadband services;
 - review how the mobile spectrum has been allocated historically, the resulting spectrum holdings, and consider future spectrum awards that might be relevant for mobile services; and
 - consider the key question of how frequency of operation impacts upon the way 3G systems work, how an operator builds their network in light of this and the potential cost implications associated with building 3G networks at different frequencies.

Mobile sector in the UK

- 5.3 The mobile sector plays a vitally important role to citizens and consumers in the UK. It generated £16.5bn¹² in retail and wholesale revenues in 2006 which amounted to just over a third of the total UK retail and wholesale telecoms industry revenue for 2006. The sector continues to see increasing subscriber numbers. At the end of the first quarter of 2007 there were 70.2 million active mobile subscriptions in the UK¹³, more than the total number of people in the country and up nearly 5% compared to the previous year.
- 5.4 In the UK the provision of mobile services is generally regarded as having one of the more competitive structures in Europe. In August 2003 the then telecommunications regulator Ofcom found that the market for outgoing services (access and call origination) was not characterised by single or collective dominance¹⁴. There are currently five Mobile Network Operators (MNO) who own and operate a mobile network in the UK. These are Vodafone, O2, T-Mobile, Orange and Hutchison 3G. Additionally there are a number of Mobile Virtual Network Operators (MVNO) such as Virgin Mobile or Tesco Mobile. These companies do not own a network but instead buy wholesale services from one of the five MNOs.
- 5.5 Due to the size of the mobile sector even small changes in its structure can have large impacts. This is particularly salient regarding factors such as competition where what might appear to be a small reduction in the level of competition can result in substantial losses to overall welfare of citizens and consumers.

¹² Ofcom/Operators – includes estimates where Ofcom does not receive data from operators.

¹³ Ofcom/Operators – includes estimates where Ofcom does not receive data from operators.

¹⁴ http://www.ofcom.org.uk/static/archive/oftel/publications/eu_directives/2003/mobileaco0803.pdf

Future importance of 3G and mobile data services

- 5.6 At present the spectrum in the 2100 MHz band (awarded in 2000) is the only band used for 3G. Implementation of the RSC Decision will make significant extra spectrum available for 3G services, so in considering how we implement the Decision, it is useful to understand the potential future demand for 3G and the mobile data services it enables. Although we can never be certain how the future demand for 3G services will develop, we can look at the way current demand for these services is evolving and using a range of sources come to a view as to the more likely possible outcomes.
- 5.7 The following subsections consider:
- What type of services are best suited to provision over 3G networks (rather than 2G or 2.5G) and could therefore act as a driver for further take-up of 3G?
 - What might the future demand for the services be?
 - How important will coverage be for those services?

Services best suited to 3G networks – ‘mobile broadband’ services

- 5.8 An important factor for the future demand for 3G networks is the types of services that can only be delivered, or can be delivered to a higher standard and quality, by a 3G network compared to a 2G network. The characteristics where 3G has an advantage over 2/2.5G are:
- Peak and typical data rates
 - Latency
 - Network capacity
- 5.9 Currently 2G networks deliver voice services to a relatively good quality and 3G does not materially alter the delivery of standard circuit switched voice. Second generation networks with enhancements such as General Packet Radio Service (GPRS) or Enhanced Data rates for GSM Evolution (EDGE) also deliver a basic data service that can support lower data rate applications such as e-mail, limited web browsing and smaller file downloads. An EDGE enabled 2G network can typically deliver data speeds in the general region of 25 to 100kbps depending on the signal quality. However the latency¹⁵ of the data is generally poor which limits the range of applications that can be serviced. For example, the delay would be very noticeable to a user trying to engage in a video call or interactive gaming and is likely to make these applications unattractive to use over 2G.
- 5.10 Considering 3G networks, the typical data rates currently available are in the region of 100 to 300kbps and will be moving towards speeds of 1Mbps and beyond with deployment of High Speed Packet Access (HSPA) evolutions. This will allow services such as video streaming, normal web browsing and larger file downloads to be provided. Also 3G networks, especially when HSPA upgrades are implemented, have

¹⁵ By latency we mean the time delay that data being sent and received by a user experiences. Current EDGE deployments typically experience round trip delays in the region of 500 to 600ms with future network enhancements potentially halving this. Source ‘Mobile Broadband, EDGE, HSPA & LTE’, Sept 2006 White paper prepared for 3G Americas.

much better control of latency than 2.5G and applications such as Voice over Internet Protocol (VoIP), video calling or interactive gaming become viable.

- 5.11 It is generally accepted that 3G systems provide a more spectrally efficient solution than 2G. By spectrally efficient we mean that the amount of traffic (often referred to as throughput) a fixed quantity of bandwidth can handle is greater for 3G than 2G. This efficiency becomes an issue if mobile broadband demand increases as 3G will be much better placed to handle increasing numbers of users requesting higher speed services.
- 5.12 The types of mobile data services that are best suited to delivery by 3G are referred to as “**mobile broadband**” services in the rest of this consultation. The boundary between 3G and 2.5G is not absolute and services will typically fall across any arbitrarily set level of, say, download speed. In light of this we are not setting out a technical definition for mobile broadband.

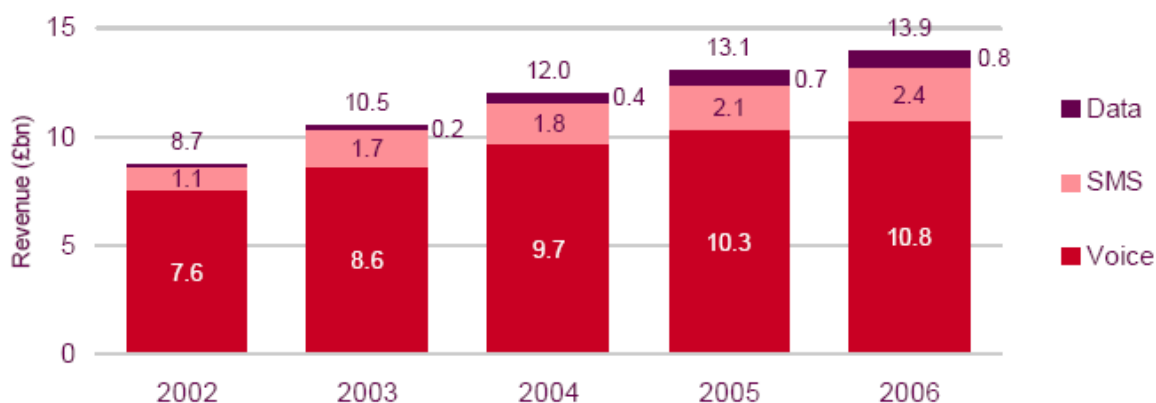
Consumer demand for mobile broadband

- 5.13 To understand how demand for mobile broadband services might develop we have considered the available evidence on:
- Trends in mobile data use in the UK
 - Market research
 - Use of mobile data services in other countries

Trends in mobile data use in the UK

- 5.14 Looking at the revenues mobile operators in the UK obtain from voice, SMS and data services first, we can see a steady increase in the proportion of total revenues that are generated just from data services – excluding SMS. This has risen every year since 2003 and now stands at just over 5% of total revenues. The figure below shows this breakdown since 2002.

Figure 1: Total revenue for mobile in the UK split between voice, SMS and data

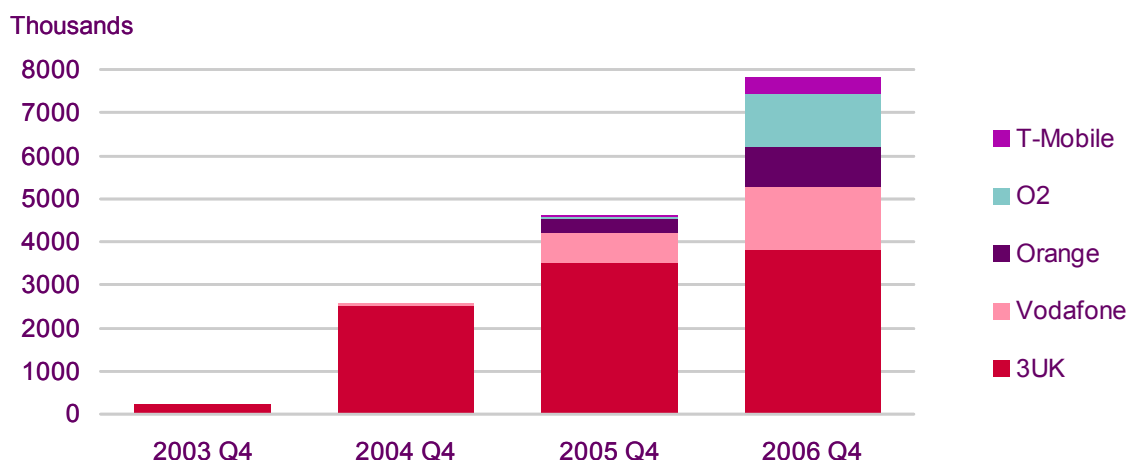


Source: Ofcom/Operators. Includes estimates where Ofcom does not receive data from operators

- 5.15 The number of subscribers to 3G in the UK is also rising. Although the different MNOs place varying degrees of importance in mobile broadband going forward, the end of 2006 saw all 5 MNOs having significant numbers of 3G subscribers. This was

a change from the previous year when only three of the five had significant numbers. At the end of 2006 the total 3G subscribers stood at just under 8 million, or about 11% of total UK mobile subscriptions¹⁶.

Figure 2: 3G subscriptions in the UK by MNO



Source: Ofcom/operators/Informa: Includes estimates where data was unavailable

Market research on consumers' interests

- 5.16 Consumers' and citizens' attitudes to mobile broadband services were investigated as part of the research undertaken for the Digital Dividend Review (DDR) consultation¹⁷. One of the aspects of this research was to investigate the price that consumers were willing to pay for a mobile broadband connection. This research found that 15% of people would be prepared to pay £5 a month for a 2Mbps mobile broadband service. Also of note from the DDR market research was the finding on coverage of a mobile broadband service. More than half the survey respondents considered wide coverage to be of value to society – i.e. mobile broadband services should be available to as many people as possible and in as many locations.
- 5.17 In July 2006 Ofcom published a report on consumer engagement with digital services¹⁸. The findings of this report regarding mobile broadband were broadly in line with the DDR findings outlined above in highlighting that 3G features are only currently valued by a segment of consumers. The report found that none of the portable features enabled by 3G were valued by more than one-fifth of consumers (for example, emailing larger files, making video calls, watching TV). When asked the question: 'I'm not sure what additional benefit I would get from a 3G phone', 66% of respondents agreed.
- 5.18 However, it should be remembered that market research is a product of its time hence does not necessarily tell us much about how interest may grow in the future. The 15% of consumers who were willing to pay £5 a month for a mobile broadband service in the DDR research is broadly consistent with the current level of 3G take-up which, as indicated above, stands at around 11% of mobile subscribers. As take-up of 3G services increases and awareness of the service grows, we would expect interest amongst consumers to grow and the amount they are willing to pay for the services on average to increase.

¹⁶ 11% figure is based on total active mobile subscriptions in the UK at end of 2006 of 69,650,000.

¹⁷ The full research report commissioned for the DDR consultation can be found here on the Ofcom website: <http://www.ofcom.org.uk/consult/condocs/ddr/mktresearch/>

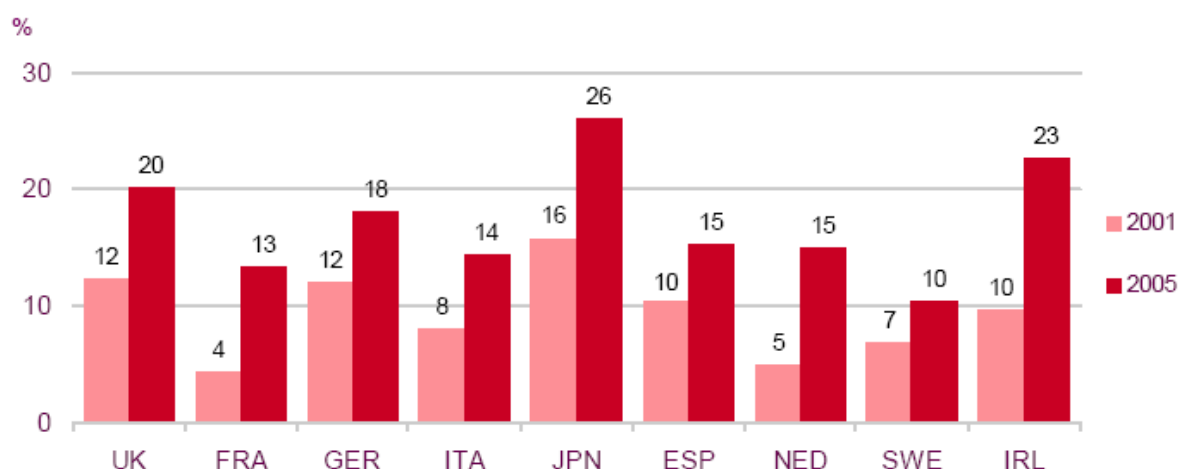
¹⁸ http://www.ofcom.org.uk/research/cm/consumer_engagement/

- 5.19 A higher level of interest in mobile internet applications is suggested by research recently published by Point Topic¹⁹. When asked what users would like to be able to do on the move they found that almost 60% of those interviewed would like to be able to email on the move, more than 45% wanted to be able to browse and search the internet and over 30% would like to do their banking while mobile.

Mobile data services outside the UK

- 5.20 It is also useful to look at how mobile broadband is developing in other countries. Japan provides one example of an advanced and established market for 3G data services. There were 39.4 million 3G customers by mid-2006 in Japan (42% of mobile subscribers) and data services (including SMS) were approaching 30% of total revenues. The leading network in Japan is NTT DoCoMo which offers a 3G network covering effectively 100% of the population at speeds of 384kbps²⁰.
- 5.21 Ofcom's International Communications Market report published in November 2006 also contains information on how mobile data services have developed between 2001 and 2005 in a number of different countries. The figure below shows how revenue from data services have become a lot more important in all of the countries surveyed (note that these figures include SMS which makes the contribution from mobile broadband harder to gauge). All countries experienced significant rates of growth in data revenues and by 2005 three countries (Japan, Ireland and the UK) collected a fifth or more of total mobile revenue from data.

Figure 3: Mobile data service (inc SMS) revenue as a % of total mobile revenue



Source: IDATE / estimates based on operator and regulator data/Ofcom research

Importance of coverage for mobile broadband services

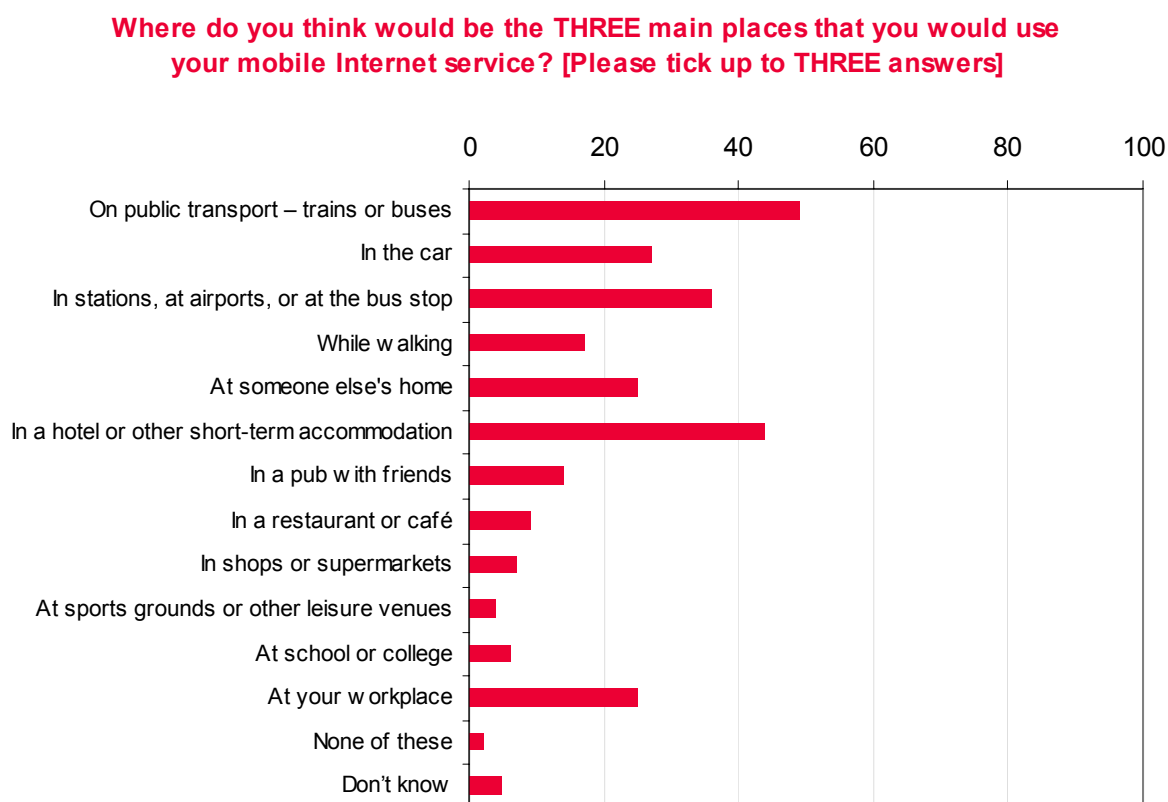
- 5.22 As discussed later in this chapter, the ability to use lower frequencies for providing 3G services (as a result of implementing the RSC Decision) could provide significant coverage advantages compared to existing 3G networks. Therefore it is important to consider how significant the coverage of 3G networks for providing mobile broadband services might be. Note that the importance of 3G coverage for providing voice and low data rate services is perhaps less because there is presumed to be a 2G network with greater coverage to fall back on.

¹⁹ <http://point-topic.com/>

²⁰ Informa: Global Mobile Strategies for Quadruple Play

- 5.23 As mobile broadband services are still being developed, it is useful to look first at the importance of coverage for existing 2G services. Market research undertaken as part of Ofcom's mobile call termination market review in early 2005 showed that 8% and 6% of consumers mentioned 'best signal reception' and 'best geographic coverage' respectively as factors to consider when choosing a network provider²¹. Five other factors came in above these two, but with the exception of 'recommended by others', they were, as might be expected, all cost related factors concerned with having cheaper calls. This suggests that, after price factors are stripped out, consumers require good signal quality and coverage when choosing a network. Furthermore, given that current coverage/availability of 2G networks is very high, these factors are less likely to be a high priority for users who currently use their phones mostly for voice/SMS services. Therefore one would not expect them to rank these features highly. As 3G services such as mobile broadband develop and take off, one might expect consumers to realise that their access to such services is potentially limited by 3G coverage, and their concern over these types of issues may then increase.
- 5.24 Information on where consumers might use mobile internet is also important. Recent research undertaken by Point Topic in May 2007 asked people where they might expect to use mobile broadband services. The most common reply was on public transport. This was closely followed by use in a hotel or temporary accommodation with the third most popular being while waiting in stations and airports or for buses.

Figure 4: Places where people think they would use mobile broadband



Source: Point Topic

²¹ <http://www.ofcom.org.uk/consult/condocs/mct/summary/mct.pdf>, page 15

Conclusions on the importance of mobile broadband services for citizens and consumers

- 5.25 As indicated earlier we cannot predict with certainty to what extent consumers will take up mobile broadband. It is Ofcom's belief that overall the evidence reviewed above suggests that it is likely that mobile broadband will become a more important and more widely used service for consumers. However we do recognise that not all the evidence supports this conclusion and that there is the possibility, albeit less likely in our opinion, that mobile broadband will not become any more important than it is today.
- 5.26 To deal with this uncertainty we have chosen three demand scenarios (low, medium and high) to describe how significant mobile broadband services will become for consumers. These are essentially based around how large the demand will be for these services and the sensitivity of consumers to their quality - including the coverage (indoors and outside) and data rate - and thus how important it will be for operators to provide high quality mobile broadband networks.
- 5.27 We define these three scenarios in the following way:
- Low demand – Mobile broadband services develop slowly and for the majority of consumers, sensitivity to differences in 3G quality is no higher than it is today; i.e. as long as the quality is above a minimum acceptable level, other factors such as handset choice are likely to be more important in choosing a supplier.
 - Medium demand – Mobile broadband services are assumed to grow more strongly and those consumers who make significant use of these services are sensitive to quality differences in 3G. However, there are also a considerable number of users who use mobile broadband services much less frequently and are therefore less sensitive to differences in the quality of 3G services. Hence it is not critical for operators to match the quality provided by the market leader in order to retain market share.
 - High demand – Mobile broadband services become a vital component for the majority of users and the quality of their provision must be good enough or users will switch provider. Operators must be able to match the quality provided by the market leader in order to retain market share.
- 5.28 These scenarios are used in later sections when assessing the merits of policies which are sensitive to assumptions about the future demand for mobile broadband services.

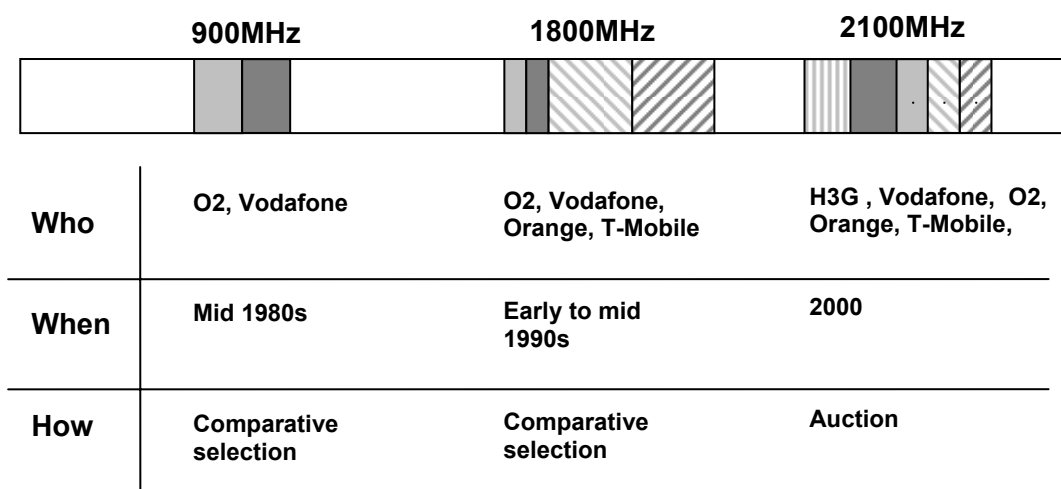
Existing allocations of mobile spectrum and new spectrum awards

Existing spectrum holdings of the 2G and 3G mobile network operators

- 5.29 In order to operate a wireless communications system in the UK a Wireless Telegraphy Act licence is required. This will specify the frequencies that the holder can use and often parameters such as transmit levels or the technology that can be operated. Also licences can carry conditions or obligations that the holder of the licence must meet. The way that licences have been allocated for mobile services has varied over the past twenty or so years and a brief review of some of the key aspects is provided in the following paragraphs.

- 5.30 Mobile telephony services have been available in the UK since the mid 1980s. Initially there were just two MNOs, Racal-Vodafone and Cellnet, now Vodafone and O2 respectively. They were first issued licences for 900 MHz spectrum in 1985 and operated first generation analogue networks using a system called Total Access Communication System (TACS). These licences were assigned to them through a comparative selection process by the Government and carried the requirement that each licence holder should provide service to an area where 90% of the population live and ensure that reasonable demands for provision of services could be satisfied. These analogue networks were very basic by today's standards offering only plain voice services, having no support for international roaming and lacking security.
- 5.31 Second generation systems or 2G began to be introduced in the early to mid 1990s. In the UK and across Europe the GSM (Global System for Mobile communications) standard was adopted. GSM allowed international roaming to become a reality, had robust security and has evolved to provide basic data services through enhancements such as GPRS and EDGE. GSM could operate in 900 MHz or 1800 MHz bands and the development of the new 1800 MHz band allowed the introduction of new network operators into the UK market.
- 5.32 The first licences for 1800 MHz spectrum were issued in 1991. However after this a number of mergers and failed ventures followed which meant that by 1995 there were just two network operators in the 1800 MHz band, Mercury One-2-One and Hutchison Orange, now T-Mobile and Orange respectively. The licences were again assigned by the Government through a process of comparative selection and like the 900 MHz operators they had the obligation to provide service to 90% of the population by 31 December 1999. In 1996 the two 900 MHz operators, Vodafone and O2, were assigned additional channels at 1800 MHz and additional spectrum at 1800 MHz was assigned to Orange and T-Mobile.
- 5.33 The third phase of network evolution is currently underway involving 3G or third generation technologies. In the UK the UMTS (Universal Mobile Telecommunications System) standard has been adopted after the assignment of 3G spectrum via auction in 2000. This auction offered 5 packages of spectrum in the 2100 MHz band²² and introduced a fifth mobile network operator, Hutchison 3G UK Ltd (H3G), through a package of spectrum in the auction being specifically set aside for a new entrant. 3G technologies offer higher data rates and more efficient use of the available spectrum and with enhancements such as HSDPA being deployed by some operators, typical download rates will be moving into the range of one Mbps and more.

²² 2100MHz band refers to the paired spectrum 1920 – 1980MHz uplink and 2110 – 2170MHz downlink. Note that this auction also included unpaired TDD spectrum in the 1900 – 1920MHz range.

Figure 5: Summary of ownership of bands and dates of spectrum assignment

NB - Diagram indicative of actual spectrum holdings – not to scale

- 5.34 The result of this history of mobile spectrum decisions is the set of current assignments shown in Figure 5 above and Table 2 below. It is worth noting that the entirety of the 900 MHz spectrum is assigned to only two operators (Vodafone and O2). 1800 MHz spectrum is assigned to four operators but most is held by two operators (Orange and T-Mobile). Finally there is one operator, H3G, which holds neither 900 MHz nor 1800 MHz spectrum.
- 5.35 The terms 'paired' and 'unpaired' refer to whether or not the spectrum consists of matched bands that allow uplink and downlink transmission to be carried out in separate spectrum bands. An entry in the table such as "2 × 5.8" means a total of two blocks, each of 5.8MHz, one designated for uplink and the other for downlink. The blocks are not necessarily contiguous and may be fragmented into smaller packages spread across the band that add up to the total shown.
- 5.36 The distinction between paired and unpaired spectrum has been made as in the UK the 2G and 3G networks currently all use paired spectrum to operate in a mode known as Frequency Division Duplex (FDD). UMTS standards also cater for an alternative to FDD called Time Division Duplex (TDD) which allows unpaired spectrum to be used. However none of the MNOs with unpaired spectrum allocations have chosen to rollout this technology as yet.

Table 2: Listing of current mobile operator spectrum allocations for paired and unpaired spectrum.

| | Vodafone | O2 | T-Mobile | Orange | H3G |
|--------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 900 MHz paired | 2 × 17.2 | 2 × 17.2 | 0 | 0 | 0 |
| 1800 MHz paired | 2 × 5.8 | 2 × 5.8 | 2 × 30.0 | 2 × 30.0 | 0 |
| 2100 MHz paired | 2 × 14.8 | 2 × 10.0 | 2 × 10.0 | 2 × 10.0 | 2 × 14.6 |
| Total paired | 2 × 37.8 | 2 × 33.0 | 2 × 40.0 | 2 × 40.0 | 2 × 14.6 |
| 2100 MHz unpaired | 0 | 5.0 | 5.0 | 5.0 | 5.1 |
| Total unpaired | 0 | 5.0 | 5.0 | 5.0 | 5.1 |

Terms of the 2G and 3G licences

- 5.37 The current spectrum assignments of the five mobile operators come with a number of restrictions and obligations on the licence holders. These generally dictate the technology that may be used and in some cases impose obligations, for example to meet coverage targets. The most useful way of setting these differences out is to discuss them in terms of the 2G licences (900 MHz and 1800 MHz) and 3G licences (2100 MHz).

2G licence conditions

- 5.38 Consistent with the GSM directive, the licences held by the four 2G licence holders (Vodafone, O2, T-Mobile, Orange) are technology specific and currently only allow GSM services to be delivered. The licences are subject to AIP (Administrated Incentive Pricing) which is currently set at £142,560 per 2×200kHz of 900 MHz spectrum and £110,880 per 2×200kHz of 1800 MHz spectrum.
- 5.39 The 2G licences contain provisions permitting variation or revocation of the licences on one year's notice for reasons related to the management of the radio spectrum.

3G licence conditions

- 5.40 The winning bids for the five 3G licences auctioned in 2000 totalled just under £22.5bn²³. The amounts bid have been the subject of legal dispute over whether or not the licence fees paid included VAT. This dispute was recently resolved when, on the 26th June 2007, the European Court of Justice rejected the claims that the fees included VAT.
- 5.41 The five 3G licences are technology specific, allowing only UMTS technology to be used to deliver services. As the licences were awarded via an auction they are not subject to AIP.

²³ Full details of the individual winning bids may be found here:
<http://www.ofcom.org.uk/static/archive/spectrumbauctions/press/200427.htm>

- 5.42 The 3G licences have rollout obligations. These oblige the holders of the licences to roll out 3G networks to an area where at least 80% of the UK population live by 31 December 2007. The issues of measuring and complying with this obligation are discussed in the documents related to the consultation and statement on 3G rollout obligations²⁴ and will not be discussed in this consultation.
- 5.43 The duration of the 3G licences is also different to the 2G licences. These licences had a fixed term of approximately 20 years when they were awarded at auction. They are due to expire on 31 December 2021.

Summary of differences in current assignments of spectrum

- 5.44 It is clear from the discussion above that the history of mobile spectrum allocations has produced a range of asymmetries in the quantity and frequency of holdings. In summary the key differences are:
- Method of assignment: The existing holdings are the results of different assignment mechanisms. The 900 MHz and 1800 MHz spectrum was assigned through a process of comparative selection. On the other hand 2100 MHz spectrum was assigned as a result of a competitive auction.
 - Frequency of assignment: The frequencies that the MNOs have are different. The 900 MHz 2G spectrum is held by just two operators; Vodafone and O2. The 1800 MHz spectrum is held by four MNOs but over 80% is in the hands of just two, Orange and T-Mobile, with the rest split between Vodafone and O2. All five MNOs have access to the 2100 MHz band.
 - Quantity of assignment: The quantity of spectrum held by each MNO also varies. Orange and T-Mobile have total holdings of 40MHz of paired spectrum each. Next is Vodafone followed by O2 with 37.8MHz and 33.0MHz of paired spectrum respectively. Finally H3G has 14.6MHz of paired spectrum.

New spectrum becoming available

- 5.45 Ofcom has a programme of spectrum awards that will make more spectrum available for wireless services²⁵. Some of these awards are potentially well suited to the delivery of mobile broadband services which we outline briefly below.
- 5.46 In considering the appropriate approach to implementing the RSC Decision it will be relevant to consider the extent to which these new awards could act as substitutes for 900 MHz and 1800 MHz spectrum. Substitutability with regard to the 2500 – 2690MHz band and the Digital Dividend is discussed further in section 6 as those are the bands which are most relevant to our current consideration of 900 and 1800 MHz spectrum.

2500 – 2690MHz and associated bands

- 5.47 This spectrum award consists of 190MHz between 2500 and 2690MHz and two smaller portions of 15MHz between 2010 – 2025MHz and 10MHz between 2290 – 2300MHz. It provides the possibility for acquiring paired and unpaired spectrum and was the subject of an initial consultation published in December 2006²⁶ followed by a

²⁴ See http://www.ofcom.org.uk/consult/condocs/3g_rollout/

²⁵ See <http://www.ofcom.org.uk/radiocomms/spectrumawards/>

²⁶ See http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_2010/

further discussion document with updated proposals published in August 2007²⁷. The award is currently expected to take place in 2008.

- 5.48 There are many uses that this spectrum might be put to for providing consumers and businesses with mobile broadband services. Due to the size of the band there is a lot of potential capacity available. However the propagation losses that signals experience around 2.6GHz are much larger than those experienced at 900 MHz or 1800 MHz. This means that many more cell sites would be needed at these frequencies to provide comparable coverage to a network using 900 MHz or 1800 MHz spectrum.

Digital Dividend Review (DDR) bands

- 5.49 Ofcom's Digital Dividend Review (DDR) is reviewing how to release for new uses the spectrum in the UHF band between 470 MHz and 862 MHz freed up by Digital Switchover (DSO). It consulted on a proposed approach to the award of this spectrum in December 2006²⁸ and expects to release a statement before the end of 2007 detailing its final proposals. It also expects to publish a further consultation on certain issues of detail regarding this award.
- 5.50 Under current proposals, 120 MHz of cleared spectrum will be awarded. There is also interleaved spectrum, comprising 'white spaces' that will exist between the transmitters operated for digital terrestrial television. These cleared and interleaved bands will be available across the UK once DSO is completed in 2012.
- 5.51 Physically, the digital dividend is a good substitute for 900 MHz and 1800 MHz spectrum. Due to its lower frequency than 900 MHz spectrum, it provides as good as, if not better, propagation characteristics.
- 5.52 However, there are currently restrictions on the use of the digital dividend for two way communications. These stem from the agreements reached at the Regional Radiocommunications Conference 2006 (RRC06) and bilateral agreements between the UK and other European countries. Ofcom understands that more base stations will be required to avoid breaching these restrictions than if no restrictions were in place. It is possible that the restrictions could be reduced in the future if neighbouring countries were also interested in using this spectrum for two way mobile services. However, this is subject to uncertainty and would require further bilateral agreements. Additionally, any use of the interleaved spectrum would require adequate geographic separation.
- 5.53 The digital dividend is currently not included in the 3GPP mobile standards. However, the process of agreeing a suitable sub-band within the digital dividend for mobile use across the EU has recently moved forward with recommendations from ECC TG4²⁹ that a preferred sub-band be harmonised on a non-mandatory basis for mobile applications at the upper end of the digital dividend, including as a minimum the range 798-862 MHz (channels 62 to 69). This may result in the development of network equipment and handsets for use in this sub-band. However, given that standards are not currently available, equipment will be further away from general availability than is likely to be the case for 900 MHz spectrum.

²⁷ See <http://www.ofcom.org.uk/consult/condocs/2ghzdiscuss/main.pdf>

²⁸ See <http://www.ofcom.org.uk/consult/condocs/ddr/>

²⁹ The Task Group 4 of the Electronic Communications Committee.

L-band (1452 – 1492MHz)

- 5.54 The L-band award is a block of 40MHz of spectrum between 1452MHz and 1492MHz. The award of this band was first consulted on in March 2006. It was the subject of two discussion documents regarding auction approach and technical aspects of a potential award in February 2007³⁰ and a further consultation published in July 2007³¹.
- 5.55 One of the more likely uses of the L-band is for mobile broadcast applications such as mobile TV. Regarding its use for mobile broadband, while the physical characteristics of spectrum at these frequencies are relatively attractive, the lack of support in standards coupled with the limited bandwidth available means that we do not consider this award to be a substitute for either 900 MHz or 1800 MHz spectrum.

Independent audit of spectrum holdings

- 5.56 Professor Martin Cave's 'Independent Audit of Spectrum holdings' was published in December 2005 and recommended wide ranging changes in several areas of spectrum managed by the public sector. The Government accepted the recommendations of the audit and is in the process of implementing them. The outcome of this is that additional spectrum below 2.6GHz suited to mobile applications might become available in the medium to long term. However, there are at present no relevant international standards in place for mobile use of this spectrum. Further information on the implementation of the audit may be found on the Independent Audit of Spectrum Holdings website³².

Effects of frequency on deployment of 3G services

- 5.57 The final parts of this section consider how different frequencies impact the provision of 3G services. It sets out the differences between how 2G and 3G systems perform at different frequencies and summarises the analysis Ofcom has undertaken into the cost implications of this. The full analysis is set out in Annexes 6, 7 and 8.
- 5.58 The RSC Decision requires the 900 MHz and 1800 MHz spectrum to be made available for 3G and therefore Ofcom considers that in order to judge how to implement this Decision it is important to compare how the use of different frequencies affect the provision of mobile broadband services. The outcome of this analysis is highly relevant to the decision Ofcom needs to make regarding the appropriate method of implementation.

Frequency and its effect on propagation of radio signals

- 5.59 To begin with it is important to understand some of the fundamental differences that changing frequency has on the behaviour of radio waves. The first difference we are interested in is that higher frequency radio signals lose more energy than lower frequency signals when travelling through air or over realistic terrain and buildings, particularly in densely built-up areas. All other things being equal, this means that a lower frequency signal can cover a greater distance than a higher frequency one.

³⁰ See http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_1452/

³¹ See http://www.ofcom.org.uk/consult/condocs/1452_1492/1452_1492.pdf

³² See <http://www.spectrumbauidit.org.uk/>

- 5.60 The other key effect of particular relevance is that lower frequencies are generally better at penetrating deeper into buildings. This means that, all other things being equal, a person using a mobile phone at a lower frequency will be able to use that phone deeper inside a building compared to someone using a higher frequency.
- 5.61 For both of these effects it is also useful to express them in a slightly different way by considering the signal strength that a mobile phone user receives. With all other things being equal again, if there are two users standing at the same distance from the base station and the only difference between them is the frequency that their mobile uses, then in both of the cases outlined above the lower frequency user will receive a stronger signal (when averaged over short distances) than the higher frequency user. This signal strength difference has important implications that we will expand upon later.
- 5.62 Very generally these effects manifest themselves for mobile network operators in the need to build more cell sites when using higher frequencies. These extra cell sites are needed to obtain the same level of coverage that lower frequency operators enjoy with fewer cell sites.

How frequency interacts with 2G and 3G mobile technologies

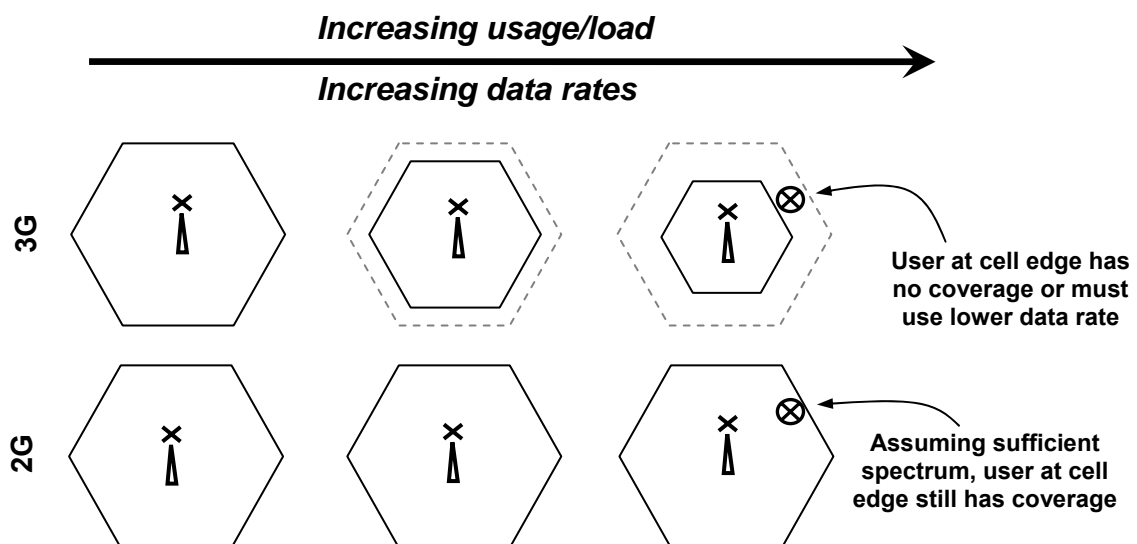
- 5.63 To understand the implications of different frequencies for 3G networks and services we need to appreciate how frequency affects the technology used in 3G networks. As defined in section 2, when we use the term 3G here we are specifically talking about W-CDMA UMTS technology. When talking about 2G we specifically mean GSM technology.
- 5.64 Although the discussion below is focused on W-CDMA UMTS technology the general finding is consistent with other 3G technologies. This is because all 3G technologies are trying to achieve the same goal which is essentially to use the available bandwidth in a more efficient manner than 2G. To do this they all use techniques that optimise the performance dynamically for each individual user so although they might use different technologies, the high level outcome described below will be broadly the same.

Overview of GSM and UMTS: relationship between coverage and capacity

- 5.65 To allow many people to share the same spectrum 2G is based on a technology called TDMA (Time Division Multiple Access). Very simply this works by letting different users take turns to use the same portion of frequency. Each user gets the whole of this frequency to themselves, but only for a short time, after which they wait until their turn comes up again. This cycling of turn happens over 200 times a second.
- 5.66 The capacity – how many users or total data load a cell can serve – is determined by the amount of spectrum available and the levels of interference present. With GSM, as long as sufficient spectrum is available, the interference is limited to manageable levels by using different frequencies in adjacent cells. Capacity is then practically determined only by the amount of spectrum available.
- 5.67 The key conclusion from this is that for GSM capacity and coverage are effectively independent. This means that the number of users does not significantly alter the coverage available; it remains the same whether 1 or 80 people are using the cell (assuming sufficient cell capacity for 80 people).

- 5.68 3G uses a different approach to sharing the spectrum called Code Division Multiple Access (CDMA). Unlike GSM everyone transmits at the same time with different users' signals separated using different codes and specialised signal processing that stops users interfering with each other. This process is not perfect in avoiding interference between different users though and the more people that use the cell the higher the interference level is.
- 5.69 There is a second effect with 3G that impacts people using higher data rates. To achieve these services users need to receive a stronger signal, in other words they must be closer to the cell site, or else they use up a greater proportion of the available power. This means that the coverage of the cell for higher data rate services is less than for lower data rates.
- 5.70 Combining these two aspects of 3G results in quite a different conclusion on how capacity and coverage are related than with 2G. For 3G capacity and coverage are closely interlinked with more capacity obtained at the expense of coverage and vice versa. This is different to 2G (where capacity and coverage are independent) and leads to an effect called cell breathing, where the coverage of a cell changes over time as user numbers and the data rates they demand vary.
- 5.71 The figure below attempts to show the general principle of the relationship between coverage and capacity in 3G and 2G systems. Simply put, at higher data rates and/or higher usage the coverage of the 3G cell shrinks which means a user at the edge will have service degraded or even lost completely. It should be noted that this diagram is not comparing the systems with all things being equal – it is just showing what happens up to maximum capacity. For 2G once maximum usage is reached coverage effectively falls to nothing for any new users because they cannot access the cell.

Figure 6: Coverage/capacity relationship between 2G and 3G



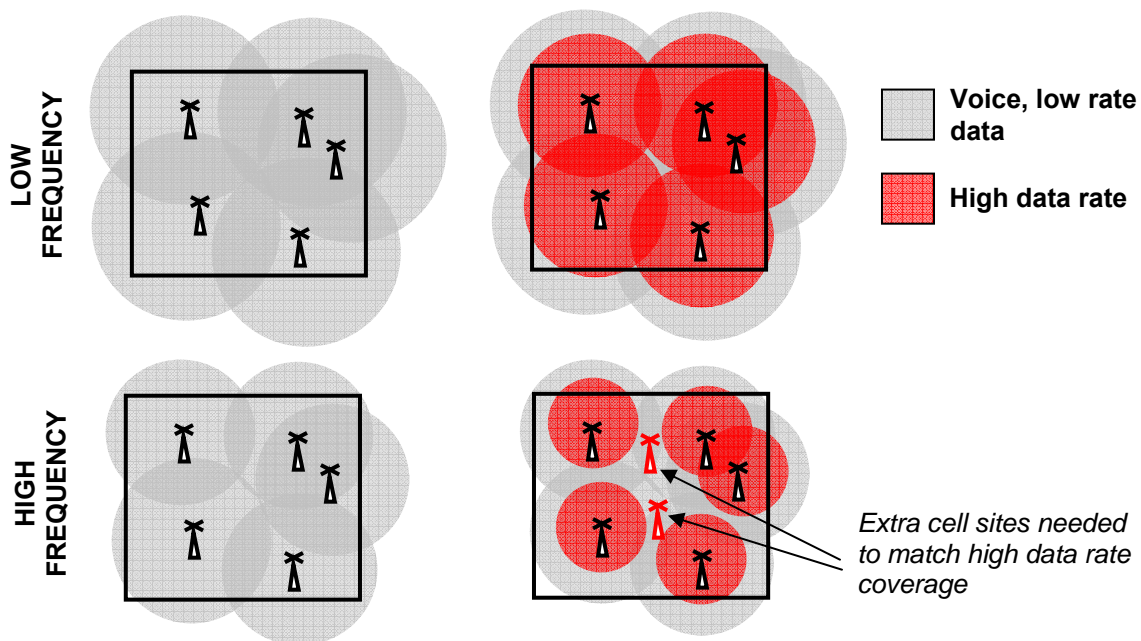
What impact does different frequency have on 2G and 3G?

- 5.72 An important point highlighted above is that at the edge of a cell a 3G user can lose coverage if the cell becomes more heavily loaded or a higher data rate is needed.

Being at the edge of a cell just means that the loss of signal from the base station is at the highest tolerable level. Anything that increases the signal loss for a user, such as being within a building, effectively puts them on the edge of the cell and they are thus exposed to losing service or having to accept a lower data rate if a 3G system is being used.

- 5.73 As was outlined in paragraph 5.60, lower frequencies generally penetrate into buildings more easily. For a 2G system this means that service is obtained deeper within a building. However for 3G the capacity/coverage trade off we discussed comes into play and so not only does coverage within a building reduce when using higher frequencies, but the services available (maximum data rates) to both that user and all others within the cell are also reduced. As 3G shares resources between users there is also a reduction in maximum aggregate capacity for the cell when using higher frequencies.
- 5.74 The impact of these differences is that operators using higher frequencies will need to roll out additional cell sites to match the service quality and coverage of operators using lower frequencies. Figure 7 below illustrates the principle of how additional cell sites are needed by operators using higher frequencies to provide comparable coverage within urban or suburban areas, especially in buildings. The figure shows how voice or low data rate services can still obtain sufficient coverage using the same base of cell sites but moving to higher rate services causes gaps in coverage to appear requiring additional cell sites if coverage is to be maintained. A large part of this coverage shrinkage is due to the greater propagation losses when trying to reach customers in buildings or outdoors in built-up areas at higher frequencies.

Figure 7: 3G operators at higher frequencies need additional cell sites to match coverage for high data rate services.



With similar cell site distribution basic services can be offered with similar coverage at both low and high frequency

High speed data suffers more at higher frequency and extra cell sites are needed to match coverage of operator using lower frequency

- 5.75 For 2G systems, networks operating at lower frequencies gain advantages from needing fewer sites to obtain similar coverage to networks operating at higher

frequencies. However the advantage is generally limited to instances where only coverage is needed (sparsely populated or rural areas). Once capacity starts to be an issue (i.e. once you cannot increase capacity by adding more spectrum as you have used it all up, typically in urban or suburban areas) the advantage of lower frequencies are limited and differences between frequencies are more focused on the total amount of spectrum held rather than frequency of operation.

- 5.76 For 3G the same advantages as are experienced for 2G systems are present when using lower frequencies and just requiring coverage (sparsely populated/rural areas). However, in urban and suburban areas where capacity becomes a problem the 3G operator using lower frequencies experiences additional advantages of being able to offer higher data rate services to a much wider coverage area (particularly outdoors in built-up areas or inside buildings) when using the same number of cell sites as an operator using higher frequencies. For the operator using higher frequencies matching coverage of higher data rate services requires them to install additional sites. This is a direct result of the capacity/coverage trade off experienced in 3G and the better urban/in-building coverage of lower frequencies.

Importance of 900 & 1800 MHz spectrum – effects of frequency on the costs of deploying 3G network infrastructure

- 5.77 The nature of 3G technology has implications for the costs of deploying these networks at different frequencies. In order to understand the cost impact we have undertaken an extensive programme of modelling work. The work is partitioned by considering an operator's network in terms of core and non core areas. Core areas are those of dense population, typically towns and cities that would represent coverage of 80% of the population. Non core areas are lower population areas that would typically be more rural in nature and represent coverage beyond the 80% of population out to 99% population coverage.
- 5.78 We have chosen to use different modelling methodologies in the core and non core areas. The core area represents the minimum coverage specified by the 2100 MHz licence obligation. This area represents the main future potential deployment for deeper and higher quality coverage and in response to this our modelling exercise in this area is based on improving coverage and capacity for high quality mobile broadband services. The non core area is more likely to have future deployment based only upon extending coverage rather than deepening it. In light of this our approach to non core areas has been to estimate the costs of simply providing a basic level of 3G coverage to a given percentage of the population.
- 5.79 By necessity, the following discussion focuses on the key results and important aspects of the modelling work. For a full description of results and methodology see Annexes 6, 7 and 8.
- 5.80 Before going on to discuss the results of the modelling work the following general points should be borne in mind when interpreting our results:
- In this discussion greater attention is paid to the modelling of the core area as the impact of frequency differences in this area has a larger impact on the costs of network deployment and (as discussed above) is likely to experience the biggest difference between 2G and 3G networks. This is also reflected in the level of sophistication of our modelling approach between these two areas.
 - Our central estimates have focused on assessing the cost advantage for existing mobile operators, taking into account where appropriate the fact there are

existing 3G and 2G networks, because they are likely to be among the users of the band. The cost advantage of lower frequencies which would arise for a new entrant is expected to be at least as high if not higher, because they would be likely to have less sites available for upgrade (our sensitivity analysis of sites available for upgrade considers this possibility).

- The purpose of the modelling work is to provide an order of magnitude assessment of the potential cost advantage of access to lower frequencies. In order to do so it has been necessary to hold constant other potential differences between networks which will impact upon the cost of network deployment, for example variations in the quality of coverage provided and the precise location, number and type of existing sites.
- As the modelling work seeks to assess the magnitude of the cost differences which could arise from using lower frequencies the cost impact which is quantified is the additional cost which is incurred when a network operator has to rollout additional sites. Therefore, the cost estimates provided are not indicative of the full cost of rolling out 3G networks.
- In order to reflect the level of uncertainty over the magnitude of the potential cost advantage our modelling work has considered a number of different scenarios and we have completed detailed sensitivity analysis of the key assumptions made. For the core coverage area these are discussed below, for the non-core coverage area, details of the sensitivity analysis can be found in the annexes.

Modelling in core areas

- 5.81 For the core area we have undertaken a modelling exercise that is based on a simulated deployment in a typical urban/suburban landscape. This study has looked at the number of macrocell base stations which operators using different frequencies would need to deploy in order to provide mobile broadband services at the same level of high quality indoor and outdoor coverage. The purpose of this modelling is to understand the advantage of 3G systems working at different frequencies, specifically the extra sites (and thus extra cost) an operator would have to deploy to overcome any disadvantage from using higher frequencies. It should be noted that when we convert site numbers into costs we have assumed that cost of network equipment and its availability is the same regardless of the band being used. We consider the reasonableness of this assumption below (see paragraphs 5.104-5.110).
- 5.82 The core area modelling can be very simply split into a three stage process. The first stage is a set of simulations of a 10km square area of North London. Using industry standard network planning tools, the number of base stations needed to achieve different coverage scenarios (termed adoption scenarios) has been calculated for operators using frequencies at 900 MHz, 1800 MHz and 2100 MHz. The second stage takes these numbers and carries out a scaling exercise to extrapolate the results to a level that represents covering 80% of the UK population. The output of the second stage provides us with the total number of macro cell sites needed in the core area. Finally, the third step is to convert this into a cost difference at the different frequency bands. In this step we take account of the number of existing sites which it may be possible to upgrade in order to determine how many completely new sites are required. It is important to draw a distinction between these two categories of site when converting site numbers into cost, as the cost of upgrading a site is less than the cost of a new build.

Model parameters and assumptions

5.83 The modelling relies on a number of parameters, many of which cannot be precisely determined. Some of these parameters impact how many base station sites are required while others only alter the size of the cost differential implied by the site numbers. Our central cost estimates are based on a set of assumptions that we believe are reasonable. However, recognising the inherent uncertainty in many of these parameters, ranges around these assumptions and their impact on the results are considered in the discussion of sensitivities below.

5.84 The main model parameters and our central assumptions are described below:

- i) Propagation – This parameter concerns how signals at different frequencies travel over terrain and buildings and how they penetrate into buildings. Lower frequencies experience reduced losses over the outdoor part of the path from the base station towards the edges of the cell. This effect is well documented in general literature and has been accounted for by the use of standard published propagation models. Generally as this difference increases more cell sites must be installed at higher frequencies to match the coverage of a lower frequency network. These extra sites compensate for the greater losses of the signals. For users accessing services indoors, an additional building penetration loss is incurred. The factors affecting the penetration loss involved in propagation into buildings are complex and vary from building to building. However on balance lower frequencies are generally better than higher frequencies for penetrating deep into buildings. To reflect this Ofcom has chosen values of 10dB, 12dB and 13dB for the average losses at 900 MHz, 1800 MHz and 2100 MHz. Annex 8 discusses these factors in greater depth.
- ii) Adoption of mobile broadband – Higher adoption of mobile broadband services means that more base stations must be installed in order to maintain coverage and quality of service. We have defined three levels of adoption for the purpose of our modelling: low, medium and high. These describe the proportion of users that will be demanding higher data rate services along with the amount they will use them and how many will use services inside buildings. They provide a view on how the number of sites an operator needs to deploy will change as the demand for mobile broadband services rises. For our central estimate we have assumed medium adoption of mobile broadband services, defined as follows: 30% of users using voice and mid-rate data services with 144 kbps downlink and 64 kbps uplink to a total of 10 Mbits per day (downlink) with 80% of this data traffic indoors. The other 70% of users only use voice and basic data services at an average of 20 millierlangs per user in the busiest hour of the day with 70% of this traffic indoors. Roughly, the medium level of adoption can be thought of as a situation in which there is moderate growth demand for mobile broadband services from today and indoor use of mobile data services is a somewhat higher in importance to that experienced on 2G networks today, due to the likely applications and terminal types relevant to data services.
- iii) Quantity of spectrum - The simulation study assumed that all operators used two 2×5 MHz carriers. The reason for this assumption is that we are most interested in the effect which differences in frequency have on the costs of deploying a network. If in our analysis we varied the number of carriers between frequency bands we would not be able to make a direct comparison of the effect of frequency. This is because differences between bands would be driven by a combination of both the difference in the frequency and the availability of

spectrum. However, the effect of varying the number of carriers available at different bands is considered in our sensitivity analysis.

- iv) **Cost of sites** - The costs used for converting differences in the numbers of sites required at different frequencies into a cost impact are estimates of the capital and operating expenditures which are driven by the number of sites required. The costs are expressed as a net present value (NPV) of the relevant expenditures over a 20 year period. The discount rate used in deriving the NPV is discussed below. When assessing the cost impact of deploying networks at different frequencies we take into account the number of existing sites which it may be possible to upgrade, as the cost of upgrading existing sites is lower than the cost of building new sites. The cost estimates used in the analysis are based upon a number of different sources (as discussed in annex 6). Based on this information our central estimate of the first year capital expenditure of new builds and upgrades is £105,000 and £45,000 respectively. The operating expenditure is then assumed to be 10% of the capital cost. When expressed as a 20 year NPV the capital and operating expenditure incurred for new builds and upgrades are in total £240,000 and £75,000 respectively for sites built/upgraded in 2009/10. In order to capture uncertainty over the magnitude of the costs we assess the sensitivity of our results to these assumptions. This analysis is discussed later in this section. It should be noted that, as our cost estimates only reflect costs which vary when the number of sites varies, they are not indicative of the full cost of deploying a network.
- v) **Re-use of existing sites** – As the cost of re-using existing base station sites and simply upgrading them is significantly less than the cost of building new ones, the proportion of existing sites that can be re-used is important for determining the cost impact of the number of sites required at different frequencies. We assume that many, but not all, existing sites will be suitable for upgrade. The proportion is difficult to calculate exactly as it involves many factors that vary on a site by site basis. Ofcom has assumed that a reasonable value to use is 85%. For example, if an operator has 6500 sites within the core area then 5525 will be suitable for upgrade when deploying a 3G network using lower frequency spectrum. It should be noted that for 2100 MHz networks only we have assumed that there are 6500 existing sites operating at 2100 MHz. As our modelling is focussed on the effect of frequency differences on existing operators, these sites are all assumed to contribute to the total sites needed for a 3G network at 2100 MHz and are assumed to need no upgrade. Thus these sites can be taken from the total sites required when calculating costs for deploying 3G at 2100 MHz. For example if a simulation shows that 10,000 sites are needed at 2100 MHz the cost will be based purely on building 3500 new sites which is the number left after the 6500 existing sites are taken into account.
- vi) **Use of multiple frequencies** – The approach taken to the modelling is to assume that operators deploy networks using only one frequency band. Hence, if an existing operator is to deploy a network using either 900 MHz or 1800 MHz they would use this frequency to meet all their coverage and capacity requirements. Hence, any existing 2100 MHz infrastructure will not count towards meeting this requirement. This assumption is made as we believe that an operator would use lower frequency spectrum to provide a new base layer of coverage, rather than using it to fill in gaps in existing 2100 MHz coverage.
- vii) **Discount rate** – We present costs as 20 year NPV values and in order to do this we must set an appropriate discount rate. Our central estimates are based on a social discount rate of 3.5%. This is because in this document we are in most

cases considering the costs and benefits to society of different policy options, rather than on the commercial decisions of operators for which a commercial discount rate (assumed to be approximately 11.5%) would be more appropriate. In section 6 we look at the likely effect on operator's investment decisions of the cost advantages and in that context we use the results using a commercial discount rate.

Results of modelling core areas – central estimate

5.85 Using the values for the key parameters described above, we have calculated how many sites are needed at 900 MHz, 1800 MHz and 2100 MHz in order to provide coverage in the core area to meet the level of take-up implied by our medium adoption level. The results of this are 7,500, 13,400 and 17,800 sites respectively. The differences in numbers of sites required are shown in the table below.

Table 3: Central estimate of site and cost advantages for different frequencies

| | Advantage of 900 MHz over 2100 MHz | Advantage of 900 MHz over 1800 MHz | Advantage of 1800 MHz over 2100 MHz |
|-----------------------------|---|---|--|
| Site advantage | 10,300 | 6,000 | 4,400 |
| Cost advantage (£bn) | 1.7 | 1.3 | 0.4 |

All costs are 20 year NPVs using a social discount rate of 3.5%

5.86 This table also shows the cost advantage related to each frequency. The simplest estimate of costs would be to assume that every site is a new build. However this is less useful for our analysis of competition in the market as the five MNOs all have an extensive existing network of base stations that we assume can be reused at a rate of 85% if they were to deploy a new network at 900 MHz or 1800 MHz and existing 2100 MHz networks which they could use in their entirety if they continue to deploy at this frequency. Using this assumption and our estimates of new and upgrade costs we obtain the costs for 900 MHz and 1800 MHz networks.

5.87 As we noted earlier the costs for 2100 MHz are calculated differently to the 900 MHz and 1800 MHz cases due to the fact that 2100 MHz 3G networks already exist and can be used straight away. The assumption we have used is that the core area currently comprises 6500 sites at 2100 MHz frequencies. This means cost disadvantage of 2100 MHz is generally less than a simplistic interpretation of the site numbers would suggest. This is because the cost disadvantage is partly offset by the existing 2100 MHz infrastructure which can be reused in its entirety, whereas for 900 MHz or 1800 MHz it is assumed only 85% of existing infrastructure can be reused, and even when it is reused an upgrade cost is incurred. Ofcom believes that this approach is likely to be the way an existing operator at 2100 MHz would assess the benefits to them of using an alternative lower frequency to provide their base coverage layer instead of continuing to use 2100 MHz. Also by assuming all existing 2100 MHz infrastructure is available and can be used at no additional cost, Ofcom

believes that it accurately identifies the cost impacts to society of network deployment at this frequency compared to 900 MHz and 1800 MHz.

- 5.88 Nonetheless, our central cost estimates indicate 900 MHz spectrum has a significant cost advantage of around £1.7bn over 2100 MHz and also over 1800 MHz where the difference is £1.3bn. For 1800 MHz the cost advantage over 2100 MHz is around £0.4bn.

Sensitivity analysis

- 5.89 The results presented above represent our central estimate of the cost advantage of deploying a 3G network at 900 MHz and 1800 MHz compared to 2100 MHz (after taking into account existing network deployment) using our central assumptions for the key model parameters. However there is a degree of uncertainty around many of these values and in order to ensure our analysis is robust we have undertaken a sensitivity analysis to see how the model is affected by using different values.
- 5.90 Our analysis has changed just one value at a time leaving all other parameters at the central estimate values described earlier. The results have been expressed as changes in the sites required and the cost differences between frequencies. Note that sensitivities for which the site numbers are the same as the central estimate are sensitivities to assumptions which affect the costs of sites or the derivation of the cost differential.

Figure 8: Sensitivity analysis for core model in terms of cell site differences

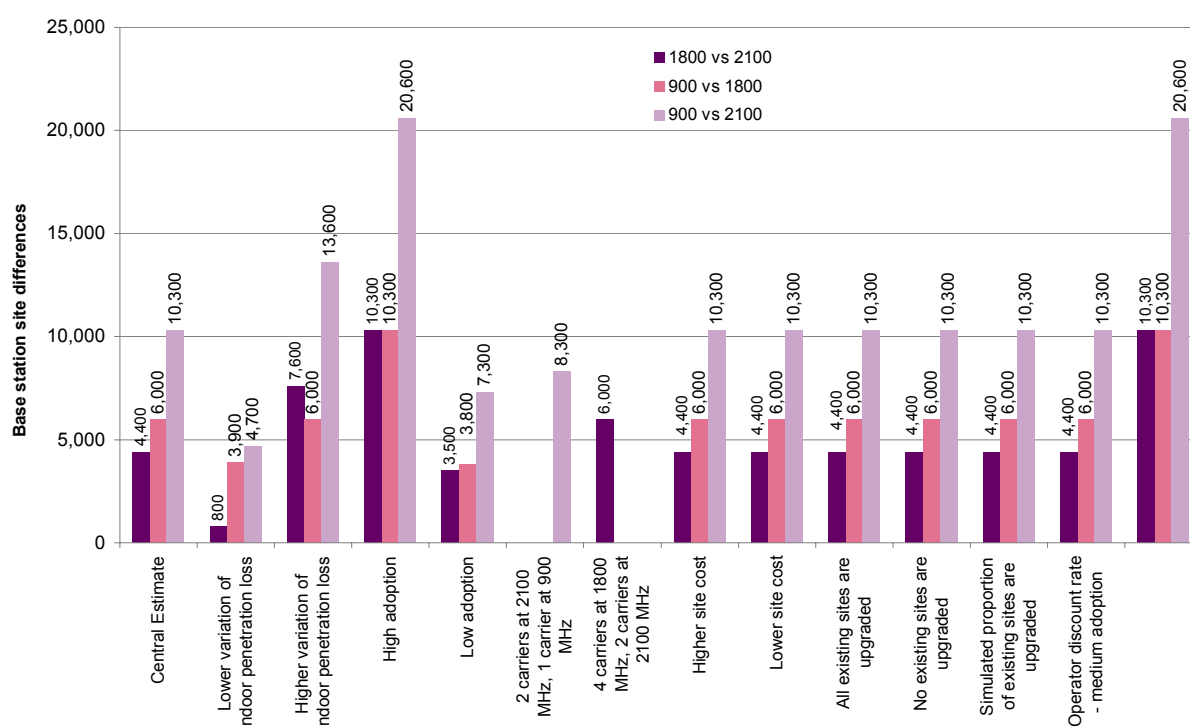


Figure 9: Sensitivity analysis for the core model in terms of cost differences



All costs are 20 years NPVs using a social discount rate of 3.5% except those specifically labelled operator discount rate

5.91 We can now discuss each parameter and discuss the results of the sensitivity analysis.

5.92 Propagation – building penetration loss

5.92.1 Our sensitivity analysis for the variation in building penetration loss with frequency has considered a higher level of variation which increases the differences in penetration loss between 2100 and 900/1800 MHz, and a lower level which has assumed that there is no variation in penetration loss between frequency bands. The higher level of penetration loss increases the differences between the frequencies by changing the 2100 MHz loss from 13 to 15dB (900 and 1800 MHz stay the same at 10 and 12dB respectively). The lower level assumes that all frequencies have the same penetration loss of 10dB.

5.92.2 For higher variation in penetration loss the costs increase significantly with the difference between 900 and 2100 MHz increasing to £2.5bn while the difference between 1800 and 2100 MHz moves to £1.1bn. The difference between 900 and 1800 MHz is not affected by this sensitivity as the higher variation assumption effects only 2100 MHz. The rationale behind considering this higher level case is that in the future it is possible that changes in the construction of buildings (principally with metallised energy efficient window coverings) will increase further the losses signals experience. However it must be kept in mind that the estimate we have used here is likely to overstate the impact as it only increases 2100 MHz and not 900 MHz or 1800 MHz which would in practice both experience increased losses from these windows. With this in mind Ofcom believes the result for the higher variation case is an unlikely outcome and thus there is

limited potential for the cost advantages to be as high as this sensitivity suggests for that reason.

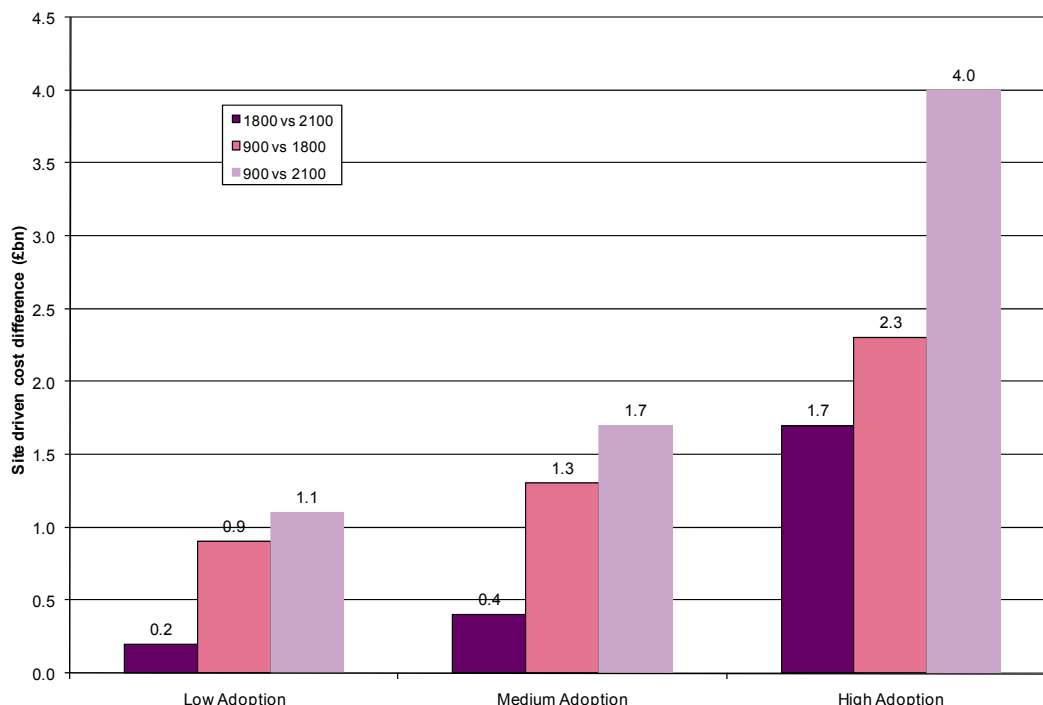
- 5.92.3 When the variation in building penetration loss is lower, such that there is no variation between the frequency bands, the cost differences between bands reduce with 900 MHz having an advantage of £0.5bn while deploying at 1800 MHz (taking into account existing deployment at 2100 MHz) would result in a cost disadvantage of £0.4bn. This is because of the assumption described earlier that at 2100 MHz there are 6500 existing sites requiring no expenditure, compared to only 85% of existing sites which can be reused at 1800 MHz, all of which incur an upgrade cost. When combined with smaller differences in sites between operators (the result of the no variation in penetration loss assumption) this effect can cause the 1800 MHz network to become more expensive than the 2100 MHz network giving the negative value shown in Figure 9. In practice we would not expect this cost disadvantage to be incurred as existing operators all have the opportunity to use their existing 2100 MHz spectrum rather than deploying alternative 3G networks at 1800 MHz.
- 5.92.4 In the lower, no variation, case the cost advantage at 900 MHz is still large enough to be considered significant. This is because the propagation losses outside the building are still less at lower frequencies regardless of the degree of loss experienced when penetrating into buildings. We do not believe that this situation represents the typical behaviour of signals entering buildings though, only something that occurs occasionally, and signals will usually experience increasing loss in penetrating deep into a building as frequency increases.

5.93 Adoption

- 5.93.1 Whilst our central estimates have assumed a 'medium' level of mobile broadband adoption, we have also investigated the effect of higher or lower adoption of mobile broadband services (the cost differences which result for each adoption level are shown in Figure 10). We assume a 'high' adoption to be the case where 10% of users (90% of whom are indoors) are using services at 384/114kbps (downlink/uplink) to a total of 20Mbits per day (downlink) and 40% of users (80% indoors) are using mid-rate data services (as described in the discussion of the central case assumptions above), with the remaining 50% of users (70% indoors) using voice and basic mobile data services at an average of 20 millierlangs per user in the busiest hour of the day. Our 'low' adoption is very conservative in that it assumes that operators provide good quality indoor coverage but only with sufficient capacity for voice and the basic level of mobile data services (essentially at a level no more demanding on the network than voice). Hence it very much represents a limiting lower case as almost any growth in mobile broadband take up is likely to be above this level.
- 5.93.2 As would be expected, higher adoption increases the cost advantage of lower frequencies where as lower adoption reduces it. The growth in cost advantage with adoption appears most pronounced for 900 MHz rather than 1800 MHz, with a very significant advantage of around £4.0bn in the high scenario. 1800 MHz spectrum only appears to provide any advantage of significance at the high level of adoption. So in practice an operator with 900 MHz would start with an advantage and see this grow significantly as mobile broadband adoption increased, whereas an operator using 1800

MHz would only start to see an advantage when adoption reached high levels.

Figure 10: Nationwide infrastructure cost advantage (£billion) within core coverage area.



5.94 Quantity of spectrum

5.94.1 We have also investigated the impact of access to extra spectrum capacity (ie more carriers) at higher frequencies. In order to study this effect we looked at two main cases: first where the 900 MHz operator had only one block but the 1800 MHz and 2100 MHz operator continues to have two blocks; and second where the 1800 MHz operator had four blocks while the 900 MHz and the 2100 MHz operators continue to have two blocks. By doing this sensitivity we are testing whether or not and to what extent additional blocks of spectrum can compensate for reduced coverage associated with the use of higher frequencies.

5.94.2 The effect of more spectrum on coverage will be to relieve loading on the downlink path and thus increase the available range through the effect of 3G trading off capacity for coverage. However it will have relatively little effect upon the uplink so the advantage in coverage will be limited. The downlink gain will result in fewer sites being needed to be added to meet capacity but this is a longer term effect that only comes into play after sufficient coverage has been achieved. In addition, these capacity advantages can to a large extent be replicated through additional spectrum at any frequency. Hence, the acquisition of additional spectrum at 2.6GHz, or the use of 2100 MHz in combination with a limited amount of 900 MHz spectrum for example, could be used to achieve much of the capacity benefit shown in these sensitivities. These issues are discussed in more detail in Annex 8.

- 5.94.3 The impact of having just one block at 900 MHz (compared to two blocks at 2100 MHz) is to reduce the advantage compared to 2100 MHz to £1.3bn, which is still a significant advantage. As mentioned above, it is likely that further benefits from a single block of 900 MHz could be realised if it were combined with some higher frequency spectrum. This is because in practice peaks of traffic occur in limited 'hot spots'. Alternatively these hot spots can also be addressed with solutions such as microcells that are cheaper than macro cells to install and operate.
 - 5.94.4 It is therefore expected that most of the benefit associated with 900 MHz, which is driven by the benefits it brings in achieving coverage both in open areas and inside buildings, can be obtained by access to a single 900 MHz carrier, provided the operator has existing spectrum at higher frequencies.
 - 5.94.5 Increasing the number of 1800 MHz blocks to four does in principle increase its advantage over 2100 MHz to around £0.8bn. Ofcom has also looked at the impact of four blocks at 1800 MHz compared to two blocks at 900 MHz and this, as expected reduces the cost advantage of 900 MHz but it remains material at £1bn. However in both cases, as explained above, much of advantage associated with the extra 1800 MHz capacity could be replicated by acquiring additional spectrum at alternative frequencies such as 2.6GHz.
- 5.95 Cost of sites
- 5.95.1 The estimates of the cost of sites are based on a range of sources including operator data and independent consultants. We have chosen to flex the results of the modelling by using higher and lower cost estimates when deriving the size of the cost differential. The higher and lower cost estimates reflect the high and low point of the range of cost estimates obtained for the range of sources used. The high and low cost estimates for new builds are based on first year capital expenditure of £140,000 for high case and £75,000 for the low case (compared to the central case assumption of £105,000 for new builds). For upgrades the high case is £75,000 and the low case £25,000 (compared to a central case assumption of £45,000 for upgrades).
 - 5.95.2 Lower costs might occur if costs could be reduced by measures such as network sharing and by increasing commoditisation of the labour and equipment components of site costs.
 - 5.95.3 However costs could be higher if, given a large increase in demand for sites involving several operators requiring suitable sites over a limited time period, the pricing of sites increases given the limited supply of suitable locations. We have made the assumption in all cases that the marginal cost of sites is constant. In other words cost of an additional site is the same whether it is first additional site need or the 10,000th. This assumption was made to simplify the analysis and because Ofcom had no alternative. However, it is very unlikely to reflect the true position, which is likely to be that there is an increasing marginal cost of sites due to the increased difficulty of finding sites the more that are required. Therefore, in this regard the cost numbers presented can be regarded as conservative estimates.
 - 5.95.4 Additionally, it is assumed that all cost differences are associated with the sites themselves. It may be that the process of monitoring, managing and

optimising larger numbers of sites also increases when considered on a per-site basis for large number of sites.

- 5.95.5 As expected the higher costs make the differences greater while the lower costs make them smaller. This impact of this sensitivity may appear to be less than expected, but this reflects the impact of the assumptions over the proportion of sites which can be reused, and their cost, at the different frequencies.

5.96 Reuse of sites

- 5.96.1 We have considered two alternatives to our assumption that 85% of existing sites can be re-used, either no sites can be upgraded or all sites can be upgraded:
- If no sites can be re-used, in other words all base station sites are completely new, the cost advantages of different frequencies are indicative of the advantages which would result if operators did not have existing networks to build on. This sensitivity results in a cost advantage of £2.3bn at 900 MHz and £1.0bn at 1800 MHz when compared to 2100 MHz. The cost advantages are higher in this case because the absolute costs of new sites are higher than upgrades. The results of this sensitivity are representative of the frequency driven cost differential that a new entrant could face if it were unable to gain access to any existing sites. It does not however seem a reasonable assumption given that there are a very large number of existing sites which could be re-used. However, on the other hand, if a new entrant were to enter the market using 2.6 GHz spectrum, the cost disadvantage it would face relative to entering at either 900 MHz or 1800 MHz would be greater than those indicated by this analysis.
 - All sites being upgradeable represent the most favourable situation for the existing MNOs. In this case the cost advantage at 900 MHz increases to £1.9bn while the advantage at 1800 MHz moves to £0.6bn. The cost advantages increase in this sensitivity as the mix of upgrades compared to new builds in the case of 900 MHz and 1800 MHz networks has increased relative to the central case assumption for 2100 MHz, which allowed all existing sites to be reused. However, in both cases these changes represent relatively limited movement around the central estimates and as such do not alter our conclusions on the cost advantages in each case.
 - Finally we note that the first stage of the simulations using the 10km square grid of North London gave estimates of cell site reuse at the 900 MHz and 1800 MHz frequencies. We choose to use a constant upgrade rate of 85% rather than the outputs of the simulation to allow us to focus on the effects of frequency more clearly. Although the upgrade levels identified in the simulations differ between 900 and 1800 MHz their impact, which is discussed in more detail in Annex 8, is minimal.

5.97 Discount rate

- 5.97.1 The majority of our analysis considers the benefits to society of different frequencies, and hence a social discount rate is appropriate. However, it is

also important to understand the implications for operators' investment decisions (particularly for our analysis in section 6), for which a commercial discount rate is more appropriate. The use of a commercial discount rate (assumed to be 11.5%) reduces the advantage, as a 20 year net present value, of lower frequencies. This is because a large proportion of the costs associated with additional base stations take the form of recurring opex over 20 years, which are discounted significantly more under a (higher) commercial discount rate.

- 5.97.2 It should also be noted that both the 3.5% and 11.5% are themselves estimates of social and commercial rates respectively although varying these (eg taking a 3% social discount rate) does not materially affect our conclusions.

5.98 Solutions other than macrocells

- 5.98.1 It should be noted that the core area model provides results for addressing shortfalls in coverage and quality through the provision of additional macrocells. In the core areas operators using higher frequencies would likely not always use macrocells to address coverage and quality shortfalls in all instances. A proportion of the shortfalls may be more economically addressed through the provision of microcells and dedicated in-building solutions. This is a difficult figure to predict though and we have therefore not attempted to factor this into our calculations. It should also be recognised that these solutions are not considered to be a viable alternative to a macrocell network – only a complement to one. A fuller discussion of this is included in Annex 8.

Key points arising from the core modelling

- 5.99 Ofcom's initial view is that the key points that can drawn from the core modelling and sensitivity analysis are:
- 900 MHz appears to have a significant advantage over 2100 MHz even if more conservative assumptions than the central case are adopted.
 - 1800 MHz only appears to provide a material advantage under certain assumptions.
 - The cost advantages of 900 MHz are consistently larger than for 1800 MHz. This is most clearly demonstrated by Figure 9 where the cost advantage for 900 MHz never drops below £0.5bn and in every case is always greater than the 1800 MHz cost advantage.

Modelling in non core areas

- 5.100 For the non core areas a more generic approach has been adopted based purely on meeting outdoor coverage targets. The model provides estimates of the number of cell sites that operators using the different frequencies would require in order to extend 3G coverage. This extension is from 80% population coverage out to 99%. Estimates of site reuse proportions and site costs are then used to generate estimates of the cost advantages of operating at lower frequencies. The central estimate assumptions for these two variables are the same as those used for the core area modelling discussed above.

5.101 Our base case results indicate that using 900 MHz 2,300 base stations are required, whilst networks using 1800 MHz and 2100 MHz require 3,700 and 5,000 respectively in order to extend coverage to 99%. This amounts to 1800 MHz requiring 60% more base stations, whilst 2100 MHz requires 120% more base stations than 900 MHz. This difference in number of required base stations results in lower costs of providing 3G services using lower frequencies in less densely populated areas as shown in Table 4.

5.102 As with the core modelling there are a number of key assumptions made in this analysis that impact upon the results. These include assumptions in relation to the proportion of sites that can be reused and assumptions used in estimating the number of base stations required per unit area. Annex 7 contains a full discussion of the non core modelling along with sensitivity analysis which highlights the impact of key modelling assumptions on the results.

Table 4: Cost to extend coverage from 80% to 99% of the population at different frequencies

| | Advantage of 900 MHz over 2100 MHz | Advantage of 1800 MHz over 2100 MHz | Advantage of 900 MHz over 1800 MHz |
|----------------------------|---|--|---|
| Site advantage | 2,700 | 1,400 | 1,400 |
| Cost advantage (£m) | 250 | 130 | 130 |

All costs are 20 year NPVs using a social discount rate of 3.5%

5.103 The magnitude of the cost saving from using 900 MHz is dependent upon the particular assumptions and input values chosen. However, in the central case the cost saving of using 900 MHz rather than 2100 MHz is estimated to be around £250m per operator and the saving from using 900 MHz rather than 1800 MHz is around £130m. Hence, the potential magnitude of the cost advantages of lower frequencies in providing coverage in non-core areas is significantly less than the advantage which results in areas of core coverage.

Availability and pricing of equipment at 900 MHz and 1800 MHz

5.104 We have discussed above how operating 3G networks at lower frequencies confers important advantages for an operator in terms of fewer base stations, and in principle lower costs, required to provide a given level of coverage. That analysis assumed that equipment was available for all bands at equivalent costs. However the other key consideration when assessing the advantage of different frequencies is the availability and pricing of network infrastructure and compatible handsets.

5.105 For UMTS network equipment at 900 MHz ('UMTS900') trials have been taking place since early 2006. These have involved many of the major equipment vendors and mobile operators³³. In addition it is expected that the first commercial UMTS900

³³ Examples of some of the trials that have taken place include O2/Alcatel-Lucent in Isle of Man, Vodafone/Nortel/Qualcomm in Portugal and Nokia/Elisa in Finland.

networks will start being rolled out by the end of 2007 or the start of 2008. The most likely countries for these deployments currently appear to be Finland and France. The result of this is that it is not unreasonable to expect that network infrastructure for UMTS900 will be commercially available around this time.

- 5.106 Regarding handsets compatible with UMTS900 Ofcom understands that there are no significant technical barriers to producing these handsets. Indeed the first commercial handsets compatible with UMTS 900 MHz have now been announced³⁴. With the numerous trials taking place and multiple vendors being involved the availability of handsets for UMTS900 is unlikely to be a problem. Indeed it is not unreasonable to expect that multimode handsets and data cards will be generally available from mid 2008 onwards assuming the first UMTS900 networks are rolled out in Europe as expected.
- 5.107 The picture for UMTS at 1800 MHz ('UMTS1800') is less clear. As with UMTS900, Ofcom understands that there are no significant technical barriers to providing network equipment and handsets at 1800 MHz and the issue is rather one of there being sufficient demand to justify volume production particularly with handsets.
- 5.108 Regarding the demand for UMTS at 1800 MHz Ofcom is not aware of any trials currently underway that involve UMTS1800. Neither are we aware of plans by European operators to deploy UMTS networks in 1800 MHz spectrum, or of strong intentions to produce equipment from manufacturers. This would tend to indicate that the availability of UMTS1800 infrastructure and devices is likely to lag behind that for UMTS900 by some time and might result in offerings being more expensive initially. In particular we doubt the ability of the UK market alone to support 1800 MHz equipment and handsets in sufficient volumes to provide equipment at competitive prices. Thus the use of 1800 MHz for UMTS is likely to be constrained in the short to mid term by equipment availability and whether other EU countries roll out UMTS1800 networks.
- 5.109 The lack of momentum with UMTS1800 compared to UMTS900 is due in part to the number of MNOs in other European countries and the distribution of 900 MHz spectrum. Access to 900 MHz spectrum is much more evenly distributed in other EU states with more MNOs having access to 900 MHz and not many MNOs only having access to 1800MHz. Hence the demand for UMTS1800 equipment is likely to be lower, and the economies of scale in its production smaller, than for UMTS900. Thus UMTS1800 equipment, particularly handsets, might still be more expensive than UMTS900 or UMTS2100 even in the long term.
- 5.110 Ofcom's current view is that even a relatively small cost premium for UMTS1800 handsets could have a significant impact on the costs for an operator to deploy 3G at 1800 MHz if they persisted in the longer term. This is because of the large number of devices involved and because ongoing handset replacement would result in a recurring cost premium being incurred (ie every time a customer's handset was replaced). Therefore, in practice any cost advantage that arose from savings in network infrastructure costs (due to fewer sites) could feasibly be significantly reduced or eliminated due to increased handset costs.

Summary

- 5.111 This section has covered a number of complex issues. In light of this it is useful to outline briefly the key initial views at which we have arrived.

³⁴ For example Nokia 6121 launched in June this year <http://europe.nokia.com/A4432470>

- 3G technologies are much better than 2G at providing more advanced and demanding mobile data services, services which we refer to as mobile broadband services.
- There is the potential for demand for high quality mobile broadband services to grow significantly in the future and for the quality of their provision to be important enough to affect users' choice of provider. However we recognise that this outcome is not certain.
- Due to the long and varied history in the administration of spectrum for mobile services in the UK there are substantial differences in the quantity and frequency of each MNO's spectrum holdings. The spectrum at 900 MHz is only held by just two out of the five MNOs.
- The modelling demonstrates that access to 900 MHz spectrum provides a significant cost advantage for providing good in-building quality and coverage in core areas, and extending coverage into the non core areas. Our central estimate of the cost advantage of 900 MHz in core areas over 2100 MHz is £1.7bn and even when sensitivity analysis is carried out the advantage never drops below £0.5bn. In considering the options for implementation of the RSC Decision in subsequent sections, for reasons of simplicity Ofcom has generally presented the cost advantage provided by 900 MHz as £1bn per operator. On the basis of the modelling work it has done it regards this as a reasonably conservative estimate of the likely cost advantage. For non core areas our central estimate of the advantage of 900 MHz is £250m.
- Meanwhile the modelling of the advantage resulting from access to 1800 MHz spectrum shows that in theory there might be some cost advantages. However, this is significantly less than the advantage resulting from access to 900 MHz, which when combined with uncertainties over equipment availability and parameter assumptions mean that we do not consider it likely that 1800 MHz will offer a cost advantage in practice.

Question 5.1 Do you agree that the 900 MHz spectrum is likely to provide a cost advantage over higher frequencies for the provision of mobile broadband services? If so, do you believe that Ofcom's estimates of the size of that cost advantage are representative of what would realised in practice?

Question 5.2 Do you agree that the 1800 MHz spectrum is unlikely in practice to provide a cost advantage over higher frequencies for the provision of mobile broadband services?

Section 6

Impact of distribution of 900 MHz & 1800 MHz spectrum on competition and efficiency

Introduction

- 6.1 The previous section has established that 900 and 1800 MHz spectrum may have cost advantages over 2100 MHz in providing 3G services. For 900MHz these cost advantages could be significant, although for 1800MHz our current view is that these advantages are not likely to be realised in practice. As a result, implementing the RSC Decision will potentially bring significant benefits to UK citizens and consumers due to the lower cost of deploying high quality 3G networks using lower frequencies. However the five existing 3G operators hold different amounts of this spectrum. Only two operators, Vodafone and O2 hold 900 MHz spectrum and four operators (all the MNOs except H3G) hold 1800 MHz spectrum, of which Orange and T-Mobile hold considerably more than the other two. H3G, along with potential new entrants, holds neither 900 nor 1800 MHz spectrum.
- 6.2 This section examines whether the current asymmetric distribution of 900 and of 1800 MHz spectrum could affect the extent to which the benefits of implementing the RSC Decision, as identified in the previous section, would be realised. In particular, given Ofcom's duties to promote competition and optimal use of spectrum, we assess whether a wider distribution of spectrum could be more competitive and efficient³⁵. We look at the extent to which this assessment may vary depending on the demand for mobile broadband. We then consider the likelihood that, in practice, the current distribution of spectrum could have an adverse impact on competition, following liberalisation. Similarly we assess the potential impact on efficiency, if liberalisation took place with the current distribution of spectrum in place. Finally, we consider whether asymmetries in the total holdings of spectrum would have effects on competition and efficiency.

Could wider access to 900 MHz or 1800 MHz spectrum be pro-competitive?

Differences in quality

- 6.3 As shown in section 5, 900 MHz and 1800 MHz spectrum may have cost advantages in providing higher quality in-building coverage and extending coverage in less densely populated areas compared to the higher frequency spectrum which is, or may be available in the future for 3G services.
- 6.4 If cost differences in providing quality are significant, profit maximising levels of quality in the downstream market may vary according to access to liberalised 900 MHz and 1800 MHz spectrum, and operators may provide different levels of quality as a result. By quality we mean attributes of the service which would affect

³⁵ A related issue is whether the market would lead to a more symmetric distribution of spectrum, were it more efficient. This is examined in section 8 which assesses the option of liberalising 900 and 1800 MHz spectrum in the hands of the incumbents.

consumers' choices between one provider and another. This could include a number of factors such as:

- ability to make a call or use data services within buildings
- the extent of coverage in less densely populated areas
- the number of subscribers able to use data services at any one time (which is also related to capacity)
- the peak data rate that can be supported, indoors and outdoors.

6.5 If quality is a decisive factor in consumers' choices between operators, competitive intensity in the provision of mobile broadband services could be limited if only a subset of the 3G MNOs were able to provide high quality services. Prices for mobile broadband services could be higher than otherwise, because there would be less pressure to keep prices to competitive levels due to lower intensity of competition. Given the size of the contribution of the mobile sector to the UK economy, even small changes in competition, such as a 1% increase in prices, could lead to very large reductions in consumer welfare.

6.6 MNOs able to offer higher quality may be able to distinguish the customers who value higher quality most either by the type of service used (e.g. data service users may be more sensitive to service quality than other users) or by getting them to self-select by offering different packages of services with varying levels of quality (e.g. if high volume users are more sensitive to quality they can be targeted with specific tariff packages). Moreover, the proportion of consumers using higher quality mobile broadband services may increase in the future as part of the natural evolution of demand. As a result the addressable market for MNOs not able to offer high quality mobile broadband services could diminish.

The impact of cost and quality differences on competition depends on the significance of quality to consumers

6.7 Section 5 concluded that cost differences of 900 MHz compared to higher frequency spectrum could be significant. For 1800 MHz, while in theory it could have cost advantages over higher frequency spectrum, in practice cost advantages are unlikely, because of the possibility that 1800 MHz 3G equipment will not be available and even if it were, it would be likely to have a higher cost compared to equipment at other frequency bands. The cost differences, should they arise, were also likely to be smaller than for 900 MHz. However we must also consider the significance of quality differences to consumers and the degree to which spectrum is asymmetrically distributed before making conclusions on the potential impact on competition of the asymmetric distribution of 900 and 1800 MHz spectrum.

6.8 There is limited evidence on the importance of quality for mobile broadband services to consumers. In the absence of conclusive data, it is useful to consider a set of hypothetical cases which can delimit the potential impact of differences in quality on consumers and as a result the impact on operators.

6.9 In theory, different types of consumer may be more or less sensitive to quality differences in 3G services. It may be easier to identify such consumers according to the services they use rather than identify them directly. For example mobile broadband users may be more sensitive to differences in the quality of 3G services than voice users. Voice services are already widely available and of appropriate

quality on 2G networks which provide a fallback for 3G users (assuming consumers have a dual mode handset). 2G networks, however, may be unlikely to provide an adequate fallback for users for whom mobile broadband services are important. From an operator's viewpoint, the importance of quality in providing mobile broadband services will depend on two factors:

- the degree to which consumers, and mobile broadband users in particular are sensitive to quality
- the proportion of quality sensitive consumers in the total customer base.

6.10 For simplicity we focus on the second factor, which will be determined by the growth of mobile broadband usage, on the assumption that these consumers are those most likely to be sensitive to 3G service quality. Therefore we assume that the faster the growth of mobile broadband services, the greater the potential significance of quality among the customer base. As outlined in section 5, we have chosen three potential market demand scenarios where differences in the significance of quality of 3G services will vary according to the demand for mobile broadband services (recognising that, in the limit, wide differences in quality will have a profound significance for all consumers):

- low demand
- medium demand
- high demand.

6.11 In the low demand scenario, we assume that mobile broadband services develop slowly and that consumers' sensitivity to differences in 3G quality is not markedly different from today; i.e. as long as quality is above a minimum acceptable level, other factors such as price in particular will be more important in choosing a supplier.

6.12 In the medium demand scenario, there is assumed to be stronger demand for mobile broadband services and those consumers who would make frequent use of these services are sensitive to quality differences in 3G. However, there is also a considerable number of users which would use mobile broadband services much less frequently and are therefore less sensitive to differences in the quality of 3G services. Hence it is not critical for operators to match the quality provided by the market leader in order to stay in the market. MNOs without access to liberalised 900 and 1800 MHz spectrum can target the consumers who are less sensitive to quality differences and only improve the quality of their 3G services up to the point at which it is profitable to do so. (In other words, when the benefit from making an incremental improvement in quality falls below the incremental cost.) Provided that the customer base is large enough to recover their fixed costs, such strategies will be financially viable, though profits will be higher if the MNO has 900 MHz spectrum.

6.13 In this scenario, an asymmetric distribution of 900 and 1800 MHz spectrum could lead to less intensive competition in the provision of high quality mobile broadband services over 3G networks, because there is likely to be a restricted number of operators providing these service.

6.14 In the high demand scenario we assume that there is high demand for mobile broadband services and that the majority of consumers are sensitive to quality differences in 3G services. If an operator offered lower quality than the market leaders it would not be able to retain or attract sufficient customers to stay in the

market. An operator without access to 900 and 1800 MHz spectrum would therefore be faced with two choices, either:

- to match the quality provided by operators using liberalised 900 and 1800 MHz spectrum to provide 3G services, perhaps at significantly higher cost or
- to exit the market if the cost of improving quality to the necessary level were so large that the MNO would be making a loss overall.

6.15 If incurring the cost of using higher frequency spectrum to match quality provided using 900 and 1800 MHz spectrum did not lead to exit, operators who did not hold 900 and 1800 MHz spectrum would be likely to face a negative profit shock relative to those operators who hold 2G spectrum. Normally, profit shocks are not expected to affect competition where they arise from changes in fixed costs. However, if profit shocks were sufficiently large they could have indirect effects on competition, for example profit shocks could be so great as to induce exit³⁶.

The likelihood of an adverse impact on competitive intensity regarding 900 MHz spectrum

6.16 The future growth of demand for mobile broadband services is uncertain at the moment. However, if either the medium or the high demand scenarios were to be realised, competitive intensity could be significantly weakened. In the medium demand scenario, asymmetric access to 900 MHz spectrum is likely to lead to significant differences in the quality of 3G services that operators choose to provide. According to the research on the effects of frequency on the provision of mobile broadband services, summarised in section 5 and annex 8, our central estimate of the cost advantage of 900 over 2100 MHz spectrum in providing high quality mobile broadband services in core areas (ie that covering 80% of the UK population) is of the order of £0.9 to £2.0 billion³⁷ per operator, depending on the level of adoption of mobile broadband services. This estimate represents the cost that an operator with only 2100 MHz would have to incur in order to provide the same level of quality as a 900 MHz operator for a medium or high level of adoption.

6.17 This cost advantage (and the 'non-core' advantage presented below) is lower than our central estimates presented in section 5, because here we are assessing the impact of the cost advantage on operators' network deployment choices, rather than the considering the benefits of the cost advantage to society. Therefore, in this context a higher (commercial) discount rate is applied when calculating the net present value of the cost advantages (see section 5.97 for further detail)³⁸.

6.18 In less densely populated 'non core' areas, 900 MHz spectrum also has a potential cost advantage over 2100 MHz. Our central estimate of this cost advantage is £150 million³⁹ for an operator to extend their 3G network from 80% to 99% population coverage. Though this number is smaller in scale than the cost advantage in core

³⁶ The impact of profit shocks are considered in more detail in section 8

³⁷ NPV of operating and capital expenditure, 20 years from 2009/10, operator discount rate of 11.5%.

³⁸ NPV of operating and capital expenditure, 20 years from 2009/10, operator discount rate of 11.5%. There are many other assumptions which could push these estimates up or down, for example average building penetration losses at different frequencies, how the costs of new sites varies with the number deployed, and the potential impact of using alternatives to macrocells. These issues are discussed in more detail in section 5.

³⁹ NPV of operating and capital expenditure, 20 years from 2009/10, operator discount rate of 11.5%.

areas, competition effects might still arise from this cost difference, particularly for consumers in non-core areas.

- 6.19 Clearly the extent to which these cost advantages could be realised would occur depends on the demand for mobile broadband services, which is uncertain. In the low demand scenario, it is assumed that demand for mobile broadband does not take off and quality differences between operators are not important competitive differentiators. Hence the scope for cost advantages to lead to differences in competitive intensity is low.
- 6.20 In contrast, in the medium and high demand scenarios, mobile broadband demand would be substantial, therefore cost advantages could lie within the range stated above, with cost advantages in the high demand scenario being closer to the upper end of the range than in the medium demand scenario.
- 6.21 Given these costs it is possible, therefore, that asymmetric access to 900 MHz spectrum could lead to lower competitive intensity. In the medium demand scenario, operators with 900 MHz may provide higher quality (than those without) due to their potential cost advantages, and as a result competitive intensity in providing mobile broadband services would fall.
- 6.22 In the high demand scenario, the potential cost advantage to having access to 900 MHz could represent a large profit shock. Such large profit shocks could have an adverse impact on competitive intensity, either because in the extreme, an operator without access to 900 MHz could be forced to exit the market, or by indirectly affecting the ability of firms without access to 900 MHz to compete. We also consider separately in section 8 whether there are any other concerns arising from profit shocks.
- 6.23 Ofcom's initial view is that both the medium and the high demand scenarios are plausible scenarios for how mobile communications could develop. As a result, if liberalisation does not facilitate wider access to 900 MHz spectrum, there is a clear risk that an adverse impact on competition could occur. Moreover, because only two operators currently have access to 900 MHz, the risk and scale of the potential impact on competitive intensity is heightened.

The impact of alternative spectrum on competition concerns in liberalising 900 MHz

- 6.24 Ofcom is currently consulting on the potential award of the frequency band 470-862 MHz in the Digital Dividend Review (DDR). This spectrum could in principle be used for mobile applications. If this spectrum (or part thereof) were available for mobile uses, it would in principle increase the amount of low frequency spectrum that could be available for 3G services. Further, if the digital dividend spectrum that could be allocated to mobile were a good substitute for 2G spectrum at 900 MHz, then this would reduce the need for achieving a wider distribution of the 900 MHz spectrum, provided that sufficient spectrum were available for non-900 MHz operators to address the types of competition concerns outlined above.
- 6.25 Ofcom's provisional conclusion is that within the timescale that is relevant to this decision it is unlikely that the digital dividend spectrum will be a substitute for the 900 MHz spectrum. While in pure propagation terms the respective frequencies are similar, there are uncertainties over many aspects of the potential use of the digital dividend band for mobile services. These include the extent to which any mobile use would be on a harmonised basis across Europe, and (related to this) the extent to which equipment might be available to make use of the band, the standards that this

equipment would use, the costs of that equipment and the timing of its availability. There is also a difference in the timing of the availability of the two bands, as the DDR spectrum will not be available for nationwide mobile use until the end of 2012, at the earliest.

- 6.26 It is also relevant that the need to meet the UK's international obligations in relation to the digital dividend spectrum may mean that significant constraints on its use for mobile services are needed.
- 6.27 Therefore, Ofcom's initial view is that the competition concerns raised by the asymmetric distribution of 900 MHz spectrum are not eliminated by the potential for allocation of digital dividend spectrum to mobile usage.
- 6.28 Ofcom is also consulting on the award of the band 2500-2690 MHz. This spectrum can also be used in principle for providing mobile communications services. Ofcom is proposing that the spectrum be awarded in a technology neutral way. There are a number of applications that could use this spectrum, though based on stakeholder responses to Ofcom's initial consultation, the leading potential uses are for mobile communications services using 3G or evolutions of 3G technology and mobile data services such as WiMAX.
- 6.29 Ofcom's current view is that the substitutability of this band with 900 MHz is limited. Firstly, propagation losses are greater at 2.6 GHz than at 2100 MHz, therefore it is likely to have an even greater cost disadvantage than 2100 MHz. As a result, it is likely to be much more costly to achieve comparable 3G coverage using 2600 compared to 900 MHz. However, Ofcom notes that once coverage has been provided, any higher frequency spectrum in 1800, 2100 or 2.6 GHz bands is a reasonable substitute for 900 MHz in terms of providing capacity, as discussed below at paragraphs 6.44-6.48. Secondly, operators may want to use 2.6 GHz spectrum for services beyond 3G such as LTE (Long Term Evolution). LTE is a wide channel service, e.g. 2 x 10 or 20 MHz, and there may not be sufficient spectrum available at 900 MHz to support all operators' demands.

The likelihood of an adverse impact on competitive intensity regarding 1800 MHz

- 6.30 As outlined in section 5, our analysis suggests that 1800 MHz could have a theoretical cost advantage over 2100 MHz, albeit significantly smaller than for 900 MHz. Our central estimate is that 1800 MHz spectrum could have a small cost advantage over 2100 MHz of £200 million⁴⁰ for a single operator (in terms of deploying network in densely populated areas). As in the discussion of 900 MHz an operator (rather than a social) discount rate is applied to this figure because we are assessing the potential impact of cost differences on operators' network deployment choices.
- 6.31 In practice, however, 1800 MHz is unlikely to have an advantage over 2100 MHz spectrum. This is because our analysis assumed that UMTS 1800 equipment would be available at the same cost and time as UMTS 900 equipment and these assumptions are unlikely to hold true in practice. Ofcom is currently not aware of networks being planned for UMTS 1800 and believes that equipment manufacturers are not yet developing UMTS 1800 network equipment or compatible handsets. Moreover, indications are that UMTS equipment and handsets are likely to be more

⁴⁰ NPV of operating and capital expenditure, over 20 years from 2009/10, using a commercial discount rate of 11.5%.

costly for 1800 MHz than for 900 and 2100 MHz. It is also possible that momentum could develop to use liberalised 1800 MHz spectrum for the next generation of mobile technologies such as LTE, therefore UMTS 1800 might not even develop at all. In summary, differences in quality due to holdings of 1800 MHz could have an impact on consumers' choice of operator and as a result competitive intensity, but the probability of this appears to be low.

- 6.32 In addition, Ofcom's initial view is that the potential for any cost advantage of 1800 MHz spectrum, should it exist, to have an impact on competition is much less than in the case of 900 MHz, because four of the five 3G operators hold 1800 MHz. Competition should in general be more intensive where four operators have the ability to provide high quality mobile broadband services than where only two operators can do so. Ofcom's initial view, therefore, is that it is not certain that a wider distribution of 1800 MHz would lead to greater competitive intensity. Moreover, it is worth noting that if 900 MHz spectrum were to become more widely distributed than at present and as a result the competition concerns outlined above were addressed, then the distribution of 1800 MHz spectrum would have little additional impact on competitive intensity (although liberalised 1800 MHz spectrum could still be of significant value).
- 6.33 Whether or not there could be an impact on competitive intensity, 1800 MHz operators might incur lower costs in improving quality than operators that only had access to higher frequencies, following liberalisation if UMTS1800 equipment were available at a similar cost as UMTS2100 or UMTS900. In that case 1800 MHz operators could enjoy a moderate, but positive, profit shock. As discussed above, profit shocks due to changes in fixed cost can have an impact on competition, although it is more normal to assume that they do not unless specific features such as inefficient capital markets are present. In this case, the potential profit shocks are moderate, even in the high demand scenario, therefore Ofcom's initial view is that the risk that profit shock affects competition in relation to 1800 MHz is low. We consider separately in section 8 whether there may be any other concerns arising from profit shocks.

Could a wider distribution of 900 MHz or 1800 MHz spectrum lead to more efficient use of the spectrum?

- 6.34 The extent to which using liberalised 900 and 1800 MHz spectrum to provide 3G services brings efficiency advantages depends mainly on whether MNOs without 900 and 1800 MHz spectrum would extend their networks using other spectrum holdings, therefore incurring higher costs than if liberalised 900 and 1800 MHz spectrum were available. This also depends on the importance of differences in 3G quality between operators to consumers, which affects whether operators without 900 and 1800 MHz spectrum would need to match the level of quality provided by operators with 900 and 1800 MHz spectrum in order to be able to compete in providing mobile broadband services. Our concern over the potential impact on efficiency also depends on the scale of the cost advantages. First we discuss how efficiency advantages could arise in theory, then we relate this to the evidence we have on the cost advantages of 900 and 1800 MHz spectrum.

Efficiency benefits depend on how far MNOs would deploy more infrastructure without 900 and 1800 MHz spectrum

- 6.35 If the cost advantages of 900 and 1800 MHz spectrum are significant, the potential efficiency benefits of a wider distribution of 900 and 1800 MHz spectrum depend on the extent to which MNOs without access to liberalised 900 and 1800 MHz spectrum

would improve quality and extend coverage by deploying additional network using higher frequency spectrum. If they would do so, the asymmetric distribution of 900 and 1800 MHz spectrum creates a cost difference, but no quality difference.

- 6.36 We can explore the likelihood that efficiency benefits may arise from a wider distribution of 900 and 1800 MHz spectrum by mapping out scenarios for what the MNOs might do in response to liberalisation using the same taxonomy as in the previous section, ie we define the range of options open to an MNO without 900 and 1800 MHz spectrum by considering what they would do in different demand scenarios where the significance of 3G quality differences to consumers is low, medium or high.
- 6.37 These scenarios affect the extent to which operators without liberalised 900 and 1800 MHz spectrum would choose to match the quality of 3G services provided by those with liberalised 900 and 1800 MHz spectrum, and are outlined below:
- In the low demand scenario where the significance of 3G quality differences to consumers is low, this suggests that cost differences in providing quality for 3G services are much less likely to be important. There is likely to be little potential efficiency benefit from a wider distribution of 900 and 1800 MHz spectrum in this case.
 - In the high demand scenario where the significance of 3G quality differences is high, operators without liberalised 900 and 1800 MHz spectrum would need to match (or come very close to) the quality provided by those operators with liberalised 900 and 1800 MHz spectrum. As a result, they would deploy more infrastructure at a higher cost to achieve the same level of quality than if they had access to liberalised 900 and 1800 MHz spectrum, or in the extreme case they could be forced to exit the market. There is potentially a benefit in productive efficiency⁴¹ in this case from a wider distribution of 900 and 1800 MHz spectrum.
 - In the medium demand scenario, operators without liberalised 900 and 1800 MHz spectrum would be likely only to partially match the quality provided by the operators with liberalised 900 and 1800 MHz spectrum. However, similar to the high demand scenario, they would be likely to deploy more infrastructure using higher frequency spectrum than if they had access to liberalised 900 and 1800 MHz spectrum. To the extent that operators without 900 and 1800 MHz spectrum deploy additional infrastructure, there is a potential benefit in productive efficiency in a wider distribution of spectrum (though less than in the high demand scenario).
- 6.38 In both the medium and the high demand scenarios, therefore, operators without access to 900 and 1800 MHz spectrum would deploy more infrastructure than they otherwise would using higher frequency spectrum. A wider distribution of 900 and 1800 MHz spectrum would allow these operators to deploy this infrastructure at lower cost, and this would bring productive efficiency benefits, minimising the costs to society in terms of their use of resources.

The likelihood that efficiency in the use of spectrum could be increased in respect of each band

- 6.39 In both the medium and the high demand scenarios non-900 MHz operators would use 2.1 GHz (or higher frequency) spectrum to improve quality and extend coverage

⁴¹ i.e. producing a certain level of output with the minimum resources, or at minimum cost to society

of their 3G networks. The difference is only one of the degree to which they match the coverage they would provide if they had access to 900 MHz. Taking a conservative view, and assuming a moderate adoption level for mobile broadband services, there would be an efficiency saving to society of the order of £1 billion⁴² in core areas for each operator if they had access to one block 900 MHz spectrum. If mobile broadband adoption were higher, the potential efficiency savings would also be higher⁴³. In addition 900 MHz could provide further savings in non-core areas (of the order of £250 million⁴⁴ per operator).

- 6.40 Clearly the extent to which the societal efficiency benefits that arise as a result of these cost savings would occur depends on the demand for mobile broadband services, which is uncertain. In the low demand scenario, where it would not be necessary for all operators to match quality, the scope for efficiency benefits is low. In contrast, in the medium and high demand scenarios, quality is important to the customer base, and efficiency benefits are likely to lie in the range stated above. In the high demand scenario efficiency benefits could be closer to the upper end of the range than in the medium scenario.
- 6.41 In summary, Ofcom's initial view is that there is a risk that operators without 900 MHz will forego substantial savings in infrastructure costs in having to use higher frequency spectrum (including 1800 MHz) or other technology alternatives. Given that only two operators currently hold 900 MHz spectrum, Ofcom's initial view is that it is desirable that the method of liberalisation used to implement the RSC Decision should facilitate a wider distribution of 900 MHz spectrum otherwise substantial efficiency gains for the UK economy could be foregone.
- 6.42 Liberalised 1800 MHz spectrum could in theory allow limited efficiency savings compared to higher frequency spectrum, but in practice efficiency savings are unlikely because UMTS 1800 equipment may not be available, and if it is, costs are likely to be higher than for other bands. Moreover, since four operators currently hold 1800 MHz spectrum, Ofcom's initial view is that efficiency concerns are likely to be limited and to the extent that they might arise, they could be addressed by the market.

Is it necessary to achieve a symmetric allocation of all potential 3G spectrum in total in order to promote competition and efficiency?

- 6.43 The previous part of this section looked at the 900 and 1800 MHz bands and analysed whether a wider distribution of that spectrum would be more competitive and/or more efficient. It is also useful to consider whether it is necessary to secure a symmetric distribution of the totality of existing spectrum that could be used for 3G following 2G liberalisation - i.e. 900, 1800 and 2100 MHz – in order to promote competition and efficiency. There are two potential issues associated with this question:
- whether differences in the aggregate traffic bearing capacity of 900 and 1800 MHz spectrum compared to higher frequencies at the beginning of this section might have an impact on competition

⁴² NPV of operating and capital expenditure, over 20 years from 2009/10, social discount rate of 3.5%

⁴³ As discussed earlier in this section under the likelihood of adverse effects on competition, there are many other assumptions which could push this central range up or down and these issues are discussed in more detail in section 5.

⁴⁴ NPV of operating and capital expenditure, over 20 years from 2009/10, social discount rate of 3.5%

- whether a more even assignment of the total volume of spectrum held by each MNO (i.e. in MHz) would bring competition and efficiency benefits.

Symmetry of the volume of spectrum held

- 6.44 The analysis of the previous sections suggests that there is a significant risk that the existing distribution of holdings of 900 MHz spectrum may have a serious impact on competition if unchanged at liberalisation. It also suggests that existing asymmetries in the holdings of 1800 MHz are much less likely to have that effect. Therefore it is not clear that asymmetries in the MNOs' total holdings of spectrum would affect competition directly.
- 6.45 The most significant of the advantages of 900 MHz spectrum arise from improving quality and extending coverage for 3G (as discussed in section 5). Only one 2 x 5 MHz block of spectrum is necessary to derive most of these advantages.
- 6.46 However, given that a certain level of coverage and quality in the provision of 3G services has been provided using an initial one block of lower frequency spectrum, subsequent blocks of lower frequency spectrum may provide higher aggregate capacity for a given area covered⁴⁵ than higher frequency spectrum; i.e. for an equivalent amount of spectrum, more traffic can be carried. However, as described in (section 5) this capacity advantage is likely to be moderate in effect⁴⁶.
- 6.47 To illustrate this point consider the following scenario. Would an operator with only one 900 MHz block be at a competitive disadvantage compared to an operator with more than one 900 MHz block? The operator with only one 900 MHz block would have a lower aggregate capacity than the other operator, but would be able to make good the difference using higher frequency spectrum, because higher frequency spectrum is a good substitute for 900 MHz for providing capacity. The operator may already hold other suitable spectrum or could purchase additional spectrum either at auction, e.g. the forthcoming 2.6 GHz auction, or, once trading and liberalisation have been introduced, through secondary markets in 900, 1800 and 2100 MHz spectrum (consistent with any proposed restrictions). Therefore Ofcom's initial view is that differences in aggregate capacity of operators' holdings of 900 MHz spectrum should not have an impact on competition.
- 6.48 More generally speaking, the totality of spectrum holdings is unlikely to have an impact on competition and efficiency. As long as MNOs have access to at least one block of 900 MHz, subsequent blocks of 900 MHz spectrum would largely be used to provide capacity, and spectrum at higher frequencies is a reasonable substitute for 900 MHz in terms of providing capacity. 1800 MHz spectrum appears to be more broadly substitutable for 2100 and 2.6 GHz spectrum than 900 MHz spectrum, hence differences in holdings of 1800 MHz seem unlikely to have an impact on competition. Therefore Ofcom's initial view is that it does not appear to be necessary or appropriate to equalise spectrum holdings amongst competitors in the same downstream markets.

⁴⁵ assuming that the number of sites and the power of the transmitters are equal.

⁴⁶ one reason is that additional capacity will be needed to serve peaks of traffic and these peaks are likely to be unevenly distributed across cells. This means that the coverage advantages of lower frequency spectrum would be less important because cells would focus on small areas of high density use.

Summary of initial views

- 6.49 Ofcom's initial view is that there is a significant possibility that a wider distribution of 900 MHz spectrum would be both more competitive and efficient than the current distribution, given the magnitude of the potential cost advantages and the currently highly asymmetric distribution of the spectrum.
- 6.50 For 1800 MHz spectrum, Ofcom's initial view is that it is not certain that a wider distribution of the spectrum would be more competitive and efficient, given that 1800 MHz spectrum is unlikely, in practice, to confer a cost advantage over higher frequency spectrum and the fact that currently the spectrum is relatively evenly distributed. Moreover, if 900 MHz spectrum were more widely distributed, changing the distribution of 1800 MHz would have little additional effect on competition and efficiency.
- 6.51 Finally, Ofcom notes that the majority of the cost advantages of 900 MHz spectrum accrue to the first block held by an operator. Consequently, for the purposes of competition and efficiency the most significant factor is that a wider range of operators has access to at least one block of 900 MHz spectrum. Beyond this it appears that it does not appear necessary for operators to hold equal amounts of 900 MHz spectrum in order to meet our duties in promoting competition and efficiency.

Question 6.1 Do you agree that if the existing distribution of the 900 MHz spectrum continued post liberalisation, this would be unlikely to promote competition for the provision of mobile broadband services?

Question 6.2 Do you agree that if the existing distribution of the 900 MHz spectrum continued post liberalisation, this would be unlikely to secure optimal use of the radio spectrum?

Question 6.3 Do you agree that if the existing distribution of the 1800 MHz spectrum continued post liberalisation, this would be likely to promote competition for the provision of mobile broadband services?

Question 6.4 Do you agree that if the existing distribution of the 1800 MHz spectrum continued post liberalisation, this would be likely to secure optimal use of the radio spectrum?

Section 7

Overview of the options for implementation of the RSC Decision in light of Ofcom's duties

Introduction

7.1 In the previous sections we noted that the UK is expected shortly to have an obligation to implement the RSC Decision. The existing licences for 900 MHz and 1800 MHz spectrum are currently restricted so that they can only be used for providing GSM '2G' services, and so the UK must take active steps to change the current position in order to fulfil its international obligations. The purpose of this section is to provide:

- an overview of the considerations which Ofcom has taken into account in formulating the options for consultation which follow;
- a description of the framework adopted in the analysis of the options in the subsequent sections; and
- brief outline of those consultation options.

Background considerations

7.2 The previous sections have shown that for various historical reasons, the five existing MNOs have different spectrum holdings. Out of the five existing MNOs, only two hold 900 MHz spectrum, four hold 1800 MHz spectrum, and all five hold 2100 MHz spectrum. One MNO, H3G, holds only 2100 MHz spectrum and no 900 MHz or 1800 MHz spectrum.

7.3 Ofcom's technical studies have indicated that 900 MHz spectrum could give significant advantages in the provision of mobile broadband services with good indoor coverage compared to high frequencies. Ofcom's analysis also suggests that most of the cost advantages of 900 MHz spectrum accrue to the first block held by an operator though an operator is likely to need access to additional spectrum as well for capacity reasons, but this could be at higher frequencies.

7.4 Therefore, Ofcom's initial view is that it is important that a wider range of operators have access to at least one block of 900 MHz spectrum than is currently the case.

Stakeholders are in different existing positions and will inevitably be affected to different extents

7.5 It must be acknowledged from the outset that stakeholders are not starting from the same position. As a result of the pre-existing nature of the MNOs' licence-holdings, it is therefore unavoidable that different stakeholders will be affected to different extents by the implementation of the RSC Decision, whichever option is adopted.

- 7.6 This point is supported by the fact that Ofcom has already received a wide range of differing views from stakeholders on how it should approach the liberalisation of the 900 MHz and 1800 MHz spectrum, and on the basis of submissions received to date, Ofcom considers that it is highly unlikely that any solution could satisfy all stakeholders' commercial objectives.

The application of Ofcom's duties

- 7.7 Ofcom has given careful consideration to how best to implement the RSC Decision. The RSC Decision itself does not specify how Member States must implement it. In considering how to do so, Ofcom has had regard to its principal duty under the Communications Act to further the interests of consumers, where appropriate by promoting competition, and to its principal spectrum-related duty to secure the optimal use of the spectrum. Ofcom considers that these are the key duties which Ofcom must seek to fulfil in implementing the RSC Decision. In implementing the RSC Decision in a manner which fulfils these principal duties, Ofcom will adopt an approach which is non discriminatory transparent, and proportionate.
- 7.8 In considering the available options, Ofcom has taken into account the history of licensing of spectrum which can be used to offer mobile services in the UK which has resulted in significant differences between the existing five MNOs in terms of their current spectrum holdings. In short, Ofcom is not "starting with a blank page". It follows from this that any particular approach to implementing the RSC Decision is likely to have different commercial impacts on individual licensees.

Stakeholders' expectations relating to the 2G Licences

- 7.9 Ofcom has carefully reviewed statements made in relation to the potential for the 2G Licences to be reformed or liberalised, including those made at the time of the 3G auction in 2000. Ofcom considers that no statements or representations were given at the time of that auction or at any other time which would give rise to a legitimate expectation in law in relation to liberalisation of the 2G licences. Further Ofcom considers that the events at the time of the 3G auction should (in any case) in principle not be used to prevent the realisation of the benefits that would follow from the liberalisation of 2G Licences. Spectrum licensees are not entitled to expect that spectrum management regulation and policy will remain static, particularly in the light of changes to the background EU legislation.
- 7.10 Ofcom notes that the options set out in this consultation document entail the revocation or variation of part or all of existing licences to use the 900 MHz and /or 1800 MHz spectrum. If following this consultation Ofcom decides to implement an option which entails some form of revocation or variation, notwithstanding any separate proportionality considerations, it must also have regard to any legitimate expectations which the current licence holders may have. In this regard:
- 7.10.1 Ofcom notes that the current 2G Licences contain provisions permitting variation or revocation of the licences on one year's notice for reasons related to the management of the radio spectrum.
- 7.10.2 In addition, the licences also contain a provision allowing variation or revocation for the purpose of securing compliance with an international obligation of the UK, in accordance with Schedule 1, paragraph 8(5) of the 2006 Act (previously section 4(5) of the Wireless Telegraphy Act 1998). This section provides for an undefined period of notice in writing.

- 7.10.3 Ofcom acknowledges that in its Spectrum Framework Review Implementation Plan it stated that in relation to revocation for reasons related to the management of the radio spectrum, it was likely that a longer period of revocation than one year would be required in practice. Ofcom notes, however, that at the time the UK was not subject to any international obligation to make the 2G frequencies available for 3G use.
- 7.11 In light of the above, and recognising that the RSC Decision now imposes an obligation on the UK to make the 900 MHz and 1800 MHz spectrum available for 3G use, Ofcom considers that the current 2G licence holders are aware of the possibility that their licences could be revoked or varied after a period of written notice for the purpose of securing compliance with the UK's international obligations. Furthermore, Ofcom considers that the appropriate length of any notice period for revocation would depend on a variety of factors in particular the length of time permitted by the RSC Decision, the extent of any frequencies to be revoked, the impact on the businesses of the existing users of the spectrum and benefits which would be likely to be realised for consumers as a result of the revocation.

Overview of options identified for consultation

- 7.12 Ofcom has considered in detail a number of options for the implementation of the RSC Decision and an overview of these is provided below.
- 7.13 In addition to these options Ofcom has considered whether it should simply administratively redistribute the 900 MHz and 1800 MHz spectrum between the existing five MNOs with the objective of maintaining their relative competitive positions in the provision of 3G services. Ofcom does not consider that this would be an appropriate way to proceed for a number of reasons. Ofcom's view is that such an approach would infringe the requirements of the Authorisation Directive to hold an open award process. This is considered further in section 12. In addition Ofcom does not in any case consider that it is necessary for operators:
- 7.13.1 to hold equal amounts of 900 MHz or 1800 MHz spectrum in order to be able to compete effectively or to ensure optimal use of the spectrum; or
- 7.13.2 to hold identical amounts of overall frequency capacity in order to be able to compete effectively.
- 7.14 However, Ofcom does consider that to promote effective competition and efficient use of spectrum, it is important that there is wider access to 900 MHz spectrum than there is at present. The options Ofcom has identified take different approaches to widening access to this spectrum – from allowing the market to provide wider access (eg through trading or roaming) to mandating the release of spectrum by incumbents.
- 7.15 Given the differences between 900 MHz and 1800 MHz spectrum, each of the options is considered separately for 900 MHz and 1800 MHz. 900 MHz spectrum is generally the focus given that Ofcom considers it raises the most significant competition and efficiency issues.
- 7.16 Ofcom has identified four broad options for liberalisation of 900 MHz and 1800 MHz spectrum. These are outlined below and discussed in more detail in sections 8-13.

Option A: Liberalisation in the hands of the incumbents

- 7.17 Under this option Ofcom would remove the restrictions in the licences of the current holders of 900 MHz and 1800 MHz spectrum that limit the use of that spectrum to using GSM technology. Section 8 considers this option and in particular examines whether there is a risk of market failure in achieving an efficient and competitive distribution of 900 MHz and 1800 MHz spectrum, if this option were to be implemented.

Option B: Regulated Roaming

- 7.18 Under this option Ofcom would liberalise the existing licences for 900 MHz and 1800 MHz spectrum in the hands of the incumbents (as Option A) and impose on the incumbents a requirement to offer roaming to third parties who did not hold that spectrum, under regulated terms and conditions. Section 9 considers this option.

Option C: Partial Mandatory Spectrum Release

- 7.19 Under this option Ofcom would mandate the release of some 900 MHz and/or 1800 MHz spectrum currently held by the incumbent holders and make this available to the market on liberalised terms in order to address the competition and efficiency concerns. The remainder of the 900 MHz and/or 1800 MHz spectrum would be retained by the incumbents and be liberalised.
- 7.20 The case, in principle, for any form of mandatory spectrum release (both partial and full) is considered in section 10. The specification of partial spectrum release is considered in more detail in sections 11, which considers the quantity of spectrum to be released and the timing of any such release. Section 12 considers implementation issues including the mechanism of any release.

Option D: Full Spectrum Release

- 7.21 Under this option Ofcom would mandate the release of all the 900 MHz and/or 1800 MHz spectrum currently held by the incumbent holders and make this available to the market on liberalised terms in order to address the competition and efficiency concerns identified. This option is considered in more detail in section 13.

Section 8

Option A: Liberalisation in hands of incumbents

Introduction

- 8.1 This section considers whether liberalising 900 and 1800 MHz spectrum in the hands of the incumbents would enable Ofcom to meet its duties while implementing the RSC Decision. Liberalisation in the hands of the incumbents means that Ofcom would remove the restrictions in the licences of the current holders of 900 and 1800 MHz spectrum that limit the use of that spectrum to providing GSM services and using GSM technology. Ofcom would also continue to set charges for use of the spectrum under Administered Incentive Pricing (AIP) on the basis of its opportunity cost and would review the level of AIP in the context of liberalisation.
- 8.2 This option would allow the RSC Decision to be implemented on the shortest possible timescale, possibly 2008 or 2009, so enabling early realisation of the benefits of liberalisation, and would impose the lowest cost on the incumbent holders of the spectrum. It could bring efficiency benefits by allowing the incumbent holders to deploy 3G networks at lower cost than if they use 2100 MHz and would enable liberalisation to be achieved with minimum risk to the provision of existing services.
- 8.3 However, given the analysis in section 6 on whether the existing distributions of 900 and 1800 MHz spectrum would be efficient and pro-competitive in the context of liberalisation, this section analyses the following issues:
- whether, following liberalisation, market mechanisms would be likely to secure a wider distribution of spectrum that would promote competition and efficiency
 - if market mechanisms could not achieve a wider distribution of spectrum, whether AIP would be effective in achieving this outcome.
 - whether differential effects may arise from this option in the form of price paid for spectrum in relation to the value derived from its use.

Risk of market failure in achieving an efficient and competition distribution of 900 MHz

- 8.4 In section 6, Ofcom concluded that, in the context of liberalising 900 MHz spectrum, there is a risk that the current asymmetric distribution of 900 MHz spectrum could lead to concerns over efficiency and competition⁴⁷. Our analysis in section 5 and Annex 8 indicates that a 3G operator would need only one 2 x 5 MHz block of spectrum in order to exploit the main benefits of liberalised 900 MHz spectrum in terms of extending coverage and improving quality. Sufficient spectrum is available to

⁴⁷ The future development of demand for mobile broadband services, which is uncertain at the moment, is the most important determinant of this. Ofcom created scenarios to look at these effects. In the medium and high demand scenarios, there is a substantial risk that there might be adverse effects on competition and efficiency. In the low demand scenario for mobile broadband, operators might still want, ultimately, to switch services from 2G to 3G networks because of the greater technical efficiency of 3G, thus wider access to 900 MHz spectrum could still lead to greater economic efficiency.

create seven such blocks for 3G in the 900 MHz band, therefore providing wider access to the 900 MHz band would in principle be feasible.

- 8.5 This section considers how the market might in theory effect a redistribution of or wider access to 900 MHz in two ways, along with the risk of market failure they might carry:
- Operators could use the secondary market to trade spectrum (premised on spectrum trading being allowed for this band). In principle, operators could redistribute spectrum amongst themselves according to who valued it most.
 - Alternatively, operators could enter commercial roaming agreements so that the holders of 900 MHz spectrum offered to carry non-900 MHz operators' traffic on their networks and would agree charges between themselves.

Secondary market trading

Why secondary market trading should work in principle

- 8.6 The current holders of 900 MHz spectrum would have an incentive to trade each block of the spectrum they hold to operators without 900 MHz, if the value of each block to them was lower than its value to another operator.
- 8.7 In practice the value of 900 MHz to the existing holders will depend not only on its potential value for providing 3G services, but also its value in currently providing 2G services plus the costs of potentially making 900 MHz spectrum available for 3G services. However, for ease of exposition, we discuss trading in terms of the value in providing 3G services.
- 8.8 In general, the value of one block of 900 MHz spectrum in providing 3G services is higher than the value of a second (or subsequent) block because only one block is needed to derive most of the (significant) benefits of extending coverage and improving quality of 3G services.
- 8.9 If redistributing 900 MHz spectrum had no impact on the intensity of competition, the value of the second (and all subsequent) blocks of 900 MHz spectrum to the current holders Vodafone and O2 should be less than the value that an operator without 900 MHz spectrum would place on acquiring one block. Table 5 provides a simple illustration of how the secondary market might work in this case.

Table 5: Illustration of an efficiency enhancing trade

| | Value of first liberalised 900 MHz block | Value of second liberalised 900 MHz block | Value of third liberalised 900 MHz block |
|-------------------------|--|---|--|
| Existing 900 MHz holder | 100 | 50 | 50 |
| Non- 900 MHz operator | 100 | 50 | 50 |

- 8.10 In the table above, the existing 900 MHz holder would be willing to trade one block of 900 MHz spectrum to the non-900 MHz operator. This is because the value to the first block to the operator without 900 MHz spectrum is 100, and this is higher than the value of the second and third blocks to the existing 900 MHz operator which is 50. As long as the two parties can agree a price anywhere between 50 and 100, both will gain from a trade and efficiency will be enhanced.

- 8.11 Secondary market trades may not happen even though they would otherwise be efficiency enhancing, due to:
- transaction costs (i.e. costs associated with carrying out a trade that are unrelated to the value of the spectrum)
 - asymmetric information on the part of buyers and sellers
 - the impact of changes in competitive intensity on the incentives of the incumbents
- 8.12 If transaction costs exceed the potential gains from trade (the difference in value between buyer and seller) trades will not take place. However, given that the potential cost savings from using 900 MHz spectrum are considerable, transaction costs would have to be equally considerable to act as a constraint on trade.
- 8.13 Asymmetric information over the value of spectrum can also reduce the likelihood that efficiency enhancing trades occur. In particular, when there is a lot of uncertainty over the value of spectrum, buyers and sellers may be unable to agree a price at which both would benefit. In the case of 900 MHz spectrum, buyers and sellers are similar enough in position and their understanding of the market that the potential for significant asymmetries of information to occur should be limited. However, the incumbent 900 MHz operators will have better information over the net costs they would incur in releasing 900 MHz spectrum (particularly where costs arise from bringing investment forward that they would have done anyway). As a result there is a risk of a market failure from information asymmetries, but it is difficult to predict whether it may have an effect. The smaller it is in relation to valuations of the spectrum, the less likely it is to have an effect.

Competition effects may prevent efficiency enhancing trades

- 8.14 If 900 MHz spectrum is liberalised in the hands of the incumbents and the current distribution remains unchanged, competition in the provision of mobile broadband services could be less intense for the reasons given in section 6. Trading 900 MHz spectrum to third parties would lead to more intensive competition, which would have a negative impact on the incumbent 900 MHz operators - the incumbents' profits could be lower due to reductions in their market share and/or if prices fall because of increased competitive intensity. Vodafone and O2 would therefore include the effect of an increase in the intensity of competition in their valuations of 900 MHz spectrum. In contrast, increased competitive intensity would have a positive effect on consumer welfare and this is likely to exceed the negative impact on incumbents⁴⁸. Efficiency enhancing trades could therefore fail to take place if the competition effect was sufficient to push the total value of a 900 MHz block to Vodafone and O2 above its value to the non-900 MHz operators.
- 8.15 Ofcom's initial view is that the value of such a change in competitive intensity could be large in the case of 900 MHz spectrum. As discussed in section 6, there is a significant risk that quality differences occur due to the asymmetric distribution of 900 MHz and that competition is less intensive as result. Moreover, there are only two holders of 900 MHz spectrum, therefore the potential impact in the downstream market is larger than if more firms held 900 MHz spectrum.

⁴⁸ there will be an overall gain in total economic welfare, if output is higher and prices are lower as a result of increased competitive intensity - i.e. the gain to consumers will exceed the loss to producers from widening access to 900 MHz spectrum.

- 8.16 Table 6 provides a simple illustration of how an efficiency enhancing trade might not take place if the impact of the potential change in competitive intensity is of sufficient size.

Table 6: Illustration of a market failure in trading

| | Value of first liberalised block | Value of second liberalised block | Value of third liberalised block |
|--|----------------------------------|-----------------------------------|----------------------------------|
| Existing 900 MHz holder (more than two MNOs have access to 900 MHz) | 100 | 50 | 50 |
| Existing 900 MHz holder (only two MNOs have access to 900 MHz) | 160 | 110 | 110 |
| Non-900 MHz operator | 100 | 50 | 50 |

- 8.17 This illustration is similar to the previous one, except that for the existing 900 MHz holder, the value of the spectrum is now contingent on the number of MNOs which have access to 900 MHz spectrum. If access to 900 MHz is wider than the current two existing holders, we assume that the value of the spectrum is the same as in the previous example and an efficiency enhancing trade will occur.
- 8.18 However, if access to 900 MHz is limited to the two existing holders, competitive intensity in the provision of high quality 3G services will be lower, therefore the value of the spectrum to the existing holders will be higher. The value of all three blocks of 900 MHz spectrum to the existing holders is higher than the value of the first block to the non-900 MHz operator, plus consumer welfare will be lower than if competitive intensity were greater following a trade. Hence an efficiency enhancing trade will not take place, purely as a result of the value to the existing holders of the difference in competitive intensity that would result from widening access to 900 MHz.

Strategic interactions between firms

- 8.19 The above analysis makes a simplifying assumption about the nature of competition between the MNOs with 900 MHz, namely that each MNO does not consider its rival's reaction in deciding its own course of behaviour. It is necessary to examine the implications of relaxing this assumption before drawing conclusions on whether secondary trading would lead to a redistribution of 900 MHz spectrum.
- 8.20 In a market where there is a small number of firms, the firms behaviour is likely to depend on the decisions other firms have taken. Thus the strategic interactions between firms become very important in determining behaviour. Firm behaviour, in theory and as observed in practice, can be very different depending upon whether the interactions between firms are one-off (i.e. firms face one interaction in which their decisions affect each other and thereafter they can act independently of each other) or a part of a wider set of repeated interactions in the competitive process.
- 8.21 For the purposes of illustration we outline a simple one-off interaction between the existing 900 MHz operators. We assume there is significant demand for mobile broadband services and that each player has a similar view of the potential effects on competition and prices of widening access to 900 MHz spectrum.

- 8.22 It can, therefore, be argued that in choosing whether to trade, Vodafone and O2 will consider each other's likely actions and that this could lead one of them to trade even though the competitive intensity in the provision of high quality 3G services might significantly increase. Consider for example the case of one block in isolation. If Vodafone refused a request to trade a block of 900 MHz spectrum in order to maintain the lower level of competitive intensity, it would have to consider what O2 as the other holder of 900 MHz spectrum would do. If O2 were to trade, competitive intensity would still increase and it would then be worse off than if it had consented to the trade, because it would have at least received payment for the trade.
- 8.23 If O2 did not trade, Vodafone would maximise its pay-off if it too decided not to trade because at the level of competitive intensity in the downstream market would be unchanged. However Vodafone cannot be sure of O2's reaction. As a result, a "prisoner's dilemma" situation could develop in which Vodafone and O2 did not reach the outcome that maximised their joint benefit because they could not be certain what the other would do. If the other traded they could be much worse off than if they made the trade. The result in this scenario would be that both parties would seek to be the first to make the trade, even though they would both be better off if no trade took place⁴⁹.

Repeated interactions between firms

- 8.24 The decision faced by Vodafone or O2 over whether to trade spectrum can also be considered as part of a repeated set of interactions, either because there could be multiple opportunities to trade spectrum, or because a decision to trade which affects competition more generally could be seen as part of a wider set of competitive interactions between the two 900 MHz operators. Ofcom's initial view is that looking at strategic interactions between firms as part of a repeated game is likely to provide a better representation of competition in the mobile market than a one-shot interaction and is a common approach to modelling competition in markets characterised by a few incumbents.
- 8.25 The key conclusions from academic economic analysis of repeated strategic interactions is that the possibility of repeated interactions enables many different outcomes in addition to the outcome of the one-off interaction of the prisoner's dilemma. For the reasons explained below, Ofcom considers that a plausible outcome of the strategic interaction between the 900 MHz operators is for no trades to happen.
- 8.26 The key difference between the analyses of repeated and one-off interactions which leads to this conclusion is that repeated interactions allow firms to "retaliate" if one takes an action which lowers the other's pay-off (or profits). Retaliation means that come the next interaction, the firm which lost out previously will choose an action which has a negative impact on the pay-off to the other firm. This could encompass trading a block of spectrum to a third party, thus allowing further entry which would put downward pressure on prices and reduce the profits of both incumbents. Other alternatives could involve agreeing to provide roaming services to new entrants including MVNOs⁵⁰, or changes in retail prices (to which the other firm would have to react in ways that would reduce its profits), plus retaliation could take place in other geographic markets, i.e. outside the UK.

⁴⁹ In practice the impact of trading on the two incumbents could be different because of, for example, product differentiation, or the degree to which competition expands the market or displaces the market share of the incumbent.

⁵⁰ Mobile Virtual Network Operators

- 8.27 As long as there is a threat of retaliation⁵¹ rational strategies can exist in which each firm has an incentive not to trade conditional on what the other operator has done in their previous interactions - e.g. operator A decides not to trade 900 MHz spectrum as long as operator B does the same, but if operator B does decide to trade spectrum, then operator A takes a retaliatory action in each and every subsequent interaction between them.
- 8.28 The threat of retaliation acts as a disincentive to each operator to agree to a trade because if it trades, the result of all subsequent interactions between the firms will be the relatively low profit prisoner's dilemma outcome. Whereas, as long as both firms decide not to trade they will enjoy the benefits from reduced competitive intensity. As long as the value of future profits in relation to current profits⁵² is sufficiently high, then the no trading outcome is plausible. In contrast, if operator A has a very short time horizon and attaches little value to what happens in the future compared to profits it can earn today, then the threat of retaliation would carry little weight, and so trading could occur.
- 8.29 In practice, many factors will affect the effectiveness of the potential retaliation, including the nature of the retaliation and the timeliness with which it could be applied. Generally, as mentioned above, retaliation need not be limited to the threat of further sales of 900 MHz spectrum. It could easily take the form of other decisions such as pricing in downstream markets. In terms of spectrum trading itself, the retaliation for selling 900 MHz spectrum to a first "entrant" could involve selling 900 MHz spectrum to a second "entrant". The effectiveness of this particular threat will depend on the impact on competitive intensity of a second "entrant". Although simple oligopoly models suggest that this impact will be less than that of the first "entrant"⁵³, it is difficult to say in reality whether the threat would be effective. There could also be delays in the ability of the second incumbent to find a buyer for its spectrum and this could reduce the effectiveness of this form of retaliation.
- 8.30 It is important to note that there is no presumption of explicitly collusive behaviour. The incumbents do not have to explicitly collude to achieve the no trading outcome, although this outcome may be tacitly collusive. Experimental evidence, also supports the above analysis that in repeated interactions of this general type, it is also plausible that tacitly collusive outcomes can occur⁵⁴.
- 8.31 Ofcom's initial assessment therefore is that the strategic interactions that 900 MHz operators would be likely to undergo in the context of trading liberalised 900 MHz spectrum point to a risk that trading will not occur because of the impact on competitive intensity. As a result, secondary trading could fail to achieve a more efficient and competitive distribution of 900 MHz spectrum. Ofcom's initial view is that it is appropriate to consider alternative options for implementing 2G liberalisation on a

⁵¹ Formally, the retaliation is possible if the interactions are infinitely repeated, however, even when the series of interactions is finite, it can be shown that under certain circumstances, the same results occur as in an infinitely repeated interaction - e.g. uncertainty about when the series of interactions will actually end and uncertainties about the pay-offs to the other player - see Kreps, Milgrom, Roberts, and Wilson, 1982. Rational Cooperation in the Finitely Repeated Prisoner's Dilemma. Journal of Economic Theory.

⁵² i.e. the discount rate is sufficiently low

⁵³ Moreover, if a firm wished to depart from the tacitly collusive strategy it could opt to trade with more than one competitor (although it might not be able to free up sufficient spectrum). This would further reduce the effectiveness of retaliation based on the other incumbent selling spectrum to prospective "entrants".

⁵⁴ e.g. see Axelrod R., The Emergence of Cooperation Among Egoists. American Political Science Review 75, 1981

precautionary principle of avoiding this potential risk, because the detrimental impact on competition and efficiency could be significant should this situation arise.

Commercial roaming solution

- 8.32 It is also possible in principle that the 900 MHz spectrum could be used efficiently, without a redistribution of spectrum, if Vodafone or O2 were to provide commercial roaming services to operators without 900 MHz spectrum.
- 8.33 If Vodafone and O2 improved the quality of their 3G networks using UMTS 900, they would be vertically integrated in the provision of high quality 3G services and this could affect their decision to provide commercial roaming services. It would depend on:
- the profit they would make in the upstream market, i.e. revenues from roaming services (which would depend on the roaming charge they set) minus the cost of providing roaming
 - the costs to them in terms of lost profits in the downstream market, due to:
 - erosion of market share due to market entry
 - lower retail prices due to increased competition through market entry.
- 8.34 Vodafone and O2 would have incentives to offer commercial roaming services if they would be at least no worse off by doing so. They would ideally set the roaming charge according to their retail price minus the cost⁵⁵ of activities such as sales and marketing which the other operator would provide. If this roaming charge allowed the operator without 900 MHz at least to break even, it would accept the charge. This means that if a 900 MHz operator were to provide roaming services, it could still earn the same retail margin on the share of the market it lost to the other operator. Therefore, even if the loss in market share fell disproportionately on the operator that provided roaming, it would not be worse off.
- 8.35 However, providing commercial roaming would be likely to increase the intensity of competition in the provision of mobile broadband services which would put downward pressure on prices in the downstream market. Both the incumbents' profits would fall as a result of this effect, therefore it is possible that neither operator would provide commercial roaming services as a result. As discussed above, Ofcom's initial view is that there is a risk that the impact of a change in the competitive intensity of providing high quality 3G services would be large if more than two operators have access to 900 MHz spectrum. There is a risk, therefore, that commercial roaming services may not develop, even though they would increase total welfare (i.e. for both consumers and producers).
- 8.36 Similar arguments apply as in the discussion of trading 900 MHz spectrum, on the nature of the strategic interactions that could take place between the two incumbent 900 MHz operators. Ofcom's initial view is that it is possible that the 900 MHz operators might not offer commercial roaming services because it might lead to an increase in competitive intensity which would outweigh the potential gains from providing roaming. The two incumbents would be in a similar position to the spectrum trading scenario discussed above, ie the two incumbents could face repeated interactions together with ongoing opportunities for retaliation. In this context, it is

⁵⁵ e.g. the cost per unit of roaming traffic in the busy period

quite plausible that commercial roaming might not be offered if the potential impact on competitive intensity in mobile broadband services were significant.

- 8.37 Ofcom notes that there might be other drawbacks of a roaming solution. Efficiency could be limited because the roaming operators would not have control over network development. They would be limited by the extent and the timetable to which Vodafone and O2 deployed additional infrastructure. Roaming would also limit the number of networks able to provide high quality 3G services to two in the case of 900 MHz spectrum. This could have an impact on dynamic efficiency, for example the potential for innovation could be weakened.

Could AIP create incentives for a wider distribution of the spectrum

- 8.38 AIP is used as a mechanism to promote the efficient use of spectrum, therefore it is reasonable to consider whether it would create incentives for a wider distribution of the spectrum.
- 8.39 Ofcom's initial view is that AIP is unlikely to lead to a redistribution of spectrum in this case. Ofcom typically sets AIP on the basis of the opportunity cost of spectrum⁵⁶. The opportunity cost of the spectrum is likely to be equal to the value of a block of 900 MHz spectrum to an operator without 900 MHz spectrum⁵⁷, which would reflect the cost savings in using 900 MHz to extend 3G coverage and improve 3G quality. Therefore AIP would not typically be set higher than this value.
- 8.40 However, the incumbent 900 MHz operators would face exactly the same decision in considering how to respond to AIP as they would if a non-900 MHz operator offered to buy the spectrum. If the incumbent 900 MHz operators were not willing to trade 900 MHz spectrum to non-900 MHz operators because the value to the incumbents was higher (for the reasons described above), then AIP would be unlikely to give them sufficient incentives to return spectrum to Ofcom either.

Risk of market failure in achieving an efficient and competitive distribution of 1800 MHz

- 8.41 Ofcom's initial view, as discussed in the section 6, is that it is not certain that a wider distribution of 1800MHz spectrum would be more competitive and efficient, given that 1800 MHz spectrum is unlikely in practice to confer a cost advantage over higher frequency spectrum and that at present the spectrum is relatively evenly distributed. However, in the event that a wider distribution of 1800 MHz could be more competitive and efficient, Ofcom's initial view is that the risk of market failure in securing a wider distribution of spectrum is low. Moreover the risk of market failure would be lower still if access to 900 MHz spectrum were to become more widely distributed.
- 8.42 Currently, four of the five 3G MNOs hold 1800 MHz spectrum. Although Vodafone and O2 hold considerably less spectrum at 1800 MHz than T-Mobile and Orange, each operator holds sufficient 1800 MHz to trade at least one block of spectrum if it were used for 3G services. As we have outlined above, the benefits of using lower frequency spectrum for 3G largely reside in the first block of spectrum. Subsequent blocks confer less of an advantage relative to higher frequency spectrum, such that

⁵⁶ Ofcom's usual practice is to review AIP regularly, updating it where necessary in response to changes in the opportunity cost over time

⁵⁷ assuming that there is no higher value use of the spectrum

the latter are likely to be closer substitutes once a first block of 900 MHz spectrum is held.

- 8.43 As identified before, the chief barrier to secondary trading or commercial roaming in the scenario when spectrum is liberalised in the hands of the existing holders is that providing another operator with access to spectrum will increase the intensity of competition in providing services in the downstream market. This would typically lead to a reduction in retail prices if the downstream market were not fully competitive.
- 8.44 Since there are four holders of 1800 MHz spectrum, the potential impact on competition of a fifth operator gaining access to liberalised 1800 MHz spectrum should be lower than in the case of 900 MHz, where only two operators currently hold spectrum. Therefore the risk that the market fails to lead to an efficient and pro-competitive outcome is also much lower.
- 8.45 Finally, the more widely that liberalised 900 MHz spectrum were available, the less likely it would be that a competitive advantage would accrue to liberalised 1800 MHz. Ofcom, therefore, considers it likely that the market would secure an efficient and pro-competitive outcome if a wider distribution of 1800 MHz was necessary to achieve this.

The potential for asymmetric profit shocks to result from this option

- 8.46 As a result of implementation of the RSC Decision, some operators' profits could increase (or decrease) in comparison to other operators. These changes in relative profits may be due to changes in fixed costs, marginal costs and/or changes in revenues (e.g. due to the ability to offer higher quality services. We have termed these effects profit shocks. A number of potential sources of profit shocks which could arise as a result of liberalisation of 900 and 1800 MHz spectrum in the hands of the incumbents have been identified in this section and section 6:
- higher profits due to the ability to provide higher quality (assuming that users are sensitive to differences in quality, but operators do not have to match quality to remain in the market)
 - higher profits due to less intensive competition in the provision of high quality mobile broadband services if the current asymmetric distribution of spectrum is unchanged - in particular 900 MHz spectrum where only 2 MNOs currently hold spectrum
 - cost savings due to the technical advantages of lower frequency spectrum (assuming that the same level of quality is provided)
 - portfolio effects - reduction in technology risk through holding spectrum in several different bands and being able to benefit from potential band specific innovations
 - higher aggregate capacity - being able to serve more traffic in aggregate as a result of the operator's initial spectrum endowment (assuming that the price of the spectrum is less than the price paid by other operators for substitute spectrum).
- 8.47 The first two effects benefit holders of liberalised 900 MHz spectrum if none of their competitors has access to 900 MHz spectrum. The two incumbent holders would have lower costs in providing high quality mobile broadband services and benefit from lower competitive intensity in the provision of these services. However, a wider

distribution of 900 and 1800 MHz spectrum⁵⁸ would be sufficient to negate both the competition effects and the profit shock issues associated with them.

- 8.48 The last three effects could possibly have indirect effects on competition (as opposed to the first two which result from potential changes in competitive intensity). Economic models of competition typically take the viewpoint that profit shocks (fixed costs) do not affect competition because firms set prices and output in relation to their marginal, (not fixed) costs.
- 8.49 However, fixed costs can be shown to affect competition indirectly if some of the standard assumptions underlying these models are relaxed. For example, if capital markets were imperfect, operators might have to rely on retained profits to finance future investment, therefore fixed cost profit shocks or windfalls gains could affect competition. However, though these non-standard models may be plausible in some cases, they must be applied carefully since they are departures from standard economic analysis. Ofcom's initial view is that, in a sector with large, well resourced, multinational players, it seems unlikely that capital markets would be sufficiently inefficient for profit shocks to have an impact on competition.
- 8.50 Another way in which profit shocks could affect competition is if they cause firms to exit the market, or raise barriers to entry. However, since the profit shocks that may arise from 2G liberalisation relate more to cost savings or increases in asset values accruing to holders of 900 and 1800 MHz spectrum, Ofcom's current view is that they are unlikely to cause other firms to exit.
- 8.51 Assuming then that there is no indirect effect on competition, the last three profit shocks would still affect the distribution of profits across the MNOs. Although Ofcom's relevant primary duties are towards promotion of competition and efficient spectrum use, Ofcom believes it is important to consider (all other things being equal) measures to reduce the differential impacts of its policies where appropriate tools exist. For example, if regulatory decisions have unpredictable asymmetric effects on industry players, this may lead to regulatory uncertainty which can dampen incentives for investment. Hence this would affect Ofcom's objective of promoting efficient spectrum use.
- 8.52 Under this option of liberalisation in the hands of the incumbents, Ofcom would continue to set AIP on the basis of the opportunity cost of the spectrum. Following liberalisation, the opportunity cost of the spectrum could increase. Ofcom is committed to regularly reviewing the level of AIP, so any changes in the opportunity cost of the spectrum would be expected to be reflected in the level of AIP in due course. Ofcom would take all available information into account in setting AIP, including for example, the results of any auctions for related spectrum in the future.
- 8.53 In summary, Ofcom's initial view is that, as a consequence of revising AIP to reflect opportunity cost, those profit shocks which would have purely distributional effects on profits are likely to be reduced. As a result, the potential for regulatory uncertainty should also be minimised. These profit shocks may not be completely eliminated, however, because AIP is intended to promote the efficient use of spectrum. For this reason AIP is based on the opportunity cost of the spectrum to society. AIP may not correspond exactly, therefore, to the price needed to eliminate profit shocks. Moreover, there may be difficulties in accurately estimating the opportunity cost of the spectrum and Ofcom's policy is to set AIP conservatively.

⁵⁸ whether market induced, as Ofcom considers would be likely to happen if required in the case of 1800 MHz, or brought about by an alternative method of liberalising the spectrum

- 8.54 As noted above in section 8.38-8.40, AIP is unlikely to resolve the direct competition concerns arising from the asymmetric distribution of 900 MHz spectrum. However, if the distribution of 900 MHz spectrum were to change and it would resolve these competition concerns anyway.

Would network sharing by non-900 MHz MNOs be efficient and pro-competitive

- 8.55 MNOs without access to 900 MHz spectrum could decide to enter network sharing agreements in order to reduce the cost disadvantage of extending and improving their networks using higher frequency spectrum. We note that network sharing may be subject to regulatory approval, and this is not certain because of the competition concerns it raises.
- 8.56 Various different combinations of network sharing could arise. For example all three operators without 900 MHz could build a shared network at 2.1 GHz. Alternatively, the 1800 MHz operators could decide to build a shared UMTS 1800 network, with or without the participation of operators and potential new entrants that did not have 900 or 1800 MHz spectrum.
- 8.57 Network sharing appears to be a second best solution from the perspective of the MNOs, for a number of reasons.
- it is uncertain whether network sharing could entirely eliminate the cost disadvantages of 1800 and 2100 MHz compared to 900 MHz because
 - costs would not necessarily fall in proportion to the number of operators sharing networks
 - additional network and administrative structures would be necessary to manage the interests of the multiple operators sharing the network, e.g. devising and operating protocols for allocating capacity on the network
 - the commercial freedom of the participating operators might be curtailed, e.g. their ability to differentiate their services by extent or quality would be limited, and early mover advantages would be more difficult to exploit.
- 8.58 Since network sharing may not fully eliminate cost differences between operators, efficiency concerns will only be partly addressed and so the 900 MHz spectrum is not being put to its most valuable use.
- 8.59 Network sharing could also have undesirable consequences for competition. For example, MNOs could collaborate on network development and gain information about each other's costs and plans which may have a chilling effect on competition in the retail market. Dynamic efficiency may also be lower with fewer networks able to provide high quality mobile broadband services. End-to-end competition, i.e. at both the network and service level could lead to greater innovation, which could bring significant benefits for consumers. We note that the competition concerns would be amplified if the 900 MHz operators were themselves to decide to share a single UMTS 900 network in response to the actions of their competitors.
- 8.60 While it is difficult to quantify the potential impact of these effects, Ofcom's initial view is that there is a significant risk that both competitive intensity and innovation in mobile broadband services would be weakened, with potentially serious impacts on consumer welfare. Hence Ofcom's initial view is that network sharing is unlikely to

address adequately the competition and efficiency concerns that arise in liberalising 900 MHz spectrum in the hands of the incumbents.

Initial views

900 MHz

- 8.61 Ofcom's initial view is that this option would enable the RSC Decision to be implemented and would have certain benefits. Liberalisation could be implemented quickly and the operators with access to 900 MHz and their customers could benefit from the reduced costs and/or the improved quality and coverage that access to 900 MHz could deliver.
- 8.62 However, if 900 MHz spectrum were liberalised in the hands of the incumbents, Ofcom's initial view as illustrated in this section is that there is a clear risk that the market would not deliver wider access to 900 MHz spectrum. Hence the benefits of this option in terms of promoting competition and efficient use of spectrum could be limited in comparison to alternative options for implementing the RSC Decision which did lead to wider access to 900 MHz.
- 8.63 Section 6 presented our analysis of why a wider distribution of the spectrum than the current distribution is likely to be significantly more competitive and efficient, particularly in a scenario where demand for mobile broadband services were medium or high. Even in the low demand scenario where the competition and efficiency benefits of a wider distribution of the spectrum may not be large, they are unlikely to be negative. Furthermore, our analysis suggests that neither secondary market trading nor commercial roaming would be likely to achieve the wider distribution required to ease competition and efficiency concerns.
- 8.64 To summarise, competition concerns vary according to the scenario for the growth of mobile broadband. In the low demand scenario, competition concerns are small, but both the other scenarios raise significant competition concerns, although they are different in nature. In the medium demand scenario, restricted access to 900 MHz spectrum could lead to a significant reduction in competitive intensity in the provision of high quality 3G services. In the high demand scenario, at the extreme it might not be financially viable for an operator without 900 MHz to provide the level of quality required to be able to compete with 900 MHz operators, and such operators could be forced to exit the market.
- 8.65 Efficiency concerns also vary according to the demand scenario. In the low demand scenario, the efficiency concern is again small. However, in the medium demand scenario, there is a concern that both productive and allocative efficiency losses⁵⁹ will occur and in the high demand scenario, potentially very large losses in productive efficiency could occur. Even in the low scenario there is some risk of inefficient extension of basic 3G services using higher frequencies.
- 8.66 Ofcom's initial view is therefore that if Option A were implemented for 900 MHz spectrum there is a significant risk that competition and efficiency would be significantly lower than they could be if 900 MHz spectrum were more widely held (though it is difficult to quantify precisely the risk because of the underlying uncertainty over demand). As a result the benefits of Option A might be limited

⁵⁹ productive efficiency losses would arise in relation to the extent an additional network is deployed at higher cost, allocative efficiency losses would arise in relation to operators providing a lower level of output/quality than if they had access to 900 MHz.

compared to other options that ensured wider access to 900 MHz spectrum. Moreover, Ofcom's initial view is that the future availability of alternative spectrum such as DDR and 2.6 GHz would not remove these concerns because these alternative spectrum bands are not reasonable substitutes for 900 MHz spectrum.

- 8.67 In addition, market participants may receive differential profit shocks depending on whether or not they hold 900 MHz. As discussed above Ofcom currently believes that profit shocks arising from differences in fixed costs are unlikely to lead to direct or indirect effects on competition. If there are effects due to profit shocks, AIP (set on the basis of opportunity cost) can reduce them, although it may not eliminate them altogether.

Implications for alternative options for liberalising 900 MHz spectrum

- 8.68 In order to address these concerns, the method of liberalising 900 MHz spectrum should address the fact that wider access to 900 MHz spectrum could achieve a more competitive and efficient outcome in liberalising the spectrum. The distribution of 900 MHz spectrum would have to change so that either:
- it was reasonably certain that secondary trading or commercial roaming would lead to further redistribution of the spectrum, if it were efficiency enhancing; or
 - competition and efficiency concerns were minimised in that the risk of an adverse impact on either was low.
- 8.69 Ofcom has considered the potential regulatory solutions which might do this and identified the following potential options:
- requiring regulatory roaming
 - requiring some form of partial spectrum release
 - requiring the release of all the 900 MHz spectrum.
- 8.70 Sections 9-14 discuss the extent to which these options would address competition and efficiency issues arising in the liberalisation of 900 MHz spectrum.

1800 MHz

- 8.71 Ofcom's initial view in relation to 1800 MHz spectrum is that:
- it seems unlikely that 1800 MHz spectrum would in practice offer a cost advantage compared to 2100 MHz spectrum (see section 5 and annexes 6 to 8)
 - even if there was a cost advantage, material competition and efficiency issues are unlikely to arise because 1800 MHz spectrum is held by four operators, compared to two for 900 MHz spectrum (see section 6).
 - wider access to 1800 MHz spectrum is likely to be provided by the market if that would lead to more efficient use of spectrum (see paragraphs 8.41-8.45 above).
- 8.72 Market participants may receive differential profit shocks depending on whether or not they hold 1800 MHz spectrum. As discussed above Ofcom currently believes that profit shocks arising from differences in fixed costs are unlikely to lead to direct or indirect effects on competition. If there are effects due to profit shocks, AIP (set on

the basis of opportunity cost) can reduce them, although it may not eliminate them altogether. In addition, the likelihood and size of differential profit shocks arising for 1800 MHz spectrum is likely to be much lower than for 900 MHz spectrum.

- 8.73 Therefore Ofcom's initial view is that liberalising 1800 MHz spectrum in the hands of the incumbent holders would be effective in promoting competition and efficient use of spectrum and that Option A is likely to be an appropriate way to implement the RSC Decision.
- 8.74 This option would be the least intrusive of the options which Ofcom is considering in this consultation document, because it does not require spectrum to be redistributed therefore Ofcom's initial view is that it would be proportionate to implement this option.
- 8.75 Ofcom's initial view is that this option would be non-discriminatory because only operators which hold 1800 MHz spectrum could be said to be in comparable situations in respect of this option, and these operators would be treated in the same way.
- 8.76 Finally, this option would be timely in that the RSC Decision could be implemented quickly, for example in 2008 or 2009.

Question 8.1 Do you agree with Ofcom's assessment of the merits of Option A (Liberalisation in the hands of the incumbents) for the implementation of the RSC Decision in respect of the 900 MHz spectrum?

Question 8.2 Do you agree with Ofcom's assessment of the merits of Option A (Liberalisation in the hands of the incumbents) for the implementation of the RSC Decision in respect of the 1800 MHz spectrum?

Section 9

Option B: Regulated roaming

Introduction

- 9.1 Under this option, Ofcom would liberalise the existing licences for 900 and 1800 MHz spectrum in the hands of the incumbents and continue to set AIP on the basis of the opportunity cost of the spectrum, similarly to Option A. In addition, Ofcom would impose on the holders of that spectrum a requirement to offer roaming to third parties who did not hold that spectrum, under regulated terms and conditions. The key components of roaming would be the scope of services offered under the agreement and the price for those services. Ofcom's involvement could range from requiring the parties to negotiate, but reserving the power to intervene if an agreement cannot be reached, to setting these conditions itself.
- 9.2 Our analysis in this section focuses on 900MHz because, as explained in section 8, our initial view is that Option A, liberalisation in the hands of the incumbents, appears likely to meet Ofcom's objectives of promoting competition and efficiency. Therefore, it seems unlikely that it would be necessary to impose a roaming obligation on 1800 MHz spectrum. For 900 MHz, we consider whether the addition of a roaming obligation would be sufficient to address the competition and efficiency concerns which would seem likely to arise from just two players holding 900 MHz spectrum, as discussed under Option A.
- 9.3 The analysis in this chapter considers how well regulated roaming would meet Ofcom's objectives in implementing the RSC Decision, making the initial assumption that there is demand for mobile broadband services, for ease of analysis. We then examine how the conclusions would vary for different scenarios of mobile broadband demand.

How regulated roaming for 900 MHz may promote competition and efficiency

- 9.4 In principle, regulated roaming would enable operators without access to liberalised 900 MHz spectrum to gain access to UMTS 900 infrastructure that would be built by the two incumbent 900 MHz operators. For the agreement to be pro-competitive, two conditions would need to be satisfied. First, roaming operators would need to be able to provide an equivalent range of 3G services to the 900 MHz operator. Second, roaming charges would need to be set within the range of a "retail minus"⁶⁰ level and marginal cost, because:
- if roaming charges were below marginal cost it would be unprofitable for 900 MHz operators to supply roaming services; and
 - if roaming charges were above the retail minus level, an otherwise efficient operator without 900 MHz spectrum would not be able to price competitively in the downstream market.
- 9.5 Roaming charges at the retail minus level would enable equally or more efficient competitors in the downstream market to be competitive. However, the closer

⁶⁰ the price of each roaming service is set on the basis of the relevant retail price minus an allowance for the costs of providing the service to the consumer that the 900 MHz operator does not incur because the consumer is served by the roaming operator.

roaming charges are to marginal cost, the greater economic welfare is likely to be since this will allow retail prices to be lower and output higher. The 900 MHz operators could also benefit from positive profit shocks, the closer roaming charges are to retail minus levels, however, Ofcom would not expect such profit shocks to be unduly large if the retail market continues to be relatively competitive.

- 9.6 Regulated roaming also may address the efficiency concerns that would arise from liberalisation of 900 MHz in the hands of the incumbents, i.e. that operators without 900 MHz would have to rollout infrastructure at much higher cost than if they had 900 MHz.
- 9.7 Hence, to the extent that roaming onto a 900 MHz operator's network would enable the non-900 MHz operators to provide the same level of coverage and quality as if they held 900 MHz spectrum, the outcome would in principle be allocatively efficient. The outcome would also in principle be productively efficient because non-900 MHz operators would not have to rollout higher cost infrastructure. In fact, static efficiency may be higher than a situation in which each of the players in the market extended its 3G network using UMTS 900. If the incumbent 900 MHz operator's UMTS 900 network could carry more than one operator's traffic, then a roaming solution would avoid the duplication of resources that would result if each operator were to build its own UMTS 900 network. These benefits would be likely to be proportionately larger in less densely populated areas, where the load on the network is likely to be less, than in more densely populated areas.
- 9.8 A regulated roaming option could in principle be established quickly. However, if Ofcom had to set conditions either from the beginning, or because negotiations breakdown, then the implementation of this option could take considerably longer.

Drawbacks to regulated roaming

Risk of reduced innovation and dynamic efficiency

- 9.9 Although regulated roaming has some advantages, as detailed above, it also has several disadvantages, the most important of which is that it may reduce innovation and dynamic efficiency.
- 9.10 In the short term, a requirement to provide roaming may change the incentives of the holders of 900 MHz spectrum and slow down the rate at which the incumbents deploy UMTS 900 infrastructure. This is because the competitive advantage the 900 MHz operators could gain from rolling out UMTS 900 would be limited by their obligation to provide roaming services to their competitors - providing roaming would enable wider access to 900 MHz spectrum and increase competitive intensity in the provision of mobile broadband services. As a result retail prices would be likely to fall and this would have a negative impact on the incumbent 900 MHz operators' profits.
- 9.11 Regulated roaming may also lead to (dynamic) inefficiency in the longer term. Since roaming is only a service obligation, although it may lead to static efficiency and competition at the service level, it would not foster any increase in network infrastructure competition. With only two networks providing the infrastructure to support mobile broadband services, there would be a significant risk of dynamic inefficiency. Firstly, infrastructure might not be deployed as widely or as quickly as if there were greater network level competition. Secondly the rate of development and the rollout of new network technologies could be slower than if there were more network competition. This might also limit the rate of innovation at the service level, and delay or restrict the development of new services.

- 9.12 Finally, there would also be an increased risk to operators and consumers of disruption in the provision of 3G services. In more densely populated areas, there is a risk that the capacity of UMTS 900 networks would be over-stretched, at least in the short term, with consequent reduction in the quality that end-users receive.

Failure to achieve desired objectives

- 9.13 In addition to the concerns over dynamic efficiency, we note that, regulated roaming may fail to achieve fully Ofcom's objectives of promoting competition and efficiency due to the potential regulatory risks in the following areas:
- specifying the scope of roaming agreements
 - setting roaming charges
- 9.14 Specifying the scope of roaming agreements so that roaming operators can offer the same services as the operators whose networks they are using is complex. Ofcom would have to define an appropriate service obligation across numerous service parameters (e.g. the priority in which customers are served if the network is running close to capacity). Moreover Ofcom would have to do so for a network that had not yet been established. The information available to Ofcom is thus likely to be incomplete and this may affect the degree to which regulated roaming achieves our objectives.
- 9.15 Assuming that the specification of roaming services were right when liberalisation took place, services can evolve and it may not be right at some point in the future. This might require Ofcom to review roaming agreements regularly, or to intervene in disputes on changes to the scope of roaming agreements. Ofcom notes that the ongoing commitment of maintaining this may require significant resource.
- 9.16 As noted above, there is also a risk of inaccuracy if it were necessary for Ofcom to set roaming charges (as there is in setting any regulated charge), although it is possible that roaming charges could be agreed amongst the operators themselves. Inaccuracies could arise from incomplete information over the costs of building a UMTS 900 network or misspecification of the split between network and retail costs. However, this would only have a material impact on competition if the charge fell outside the marginal cost-retail minus range, thus potential regulatory risks may be limited.

Should regulated roaming be applied to 1800 MHz spectrum

- 9.17 Ofcom set out its current view in section 8 that Option A (liberalising 1800 MHz spectrum in the hands of the incumbents) could be both pro-competitive and efficient, for a number of reasons, including that 1800 MHz spectrum is unlikely to provide a cost advantage in practice over higher frequencies and because market solutions were more likely to lead to a redistribution of spectrum if this were efficient, as four operators hold 1800 MHz spectrum. Notwithstanding this initial view, we now consider whether regulated roaming could provide a better solution for liberalising 1800 MHz spectrum than Option A.
- 9.18 Firstly, under Option A, Ofcom's initial view is that if it were efficient for commercial roaming to take place, then the only impediments would appear to be transaction costs and imperfect information about the costs and value of roaming services on the part of potential buyers and sellers. If information were imperfect for the MNOs, Ofcom would be likely to be at even more of a disadvantage than the market,

therefore only if there were significant transaction costs might there be grounds for intervention. Ofcom's initial view is that there is no evidence to suggest that transaction costs would be large enough to justify intervention.

- 9.19 However, there are significant regulatory difficulties in implementing regulated roaming, as identified in the discussion relating to 900 MHz above. It also imposes an administrative burden on both Ofcom and the operators. For these reasons, Ofcom's initial view is that on balance Option A is better in the case of 1800 MHz than regulated roaming because the risks and the costs of market failure appear to be significantly less than the regulatory risks and costs. Given this, Option A also appears to be more proportionate than the more interventionist option of regulated roaming.

The potential for asymmetric profit shocks to result from this option

- 9.20 Unlike Option A, the scope for asymmetric profit shocks to arise under this option appears limited. Provided that roaming agreements are specified appropriately, roaming operators should be able to provide similar services to the incumbents. Provided that roaming charges are set at or below the "retail minus" level, roaming operators should have similar flexibility to set tariffs in the downstream market as the incumbent 900 MHz operators. Roaming operators should also not be disadvantaged if future innovations are developed that make use of 900 MHz spectrum (to the extent that there is flexibility to redefine the scope of roaming agreements to cover such developments where necessary).
- 9.21 In this situation, profit shocks would arise if roaming charges are above marginal costs. If AIP for the incumbent's 900 MHz spectrum is set on the basis of opportunity cost, it might be able to take account of this type of profit shock. Firstly it would depend on whether the provision of roaming services affected the marginal value of the spectrum. Secondly, Ofcom would need to be able to forecast the potential profits from roaming services accurately, and it might be difficult to predict how roaming traffic and roaming prices would change in response to a theoretical change in the incumbents' holdings of 900 MHz. It is more likely that Ofcom would try to approximate the opportunity cost by estimating how an operators costs might change in response to a change in the amount of spectrum they held. Therefore AIP might not totally eliminate profits shocks relating to the profits earned by the incumbents from roaming. In any event, the purpose of AIP is to promote efficient spectrum use and not to eliminate profit shocks.

Summary and initial views

- 9.22 For 900 MHz, regulated roaming could in principle address competition concerns that would arise in the retail market from Option A (liberalising 900 MHz in the hands of the incumbents) recognising that the closer roaming charges were to marginal costs, the greater the potential impact on prices downstream.
- 9.23 Regulated roaming also addresses in principle the efficiency concerns that would arise from Option A, and may bring further efficiency benefits from avoiding inefficient duplication of resources that could arise if there were more than two UMTS 900 networks.
- 9.24 Regulated roaming would appear to have some merit in that it could lead to increased competition and efficiency compared to Option A: liberalisation in the hands of the incumbents. However, regulated roaming appears to have some substantial potential disadvantages as well. Firstly, the potential static inefficiency

from having multiple networks should be set against the potential benefits of having network level competition which may lead to greater innovation. Secondly, Ofcom's initial view is that regulatory risks are significant, in particular given the potential complexity of specifying roaming agreements and charges for networks that would still be in the process of being constructed. Thirdly, even if operators were able to negotiate (or Ofcom specify) appropriate agreements, operators without 900 MHz would find themselves dependent on the scope and pace of deployment of the 900 MHz operators.

- 9.25 As with Option A, the potential benefits of regulated roaming depend on demand for mobile broadband services. The faster the take-up of mobile broadband, the greater the potential competition and efficiency benefits. The potential costs of regulated roaming do not appear to depend so much on mobile broadband developments, however. Hence, in a low demand scenario, this option runs the risk of creating unnecessary burdens for operators and Ofcom. In the higher growth scenarios, the balance of potential costs and benefits is as summarised above.
- 9.26 Ofcom's initial view is, therefore, that the extent to which regulated roaming addresses competition and efficiency concerns is questionable, and that it risks imposing significant costs – not only the administrative burden, but also it may act as a disincentive for 900 MHz operators to deploy UMTS 900 networks. Accordingly, Ofcom's initial view is that Option B is unlikely to be the most appropriate way to implement the RSC Decision for 900 MHz spectrum in line with our duties and objectives.
- 9.27 Ofcom's initial view is that for 1800 MHz is that regulated roaming is unlikely to be a more proportionate way to implement the RSC Decision than Option A of liberalising 1800 MHz in the hands of the incumbents, because although both can lead to an efficient pro-competitive outcome, in principle, regulated roaming carries a much greater regulatory risk.

Question 9.1 Do you agree with Ofcom's assessment of the merits of Option B (Liberalisation in the hands of the incumbents subject to a roaming condition) for the implementation of the RSC Decision in respect of the 900 MHz spectrum?

Question 9.2 Do you agree with Ofcom's assessment of the merits of Option B (Liberalisation in the hands of the incumbents subject to a roaming condition) for the implementation of the RSC Decision in respect of the 1800 MHz spectrum?

Section 10

Background to options C & D: Partial and full mandatory spectrum release

Introduction

- 10.1 Options C and D for implementation of the RSC Decision involve the mandatory release of some or all of the 900 MHz and/or 1800 MHz spectrum currently held by the incumbent 2G MNOs to Ofcom for re-award to third parties in order to address the competition and efficiency concerns discussed in section 6. All of the 900 & 1800 MHz spectrum, including the spectrum retained by the incumbents in the case of a partial release, would be liberalised.
- 10.2 The purpose of this section is to:
- consider whether in principle some form of mandatory spectrum release is an appropriate way to implement the RSC Decision for 900 MHz and/or 1800 MHz spectrum while meeting Ofcom's duties and objectives; and
 - provide background to the more detailed analysis of partial and full spectrum release options C & D in subsequent sections by:
 - outlining the different variations of mandatory spectrum release that need to be considered;
 - introducing the cost benefit analysis used in sections 11 and 13 to assess the different variations of mandatory spectrum release; and
 - summarising the principal sources of costs and benefits of mandatory spectrum release used in the cost benefit analysis (drawing on detailed analysis of costs and benefits in annexes 6-10).
- 10.3 Partial release is considered in more detail in sections 11 and 12, and full release is considered in section 13.

Assessment of mandatory spectrum release in principle for 900 MHz

- 10.4 The fundamental motivation for considering some form of mandatory spectrum release is to change, through regulatory action, the distribution of spectrum in order to address the competition and efficiency concerns that might arise from the present asymmetric spectrum holdings. However, as discussed in sections 5, 6 and 8, these concerns vary considerably between 900 MHz and 1800 MHz spectrum.
- 10.5 In section 8 we reached the initial view that if 900 MHz spectrum were liberalised in the hands of the incumbent holders (ie Option A was implemented) there is a significant risk that competition and efficiency would be significantly lower than they could be if 900 MHz were more widely held (though it is difficult to quantify precisely the risk because of the underlying uncertainty over demand). As a result the overall benefits of Option A might be limited compared to options that enabled wider access to 900 MHz spectrum.

- 10.6 Mandatory release of 900 MHz spectrum to third parties could ensure that spectrum was more widely held by re-distributing some or all of that spectrum, so that other players could offer services in competition with the incumbent holders, and do so without a significant cost disadvantage.
- 10.7 Whilst our analysis has focused on the effectiveness of spectrum release in relation to the provision of 3G services – which is the most likely new use at present of 900 MHz spectrum - we consider that the competition and efficiency concerns issues arising from an asymmetric distribution of 900 MHz are likely to be at least as great for future technology developments. This is because other modern mobile broadband technologies also exhibit a trade-off between coverage and capacity, hence in principle providing significant advantages at lower frequencies. This behaviour includes systems which use adaptive techniques such as smart antennas and adaptive modulation and coding.
- 10.8 Another development which could affect the long term effectiveness of spectrum release is the possibility of future mergers or acquisitions within the mobile sector. These might in principle undo the re-distribution brought about by spectrum release. However, if there was a concern that a future merger or acquisition created competition problems through the concentration of spectrum holdings, then we would expect this to be a relevant consideration when the Office of Fair Trading (OFT) or European Commission examined the transaction.
- 10.9 In summary, our initial view is that mandatory release of 900 MHz spectrum (of some form) has some merit as a means of implementing the RSC Decision because it could be more effective in promoting competition and efficient use of spectrum than simply liberalising 900 MHz spectrum in the hands of the incumbent holders. However, because spectrum release is likely to impose some costs, we need to carefully consider whether it would be proportionate.
- 10.10 For example, the costs of some forms of spectrum release could be high and the size of the competition and efficiency benefits are not entirely certain. In addition, the benefits and costs of mandatory spectrum release are dependent on the form that it takes, in particular how much spectrum is released and when. To consider whether spectrum release is likely to be proportionate and the relative merits of different forms of release we use a cost benefit analysis, our approach to which is set out later in this section at paragraphs 10.18 – 10.43. Sections 11, 12 and 13 then consider in more detail the options for partial and full release of 900 MHz spectrum.

Assessment of mandatory spectrum release in principle for 1800 MHz

- 10.11 Our initial view in relation to 1800 MHz spectrum is that liberalisation in the hands of the incumbents (Option A) is likely to be effective in promoting competition and efficient use of spectrum (see section 8). This is for a number of reasons:
- it is unlikely whether 1800 MHz would in practice offer a significant cost advantage compared to 2100 MHz spectrum;
 - even if there were a cost advantage, material competition and efficiency issues are unlikely to arise because 1800 MHz spectrum is held by four operators, compared to two for 900 MHz spectrum;
 - that wider access to 1800 MHz spectrum is likely to be provided by the market if that would lead to more efficient use of spectrum.

- 10.12 Regulatory intervention to ensure wider access to 1800 MHz therefore seems unlikely to bring significant additional competition and efficiency benefits compared to Option A. It would however be likely to impose costs on the incumbent holders of 1800 MHz spectrum. In contrast, Option A would not impose any significant additional costs.
- 10.13 In addition, as the advantages of 1800 MHz spectrum are likely to be significantly less than those of 900 MHz, requiring release of 1800 MHz spectrum in a context where 900 MHz spectrum was released seems even less likely to bring additional benefits. Further, greater competition as a result of 900 MHz release is likely to make it even more likely that the market would secure the efficient use of 1800 MHz spectrum (if the current distribution were not the most efficient).
- 10.14 Therefore, taking all the above considerations into account, our initial view is that mandatory release of 1800 MHz spectrum is unlikely to be a proportionate option for implementing the RSC Decision as there is a less costly option (Option A) that appears to fulfil our duties and objectives. Consequently, all further analysis in this section, and in sections 11, 12 and 13, specifically focuses on the details of releasing 900 MHz spectrum.

Key parameters of mandatory spectrum release

- 10.15 There are four key parameters of mandatory spectrum release:
- the quantity of spectrum to be released by the incumbents to third parties;
 - the timing of the release, including different stages of release, the relationship with the timing of liberalisation, and who determines the timing;
 - the mechanism for releasing spectrum, for example whether the spectrum is to be returned to Ofcom and re-awarded through an auction or by some other means; and
 - the pricing and terms of spectrum retained by the incumbent operators (in case of partial release).
- 10.16 In theory, there are a very large number of options for mandatory spectrum release, taking all possible variants of these parameters in combination. Individual analysis of all these possible options would be both very complex and burdensome for stakeholders, but would also be likely to obscure the main trade-offs between them. Therefore, the general approach we have taken is to analyse each of these elements in turn, holding the other elements constant where necessary, to identify the range in which the best options are likely to lie.
- 10.17 As a result, the analysis of partial release is broken down between section 11, which considers the *quantity* of 900 MHz spectrum to be released and the *timing* of release, and section 12, which considers in more detail how partial spectrum release might be implemented, including the mechanism for release and the treatment of retained spectrum. Section 13 considers full mandatory spectrum release.

Assessing spectrum release options

- 10.18 In order to assess how effective different spectrum release options are in promoting competition and efficiency, and the proportionality of different options Ofcom has carefully considered their costs and benefits.

- 10.19 The approach Ofcom has used is to assess the costs and benefits of different spectrum release options compared to Option A (liberalisation in the hands of the incumbents), and in some cases against each other. Option A is a useful benchmark to compare against because it is the option with the lowest implementation costs on industry for implementation of the RSC Decision. In judging whether a spectrum release option is better than Option A we use a cost benefit analysis to assess whether it is likely to have net benefit compared to that option. Comparison of the differences in costs and benefits between different options for spectrum release are important to inform our view of the relative merits of those options. They are also useful where the differences in costs and benefits between options are easier to judge than the absolute levels.
- 10.20 Ofcom has undertaken modelling work to inform its understanding of the size of the costs and benefits associated with spectrum release. This work is described in detail in annexes 9 (costs) and 6, 7, 8, and 10 (benefits). In the case of the costs this provides an indication of the nature of the cost function and some broad estimates of cost levels. In the case of the benefits the modelling is illustrative of the possible effects.
- 10.21 While this modelling work is informative the judgement of the net benefit associated with any particular option is qualitative. This is because there are many elements that are not subject to definitive empirical analysis. These include:
- the extent and timing of mass market demand for high quality mobile broadband services;
 - the benefits of competition in the mobile sector;
 - the risk and importance of temporary quality degradations that might arise from implementing some forms of mandatory spectrum release; and
 - the future growth of 3G subscribers and 2G traffic volumes.
- 10.22 When assessing the costs and benefits of different spectrum release options it is important to be clear about the assumptions made, particularly those assumptions made about the case being compared against. The most important assumption is the level of market demand for high quality mobile broadband services because different assumptions significantly affect the benefits of spectrum release and to some extent the costs. To deal with this critical uncertainty we use a scenario based approach.

Market demand scenarios

- 10.23 As discussed in section 5, there is uncertainty over the level of future market demand for mobile broadband services. To deal with this uncertainty our cost-benefit analysis in sections 11 and 13 is undertaken for the two limiting demand scenarios – low and high demand for mobile broadband services – introduced in section 5 and developed in sections 6 and 8.
- 10.24 Before assessing the costs and benefits of spectrum release options in these two scenarios, it is necessary to review what are reasonable assumptions about the outcome of Option A - liberalisation in the hands of the incumbents, in those scenarios. This is to understand what the costs and benefits of mandatory spectrum release are to be compared against.

Low demand scenario

- 10.25 The low demand scenario assumes that demand for mobile broadband services does not develop and consumers' sensitivity to differences in 3G quality is not markedly different from today. In this scenario, the better quality – in particular higher data rates and improved indoor coverage - that deploying 3G at 900 MHz facilitates (compared to existing 2100 MHz 3G services) is not of significant value to consumers. Consequently, in this scenario it seems reasonable to assume that incumbents could not justify re-farming and investment in 3G at 900 MHz in order to offer higher quality mobile broadband. Similarly, incumbents and other operators would be unlikely to make any significant further investments in UMTS2100 to improve the quality of mobile broadband services provided. This would not however rule out some investment to increase 3G capacity and coverage for voice and basic data services.
- 10.26 Incumbents might still consider re-farming and deploying 3G at 900 MHz in the future, rather than continuing investment in their existing 2G network, in order to continue to provide voice and basic data services. This however, is uncertain and we assume this point would not be reached until a more distant date, perhaps 2013-2015.

High demand scenario

- 10.27 The high demand scenario assumes that there is high demand for mobile broadband services and that the majority of consumers are sensitive to quality differences in 3G services. If an operator offered lower quality than the market leaders it would not be able to retain or attract sufficient customers to stay in the market. In this scenario, the incumbent holders of 900 MHz spectrum would have strong incentives to re-farm and deploy 3G at 900 MHz. As discussed in section 6, other operators without access to 900 MHz spectrum would therefore be faced with the choice of either matching the quality provided by incumbent operators at higher cost using higher frequencies or exiting the market altogether if the costs of improving quality to the necessary level were so large that the operator would be making a loss overall.
- 10.28 These scenarios deliberately represent simplified outcomes. Simplistically, the low scenario corresponds to the lowest benefits of spectrum release and the high scenario the highest. In practice, the outcome is more likely to be something in between these extremes (the medium demand scenario for example) where there is demand for mobile broadband but it is not critical for operators to match the quality provided by the market leader in order to stay in the market. These intermediate outcomes could lead to a weakening of competition and inefficiency, but perhaps not to the extreme degree (eg market exit) possible in the high scenario.
- 10.29 However, Ofcom considers it sensible to use the low and high scenarios for the cost benefit analysis because:
- they can be more clearly defined and most openly show the impact of market demand on the costs and benefits of mandatory spectrum release; and
 - it is simpler and more transparent to analyse and quantify extremes rather than more complicated intermediate cases.
- 10.30 Therefore, the costs and benefits of mandatory spectrum release options are assessed in both the low and high demand scenarios. However, the overall policy judgement of different options reflects all possible intermediate scenarios.

Assumptions for cost benefit analysis

10.31 Table 7 below summarises the assumptions made about the market outcome of liberalisation in the hands of the incumbents (Option A), in low and high demand scenarios, for the purpose of the costs and benefits analysis of mandatory spectrum release options.

Table 7: Assumed outcome of liberalisation in hands of incumbents (Option A) in low & high demand scenarios for purpose of cost benefit analysis

| | Low demand scenario | High demand scenario |
|--|--|---|
| Market significance of mobile broadband | Low – no greater than today. | High – critical for operator to meet demand for mobile broadband in order to stay in market. |
| Incumbent strategies | Do not deploy 3G in their 900 MHz spectrum (re-farm) to provide mobile broadband. Possibility of much later re-farm in order to replace existing 2G network. | Both re-farm and invest in 3G 900 MHz networks. Assume start to offer services using them in 2010. |
| Other operator strategies | No significant further investment in 2.1GHz network | Invest in higher frequency 3G networks (2.1GHz or 1800 MHz) to match the quality provided by incumbents OR Exit the market altogether |
| Penetration of 3G handsets | Around 15% of mobile users have 3G handsets in 2010 | Around 35% of mobile users have 3G handsets in 2010 |
| 2G traffic levels | 20% higher in 2010 than in 2006 | 2010 traffic levels at same level as 2006 |

Introduction to the costs and benefits of mandatory spectrum release

10.32 This sub-section provides a general introduction to the sources and nature of different costs and benefits of mandatory spectrum release compared to liberalisation in the hands of the incumbents (Option A). It draws on more detailed information in annexes 6 to 10 and provides background for the analysis of different options that follows in sections 11, 12 and 13.

Benefits of mandatory spectrum release

10.33 The benefits of a mandatory spectrum release policy are measured as the incremental benefits resulting from this policy compared to liberalising spectrum in the hands of the incumbents (Option A), i.e. the difference in benefits between these two scenarios. Mandatory spectrum release can potentially generate benefits in three areas compared to liberalisation in the hands of the incumbents.

- **Efficiency.** If spectrum is released, other parties are able to build more efficient networks than they otherwise would be able to. Section 5 examines the costs that could be saved (drawing on annexes 6-8). There is also a potential offsetting efficiency effect. That is if spectrum release results in more networks serving a similar amount of traffic, more costs might be incurred than would otherwise have been the case. However, we do not believe this effect will be significant when compared to the efficiency benefits from allowing wider access to 900MHz. (This issue is further discussed in section 11)
- **Competition.** In the high demand scenario access to spectrum at 900 MHz is by definition essential to remain competitive in providing mobile broadband services.

Therefore spectrum release has the benefit of promoting competition in the provision of these services. Our tools for assessing the welfare effects of changes in competition necessarily involve a very simplified approach to a complex set of interactions and so the quantifications presented in annex 10 should be viewed as indicative of the order of magnitude of benefits potentially at stake, rather than definitive or precise. However, the size and importance of the UK mobile market (total revenues of £16.5bn in 2006)⁶¹ means that the losses from a fall in competition could be very significant.

- Innovation. One of the potential benefits of more players having access to 900 MHz spectrum in a competitive market is that it is likely to provide greater incentives for dynamic efficiency. One effect of this may be to increase the rate of innovations or their earlier introduction. By this we mean the introduction of new services that generate extra value for customers and the firms that supply them. Given that the exact drivers of innovation and the role of competition are not straightforward, again the quantification presented in annex 10 is a simplified approach intended to demonstrate the orders of magnitude that this effect can take. Care should therefore be taken to interpret the results taking this into account.

10.34 Different spectrum release scenarios will have these effects associated with them to different extents. Whilst we have quantitatively estimated each effect individually it would not be appropriate to add the individual effects to attempt to reach a total, or net, welfare effect. This is because the individual estimates rely on many assumptions, implicit and explicit, which would invalidate the results if they were to be combined. For example, it would not be appropriate to sum the estimates of the efficiency and competition effects as one of these assumes that operators without 900 MHz spectrum do not rollout, whilst the other assumes the opposite. Our quantitative analysis has been designed to inform our thinking regarding the order of magnitude of these separate effects, and we have not attempted to produce a single, comprehensive estimate of all of the benefits combined.

Costs of mandatory spectrum release

10.35 The costs of mandatory spectrum release are the incremental costs resulting from a policy of mandatory spectrum release compared to the costs that would have been incurred in Option A (liberalisation in the hands of the incumbents), ie the cost *difference* between these two options.

10.36 The costs of mandatory spectrum release principally originate from the following.

- Direct costs on incumbents resulting from necessary network upgrades etc. These are considered further below and in annex 9. Because we are only considering cost differences, this does not include network upgrades that operators would undertake regardless if spectrum were liberalised in their hands.
- Potential quality degradations falling on consumers (eg lower coverage or increased call blocking) and indirectly affecting incumbents (eg as increased churn in customer base) for an interim period due to engineering changes to their networks to effect release. In general, we expect operators would seek to avoid or minimise any reduction in quality of service, however some requirements for spectrum release might unavoidably increase risks to quality.

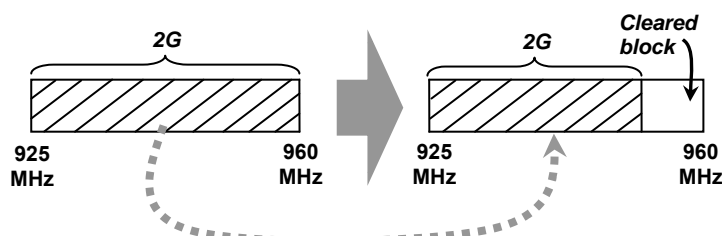
⁶¹ Ofcom report "The UK Communications Market 2007" published 23rd August 2007

- 10.37 For incumbents, the principal reason why spectrum release could lead to higher costs is because their 900 MHz spectrum is currently being used to carry existing 2G mobile traffic, so they would need to clear traffic from that spectrum in order to release it. The displaced traffic would continue to need to be carried by some means (if consumers are not to lose service), and therefore operators would need to invest in alternative network capacity to carry it.
- 10.38 There are various strategies that an operator might employ to deal with the traffic displaced by spectrum release and these are discussed in some detail in Annex 9. In estimating the cost of release, Ofcom has not attempted to analyse in depth all of the possible strategies. Rather, we have identified what seem to us to be two plausible approaches that individually or in combination would allow an operator to absorb displaced traffic.
- 10.39 Broadly, the two main strategies considered (and simply illustrated in Figure 11) are:
- **2G upgrade.** Operators may seek to squeeze more capacity out of their existing 2G networks. We have specifically considered implementation of synthesised frequency hopping (SFH); and
 - **3G accelerated migration.** Accelerating the take-up of 3G handsets and deploying additional 2100 MHz 3G sites outside areas already covered by 3G.
- 10.40 These are not mutually exclusive – in practice operators may upgrade 2G as far as possible and absorb the remaining traffic through 3G accelerated migration.

Figure 11: Strategies for implementing spectrum release

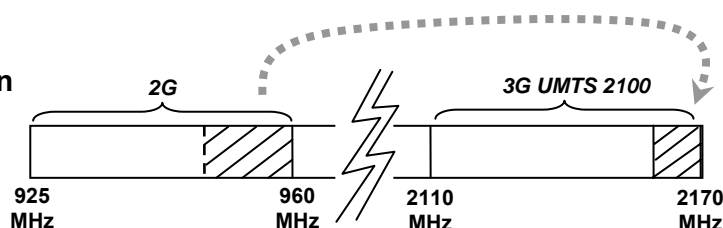
1. 2G upgrade

Implement technologies on 2G network which use spectrum more efficiently. This allows a block to be cleared for release.



2. 3G accelerated migration

Migrate 2G traffic onto 3G UMTS2100 network allowing a block to be cleared.



- 10.41 In addition, operators could employ other technologies such as WiFi and in-building solutions for corporate customers. However, these could only be supplementary to other approaches and would not offer a total solution to absorbing displaced traffic.
- 10.42 The strategies we have considered could be used where liberalisation and spectrum release occur simultaneously. An alternative means of implementing 3G accelerated migration might be feasible if liberalisation occurred before spectrum release. This would involve the releasing operator first deploying 3G at 900 MHz and then

releasing 900 MHz spectrum by migrating 2G customers to 3G at 900 MHz. This is in principle possible due to the greater spectral efficiency of 3G compared 2G.

- 10.43 In addition, prior to release of spectrum a complete reconfiguration of the 900 MHz band may be necessary to remove the current interleaving of spectrum between Vodafone and O2. Both Vodafone and O2 could each re-farm or release a single block of 2 x 5 MHz of E-GSM spectrum without needing significantly to reconfigure their overall spectrum holdings in the 900 MHz. However, to re-farm and/or release efficiently a larger portion of the 900 MHz band, reconfiguration of their spectrum holding becomes either highly desirable or essential (depending on the amount of spectrum to be cleared). Re-configuration to remove interleaving would require Vodafone and O2 to work cooperatively to the same timetable.

Summary

- 10.44 In summary, this section has:

- Considered mandatory release of 900 MHz spectrum and reached the initial view that in principle it has some merits compared to Option A as means of implementing the RSC Decision. However, as it is likely to impose some costs, we need to carefully consider the costs and benefits of different release options to assess whether they would be proportionate.
- Considered release of 1800 MHz spectrum and reached the initial view that this is unlikely to be a proportionate option for implementing the RSC Decision as there is a less intrusive option (Option A) that appears to fulfil our duties and objectives.
- Introduced our approach to analysing partial and full release (options C & D) of 900 MHz spectrum in subsequent sections, including the demand scenarios to be used and qualitative explanation of the relevant costs and benefits to be analysed.

- 10.45 The next section considers what might be the appropriate *quantity* of 900 MHz spectrum to be released under Option C and at what *time*.

Question 10.1 Do you agree that in principle some form of mandatory release of 900 MHz spectrum is appropriate in order to implement the RSC Decision?

Question 10.2 Do you agree that in principle some form of mandatory release of 1800 MHz spectrum is unlikely to be appropriate and that Option A is likely to be the most appropriate means to implement the RSC Decision in respect of the 1800 MHz spectrum?

Section 11

Option C: Partial Mandatory spectrum release – Quantity and timing options for 900 MHz spectrum

Introduction

- 11.1 This section considers the options for the *quantity* of 900 MHz spectrum to be released under Option C and the *timing* of release. Option C, partial mandatory spectrum release, would involve the release of some, but not all, of the spectrum currently held by incumbent operators, with the remaining (retained) spectrum being liberalised in their hands.
- 11.2 The objectives of this section are:
- to consider whether any form of partial mandatory spectrum release is a proportionate means of implementing the RSC Decision for 900 MHz while meeting Ofcom's duties and objectives; and
 - to consider the relative merits of different timing options for partial release options and to identify those which are likely to fit best with our duties and objectives.
- 11.3 The approach used in this section to analyse the costs and benefits of spectrum release was introduced in section 10 which is important background reading to this analysis. The next section, section 12, considers in more detail how a partial mandatory spectrum release option might be implemented, including the mechanism for release of spectrum and the treatment of retained spectrum.

Interdependencies in specifying quantity and timing of partial release

- 11.4 The costs and benefits of spectrum release are highly dependent on the quantity of spectrum that is required to be released and to some extent the timing of the release. Hence, specifying the right combination of quantity and timing is key to identifying an effective and proportionate spectrum release option.
- 11.5 Because both quantity and timing affect costs and benefits, a conclusion on quantity cannot be made completely independently of timing. This is because the judgement on the appropriate quantity depends on the costs of different quantities, but these costs can be time dependent. The basic relationships are illustrated in table 8 below and explored in more detail in the rest of this section. Given these interdependencies our approach is to examine quantity whilst holding assumptions about timing constant, and then to consider timing variations.

Table 8: Interdependencies in specifying spectrum release

| | Impact on benefits | Impact on costs |
|--|---|--|
| Effect of increasing quantity of release | ↑ Additional benefit due to more competing networks <i>and/or</i> ↑ Additional benefit due to more networks built efficiently using lower frequencies ↓ Possible reduction in benefits due to increased risk of promoting inefficiently large number of networks | ↑ Increased costs because more 2G traffic to be cleared |
| Effect of delaying release & liberalisation | ↓ Less benefit because more network inefficiently built using higher frequencies <i>and/or</i> ↓ Less benefit because of delay to better 3G services being made available | ↓ Possibly reduced costs in long term if 2G to 3G migration results in there being less 2G traffic to be cleared |

Structure of this section

11.6 The analysis of quantity and timing options is organised as follows in the rest of this section:

- **Quantity** is considered first with some assumptions about timing – spectrum release and liberalisation of retained spectrum in 2010 (probably the earliest practical date) - held constant. The variation of costs and benefits of spectrum release with quantity are analysed.
- **Timing** variations to the assumptions used in quantity analysis are considered, covering:
 - Costs and benefits of delaying spectrum release beyond 2010
 - Costs and benefits of staged releases of spectrum (eg some released in 2010 and some in 2012)
 - Whether the market could determine the timing of spectrum release
- **Summary and initial views** on the most appropriate quantity and timing for partial mandatory spectrum release.

Quantity of spectrum release

11.7 This sub-section analyses the quantity options for partial release of 900 MHz spectrum assuming that spectrum is released to third parties in 2010, and that there is simultaneous liberalisation of the remaining 900 MHz spectrum retained by the incumbents.

11.8 It is structured as follows.

- The rationale for the **timing assumptions** used in the quantity analysis.
- Variation in **benefits** with different quantities of spectrum release.
- Variation in **costs** with different quantities of spectrum release.
- **Assessment** of different quantities of spectrum release taking into account their costs and benefits.
- **Summary** of initial conclusions on quantity of release in 2010.

11.9 Important background information on the cost benefit analysis used for comparing quantity options is provided in section 10.

Timing assumptions for quantity analysis

11.10 For the purpose of our analysis of quantity options, 2010 is taken as an estimate of the earliest practical timing for implementation of spectrum release. This is because:

- It is assumed that incumbents could start to implement spectrum release following an Ofcom policy statement and other relevant measures in 2008.
- We assume that it would not be practical to implement the necessary engineering changes for spectrum release within less than two years.

11.11 Taking the earliest practical time for release is also consistent with ensuring a timely implementation of the RSC Decision.

11.12 The analysis assumes that liberalisation of 900 MHz spectrum retained by incumbents would occur simultaneously with the release of 900 MHz blocks to third parties. The reason for this would be to ensure that incumbents and new entrants get access to liberalised 900 MHz spectrum at the same time, and therefore the competitive benefits of spectrum release are maximised.

11.13 Alternatives to both these assumptions – later releases of spectrum, and de-coupling liberalisation from release – are considered further in the analysis of timing options later in this section.

How do benefits vary with quantity of release?

11.14 The quantity of spectrum release is most easily discussed in terms of the total number of blocks released to third parties. Each block is 2x5MHz and can carry one UMTS carrier.

11.15 Ofcom's analysis in annex 8 and section 5 indicates that a 3G operator could obtain most of the cost and quality advantages of 900 MHz with access to just one 2x5MHz block of 900 MHz spectrum. It is likely to need further spectrum for capacity reasons but this could be at higher frequencies. Requirements for high capacity are usually associated with limited 'hot-spot' areas, whose loading effect can be reduced by carrying this traffic over the higher frequency network on just the closest cells, while the traffic in areas poorly served by the higher frequency network, e.g. deep in buildings, is carried at 900 MHz. Overall, Ofcom's judgement is that most of the benefit associated with 900 MHz spectrum can be obtained by access to a single 900 MHz carrier, provided the operator has other spectrum at higher frequencies.

- 11.16 As there are two incumbent operators with 900 MHz spectrum, Vodafone and O2, and each of these operators has a similar quantity, the quantity released by each of Vodafone and O2 is assumed to be half the total. Table 9 summarises the relationship between spectrum released by incumbents and the number of third parties with access to at least one block of 900 MHz spectrum and hence able to obtain most of the benefits of 900 MHz spectrum. It is assumed that each block released is not acquired by O2 or Vodafone and is acquired by an additional operator.

Table 9: Relationship between quantity of release and potential operators with 900 MHz spectrum

| 2x5MHz blocks released by each of Vodafone & O2 | Total 2x5MHz blocks released to third parties | Potential number of operators with at least one 2x5MHz block @ 900 MHz |
|---|---|--|
| 0.5 (2x2.5 MHz) | 1 | 3 |
| 1 (2 x 5 MHz) | 2 | 4 |
| 1.5 (2x7.5 MHz) | 3 | 5 |
| 2 (2x10 MHz) | 4 | 6 |

- 11.17 The potential benefits of spectrum release vary with demand and the analysis below considers the “low” and “high” demand scenarios (as explained in section 10) before discussing the implications for intermediate ‘medium’ demand cases.

Low demand scenario

- 11.18 In the low demand scenario there are by definition very limited competition related benefits of spectrum release because the better quality – in particular higher data rates and improved indoor coverage – facilitated by access to 900 MHz spectrum, are not valued by consumers. Consequently, in this demand scenario it is assumed that incumbents and other operators that gained access to 900 MHz would not re-farm and invest in 3G at 900 MHz in order to offer higher quality mobile broadband. Even if they did, consumers’ indifference to the higher quality services offered, would mean their competitive position would be unchanged. Similarly, releasing 900 MHz spectrum to third parties would not bring efficiency benefits in relation to provision of mobile broadband services if operators are unlikely to invest in their provision.
- 11.19 Access to 900 MHz spectrum also allows more efficient extension of 3G coverage of voice and basic data services in less densely populated areas compared to higher frequencies. If an operator would have otherwise extended their 3G network coverage using 2.1GHz, access to 900 MHz spectrum would bring some efficiency benefits. For example, extending basic 3G coverage from 80% to 99% population coverage might cost around £250m less using 900 MHz than 2100 MHz spectrum (see annex 7). However it is uncertain whether operators would go this far using 2.1GHz, particularly if they have an existing 2G network with high population coverage, and the benefits would be much less for lower coverage extensions. Alternatively, more operators might extend basic 3G coverage further if they had access to 900 MHz spectrum than if not. The benefit in that case might be an increase in competition in the areas affected due to the greater number of networks offering 3G services to consumers in those areas.

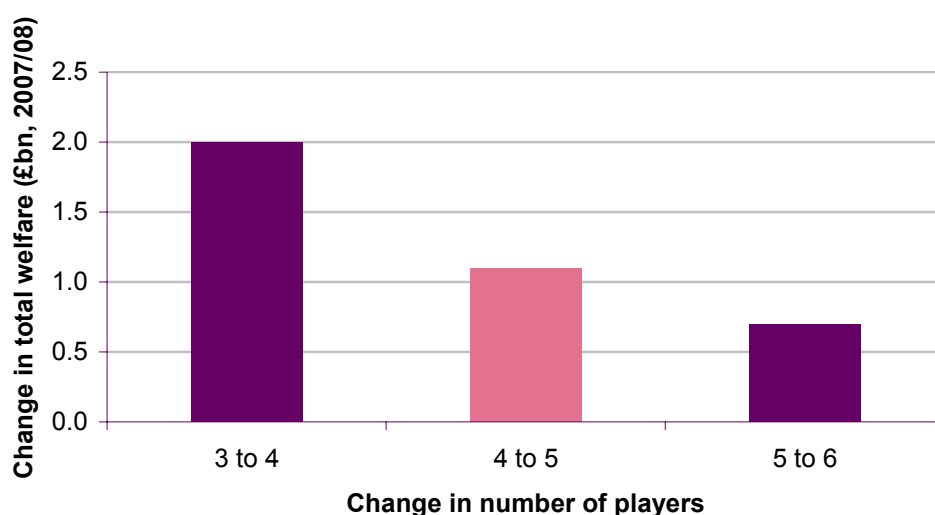
- 11.20 Ultimately, operators might decide to replace their entire 2G network with a 3G network due to the greater efficiency of 3G. In this case, access to 900 MHz spectrum would allow operators to deploy this 3G network at significantly lower cost than if they only had higher frequency spectrum. However, these benefits are uncertain and are only likely to be realised within a relatively long timeframe.
- 11.21 In summary, spectrum release in the low demand scenario seems likely to bring only limited efficiency and competition benefits. The efficiency benefits are uncertain and would arise from additional networks extending their basic 3G coverage, or perhaps complete replacement of existing 2G networks. Though these benefits could increase with quantity released, their limited magnitude suggests that they would not have a significant impact on the choice of quantity of release (in particular compared to the much higher benefits in the high demand scenario).

High demand scenario

- 11.22 In the high demand scenario without spectrum release (ie Option A – liberalisation in the hands of the incumbents), incumbent holders of 900 MHz spectrum could be expected to re-farm and deploy 3G at 900 MHz in order to provide high quality mobile broadband services. The extreme choice for other operators without access to 900 MHz spectrum would then be either to match the quality provided by incumbent operators at higher cost using higher frequencies or exit the market altogether. Therefore, in this limiting case, the benefits of releasing 900 MHz spectrum to third parties would either be a large efficiency benefit – if it enabled them to provide high quality mobile broadband services at lower cost *or* significant competition benefits if it enabled them to remain in the market. The variation in benefits with quantity of spectrum released for these two outcomes is discussed below.
- 11.23 The marginal **competition** benefits of each additional block released tends to diminish with quantity:
- For example the competition benefits of a sixth competitor entering a five player market are typically less than the benefits a fifth competitor entering a four player market etc. The diminishing benefit of additional competing mobile operators is illustrated in figure 12 below. This represents the upper bound where the number of operators in the whole mobile sector changes.
 - As the number of competitors with access to 900 MHz spectrum increases, there is an increased probability of the market effectively providing wider access to the benefits of 900 MHz spectrum. For example, a wholesale market in commercially-offered 3G roaming or other commercial arrangements may develop. Whilst this could increase the benefits of additional blocks up to a point, the benefits of further blocks would decline as the scope for competitive improvements would be reduced. Trading of 900 MHz spectrum (in a way that increases the number of operators holding 900 MHz) seems less likely as the number of operators with 900 MHz *to spare* would be unlikely to change as a result of spectrum release.
 - Beyond a certain point, releasing extra blocks may fail to induce additional competitors to deploy a 3G network at 900 MHz, if the market could not sustain more than a certain number of competing networks (although this point is clearly very difficult to determine). At this point operators might prefer to use additional blocks to provide additional capacity, ie to use 2 blocks for 3G at 900 MHz (as discussed above we would expect this to give a much smaller efficiency benefit than the first block).

- 11.24 In addition, if wider access to 900 MHz spectrum induced an increase in the number of networks, then there may be some reduction in the overall benefits due to an inefficient duplication of fixed costs (productive inefficiency), i.e. when the scale of traffic means that costs are lower with fewer networks. This effect is likely to be more pronounced for network build in areas with low demand (rural areas) rather than high demand. In high demand areas, a greater proportion of the costs are driven by capacity requirements than those incurred in providing a basic level of coverage. Therefore these capacity driven costs will largely still be incurred (though there may be some technical efficiencies) whether traffic is carried over one or several networks, whereas only the costs related to the basic coverage level will be saved.
- 11.25 This also means that the higher the take up of mobile broadband, the greater the proportion of capacity driven costs and the less important this effect is compared to the potential costs savings or competition effects.

Figure 12: Illustrative competition benefits of additional players in mobile sector



- 11.26 Extra competition in the high demand scenario might also encourage more rapid **innovation** in the mobile sector. The value of this could be large but its level is very uncertain. As an illustrative example, the loss of total welfare to society of delaying the introduction of an innovation into the mobile sector might be in the region of £250m to £1.5bn under some assumptions (see Annex 10). It is difficult to associate these benefits with particular increases in quantity – but it is expected that the likelihood of these benefits increases with the quantity of spectrum released.
- 11.27 If other operators would have matched the quality of incumbents even without 900 MHz spectrum, there would be a significant **efficiency** benefit from increasing the quantity of spectrum released, up to the number of players without access to 900MHz expected to still compete in the market. This benefit arises from the lower cost of deploying network to support high quality mobile broadband services using 900 MHz spectrum compared to higher frequencies. Ofcom estimates on a reasonably conservative basis that the efficiency benefits of using one block of 900 MHz spectrum to provide high quality mobile broadband services rather than 2100 MHz spectrum could be in the order of £1bn per operator (see section 5 and Annex 8). Again it is not certain that the full extent of these benefits would be realised since

in practice operators may not deploy this level of infrastructure using 2.1GHz macrocells. For example they may rely to some extent on dedicated in-building systems which might reduce the cost savings of having access to 900 MHz spectrum but as explained in section 5 and annex 8 we do not believe this could be a complete solution.

11.28 In contrast to the competition benefits, these efficiency benefits might be expected to broadly increase at a constant rate with increasing quantity as each block released would enable an additional operator to realise cost savings, at least up to the limit where no further operators would deploy 3G at 900 MHz.

11.29 In summary, in the high demand scenario the variation in benefits of spectrum release with increasing quantity seem likely to be either:

- Competition benefits that increase but with a diminishing marginal benefit of each additional block; or
- Efficiency benefits that increase at a roughly constant rate

11.30 Both of these seem only likely to increase a limited amount beyond a certain quantity which is related to the maximum number of operators that the market would support (which is uncertain and difficult to identify in advance).

Medium / intermediate demand scenarios

11.31 In practice, a less extreme outcome than either the low or high demand scenario seems more likely. In the medium demand scenario, mobile broadband is important but it is not critical to match the quality of the market leaders in order to remain in the market. Operators without 900 MHz spectrum may consequently remain in the market and make some investment in 2.1GHz network to improve their quality, but still fall significantly short of the quality offered by their competitors. Therefore, compared to Option A, getting access to 900 MHz spectrum would allow them to reduce or eliminate their competitive disadvantage as well as deploying network more efficiently than 2.1 GHz. The benefits of spectrum release in that demand scenario would therefore be a combination of efficiency and competition, but at a lower level than those in the high demand scenario (the balance between these benefits and their level compared to the high demand scenario is very difficult to predict). Together these would result in a diminishing marginal benefit with each additional block but less so than if there were only a competition benefit (because of the linear change in efficiency benefits).

Summary

11.32 In summary, our initial view on the variation of benefits with quantity of release for each demand scenario is as follows:

- **Low demand scenario.** Uncertain but probably limited benefits which could increase with quantity
- **High demand scenario.**
 - Competition benefits are very large but have diminishing marginal benefit; or

- Efficiency benefits are very large and increase at a constant (linear) rate with quantity.
- Both of these only increase a limited amount beyond a certain quantity which is related to the maximum number of operators that the market would support (which is uncertain).
- **Medium demand scenario.** Release could have both competition and efficiency benefits, though of uncertain level. Both increase with quantity but the competition benefits have diminishing marginal benefit, and efficiency benefits increase at a constant (linear) rate. The overall effect is therefore that marginal benefits diminish with quantity, though less so than if there were only a competition benefit.

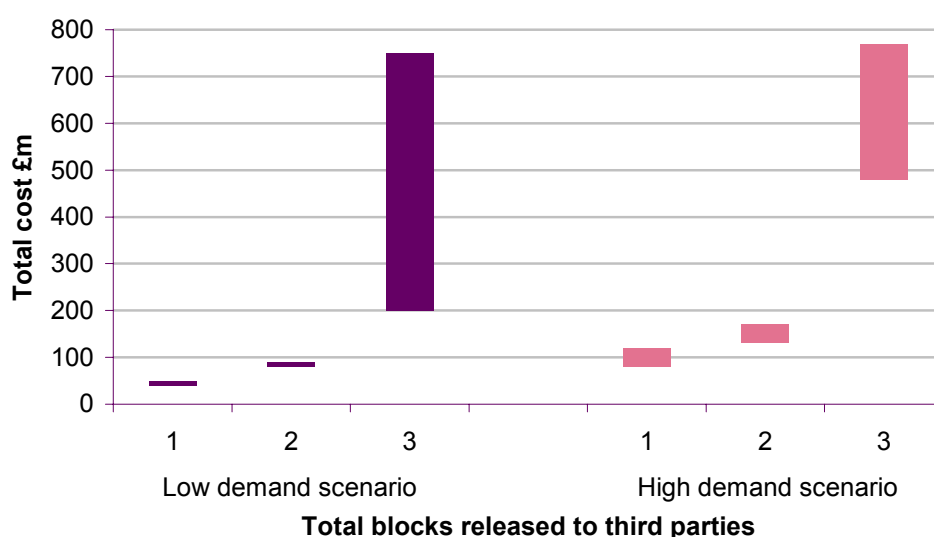
How do costs vary with quantity of release?

- 11.33 The costs of release increase with quantity because more of the incumbent's existing 2G traffic needs to be cleared from the 900 MHz spectrum it is currently using, and carried in other ways (we refer to this traffic as the 'displaced traffic'). The marginal costs of clearing each additional block in principle increase with quantity. In very simple terms, this is because traffic is removed from more lightly loaded spectrum first, so the more spectrum that is cleared the more likely it is to be highly utilised, and because the lowest cost means of absorbing displaced traffic are also used first. In practice there may be jumps in costs when operators have to switch to a different technical strategy for dealing with displaced traffic. The various strategies that an operator might employ to deal with the traffic displaced by spectrum release and their costs were outlined in section 10 and are explained in more detail in annex 9.
- 11.34 Where release is simultaneous with liberalisation (and so operators do not have the option of re-farming before release) what seems most likely is that incumbents would first upgrade their 2G network to add additional capacity. In other words they would continue to carry their 2G traffic but using a smaller amount of 900 MHz spectrum. Ofcom's understanding is that a plausible means to achieve this may be the implementation of Synthesised Frequency Hopping (SFH) (see annex 9). This may be preferred to accelerating the migration of customers to 3G at 2100 MHz because of the likely greater costs associated with that strategy. However, for higher quantities of release, an operator would be likely to need to accelerate migration of traffic to 3G in addition to implementing SFH.
- 11.35 In addition, increasing the quantity of spectrum released might increase the risk of network quality problems (eg network congestion and dropped calls) for an *interim* period whilst changes to the network are made. Although mobile operators are likely to have incentives to minimise quality problems, some unavoidable transitional problems might remain, due for example to the potential risks of introducing new technologies into the network. We cannot reliably quantify the risk of quality problems or the loss in consumer welfare that might result. If quality problems were widespread and for more than a short period, this could have a significant impact on consumer welfare, particularly given the size and importance of the mobile sector. Therefore, in estimating the costs of release we have assumed that the long term quality of 2G services is maintained, i.e. less costly means of implementing spectrum release are not considered if these would lead to a reduction in quality.
- 11.36 Ofcom's estimates of the costs of releasing between one and three blocks of 900 MHz spectrum to third parties in 2010, simultaneous with liberalisation, are summarised in the figure and table below. These draw on more detailed analysis in

annex 9. In the case of a four block release, this is likely to leave the incumbents 2G network with insufficient capacity to deal adequately with assumed 2G traffic levels. There is, therefore, considerable uncertainty over the cost and feasibility of such a release. Some estimates have been included though they should be treated with considerable caution.

- 11.37 In the high demand scenario the costs allow for operators re-farming one block of spectrum for themselves in addition to releasing spectrum to third parties. In this scenario, the costs of release estimates are conservative (i.e. avoid understating) because they attribute the highest cost of clearing spectrum to the released blocks, rather than the re-farmed blocks. Attributing costs in a different way between re-farmed and released blocks could reduce the costs of release. In the low demand scenario, no re-farming is assumed, but there is higher assumed growth in 2G traffic (and hence increased utilisation of 900 MHz spectrum) if mobile broadband demand, and 3G take-up, does not develop.

Figure 13: Estimated costs of releasing spectrum to third parties in 2010 in high and low demand scenarios



- 11.38 In summary, the main points that can be drawn from this analysis are that:

- The incremental costs of releasing the second block over the first block are relatively low (at around £40-50m). This is because we expect that both the first and second blocks can be released through implementation of SFH, the main difference is the extent to which SFH needs to be applied across the 2G network.
- Beyond a 2 block release, there is likely to be a large increase in costs (an increase of around £120-£660m) because the limit of SFH in increasing 2G network capacity is likely to be reached at this point. Consequently operators are likely to have to invest in migrating 2G customers to 3G, of which the most significant element is the cost of additional 3G handset subsidies.

Assessment of quantity options

- 11.39 Ofcom has carefully considered different quantities of spectrum release to assess what quantity is likely to be the most appropriate in particular taking into account the need to guard against the risk of a significant reduction in competition if there is significant growth in the demand for mobile broadband services, while recognising that such a growth in demand is uncertain, and costs which spectrum release will create which are much more certain, albeit difficult to estimate accurately.
- 11.40 In assessing what is the most appropriate quantity of spectrum to be released it is appropriate to start with the minimum quantity as that would impose the lowest cost, ie one 2 x 5 MHz block. Ofcom has then considered whether the further blocks of spectrum should be released. A helpful way to do this is by considering what the incremental cost and benefits would be for each further block released until it is clear that cost would be likely to exceed the benefits.
- 11.41 Each of the quantity options are discussed further below and the costs and benefits of different quantities are summarised in Table 10. This brings together the separate analysis of cost and benefits covered above (and supported by annexes 6 to 10). Note that in general the competition and efficiency benefits cannot be added. This is because they relate to different assumptions, in particular about the extent to which operators would have deployed networks in the absence of spectrum release.

Table 10: Summary of costs & benefits of release in 2010⁶²

| Quantity of release in 2010 (no of 2x5MHz blocks) | Assumed implementation (in some cases includes reconfiguration of 900 MHz band to remove interleaving) | Demand scenario | Costs of release (£m) | | Benefits of release | | Initial overall assessment |
|--|---|-----------------|-----------------------|---------------------------|---|--|--|
| | | | Total costs | Costs of additional block | Max competitive benefits of addition of block | Max efficiency benefits of additional block | |
| 1 | Implementation of SFH | Low | 40-50 | - | Limited | Limited | ✗ Clearly better than Option A but leaves considerable scope for further improving competition and efficiency and therefore higher quantities of release should be considered. |
| | | High | 80-120 | - | 3rd competing provider of mobile broadband | One extra operator benefits from 900 MHz cost savings (of the order of £1bn) | |
| 2 | Implementation of SFH | Low | 80-90 | 40 | Limited | Limited | ✓ Likely to have significant net benefits over a one block release. |
| | | High | 130-170 | 50 | 4th competing provider of mobile broadband | As 1 block | |
| 3 | Implementation of SFH, plus accelerated 3G migration (includes widening of 2100 MHz 3G coverage and 3G handset subsidies) | Low | 200-750 | 120-660 | Limited | Limited | ✓ Preferable to a two block release in order to safeguard competition in the mobile market. |
| | | High | 480-770 | 350-600 | 5th competing provider of mobile broadband | As 1 block | |
| 4 | As above, plus much greater level of 3G migration | Low | 500-1300 | 300-550 | Limited | Limited | ✗ Not likely to be an appropriate option because costs are unlikely to be proportionate to its benefits. |
| | | High | 830-1420 | 350-650 | 6 th + competing providers of mobile broadband | As 1 block | |

⁶² All costs and benefits are 20 year NPVs using social discount rate. See annexes 6 to 10.

Release of one block of 900 MHz spectrum

- 11.42 In the high demand scenario, release of one block of 900 MHz spectrum could bring significant benefits compared to no release (ie Option A) because it would enable three rather than two competitors to offer high quality mobile broadband services efficiently using 900 MHz. Ofcom estimates that the total costs of release in this case to be around £120m. Ofcom's initial view is that the competition and efficiency benefits of another operator having access to 900 MHz are very likely to significantly exceed the costs of releasing one block of spectrum. It is true that if such growth in demand for these services does not materialise then there could be a net cost associated with this option. However, any such cost would be relatively small when set against the risk of lost competition and efficiency benefits if it did arise. Therefore, Ofcom believes that the costs of this option would be proportionate.
- 11.43 Nonetheless, this option might still result in there being only three operators competing to offer high quality mobile broadband services, and hence there would still be considerable scope to further promote competition in the provision of these services. For example, it could result in a significantly less competitive mobile market than today. Alternatively, operators without 900 MHz spectrum might make additional investments in their higher frequency networks to match the quality of 900 MHz operators, in order to compete in the provision of mobile broadband. This is likely to result in significant inefficiencies given that the very substantial cost disadvantage they would face, perhaps in the region of £1bn⁶³ for each operator that sought to match the quality of 900 MHz networks.
- 11.44 In summary, Ofcom's initial view is that this option would significantly improve competition and efficiency compared to Option A, and at a proportionate cost. However, it leaves considerable scope for further improving competition and efficiency and therefore suggests that higher quantities of release should be considered.

Release of two blocks of 900 MHz spectrum

- 11.45 Ofcom estimates that the incremental costs of clearing the spectrum associated with a two block release would be in the region of £40-50m. This could enable competition between four operators efficiently providing high quality mobile broadband services compared to three in the case of a one block release. In the case where there is demand for those services, Ofcom's initial view is that it is highly likely that the incremental benefits would exceed the costs.
- 11.46 Although it is not possible to quantify with any precision the incremental benefits of competition the simple oligopoly model that Ofcom has constructed (see annex 10) provides some context for this judgement. Under many simplifying assumption, this suggests that the total welfare benefits of four compared to three players in the mobile market would be in the region of £2bn, comprising of a benefit to consumers of around £7bn and a loss to producers of £5bn (see above and annex 10). Even if mobile broadband services represented a small part of this market, this suggests that the incremental competitive benefits of releasing a second block could be an

⁶³ Estimated cost saving of using one block of 900MHz spectrum compared to 2 blocks of 2100MHz spectrum for providing high quality mobile broadband. See section 5.

order of magnitude greater than its incremental costs. An alternative way to look at this is to consider the quantification we have carried out for the possible efficiency benefits of releasing a second block of 900 MHz spectrum. In this scenario the quantification is produced on the assumption that the networks without access to 900 MHz still roll out using 2.1 GHz spectrum which results in a productive efficiency loss, but has no impact on competition. The efficiency loss could be large; our conservative estimate is around £1bn per operator. This also suggests that incremental benefits are likely to be an order of magnitude greater than the incremental costs.

- 11.47 Again if growth in demand for these services does not materialise then there could be an incremental net cost associated with releasing two blocks compared to one. However, Ofcom's initial view is that incremental net costs of around £40-50m, are relatively small when set against the risk of very large lost benefits, e.g. from the absence of a fourth competitor providing high quality mobile broadband services.
- 11.48 In summary, Ofcom's initial view is that on balance this option is likely to have significant net benefits over a one block release.

Release of three blocks of 900 MHz spectrum

- 11.49 Ofcom estimates that the release of a third block of 900 MHz spectrum would lead to a significant increase in costs compared to a two block release. The incremental costs of a third block, at around £120-660m (depending on the demand scenario), are much higher than the incremental cost of a second block. This is because for a 3 block release the amount of spectrum available to the releasing 900 MHz operators to carry their 2G traffic has been significantly reduced (by about one third) and is likely to require them to undertake extensive investment in order to be able to continue to provide services to their subscribers.
- 11.50 One way to assess this option is to consider the likely extra efficiency benefits of a three block release over a two block release. As explained above, we have created an estimate of these on the assumption that the fifth operator without 900 MHz still rolls out to the same extent as the 4 operators with access to 900 MHz. Ofcom's conservative estimate suggests a potential productive efficiency loss of in the order of £1bn per operator. Therefore it is quite possible that the incremental efficiency benefits could exceed the incremental costs. Alternatively, if the fifth operator without 900 MHz did not rollout further using 2.1 GHz, then competition would be affected but not efficiency. Accordingly it is also helpful to consider the potential competition benefits which could arise from a three block release, particularly if the operator without access to 900 MHz spectrum choose not to roll out to the same extent as those with 900 MHz spectrum.
- 11.51 The incremental competition benefits of the third block are likely to be lower than the incremental benefits of the first and second blocks but could still be significant. This is because the competitive benefits of five operators versus four operators, are generally less than the benefits of four operators versus three operators. It might also be argued that if four operators held 900 MHz spectrum this could lead to commercial roaming (for example) being offered to a fifth operator and so increasing retail, but not network competition. Nonetheless, the presence of a fifth operator providing mobile broadband services could have significant competitive benefits. Ofcom notes that at

present there are five operators in the mobile market and that the addition of the fifth operator since 2000 has created greater intensity of competition to the benefit of consumers. A simple illustration of the impact of having four rather than five operators suggests it could lead to a total loss in welfare of £1.1bn. It should be noted that is comprised of a loss to consumers of £4.9bn and a gain to producers of £3.8bn. Even if the mobile broadband services represented only a part of the market, this suggests that the incremental benefits to consumers of releasing three blocks could be significantly greater than the incremental costs. There is also potential for dynamic gains from greater competitive intensity, such as faster or greater innovation.

- 11.52 Therefore, in summary the key question is whether the extra benefits of having five operators compared to four operators with access to 900 MHz would be likely to be greater than the costs. This depends on how the market develops. Ofcom considers that if there were growth in demand for mobile broadband services, which Ofcom considers quite plausible, then it is likely that the benefits could exceed the costs. Accordingly, Ofcom's initial view is that on balance a three block release option is preferable to a two block release, particularly in order to safeguard competition in the mobile market, given the significant impact that any reduction in competition could have for consumers.

Release of four blocks (and higher) of 900 MHz spectrum

- 11.53 The arguments discussed above for release of a third block – of increasing incremental costs and decreasing incremental benefits - apply to the release of a fourth block but to a significantly greater degree.
- 11.54 Although the absolute level of the costs for a four block release are very uncertain, Ofcom's has made an estimate of the incremental costs which would be imposed by such an approach, they range from £300-650m and may be higher as it is more difficult to estimate the costs for this amount of release accurately. The costs are driven by the likely need for operators to have to incur very large costs in migrating large numbers of additional customers from 2G to 3G handsets.
- 11.55 Even where there is demand for high quality mobile broadband, Ofcom does not believe that is plausible to believe with sufficient certainty that an additional 6th operator at 900 MHz would be likely to generate additional benefits sufficient to exceed the costs. In the case where demand for mobile broadband did not develop, there would be very large net costs, that would be difficult to justify by the potential benefits. Therefore, Ofcom's initial view is that this would not be an appropriate option because its costs are not proportionate to the benefits.
- 11.56 In addition, as incremental costs generally increase and incremental benefits of additional blocks generally decrease, Ofcom's initial view is that releases of greater than four blocks are also unlikely to be appropriate. The particular case of full mandatory spectrum release is considered in more detail in section 13.

Summary of initial views on quantity of release in 2010

- 11.57 In summary, Ofcom's initial views on the quantity of spectrum release in 2010, with simultaneous liberalisation of retained spectrum, are that:

- a release of 2 or 3 blocks would be appropriate;
- a 3 block release would be preferable in order to safeguard competition in the mobile market;
- a 4 block release or higher is unlikely to be proportionate.

11.58 The subsequent subsection considers whether varying the timing of release, including later releases than 2010 and staggering the release of spectrum over 2 phases is likely to materially affect the overall assessment. A key issue considered is whether different timing would affect the assessment of a 3 block release.

Timing of release

11.59 This sub-section analyses the timing options for partial release of 900 MHz spectrum and considers whether these affect the initial views regarding quantity of spectrum release.

11.60 It is structured as follows:

- Variation in **benefits** with different timing of spectrum release
- Variation in **costs** with different timing of spectrum release
- Consideration of **later releases** than 2010
- Consideration of **staged spectrum release** over two phases (eg 2010 and 2012)
- Consideration of whether **liberalisation** of incumbents' retained spectrum could occur **before any spectrum is released** (eg before 2010)
- Consideration of the potential **role of the market** in determining timing of release.

How do benefits of release vary with timing?

11.61 Assuming that liberalisation and spectrum release occur at the same time, the main effects of delaying release and liberalisation are:

- to reduce the benefits of liberalisation because of more inefficient network build and/or delays to improved 3G services
- to increase competitive benefits because acquirers of released spectrum will have more time to match the network rollout of incumbents

11.62 These are discussed below.

Reduction of liberalisation benefits with later release

11.63 In the high demand scenario, if spectrum were liberalised in the hands of the incumbents in 2008 or 2009, incumbents might start to offer higher quality 3G services using 900 MHz spectrum in around 2010, though full roll-out of

services might not be complete until a number of years later. Therefore, consumers could start to benefit from liberalisation from around 2010.

- 11.64 In contrast, if spectrum release and liberalisation were later than 2010 this could delay incumbents from offering 3G services using 900 MHz spectrum. However, it may not delay incumbents in building a 900 MHz 3G network, only in their ability to start to offer services to consumers using that network. The implications of delay could be either:
- 3G network build using 900 MHz and consumer take up of 3G services being delayed – effectively postponing the benefits of liberalisation.
 - 3G network being built using 2.1GHz spectrum during the delay which would have been more efficiently built using 900 MHz spectrum.
- 11.65 These two effects are considered below. In practice a more complicated outcome combining the two effects may be likely, for example where 3G take-up is slower than it would have been and more 2.1GHz network is built than would otherwise been efficient.
- 11.66 Our analysis in annex 8 has shown that the additional cost of providing higher quality 3G services using 2.1GHz rather than 900 MHz could be around £1.0bn per operator. So if delay meant that both incumbents upgraded their 2.1GHz network instead of using 900 MHz and built it to provide the same level of quality, the total inefficiency could be around £2.0bn. This however represents an extreme outcome, where all the efficiency benefits of 900 MHz spectrum are forgone, which seems unlikely unless the date of liberalisation was sufficiently distant or very uncertain.
- 11.67 If delays in liberalisation resulted in delays in the take-up of 3G services, the 'cost' of the delay is more uncertain to predict as it would depend on what the rate of take-up of 3G would have otherwise been and in the additional value of the higher quality 3G services. In the high demand scenario, 3G mobile broadband services are (by definition) very important so there is likely to be a large impact, particularly considering the size and value of the mobile sector.

Increase in competition benefits with later release

- 11.68 If liberalisation is simultaneous with release, the competitive benefits of release should not vary significantly with its timing because all players would get access to liberalised 900 MHz spectrum at the same time. There is however one competitive concern arising in the high demand scenario, which relates to incumbents' potential head start in deploying a 900 MHz 3G network, that might be reduced through later release and liberalisation.
- 11.69 Incumbent holders of 900 MHz spectrum are likely to gain certainty about access to liberalisation 900 MHz spectrum earlier than operators who acquire released spectrum. This is because incumbents could be certain about access following from an Ofcom policy statement (probably in 2008), where as acquirers would only have certain access following completion of the award process (which for example might take place in 2009). Therefore, assuming operators would only start to invest in deploying 900 MHz 3G networks once they had certainty of access, the incumbents could have around a one year head start in deploying their network, and therefore potentially gain some competitive advantage.

- 11.70 Neither incumbents nor acquirers of 900 MHz spectrum could of course start using a 900 MHz 3G network until the spectrum was liberalised. Therefore increasing the time delay between the released spectrum being awarded and 900 MHz spectrum being liberalised would give acquirers of released spectrum sometime to catch-up with incumbents in their network deployment. If liberalisation and release occurred in 2010, this would only give them around one year to catch-up. But if liberalisation and release were in 2012, this could give them around three years to catch-up. So delaying liberalisation and release could give acquirers of released spectrum more time to catch-up in their network deployment with incumbents, and so there may be greater competitive benefits.
- 11.71 However, the competitive impact of this effect is uncertain – it depends whether all operators would want to roll-out immediately and the extent to which a head-start in network deployment would feed through to a longer term weakening in competitive intensity. In the low demand scenario, this effect does not seem applicable as there would be no urgency to rollout a 900 MHz 3G network.
- 11.72 The impact of this effect must also be weighed against the wider loss in benefits of delaying release and liberalisation. Ofcom's initial view is that that loss is likely to have a much more significant impact and therefore dominate the possibility of somewhat increased competition due to this effect.

Summary

- 11.73 In summary, in the high demand scenario:

- Benefits in general seem likely to decline with time, though the rate of decline, and the point at which they start to drop is very uncertain, because it is not possible to predict exactly how the market will evolve.
- The loss in benefits could be large if spectrum release delayed introduction of innovations resulting from liberalisation, and the longer the delay the more likely these losses are to materialise.
- Competitive benefits might be increased by delaying release and liberalisation, though it is unclear that these would outweigh the other factors that reduce benefits.

- 11.74 In the low demand scenario, there may only be limited benefits from spectrum release and hence the timing of release seems unlikely to significantly affect the overall level of benefits.

How do costs of release vary with timing?

- 11.75 The costs of release are closely related to the volume of traffic carried on the incumbents' 2G network because this directly affects the volume of traffic displaced by spectrum release and the costs of accommodating that traffic elsewhere.
- 11.76 In the high demand scenario, the volume of 2G traffic, and hence some of the costs of release, are expected to start to fall in future as customers migrate to 3G services, but the time and rate at which it falls is quite uncertain as this depends on the overall growth of mobile traffic and the rate of 3G take-up.

- 11.77 In the low demand scenario it seems likely that 2G to 3G migration would be slow, and so assuming that total mobile traffic continues to grow, 2G traffic volumes might continue to grow or not start to fall for a number of years. Indeed some of this traffic might be due to 3G users' traffic continuing to be carried over 2G networks when out of 3G coverage and hence might only be reduced following re-farming.
- 11.78 In addition, costs which arise from accelerating migration of customers to 3G, either at 2.1GHz or 900 MHz would be sensitive to two other time dependent factors:
- The penetration of 3G handsets will increase over time so making it easier to move the displaced traffic to the operator's 3G network.
 - 3G handsets, particularly dual band (900/2100 MHz) ones, will improve in quality and fall in cost over time, so reducing the cost of accelerating their penetration.
- 11.79 In summary, it is uncertain when costs of release will begin to fall and by how much because they depend on how the market develops. But in general costs will only fall where there is significant migration of customers to 3G, and this is more likely in the high demand scenario than the low demand scenario.

Delayed release and liberalisation - Release of 3 blocks in 2012

- 11.80 If release and liberalisation were to be delayed beyond 2010, the discussion above (on the variation of costs and benefits with time) suggests that costs and benefits are likely to decline, but that the overall effect of delay is uncertain.
- 11.81 The particular option for later release which Ofcom has considered is a 3 block release in 2012. This is because our analysis of release of 3 blocks simultaneously in 2010 suggested that this may be the preferable quantity option. Therefore, it is worth considering how timing variations would change the case for this.
- 11.82 2012 is chosen because a significantly later date may not be consistent with the requirements on the UK resulting from the RSC Decision. Taking the longest reasonable implementation period for the RSC Decision as 5 years (see section 3), this would suggest that Ofcom should seek to ensure spectrum is liberalised, and hence, where necessary released to third parties, by the end of 2012 (assuming the RSC Decision comes into force by the end 2007). In addition, later dates would further delay realisation of the possibly significant benefits of liberalisation.
- 11.83 The impact of delay compared to the 3 block 2010 option is considered below for the low and high demand scenarios.
- 11.84 In the low demand scenario we would not expect a significant impact because costs may be reduced but possibly not significantly (as 2G to 3G migration would not be driven by growth of mobile broadband) and benefits would be unlikely to be affected (from a base of being low). Indeed if 2G traffic rises the costs may increase.

- 11.85 In the high demand scenario costs would be likely to be reduced as growth of mobile broadband would be expected to encourage 2G to 3G migration and hence reduce the volume of traffic incumbents need to clear from their 2G network to some degree. A large reduction in benefits could be expected due to the delay of liberalisation where use of 900 MHz for 3G mobile broadband services is important.
- 11.86 Although these effects cannot be quantified with any accuracy, Ofcom's initial view is that the magnitude of potential benefit losses, ie delays to the very significant benefits of liberalisation, is likely to be higher than the potential cost reductions. Therefore, our initial view is that release of 3 blocks in 2012 would not be appropriate as it is likely to lead to lower net benefits than release of 3 blocks in 2010.

Staged release – 2 blocks in 2010 + 1 in 2012

- 11.87 An alternative to the release of spectrum at the same time in 2010 would be to release it in two stages, with the retained spectrum held by incumbents being liberalised when the initial blocks are released to third parties, and one or more further blocks being released to third parties in the second stage. The potential advantage of this is that for the second stage release, incumbent operators might have the opportunity to re-farm and deploy 3G at 900 MHz. Moving existing 900 MHz 2G traffic to their 900 MHz 3G network might then be a lower cost means of releasing additional spectrum.
- 11.88 The particular option which Ofcom has considered for a staged release is where a 3 block release takes place in two stages. The possible timing for this approach would be:
- 2010 for the initial release and liberalisation of retained spectrum. As discussed above, this is because 2010 is estimated as the earliest reasonable practical timing for release.
 - 2012 for the further release. This is because two years is estimated to be the minimum that is likely to be practical to implement the further release and because 2012 may be the latest reasonable time for implementation of the RSC Decision.
- 11.89 In the low demand scenario this approach may in practice have similar costs and benefits compared to simultaneous release in 2010. This is because incumbents would not be expected to re-farm and deploy 3G at 900 MHz in this scenario, and so deploying 3G (and associated handsets) simply to enable release is likely to be a more costly option than upgrading their 2G or UMTS2100 networks. The benefits of release would be low even when spectrum is released in 2010, so staging would be unlikely to have an appreciable impact.
- 11.90 In the high demand scenario, incumbents are expected to deploy a 900 MHz 3G network in order to meet the demand for high quality mobile broadband services. If they did so in 2010 once their 900 MHz spectrum had been liberalised, then in principle they could clear further 2G spectrum by moving traffic onto their 900 MHz 3G network. If mobile broadband demand were high and incumbents took an aggressive strategy to meet that demand, then it is conceivable that they would not need to migrate any more customers to 3G at 900 MHz to release a third block than they would have done as a result of a

purely commercial strategy. In this case the incremental costs of releasing the third block are likely to be minimal. However, it is uncertain whether operators would or could pursue this strategy as slippages in their deployment of 900 MHz 3G network or handsets, could leave them with insufficient capacity (potentially leading to loss of service to consumers) at the time the further block had to be released.

- 11.91 Therefore, if it were not possible or too risky to adopt this approach, then operators may implement the same release strategy as a simultaneous 3 block release, and therefore no appreciable savings would be realised as a result of the delay. In summary, it is uncertain whether staging the release of a third block would in practice lower the costs of release.
- 11.92 The competitive benefits of releasing a later block would however be less than if they were released in 2010. This is because other operators (incumbents and acquirers of initial blocks) would get access to liberalised 900 MHz spectrum 2 years earlier. The acquirer of the later block would be at some competitive disadvantage and this could weaken competition in the longer term. The extent of this impact on competition would seem to depend on:
- The extent to which incumbents and acquirers of the 2010 blocks deploy 900 MHz 3G network and handsets and start to offer services using them before 2012.
 - The extent to which there are first mover advantages in provision of 3G services using 900 MHz which create a long term competitive disadvantage for acquirers of later blocks.
- 11.93 In summary, Ofcom's initial views are that it is possible but by no means certain that this approach might reduce the costs of releasing spectrum relative to a simultaneous 3 block release. On the other hand it would definitely reduce the benefits (though to an uncertain degree), as the fifth 900 MHz operator would gain access later. Therefore Ofcom currently believes there is insufficient certainty that the net position resulting from a 3 block staged release would be better than a 3 block simultaneous release and so currently favours a simultaneous release.

Liberalisation before release of initial blocks

- 11.94 The preceding analysis has been on the basis that liberalisation of 900 MHz spectrum occurs in 2010, ie simultaneously with release of 900 MHz spectrum to third parties. However, the discussion of staged release above highlighted that releasing spectrum after liberalisation has the potential advantage of providing the incumbents with the option to migrate traffic to their 900 MHz 3G network (if they have decided to build one), and that this would potentially be less costly in accommodating traffic than releasing additional blocks simultaneously with liberalisation.
- 11.95 A further timing variation therefore would be to liberalise the 900 MHz spectrum first, in 2008, before release of spectrum to third parties in 2010. However, Ofcom's initial view is that this is unlikely to represent an improvement on other options identified for the following reasons:

- 11.96 First, early liberalisation might not enable significant reductions in the costs of release. To move 2G traffic onto 3G at 900 MHz by 2010 network incumbents would probably have to deploy their 900 MHz 3G network earlier and more quickly than otherwise and because the additional handset subsidies (to ensure enough consumers have dual band 900/2100 3G handsets) might be very large at this point because relatively few consumers would initially have such handsets.
- 11.97 Second, there may be a much greater risk of long term impact on competition than a staged release because:
- It seems more likely for incumbents to develop a strong first mover advantage if they initially faced no competitors with 900 MHz. This is in contrast to staged release where there would at least be some competitors with 900 MHz at the point of liberalisation.
 - Where there is a strong first mover advantage, the overall competitive impact is likely to be greater as this would be held by a maximum of two operators (the incumbent 900 MHz holders) rather than four (for example) in staged release.

Market determined timing

- 11.98 All the preceding analysis has been undertaken on an assumption that Ofcom determines timing of release. However, that analysis has highlighted the uncertainties Ofcom would face in assessing the costs and benefits of different timing options and consequently risk not identifying the optimal timing of release. An alternative is therefore to consider whether it might be better for the market to have a role in determining the timing of release and liberalisation.
- 11.99 There are a number of ways in which this might work in practice, and would partly depend on the way in which spectrum release was implemented (see section 12). Ofcom believes that however implemented there would need to be a regulatory defined 'back-stop' date, which would be the latest date by which liberalisation had to take place. Our initial view is that such a regulatory backstop date would need to be around 2012. This is to ensure timely implementation of the RSC Decision and to safe guard against indefinite and uncertain delay to liberalisation significantly reducing its benefits to consumers.
- 11.100 Ofcom's initial view is that if the incumbent 900 MHz operators *alone* set the timing there is a risk that liberalisation and spectrum release would occur later than would be economically and socially optimal. This is because they would not take account of the benefits of spectrum release to other operators. However, if the timing of released and liberalisation were commercially determined between incumbents and acquirers of spectrum, this might in principle reflect the underlying costs and benefits better than if Ofcom tried to set the date.
- 11.101 For the purpose of this discussion it is useful to sketch two examples in which the market (incumbents and acquirers) might have a role in determining timing:

- Ofcom could award rights to use the released spectrum from 2012 and each acquirer of released spectrum would be allowed to negotiate commercially with the incumbent to bring the date of release (and also the date of liberalisation of retained spectrum) forward. These agreements might be subject to some commercially agreed payments.
- If an auction were held for the released spectrum, this could be expanded to enable the release date to be determined, for example to allow bidders to express the value of acquiring the spectrum before the backstop date (the details of the design of such an auction of not considered here).

11.102 The main arguments in relation to market determined timing are discussed below.

11.103 The primary advantage is that market participants are likely to have better information on the factors affecting the optimal release date than Ofcom, for example:

- The costs of release and how these change over time, for example depending (amongst other things) on the future level of 2G traffic.
- The benefits of release and how these are likely to change over time, for example depending (amongst other things) on the level of demand for mobile broadband services.

11.104 However, there are a number of issues which are outlined below.

11.105 First, market determined timing seems likely to create additional uncertainty, particularly for acquirers, and complexity. Although there would be risks if Ofcom set the date for liberalisation and release there would also be benefits in terms of reducing the uncertainty around the timing and having a much simpler process.

11.106 Second, the need to ensure timely implementation of the RSC Decision would seem to constrain the degree to which the market could be given flexibility to determine the date of liberalisation. A regulatory backstop date, perhaps 2012, together with practical limits on the earliest timing for release, perhaps 2010, would leave a fairly narrow window for market flexibility and hence for the extent of benefits that a market approach could bring.

11.107 Third, there might be a risk of market failure because benefits to consumers from deployment of UMTS 900 may not be taken into account (ie there are externalities) if operators are not able to extract the additional value created for 3G consumers as a result of improving quality. In practice mobile operators have considerable pricing flexibility in targeting different market segments which might enable them to internalise these externalities.

11.108 In summary, although recognising some risk in making the judgement as to the timing of release and liberalisation, Ofcom's initial view is that on balance regulatory specified timing is preferable to market determined timing. This is because of the need to guard against undue delay in implementing the RSC Decision in order to allow the potentially very large competition and efficiency benefits to be realised. In addition, the benefits of market determined timing are in practice likely to be quite limited due to the limited timeframe in which

there is likely to be flexibility, so seem unlikely to justify the additional uncertainty and complexity that such an approach is likely to introduce,

Summary of quantity and timing analysis

11.109 The analysis in this section has considered a wide range of options for the quantity and timing of spectrum release and has suggested initial views on which ones might be appropriate means of implementing the RSC Decision and which ones seem unlikely to be appropriate. Table 11 below sets out the initial findings of that analysis.

Table 11: Summary of initial quantity and timing analysis

| Option | Could be an appropriate variant? | Comments |
|---------------------------------------|----------------------------------|--|
| <u>Quantity options in 2010</u> | | |
| 1 block in 2010 | ✗ | Leaves considerable scope for further improving competition and efficiency and therefore higher quantities of release should be considered. |
| 2 block in 2010 | ✓ | Likely to have significant net benefits over a one block release. |
| 3 blocks in 2010 | ✓ | Preferable to a two block release in order to safeguard competition in the mobile market. |
| 4 blocks in 2010 | ✗ | Not likely to be an appropriate option because costs are unlikely to be proportionate to its benefits. |
| <u>Timing variants</u> | | |
| 3 blocks in 2012 | ✗ | Would not be appropriate as it is likely to be lead to lower net benefits than release of 3 blocks in 2010. |
| 2 blocks 2010 + 1 block 2012 | ✗ | Does not seem attractive compared to simultaneous release as would reduce benefits and it is uncertain whether it would appreciably reduce costs. |
| Liberalisation before initial release | ✗ | Does not appear to be appropriate because of the risks of reducing the competitive benefits of spectrum release. |
| Market determined timing | ✗ | Regulatory determined timing preferable given the constraints of the RSC Decision and the uncertainty, complexity and delay that a market process might introduce. |

11.110 In summary our initial views on timing and quantity for 900 MHz spectrum are:

- release of 2 or 3 blocks would be appropriate;
- a 3 block release would be preferable;
- release should occur in 2010 simultaneously with liberalisation of 900 MHz spectrum.

Question 11.1 Do you agree with Ofcom's assessment that the version of Option C in which there is the simultaneous release of three 2 x 5 MHz blocks of 900 MHz spectrum in 2010 is likely to be the most appropriate means to implement the RSC Decision in respect of the 900 MHz spectrum?

Section 12

Option C: Partial mandatory spectrum release – Implementation issues for 900 MHz spectrum

Introduction

- 12.1 Option C, partial mandatory spectrum release would involve the release of some, but not all, of the spectrum currently held by incumbent operators, with the remaining (retained) spectrum being liberalised in their hands.
- 12.2 Section 10 considered mandatory spectrum release in general and reached the initial view that release of 900 MHz spectrum in principle it had some merits compared to Option A as means of implementing the RSC Decision.
- 12.3 Section 11 considered the appropriate *quantity* of 900 MHz spectrum to be released under a partial release (Option C) and the *timing* of that release. Its initial view was that a partial release comprising 2 or 3 blocks with a preference for 3 in 2010, was the option most likely to fulfil Ofcom's duties and objectives.
- 12.4 This section considers in more detail how such a partial release option might be implemented, including the mechanism for releasing spectrum and treatment of retained spectrum.

Structure of this section

- 12.5 The section is broadly split between consideration of the 900 MHz spectrum released by incumbents and the 900 MHz spectrum retained by incumbents:
 - Released spectrum
 - Mechanism for releasing spectrum, eg revocation followed by re-award by Ofcom
 - Terms of the released spectrum, including potential for trading restrictions
 - Retained spectrum
 - Administered Incentive Pricing (AIP) applied to retained spectrum
 - Terms of the retained spectrum
 - Secondary market rules
 - Summary of preferred implementation and possible next steps

Released spectrum

- 12.6 Three alternative mechanisms for releasing 900 MHz spectrum are considered below:
- **Auction.** Revocation of a particular quantity of 900 MHz spectrum, to be returned to Ofcom for re-award by auction.
 - **Beauty contest.** Revocation of a particular quantity of 900 MHz spectrum, to be returned to Ofcom for re-award by a comparative selection process.
 - **Administrative allocation.** Revocation of a particular quantity of 900 MHz spectrum - Ofcom would specify who would be granted the released 900 MHz spectrum and administratively allocate it accordingly.
- 12.7 As set out in section 4, Article 5(2) of the Authorisation Directive requires Ofcom to grant rights of use of radio frequencies by means of an open, transparent and non-discriminatory procedure. If Ofcom decides to require release of part of the 900 MHz spectrum for distribution to a wider number of operators, it would be legally required to ensure that any such distribution is effected by means of a process which complies with Article 5(2).

Auction

- 12.8 The main elements of this approach to implementing partial mandatory spectrum release would be:
- Incumbent holders of 900 MHz spectrum would be served a revocation notice for the 900 MHz blocks to be released. This would most likely happen shortly after Ofcom's statement on mobile liberalisation in 2008. (Section 4 summarises the legal framework relevant to revocation of existing licences).
 - An auction for the released spectrum would be held. One option would be for the auction to be held in 2009 ahead of the release date in 2010.
- 12.9 Holding an auction would be likely to address the efficiency and competition concerns motivating spectrum release, because it would allow the spectrum to be acquired by the entity which values it most. In addition, Ofcom's view is that holding an auction complies with the legal requirement to conduct an open, transparent and non-discriminatory process for awarding spectrum.
- 12.10 However, in order to be an effective means of addressing the concerns motivating spectrum release, it is likely that it would be necessary to put in place some particular rules in relation to the auction.

Auction rules

- 12.11 The key purpose of a spectrum release approach would be to enable wider access to 900 MHz spectrum. As discussed in section 8, we would not expect the market to redistribute efficiently access to 900 MHz absent any requirement to release spectrum given the competitive advantages that it would give incumbents. For the very same reasons, we would not expect an auction to allocate efficiently released blocks of 900 MHz spectrum if

incumbents were allowed to participate in the auction. This is because incumbent's valuation of the spectrum would include the benefits (to them) of holding that spectrum to reduce competition in the downstream market. This could result in incumbent's re-acquiring the spectrum even if it would be more efficient (and pro-competitive) if it were acquired by other operators.

- 12.12 Therefore, Ofcom's initial view is that in order for the auction to achieve the benefits of spectrum release, the existing holders of the 900 MHz spectrum, O2 and Vodafone, would not be permitted to participate in the auction of the released 900 MHz spectrum. To do otherwise would be likely to frustrate the policy objective of widening access to 900 MHz spectrum to protect against a reduction in competition and allow efficiency gains to be realised.
- 12.13 For similar reasons, Ofcom's initial view is that all other parties participating in the auction would need to be limited to acquiring one 2 x 5 MHz block. This is to ensure that the policy objective of broadening access to the 900 MHz spectrum would be achieved.

Beauty contest

- 12.14 As for an auction, a 'beauty contest' or comparative selection procedure would first require Ofcom to serve a revocation notice to the existing holders of the 900 MHz spectrum. Ofcom would establish criteria for judging competing uses and users of the released 900 MHz spectrum and invite applications based on those criteria. Ofcom would judge the applications and award the spectrum to those applicants that best meet the criteria. Ofcom considers that this approach could potentially meet the requirements of Article 5(2) of the Authorisation Directive, but it is not clear that it could be as effective as an auction in ensuring that the released spectrum is awarded to the most efficient use or user for the reasons explained below.
- 12.15 If Ofcom were to hold a comparative selection process, as explained above it would need to define a set of criteria against which applications would be assessed. These would need to be objective and reflect Ofcom's statutory duties (as set out in Section 4). As explained above in Section 7, the key duties which are relevant to the decisions Ofcom will need to make in relation to the liberalisation of the 900 MHz spectrum are the promotion of competition and securing the optimal use of the radio spectrum. Accordingly, Ofcom envisages that the key criteria in a beauty contest would be likely to reflect those duties.
- 12.16 The beauty contest process would require Ofcom to assess which of the applications it had received provided the best fit with the criteria that had been specified. It would have to do this by reference to the information which was available, including in particular information that is provided by the applicants themselves (for example, their business plans and financial information). The assessment of the applications would require Ofcom to make difficult judgements. There is some doubt over how effectively Ofcom could make those judgements for a number of reasons. These include the partial and imperfect nature of the information that is likely to be available, the inherent difficulty of assessing the risk involved in different applications, and the fact that the regulator is less well-suited than the market to judging business plans.

- 12.17 Ofcom's initial view is that, were it to conduct a beauty contest in order to award the released 900 MHz spectrum, there is a significant risk that it would not identify the most efficient user of the spectrum. Ofcom considers that an auction would be more likely to lead to an efficient outcome, by assigning the spectrum to the user for whom the spectrum has the highest value. Therefore, Ofcom has set out its initial view in this consultation that it should hold an auction for the released 900 MHz spectrum.

Administrative re-allocation

- 12.18 Ofcom has considered whether it could redistribute the 900 MHz spectrum by means of an administrative allocation, whereby Ofcom would select the operators who would be granted rights of use over it. However, such a process would by its nature not be open for all potentially interested parties. Ofcom has therefore concluded that administrative allocation would not comply with the requirements of Article 5(2).
- 12.19 In addition, Ofcom believes that such an option may not achieve the same level of competition or efficiency benefits as an open award process, because an administrative decision may not be as effective as an open auction process in selecting the user that will make optimal use of the spectrum.

Initial views on mechanism

- 12.20 In summary, Ofcom's initial views on the most appropriate mechanism for mandating spectrum release are:
- A revocation notice would be served on the incumbents for the 900 MHz blocks to be released (probably in 2008).
 - An auction would be held for all of the released blocks. This might be held in 2009 ahead of the release. Following the auction licences to use the release spectrum would be granted with rights to use beginning when the spectrum is cleared (ie 2010 for a 2010 release).
 - The incumbent holders of 900 MHz spectrum would not be permitted to participate in the auction for the released 900 MHz spectrum.
 - No auction participant would be permitted to acquire more than one 2x5MHz block of 900 MHz spectrum.
- 12.21 Ofcom proposes that in the auction it would offer new licences for the released 900 MHz spectrum which would have terms similar to those established for other newly awarded spectrum. That is to say they would be technology neutral (subject to the proposals in section 14), have an indefinite term with a minimum term of 15 years, subject to 5 years notice of revocation for spectrum management reasons, be tradable and contain no rollout obligations or similar non spectrum licence conditions.

Retained spectrum

- 12.22 Partial mandatory spectrum release would involve some 900 MHz spectrum being released by the incumbents and some being retained by the incumbents and liberalised. The terms of the retained spectrum and its pricing are discussed below.

Terms of retained spectrum

- 12.23 The 900 MHz spectrum not subject to revocation by Ofcom would be liberalised in the hands of the incumbent licensees. This would take place by variation of their licences and would come into effect at the same time as spectrum is released. In the case where there is a staged release, this would be at the time of the initial release.
- 12.24 The licences for spectrum would also be made tradable. Ofcom also considers that it is likely to be appropriate to vary the term of licences for the retained spectrum in a similar way to other licences which have been liberalised and made tradable. Accordingly, the licences would be indefinite but subject to 5 years notice of revocation for spectrum management reasons.

Administered Incentive Pricing (AIP) of retained spectrum

- 12.25 Ofcom's initial proposal under this option would be to review the AIP payable on the spectrum retained by the incumbents in light of the auction of released spectrum if that approach is adopted and other relevant considerations, including the legal framework which specifies the matters Ofcom is permitted to take into account when setting AIP.
- 12.26 If Ofcom decides as proposed to hold an auction for the released spectrum, applying AIP in this way would help to minimise the differential impacts, between those holding retained spectrum and acquirers of spectrum in the auction, which could arise from this spectrum release option, but may not totally eliminate them. Differential impacts could arise due to fixed cost profit shocks, for example:
- If the acquirers of the released spectrum have to purchase the spectrum at auction, and pay a different price for the spectrum than the AIP currently charged for the spectrum held by the incumbents.
 - Also after spectrum release, the incumbents would be likely to hold several blocks of 900 MHz spectrum whilst it is likely that those who obtained released spectrum would be limited to acquiring one block. This may reduce the incumbents' costs of providing capacity (as opposed to coverage) compared to operators with only one block of 900 MHz spectrum.
- 12.27 As discussed above for Option A, Ofcom believes that profit shocks arising from differences in fixed costs are unlikely to lead to indirect effects on competition, therefore addressing them is a secondary consideration compared to Ofcom's primary goals in liberalising 900 MHz spectrum of promoting competition and promoting efficient use of the spectrum. However, Ofcom considers that it is still relevant to address differential impacts, in so far as this does not conflict with meeting its primary duties. This is because if operators suffer differential and unpredictable profit shocks as a result of regulation, this may increase regulatory uncertainty and dampen incentives for investment.

Secondary market rules

- 12.28 It is proposed that both the released and retained 900 MHz spectrum would be made tradable. Therefore, it is also necessary to consider what rules should apply in the secondary market in relation to the trading of 900 MHz spectrum. If as proposed Ofcom decides to hold an auction for the released spectrum, there may be a case for continuing restrictions equivalent to those that might be imposed in an auction – that the incumbents holders of 900 MHz spectrum would not be allowed to re-acquire the spectrum and no one should be able to acquire more than one 2x5MHz block of 900 MHz spectrum. The reasons for these restrictions would be the same as those for those in an auction, ie to ensure the competitive and efficiency objectives of spectrum release are not frustrated.
- 12.29 However, a very mechanistic rule might in the longer term create barriers to commercial developments which could bring benefits to citizens and consumers. Ofcom's initial view is that it would be preferable to introduce trading, but that some form competition review of trades would be important to prevent the competition benefits of spectrum release being undone.

Summary of initial views on implementation

- 12.30 In summary, Ofcom's initial views with regard to how best to implement partial mandatory spectrum release are:
- A revocation notice would be served on the holders of 900 MHz spectrum requiring them to release a specified quantity of spectrum in 2010.
 - An auction would be held, possibly in 2009, for that released spectrum. The incumbent holders would not be permitted to participate and no one could acquire more than one block.
 - The remainder of the spectrum would be liberalised in the hands of the existing holders of 900 MHz at the same time as the spectrum was released.
 - AIP would be applied to the retained spectrum.
 - The new licences for the released spectrum and the varied licences for the retained spectrum would both be made tradable and the tenure made indefinite subject to appropriate terms for revocation

Question 12.1 Do you agree with Ofcom's proposal for the mechanism of release and the terms and condition for the released 900 MHz spectrum?

Question 12.2 Do you agree with Ofcom's proposal for the terms and conditions for the retained 900 MHz spectrum?

Section 13

Option D: Full mandatory spectrum release for 900 MHz spectrum

Introduction

- 13.1 This section considers the option of full mandatory spectrum release for 900 MHz and outlines some initial views in the light of Ofcom's duties and objectives.
- 13.2 This option would involve the mandatory return of all the 900 MHz spectrum held by the incumbent holders, O2 and Vodafone, to Ofcom (the equivalent of approximately seven 2x5MHz blocks) and their re-award by Ofcom. It builds on our initial view that in principle some form of mandatory spectrum release may be an appropriate option for implementing the RSC Decision in relation to 900 MHz spectrum, and our analysis in section 11 of the costs and benefits of spectrum release.
- 13.3 This section is structured as follows:
- Costs and Benefits of mandatory full spectrum release in general
 - Costs and benefits of different timing options
 - Implementation issues
 - Summary and initial views on full mandatory spectrum release

Costs and Benefits of mandatory full spectrum release in general

- 13.4 As discussed in section 10 our initial view is that mandatory release of 900 MHz spectrum in principle has some merits in terms of promoting competition and efficiency, compared to Option A as means of implementing the RSC Decision.
- 13.5 A full release of 900 MHz spectrum would mean that in principle up to seven different operators could hold 900 MHz (i.e. one block each), therefore potentially providing significant efficiency and/or competition benefits. For example, all the existing mobile operators and potentially two new entrants could hold one block of 900 MHz spectrum each, possibly leading to a more competitive mobile market in the UK. These operators would also realise significant efficiency benefits compared to deploying a network using higher frequency spectrum alone.
- 13.6 However, there is some uncertainty whether all these benefits would be realised, particularly because it is unclear whether in practice there would be this level of entry into the market. It might also result in some productive inefficiencies due to duplication of network infrastructure. Further, the marginal benefits of additional competitors generally decreases (as discussed in section 11). For example the competitive benefits associated with a seventh operator could be significantly smaller than the benefits associated

with a fifth operator. Therefore, the additional benefits of full release over partial release (say of 3 blocks) might be relatively limited.

- 13.7 In addition to the potential for further entry, another possible benefit of full release compared to partial release is that it could result in a more efficient distribution of spectrum if awarded through an auction in which the incumbents were allowed to participate (also see discussion below). This is because it would enable a wider range of possible distributions of 900 MHz spectrum. For example, it would enable a distribution where the incumbent 900 MHz spectrum operators held one block of 900 MHz spectrum whilst a new entrant held two blocks – if that were the most efficient distribution. It is of course very uncertain how likely such distributions would be.
- 13.8 However, this analysis of the benefits takes no account of what would be required if Ofcom were to take back all the 900 MHz spectrum. In particular in order to continue to serve their existing and future mobile subscribers O2 and Vodafone would be likely to need to incur significant costs to expand and deepen the coverage of their 2.1 GHz networks. This would have two consequences: first it would impose huge costs on those two operators. Ofcom has not undertaken a detailed assessment of the magnitude of the costs but as set out in Annex 9 it estimates that these could exceed £3-4bn in total (for release in 2010/11). Second this option may in practice lead to lower benefits than a partial release approach. This is because it would reduce significantly the scope to realise the potential cost savings associated with a 900 MHz network for the two operators that are releasing spectrum as they would have had first to deploy a much more extensive network at 2.1 GHz. This could reduce the benefits of this option by 40% compared to Option C.
- 13.9 In summary, full mandatory spectrum release could in principle provide some benefits. However, it has huge costs and in practice may offer fewer benefits than Option C.

Costs and benefits of different timing options

- 13.10 The costs and benefits of mandatory full spectrum release are likely to vary for different timings and therefore three different timing options are considered:
- Early release – assumed to be 2010
 - Late release – assumed to be 2018
 - Phased released – assumed to be phased between 2010 and 2018

Early full release

- 13.11 Although it is uncertain what the earliest practical date would be for full release, 2010 is considered as an extreme option in order to illustrate the issues with early release and to enable comparison with partial release options considered in sections 11.
- 13.12 In our analysis of partial release options in section 11 we reached the initial view that a mandatory release of 4 blocks in 2010, with simultaneous liberalisation in 2010, was unlikely to be proportionate, due to the large costs of clearing sufficient 900 MHz spectrum. We also identified that in general

the marginal costs of release increase with quantity and the marginal benefits decrease. Therefore, by extension of these arguments, it seems very likely that a mandatory release of all 900 MHz spectrum in 2010 would also be disproportionate.

- 13.13 This is illustrated by a simple consideration of the costs for incumbents to clear all their existing 900 MHz spectrum. These costs have only been assessed at a simple level in order to identify the likely order of magnitude. For example, in order for incumbents to migrate all of their existing 2G customers onto their 2.1 GHz 3G network, an operator would need to:
- Provide all 2G only customers with a 3G handset. This might cost in the region of £1.0bn - £1.4bn per operator (see annex 9)
 - Extend their existing 2.1GHz 3G network to offer equivalent population coverage as their 2G 900 MHz network. Increasing the population coverage of this network from 80% to 99% might cost around £460m per operator (see annex 7).
 - Improve the indoor coverage of their existing 2.1 GHz network to a level similar to their 2G network if consumers are not to experience a poorer quality service. These costs have not been estimated, but are likely to require a large number of extra 2.1 GHz sites in built-up areas. This would also effectively mean that most of the efficiency benefits of liberalisation to incumbents, i.e. the ability to provide better 3G coverage using 900 MHz, would be lost.
- 13.14 So in total the costs of early full release might easily be significantly in excess of £3bn, or over £2bn more than a partial release of 3 blocks in 2010. It does not seem at all likely that benefits of such an approach would exceed the costs. In particular the investment necessary in 2.1 GHz networks to clear spectrum would significantly reduce the efficiency gains associated with liberalisation.
- 13.15 Costs might be lower if incumbents had certainty that they had re-acquired spectrum sufficiently ahead of the required release, so that they only incurred the costs of clearing blocks that they did not re-acquire. For an early release, the award of spectrum would be unlikely to be sufficiently before release in order for incumbents to do this. However, it might be possible for the late and phased timing options and this is considered below.
- 13.16 In summary, Ofcom's initial view is that the very high costs of an early full release mean that it is very likely to be a disproportionate option for implementing the RSC Decision.

Late release 2018

- 13.17 In this option all spectrum would be released in 2018. The spectrum might potentially be awarded before release, perhaps 2-3 years before (2015-2016). It might be undesirable to hold an auction considerably earlier due to the inevitable uncertainties that would arise in awarding spectrum significantly before it became available. None of the 900 MHz spectrum would be liberalised before 2018.

13.18 The costs of this option may be significantly lower than an early full release because:

- By that time a large proportion, if not all, mobile users might have migrated to 3G handsets, so reducing the need for extra handset subsidies to 'force' migration. However, further investment in 2.1 GHz network would still be required.
- Incumbents would have the option to wait until the award was known before incurring some of the costs of release. For example, if the incumbents were successful in re-acquiring 4 blocks in total (2 each), then they might only need to incur the costs of clearing 3 blocks in total (1.5 blocks each).

13.19 However, the benefits of this option are also likely to be reduced significantly, because the benefits of liberalisation, for example the ability to efficiently provide high quality mobile broadband services in the high demand scenario, could be delayed by several years (eg 8 years compared to the proposal of 2010 for Option C). The efficiency benefits of liberalisation are also likely to be reduced due to further deployment of 2.1GHz network during this period (see section 11 for further discussion of how delaying liberalisation is likely to reduce its benefits).

13.20 Finally, a late release is unlikely to be consistent with timely implementation of the RSC Decision. Our initial view outlined in section 3 is that 5 years from the date of adoption (ie around 2012/2013) is likely to be the latest reasonable deadline for implementation of the RSC Decision.

13.21 In summary, Ofcom's initial view is that late full release is unlikely to be an appropriate option because of the significant delay to realisation of the benefits of liberalisation and because this is likely to be inconsistent with the requirements of implementation the RSC Decision.

Phased release

13.22 A phased full release of spectrum would involve an initial release of part of the 900 MHz spectrum with the rest of the spectrum being released in one or more later phases. For example 2 blocks of 2x5 MHz in 2010, 2 further blocks in 2012 and 3 final blocks in 2014 (though there are clearly many variations in phasing, we mainly focus on the general issues of principle). The rationale for phasing is the same as that for phased partial releases: the early blocks allow early benefits of liberalisation, whilst delaying the release of additional blocks may reduce the costs of release.

13.23 The initial blocks to be released would be awarded as soon as possible, possibly during 2009, with awards for subsequent releases taking place around 2 years before the release. It is unlikely that it would be appropriate to award all the spectrum as early as 2009, given the inevitable uncertainties that would arise in awarding spectrum up to five years before it became available. Spectrum would not be liberalised before it was released.

13.24 A phased full release would appear to reduce some of the major issues facing the early and late full release options. It would avoid to some degree the very large costs of an early full release, and would allow some benefits of liberalisation to be realised at an earlier date. However, it seems likely that it

would have several disadvantages compared to the partial release options identified in the previous sections:

- It would create greater uncertainty for all market participants, by delaying information about ultimate ownership of spectrum to the point at which the later phases of spectrum were awarded (perhaps 2012), and hence could significantly reduce the level of investment in the sector as a result.
- It could incur greater costs (of releasing additional blocks) for benefits which are uncertain, in relation to both
 - market demand, i.e. whether demand for mobile broadband develops; and
 - the number of operators the market could sustain (i.e. whether additional blocks would bring any benefits in terms of new entry).

13.25 Therefore, our initial view is that a phased full release is very unlikely to be a proportionate means of implementing the RSC Decision. In addition, the later phases of a phased release might constitute an unacceptably late implementation of the RSC Decision.

Implementation issues

13.26 Some of the main issues in relation to implementation of mandatory full spectrum release are outlined here. The main implementation issues that are relevant are:

- How should the released spectrum be awarded?
- What should the terms of the released spectrum be?

13.27 Ofcom considered these questions in section 12 in relation to partial mandatory spectrum release and considers that its initial views are also relevant to full release:

- Released spectrum should be awarded through an auction, although as discussion in section 12 an alternative would be to run a beauty contest.
- Released spectrum should have terms similar to those established for other newly awarded spectrum, ie technology neutral, have an indefinite term with a minimum term of 15 years, be tradable and contain no rollout obligations or similar non spectrum licence conditions.

13.28 However, in relation to the restrictions that might be appropriate to apply to the auction, there are slightly different considerations:

13.29 As discussed in section 10, the primary benefit of spectrum release options is that they ensure wider access to spectrum in order to avoid the competition and efficiency issues outlined in section 6. On this basis, in order for spectrum release to achieve these aims, Ofcom's current view is that an auction of spectrum in a partial release option would need to exclude incumbents in order to avoid them re-acquiring all the released spectrum (so returning to the pre-existing status quo of only two operators holding 900 MHz).

- 13.30 For full release, the competition concern becomes the risk that *any* one or two operators (not limited to the incumbents) could end-up acquiring all the 900 MHz spectrum. Therefore, although there would appear be no basis for excluding incumbents from an auction of all the spectrum, there would still seem to be a good argument for some limits on the quantity of 900 MHz spectrum any one operator could acquire to avoid competition problems being re-created. Specifying the optimal rules could be complex, particularly for a phased release, and is not considered further in this consultation.
- 13.31 The other issue that might be a concern when auctioning all of the 900 MHz spectrum is the potential for participants to bid up the value of blocks where they are confident that incumbents have to re-acquire them in order to continue their existing business or avoid very large costs of release. Again, assessing this risk and designing the auction to reduce it (if present) is not the subject of this consultation.

Summary and initial views on full mandatory spectrum release

- 13.32 In summary, having considered different timing options, our initial view is that although full release could bring significant competition and efficiency benefits, it is likely to be disproportionate or cause unreasonably delay to (and hence reduce) the benefits of liberalisation. In particular:
- An early full release would have very high costs, reduce the benefits of liberalisation and is very unlikely to be proportionate.
 - A late full release would significantly delay the benefits of liberalisation and it is unlikely that it would be consistent with timely implementation of the RSC Decision.
 - A phased full release may have some advantages compared to an early or late full release. However it is still very unlikely to be proportionate, particularly when compared to phased partial release options.
- 13.33 Finally, Ofcom's initial view is that in all cases the analysis suggests that full release is not required to address the competition and efficiency concerns identified with Option A. Rather it is likely that access to one block of 2x5MHz is sufficient to obtain the advantages of 900 MHz provided there is access to other higher frequency spectrum. Analysis in section 11 has suggested that the competition and efficiency benefits of more than five operators having access to 900 MHz (i.e. more than 3 blocks being released) are likely to be small. Accordingly, our current view is that it is not clear that there is a convincing case for release of all 7 blocks.

Question 13.1 Do you agree with Ofcom's assessment of the merits of Option D (Full Mandatory Spectrum Release) for the implementation of the RSC Decision in respect of the 900 MHz spectrum?

Section 14

Conclusion and next steps on implementation of RSC Decision

Introduction

- 14.1 This section summarises the assessment of the options for implementation of the RSC Decision analysed in sections 8-13 against Ofcom's statutory duties and objectives, compares these options and draws initial conclusions about the preferred approach.
- 14.2 The options considered are:
- A: Liberalisation of 900 MHz spectrum / 1800 MHz spectrum in the hands of the incumbent holders
 - B: Regulated roaming. Liberalisation of 900 MHz spectrum in the hands of the incumbent holders, but with a requirement to offer roaming to third parties
 - C: Partial mandatory spectrum release – mandatory release by incumbent holders of part of their 900 MHz spectrum to third parties, with liberalisation of their retained spectrum
 - D: Full release – mandatory release by incumbent holders of all of their current 900 MHz spectrum
- 14.3 The framework for assessing these options was set out in section 7 drawing on our legal duties as set out in section 4. In summary we consider the extent to which the options identified promote competition, secure efficient use of the electro-magnetic spectrum; and effect implementation of the RSC Decision in a timely manner. Ofcom also recognises its general duty to ensure that its actions are proportionate, non-discriminatory and transparent.
- 14.4 As discussed in section 5 there is a range of alternative scenarios for the development of the mobile sector. Whilst current industry trends suggest that consumer demand for mobile broadband services is a real possibility, it is not possible to be certain about how the market will develop in the future. Indeed, market participants appear to have different views about this and to adopt different commercial strategies accordingly. Ofcom has considered a number of scenarios in reaching its initial views. In order to illustrate the issues the table below sets out the likely impacts of different options in a low and high demand scenario. Ofcom's initial view is that it is quite plausible there will be significant growth for mobile broadband services in the future and therefore the impacts illustrated in the high demand scenario are more relevant than those in the low scenario in reaching its initial views on the merits of the options.
- 14.5 The 900 MHz and 1800 MHz spectrum are considered separately due to the significant differences between them, in terms of the spectrum characteristics, equipment availability and distribution of spectrum holdings. In particular, our

analysis suggests that 900 MHz spectrum provides significantly greater advantages over alternative higher frequency spectrum than 1800 MHz spectrum, and that there are likely to be competition and efficiency concerns with the current distribution of 900 MHz spectrum but not with 1800 MHz spectrum. So we first consider what is likely to be the appropriate option for dealing with 900 MHz spectrum and then consider 1800 MHz spectrum in the light of that.

Summary assessment of options for 900 MHz spectrum

- 14.6 The table below provides a summary of each of the options considered. This is followed by a brief discussion of our initial views with regard to each option (drawing on more detailed analysis in previous sections) and our initial view on the preferred option for 900 MHz spectrum.

Table 12: Summary assessment of options for implementation of RSC Decision for 900 MHz

| | Demand Scenario | Promotion of competition | Efficiency | Timely implementation of RSC Decision | Costs of implementation |
|---|-----------------|--|--|--|---|
| A: Liberalisation in the hands of the incumbents | Low | No major change to current level of competition | Some risk of inefficient extension of basic 3G services using higher frequencies | ✓ | Negligible |
| | High | Risk of significant weakening of competition or, at extreme, market exit | Very large inefficiency for operators remaining in market | ✓ | |
| B: Regulated Roaming | Low | Could lock-in market structure and limit network investment & innovation | Could have negative impact on dynamic efficiency. | ✓ | Intrusive ongoing intervention; regulatory risks in specification and pricing |
| | High | As low scenario, but could support retail competition. | As above, but could have productive efficiency advantages | | |
| C: Partial mandatory spectrum release: - 2 or 3 blocks in 2010 | Low | No change (as A) | Some benefits from wider access to 900 MHz for basic 3G services | ✓ | High one off costs. Estimated total costs at around: |
| | High | Promotes competition with very significant benefits to consumers. | Significant benefits from provision of high quality mobile broadband using 900 MHz | | 2 blocks £80-170m 3 blocks £200-770m |
| D: Full mandatory spectrum release - phased | Low | No change (as A) | Some benefits from wider access to 900 MHz for voice | (x) Clearance of all spectrum may in practice take too long | Likely to be very high costs; long implementation period |
| | High | Promotes competition in high quality mobile broadband services | Significant benefits from provision of high quality mobile broadband using 900 MHz but offset by inefficient forced extension of 2.1GHz networks for releasing operators | | |

Option A: Liberalisation in hands of incumbents

- 14.7 This option would involve 900 MHz spectrum being liberalised as soon as practical, perhaps 2008, in the hands of the incumbent holders of that spectrum without any further condition being imposed on them. This option was assessed in detail in section 8. Our initial view is that this is not an appropriate option due to the risk of significant negative impact on competition and/or efficiency if demand for mobile broadband develops. Ofcom consider this is a real possibility, and therefore our initial view is that such an approach to liberalisation is unlikely to fulfil our duties.

Option B: Regulated roaming

- 14.8 This option would involve Ofcom imposing a regulated roaming condition on the two incumbent holders of 900 MHz spectrum if they wanted liberalised use of 900 MHz. Ofcom's initial views are that this option:
- could bring some competitive advantages compared to Option A, although these would be mainly at the retail level and the level of infrastructure competition would be limited;
 - is an ongoing intrusive intervention with significant practical challenges to implement effectively;
 - may act as a disincentive for 900 MHz operators to deploy UMTS 900 networks.
- 14.9 Accordingly, Ofcom's initial view is that Option B is not the most appropriate or proportionate way to implement the RSC Decision for 900 MHz spectrum.

Option C: Partial mandatory spectrum release

- 14.10 This option would involve the mandatory release by incumbent holders of part of their 900 MHz spectrum to third parties, with the spectrum they retained being liberalised at the time of the release. In principle this addresses the heart of the competition and efficiency concerns associated with the current asymmetric distribution of the 900 MHz spectrum. A wide range of sub-options, including various quantity, timing and implementation options were analysed in sections 11 and 12. In summary, our initial view is that the release of two or three blocks in 2010 may be appropriate but three would be preferable.
- 14.11 Our initial view is that the preferred implementation approach would be to issue a revocation notice to the incumbent holders and hold an auction for the released spectrum, possibly as early as 2009. There would need to be some restrictions in the auction, including that the incumbent holders of 900 MHz spectrum could not participate, and that no more than one block could be acquired by any one participant.

Option D: Full mandatory spectrum release

- 14.12 This option would involve the mandatory release by incumbent holders of all of their 900 MHz spectrum and was considered in detail in section 13. Ofcom's initial view is that this approach would not be consistent with its duties, nor be proportionate. Having considered different timing options for full

spectrum release, it is likely to be disproportionate, cause unreasonable delay to, and hence significantly reduce, the benefits of liberalisation. In particular:

- Full release is unnecessary to address competition and efficiency concerns identified with Option A (the least intrusive approach)
- An early full release would have very high costs, is likely to be disproportionate and is likely to significantly reduce the benefits of liberalisation.
- A late full release would significantly delay and reduce the benefits of liberalisation and it is unlikely that it would be consistent with timely implementation of the RSC Decision.
- A phased full release may have some advantages compared to early or late full release. However it is still unlikely to be proportionate, particularly when compared to partial release options.

Initial views in relation to 900 MHz

- 14.13 Ofcom's initial view is that Option C - Partial mandatory spectrum release is the preferred option for implementing the RSC Decision in relation to 900 MHz spectrum in light of its duties and objectives. This is because it seems likely that it could effectively promote competition and efficient use of spectrum in the mobile sector by widening access to 900 MHz spectrum, and given the size and importance of the mobile sector these benefits could be very significant. Although there might be significant costs in clearing the spectrum to be released, the competition and efficiency benefits seem likely to materially outweigh these in any scenario in which demand develops for mobile broadband services with good indoor coverage to a greater extent than today.
- 14.14 However, the size of these benefits is uncertain largely because they depend on the future demand for these services. Hence, the main potential concern with mandating spectrum release is that it could incur a significant one-off cost without corresponding benefits if demand for mobile broadband does not develop.
- 14.15 Ofcom believes that a precautionary approach is sensible in light of this uncertainty. If spectrum release were not mandated, there is a risk of significant weakening of competition in the UK mobile sector, with potentially far-reaching adverse effects for consumers of mobile services. If spectrum release is mandated, there is a risk of a one-off cost being imposed without corresponding benefits. Ofcom's analysis suggests that the impact of the former risk being realised would be much greater than the impact of the latter.
- 14.16 Therefore our initial view is that requiring partial spectrum release is most likely to meet Ofcom's objectives given the uncertainty regarding the future market development.
- 14.17 Of the wide range of parameters for partial release, our analysis suggests the preferred form is likely to lie within the following parameters summarised in table 13 below.

Table 13: Summary of mandatory partial release (Option C) proposals for 900 MHz

| | |
|-------------------------------------|--|
| Quantity and timing | <ul style="list-style-type: none"> Two or three blocks, three blocks considered preferable Released in 2010 |
| Mechanism for implementation | <ul style="list-style-type: none"> Award of release spectrum (possibly in 2009 prior to date of release) Restrictions in award: <ul style="list-style-type: none"> Incumbents prevented from bidding in award Bidders cannot acquire more than one block each |
| Terms of released spectrum | <p>Similar to those established for other newly awarded spectrum:</p> <ul style="list-style-type: none"> Indefinite term with a minimum term of 15 years and thereafter subject to 5 years notice of revocation for spectrum management reasons. Technology and service neutral (subject to restrictions required for interference reasons) Tradable, with review of trades on competition grounds |
| Terms of retained spectrum | <ul style="list-style-type: none"> Liberalised in the hands of incumbent holders in 2010 at the same time as spectrum is released Indefinite but subject to 5 years notice of revocation for spectrum management reasons Technology and service neutral (subject to restrictions required for interference reasons) Tradable, with review of trades on competition grounds AIP for the retained spectrum to be reviewed in light of auction of released spectrum (if that approach is adopted) and other relevant information |

Summary assessment of options for 1800 MHz spectrum

14.18 A brief discussion of our initial views with regard to each option for 1800 MHz spectrum, drawing on earlier sections, is set out below. These options are considered in light of the proposals for implementing the RSC Decision for 900 MHz spectrum, i.e. some form of mandatory partial release of 900 MHz spectrum.

Option A: Liberalisation in the hands of the incumbents

14.19 The assessment of this option for 1800 MHz spectrum is different to that for 900 MHz spectrum. First, Ofcom's initial view is that there do not appear to be significant competition and efficiency issues arising from the current distribution of 1800 MHz spectrum. This is because:

- Although 1800 MHz spectrum provides some theoretical advantages over 2100 MHz, these are significantly lower than the advantages of 900 MHz spectrum and seem unlikely to be realised in practice due to lack of equipment availability and higher costs (particularly for handsets).
- 1800 MHz spectrum is currently held by four mobile operators and so there is already wider access than for 900 MHz spectrum.

- 14.20 Second, even if it were the case that wider access to 1800 MHz spectrum were more efficient, it is reasonable to expect the market to achieve that outcome through trading. Third, it seems likely that any benefits of wider access to 1800 MHz spectrum would be not be large in light of the proposed re-distribution of 900 MHz spectrum (ie partial release), which offers much greater advantages compared to higher frequencies than 1800 MHz spectrum does.
- 14.21 Therefore, it does not seem necessary or appropriate to seek through regulation to create wider access to 1800 MHz spectrum in order to realise the competition and efficiency benefits of liberalisation. This option is also low cost and less complex to implement and is therefore likely to be a proportionate means of implementing the RSC Decision.
- 14.22 Accordingly, Ofcom's initial view is that liberalising 1800 MHz spectrum in the hands of the incumbent holders is likely to be an appropriate method for implementing the RSC Decision for 1800 MHz spectrum. There does not seem to be a strong case for considering in detail other more interventionist options, as these are unlikely to be proportionate when a less interventionist approach can meet Ofcom's duties and objectives. These other options are therefore only briefly reviewed below.

Other options

- 14.23 **Option B: Regulated roaming** has the same disadvantages for 1800 MHz spectrum as discussed above for 900 MHz spectrum. In addition, it is more likely to be disproportionate because our initial view is that there is unlikely to be a competition and efficiency concern for it to address.
- 14.24 **Options C & D – Partial & full mandatory spectrum release.** Our initial view is that the costs of mandatory partial or full spectrum release are unlikely to be proportionate given that:
- the principal concerns motivating wider access to the 900 MHz spectrum do not appear to be present in the case of 1800 MHz spectrum; and
 - there is a less intrusive option, Option A (liberalisation in the hands of the incumbents), which seems adequately to satisfy our duties and objectives.

Initial views in relation to 1800 MHz spectrum

- 14.25 Our initial view is that liberalisation in the hands of the incumbents (Option A) is the preferred option for implementing the RSC Decision in relation to 1800 MHz spectrum. All other options seem disproportionate given that liberalisation of 1800 MHz spectrum does not appear to present a significant risk of competition and efficiency concerns.
- 14.26 Our proposals for implementing this option are in summary:
- The existing licences for 1800 MHz spectrum would be liberalised so the spectrum could be used for 3G and other technologies. This would occur as soon as feasible, probably in 2008 or 2009.
 - Those licences would be made tradable and their tenure made indefinite subject to appropriate terms for revocation.

- AIP for the retained spectrum would be reviewed.

Next steps & implementation

14.27 To illustrate what the next steps might be for implementing the proposals discussed above, an example timeline is outlined in the table below. The actual implementation will be dependent on the responses to, and outcome of this consultation.

Table 14: Possible timetable for implementation of RSC Decision if Ofcom's preferred options are adopted

| | |
|------|--|
| 2008 | <ul style="list-style-type: none"> • Statement setting out our approach for implementation of the RSC Decision • Consultation on award of released 900 MHz spectrum and other implementation issues • Issue of relevant revocation and variations notices to incumbent 900 MHz and 1800 MHz operators |
| 2009 | <ul style="list-style-type: none"> • Possible auction of licences for released 900 MHz spectrum |
| 2010 | <ul style="list-style-type: none"> • Release of 900 MHz spectrum by incumbents and available for use by winners of the award process • Liberalisation of incumbents' 900 MHz licences |

Question 14.1 Do you agree with Ofcom's proposals for the implementation of the RSC Decision in relation to the 900 MHz spectrum?

Question 14.2 Do you agree with Ofcom's proposals for the implementation of the RSC Decision in relation to the 1800 MHz spectrum?

Section 15

Other issues relating to 900 MHz and 1800 MHz Spectrum

15.1 This section briefly discusses other issues associated with the 900 MHz and 1800 MHz spectrum, namely:

- the scope of liberalisation of that spectrum;
- the application of spectrum trading to the licences for that spectrum

Scope of liberalisation of 900 & 1800 MHz Spectrum

15.2 As explained in Section 3 above, the RSC Decision gives Member States the option of making the 900 MHz and 1800 MHz spectrum available for technologies other than GSM and UMTS. This Section sets out an initial consideration of whether Ofcom should choose to exercise that option.

15.3 The RSC Decision requires that any systems other than GSM and UMTS may only be authorised to use the spectrum provided that they can co-exist with GSM and UMTS both in the UK and in neighbouring Member States. Ofcom has not yet undertaken detailed technical work to consider the feasibility of other systems using the spectrum. However, its initial view is that the requirements of the RSC Decision are likely to mean that only other mobile FDD technologies that respect the same uplink/downlink arrangements as current GSM use could use the spectrum. This is because if other duplex arrangements were allowed this would be likely to cause interference such that the spectrum could not be effectively used by GSM and or FDD UMTS technologies.

Liberalisation is likely to bring benefits

15.4 Ofcom believes in general a technology neutral approach to licensing is likely to bring greater benefits to consumers and citizens than a technology specific approach. Accordingly it has developed the policy of liberalisation of spectrum which is already licensed and of awarding technology neutral licences in the case of new spectrum. This approach has been described elsewhere, see for example in the Spectrum Framework Review published in November 2004, and the SFRIP.

15.5 In the case of the 900 MHz and 1800 MHz spectrum Ofcom's initial view is that it is likely not to be necessary to restrict use of the spectrum to FDD UMTS and GSM provided that any other technologies allowed to use the spectrum respected the same general duplex arrangements. Ofcom believes that such a technology neutral approach would create the opportunity for other technologies to use the spectrum may create benefits for citizens and consumers. In particular it may create the potential for further innovation.

15.6 Accordingly, it is Ofcom's initial view that it should adopt a technology neutral licensing approach to the 900 MHz and 1800 MHz spectrum, subject to a restriction that the technologies must be FDD and follow the same duplex

arrangements as current GSM use (i.e. uplink/downlink directions) and so exercise the option created by the RSC Decision to authorise other technologies to use the spectrum. The next section considers some alternative approaches for how this might be done.

Technology neutral licensing - possible approaches to implementation

- 15.7 Before discussing possible approaches it is important to note that work being undertaken at a European level under the WAPECS mandate may impact on how the UK authorises technologies other than GSM and UMTS in the 900 MHz and 1800 MHz spectrum.
- 15.8 The CEPT interim report on minimal and least restrictive technical conditions for WAPECS provides information on the conditions for co-existence between GSM and UMTS in the 900 and 1800 MHz bands and establishes that these two technologies can co-exist (under most circumstances) provided that minimum carrier separation is maintained. Further study in CEPT may lead to the extension of this work to demonstrate how other technologies may co-exist with GSM and UMTS in the 900 MHz and 1800 MHz and Ofcom will need to take any developments on this topic into consideration when making decisions on technology neutral licence conditions.
- 15.9 Ofcom's initial consideration of the issue of how to introduce technology neutral licences for the 900 MHz and 1800 MHz spectrum has led it to identify 2 possible approaches.
- Approach A: technology neutral licences including full specification of technical conditions introduced at the outset
 - Approach B: initially licences only allow GSM and UMTS but use by other technologies implemented by licence variation on a case by case basis
- 15.10 The key advantage of Approach A is that it significantly reduces the need for subsequent regulatory action and creates a high degree of regulatory certainty regarding the potential uses of the spectrum. The difficulty with this approach is that it may be difficult to specify a full set of technology neutral usage rights for the spectrum given the uncertainty over the other potential technologies which might use the spectrum. This means that it may be difficult to set out in advance at this stage the necessary technical conditions and there is a risk that uncertainty might lead to an overly restrictive approach. This approach might also lead to a delay in the making the spectrum available for UMTS while the technical issues relating to other uses were being resolved.
- 15.11 Approach B is the simplest approach to implement. Under this approach the licences would only permit GSM and UMTS use and any other use would only be allowed after a licence variation request has been received and approved by Ofcom. The onus would be on the licensee to bring forward proposals for alternative use which Ofcom would then assess. The key disadvantage with this approach is that it gives little regulatory certainty regarding the deployment of other technologies which may create disincentives and delays to innovation.
- 15.12 Ofcom's initial view is that Approach A is likely to be preferable as it gives the market more regulatory certainty and creates less disincentive to innovation

provided that by adopting it would not lead to a material delay in making the spectrum available for UMTS.

Question 15.1 Do you think that Ofcom should make the 900 and 1800 MHz spectrum available for systems other than GSM and UMTS? If so, for what systems, on what timescale and by what mechanism?

Spectrum trading of licences for 900 MHz & 1800 MHz spectrum

15.13 Alongside the implementation of the RSC Decision discussed in previous sections of this consultation, Ofcom is considering whether to extend its policy of making spectrum tradable to the licences held for 900 MHz and 1800 MHz spectrum.

15.14 Making spectrum tradable has been identified as a key component of Ofcom's overall strategy towards the management of the radio spectrum. The likely benefits that may be created by the introduction of spectrum trading have been identified in other publications (see Spectrum Trading Statement, published in August 2004). In summary as set out in the SFRIP Ofcom considers that:

“Spectrum trading allows the transfer of rights and obligations arising under licences. It therefore allows the market rather than the regulator to determine who uses spectrum. Ofcom considers that spectrum trading will help to optimise the use of the finite spectrum resource for the benefit of UK citizens and consumers.”

15.15 In the SFRIP Ofcom also set out its view that the extension of trading to 900 MHz and 1800 MHz spectrum is likely in due course to bring benefits to citizens and consumers. However that the introduction of trading should be considered alongside the wider questions of liberalisation of the spectrum. (see paragraphs 9.64-9.67 of SFRIP). Responses to the SFRIP on this issue are discussed in Annex 11.

15.16 It remains Ofcom's view that the introduction of trading has the potential to bring benefits to consumers and citizens and that it should be considered in parallel with the liberalisation of the spectrum as that fundamentally affects the nature of the licences which would be tradable. Accordingly, Ofcom proposes to introduce trading for licences of the 900 MHz and 1800 MHz spectrum when it carries out the necessary licence variations and other actions required to implement the RSC Decision for each band. Given Ofcom's provisional conclusion of the competition issues associated with acquisition of the 900 MHz spectrum, in Section 12 Ofcom suggested the potential need for trades of 900 MHz spectrum to be subject to a competition assessment prior to being approved.

15.17 Ofcom envisages that it will make more detailed proposals on the introduction of spectrum trading including the draft regulations at a later point.

Q 15.2: Do you believe that licences for the 900 and 1800 MHz spectrum should be made tradable? If so, on what timescale and should trading be subject to any competition restrictions ?

Section 16

Application of spectrum trading & liberalisation to licences for 2100 MHz Spectrum

- 16.1 The main focus of this document has been on the issues surrounding the application of the policies of spectrum liberalisation and trading to 900 MHz and 1800 MHz spectrum in the light of the requirement to implement the RSC Decision. This Section briefly considers the position of the licences for the 2100 MHz spectrum.
- 16.2 As explained in Section 5 above the licences for the 2100 MHz spectrum were awarded in 2000. The key characteristics are the following:
- They were awarded by auction.
 - They are technologically specific: 1920 - 1980 MHz paired with 2110 – 2170 MHz specified for FDD UMTS use; 1900 - 1920 MHz specified for TDD UMTS use.
 - They are not tradable at present.
 - They contain a rollout obligation requiring licence holders to provide UMTS 3G services to 80% of the population by the end of 2007 and maintain such coverage.
 - They are for a fixed term of 21 years.

Possible liberalisation of 2.1 GHz licences

- 16.3 At present there is no international measure requiring Ofcom to make 2.1 GHz spectrum available for alternative uses as is now the case for 900 MHz and 1800 MHz spectrum. At the same time there is at present no international harmonisation measure which would prevent the authorisation of use of the spectrum for uses other than UMTS. Therefore Ofcom considers that it is open to it to remove the technology restrictions which exist in the existing licences for 2.1 GHz but that it is under no obligation to do so.
- 16.4 An initial consideration of the impact of liberalisation of existing licences for 2.1 GHz suggests competition and efficiency issues of the significance as identified in relation to the 900 MHz spectrum (see Sections 6, 8, 10 -14 above) are unlikely to exist in relation to liberalising the 2.1 GHz spectrum. This is because of the nature of the spectrum, the fact that it was awarded by auction and that it is relatively symmetrically held by all the existing competitors for the provision of 3G services. Accordingly, Ofcom's current expectation is that liberalisation of 2.1 GHz is unlikely to raise the same issues regarding spectrum release as discussed above in relation to the 900 MHz spectrum and so it may be possible to implement liberalisation through a simpler approach of removing the restrictions in the licences in the hands of the existing holders.

- 16.5 While in general Ofcom believes that liberalisation is likely to bring benefits to citizens and consumers, it is not aware of any specific need to bring about liberalisation of 2.1 GHz spectrum at present. For example it is not aware of any uses of the spectrum that licensees might wish to deploy but that restrictions in the licences would prevent. Ofcom is also aware that the future conditions of use that apply to harmonised bands are the subject of active consideration in various European fora, for example CEPT SE 42 project team and EU institutions. Ofcom will wish to monitor developments in these fora carefully and take full account of these international discussions before making any decisions in relation to the 2.1 GHz band. Accordingly, at this stage, it is not making any specific proposals to bring about the liberalisation of 2.1 GHz licences but would welcome views on whether there is a need to do so.

Extension of trading to licences for 2.1 GHz

- 16.6 There is also the question of whether the licences for 2.1 GHz should be made tradable. In principle Ofcom believes that spectrum trading is likely to bring benefits to consumers and citizens and it sees no reasons why this should not apply to the licences for 2.1 GHz. As with any trade Ofcom would have to consider on a case by case basis whether after the trade the licence conditions can be fulfilled and this may be particularly relevant to these licences given the roll out obligation. Ofcom is proposing to introduce trading for these licences following this consultation.

Question 16.1 Do you believe that the licences for 2.1 GHz should be liberalised and if so on what timescale?

Question 16.2 Do you believe that the licences for 2.1 GHz should be made tradable and if so on what timescale?