



Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues

Consultation

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Section 1

Executive summary

- 1.1 This consultation sets out our proposals for the largest ever single award in the UK, of internationally harmonised mobile spectrum – the 800MHz and 2.6GHz bands. We expect this spectrum to be used to deliver the next generation of mobile broadband services, using fourth generation (4G) mobile technologies such as LTE and WiMAX. These mobile broadband services might have speeds approaching today's fixed broadband services, with coverage significantly better than today's 3G coverage instead approaching today's 2G (voice) coverage.
- 1.2 The award of this spectrum is vital to the UK's economic and social growth. It will enable mobile operators to meet the significant growth in demand for mobile data. This is being fuelled by growth in the take up of smart phones and tablets, offering services such as video streaming, social networking and mobile gaming, as well as applications such as messaging and email.
- 1.3 Access to this spectrum is expected to be vital to the future commercial success of existing and prospective new entrant mobile network operators. The proposals set out in this consultation are likely to shape the future competitiveness of the mobile sector for at least the next decade. We set out in this consultation document our assessment of the impact of the distribution of spectrum on future competition in mobile markets, and our proposals for the rules that should apply, in the auction and more generally, to promote competition.
- 1.4 Part of this spectrum – the 800 MHz band – is also expected to be key to the economic delivery of next generation mobile broadband services in less densely populated areas. This award therefore represents an important opportunity to ensure that such services are made available in less urban areas, as well as in the more commercially attractive more densely populated areas. This consultation therefore also sets out proposals for how we might ensure that next generation mobile broadband services are available throughout the UK for the benefit of citizens and consumers.

Background

- 1.5 The two bands of spectrum to be awarded at 800 MHz and 2.6 GHz comprise 250 MHz of mobile spectrum. This is equivalent to three-quarters of the mobile spectrum in use today and 80% more than was awarded through the 3G auction in 2000.
- 1.6 The lower frequency 800 MHz band is part of the digital dividend, which is being freed-up as the UK switches from analogue to digital TV. This spectrum is ideal for wide-spread and indoor mobile coverage. The 2.6 GHz band is at a higher frequency, and is ideal for delivering the capacity needed to deliver higher speeds and provide services simultaneously to many users. The combination of low and high frequency spectrum creates the potential for next generation mobile broadband services to be widely available across the UK, while at the same time having the capacity to cope with significant demand, even in urban centres.

- 1.7 This consultation is about how Ofcom should award this new spectrum in a way that secures the best use for the benefit of citizens and consumers.
- 1.8 The award of the 800 MHz and 2.6 GHz bands was referred to in the Government's Direction to Ofcom made in December 2010¹ (the Direction). The Direction requires us to:
- assess likely future competition in markets for the provision of mobile electronic communication services after the conclusion of the award of 800 MHz and 2.6 GHz bands;
 - hold an auction of the 800 MHz and 2.6 GHz bands as soon as reasonably practicable after concluding the competition assessment;
 - revise the annual licence fees paid for 900 MHz and 1800 MHz to reflect full market value having particular regard to the sums bid for licences in the 800 MHz and 2.6 GHz auction.
- 1.9 This consultation document is the first in a series. It sets out our competition assessment and proposals for how to award the available spectrum at 800 MHz and 2.6 GHz and for how to authorise the use of new technologies in mobile bands that are currently in use for 2G and 3G, at 900 MHz, 1800 MHz and 2.1 GHz. We have developed these proposals so as to fulfil the requirements of the Direction and maximise benefits to citizens and consumers from spectrum use, consistent with our statutory duties.
- 1.10 This consultation document contains proposals for the award in the following areas:
- a) how to promote competition in mobile markets following the auction;
 - b) whether to include rollout or coverage obligations in the new licences;
 - c) what non-technical licence conditions are likely to promote optimal use of this spectrum;
 - d) which spectrum packaging and auction design are likely to support the most efficient assignment of spectrum; and
 - e) how to set annual licence fees for 900 MHz and 1800 MHz spectrum in accordance with the Direction.
- 1.11 Further documents will follow as part of the preparations for the award. These will cover specific technical issues, in particular our proposals for technical conditions to manage the risk of interference into uses that are adjacent to the 800 MHz and 2.6 GHz bands including Digital Terrestrial Television (DTT). We also expect to provide further updates on our programme of spectrum clearance in the 800 MHz band and the radar modification programme at 2.7 GHz.
- 1.12 The purpose of this consultation is to seek input from stakeholders and any other interested parties. In particular, whilst this consultation document contains a number of specific questions, we are not seeking to limit the issues on which respondents

¹ The Wireless Telegraphy Act 2006 (Directions to OFCOM) Order 2010 (S.I.2010 No. 3024) which can be found at: <http://www.legislation.gov.uk/ukSI/2010/3024/contents/made>

may wish to comment and respondents are invited to include representations on any issues which they consider to be relevant.

Promoting future competition in mobile markets

- 1.13 We have carried out a competition assessment as required by the Direction and as a consequence considered carefully whether it would be appropriate for us to put in place measures in the auction of the 800 MHz and 2.6 GHz bands to promote competition. We consider that there are risks to future competition if bidders could bid for and acquire any amount of spectrum in an open auction and these are sufficient to justify putting in place measures designed to promote competition.
- 1.14 We believe that competition at the national wholesale level is essential to future competition in mobile markets and to maximising consumer and citizen benefits. To be a credible national wholesaler, a competitor is likely to need enough spectrum of the right kind to be able to run a national network of their own or to negotiate a network sharing deal with a national competitor. Our analysis suggests that future competition between credible national wholesalers could be at risk if we do not take action now to promote competition through measures in the award of 800 MHz and 2.6 GHz.
- 1.15 We are proposing to promote competition at the national wholesale level in two main ways.
- 1.16 First we propose to ensure that after the auction, subject to demand, there are at least four holders of a minimum spectrum portfolio that mean they are credibly capable of providing high quality data services in the future. We currently believe that to be a credible national wholesaler an operator is likely to need at least as much spectrum as one of the following minimum spectrum portfolios. This is however a matter on which we are particularly keen to receive views and evidence from stakeholders in response to this consultation.
- a) 2x5 MHz of sub-1 GHz spectrum and 2x20 MHz of 2.6 GHz spectrum; or
 - b) 2x5 MHz of sub-1 GHz spectrum and 2x15 MHz of 1800 MHz spectrum; or
 - c) 2x10 MHz of sub-1 GHz spectrum and 2x15 MHz of 2.6 GHz spectrum; or
 - d) 2x10 MHz of sub-1 GHz spectrum and 2x10 MHz of 1800 MHz spectrum; or
 - e) 2x15 MHz of sub-1 GHz spectrum.
- 1.17 We propose to implement this through use of spectrum 'floors' in the auction. This involves disregarding any potential auction outcome in which a minimum number of licensees (currently proposed to be four) do not win at least the minimum amount of spectrum. We expect competition in the auction to determine how much spectrum each bidder in fact wins and anticipate that this may well exceed the minimum that we propose to set, but we nevertheless consider it important for competition that we put in place this back-stop provision.
- 1.18 Second we propose to set safeguard spectrum caps. These would place restrictions on the amount of spectrum each participant could win in the auction. The proposed caps are a maximum of 2x27.5 MHz of sub-1 GHz spectrum and 2x105 MHz of mobile spectrum in total. These proposals are intended to provide flexibility to bidders

to express their preferences, while preventing highly asymmetric outcomes that might distort competition in the future.

- 1.19 We have also considered the potential for market entry. In proposing a minimum of four licensees capable of being credible national wholesalers it is important to realise that we are not ruling out the potential for some of those licensees to be new national wholesale entrants. We would not be surprised if one or more prospective new entrants were to bid for the minimum spectrum portfolios that we have identified; for example in the recent 800 MHz auction in Sweden two of the bidders were prospective new entrants. Our proposals are neutral as to the identity of the four licensees; they seek to provide all parties with equality of opportunity to bid for sufficient spectrum to be credible national wholesalers in the future.
- 1.20 We have also received suggestions that entry by sub-national vertically integrated operators might be possible and of interest to some companies, and that this could bring benefits to consumers through increased competition and innovation. It has been suggested that such operators would need access to sufficient spectrum to deliver competitive mobile services indoors and in localised outdoor environments such as campuses. The suggestion is that a number of such operators could share a block of 2.6 GHz spectrum. They may also need to secure wholesale access to services provided by a national wholesaler to complete their coverage.
- 1.21 We believe that there is a good case for ensuring that bidders with an interest in such shared low-power use can compete in the auction with those bidders who have an interest in individual high-power use, for access to at least a part of the 2.6GHz spectrum. We include proposals for how this might be achieved in this consultation.
- 1.22 We furthermore believe that there may be benefits for consumers in taking measures in the auction to actually reserve spectrum some spectrum at 2.6 GHz for such shared low-power use, although the extent of such benefits is uncertain. Any reservation might however impose costs, such as reducing the opportunity for other bidders to win large contiguous blocks of 2.6 GHz spectrum, which may affect their ability to offer high speed services. At this stage, we believe it is unclear whether the benefits would outweigh such costs. As a result we have set out a number of options for consultation on this issue.
- 1.23 We are also proposing to liberalise the use of mobile frequencies at 900 MHz, 1800 MHz and 2.1 GHz for LTE and other technologies at the earliest opportunity, following the conclusion of discussions in European groups. We consider that this would be likely to be in the interests of consumers, and do not believe that it would raise competition issues not already addressed through the measures we propose to put in place to promote competition set out above.

Promoting the availability of future mobile services for citizens and consumers

- 1.24 We expect that over time new mobile services using LTE and possibly other advanced technologies will become available to a large proportion of the UK population as a result of the competitive market we are seeking to promote. However, the speed at which such services are provided across the UK is uncertain. Moreover, there will always be limits to the extent and depth of coverage that will be commercially viable for any mobile network; although it is difficult for us to anticipate in advance what that level might be.

- 1.25 It is possible for us to include coverage obligations in auctioned licences to require certain minimum levels of coverage to be achieved by certain dates. We believe that there is a case for doing so in this case in order to guarantee a minimum coverage level for consumers and citizens. But in specifying the obligation, it is necessary to ensure that it is proportionate and does not impose too great a cost relative to its benefits.
- 1.26 We propose to include a coverage obligation in one licence for the 800 MHz spectrum to deploy an electronic communications network that is capable of providing mobile telecommunications services with a sustained downlink speed of not less than 2Mbps with a 90% probability of indoor reception to an area within which at least 95% of the UK population lives. We believe this should result in coverage of future mobile broadband services that approaches today's 2G coverage by the end of 2017. We consider that such an obligation would be proportionate taking in to account the likely costs and benefits. A key question on which we are seeking views from stakeholders is the best way to specify such an obligation, in particular as regards coverage in more rural areas.
- 1.27 We have also considered whether the award of 800 MHz and 2.6 GHz should play a role in addressing existing mobile not-spots, particular for voice coverage. We consider that improving today's mobile coverage, in particular for voice, has the potential to benefit consumers and citizens in areas currently not covered, not least in terms of basic social communications, safety and security and dealing with emergency situations. We are already pursuing a number of initiatives in this area, namely facilitation of discussions to address railway co-ordination problems, research on the extent of specific short falls in road coverage, and improved consumer information. In addition we will shortly be taking forward a new strand of work to better understand the costs and benefits of more comprehensive solutions to existing voice not-spots, and to assess the different mechanisms available to us to bring these about. Options which we will consider as part of this work include, for example, variations to existing licences possibly combined with amendments to spectrum licence fees. We will bring forward proposals on this later this year. For these and other reasons we are therefore proposing not to use the award to address existing voice not-spot issues.
- 1.28 We are also consulting on the possibility of retaining the power to partially revoke the awarded licences in specific circumstances, even during the initial period of 20 years. The specific circumstances of concern are where the spectrum is needed to meet a specific public policy goal (such as the provision of broadband in rural areas), the spectrum is unused, and the licensee is unable to unwilling to provide the required service even when offered appropriate funding.

Non-technical licence conditions to promote optimal spectrum use

- 1.29 Our proposals for non-technical conditions are consistent with our previous approach to licences granted through auction. We consider that the licences in this award should be UK-wide and technology and service neutral. We propose that all types of spectrum trading should be permitted for individual high-power licences, subject to a review of the impact of the proposed trade on competition; in the case of concurrent low-power licences at 2.6 GHz (if any), only those types of trades that do not increase the number of licensees in the band would be permitted.
- 1.30 We propose that the licences be of indefinite duration, continuing in force until relinquished or revoked. During the initial period of 20 years our powers to revoke a licence would be limited to specific circumstances, and would not include the power

to revoke for spectrum management reasons. Thereafter we would be able to revoke a licence for spectrum management reasons on five years' notice.

- 1.31 We also plan to include conditions in the licences requiring licensees to provide us with information regarding their use of the licensed frequencies. We may publish this information in order to promote opportunities for more efficient use of spectrum and to facilitate potential spectrum trades.

A combinatorial clock auction with generic lots for bidders to aggregate

- 1.32 The competitive process through which we propose to assign the rights to use the 800 MHz and 2.6 GHz bands is a combinatorial clock auction. This follows the broad structure that we have previously used for two auctions (L-band and 10 to 40 GHz, both in 2008) and that we had put forward in 2008 for a stand-alone award of the 2.6 GHz band.
- 1.33 We have further developed this structure with some specific rules for the circumstances of this award, particularly to implement our proposals to promote competition through at least a minimum number of holders of spectrum portfolios that we consider necessary to be a credible national wholesale service provider.
- 1.34 We propose to make the spectrum available in the auction in as generic a way as possible, subject to technical conditions, in lot sizes that are consistent with the sizes of likely usage requirements. This means having several categories of 2x5 MHz lots at 800 MHz, a single category of 2x10 MHz lots for individual high power use at 2.6 GHz, and a potential category for low-power use by up to 10 concurrent licensees at 2.6 GHz.
- 1.35 We are still investigating the precise nature and extent of technical restrictions that are likely to apply to the available spectrum, so we have put forward an illustrative packaging arrangement for the purpose of this consultation.
- 1.36 We are not proposing to allow relinquishment of 900 MHz or 1800 MHz spectrum through the auction, but we have included proposals for how this would work if there were a case for doing so.
- 1.37 The circumstances of this auction may also justify a particular approach to reserve prices to guard against certain inefficiency risks. Such an approach would lead to reserve prices that would be higher than under our previous approach of using a value that is just sufficient to deter frivolous bidding. They may be based on a principle of recovering the costs of activities to clear the spectrum and/or some estimate of the likely value of the spectrum.
- 1.38 We are planning to hold the auction as soon as practicable, which we currently anticipate to be the first half of 2012.

Annual licence fees for 900 MHz and 1800 MHz spectrum that reflect full market value

- 1.39 The Direction requires us to revise the level of annual licence fees for 900 MHz and 1800 MHz spectrum to reflect full market value, having particular regard to the sums bid for licences in the auction for the 800 MHz and 2.6 GHz bands.

- 1.40 We envisage that the bids in the auction will provide the relevant basis for setting these fees as they are likely to provide the most reliable source of information on the value of similar spectrum.
- 1.41 We have developed detailed proposals for determining the revised fees, which are set out in this consultation. They comprise two principal steps. The first step is to identify lump sum amounts from the auction that provide an estimate of the full market value of various spectrum bands, from which we can derive annual fees. The second step is to convert this lump sum information into annual licence fees in constant real terms (i.e. annual fees indexed on a measure of inflation).
- 1.42 We are including a discussion of these issues in this consultation as we believe stakeholders are likely to wish to understand the likely approach ahead of the auction. However, we believe that we cannot reasonably decide on the final approach until after the auction and plan to consult again accordingly at that time.

Next steps

- 1.43 We are inviting responses to this consultation by 31 May 2011. We plan to hold a number of events during this period, to present our proposals and receive early feedback from stakeholders.
- 1.44 We are also planning to publish one or more consultation documents relevant to this award in the next few months covering:
- our detailed proposals for the steps to be taken to protect adjacent DTT use; and
 - our proposals for the technical conditions more generally for use of the 800 MHz and 2.6 GHz bands, including a review of adjacency conditions.
- 1.45 Following these consultations, and subject to stakeholders' comments, we plan to set out our decision for the award in a statement in the autumn. Alongside that statement, we plan to publish draft auction regulations for statutory consultation.
- 1.46 We will then make the auction regulations as soon as practicable thereafter. We will aim to start the award process at the earliest opportunity, having given sufficient time for potential participants to prepare. We expect that the process would start in the first quarter of 2012 with the submission of applications by prospective bidders.

Section 2

Introduction

Introduction and summary

- 2.1 This consultation sets out proposals for the award (the combined award) of Wireless Telegraphy licences for the use of 790 to 862 MHz (the 800 MHz band) and 2500 MHz to 2690 MHz (the 2.6 GHz band). In this section we set out the background to the combined award and the scope of this consultation.

Background to the award

800 MHz band

- 2.2 The 800 MHz band forms part of the UK's digital dividend, which is the spectrum freed up for new uses by the switchover of terrestrial television transmissions from analogue to digital. The band, together with the so-called 600 MHz band, is that part of the digital dividend to be cleared of television use. This so-called 'cleared spectrum', under the original plan for the digital dividend awards, comprised two bands - 550 to 630 MHz and 806 to 854 MHz, and in June 2008 we published a consultation on the detailed design for these bands. That consultation raised a number of complex issues, particularly on technical licence conditions, spectrum packaging and award design, and we anticipated a further consultation later in 2008. At that time we expected the award to begin in summer 2009.
- 2.3 During this process it became increasingly clear that a critical mass of European countries were also creating a digital dividend, but with a single larger upper band of cleared spectrum than we had been planning. This extended band comprised 72 MHz at 790 to 862 MHz. On 2 February 2009 we published a consultation² that considered the costs and benefits for the UK of aligning the upper band of our digital dividend with that of other European countries. We expected very substantial net benefits to UK citizens and consumers from making this change, estimating them conservatively at £2bn to £3bn in net present value. However, making the change had important implications, in particular from the need to clear planned DTT and PMSE use from channels 61 to 62 and channel 69 respectively (i.e. the channels at the bottom and top of the 800 MHz band). We considered the cost of clearing these channels would be modest (£90m to £200m) compared to the expected benefits and proposed to proceed with their clearance.
- 2.4 The responses to the consultation broadly supported or accepted the proposal and in June 2009 we published a statement³ setting out our decision to clear channels 61, 62 and 69 and to award the 800 MHz band separately from the lower band of cleared spectrum. In looking at the next steps, we said we would need to consider the timetable for the Government's Digital Britain process (see below paragraphs 2.11ff) and expected to be in a position in late autumn 2009 to set out how we proposed to proceed with the award of the 800 MHz band.
- 2.5 All relevant documents on the previously proposed award of the 800 MHz band can be found at <http://stakeholders.ofcom.org.uk/spectrum/project-pages/ddr/>.

² <http://stakeholders.ofcom.org.uk/binaries/consultations/800mhz/summary/800mhz.pdf>

³ <http://stakeholders.ofcom.org.uk/consultations/800mhz/statement/>

- 2.6 In 2010, the European Commission adopted the text of a decision that aims to harmonise the technical conditions for the availability and efficient use of the 800 MHz band. This decision is binding on Member States if they decide to make the band available, and in that case requires them to do so on a non-exclusive basis for terrestrial systems capable of providing electronic communications services, subject to a number of specified technical parameters relating to harmful interference.

2.6 GHz band

- 2.7 In January 2005 we set out our proposal to award the 2.6 GHz band in the Spectrum Framework Review: Implementation Plan⁴. At that time there were continuing discussions at a European level on possible harmonisation measures and we intended to prepare detailed proposals for the award of the band when the European discussions had been concluded.
- 2.8 In 2006 we started detailed work on the award of the band, inviting stakeholders to submit evidence and views in preparation for the publication of detailed consultation proposals. We developed and refined our proposals on the award - in terms of our general approach, the technical and non-technical licence conditions and the auction rules - through three consultations (in December 2006, August 2007 and December 2007) and a series of seminars and meetings with interested parties.
- 2.9 This work culminated with the publication of a statement⁵ on 4 April 2008 that set out our decisions on the award of both the 2.6 GHz band and the 2010 to 2025 MHz band and explained the way in which the award would be structured and the conditions that would be attached to the licences. We expected the application date for the award to be in July or August 2008. Following the publication of the Government's Digital Britain report, we withdrew our decision to hold the award at that time.
- 2.10 All relevant documents on the previously proposed award of the 2.6 GHz band can be found at http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-in-preparation/award_2010/.

Government direction to Ofcom

- 2.11 In January 2009 the Government published its interim Digital Britain report⁶ setting out a series of actions designed to maximise the opportunities for the UK in the digital age. It identified a complex set of challenges that it considered were hindering the release of spectrum for next generation broadband services and appointed an independent spectrum broker (ISB) to examine possible solutions to these challenges. The ISB's report was published in May 2009 and in the Government's final Digital Britain report⁷ it indicated it was minded to implement the ISB's proposals, subject to further work designed to address a number of issues. One of the proposals was that Ofcom should conduct a combined auction of 800 MHz and 2.6 GHz spectrum. The ISB also proposed that the 2G and 3G licences should be liberalised in the hands of existing licensees.

⁴ <http://stakeholders.ofcom.org.uk/consultations/sfrip/>

⁵ <http://stakeholders.ofcom.org.uk/binaries/consultations/2ghzrules/statement/statement.pdf>

⁶

http://webarchive.nationalarchives.gov.uk/20100511084737/http://www.culture.gov.uk/what_we_do/broadcasting/5944.aspx

⁷ <http://www.bis.gov.uk/assets/biscore/corporate/docs/d/digital-britain-final-report.pdf>

- 2.12 The Government noted that there was an option to direct Ofcom to implement any decision to take forward the proposals and that it would be obliged to consult on any such direction. Following the ISB's final report it decided to proceed in this way. On 16 October 2009 it published its consultation⁸ on a *Direction to Ofcom to Implement the Wireless Radio Spectrum Modernisation Programme*. This consultation proposed that a combined auction for 2.6 GHz and 800 MHz be conducted without delay after the direction was in place. In March 2010, the Government published its response to the consultation⁹ and subsequently laid a draft statutory instrument before Parliament in March 2010 directing Ofcom to undertake a number of measures including the auctioning of 2.6 GHz and 800 MHz. The direction was however not considered by Parliament prior to the General Election.
- 2.13 Following the Election the Coalition Government decided to make a revised direction comprising a sub-set of the proposals set out in the previous draft. A revised draft direction was laid before Parliament in July 2010. The Direction was made on 20 December 2010 and came into force ten days after being made.
- 2.14 Proposals in this consultation are designed (among other things) to give effect to a number of provisions in the Direction.

Scope of the consultation

- 2.15 This consultation covers five inter-linked areas:
- an assessment of future competition in mobile markets;
 - a consideration of how to secure adequate mobile coverage;
 - detailed proposals for the design of the combined award;
 - consideration of the variation of existing 2G and 3G licences to permit the use of LTE (Long Term Evolution) and WiMAX (Worldwide Interoperability for Microwave Access) technology; and
 - how licence fees will be set for 900 MHz and 1800 MHz after the auction.
- 2.16 This consultation does not cover the potential for mobile use of the 800 MHz band to cause interference to adjacent users, in particular Digital Terrestrial Television (DTT) or the means by which such interference might be mitigated. That will be covered in a separate consultation that we intend to publish. We will also publish a separate consultation setting out our proposals for the technical licence conditions that should apply to use of the 800 MHz and 2.6 GHz bands.

Competition assessment

- 2.17 The Direction requires us to assess likely future competition in markets for the provision of mobile electronic communications services after the conclusion of the award. We are required to take into account possible effects of the award on that future competition. The Direction requires us to put in place measures to promote competition in the relevant markets, if we think it fit to do so and those measures are appropriate and proportionate. Such measures may include rules governing the

⁸ <http://www.bis.gov.uk/consultations/ofcom-wireless-modernisation-programme>

⁹ <http://www.bis.gov.uk/assets/biscore/business-sectors/docs/10-737-government-response-consultation-ofcom-implement-spectrum-modernisation>

auction. We are also expressly required to consider the potential for new entry into the markets for these services. Our proposals must be consistent with our statutory duties.

The combined award of 800 MHz and 2.6 GHz

2.18 The design of the award has numerous aspects, which in broad terms come under the following headings:

- definition of the spectrum that is the subject of the award;
- the procedure for awarding licences, including the auction design and payment arrangements;
- the usage rights and obligations that will be included in the licences to be awarded.

We have conducted a considerable amount of work on each of these aspects as they apply to the award. This document sets out the results of that work in relation to the first two items and our proposals on the details of the award design.

2.19 In some areas we need to do more work before we can put forward proposals. This applies particularly to some matters affecting when the 800 MHz band will become available for new services and spectrum usage rights and obligations. The spectrum available for award in the 800 MHz band arises from the decision to clear the band of terrestrial television broadcasting and PMSE. The DTT clearance programme is in an advanced state of development but we are not yet able to publish a final plan showing when the band will be cleared in specific areas. On usage rights, we need to consider what restrictions and obligations should be placed in licences for 800 MHz to protect DTT reception in channels below 790 MHz. We also need to consider whether there should be a requirement in 2.6 GHz licences to coordinate with air traffic control radars. We explain the position on these points in more detail in section 4.

Liberalisation of existing mobile spectrum for LTE and WiMAX

2.20 We explain in section 4 the licensing position in the bands currently used for mobile services and the pre-existing technology restrictions in the original licences - 900 MHz and 1800 MHz being restricted to 2G (GSM) technology and 2.1 GHz restricted to 3G (UMTS) technology. Following a consultation on our proposal to vary the existing 900 MHz and 1800 MHz licences to allow UMTS use we have varied the licences in line with the proposal.

2.21 We propose to make further variations to allow use of LTE and WiMAX in the 900 MHz, 1800 MHz and 2.1 GHz bands as soon as technical conditions have been agreed within Europe.

Structure of this document

2.22 The rest of this document is structured as follows:

- In section 3, we set out the legal and regulatory framework.
- In section 4, we describe the characteristics of the spectrum to be awarded and the position in other spectrum bands used for mobile communications.

- In section 5, we explain our assessment of future competition in mobile markets and propose measures to promote competition in those markets after the conclusion of the award.
- In section 6, we explain our consideration of mobile coverage issues in the context of the award of 800 MHz and 2.6 GHz.
- In section 7, we set out the non-technical licence conditions we propose to include in the Wireless Telegraphy licences to be awarded.
- In section 8, we describe our proposals for the types of spectrum lots that would best reflect the likely demand for the spectrum and the specific technical constraints on spectrum use.
- In section 9, we make proposals for the auction format and rules that provide the best fit for the available lots of spectrum proposed in section 8.
- In section 10 we explain how we propose to revise annual licence fees for 900 MHz and 1800 MHz after the auction, in line with the requirements of the Direction.
- In section 11, we explain the steps that will lead to the auction and provide indicative timings.

2.23 This document should be read together with the Annexes which set out the detail of our analysis to date on a number of the issues covered. The document, together with those Annexes, as a whole comprises an impact assessment, a summary of which is set out at Annex 5.

Section 3

Legal framework

Introduction

3.1 The legal framework for the award derives from both specific domestic and European pieces of legislation, and our general duties set out in the European framework for electronic communications, specifically from the Framework Directive¹⁰ and the Authorisation Directive¹¹ as transposed into UK law by the Communications Act 2003 (the Communications Act) and the Wireless Telegraphy Act 2006 (the Wireless Telegraphy Act).

The Wireless Telegraphy Act 2006 (Directions to OFCOM) Order 2010 (the Direction)

3.2 On 20 December 2010, the Secretary of State made a Direction pursuant to section 5 of the Wireless Telegraphy Act. The Direction requires Ofcom to do a number of things, of which three are directly applicable here:

- Article 8 of the Direction requires Ofcom as soon as reasonably practicable to assess likely future competition in markets for the provision of mobile electronic communications services. We address this requirement in greater detail in Section 5 of this document.
- As soon as reasonably practicable after concluding the competition assessment referred to above, Article 9 of the Direction requires Ofcom to exercise its power to make regulations under section 14 of the Wireless Telegraphy Act to provide for an auction of licences to take place for use of frequencies in the 800 MHz and 2.6 GHz bands and any other frequencies as Ofcom thinks fit (the Auction). Our proposals relating to the design of the auction is set out in Section 9 of this document.
- After completion of the Auction, Ofcom is required by Article 6 of the Direction to revise the licence fees for the licences for use of the 900 MHz and 1800 MHz licences so that they reflect the full market value of the frequencies in those bands, having particular regard to the sums bid for licences in the Auction. Our proposals relating to the revision of these licences fees are set out in Section 10 of this document.

European Law: Commission Decisions

3.3 The European Commission has adopted two Decisions which affect the 2.6 GHz band and the 800 MHz band.

The Decision relating to the 2.6 GHz band

3.4 On 2 April 2008, the Commission adopted Decision 2008/477/EC¹² (the 2.6 GHz Decision) relating to the 2.6 GHz band. The 2.6 GHz Decision, which is binding on

¹⁰ Directive 2002/21/EC of 7 March 2002

¹¹ Directive 2002/20/EC of 7 March 2002

¹² <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:163:0037:0041:EN:PDF>

Member States, requires them to designate the 2.6 GHz band within 6 months of the decision's entry into force and subsequently make it available on a non-exclusive basis for terrestrial systems capable of providing electronic communications services, subject to a number of specified technical parameters relating to harmful interference.

The Decision relating to the 800 MHz band

- 3.5 On 6 May 2010, the Commission adopted Decision 2010/267/EU¹³ (the 800 MHz Decision) relating to the 800 MHz band. The 800 MHz Decision, which is also binding on Member States, is intended to harmonise the technical conditions for the availability and efficient use of the 800 MHz band.
- 3.6 Whilst the 800 MHz Decision does not require Member States to designate or make available the 800 MHz band, it does provide that if they decide to do so (other than for high-power broadcasting networks) they must do so on a non-exclusive basis for terrestrial systems capable of providing electronic communications services, again subject to a number of specified technical parameters relating to harmful interference.

European Regulatory Framework

- 3.7 Article 8 of the Framework Directive sets out the objectives which national regulatory authorities must take all reasonable steps to achieve. These include:
- the promotion of competition in the provision of electronic communications networks and services by, amongst other things encouraging efficient investment in infrastructure and promoting innovation, and encouraging efficient use of radio frequencies; and
 - contributing to the development of the internal market by, amongst other things, removing obstacles to the provision of electronic communications networks and services at a European level, encouraging the interoperability of pan-European services, and ensuring that, in similar circumstances, there is no discrimination in the treatment of undertakings providing electronic communications networks and services.
- 3.8 Article 8 also requires Member States to ensure that in carrying out their regulatory tasks, national regulatory authorities take the utmost account of the desirability of making regulations technologically neutral.
- 3.9 Article 9 of the Framework Directive requires Member States to ensure the effective management of radio frequencies for electronic communications services in accordance with Article 8, and to ensure that the allocation and assignment of radio frequencies is based on objective, transparent, non-discriminatory and proportionate criteria. Article 9 also requires Member States to promote the harmonisation of use of radio frequencies across the Community, consistent with the need to ensure effective and efficient use of frequencies.
- 3.10 Article 5 of the Authorisation Directive provides that where it is necessary to grant individual rights of use of radio frequencies, Member States must grant such rights through open, transparent and non-discriminatory procedures.

¹³ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010D0267:EN:HTML>

- 3.11 Article 7 of the Authorisation Directive provides that where Member States decide to limit the number of rights of use to be granted for radio frequencies, they must give due weight to the need to maximise benefits for users and to facilitate the development of competition.
- 3.12 The legal duties imposed on the UK by the Framework and Authorisation Directives are transposed into UK law and given effect to by the Communications Act and the Wireless Telegraphy Act.

Forthcoming Amendment of the European regulatory Framework and implementation in the UK

- 3.13 We note that with effect from 26 May 2011, a number of amendments to key provisions of the relevant directives, including the Framework Directive and the Authorisation Directive, will need to have been implemented in UK law, as a result of changes provided for in the Better Regulation Directive¹⁴.
- 3.14 These changes will be implemented in the UK through secondary legislation to be made by the Government, which it has indicated will be made in May 2011.
- 3.15 The revisions to the directives do not materially alter the substance of the provisions set out above as to the general duty to promote competition. We do however note the following revisions in particular:
- a revision to Article 9 of the Framework Directive, which in relation to individual rights of use of radio frequencies granted after 25 May 2011 (as will be the case here) requires technology and service neutrality:
 - a) technology neutrality may be made subject to proportionate and non-discriminatory restrictions to the types of radio network or wireless access technology used, where those restrictions are necessary for a number of listed reasons, including the need to avoid harmful interference, the need to ensure maximisation of radio frequency sharing, and to safeguard efficient use of spectrum;
 - b) service neutrality may be made subject to proportionate and non-discriminatory restrictions to the type of electronic communications service that may be provided; and
 - a revision to Article 5 of the Authorisation Directive, which provides that rights of use for radio frequencies must be granted through open, objective, transparent, non-discriminatory and proportionate procedures, and in accordance with Article 9 of the Framework Directive. When granting those rights, Member States are required to specify whether they can be transferred by the holder, and if so under which conditions.

The duties imposed by the Communications Act

- 3.16 Section 3 of the Communications Act sets out Ofcom's general duties and provides that its principal duty is:
- to further the interests of citizens in relation to communications matters, and

¹⁴ Directive 2009/140/EC

- to further the interests of consumers in relevant markets, where appropriate by promoting competition.
- 3.17 In carrying out its functions, section 3(2) provides that Ofcom is required, amongst other things, to secure the optimal use for wireless telegraphy of the electro-magnetic spectrum and the availability throughout the UK of a wide range of electronic communication services.
- 3.18 Section 3(3) of the Communications Act provides that in performing its duties, Ofcom must in all cases have regard to the principles of transparency, accountability, proportionality and consistency, as well as ensuring that its actions are targeted only at cases in which action is needed.
- 3.19 Section 3(4) of the Communications Act requires Ofcom in performing its duties, to have regard to a number of factors as appropriate, including the desirability of promoting competition, encouraging investment and innovation in relevant markets, and encouraging the availability and use of high speed data transfer services throughout the UK.
- 3.20 Section 4 of the Communications Act requires Ofcom to act in accordance with the six Community requirements, which give effect to the requirements of Article 8 of the Framework Directive.

The duties imposed by the Wireless Telegraphy Act

- 3.21 Section 3 of the Wireless Telegraphy Act imposes a number of further duties relating to spectrum management. Amongst other things, in carrying out its spectrum functions Ofcom is required to have regard to the extent to which spectrum is available for use, and the demand, both current and future, for the use of spectrum.
- 3.22 Section 3 of the Wireless Telegraphy Act also requires Ofcom to have regard to the desirability of promoting the development of innovative services and competition in the provision of electronic communications services.

Application of our duties to this award

- 3.23 In considering options for this award, we have given careful consideration to the duties imposed on us by each of the pieces of legislation set out above.
- 3.24 Taking into account the relevant facts and circumstances, including the specific requirements of the Direction, we consider that our principal duty to further the interests of citizens, and the interests of consumers where appropriate by promoting competition, is of particular importance to this award.
- 3.25 In fulfilling these duties, we consider that our duties to secure optimal use of spectrum and the availability of a wide range of electronic communications services throughout the UK, and the desirability of encouraging investment and innovation, are also of particular significance.
- 3.26 Further specific duties are relevant to individual elements of the award, and we address them at the relevant sections of this document as they arise.

Section 4

Mobile spectrum bands

Introduction

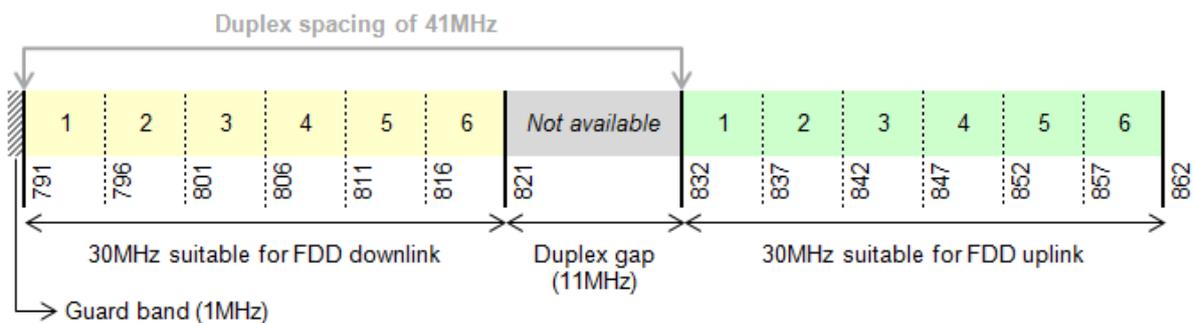
4.1 In this section we describe the spectrum available for award in the 800 MHz and 2.6 GHz bands, relevant EU harmonisation measures, and likely technical conditions for the bands. We also describe the licensing position in other spectrum bands that are used for mobile communications i.e. the 900 MHz, 1800 MHz and 2100 MHz bands.

800 MHz

4.2 The availability of spectrum for award in the 800 MHz band arises from the decision to clear the band of terrestrial television broadcasting and PMSE use. The configuration of the spectrum has been determined by the 800 MHz Decision on harmonised technical conditions for use of the 790 to 862 MHz band for electronic communications services. The Decision says that when Member States make the 800 MHz band available for networks other than high power broadcasting networks they must do so on a non-exclusive basis for terrestrial networks capable of providing electronic communications services. They must also do so in compliance with the parameters set out in the annex to the 800 MHz Decision.

4.3 The general parameters include the frequency arrangement in the band. The harmonised frequency arrangement is 2 x 30 MHz with a duplex gap of 11 MHz, based on a block size of 5 MHz, paired and with reverse duplex direction, and with a guard band of 1 MHz starting at 790 MHz. The Frequency Division Duplex (FDD) downlink starts at 791 MHz and FDD uplink starts at 832 MHz. This is illustrated by figure 4.1 below.

Figure 4.1: Frequency arrangement in the 800 MHz band

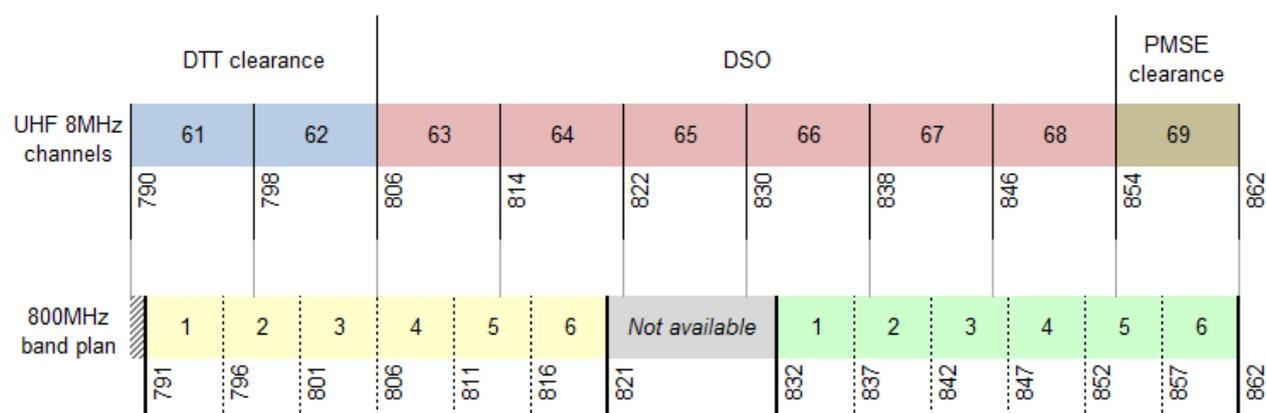


4.4 We discuss below in section 8 how we propose to package the spectrum for the award.

Other uses in the 800 MHz and adjacent bands

4.5 The availability of the 800 MHz band for electronic communications services depends on the re-location of terrestrial television services and PMSE users to other bands. Figure 4.2 shows how UHF channels used for DTT and PMSE align with the blocks for mobile use in the 800 MHz band.

Figure 4.2: UHF channels and 800 MHz band plan



Position on DTT clearance

- 4.6 In our statement of June 2009 we set out our decision to clear channels 61 and 62 of DTT (see paragraphs 2.3 to 2.4 above). Ensuring a smooth re-location of affected users to replacement spectrum is a challenging and complex process. Until this has been completed the 800 MHz band will not be available for use by new mobile services. Clearance will progress geographically, so that some parts of the UK will become available for new services earlier than others.
- 4.7 A key element of the clearance programme is the need to renegotiate international rights to use the replacement spectrum for DTT at the relevant locations. Our negotiations with neighbouring administrations are well advanced and we expect to reach agreement on the parameters for main transmitters by the end of 2011.
- 4.8 Clearing channels 61 and 62 impacts on the DSO programme and we have proceeded with its implementation by integrating it, where practicable, with DSO. Our target has been to complete the clearance so that the 800 MHz band is available across the UK for new services as early as possible. In our June 2009 statement we suggested clearance by the end of 2013 was an achievable though challenging target. Our current expectation is that all of the UK apart from Scotland will be cleared by that date: Northern Ireland by the end of 2012, Wales by October 2013, England by the end of 2013 and Scotland by October 2014.
- 4.9 We will provide further information as the position becomes clearer. We expect to be able to provide a firmer timetable later in spring 2011.

Position on PMSE clearance

- 4.10 Our decision to clear the 800 MHz band and release it for new services means that programme-making and special events (PMSE) users of channel 69 (854 to 862 MHz) must move to alternative spectrum. We have made some key commitments to PMSE users affected by our decision:
- to provide channel 38 (606 to 614 MHz), which will effectively become available UK-wide from 21 September 2011, as the replacement for channel 69;
 - to maintain PMSE access to channel 69 during the transition period; and

- to provide funding for the move from channel 69 subject to meeting eligibility criteria.
- 4.11 The timing for clearing channel 69 is particularly relevant to the award of 800 MHz.
- 4.12 In our interim statement on the future management of PMSE spectrum published on 15 April 2010¹⁵ we said:
- We had decided PMSE users should retain access to channel 69 until at least 1 July 2012 in all of the UK and at least 1 October 2012 in London, Northern Ireland and north-east England (the Tyne Tees television region).
 - We did not want to clear PMSE users from channel 69 unless it was to allow its use for new services. Many uncertainties remained around the launch of new services in the 800 MHz band and so we would review in 2011 whether PMSE access to channel 69 could be extended beyond the 1 July and 1 October 2012 dates.
 - Any extension would be up to 31 December 2012 at the latest.
- 4.13 We are therefore now seeking evidence from stakeholders (in particular prospective users of the 800 MHz spectrum) of the likelihood that there would be use of the top 2x10 MHz of the 800 MHz band in the period between 1 October 2012 and 31 December 2012 in London, Northern Ireland and north-east England, and between 1 July 2012 and 31 December 2012 in the rest of the UK (noting that in both cases there would likely have to be interim restrictions on use to protect terrestrial TV reception in areas that have not yet switched over or been cleared). We would ask that in responding to this question stakeholders provide evidence that is as specific as possible about the benefits of such access, and in particular the magnitude and nature of the benefits for citizens and consumers.

Question 4.1: What use, if any, would you make of the top 2x10 MHz of the 800 MHz band in the second half of 2012 if it were available for use? What would be the benefits for citizen and consumers of such availability?

Availability of channels 63, 64 and 68

- 4.14 Figure 4.2 illustrates that, as well as channel 69, channels 63, 64 and 68 need to be available for FDD mobile services using one pair of frequency blocks, i.e. blocks 5 and 6. One or more of the channels will remain in use until the second quarter of 2012 in London and south-east England and until the fourth quarter of 2012 in north-east England and Northern Ireland. In other parts of the UK these channels will be available, in principle, for new services from the beginning of 2012, although restrictions may remain due to continued use of neighbouring channels for terrestrial television.

Uses in bands adjacent to 800 MHz

DTT below 790 MHz

- 4.15 We identified the potential for mobile base stations in the 800 MHz band to interfere with DTT networks operating below 790 MHz in our June 2008 consultation on the award of the cleared digital dividend spectrum. Since then we have in conjunction

¹⁵ <http://stakeholders.ofcom.org.uk/binaries/consultations/bandmanager09/statement/statement.pdf>

with stakeholders undertaken a considerable amount of technical work to assess the likelihood and extent of the interference issue and what measures might be taken to address it. That work is ongoing including a field trial to consider the issue in practice. We plan to publish a separate consultation in the next few months setting out our understanding of the extent of the issue and how it might be addressed, including any restrictions that might need to be placed on future use of the 800 MHz band for mobile services.

Emergency services in 862 to 863 MHz

- 4.16 The 862 to 863 MHz band is available for emergency services and a number of systems are used throughout the UK by police and fire services. Disruption to these systems would have safety of life implications and we have assessed the impact that mobile use in the 800 MHz band might have on them.
- 4.17 We are working closely with the government departments responsible for the relevant emergency services - the Home Office (HO) and the Department for Communities and Local Government (CLG) - on technical studies of the interference potential to the emergency systems. These studies indicate that the systems would suffer a risk of harmful interference from LTE handsets operating in the top two blocks in the upper half of the 800 MHz band, which will increase as mobile deployment grows. There are a number of ways of mitigating the interference, including moving the systems to another band.
- 4.18 We expect, in conjunction with HO and CLG, to be able to determine a mitigation plan for the emergency services' systems with the relevant parties. This involves assessing the scale of use of the emergency services' systems and how they are deployed. We also have to consider whether existing equipment may have to be modified for operation in another band or whether new equipment will be needed, and the practicalities of re-equipping. As part of this work we are examining the management of potential interference from emergency services systems into mobile base stations at the top of the upper half of the 800 MHz band.
- 4.19 The plan will aim to balance the following objectives:
- to minimise disruption to the emergency services' systems so that current service levels are maintained; and
 - to minimise the impact on future use of the 800 MHz band.
- 4.20 Any justifiable costs emergency services users incur as a result of any changes required to implement the mitigation plan will be met by Government, subject to the achievement of overall spectrum policy goals and value for money considerations.
- 4.21 The aim is to have a mitigation plan in place in good time for the award. In drawing up this plan, we are conscious that 800 MHz operators may be in a position to launch services in the UK from late 2012 or early 2013. However, another factor to be taken into account in drawing up the mitigation plan is the need to avoid disruption to the emergency services' operation at the London Games between late June and late September 2012. In consequence there may be some restrictions on the use of 800 MHz in some areas beyond the end of 2012. We are examining this further and will provide an update of the position when the issue is clearer.
- 4.22 We expect to provide details of the agreed plan in the information memorandum for the award.

Short-range devices (SRDs) in 863 to 870 MHz

- 4.23 We are also investigating the possibility that mobile handsets in the 800 MHz band could cause interference to the SRDs that operate in the European harmonised band 863 – 870 MHz. We will set out our conclusions in relation to this issue in our subsequent consultation on the technical licence conditions relating to the 800 MHz band.

Cable TV systems' use of the 800 MHz band

- 4.24 Cable services, by definition, are not delivered by wireless but they can use frequencies up to and including frequencies in the 800 MHz band within the cabling and in set top boxes (STBs) and cable modems (i.e. customer premises equipment (CPE)). Interference into CPE may arise if a mobile handset operating in the top of the 800 MHz band (i.e. using frequencies 832 to 862 MHz) is used close to it.
- 4.25 During 2010 we worked with the Department for Business, Innovation and Skills (BIS), Virgin Media and technical consultants to understand the scale of the potential interference problem in the specific UK circumstances. We commissioned a series of practical tests on a Virgin Media cable network using independent consultants Cobham Technical Services (CTS). We published the results of their work on our website in December 2010¹⁶.
- 4.26 The main conclusion we have drawn from the report by CTS is that the potential interference is manageable. The reasons for this are, in summary, as follows.
- Eight of the nine STBs that CTS tested demonstrated good shielding properties from the simulated LTE user equipment at a distance of one metre; the one STB that performed badly represents a small proportion of the user base and is one of the older STBs. More resilient STBs are already available on the market and Virgin Media could either adopt them in its equipment replacement cycle or confine standard definition services to below channel 66 and continue to use there the older model STB (and any others like it).
 - CTS's testing was on the basis of one metre separation between the CPE and handset, with handsets operating at the maximum permissible transmit power (of 23 dBm plus a further 2 dB allowance for environmental factors and production tolerances) and the wanted cable TV signal at close to the minimum acceptable level. There are several points to note.
 - A more realistic separation distance of about two metres would significantly lower the potential for interference.
 - Mobile handsets will not generally operate at full power, which again reduces the interference potential.
 - If, rather than operating the STBs at close to the minimum recommended level of wanted signal, the level had been increased to the median of the normal operating range all eight of the STBs would have been immune to video interference from a handset operating at full power at a distance of about one metre or less.

¹⁶ http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/projects/ddr/2010-0792_LTE_into_CATV.pdf

- If, nonetheless, interference did arise as a result of handsets being operated within about two metres of a STB users would quickly identify the need to move away to avoid interference. Users might also be advised of the potential problem and this simple avoiding action.
- ETSI and CENELEC (the European standards bodies responsible for ensuring that consumer electronics are of a suitable standard) have proposed new immunity limits under which future cable CPE would need to be immune to interference from a mobile handset operating at full power from a distance of three metres. This limit is already achieved by a number of Virgin Media's existing STBs and should be readily achievable by new STBs and cable modems. Eight of the STBs and one of the cable modems tested - under the conditions tested - already meet the proposed immunity limit.
- Cable modems proved more susceptible to interference than the STBs; only one of the 12 tested performed well. However, Virgin Media does not provide any broadband services in the 800 MHz range at present and we consider that it could maintain this arrangement, avoiding use of broadband services in the top 40 MHz of the band and with it the potential for interference into cable modems.

4.27 Given that any significant deployment of two-way mobile services in the 800 MHz band is unlikely to occur before mid-2013 in the UK, we believe there is time to manage this issue. Virgin Media, and other cable operators, could do this by a combination of careful management of their frequency plans, replacement (if necessary) of older equipment with more resilient new equipment and basic information to customers on how to avoid interference when using LTE handsets.

Technical licence conditions for 800 MHz

- 4.28 The 800 MHz Decision sets out the technical parameters that must apply to the use of the 790 to 862 MHz band for networks other than high-power broadcasting networks. For information, we have set out in Annex 12 our current thinking on the technical licence conditions that we would apply, consistent with those parameters. We expect to include obligations on licensees to take additional measures to protect DTT reception and we are in the process of carrying out significant technical work to consider the technical conditions that should apply in adjacent bands and in the 800 MHz band following the award.
- 4.29 We will consult further when we are in a position to set out detailed proposals for the technical conditions that should apply to 800 MHz licences.

2.6 GHz

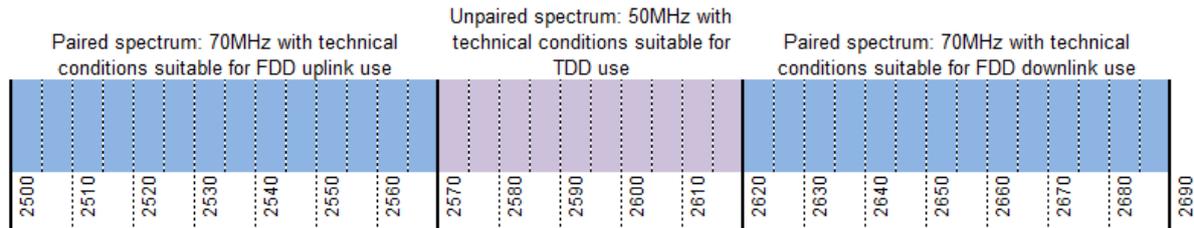
- 4.30 The 2.6 GHz band has been the subject of extensive work in various European technical fora (such as the CEPT project team SE42 with its work on the WAPECS mandate¹⁷) that have developed technical parameters for the band.
- 4.31 The 2.6 GHz Decision required Members States to designate the band within six months of the Decision's entry into force and subsequently make it available on a non-exclusive basis for terrestrial systems capable of providing electronic communications services, subject to a number of technical parameters relating to

¹⁷ Wireless Access Policy for Electronic Communications Services, a concept developed by the EU's Radio Spectrum Policy Group. See their opinion of 23 November 2005, available at http://rspg.ec.europa.eu/doc/documents/opinions/rspg05_102_op_wapecs.pdf

harmful interference. The recitals to the Decision state that the results of the technical work undertaken by CEPT, which form the basis of the technical parameters of the Decision, should be made applicable in the Community and implemented by Member States without delay.

- 4.32 Figure 4.3 below illustrates the UK band plan for 2.6 GHz. It accords with the CEPT band-plan in ECC Decision (05)05¹⁸, which designates 2500 to 2570 MHz paired with 2620 to 2690 MHz for FDD use and 2570 to 2620 MHz for Time Division Duplex (TDD) use.

Figure 4.3: 2.6 GHz band plan



- 4.33 We discuss below in section 8 how we propose to package the spectrum for the award.

Factors affecting the availability of the 2.6 GHz band

2.7 GHz radar modification

- 4.34 Radars operating in the 2.7 to 3.1 GHz band (S-band) have relatively low receiver selectivity. This means they 'over-hear' transmissions in adjacent bands. There is a high risk that future transmissions in the 2.6 GHz (and 3.4 GHz) band will degrade the performance of S-band radars unless receiver selectivity is improved. These radars are mainly used for air traffic control (ATC), so interference into the radars clearly raises safety of life considerations.
- 4.35 To avoid harmful interference, mobile network operators in the 2.6 GHz band will need to coordinate with radar operators. The main coordination measures are expected to be limited to the period before the radars are upgraded though some continuing requirement is likely to be required. At present, an estimated 43 per cent of the UK land mass, including major conurbations, would fall within the necessary coordination zones. Such large coordination zones could severely restrict the use of the 2.6 GHz band for new services, and we want to reduce the coordination distances as much as possible without putting the radars at risk.
- 4.36 We have advised civil ATC radar operators of the likely impact on their radars and that we expect to amend their Wireless Telegraphy Act licences to ensure that they take action to accommodate this change in the interference environment. We are working closely with the Civil Aviation Authority (CAA), which is the regulator for the aviation industry and manages spectrum for that sector on our behalf, to engage with civil radar operators. We have also alerted the Ministry of Defence (MOD), which operates military radars in the same frequency range, to this issue. Radar operators, civil and military, are therefore aware that they will be required to modify the

¹⁸ <http://www.ero-docdb.dk/Docs/doc98/official/pdf/ECCDEC0505.PDF>

operation of their radars to cope with the new interference environment when new services launch in the 2.6 GHz band. But it is extremely important to ensure that such modifications do not compromise safety.

- 4.37 To help the radar operators respond to these changes, we have done a significant amount of technical work to scope and understand this issue over the past two years. We have concluded that it is likely that low receiver selectivity can be remedied by modifying the affected radars. We have now also commissioned research into the design of this solution which would mitigate these effects. A prototype design for the solution required for each of the radar types used for civil ATC in the UK will be developed with a view to a commercially available solution being available from early 2012, which will allow individual radar operators to plan and procure the modification required for their radars.
- 4.38 We are working with the CAA and MOD, under the direction of Government, to jointly facilitate the programme of radar modifications that will be necessary in order for radars to operate safely adjacent to mobile services in the 2.6 GHz band. The next step will be to engage with radar operators and other relevant parties in the aviation sector to agree a roll-out plan. Our proposal is that the roll-out of radar modifications should commence in 2012 and proceed on a prioritised basis focused on enabling 2.6 GHz use in key regions first.
- 4.39 We expect interim technical restrictions in 2.6 GHz licences to be necessary until all affected radars have been modified. These are likely to take the form of maximum emission levels in a zone around each radar location, where users of the 2.6 GHz band will be required to coordinate with the radar operator.
- 4.40 After the radars have been modified we expect there will remain a need for coordination measures with airport operators in the more immediate vicinity of these airports and radars. We have commissioned detailed work to investigate the possibilities for deployment of 2.6 GHz networks at airports and will publish the results when they are available.
- 4.41 We will include in the Information Memorandum for the award (and before if possible) details of the technical restrictions and any interim restrictions on 2.6 GHz network deployment considered necessary to protect radars from harmful interference.

Use of 2.6 GHz at the London 2012 Games

- 4.42 We published a consultation on 23 August 2010¹⁹ proposing that the 2.6 GHz band be reserved for wireless cameras during the London 2012 Games, primarily in the London area, but also at other locations if Games-time demand justified this. The responses to the consultation raised points about alternative uses for the 2.6 GHz band in 2012, including new mobile services using LTE and WiMAX. We therefore sought evidence of consumer harm if we proceed on the basis of restricting the availability of the 2.6 GHz band for these services. On 10 December 2010 we published a statement setting out our conclusions²⁰.
- 4.43 In relation to new mobile service trials or services we have received no evidence of significant opportunity cost from reserving the 2.6 GHz band for the Games or resulting harm to consumers from our proposal to do so. We have received evidence

¹⁹ <http://stakeholders.ofcom.org.uk/binaries/consultations/band-2500-2690-london-2012-games/summary/condoc.pdf>

²⁰ <http://stakeholders.ofcom.org.uk/consultations/band-2500-2690-london-2012-games/statement>

from the London Organising Committee for the Olympic Games and Paralympic Games (LOCOG) of the importance of access to the 2.6 GHz band for wireless cameras – including new spectrum demand information from Olympic Broadcasting Services (OBS). This evidence indicates the importance of access to the 2.6 GHz band to enable wireless camera coverage of the Games and its particular importance for airborne coverage, which is not possible in many alternative bands.

- 4.44 In the absence of evidence of a significant opportunity cost of reserving the 2.6 GHz band for the Games or evidence of resulting harm to consumers we have decided to reserve the whole 2.6 GHz band for wireless cameras between 28 June and 23 September 2012.
- 4.45 It may be possible to grant licences for non-operational trials and tests of new mobile or broadband data services if these are carefully co-ordinated. The provision of services to the Olympic Family will take precedence over other uses of the spectrum during the Games, but we will endeavour to coordinate other uses in order to promote opportunities for new services to citizens and consumers.
- 4.46 Our reservation of the 2.6 GHz band for the Games does not require us to revoke or vary existing spectrum licences to meet Games requirements, but we do intend, in licences issued as a result of the 2.6 GHz award, to exclude temporarily the operation of the new services between 28 June and 23 September 2012 at the London venues for the Games, surrounding areas and other geographical locations depending on demand at Games time.

PMSE use in 2.6 GHz

- 4.47 The 2.6 GHz band is currently licensed for PMSE use. Short-term licences for use in the band are currently available but access to these frequencies for PMSE will cease on three months' notice. This three months' notice will be triggered when we announce the provisional application date to participate in the combined award.

Future low-power use in 2.6 GHz

- 4.48 In our competition assessment we have considered whether a network focussed on indoor coverage through small cells inside buildings would provide the opportunity for new competitive impetus and innovation and whether we should take action to reserve spectrum for such use. We believe there may be a case for this but it is not clear cut and we are seeking views on the issue (see paragraphs 5.101ff). It is possible that we may designate part of the paired spectrum in the 2.6 GHz band for shared low-power use. Under this proposal, several licences for low-power use of the spectrum would be awarded on a competitive basis. Each licensee would have non-exclusive access to the spectrum. In areas where two or more licensees wished to provide services, they would be expected to coordinate to manage the shared access to the spectrum.
- 4.49 In order to make an assessment of the technical issues associated with low-power shared use of the band we commissioned a technical study, which was undertaken by Real Wireless Ltd. The study considered various potential usage scenarios, including residential, indoor/outdoor public spaces and campuses or business parks. It also looked at the technical options of designating part of the 2.6 GHz band exclusively for low-power shared access or an underlay approach, where low-power shared access uses the same spectrum as a wide-area (high power) network.
- 4.50 Real Wireless's modelling indicates that:

- Managing interference between shared access licensees could be implemented through a combination of licence conditions and a code of practice licensees would agree among themselves. There could be a need for information sharing between licensees but some interference management could be done autonomously. Under certain conditions a coordination process might be required.
- Shared access licences should have a maximum power limit of 30dBm EIRP. This would provide flexibility for coverage in the campus or business park scenario. We anticipate that indoor access points would operate at lower power levels: residential dwellings could require up to 20dBm and offices might deploy several access points at powers below 20dBm to manage coverage and capacity. Antenna height restrictions would help to mitigate interference between licensees and an upper limit of 12m is recommended.

4.51 Real Wireless considered the options of designating part of the 2.6 GHz band exclusively for low-power shared access or an underlay approach, where low-power shared access uses the same spectrum as a wide-area (high power) network. Designating 2x20 MHz of spectrum for low-power networks would provide the greatest flexibility to low-power licensees to provide high data rate services and manage sharing among themselves. However, only 2x50 MHz would remain for wide-area licences. In a full underlay approach, where 2x20 MHz was licensed for wide-area use and could also be used by low-power networks, a requirement to avoid interference to the wide-area network would reduce the number of locations where low-power systems could be deployed and the power that they could use. The study finally considered a third option, based on a hybrid of 2x10 MHz underlay and 2x10 MHz exclusive spectrum, in order to provide the opportunity to use 20 MHz systems. In locations where underlay use would cause interference to the high power licensee, low-power users would still have access to 2x10 MHz.

4.52 This hybrid has some attractions but we recognise that there are still some open issues that we would need to consider further when developing licence conditions for such an approach. Those issues include:

- the relative priority for access to the shared 2x10 MHz spectrum between the high power network and the low-power networks;
- how low-power and high power networks can manage interference and access in the shared 2x10 MHz spectrum;
- the method of avoiding interference to macrocell users passing close to a low-power access point (in the case where a low-power access point punches a hole in macro network coverage); and
- the method of managing terminal transmit power on low-power networks to avoid desensitisation of nearby macrocell base stations, which would affect other users at the edge of macrocell coverage.

Question 4.2: If we were to offer shared access low-power licences in some way, do you have any comments on the appropriate technical licence conditions which would apply for the different options?

4.53 The study by Real Wireless is published at <http://stakeholders.ofcom.org.uk/binaries/consultations/combined-award/annexes/real-wireless-report.pdf>.

Technical licence conditions for 2.6 GHz

- 4.54 The 2.6 GHz Decision set out a number of technical parameters that must apply to the use of the band. For information, we have set out in Annex 12 our current thinking on the technical licence conditions that we would apply, consistent with those parameters.
- 4.55 We are currently considering whether to make spectrum available for low-power shared access. If we decide to make proposals for such use, we will also bring forward proposals for technical licence conditions covering this use. We also expect to include obligations on licensees to take additional measures to protect radar use in the spectrum above 2700 MHz.
- 4.56 We will consult further when we are in a position to set out detailed proposals for the technical conditions that should apply to 2.6 GHz licences. The technical licence conditions we propose to adopt are outlined below. They are fully consistent with those parameters.

Licensing position in other spectrum bands that are used for mobile communications

- 4.57 The UK has three bands allocated for 2G and/or 3G mobile services:
- 880 to 915 MHz paired with 925 to 960 MHz (the 900 MHz band);
 - 1710 to 1785 MHz paired with 1805 to 1880 MHz (the 1800 MHz band); and
 - 1890 to 1980 MHz paired with 2110 to 2170 MHz (the 2.1 GHz band).

The 900 MHz and 1800 MHz bands were originally licensed for 2G (GSM) services only and the 2.1 GHz band for 3G (UMTS) services only. The 900 MHz and 1800 MHz bands are now licensed for both 2G and 3G services. The 2.1 GHz band is still licensed only for 3G services.

- 4.58 Three operators hold licences for the 900 MHz and 1800 MHz bands – Everything Everywhere, O2 and Vodafone. Everything Everywhere has spectrum only in the 1800 MHz band (2 x 60 MHz) whereas O2 and Vodafone have spectrum predominately in the 900 MHz band but also have a small assignment of 2 x 5.8 MHz each in the 1800 MHz band.
- 4.59 The same three operators plus Hutchison 3G (H3G) hold licences for the 2.1 GHz band. All four operators have duplex FDD assignments. In addition Everything Everywhere, O2 and H3G have TDD assignments, though to date they have not used them. Table 4.1 below shows the frequency assignments of each operator.
- 4.60 Part of the 2.1 GHz band has not been assigned to any operator; this is 2010 MHz to 2025 MHz. In May 2010 we sought stakeholders' views on the best way to release this spectrum for new uses²¹. On 16 February 2011 we published a statement²² setting out our decision to release the spectrum through a competitive award (independent of the combined award). We will consult further on a detailed award process as soon as practicable. The earliest feasible date for an award of the

²¹ http://stakeholders.ofcom.org.uk/consultations/release_2010_2025/

²² http://stakeholders.ofcom.org.uk/binaries/consultations/release_2010_2025/statement/statement.pdf

spectrum is in the first quarter of 2012. However, the timing of the award will depend on the prioritisation of this work relative to our other spectrum management activities and on whether any additional evidence emerges on demand for this spectrum or its value. We will allow temporary use of the band for PMSE pending a competitive award and make the band available for the London 2012 Games.

Table 4.1: Licensing position in the 900 MHz, 1800 MHz and 2.1 GHz bands

	Everything Everywhere (T-Mobile and Orange)	O2	Vodafone	H3G	Total
900 MHz Paired	-	2x17.4	2x17.4	-	69.6
1800 MHz Paired	2x60	2x5.8	2x5.8	-	143.2
2.1 GHz Paired	2x20	2x10	2x15	2x15	120.0
2.1 GHz Unpaired	1x10	1x5	-	1x5	20.0
Total	170	71.4	76.4	35	352.8

1800 MHz divestment

4.61 In March 2010 the European Commission approved the merger between T-Mobile and Orange in the UK. One condition of the Commission's approval was that the merged operator Everything Everywhere would divest 2x15 MHz of the spectrum it holds in the 1800 MHz band. This spectrum could be divested through a private sale to a single purchaser or unconditionally offered for sale as part of the combined award or another spectrum award (i.e. handed back to Ofcom for re-award). This is discussed further in section 8 (paragraphs 8.62ff).

Variations to 2G and 3G licences and regulations

4.62 A number of provisions in the Direction (see paragraphs 2.11 to 2.14 above) relate to existing 2G and 3G licences. They are:

- Amend the Spectrum Trading Regulations²³ to permit the transfer of the rights and obligations in 900 MHz, 1800 MHz and 2.1 GHz licences.
- Vary 900 MHz and 1800 MHz licences:
 - to permit use for both 2G (GSM) and 3G (UMTS services)
 - to extend the revocation notice period to five years.
- Vary 2.1 GHz licences to provide:
 - a new coverage obligation;
 - a change to licence duration;
 - a revocation notice period of five years (such revocation not to be capable of taking effect before the period for which the licences were auctioned expires); and

²³ <http://www.legislation.gov.uk/ukxi/2004/3154/introduction/made>

- to charge annual licence fees from the end of 2021 (when the period for which the licences were auctioned expires).
- 4.63 In anticipation of the Direction being made, on 28 October 2010 we published a Notice proposing to vary the existing 900 MHz and 1800 MHz licences to allow UMTS use. Having considered all the responses to the Notice we decided to vary the licences in line with the proposal in the Notice, subject to some minor changes to the drafting of the licences²⁴. We published a statement on 6 January 2011²⁵.
- 4.64 We published a notice²⁶ (the trading notice) on 2 February 2011 setting out how we proposed to amend the Spectrum Trading Regulations to permit the transfer of the rights and obligations in 900 MHz, 1800 MHz and 2.1 GHz licences. The closing date for responses was 17 March 2011.
- 4.65 We also published on 2 February 2011 a consultation on how we propose to vary the 2.1 GHz licences as required by the Direction, subject to the consent of the licensees. The closing date for responses was 17 March 2011²⁷.
- 4.66 We propose to make further variations to allow use of LTE and WiMAX in the 900 MHz, 1800 MHz and 2.1 GHz bands as soon as technical conditions have been agreed within Europe.

LTE equipment availability

- 4.67 LTE technology was initially specified by 3GPP in its release 8 specification which was functionally frozen in December 2008 and included the 2.6 GHz band in both FDD and TDD configurations as well as the 900 MHz, 1800 MHz and 2.1 GHz band. The 800 MHz band, in an FDD-only configuration, was included in 3GPP Release 9, frozen in December 2009.
- 4.68 Licences for the 2.6 GHz band have been awarded in several European countries and are coupled with a general assumption that the 800 MHz spectrum will become available in the first European countries around 2012 or 2013. The 1800 MHz band has also been targeted for LTE by several operators. Elsewhere the launch of commercial services has been focused on the 700 MHz band, notably in the US²⁸.
- 4.69 Given these factors, equipment manufacturers are developing and producing a range of mobile devices for LTE. Data cards and dongles are usually released first for a given frequency band, followed by handsets. While data cards are already available commercially for 2.6 GHz and handsets are expected to follow shortly, 800 MHz devices are not yet fully commercial and it is expected that these will follow in mass production for dongles around 2011 or 2012 and for handsets in 2013 or 2014.
- 4.70 In February 2011 the Global Mobile Suppliers Association (GSA) published a list of LTE user devices either under development or currently available on the market for each of the respective frequency bands²⁹. The evidence collected by the GSA shows there is considerable traction within the mobile industry for the production of LTE user devices, predominantly in the 700 MHz band where thirty-five devices are listed.

²⁴ <http://stakeholders.ofcom.org.uk/consultations/900-1800mhz-wireless-telegraphy/>

²⁵ <http://stakeholders.ofcom.org.uk/binaries/consultations/900-1800mhz-wireless-telegraphy/statement/Statement.pdf>

²⁶ <http://stakeholders.ofcom.org.uk/consultations/trading-900-1800-2100/>

²⁷ <http://stakeholders.ofcom.org.uk/consultations/2100-MHz-Third-Generation-Mobile/>

²⁸ http://wireless.fcc.gov/auctions/default.htm?job=auCTION_summary&id=73

²⁹ http://www.gsacom.com/gsm_3g/info_papers.php4

Three devices supporting the 2.6 GHz band are listed, with only one at 1800 MHz and none for either 800 MHz or for 900 MHz.

- 4.71 Recent commercial launches of LTE handsets have taken place, for example, in the US on the Metro PCS network in late 2010 with the Samsung Craft³⁰ for the AWS frequency band (1.7 GHz and 2.1 GHz) and the soon to be launched HTC Thunderbolt on the Verizon network in the 700 MHz band³¹.
- 4.72 At present only USB dongles and embedded modems are available at 2.6 GHz but TeliaSonera has predicted LTE handsets will be available in 2011³². This will be further supported by the development and commercial launch activity of LTE handsets in the USA.
- 4.73 3GPP supports both FDD and TDD modes of LTE with equal priority. Although initial devices for 2.6 GHz support the FDD mode, there is considerable international support for TD-LTE amongst operators such as China Mobile, Bharti Airtel, Softbank Mobile, Vodafone and others as indicated by the launch of the Global TD-LTE initiative³³. Baseband chipset manufacturers are incorporating both TDD and FDD modes in their initial products, indicating that TD-LTE may be relatively easier to implement. Reports indicate that TD-LTE devices for 2.6 GHz will become available as soon as Q3 2011³⁴.
- 4.74 While no commercial devices for 800 MHz are yet available, the underlying technology is in an advanced stage of development and it is expected devices will be ready for any early commercial deployments in this band towards the end of 2011. For example, an embedded modem module supporting both 2.6 GHz and 800 MHz has been announced³⁵ and a multiband modem is expected shortly³⁶.
- 4.75 The Global Certification Forum (GCF) certifies LTE user devices. Its LTE certification scheme was originally launched in early 2008 to include the 700 MHz and 2.6 GHz bands. It announced the extension of the scheme to include the 800 MHz band in February 2010³⁷.
- 4.76 Trials of LTE equipment in the 800 MHz band have included both user devices and infrastructure equipment. Both Alcatel Lucent³⁸ and Nokia-Siemens Networks³⁹ announced trials of pre-commercial LTE infrastructure equipment for the 800 MHz band in the latter half of 2010, including three trials in the UK^{40, 41, 42}. Commercially

³⁰<http://hothardware.com/News/First-4G-LTE-Phone-Gets-Approved-By-The-FCC/>

³¹<http://www.zdnet.com/blog/btl/verizon-htc-thunderbolt-coming-very-shortly-lte-tiered-pricing-too/45482>.

³²http://www.lightreading.com/document.asp?doc_id=192794&

³³<http://next-generation-communications.tmcnet.com/topics/nextgen-voice/articles/147763-ovum-global-td-lte-initiative-accelerates-ecosystem-development.htm>

³⁴<http://next-generation-communications.tmcnet.com/topics/nextgen-voice/articles/147763-ovum-global-td-lte-initiative-accelerates-ecosystem-development.htm>

³⁵http://www.sierrawireless.com/productsandservices/AirPrime/Wireless_Modules/High-speed/MC7710.aspx

³⁶<http://www.ipwireless.com/news/2010/07/ipwireless-and-altair-semiconductor-partner-develop-wireless-industry%25E2%2580%2599s-first-multi-ban>

³⁷http://www.globalcertificationforum.org/WebSite/public/PR_GCF_VALIDATION_OF_FIRST_LTE_TEST_CASES_Feb2010.aspx

³⁸<http://www.cellular-news.com/story/46861.php>

³⁹<http://www.rethink-wireless.com/2010/07/02/lte-trials-completed-800mhz-18ghz.htm>

⁴⁰<http://blog.epn-online.com/rfwirelessblog/2010/07/clear-mobitel-announces-uk-lte-trial-in-800mhz-digital-dividend-spectrum-in-cornwall.html>

⁴¹<http://www.cellular-news.com/story/46861.php>

services are expected to be launched in Germany in the second quarter of 2011⁴³ using Nokia-Siemens Network equipment with co-parent company, Nokia, supporting using their multimode, multiband RD-3 Internet Modem⁴⁴.

- 4.77 Over the past year there have been advances in new converged radio technology to enable mobile service providers to support any mix of 2G, 3G and LTE on the same network. Developments in dual mode and multi mode devices have already reached the market with Teliasonera launching a new Samsung USB dongle in the second quarter of 2010 which allows roaming from its LTE network to both its GSM and WCDMA network⁴⁵.
- 4.78 A total of 17 commercial LTE services had been launched by January 2011, with a total of 128 operator commitments to LTE⁴⁶. This evidence suggests that there has been considerable activity within the mobile industry and especially a rise in commercial LTE commitments and network roll-outs. Therefore, the number and type of LTE devices is very likely to increase across all available frequency bands including 2.6 GHz, 800 MHz, 900 MHz and 1800 MHz, but with some difference in the timing of this availability. In general 2.6 GHz devices are expected to be available first, 800 and 1800 MHz available a little later and 900 MHz later still due to the relatively higher priority of devices supporting UMTS/HSPA in that band. Data modem availability generally precedes that of handsets.

WiMAX equipment availability

- 4.79 WiMAX technology was formalised by the WiMAX Forum⁴⁷ (formed in June 2001 to promote conformity and interoperability of the standard) and is a competing telecommunications protocol to LTE. As with LTE, WiMAX is capable of providing fixed and mobile Internet access. The primary advantages of the WiMAX standard are to enable the adoption of advanced radio features in a uniform fashion which helps to reduce costs for companies that are part of the WiMAX ecosystem.
- 4.80 Since 2001 the IEEE⁴⁸ (Institute of Electrical and Electronics Engineers) has continued to update and modify the IEEE 802.16 system specifications to further improve its capabilities. Particular sets of features within the standard are adopted by the WiMAX Forum as profiles. The WiMAX Forum then certifies products that meet the requirements of its system profiles for fixed and nomadic devices which can then be released on to the market. Features and enhancements are constantly being developed across specific key frequency bands increasing the portfolio of devices enabled for WiMAX.
- 4.81 The WiMAX Forum has published three licensed spectrum profiles for 2.3 GHz, 2.6 GHz and 3.5 GHz, in an effort to drive standardisation, promote interoperability and decrease cost. The most recent versions of both IEEE 802.16d (fixed WiMAX) and IEEE 802.16e (mobile WiMAX) cover spectrum ranges from at least the 2 GHz range through to the 66 GHz range. The wide frequency range covered by the WiMAX system profiles has led to consistent progress in network deployments. The

⁴²<http://www.intomobile.com/2010/05/22/o2-uk-to-trial-lte-at-800mhz/>

⁴³<http://www.telecompaper.com/news/o2-germany-selects-huawei-nsn-for-commercial-lte-roll-out>

⁴⁴<http://www.phonesreview.co.uk/2009/09/07/nokia-internet-modem-rd-3-supports-not-all-about-mobiles/>

⁴⁵<http://blogger.xs4all.nl/jurjen1/archive/2010/07/22/558594.aspx>

⁴⁶http://www.gsacom.com/downloads/pdf/GSA_Evolution_to_LTE_report_120111.php4

⁴⁷<http://www.wimaxforum.org/>

⁴⁸<http://www.ieee.org/index.html>

WiMAX Forum recently announced at Mobile World Congress 2011⁴⁹ there are now WiMAX networks covering more than 823 million people in approximately 149 countries and is on track to reach one billion people by the end of 2011.

- 4.82 There are already numerous devices on the market that provide connectivity to a WiMAX network. This includes handsets (similar to cellular smart phones), PC peripherals (PC Cards or USB dongles) and embedded devices in laptops. In addition, there is much emphasis by operators on consumer electronics devices such as gaming consoles, MP3 players and similar devices. The WiMAX Forum⁵⁰ website provides a list of certified devices, which includes a summary of the specification such as the availability of the different frequency bands and the module type. However, this is not a complete list of available devices as certified modules are embedded into laptops and other mobile internet devices.
- 4.83 On 12 November 2008 HTC announced the first WiMAX enabled mobile phone, but this had limited availability⁵¹ (solely in Russia). This was followed on 23 March 2010 (at the CTIA conference in Las Vegas) by the release of HTC's second WiMAX enabled mobile phone. This was made publicly available in America on 4 June 2010⁵² on the Sprint network. Following this further press coverage indicated that a number of other WiMAX enabled mobile phones were expected in the US market in 2010⁵³ and 2011⁵⁴.
- 4.84 The WiMAX device market has grown and gained support and traction based on new networks being deployed globally, most notably Clearwire's WiMAX network in the US in the 2.6 GHz band, which is used by Sprint and Comcast to deliver their services. Sprint recently announced it now includes 18 mobile devices⁵⁵ within its portfolio to access its 4G network.

⁴⁹<http://www.wimaxforum.org/news/2761>

⁵⁰<http://www.wimaxforum.org/>

⁵¹<http://www.htc.com/www/press.aspx?id=76204&lang=1033>

⁵²http://newsroom.sprint.com/article_display.cfm?article_id=1536

⁵³<http://www.eetimes.com/electronics-news/4088262/At-least-two-more-WiMax-handsets-coming-in-2010>

⁵⁴<http://htcpedia.com/news/sprint-launches-evo-shift-4g.html>

⁵⁵<http://finance.yahoo.com/news/Sprint-Continues-to-Emerge-as-bw-228074647.html?x=0&.v=1>

Section 5

Competition assessment and future mobile markets

Introduction

- 5.1 The Direction requires us to undertake an assessment of the likely future competition in markets for the provision of mobile electronic communications services, after the conclusion of the combined award. This section sets out the provisional results of that assessment and the measures we consider are appropriate and proportionate to put in place to promote competition. These measures focus on the combined award of the 800 MHz and 2.6 GHz spectrum. Our full analysis is set out in Annex 6.
- 5.2 The combined award will result in a significant increase in the supply of spectrum available for mobile services. We would typically expect a release of a large amount of spectrum to have a strong positive impact upon competition, facilitating the launch of new innovative services and potentially the entry of new competitors. However, for the reasons explained in this section, we consider that there is a risk of lower competitive intensity in mobile markets in the future compared either to today or to the degree of future competition that could be promoted. We therefore consider whether we should put in place appropriate and proportionate measures to promote competition.
- 5.3 This is a forward looking assessment, and as such is based on our predictions as to the likely future development of mobile markets in light of the evidence currently available to us and our judgement as the regulator. We recognise that any forward looking assessment is inherently uncertain. We have therefore sought to identify a number of key market factors which we consider to be important to future competition, and which we can reasonably assess in light of the evidence available to us. Based on our assessment of these key factors, we reach provisional views on whether there are any measures which we should consider putting in place now to promote effectively competitive future mobile markets which work in the interests of citizens and consumers. Where we have had to take an informed view on uncertain future developments in mobile markets we have, as far as possible, made the assumptions underlying this judgement explicit either in this section or in Annex 6 which sets out our competition assessment in greater detail.

The Government Direction and our statutory duties

- 5.4 The scope of this work is principally set by Article 8 of the Direction, which requires that:
- Ofcom should as soon as reasonably practicable assess likely future competition in markets for the provision of mobile electronic communications services;
 - the competition assessment must be in respect of the future competitiveness of those markets after the conclusion of the auction of the 800 MHz and 2.6 GHz spectrum, taking into account possible effects of that auction;

- the competition assessment must include consideration of the potential for new entry into the markets for the provision of mobile electronic communications services; and
 - in the light of the competition assessment Ofcom must, where they think fit, put in place appropriate and proportionate measures which will promote competition in those markets after the conclusion of the auction of the 800 MHz and 2.6 GHz spectrum.
- 5.5 The Direction provides us with little specific guidance as to how we are to fulfil these requirements. We therefore have a margin of discretion, which must be exercised in accordance with our statutory duties in the Communications Act 2003 and the Wireless Telegraphy Act 2006, and general public law principles.
- 5.6 In light of (i) the specific requirements of the Direction to promote competition and take account of the potential for new entry, and (ii) the characteristics of the spectrum in the auction and its likely important role in delivering future mobile services, we consider that five key elements stand out from our duties in the context of our competition assessment:
- our principal duty to further the interests of citizens and consumers, where appropriate by promoting competition;
 - our duty to secure the optimal use of the spectrum taking account of current and future demand;
 - the desirability of encouraging investment and innovation;
 - the desirability of encouraging the availability and use of high speed data transfer services through the United Kingdom; and
 - our duty to have regard to the interests of consumers in respect of choice, price, quality of service and value for money.

Approach to the competition assessment

- 5.7 The Direction requires us to consider future mobile markets and to identify whether there are any appropriate and proportionate measures that we should put in place to promote competition. We have approached this as follows.
- 5.8 Our first step is to consider future competition in mobile markets. We consider how competitive a number of key elements of the mobile markets might be after the auction, and the potential risks to competition. We assess this assuming we put in place no measures in the combined award to promote competition (in other words, an auction in which any bidder can bid for any amount of any spectrum, subject only to the technical licence conditions necessary to avoid harmful interference).
- 5.9 Our next step is to consider whether, in light of the above assessment and any potential risks to future competition in mobile markets that we identify, there are any appropriate and proportionate measures that we should consider putting in place to promote competition. In this regard we:
- identify the set of potential measures we could use to address any risks identified;

- consider whether these measures are proportionate to the magnitude/likelihood of the problem arising;
- identify which measures (if any) are likely to be appropriate, taking into account their likely effectiveness and costs.

Background and terminology

- 5.10 In 2008 and 2009 we undertook a Mobile Sector Assessment which took stock of the mobile sector, considered market trends and how well the mobile sector was functioning for citizens and consumers, and set out our approach to regulating the mobile sector. We concluded that certain mobile markets were effectively competitive, and served consumers well.⁵⁶ This assessment was completed in December 2009, before T-Mobile and Orange merged to form Everything Everywhere.
- 5.11 The European Commission considered the merger. Following commitments offered by the merging parties, it concluded that the merger did not significantly impede effective competition and was compatible with the common market, and hence cleared it in March 2010.
- 5.12 Since the merger, we see no indication that competitive pressures have significantly reduced, but we recognise that the merger is recent and there is currently little information on the period since the merger. We do not take a definitive view on the competitiveness of mobile markets currently, because our focus in this assessment is on future competition after the combined award.
- 5.13 There are currently four main Mobile Network Operators (MNOs) in the UK, namely, Everything Everywhere, H3G, O2 and Vodafone. There are also a wide variety of other companies present in the UK mobile sector. Some of these other companies also own some mobile network infrastructure, albeit on a much smaller scale to the main MNOs. For this reason, in the context of the competition assessment we believe the term MNO could be misleading. We also find the term MNO unhelpful because a company could in theory be active in the wholesale mobile market without necessarily itself “operating” a network on its own. In theory it could contract for access to a network or share network infrastructure with another company.
- 5.14 We therefore prefer the term “national wholesaler” for the purposes of the competition assessment. By national wholesaler we mean a company that provides wholesale access for the supply of mobile services at a national level. This wholesale access service could be provided to the national wholesaler’s own retail business only, or also to other retailers. It is possible for there to be fewer national radio access networks than there are national wholesalers because wholesalers may seek to share networks. The term national wholesaler allows us to recognise this more clearly. Everything Everywhere, H3G, O2 and Vodafone, are currently the only national wholesalers in the UK. Sections 2 and 4 of Annex 6 provide further details.

Future competition and potential for new entry in retail market(s)

- 5.15 We first consider future competition in retail market(s), then turn to the wholesale market(s).

⁵⁶ See Ofcom’s Mobile Evolution statement: http://stakeholders.ofcom.org.uk/binaries/consultations/msa/statement/MSA_statement.pdf. We have also set out our finding of Significant Market Power in relation to mobile call termination markets in our statement of 15 March 2011 available at <http://stakeholders.ofcom.org.uk/consultations/mtr/statement>.

5.16 Currently, consumers typically buy a ‘cluster’ of services (including access, voice origination and data services) that are likely to face a common pricing constraint. In the future, the nature or importance of the different usage segments could change. In particular, data services are likely to continue to grow in importance. We consider it is possible that separate markets could develop at the retail level associated with higher quality data services, such as:

- A high quality data market associated with reliable indoor coverage for data services.
- A separate market associated with higher data speeds and better latency (delivered by LTE) which is distinct from a market associated with lower data speeds (delivered by 2G and 3G).
- A division of the retail market into services that had priority over other services (e.g. a highly reliable business service compared to a lower priority consumer service).

5.17 For the reasons set out in section 3 Annex 6, we consider it reasonable not to rely on fixed services constraining mobile services for the period we are considering.

5.18 In the retail market currently, the four national wholesalers are major competitors. But they also provide wholesale access to their networks on a commercial basis to other companies. This allows for more competition in the retail market, with around 25 other retailers competing. We see this as a very desirable current feature of the UK mobile sector. In our competition assessment, we distinguish between two types of other retailer (see sections 2 and 4 of Annex 6):

- **Sub-national Radio Access Network (RAN) operators** who have access to certain sites (typically indoors) and operate some low-power radio access equipment. For example, these include operators with the so-called DECT guard band spectrum (such as C&WW and Teleware) and WiFi networks using licence-exempt spectrum. They typically rely on buying national wholesale access so their consumers can stay connected when outside the particular locations where they have their own RAN infrastructure.
- **Other retailers (e.g. Mobile Virtual Network Operators (MVNOs))** who purchase wholesale access to national networks and retail their own services without owning RANs. The ecosystem of these retailers encompasses a range of different companies with very different commercial models. At one end of the range, some are “pure resellers” in that they focus on developing their branding and pricing offer, but the national wholesaler providing access supplies the underlying service package in its entirety (including customer service and billing). At the other end, some operate their own customer relationship management systems, including all billing operations, have their own mobile number ranges, mobile network code and some core network infrastructure (e.g. switches), issue SIM cards to their customers, and effectively have their customers roam onto their national wholesale partner’s network.

5.19 In the Mobile Sector Assessment, we considered that the retail market was competitive. There have been material shifts in market shares, robust switching levels, new entry and evidence of innovation with new product and price options. We also concluded in the Mobile Sector Assessment that the sector has served UK citizens and consumers well. Consumers have experienced sustained real price

reductions and mobile penetration has continued to grow. We believe that competition has helped to deliver these benefits to consumers.

Ability to obtain commercial wholesale access

- 5.20 Provided it is possible for retailers to obtain wholesale access on reasonable terms in the future, we consider that the retail market is likely to be competitive in future. Barriers to entry appear relatively low at the retail level, and there are examples of entry having occurred recently, including since the merger of T-Mobile and Orange.⁵⁷
- 5.21 However, if wholesale market(s) were to develop such that it was difficult for sub-national RAN operators and other retailers to obtain wholesale access to national networks on reasonable terms, then there could be a significant reduction in competitive intensity in the retail market compared either to today or to the degree of future competition that could be promoted. It could be necessary to enter as a national wholesaler in order to be a strong competitor in the retail market, and hence barriers to entry or growth at the retail level could be as high as the wholesale level.
- 5.22 If separate retail markets associated with higher quality data services were to develop in the future, then it could be that separate markets would develop at the wholesale level. It is possible (for the reasons that we explore later) that the degree of competitive intensity may be different in these different wholesale markets. In particular, there is a risk that it would be less in markets associated with higher quality data services.

Entry for sub-national RAN operators may be harder than for other retailers

- 5.23 The barriers to entry for sub-national RAN operators may be higher than for some retailers (though much lower than for national wholesalers, as discussed later in this section). Sub-national RAN operators need to build some RAN infrastructure and may need to hold spectrum (if using licensed spectrum, as opposed to licence-exempt spectrum, such as that used to deliver Wi-Fi services). These fixed costs may make entry harder.
- 5.24 Entry or expansion by sub-national RAN operators could potentially have different kinds of competitive benefit compared to entry by other retailers. It may allow competition over more of the value chain, and may facilitate different types of business model and innovation in terms of retail offers. It could therefore be an important source of increased innovation and competitive pressure in the retail market, although the nature and scale of the benefits is uncertain. We consider there is a relatively high likelihood of sub-national RAN operators having a positive impact in terms of increasing competitive pressures in the retail market for specific or niche customer groups. We consider there is a smaller chance of a more radical effect on competition and consumers from entry by sub-national RAN operators with more unpredictable or paradigm-shifting commercial models – for example if “inside-out” models of network provision prove to be significantly more effective at providing high speed mobile broadband services.
- 5.25 Low-power use of 2.6 GHz may be particularly attractive for sub-national networks, given that a wide variety of handsets may be able to use LTE at this frequency in the near future. It may be possible for a number of different companies to coexist by sharing access to the spectrum, as is currently the case with the DECT guard band spectrum. Shared low-power use of some 2.6 GHz by a number of different operators

⁵⁷ See Section 4 of Annex 6 for examples of retail market entry.

could be an effective and efficient use of spectrum. But potential entry using shared low-power use of spectrum may be more difficult if companies need to buy spectrum in the auction. This is because potential low-power users may not be able to coordinate effectively in an auction. As a result, bids of shared low-power users may not reflect the true value of shared use. Furthermore, the aggregate value of spectrum to potential low-power users may not reflect the full social value their collective use may generate, such as any dynamic competition benefits. There is also a risk that national wholesale operators, anticipating the future competitive impacts from entry by shared low-power users, may increase their valuation of spectrum in outcomes in which no competitive threat exists and seek to foreclose entry by low-power users.

- 5.26 Therefore we consider that there is a risk that an unconstrained auction may not deliver maximum benefits for consumers if valuable entry by low-power users is deterred. We believe there is a case for considering the possible costs and benefits of helping to secure some 2.6 GHz spectrum for lower power shared use. We consider this further later in this section.

Risks for future competition in retail market(s)

- 5.27 As set out in section 5 of Annex 6, we therefore identify two potential risks to future competition in retail market(s):
- First, there may be a risk to competition from sub national RAN operators and other retailers arising from relatively weak national wholesale competition and an inability to obtain wholesale access on reasonable terms.
 - Second, there may be a risk that an auction without any measures to promote competition may not deliver maximum benefits for consumers if valuable entry by low-power users is deterred.
- 5.28 We therefore consider whether we should put in place any appropriate and proportionate measures to address these potential risks.

Future competition and potential for new entry in wholesale market(s)

- 5.29 As discussed in section 3 of Annex 6, past assessments by competition authorities have assumed a single mobile retail services market and a single wholesale access and call origination market. Our competition assessment is about future markets rather than current markets, and we do not reach a definitive view on current markets.
- 5.30 In the future, higher quality data services are likely to continue to grow in importance. It is possible that separate markets could develop that are associated with higher quality data services. The growing importance of higher quality data services is significant for this competition assessment because spectrum holdings can have a bigger impact on the ability to deliver higher quality data services than is the case for voice services.

Importance of national wholesalers

- 5.31 As well as being important to support competition in retail markets, competition between national wholesalers is important because it is at this level that many key

aspects of quality of service are determined. The quality of the network and spectrum used by the national wholesaler determines:

- speed of data services, i.e. the throughput in Mbps that consumers can enjoy;
- capacity, i.e. the number of users that a network can support;
- breadth of coverage, i.e. what proportion of the country enjoys coverage for future mobile broadband services; and
- depth of coverage, i.e. how deep into buildings consumers can enjoy these services, when taking account of attenuation from walls and other structural elements.

5.32 The importance of national wholesalers is also illustrated by their accounting for a very considerable share of the ‘retained value’ of the mobile value chain.⁵⁸

Importance of suitable spectrum portfolio for higher quality data services

5.33 Access to suitable spectrum is essential to provide a national wholesale service. Because of its key importance, national wholesalers are likely to want to hold the spectrum directly. If they did not hold the spectrum directly, they may be in a weak bargaining position with whoever holds the spectrum they are accessing or seeking to access.

5.34 While in theory it is possible for a holder of another type of asset to attain a level of influence on the market comparable to that of a national wholesaler, we consider this unlikely in practice. Other companies in the value chain (e.g. providers of sites) are much less significant in terms of their share of the retained value in the mobile value chain today.

5.35 It may be difficult for national wholesalers to provide higher quality data services without access to spectrum portfolios suitable for doing that. For example, to provide high data speed services or prioritise some services, national wholesalers are likely to need access to spectrum that can be used for LTE services. To provide reliable indoor coverage, lower frequency spectrum may be required.

5.36 The spectrum portfolio held by a national wholesaler can have a big influence over the quality of the services that can be delivered, and the number of people those services can be delivered to. It is not the only factor, as the number of macro sites deployed is also important, as are arrangements to off-load data from the macrocell network, such as with WiFi or femtocell deployments.

5.37 In theory, deploying more sites could be used to add capacity instead of a greater quantity of spectrum. However, the higher the demand, the more sites would be required to match capacity and the less feasible it would be, both in terms of practicality and financial viability. We therefore consider that a national wholesaler’s spectrum portfolio will have a significant influence over the capacity as well as the quality of service it can offer. As discussed below, if its portfolio does not include the right mix of spectrum, such as sub-1 GHz, its quality of service may be limited. In addition, if its spectrum portfolio is small, it may have limited capacity.

⁵⁸ The retained value is the share of revenues retained by a market participant after paying for or sharing the revenues with other participants. See Figure 5.1 in section 5 of Annex 6 for details on the retained value shares for different components of the mobile value chain.

- 5.38 A limit on a national wholesaler's capacity could limit the number of customers it could serve for any given quantity of spectrum. Given the significant fixed costs that are involved with achieving access to a network (even if these are shared), it may be necessary to have a large enough spectrum portfolio to have sufficient capacity to obtain a large enough customer base to be profitable. This is consistent with the observation that the mobile industry is characterised in most countries by a small number of national wholesalers (typically three to four). It may be hard for a national wholesaler with a small market share to survive given the fixed costs (even if these are shared through a network sharing arrangement). There may come a point at which if a national wholesaler does not hold a sufficient portfolio of spectrum it may struggle to be financially viable. And even if financially viable, if a national wholesaler is to be a competitive force, it needs to have capacity to serve sufficient customers to do that.
- 5.39 To provide some higher quality data services, it is likely to be necessary to use LTE technology. Some spectrum may be more suitable for this than other spectrum. Large blocks of contiguous spectrum holdings may also be important for the provision of some higher quality mobile services. UMTS only operates on 2x5 MHz channels. In contrast, LTE is designed to operate using a variety of spectrum channel sizes, up to 2x20 MHz. The larger the contiguous spectrum used for LTE, the higher the peak speeds that can be delivered. Large contiguous spectrum blocks are therefore likely to be more important for LTE than for UMTS.

Particular importance of sub-1 GHz spectrum

- 5.40 Sub-1 GHz spectrum gives advantages over higher frequencies in terms of coverage. It allows a significantly greater geographical area to be served than higher frequency bands would, for the same number of sites (because signals travel further at lower frequencies). It also tends to provide substantially better signal quality and higher download speeds (throughput) within buildings than higher frequencies since lower frequency signals are better at penetrating solid objects.
- 5.41 These advantages could mean that national wholesalers with a large amount of sub-1 GHz spectrum would have an unmatched competitive advantage over those without any sub-1 GHz spectrum. By an unmatched competitive advantage we mean that the national wholesalers without sub-1 GHz spectrum suffer a material competitive disadvantage because they are unable to develop their networks to offer services sufficiently similar to national wholesalers with sub-1 GHz spectrum. This would depend partly on technical differences between wholesalers with different spectrum portfolios and partly on how sensitive consumers are to any such technical differences, such as the quality of deep indoor coverage.
- 5.42 In our technical analysis we have explored the technical scale of these advantages. This analysis is set out in Annex 7. Our preliminary conclusion is that national wholesalers with a large amount of sub-1 GHz spectrum may have an unmatched technical advantage compared to national wholesalers without any sub-1 GHz spectrum.
- 5.43 Just because sub-1 GHz has a technical advantage in terms of coverage does not necessarily mean that this will be commercially significant. However, we consider that consumers are likely to value better quality indoor coverage and that the differences could therefore be important.

- 5.44 We therefore consider there is a risk that sub-1 GHz spectrum gives an unmatched competitive advantage. Our view of the importance of sub-1 GHz is consistent with the position taken by other European regulators in recent and upcoming auctions.
- 5.45 Our fuller assessment of the importance of sub-1 GHz spectrum is set out in section 5 of Annex 6.

Ability to negotiate potential network sharing agreement

- 5.46 Having a reasonable overall spectrum portfolio may have another commercial advantage. It may improve the negotiating position for a national wholesaler if it were seeking to agree a network sharing agreement with another national wholesaler. This is because it is much more credible for a national wholesaler to 'go it alone' if it has a portfolio of spectrum that makes it credible that they could operate on a stand-alone basis.
- 5.47 Having some sub-1 GHz spectrum may be particularly important in this regard. It is possible to provide some coverage over a large majority of the population with a relatively small number of sites with sub-1 GHz spectrum. This makes it much cheaper than with higher frequencies to build a network that provides some basic level of national coverage. Having a reasonable overall portfolio of spectrum makes it more likely that the fixed costs of the network can be recovered, making it more credible that a national wholesaler will build its own network if it could not agree acceptable terms for network sharing.

Provisional conclusions on nature of the spectrum holdings needed to be a credible national wholesaler

- 5.48 For national wholesalers to be credible competitors in terms of providing higher quality data services, we consider they are likely to need to have a spectrum portfolio that includes:
- a reasonable overall portfolio of spectrum suitable for LTE that allows them to offer higher quality data services and is of sufficient size for them to be able to cover the fixed costs of being a national wholesaler; and
 - in particular, we consider that a national wholesaler is likely to need to have some sub-1 GHz in order credibly to be able to offer higher quality data services, particularly indoors.
- 5.49 This is consistent with our technical analysis which suggests that a national wholesaler without any sub-1 GHz spectrum may struggle to match the quality of services offered by an operator with 2x20 MHz of sub-1 GHz spectrum.
- 5.50 We consider below what types of portfolios of spectrum may be sufficient for national wholesalers credibly to be able to offer higher quality data services.

High barriers to entry for national wholesalers

- 5.51 We consider that there are high barriers to entry for a potential new national wholesaler.
- 5.52 First, as discussed above, access to a minimum amount of spectrum of the right nature is necessary in order credibly to be able to deliver wholesale services. Suitable spectrum is scarce and licences are currently held by only four firms. The

800 MHz and 2.6 GHz spectrum made available in the auction may be a rare opportunity to obtain spectrum suitable for national mobile services.

- 5.53 Second, a national wholesaler needs access to a Radio Access Network (RAN). There are significant sunk costs involved in building a mobile network with national coverage. This acts as another barrier to entry. Acquiring access to new sites can be a lengthy and complex process because of the existence of a limited number of suitable locations for optimised outdoor coverage, the need for negotiations with landlords, potential planning requirements, potential works to host the network equipment and site engineering for interference management. While it may be possible to reduce the size of the costs that each national wholesaler has to bear through a network sharing arrangement, there will still be a large fixed element to the costs.
- 5.54 The scale of the fixed costs will tend to limit the number of national wholesalers who can profitably survive in a competitive market. In most developed countries there are only three or four national wholesalers, suggesting this is the norm for the number of national wholesale competitors.⁵⁹

Risk of lower competitive intensity in wholesale market(s)

- 5.55 Currently there are only two national wholesalers who have spectrum portfolios that include sub-1 GHz spectrum, that is, Vodafone and O2. Everything Everywhere has a relatively large quantity of spectrum and the largest site base, but does not have sub-1 GHz spectrum. H3G has 2x15 MHz of 2.1 GHz and no sub-1 GHz spectrum.
- 5.56 We therefore consider that, depending on the outcome of the auction, there is a material risk of a lower number of competitors providing higher quality data services, compared to the number of competitors in the wholesale market today and compared to what might reasonably be possible. For example, if Vodafone and O2 won access to all of the 800 MHz spectrum, they would hold all of the available sub-1 GHz spectrum, and might therefore be the only national wholesalers capable of providing reliable higher quality data services, particularly indoors. Especially given the high barriers to entry, we consider that if there were only two (or three, if only one other competitor won sub-1 GHz spectrum) competitors in the provision of higher quality data services, this could result in a lower level of competitive intensity compared to a situation where there were more national wholesalers.
- 5.57 If only two or three national wholesalers could win access to spectrum portfolios that would allow them credibly to offer higher quality data services, they may have a strategic incentive to bid to achieve this. Expected profits would tend to be higher as a result of lower competition. This could mean that two or three national wholesalers would have an incentive to pay more for the spectrum in order to restrict competition and the number of national wholesalers having such spectrum portfolios. In this case, the concentrated spectrum outcome would not reflect a socially optimal allocation of the spectrum, rather it would reflect likely lower competition in the case where there were only two or three credible national wholesalers. These strategic bidding incentives could make an outcome of the combined award with fewer national wholesalers with spectrum portfolios for credibly offering higher quality data services more likely.

⁵⁹ See the discussion of high barriers to entry for national wholesalers in section 5 of Annex 6 for more details on other countries.

Provisional conclusion on future competition absent measures to promote competition

- 5.58 We consider that if we put in place no measures in the combined award to promote competition, there is a material risk of an outcome that would lead to lower competitive intensity in the provision of higher quality data services compared to competition in the wholesale market today, and compared to what might be possible. This is because we consider there is a material risk of only two or three national wholesalers emerging from the auction capable of providing higher quality data services in a profitable way. This is especially the case given that there are high barriers to entry to the national wholesale market, including the difficulty of obtaining access to suitable spectrum.
- 5.59 Relatively weak competitive intensity at the wholesale level, at least in the provision of higher quality data services, would also be likely to reduce competition in retail markets. We consider that relatively weak competitive intensity in wholesale and retail markets could lead to higher prices and lower quality services and innovation for UK consumers. We consider this could result in significant consumer detriment.
- 5.60 If some national wholesalers did not have spectrum portfolios that allowed them credibly to compete in the provision of higher quality data services, this could even lead them to exit all wholesale markets. This might be the case if they were unable to be profitable without providing the higher quality data services. In this case any reduction in competitive intensity would affect all wholesale markets. We therefore consider that we should go on to assess whether there are any appropriate and proportionate measures that we should put in place to promote competition to address these concerns.
- 5.61 Section 5 of Annex 6 sets out our reasoning in more detail.

Question 5.1: Do you agree that national wholesalers need a reasonable overall portfolio of spectrum to be credible providers of higher quality data services? In particular, do you agree that national wholesalers need some sub-1 GHz in order credibly to be able to offer higher quality data services? Please state the reasons for your views.

Question 5.2: Do you agree there is a material risk of a significant reduction in the competitive pressures, at least to provide higher quality data services, in retail and wholesale markets without measures in the auction to promote competition? Please state the reasons for your views.

- 5.62 We also consider there is a risk that sub-national RAN operators may not enter or expand in a way that would be beneficial for consumers, without measures to promote competition.

Question 5.3: Do you agree there is a risk of potentially beneficial sub-national RAN uses not developing without measures to promote competition? Please state the reasons for your views.

Preference for structural measures to promote competition

- 5.63 There is a range of measures which we could put in place in the combined award to seek to ensure that consumers do not suffer as a result of relatively weak competition. These can be split into the following categories:

- **Structural measures** which address the market structure; and
- **Behavioural measures** which address the behaviour of competitors in the market.

5.64 Structural measures would involve putting in place auction rules which ensure that spectrum holdings are not too concentrated as a result of the award. Examples of these measures are spectrum floors and reserving spectrum for new entrants. For the reasons set out above we see direct holding of spectrum rights to be crucial for national wholesalers. So, by using auction rules to ensure that spectrum is not overly concentrated, we could put a likely lower bound on the number of credible competitors in the future wholesale mobile market. The key consideration we face when assessing this type of measure is an assessment of the costs involved (e.g. would we deny any benefits to society by preventing some distributions of spectrum from occurring), compared with the benefits which we consider the measure would be likely to achieve.

5.65 Behavioural measures would seek to ensure that wholesale access is provided on terms which mirror those which would emerge in a competitive market, even if the auction resulted in a less competitive market structure than would be desirable. The key considerations we face when assessing this type of measure are the degree to which these measures can really mirror the outcome of a competitive market:

- first, it is likely to be very difficult to provide national wholesalers with incentives to innovate and provide high quality services via this type of measure.
- second, there are material risks that we are unable to set the terms of the measure in a way which allows retail competitors to compete on an even footing. The information asymmetries between us and the competitors in the market, and the incentives these competitors have to influence the outcome of our decisions, mean that it is generally very difficult for us to get this type of measure exactly right. We also note that behavioural measures are generally difficult to monitor.

5.66 In our assessment of potential measures in respect of wholesale market(s), we start by considering whether there are structural measures which we could put in place in the auction to promote competition without imposing material costs. We provisionally conclude that there are measures available to us which could secure this, and which we think are likely to be proportionate to the scale of the potential competition issues we have identified. In addition, we consider whether there are any behavioural measures that would be an effective alternative, and provisionally conclude that such measures would not result in a better outcome for UK consumers than structural measures, and so may not be appropriate or proportionate as they may impose costs without achieving the desired benefits.

Proposed measures to promote wholesale competition

5.67 In exploring potential measures to promote competition we begin by considering measures in wholesale markets. This is because competition in wholesale markets has a large impact on competition in retail markets.

Benefits from ensuring at least four national wholesalers

5.68 We consider that the number of competitors who are capable of being credible national wholesalers is likely to be a key factor in how competitive mobile markets are in the future, and so most likely to further the interests of consumers. This is

especially because, as set out above, the relevant markets are characterised by particularly high barriers to entry, due partly to the scarce supply of spectrum necessary to be an effective national wholesaler. Whilst in the future, we expect all mobile spectrum to be tradable, we do not consider that we can rely on this solely to ensure that markets are competitive, because holders of spectrum may have an incentive not to trade if that increases the intensity of competition.

- 5.69 We have therefore considered whether we should put in place measures to ensure that a minimum number of companies have sufficient spectrum portfolios at the end of the auction to become credible national wholesalers capable of offering higher quality data services, and if so, what minimum is necessary to promote competition at the national wholesale level.
- 5.70 We provisionally consider there would be a material risk to national wholesale competition if there were fewer than four credible national wholesalers. This would be fewer than the number of national wholesale competitors in the current market. In our view it would also be fewer than the number of national wholesale competitors that is likely to be sustainable in future. In proposing a minimum of four licensees capable of being credible national wholesalers it is important to realise that we are not ruling out the potential for some of those licensees to be new national wholesale entrants. We would not be surprised if one or more prospective new entrants were to bid for the minimum spectrum portfolios that we have identified; for example in the recent 800 MHz auction in Sweden two of the bidders were prospective new entrants. But neither are we relying on the emergence of prospective new entrants for our proposals to achieve the minimum degree of competition that we consider to be in the best interest of consumers. Our proposals are neutral as to the identity of the four licensees; they seek to provide all parties with equality of opportunity to bid for sufficient spectrum to be credible national wholesalers in the future.
- 5.71 We set out our reasons for proposing that at least 4 national wholesalers are likely to be necessary to promote national wholesale competition in section 6 of Annex 6. In summary our analysis is that with at least four national wholesalers there is little evidence of a risk to competitive intensity and there is unlikely to be a large risk to efficiency, particularly in comparison to the competition benefits they may bring. We have also considered evidence from EU mobile markets. Experience in other EU mobile markets suggests that there is a risk that competition will not be effective if there were three or fewer credible national wholesalers, though it does not suggest that competition concerns would arise in every market where this is the case. In some EU mobile markets where there were three national wholesale competitors, regulators either found joint dominance or reached an initial view that anti-competitive behaviour was present, particularly in terms of refusal to supply wholesale services.
- 5.72 Hence, we think that there is a material risk that competitive intensity would be lower than it could be if there were not at least four credible national wholesalers. However, we recognise that this number is subject to sufficient competitors expressing demand in the auction to be credible national wholesalers.

Spectrum ‘floors’ to ensure at least four national wholesalers

- 5.73 We have considered what would be the least restrictive measures that we could put in place to promote outcomes in which at least four companies had spectrum portfolios at the end of the auction that meant they were capable of credibly providing higher quality data services. We provisionally consider that the least restrictive way of achieving this is through the use of spectrum ‘floors’ in the auction. This would

involve preferring auction outcomes (i.e. combinations of winning bids) in which at least four companies come out of the auction with no less than a certain minimum amount of spectrum of various types (minimum spectrum portfolios) taking existing holdings of 900 MHz and 1800 MHz spectrum into account.⁶⁰

5.74 In our preferred option (Option 1), we propose that companies would be regarded as having enough spectrum to credibly provide higher quality data services if they had one of the following:

- 2x5 MHz of sub-1 GHz spectrum and 2x20 MHz or more of 2.6 GHz; or
- 2x5 MHz of sub-1 GHz spectrum and 2x15 MHz or more of 1800 MHz; or
- 2x10 MHz of sub-1 GHz spectrum and 2x15 MHz or more of 2.6 GHz; or
- 2x10 MHz of sub-1 GHz spectrum and 2x10 MHz or more of 1800 MHz; or
- 2x15 MHz or more of sub-1 GHz spectrum.

5.75 We acknowledge that there is some uncertainty over what is likely to be the minimum spectrum portfolio necessary to be a credible national wholesaler and in particular whether the holding of 2 x 5 MHz of sub-1GHz spectrum combined with higher frequency holdings is likely to be sufficient. We have therefore considered in particular a second option (Option 2) in which the minimum amount of sub-1 GHz spectrum included in the portfolios is 2x10 MHz.

5.76 Our technical analysis (see Annex 7) suggests that a multi-frequency network with 2x5 MHz of sub-1 GHz spectrum and a certain amount of above-1 GHz spectrum can go a long way towards matching the coverage and maximum speed deliverable by a network with only sub-1 GHz spectrum using the same number of sites. In order to achieve this however the multi-frequency networks is not loaded to the same extent as the sub-1 GHz only network. This requirement for lighter loading does however mean that, all other things being equal, such multi-frequency networks will not be able to serve the same number of customers as a sub-1GHz only network with a similar amount of spectrum and number of sites, and so will have a lower capacity.

5.77 It may be that such differences in capacity would not preclude an operator with only a limited amount of sub-1 GHz spectrum from having a material impact on competition – such an operator may be an effective competitor notwithstanding the more limited number of customers that they can serve. Furthermore, there may also be ways in which an operator with only limited sub-1 GHz spectrum could increase the capacity of their network, such as using more higher frequency spectrum or additional sites, or making use of other technologies, such as femtocells and WiFi, to off-load traffic from their macro-cell network. Such measures have the potential therefore to enhance the effectiveness of such an operator as a competitor.

5.78 In addition to our view that the minimum spectrum portfolios in Option 1 may be sufficient to promote competition, we believe that the requirement to act proportionately also suggests this option. It may be the least onerous measure necessary to achieve our aim of promoting a minimum of 4 credible wholesale competitors. Also since under Option 1 the sub-1 GHz floor would account for a

⁶⁰ We recognise that it is possible that there are insufficient bidders or the bids are such that this requirement cannot be met. We do not consider those particularly likely but Section 9 and Annex 9 explain what would happen in such circumstances.

smaller proportion of the 800 MHz spectrum than Option 2, this means that the bidding in the auction rather than regulation would have a greater influence on determining the outcome, and therefore the risk of regulatory failure would be lower. We are therefore minded to favour Option 1. This is however a matter on which we are particularly keen to receive views and evidence from stakeholders in response to this consultation.

- 5.79 We have provisionally excluded the 2.1 GHz spectrum from these floors because we consider it is less likely to be used for LTE in Europe in the next 5 to 10 years. We have also excluded the unpaired 2.6 GHz spectrum, because it is currently unclear if TD LTE or WiMAX will gather sufficient momentum to be a realistic substitute for paired 2.6 GHz spectrum to provide higher quality data services.
- 5.80 We recognise that if more companies win spectrum as a result of measures we take in the combined award there is a risk of some inefficiency. There are a number of aspects to this. First, there is a risk that the reason some companies would not otherwise have acquired spectrum is because they would not use it as efficiently as those who would have bought it. To some extent, it may be possible to mitigate this risk through higher reserve prices. Second, there is a risk of inefficiencies from increasing costs due to the large economies of scale involved with RANs. However, it may be possible to achieve these economies of scale without losing the benefits of competition through RAN sharing, subject to competition law. Finally, there is a risk of inefficiencies from losing the benefits of large blocks of contiguous spectrum. If spectrum sharing were possible, this could mitigate or even eliminate this inefficiency, subject to competition law.
- 5.81 On balance we therefore consider the likely benefits to consumers of the lower risk of a reduction in competition outweigh the potential impact on efficiency of our spectrum floor proposals. We set out our analysis of the advantages and disadvantages of using floors to ensure at least four national wholesalers in more detail in section 6 of Annex 6.
- 5.82 We do not consider it necessary (or even possible) to take a firm view now on whether future possible sharing agreements may be in consumers' interests. This is because it would depend on the detail of the sharing agreements. Any future sharing agreements would be subject to the requirements of competition law. Similarly we recognise that a further consolidation in the market is possible and this might lead to less than four competitors. However, any such process would be subject to merger rules and/or competition law.

Safeguard caps to guard against longer term risks to competition

- 5.83 We also propose to put in place safeguard caps to guard against longer terms risks to competition from very asymmetric holdings of spectrum. While we do not think that spectrum needs to be held equally for there to be effective competition or equality of opportunity to compete, we do think that there could be a risk if some national wholesalers held a very large share of mobile spectrum. While it is difficult to speculate about future possible developments, we consider it is possible that in the longer term there could be technological (e.g. beyond LTE) or market developments that meant that very asymmetric holdings of spectrum represented a risk to competition, especially for sub-1 GHz spectrum.
- 5.84 We propose two safeguard caps:

- a sub-1 GHz safeguard cap of 2x27.5 MHz, which would mean that no one competitor could hold more than this amount of sub-1 GHz spectrum (including any existing sub-1 GHz holdings). This would be to restrict the scope of over concentration in the holding of sub-1 GHz spectrum.
 - an overall mobile spectrum holdings cap of 2x105 MHz, which would mean that no one competitor could hold more than this amount of spectrum overall (including any existing mobile spectrum holdings). This would be to restrict the scope for over concentration in overall mobile spectrum holdings.
- 5.85 These safeguard caps would still allow significant spectrum holdings, which would be unlikely to preclude national wholesalers from obtaining efficient spectrum portfolios. Therefore, whilst the benefits of the safeguard caps are uncertain, the costs are likely to be relatively small.
- 5.86 We have also considered other options for the safeguard caps as shown in the table at the end of this section.
- 5.87 As these safeguard caps are intended to prevent undue competitive advantages in the longer term, we consider it appropriate to include in the overall safeguard cap the unpaired 2.6 GHz and paired 2.1 GHz spectrum (though we exclude the unpaired 2.1 GHz). In the longer term, we consider these may be useful for LTE services or subsequent technologies.

Liberalisation of 900 MHz and 1800 MHz spectrum for LTE

- 5.88 Alongside these proposals to promote competition we are proposing to liberalise existing 900 MHz and 1800 MHz spectrum for LTE. Our analysis of the spectrum floors and caps is based upon our view that it is likely to be possible to use such spectrum to a significant extent for LTE on a broadly similar timescale to 800 MHz and 2.6 GHz, although we recognise that there may be different timelines relating to equipment availability between the bands. We have considered whether liberalisation of 900 MHz and 1800 MHz spectrum for LTE could give rise to a competition concern and our provisional conclusion is that no such concern is likely to arise given the timetable for the availability of 800 MHz and 2.6 GHz spectrum (see Annex 6 section 6 for further details.)

We consider that our proposed measures are appropriate and proportionate

- 5.89 We consider that our proposed measures are likely to impose relatively low costs, relative to their likely benefits given our concerns if there were no measures in place in the auction to promote competition (see section 6 of Annex 6). We consider that they constitute the minimum intervention needed to address our potential concerns, and so limit the opportunity cost of our measures – i.e. the extent to which firms are restricted in acquiring the most efficient quantity of spectrum. As such we consider that they are proportionate to their intended aims. In addition we think that the likelihood that the measures would fail to address our potential concerns is low.
- 5.90 Our measures could be costly if four players were not sustainable in the market. However, if only three potential national wholesalers bid in the auction, then under our proposed auction rules the floor will be reduced to three. Consolidation in the longer term cannot be ruled out. Consolidation via trading after the auction would be subject to a competition check to ensure that the proposed trade would not distort competition (as proposed in our consultation on trading of existing mobile

spectrum⁶¹). Similarly, any consolidation that was proposed via merger would be subject to applicable merger control laws.

- 5.91 We have also considered whether relying on behavioural measures might be more appropriate – for example imposing regulated access if fewer than four companies hold what we consider to be sufficient spectrum to be a credible national wholesaler. We do not think this is likely to be better than our proposed measures because, first our analysis suggests that a three wholesaler market would be unlikely to deliver lower costs, higher quality or greater innovation for consumers than a market with at least four national wholesalers. Second, we think that behavioural measures may not be as effective as structural measures because of the incentive and information problems and monitoring difficulties described above.

Question 5.4: Do you agree with the analysis that at least four competitors are necessary to promote competition?

Question 5.5: Do you agree that the specific measures we propose to take to ensure there are at least four holders of such spectrum portfolios are appropriate and proportionate?

Potential measures to promote national wholesale access

- 5.92 Given the forward-looking nature of our competition assessment, and its inherent uncertainties, we acknowledge that there is a residual risk that markets might develop in such a way that our proposed measures would not promote competition in the manner intended.
- 5.93 Hence, we have considered whether there might be a case for putting in place any access obligations in licences for the spectrum to be auctioned to ensure access to national wholesale networks in the future. We consider two types of access obligation, a ‘live’ access obligation that would apply immediately and a ‘dormant’ access obligation that would only be triggered if we had material concerns about whether the market was delivering for consumers.
- 5.94 We have in particular considered putting any access obligation on only one new licence (including 800 MHz). Any dormant access obligation would be triggered following a further competition assessment whose scope would be to consider whether commercially negotiated access at the time was sufficient to further consumers’ interests.
- 5.95 We provisionally consider that it is unlikely to be appropriate and proportionate to put in place a live access condition into any of the auctioned licences. We consider that the provision of national wholesale access services is likely to be competitive given our proposals to ensure that at least four competitors are capable of being credible national wholesalers. There may be some residual risk that competition will be insufficient, but we consider it would be more appropriate and proportionate to rely on our other powers, including our ex post competition powers, to address this risk.
- 5.96 We consider that the case for a dormant access obligation may be stronger, but our preferred option is to proceed without imposing it for the following reasons:
- We think that imposing a dormant access condition may be of limited benefit over and above using our other powers in the future, since we might have to complete

⁶¹ <http://stakeholders.ofcom.org.uk/consultations/trading-900-1800-2100/>

a very similar assessment to justify imposing the condition as we would need to under our other powers.

- Further, the dormant access condition as expressed above would in our view need to be relatively general and a review could be triggered under a wider range of situations. This may increase the uncertainty licensees face which could act as a brake on investment and could be a worse outcome for consumers than if we relied on our other powers.
- If we specified a more specific dormant access condition that was more measurable using pre-specified metrics, we would run the risk that we were unable to use it when it was in fact necessary (or that it might be triggered when not needed) because it is difficult to capture the complexities of wholesale access competition in a set of pre-specified metrics. In this case we might in any event have to fall back on our other powers.

5.97 Our full assessment of wholesale access is set out in section 7 of Annex 6.

Question 5.6: Given the measures we propose to take to ensure four holders of spectrum portfolios sufficient credibly to provide higher speed data services, do you agree that it would not be appropriate or proportionate to introduce a regulated access condition into the mobile spectrum licences to be awarded in the combined award?

Potential measures to promote retail competition

5.98 We consider that the measures we are proposing to promote wholesale competition will assist competition in the retail market(s). In particular, we consider that national wholesale access would be likely to be provided to retailers commercially given our proposals to ensure that at least four competitors are capable of being credible national wholesale competitors. Provided retailers are able to obtain national wholesale access on reasonable terms, then in general the barriers to entry in the retail markets are likely to be relatively low and competition in those markets is likely to be promoted. Retailers such as existing MVNOs and potential MVNO entrants should therefore be able to compete in future retail markets.

5.99 However, we consider that barriers to entry and expansion for retailers who wanted to operate their own sub-national RANs could be greater than for other retailers. This is because such sub-national RAN operators may need access to spectrum to provide commercially attractive services. Such competitors may be important because they could offer greater scope for innovation and could potentially have a greater impact on increasing competition in retail markets compared to other retailers. However, as we noted earlier in this section, there is a risk that such entry could be deterred in an unconstrained auction. We therefore consider whether it is appropriate and proportionate to promote entry for sub-national RAN operators.

5.100 We consider two possible approaches to assisting entry by sub national RAN operators:

- Introducing a mechanism in the auction to aggregate bids from the low-power users and allowing competing bids between high and low-power users.
- Reserving some 2.6 GHz paired spectrum to be used on a low-power shared use basis.

- 5.101 We consider that there is a strong case for aggregating bids amongst low-power users and allowing parallel bidding between low and high power users. However, it is necessary to limit any aggregation mechanism to a fixed amount of spectrum in order to avoid significantly complicating the auction process. We therefore seek stakeholders views on the amount of spectrum over which any mechanism to aggregate individual bids should apply.
- 5.102 Aggregating bids over low-power users would go some way to addressing coordination failure amongst individual low-power users. However, this approach may not be enough to secure new entry. Therefore, we consider that there may be a case for going further and reserving spectrum for low-power use, but the case for this is not clear.
- 5.103 This is because there is considerable uncertainty over the potential size of the benefits of reserving some 2.6 GHz spectrum for such use. In addition, there may be high opportunity costs associated with reserving 2.6 GHz spectrum for low-power users. For example, there is a risk that such an approach would displace more productive high power users which could potentially generate higher value for consumers than low-power users. There is a further risk of inefficiency if reserving 2.6 GHz were to limit the number of bidders that could win a large contiguous block of spectrum for high power use.
- 5.104 We consider that the costs are likely to be significant were we to reserve 2x20 MHz exclusively for low-power use and that this is unlikely to be appropriate and proportionate to its intended effect. We consider that there may be a stronger case for reserving only 2x10 MHz of 2.6 GHz spectrum for low-power use. Alternatively, there may be a case for allowing high power and low-power users to share a 2x10 MHz block if the low-power users already had access to another 2x10 MHz block; however this is subject to further technical work (see section 4). But, given the uncertainty of any benefits associated with entry by low-power users and the risks to efficiency, it is still unclear whether it is an appropriate and proportionate measure to promote competition.
- 5.105 In summary, we consider that it will be proportionate and appropriate to introduce a mechanism that aggregates low-power users' bids and allows competing bids between low and high power users. But we do not have a preferred proposal for whether we should take further measures to promote entry by reserving 2.6 GHz spectrum for low-power use. We seek stakeholders' views and relevant information on the potential costs and benefits of potential measures to promote shared low-power use of 2.6 GHz.
- 5.106 See section 8 of Annex 6 for a fuller description of measures to promote competition in retail market(s).

Question 5.7: Do you consider that we should take measures to design the auction to assist low-power shared use of 2.6 GHz? If so, what specific measures do you consider we should take?

Summary of options and proposals for measures to promote competition

- 5.107 In Annex 6 we compare the case for putting in place measures to ensure at least three, at least four and at least five national wholesalers. We provisionally conclude

that there is a case for putting in place measures to promote at least four. Given this preference for promoting at least four national wholesalers, Table 5.1 below summarises the options we are consulting on and our preferred package of options for promoting competition. Annex 6 sets out these options in more detail.

5.108 The table provides an overview of the options we have considered to promote competition and address the four main types of risks discussed above:

- a) risk of failing to promote national wholesale competition,
 - if fewer than 4 competitors hold minimum required spectrum portfolio, or
 - if there are overly concentrated or very asymmetric distributions of spectrum;
- b) risk of inefficient use of spectrum;
- c) risk that retailers cannot obtain wholesale access; and
- d) risk that low-power users are unable to acquire spectrum.

5.109 We identify in the table which options we are proposing to use subject to this consultation.

Table 5.1: Summary of options and proposals

POTENTIAL SOURCE OF CONSUMER DETRIMENT	OPTIONS TO ADDRESS COMPETITION CONCERNS																																																												
Risk of failing to promote national wholesale competition																																																													
Fewer than 4 competitors hold minimum required spectrum portfolio	<p>Minimum spectrum portfolios for four national wholesale competitors: each wholesaler must hold at least one of the following</p> <hr/> <p><u>Option 1</u>: 5 possible portfolios [OUR PROPOSAL]</p> <table border="1" data-bbox="608 663 1414 965"> <thead> <tr> <th></th> <th>Sub-1 GHz</th> <th>1800 MHz</th> <th>2.6 GHz</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>a)</td> <td>2x5 MHz</td> <td>2x15 MHz</td> <td></td> <td>2x20 MHz</td> </tr> <tr> <td>b)</td> <td>2x5 MHz</td> <td></td> <td>2x20 MHz</td> <td>2x25 MHz</td> </tr> <tr> <td>c)</td> <td>2x10 MHz</td> <td>2x10 MHz</td> <td></td> <td>2x20 MHz</td> </tr> <tr> <td>d)</td> <td>2x10 MHz</td> <td></td> <td>2x15 MHz</td> <td>2x25 MHz</td> </tr> <tr> <td>e)</td> <td>2x15 MHz</td> <td></td> <td></td> <td>2x15 MHz</td> </tr> </tbody> </table> <hr/> <p><u>Option 2</u>: 5 possible portfolios</p> <table border="1" data-bbox="608 1021 1414 1335"> <thead> <tr> <th></th> <th>Sub-1 GHz</th> <th>1800 MHz</th> <th>2.6 GHz</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>a)</td> <td>2x10 MHz</td> <td>2x15 MHz</td> <td></td> <td>2x25 MHz</td> </tr> <tr> <td>b)</td> <td>2x10 MHz</td> <td></td> <td>2x20 MHz</td> <td>2x30 MHz</td> </tr> <tr> <td>c)</td> <td>2x15 MHz</td> <td>2x10 MHz</td> <td></td> <td>2x25 MHz</td> </tr> <tr> <td>d)</td> <td>2x15 MHz</td> <td></td> <td>2x15 MHz</td> <td>2x30 MHz</td> </tr> <tr> <td>e)</td> <td>2x20 MHz</td> <td></td> <td></td> <td>2x20 MHz</td> </tr> </tbody> </table>		Sub-1 GHz	1800 MHz	2.6 GHz	Total	a)	2x5 MHz	2x15 MHz		2x20 MHz	b)	2x5 MHz		2x20 MHz	2x25 MHz	c)	2x10 MHz	2x10 MHz		2x20 MHz	d)	2x10 MHz		2x15 MHz	2x25 MHz	e)	2x15 MHz			2x15 MHz		Sub-1 GHz	1800 MHz	2.6 GHz	Total	a)	2x10 MHz	2x15 MHz		2x25 MHz	b)	2x10 MHz		2x20 MHz	2x30 MHz	c)	2x15 MHz	2x10 MHz		2x25 MHz	d)	2x15 MHz		2x15 MHz	2x30 MHz	e)	2x20 MHz			2x20 MHz
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Overly concentrated or very asymmetric distributions of spectrum	Safeguard caps on the amount of sub-1 GHz and of overall spectrum held by each bidder after the auction																																																												
Sub-1 GHz (800 MHz and 900 MHz) holdings	<p><u>Option 1</u>: 2x22.5 MHz</p> <p><u>Option 2</u>: 2x27.5 MHz [OUR PROPOSAL]</p> <p><u>Option 3</u>: no cap</p>																																																												
Overall holdings	<p><u>Option 1</u>: 2x105 MHz [OUR PROPOSAL]</p> <p><u>Option 2</u>: 2x120 MHz</p> <p>(Spectrum included in options 1 and 2: 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz (excluding unpaired 2.1 GHz) and 2.6 GHz (including both paired and unpaired 2.6 GHz, but excluding any reserved for low-power use)</p> <p><u>Option 3</u>: no cap</p>																																																												

POTENTIAL SOURCE OF CONSUMER DETRIMENT	OPTIONS TO ADDRESS COMPETITION CONCERNS
<p>Risk of inefficient use of spectrum</p>	<p><u>Option 1</u> [OUR PROPOSAL] Liberalise spectrum for new technologies as soon as the European Commission varies the relevant Decision</p> <p><u>Option 2</u> Delay liberalisation or attach conditions to liberalisation</p>
<p>Risk that retailers and sub-national network operators cannot obtain wholesale access</p>	<p>Obligation on spectrum licensees that are national wholesalers to provide access to others</p> <hr/> <p><u>Option 1</u> [OUR PROPOSAL] No access obligation – we rely on competition plus our other powers, including ex post powers if issues arise</p> <hr/> <p><u>Option 2</u> Live access obligation in new spectrum licences</p> <hr/> <p><u>Option 3</u> Dormant access obligation in new spectrum licences</p>
<p>Risk that concurrent low-power users are unable to acquire spectrum</p>	<p>Measures to promote concurrent low-power use of 2.6GHz spectrum</p> <hr/> <p><u>Option 1</u> No measures</p> <hr/> <p><u>Option 2</u> [OUR PROPOSAL AS A MINIMUM] Aggregate bids for low-power shared use in competition with high power use for 2x10 MHz</p> <hr/> <p><u>Option 3</u> [Potential alternative to option 2] Aggregate bids for low-power shared use in competition with high power use for 2x20 MHz</p> <hr/> <p><u>Option 4</u> [Potential alternative subject to more evidence on likely benefits] Reserve 2x10 MHz exclusively for low-power shared use</p> <hr/> <p><u>Option 5</u> Reserve 2x20 MHz exclusively for low-power shared use</p> <hr/> <p><u>Option 6</u> [Potential alternative subject to more evidence on likely benefits] Reserve 2x10 MHz exclusively for low-power shared use with 2x10 MHz shared between high and lower power users</p>

- 5.110 As shown in the table above, we propose the following measures to promote competition:
- To promote national wholesale competition by ensuring that at least four competitors are capable of being national wholesale service providers by:
 - Only accepting auction outcomes where at least four competitors have one of the following minimum spectrum portfolios:
 - 2x15 MHz or more of sub-1 GHz spectrum;
 - 2x10 MHz of sub-1 GHz spectrum and 2x10 MHz or more of 1800 MHz; or
 - 2x10 MHz of sub-1 GHz spectrum and 2x15 MHz or more of 2.6 GHz; or
 - 2x5 MHz of sub-1 GHz spectrum and 2x15 MHz or more of 1800 MHz; or
 - 2x5 MHz of sub-1 GHz spectrum and 2x20 MHz or more of 2.6 GHz.
 - Setting safeguard caps to guard against longer term competition concerns:
 - a sub-1 GHz safeguard cap of 2x27.5 MHz; and
 - an overall spectrum cap of 2x105 MHz (including unpaired 2.6 GHz and paired 2.1 GHz)
 - To liberalise spectrum for new technologies as soon as the European Commission varies the Decision.
 - To deal with competition risks for the provision of national wholesale access for retailers and sub national networks as they arise through other powers, including ex post powers.

5.111 We consider it would be proportionate to introduce a mechanism that aggregates low power users' bids and allows competing bids between low and high power users for 2x10 MHz or 2x20 MHz of 2.6 GHz spectrum. But we do not have a preferred proposal on whether it may be appropriate and proportionate to promote retail competition by reserving 2.6 GHz spectrum for shared low-power use of 2.6 GHz.

Provisional Conclusions

- 5.112 Our competition assessment has identified that the release of the 800 MHz and 2.6 GHz spectrum is expected to have a material influence over the development of mobile markets in the future, and as such is likely to have a significant effect on the level of competitiveness in both wholesale and retail markets.
- 5.113 This is because access to this resource is likely to be necessary for the deployment of higher quality data services which are likely to be highly valued by UK consumers, but is also particularly scarce, most notably in the case of 800 MHz.
- 5.114 The combination of these two factors creates strong incentives and provides real opportunities for bidders in the auction to seek to influence the level of competition

they face in future mobile markets by seeking to reduce the amount of spectrum other bidders are able to obtain.

5.115 Given our view that this spectrum is likely to be crucial for the deployment of services which we expect to be highly valued by citizens and consumers in the future, the potential detriment to consumers of such an outcome could be significant.

5.116 Hence, we think it is appropriate for us to seek to put in place measures to promote competition and seek to avoid outcomes which would materially reduce the level of competition in mobile markets, as well as outcomes which unduly preclude opportunities for competition to increase through entry.

5.117 In particular, we think it is appropriate for us to seek to promote outcomes in which there are at least four credible national wholesalers. In assessing what measures it is appropriate for us to put in place to achieve this outcome we have had to consider the potential costs imposed on both competitors, and ultimately on consumers, from:

- decreased spectrum efficiency from more fragmented holdings of spectrum and the risks of increasing costs where there are economies of scale, such as at the network level (noting that these risks could potentially be mitigated by future sharing arrangements);
- imposing measures which might unreasonably preclude bidders from acquiring spectrum allocations which would allow them to deliver innovative services to consumers; and
- the risks of some measure failing to achieve the desired outcome, or imposing unintended costs.

5.118 We consider that our proposals are consistent with our principal duty to further the interests of citizens and consumers, where appropriate by promoting competition.

5.119 We have also taken account of our duty to secure optimal use of the spectrum, and consider that our proposals are likely to secure an outcome in which scarce mobile spectrum is likely to be used in a manner which best exploits its potential, by ensuring a level of competition at the wholesale level which incentivises competitors to use the spectrum in the most efficient manner.

5.120 We have considered the likely impact of our proposals on investment and innovation and the availability and use of high speed data transfer services through the United Kingdom. We note that the spectrum in the combined award is highly suited to providing high speed data transfer services, and we have sought to put together proposed options which are most likely to ensure a competitive market for such services in the future. In our view, our proposals also draw an appropriate balance between existing investments by current competitors which have led to relatively competitive markets to date, and possible future investment and innovation by both existing competitors and also possible new entrants, on either a national or sub-national basis.

5.121 We have also kept in mind our duty to have regard to the interests of consumers in respect of choice, price, quality of service and value for money. We consider that by proposing measures intended to provide a vibrant national wholesale market, the retail market should be capable of providing consumers with a wide range of services at competitive prices.

- 5.122 Finally, we consider that our proposals provide equality of opportunity for competitors to be able to compete in future mobile markets, without discriminating unduly in favour of, or against, any individual or class of competitors. We have in particular taken care to take account of existing spectrum holdings, in order to ensure that the auction should not result in overall spectrum holdings which distort competition. In setting out each of our proposals, as set out above and in Annex 6, we have considered whether our proposals are the least onerous necessary to achieve our intended aims, and as such constitute proportionate and appropriate measures to put in place to promote competition.
- 5.123 For completeness we explain below why our current proposals for promoting competition set out above are consistent with our October 2010 Advice to the Government on 2G liberalisation.
- 5.124 In that Advice, we focused on whether liberalisation of 900 MHz for UMTS was likely to distort competition. We considered the risk and extent of any competitive advantage for O2 and Vodafone arising from liberalisation of the 900 MHz spectrum for UMTS to be low. This conclusion was based on technical analysis of UMTS at 900 MHz and 2100 MHz based on site numbers for the different national wholesalers that we judged likely to be possible over the relatively short timescale that was relevant to the 2G liberalisation decision. Over that timescale, we considered that Everything Everywhere, and to a lesser extent H3G, would have a significantly larger number of sites than Vodafone and O2. We considered that the site advantage enjoyed by Everything Everywhere and H3G would largely mitigate the advantages that O2 and Vodafone would enjoy with UMTS900.
- 5.125 The current competition assessment considers whether we should put in place measures to promote competition after the combined award. It focuses on LTE and is further into the future. The longer timescale of the current assessment means that national wholesalers have more scope to vary site numbers (including possibly through network sharing). We have therefore not relied on extrapolating differences in existing site numbers. As we have set out in our technical analysis, we consider there sub-1 GHz may give an unmatched technical advantage.
- 5.126 Another difference between the two assessments relates to the natures of the costs and benefits of potential measures. The potential benefits from any measures for 2G liberalisation were only expected to last for a short period, and the costs would probably have included delaying the benefits to consumers from 3G services with UMTS900. The costs and benefits from putting in place measures to promote competition in the combined award are quite different. The potential benefits could be much longer lasting, and the potential costs are not expected to include delaying consumers' access to LTE services.

Section 6

Mobile coverage and related issues

Introduction

6.1 In this section we consider the potential role of the combined award in promoting future mobile coverage and improving existing mobile coverage for consumers and citizens. In particular we look at the results of our work on mobile not-spots, what we might do to promote future mobile broadband coverage and whether the combined award should be used to address existing not-spots. We set out a proposal for including a broadband coverage obligation in one of the 800 MHz licences to be awarded. We also propose to start a new strand of work on solutions to existing voice not-spots and will bring forward proposals on this later in 2011.

Background – work on mobile not-spots

6.2 In November 2010 we published the results of research to inform our understanding of mobile not-spots⁶². Stakeholders had frequently raised mobile not-spots as an area of concern, warranting further investigation, and in our annual plan for 2010/2011 we had identified it as one of our priority areas.

6.3 In our research we categorised five types of not-spot:

- Complete not-spots: where there is no voice or broadband coverage from 2G or 3G networks. These can be over wide geographic areas or localised within urban areas and rural areas.
- Mobile broadband not-spots: where there is no 3G coverage but there is 2G coverage.
- Partial not-spots: where coverage is provided by one or more but not all MNOs.
- Interrupted coverage on the move: where reception is interrupted while travelling by rail or road.
- Indoor coverage: where coverage is poor or non-existent within buildings.

6.4 We commissioned case studies to understand the reasons why not-spots exist and considered the impact of not-spots on the lives of individuals, businesses and society. The key findings on the impacts can be grouped around the issues of most relevance to these particular groups:

- For individuals: concerns cited included not being able to make or change plans on the move or not being able to access news and social networking sites.
- For businesses: concerns cited included loss of workforce efficiency, a growing problem given the innovations in mobile data services and applications.
- For society: some respondents were concerned by an inability to contact the emergency services. Other impacts cited included lack of social connection.

⁶² <http://stakeholders.ofcom.org.uk/market-data-research/telecoms-research/mobile-not-spots/>

- Rural/urban issues: rural businesses expressed significant concerns about local coverage issues. These were felt in terms of both conducting day-to-day business activities and ensuring the safety of staff working in isolated jobs.
- 6.5 This deliberative research, while not intended to be a statistically robust analysis of consumer detriment, provides qualitative insight and has helped progress the debate by bringing personal insights from users across different parts of the UK.
- 6.6 We also explored whether market developments might address any of these problems. It was clear that the market is still developing in three areas:
- 3G rollout is still underway, improving mobile broadband coverage;
 - there is a trend towards commercial network sharing arrangements between operators, likely to make a difference to improve partial not-spots; and
 - operators are actively developing solutions such as femtocells to help improve consumer coverage indoors.
- 6.7 These are promising developments. However, we found the commercial scope to address complete not-spots over time is more limited, which means we are likely to see voice not-spots persisting, particularly in rural areas. Interrupted coverage on the move is also likely to remain an issue for citizens and consumers, particularly on railways. We considered what we could do to help progress mobile not-spot issues. We will continue to monitor developments, and we are taking forward further work on a number of fronts:
- We have undertaken in Devon a pilot survey of coverage on arterial roads and are currently analysing the results. We are planning a more extensive study of road coverage later this year.
 - We are looking at how coverage information is provided to citizens and consumers, how accurate it is and whether there is any potential for improving it. Our Devon study will help us understand the accuracy of operators' information about mobile coverage.
 - On railway coverage, although there have been some developments that have mitigated the problem of poor coverage on some routes further developments could be slow. Discussions between relevant industry players are under way, but the slow speed of development in this area demonstrates there could be some co-ordination failure. We have prioritised further discussions with stakeholders to understand whether there is potential for us to facilitate stakeholder coordination to help improve railway coverage.
 - We will continue to engage with UK Government departments and the devolved administrations and potentially highlight coverage issues as part of our new infrastructure reporting duty.
- 6.8 We noted that coverage obligations in spectrum licences had in the past been used as a mechanism to help ensure a minimum level of mobile service availability across the UK. We drew attention to the possibility of such obligations being considered in future spectrum awards and to our consulting on the award of 800 MHz, once the Government Direction was in force.

- 6.9 Current generation mobile broadband coverage (3G) is lower than for 2G services, and varies significantly across the nations. The Direction includes a new obligation for 3G licences as part of a package of changes to the licences. The obligation is to cover by mid-2013 90% of the UK population, with users having 90% probability of receiving a minimum downlink speed of 768kbps in a lightly loaded cell. Our consultation on making relevant changes to 3G licences closed on 17 March.

Role of the combined award in addressing mobile coverage

Promoting next generation mobile broadband coverage

- 6.10 We expect the 800 MHz and 2.6 GHz spectrum awarded through the combined award to be used by new LTE networks that will provide the next generation of mobile broadband services. In section 5 we have set out our proposals to promote competition in relation to such services. A competitive market is likely to ensure these services are provided to many consumers throughout the UK. In this section we consider whether further action, such as the inclusion of coverage obligations in licences, might be appropriate and proportionate to promote wider availability of mobile broadband services in future.
- 6.11 The award of 800 MHz in particular provides a rare opportunity to promote the development of mobile broadband services so consumers and citizens have access to better quality services than today. Our not-spots research examined the importance citizens and consumers placed on mobile services and this has given us an insight into the benefits consumers might realise from being able to access such services, including:
- For individuals – the ability to access news and social networking sites.
 - For businesses – greater efficiency arising from the innovations in data services and applications.
 - For society – greater social connectivity.
 - For rural communities – improved conduct of day-to-day business activities.
- 6.12 We recognise there is a possibility that, notwithstanding what we expect will be a competitive market, commercial levels of coverage and quality provided using LTE technology might fall short of what might be socially desirable. Coverage levels might be no higher than those of existing 3G networks and it could take what we might consider an unacceptable length of time to reach even that level. This would deny or delay the benefits of next generation mobile broadband to a substantial number of consumers and citizens in the UK population. This raises the question whether we should set coverage obligations to avoid that happening.
- 6.13 To ensure that setting a coverage target for future mobile broadband service was proportionate we would need to take into account the costs of achieving it. We have approached this issue by exploring what level of service might be achieved by upgrading existing 2G mobile network sites or by establishing a network of a similar size and configuration. We consider that upgrading sites is much cheaper than building new sites and therefore the cost of providing coverage that does not require significant numbers of new sites to be built is more likely to be proportionate.
- 6.14 Our technical modelling (described in Annex 8) suggests that a network on these lines using LTE technology and 800 MHz spectrum would be capable of delivering

mobile broadband coverage beyond the current 3G footprint and, rather, replicate something similar to current 2G coverage. For example, our modelling suggests that a network of around 9,000 sites using a 2x5 MHz 800 MHz carrier could provide a 2Mbps service, with 90% coverage confidence indoors, to an area within which 95% of the UK population lives.⁶³

- 6.15 We have also considered whether a higher coverage target should be set for future LTE based mobile broadband service. Any such target is likely to require a significant number of new sites to be built, which would increase the costs of meeting such a target. We have not tried to quantify costs of achieving higher coverage targets because we believe it would be very difficult and time consuming to do this accurately. Estimating the costs of meeting materially higher target levels requires the modelling to take account of the specifics of geography, terrain and the distribution of population at a very granular level. The models that we have developed to inform our regulatory policy decisions to date are not capable of doing this.
- 6.16 Our view is that the incremental costs of imposing a requirement to meet coverage to levels well above 95% are likely to exceed the incremental benefits, given that it seems likely that a significant number of new sites would need to be built while the benefits would accrue to a relatively small and declining number of people.
- 6.17 In considering whether to include coverage obligations or set a coverage target we need to consider the risks of regulatory failure associated with such measures. There are two aspects to regulatory failure which can be distinguished: first the regulatory intervention may fail to achieve its intended objectives and, second, it may have detrimental unintended consequences. Both of these are possible in respect of coverage obligations.
- 6.18 The coverage obligation or target could fail to meet its intended objective in a number of ways. If the obligation is poorly specified then it is possible that operators can comply with the obligation, but this might not mean that consumers have a meaningful service and so the objective of the obligation would not have been met. The difficulty is that it is quite difficult to specify effectively the obligation. There are a number of different parameters that affect the availability and quality of a mobile broadband service. Specifying appropriate values for these parameters is particularly difficult in situations such as exist in this case when there is some uncertainty about the technology, costs and practicalities of deployment and considerable uncertainty about what value consumers might derive from different types of service. It is far from clear that the regulator is in a better position than operators to judge this. Another way in which regulatory failure can arise concerns the problem of enforcement if there is insufficient credible threat of enforcement that can lead to an obligation failing to meet its objective. One such example is the experience of the six 28 GHz broadband fixed wireless access licences auctioned in 2000, which included an obligation to provide wireless broadband services to 10% of local units in the licence holder's area by June 2002. When only one licence holder met this obligation rather than revoke the licences of those not complying with the obligation was removed from all licences.
- 6.19 Coverage obligations or targets can also lead to the other types of regulatory failure, namely have detrimental unintended consequences. This could result for example if it distorted the investment or rollout decisions of the operators so the network was

⁶³ It should be noted that the ability of the network to deliver such a service simultaneously to a large number of users would depend on the capacity of the network as well as its coverage.

deployed in a way that resulted in less benefit for consumers and citizens than would have occurred absent such an obligation. For example this could occur in the obligation required the rollout of a wider coverage network with a low quality of service when greater value would have been created through the deployment of network providing high quality of service in particular areas. Another possible example of this type of regulatory failure could be distorting the auction outcome, for example if the coverage requirements were specified in a way that deterred new entry.

- 6.20 These risks of regulatory failure are present to some degree with all levels and implementations of coverage obligation but we consider that there are likely to be important differences of the degree of risk incurred in different cases. In our view the risks are significantly greater the higher the coverage target, both in terms of coverage *per se* and quality of service, and the less targeted and clear the implementation.
- 6.21 On balance our provisional conclusion is that we should impose a requirement for 95% population coverage to be provided, since we believe that the costs of such a requirement should be relatively low and it is likely to have benefits through ensuring access to a next generation mobile broadband service for a high percentage of consumers and citizens in the UK. We consider that while there are clearly risks of regulatory failure with such an obligation we can mitigate these to some degree through being clear in the specification of the obligation at the outset and by limiting how many licences contain such an obligation (see further below).
- 6.22 There are two main potential interventions or mechanisms we have considered in principle for achieving such a coverage level - direct funding for the provision of mobile broadband in areas that might not otherwise be covered, and a coverage obligation in spectrum licences. There is also the option of combining the two, with a coverage obligation guaranteeing a certain minimum level of coverage in the near term and funding being used to support the achievement of more challenging coverage targets in future if considered desirable at the time.
- 6.23 Direct funding has a number of advantages:
- It can be made available to a wide range of potential service providers, including existing national wholesalers, smaller operators and new entrants.
 - Funding can be awarded close to the date of investment, so making use of up-to-date information and with the opportunity to change its focus over time.
 - It can be targeted to meet particular problem areas and to support solutions involving a range of technologies relevant to particular problems.
- 6.24 However, direct funding schemes may not be so effective in addressing coverage issues over a wide area, where problems are not localised. In the early stages of addressing coverage issues a more universal approach may be more relevant than an approach that is targeted at specific areas. Addressing a wide ranging coverage problem through a directly funded scheme managed by public bodies is likely to be very challenging.
- 6.25 Given the type of coverage requirement we are proposing, we believe that a licence obligation is more appropriate because the objective is to ensure mobile broadband coverage of a substantial section of the UK population, dispersed over large geographic areas. Targeting and flexibility are not such important considerations in

this context, since the problem may not have distinctive local features. We are addressing mobile broadband coverage across the UK and consider the most likely technology solution will be based on a next generation mobile network. This means the advantage directly funded schemes may have in addressing problems that are amenable to solution by a mix of fixed line and wireless technologies, and possibly benefit from a variety of suppliers, is not so important. Finally, as the licence obligation would be detailed and published before the award bidders would be aware that they were committing themselves to meeting the obligation and take this into account in determining the level of their bids. This is an indirect way of funding.

- 6.26 A licence obligation would not preclude later government intervention (whether UK, devolved or local in character) if it appears that additional steps need to be taken. An obligation that goes some way towards ensuring good coverage can be supplemented later through direct funding if it becomes clear that better coverage is in the consumer and citizen interest and the cost is proportionate.

Implementation of the coverage obligation

- 6.27 There are several implementation issues associated with the coverage obligation:

- how to specify the obligation;
- on how many licences the obligation should be imposed; and
- how the obligation should be enforced.

- 6.28 We have considered whether there might be an alternative way of doing this, for example by reference to a set of technical characteristics that networks must meet that are consistent with a number of different consumer services. In principle this approach would seem to have some benefit. It should be easier for operators (i) to understand what is necessary to meet the obligation and therefore cost the obligation more easily in advance of the auction, and (ii) to determine what is required in order to meet the obligation when they come to roll out their networks. Also it avoids us having to specify to the same degree now, in advance of knowing what consumers will demand, the specific characteristics of the service to be provided. For example our specification is consistent with provision of a 2Mbps service with good indoor coverage. It would however also be compatible with the provision of a higher speed service, but the level of indoor coverage would be lower. However, the difficulty we have identified with this approach is that in order to specify a particular SINR level and signal strength level it becomes necessary to be very technology (in terms of the particular LTE deployment) and frequency specific. It seems unattractive to be this specific in defining the obligation ahead of the award of the spectrum and roll out of the networks. We would welcome views and comments on different ways of specifying the obligation so that it is most likely to meet its objective.

- 6.29 We have also considered specifying an obligation in terms of a minimum number of enabled base stations. However, the outcome for citizens and consumers of such a measure would not be clear and outcomes could be very different depending on the technical characteristics of the sites an operator actually established.

- 6.30 We therefore propose to specify the obligation in terms of a service that must be provided. One possible specification of that service might be:

- the provision of an electronic communications network that is capable of providing mobile telecommunications services with a sustained downlink speed of not less than 2Mbps;
- with a 90% probability of indoor reception;
- to an area within which at least 95% of the UK population lives.

6.31 In considering the deadline for meeting such an obligation we have taken into account the desirability of consumers and citizens across the UK being able to enjoy as soon as practicable the benefits of the wide range of applications that 4G technologies will provide. We also need to take into account when the spectrum will be available and how long after that point it may take in practice to deploy the network providing the necessary service in the required area. It is a difficult judgement to make given the limited information that is available, but taking into account our current understanding of the timing for the clearance of the 800 MHz band (see section 4) we propose the coverage obligation should be met by the end of 2017.

6.32 We have considered whether such an obligation should be included in all licences awarded for 800 MHz or only one. Our starting point in considering this question is the need to act proportionately and so to impose the minimum regulation necessary to address the objective of promoting future coverage. We believe that it is sufficient for one operator to be required to meet the coverage obligation. Others may in practice follow suit and also offer such coverage, but if they do not we will nevertheless have ensured that citizens and consumers in most areas will have access to such services, albeit their choice of supplier may be somewhat limited.

6.33 We discuss in section 8 on spectrum packaging which spectrum lot the coverage obligation might be attached to if we decided to include it (see in particular paragraphs 8.42 to 8.43). In order to facilitate the achievement of the coverage obligation we are proposing that the lot with the obligation should be one of those having interference conditions that are unlikely to impede significantly the provision of wide coverage. We believe the most effective sanction for non-compliance with the obligation would be the imposition of a fine. At present we do not have the power to impose such a fine in relation to this obligation as it would not be imposed as a result of a Direction from the Secretary of State to Ofcom. If we do not have the power to fine then we would expect to enforce the obligation using our existing powers to vary or revoke the licence.

Question 6.1: Do you have any comments on the proposal to include in one of the 800 MHz licences an obligation to serve by the end of 2017 an area in which 95% of the UK population lives, while providing a sustained downlink speed of 2Mbps with a 90% probability of indoor reception? Do you think there is another way of specifying a coverage obligation that would be preferable?

Possible additional obligations

6.34 Estimates of current 2G and 3G coverage levels demonstrate that coverage varies between the constituent nations of the UK and regions within nations. This is particularly significant for 3G coverage. We also recognise that meeting a 95% of UK population coverage obligation is likely to lead to different levels of coverage in different parts of the country, and in particular lower coverage in some – principally

rural - areas, with potentially adverse consequences for citizens and consumers in those areas.

- 6.35 A large part of the variation in 3G coverage between different parts of the UK can almost certainly be traced back to differences in population, in particular differences in population density – see for example the maps of 3G coverage available on our website⁶⁴. Mobile network operators tend to invest first in those areas that can be served relatively cheaply and where demand is likely to be strongest i.e. in more densely populated areas. The commercial case for investing in less densely populated areas is generally weaker, as a result of both the likely lower level of demand and the sometimes significantly higher costs of service provision⁶⁵.
- 6.36 One approach to ensuring that the majority of consumers and citizens in less densely populated areas never the less had access to next generation mobile broadband services in future, might therefore be to impose, in addition to an overall UK population coverage obligation, an additional obligation requiring the licensee to cover a certain proportion of the population living in less densely populated areas. There would however be a number of challenges to making such an approach work in practice:
- It would be necessary to identify and define the specific less densely populated areas to be served;
 - It would be necessary to assess the likely cost of serving those areas, to the coverage level intended, and also to assess the potential benefits, in order to decide whether the imposition of the obligation was proportionate;
- 6.37 It would be necessary to have a means of confirming compliance with the obligation, which could be a very resource intensive and costly process if the specification of the areas to be served was very detailed.
- 6.38 An alternative to this would be to impose a requirement to provide a lower minimum level of population coverage in different parts of the UK (that would need to be defined), in addition to the UK-wide coverage requirement. This would almost certainly mean that some areas within each such part of the UK might still not enjoy the full benefits of next generation mobile broadband coverage, but would at least go some way towards addressing the problem.
- 6.39 It might be possible to go further and specify an obligation at a more granular level, such as for each individual region or county. However, the more granular the requirement the more costly it is likely to be to meet, and the more challenging the implementation is likely to be – both to define and to enforce.

Question 6.2: We would welcome views and evidence on the costs and benefits of imposing an additional coverage obligation focussed on particular geographical areas, and if such an obligation were to be imposed what might be the appropriate specification of geographic areas?

- 6.40 Another issue we have considered is coverage on roads. Coverage on roads varies significantly across the country with those running through rural areas likely to have poorer coverage than urban roads. An obligation on the lines we propose - that would

⁶⁴ <http://licensing.ofcom.org.uk/radiocommunication-licences/mobile-wireless-broadband/cellular/3g/maps/3gmaps/>

⁶⁵ The costs of backhaul from base stations in more rural and remote areas can be particularly high.

broadly replicate current 2G coverage – might indirectly help address mobile broadband coverage on roads. However, we would welcome evidence from stakeholders as to the need and potential costs of imposing a specific licence obligation relating to the coverage of roads. One consideration will be how to identify and define the roads that would need to be covered, for example in rural areas vital road links may not be classed as A or even B roads.

Question 6.3: Do you have any comments or evidence on whether an additional obligation should be imposed to require coverage on specific roads?

Should the combined award be used to address existing not-spots?

- 6.41 As mentioned above, in our not-spots research report we noted that coverage obligations in spectrum licences had in the past been used as a mechanism to help ensure a level of mobile service availability across the UK. We drew attention to the possibility of such obligations being considered in future spectrum awards and to our consulting on the award of 800 MHz, once the Government Direction was in force.
- 6.42 We have considered which of the different types of existing mobile not-spots coverage obligations could in principle help address. In light of what we said earlier in this section about the potential market developments and our continuing work on not-spots we do not think it would be particularly useful to try to address the following:
- Coverage on the move for people on railways: this seems likely to be a problem of coordination between the various industries and we are engaging further with them and Government to understand the scope for industry-led improvement of this issue.
 - Indoor not-spots: market developments, such as the increasing use of femtocells, appear to be addressing this issue though we will continue to monitor developments.
 - Partial not-spots: operator partnerships should reduce the number of areas with partial coverage.
- 6.43 The three identified issues that we might consider addressing through the award are:
- Complete voice not-spots: 2G networks cover approximately 97% of the UK population, though in each of the devolved nations the figure is just below 90%. If left to the market, voice coverage seems unlikely to significantly extend beyond these levels.
 - Coverage issues on the move - for people on roads: improvements to complete not-spots are likely to alleviate the problem but we consider whether anything else should be done within the award.
 - Mobile broadband not-spots: 3G network coverage is less extensive than that for 2G. 87% of the UK population is covered by one or more operators but the figure in the devolved nations is considerably lower, particularly in Northern Ireland with only 40% coverage.⁶⁶

⁶⁶ More detail on coverage may be found in our Communications Market report at <http://stakeholders.ofcom.org.uk/binaries/research/cmr/753567/England-telecoms.pdf>

- 6.44 On the last of these, as mentioned above, the proposed new obligation for 3G licences to cover 90% of the UK population by mid-2013 is designed to address existing 3G not-spots and we do not propose to do more within the combined award on this issue.
- 6.45 We consider that voice not-spots and voice coverage on roads are linked. Coverage along roads is likely to vary as the road runs through different environments. We would expect that those running through rural areas are more likely to have poor coverage than urban routes. Action aimed at extending mobile voice coverage generally and rural coverage in particular should also help alleviate the problem of poor voice coverage on roads.
- 6.46 In principle it would be possible to include in one or more 800 MHz licences an obligation to address complete voice not-spots and coverage on roads. We have looked at a number of factors that have a bearing on whether the 800 MHz award is an appropriate way to address existing voice not-spots. (We do not consider such an obligation should be included in 2.6 GHz licences as this spectrum is more suited to providing capacity in areas of high demand rather than wide area coverage).
- Timing – Once spectrum licences are awarded the band will need to be cleared before it becomes available for use, which is likely to be around the end of 2013 in the majority of the UK (see paragraph 4.8). Operators will then need some time to deploy base stations. It is unclear at present when suitable handsets will be widely available. These factors mean there is considerable uncertainty on when services over an 800 MHz network will be widely available to consumers but we consider it may be three or four years after licences commence.
 - Technology – There are some questions on offering voice services over LTE. The LTE interface is capable of handling voice but the standard does not mandate support for voice services. There are some signs that the industry seems to be moving towards Voice over LTE (VoLTE) as the favoured long-term solution⁶⁷ but it is unlikely to be available in the near term and there is some uncertainty regarding the technology. Existing 2G and 3G technologies may offer a timelier and more certain solution to existing voice not-spots.
 - Nature of the problem – Our not-spots research suggests that voice not-spots can vary in size, often depending on location. They can exist in large geographic areas (mostly rural) and in localised areas (mainly in semi-rural or urban areas). This suggests that any solution needs to be carefully targeted. A licence coverage obligation does not lend itself to this approach, requiring as it does clear definition up front.
 - The award process – If we were to include a specific voice not-spot coverage obligation it could take a considerable time to define and agree the relevant condition for new licences and is likely to complicate and delay the combined award.

- see figures 5.8 to 5.11. Note these statistics provide *indicators* of coverage and are subject to a number of methodological limitations, which are described in our mobile not-spots research – see paragraph 4.9 of <http://stakeholders.ofcom.org.uk/binaries/research/telecoms-research/not-spots/not-spots.pdf>

⁶⁷ <http://gsmworld.com/newsroom/press-releases/2010/4634.htm>
<http://www.techinsider.com/news/6441>

- Other mechanisms exist – there are other mechanisms that might be better suited to addressing this specific problem. These could involve arrangements to stimulate the extension of existing mobile voice services into areas not currently covered, perhaps through some procurement arrangements. This is a more flexible approach that could be implemented incrementally.

6.47 For these reasons we do not consider imposing licence obligations on 800 MHz is an appropriate way to address existing voice not-spots.

Next steps on existing not-spots

6.48 We consider that improving today's mobile coverage, in particular for voice, has the potential to benefit consumers and citizens in areas currently not covered, not least in terms of basic social communications, safety and security and dealing with emergency situations. We are already pursuing a number of initiatives in this area, namely facilitation of discussions to address railway co-ordination problems, research on the extent of specific short falls in road coverage, and improved consumer information. In addition we will shortly be taking forward a new strand of work to better understand the costs and benefits of more comprehensive solutions to existing voice not-spots, and to assess the different mechanisms available to us to bring these about. Options which we will consider as part of this work include, for example, variations to existing licences possibly combined with amendments to spectrum licence fees. We will bring forward proposals on this later this year. For these and other reasons we are therefore proposing not to use the award to address existing voice not-spot issues.

Question 6.4: Do you have any comments on our proposal not to use the combined award to address existing not-spots?

Access to spectrum to support delivery of the Government's broadband objectives

6.49 The Government's vision, in its broadband strategy document⁶⁸, is for the UK to have the best superfast broadband network in Europe by 2015. It is committed to ensuring virtually all homes will have access to a minimum level of service of 2Mbps - its universal service commitment. However, it believes that most solutions that could deliver this would in fact deliver far more to most people and so it has aligned both its superfast broadband and universal service objectives.

6.50 The Government sees a mix of technologies being needed to deliver superfast broadband throughout the UK. These are likely to be primarily fixed technologies, given the nature of superfast broadband, with fibre deeper into the network being the key technology. Broadband Delivery UK, in its report on the conclusions of its Theoretical Exercise⁶⁹, considered broadband access would be delivered cost effectively to between 90% and 95% of premises by fibre, 5%+ by high-speed fixed wireless access and about 1% by satellite.

6.51 Access to the 800 MHz and 2.6 GHz bands may prove important to the delivery of the wireless element of these plans. We believe that the proposals we have set out in

⁶⁸ <http://www.bis.gov.uk/assets/biscore/business-sectors/docs/b/10-1320-britains-superfast-broadband-future.pdf>

⁶⁹ <http://www.culture.gov.uk/images/publications/10-1330-broadband-delivery-exercise-conclusions.pdf>

this document will facilitate that occurring if desired. In particular by awarding the spectrum as soon as we can, ensuring that there are at least four holders of spectrum, allowing trading and leasing and, to help facilitate these activities, requiring licensees to provide information for publication about their use of the spectrum or roll-out of networks.

- 6.52 There may be a concern however that holders of 800 MHz and 2.6 GHz may not be interested in providing services to meet the Government's objective (for example in response to a procurement process) nor make the spectrum available to others who wish to do so. Some have suggested a 'use it or lose it' or 'use it or sell it' obligation as the solution.
- 6.53 We do not consider that imposing obligations such as these are in the interests of consumers and citizens. This is for a number of reasons. We believe that they are very difficult to make workable in practice because of the problem of defining what constitutes use and therefore the trigger for a sale or revocation. There may be entirely legitimate reasons for spectrum remaining unused – the licensee may be holding back until it sees a suitable commercial opportunity or until the technology it wishes to use is ready. Imposing such an obligation also has the potential to distort and or chill the incentives to invest in use of the spectrum and so reduce the benefits for consumers and citizens which the award would otherwise create.
- 6.54 We have considered whether there might be some alternative measure we could take that would be proportionate to the risk identified since we recognised that our usual approach to auctioned licences would restrict our ability to take any action during the initial 20 year period of the licence. One option would be to include conditions in the licences, even during their initial term, to revoke use of some of the frequencies in particular areas if the use of the frequencies was needed to deliver a specific public policy goal (such as the provision of rural broadband). In order to ensure that this does not create the damaging impact on investment incentives identified above it would be necessary to specify carefully the circumstances and terms on which such a condition might be invoked, to ensure that its application was proportionate. It might, for example, be appropriate to make the condition subject to the licensee (i) not using the frequencies to provide the desired services in those areas, (ii) being unable or unwilling, even when offered appropriate funding, to provide the service of interest and (iii) possibly being appropriately recompensed for the loss of the spectrum, depending on the particular circumstances.

Question 6.5: Do you have any comments on our proposal not to impose 'use it or sell it' obligations but to consider including an additional power to revoke during the initial term of the licences?

Provisional conclusions

- 6.55 We consider that a coverage obligation in one 800 MHz licence would be at least as effective as direct funding to secure wide availability of next generation mobile broadband. We propose the obligation should require the licensee to provide a mobile broadband service covering an area within which 95% of the UK population live. The obligation would be framed to give the network operator flexibility in meeting different or changing customer demands or requirements at particular locations. The obligations would be included in one – not all – of the 800 MHz licences to be awarded. The date for meeting this obligation would be the end of 2017.
- 6.56 We welcome stakeholders' views on whether the licensee should also be required to provide a minimum level of coverage in various parts of the UK, or at regional or

county level, or in areas where population density is below a certain level. We also welcome stakeholders' views on whether an additional obligation relating to coverage on roads should be imposed.

- 6.57 We do not propose to take steps to address existing mobile voice not-spots through obligations in new licences awarded through the combined award of the 800 MHz and 2.6 GHz bands. We will instead pursue other approaches to the issue, including for example variations to existing licences possibly combined with amendments to spectrum licence fees. We will bring forward proposals on this later in 2011.
- 6.58 In relation to access to spectrum to support the Government's broadband objectives we do not propose to include a 'use it or sell it' obligation in licences. Instead we are considering retaining the power to revoke licences during the initial licence period in the pursuit of specific public policy goals.

Section 7

Non-technical licence conditions for 800 MHz and 2.6 GHz

Introduction and summary

- 7.1 In this section we set out non-technical conditions we propose to include in the licences to be awarded. In particular, we discuss our proposals on
- licence commencement and duration;
 - the duration of the initial period, our limited rights for revoking the licence during this period and any additional powers we have following the initial period;
 - the territorial extent of licences;
 - making the Wireless Telegraphy licences tradable in secondary markets;
 - non-technical restrictions;
 - service obligations; and
 - provision of information to promote efficient use of spectrum.

Licence commencement and duration

- 7.2 In the Spectrum Framework Review: Implementation Plan⁷⁰ we proposed that new licences to be awarded by auction should generally have an indefinite term together with an initial term. During the initial term the grounds for revocation would not include a general right to revoke for spectrum management reasons. After the end of the initial term, the grounds for revocation would include such a right, subject to a minimum notice period of five years. We also proposed that notice of revocation for spectrum management reasons could be given so that the licence ended the day after the expiry of the initial term.
- 7.3 The aim of these proposals was to provide licensees with an initial term during which they would have high security of tenure, and grounds for revocation would be limited to a narrowly defined set of conditions. The period of the initial term should be linked to a reasonable view of the period required to earn efficiently an appropriate return on the investment anticipated for efficient use(s) of the spectrum, and take into account any other factors that are relevant. The aim of proposing an indefinite duration was to give the licensee the opportunity to continue operating its business beyond the initial term. However, during this period we would be able to revoke the licences by serving a notice of revocation in a similar manner to many other spectrum licences, if this step were justified on spectrum management grounds or other specific circumstances. In addition we would reserve the right to charge a licence fee in this period to incentivise efficient use of the spectrum.

⁷⁰ *Spectrum Framework Review: Implementation Plan*. This document consults on the release of spectrum in 2005 – 08, and on extending spectrum liberalisation and trading to mobile services, Ofcom, 13 January 2005, <http://www.ofcom.org.uk/consult/condocs/sfrip/sfip/>

- 7.4 We consider that there are a number of reasons why licences with an indefinite term are likely to promote optimal use of the radio spectrum and other relevant objectives, including the promotion of competition. In particular, the award of licences with an indefinite duration reduces the need for regulatory intervention to reassign spectrum at the end of the licence term. One disadvantage of fixed term licences is that at the end of the licence term the licence expires and so the rights to use it must be returned to the regulator, unless any other action has been taken. This may result in a period during which the spectrum remains unused, as the regulator must go through a process to reassign those rights. Furthermore, incentives to invest closer to the end of a licence term are significantly reduced given that communications networks generally require continual investment. This lack of investment could result in detriment to consumers and citizens. The alternative of licences with an indefinite duration removes the requirement for return to the regulator, removes the risk of discouraging investment and creates additional opportunities for the market to secure the efficient use of the spectrum, particularly in the presence of spectrum trading.
- 7.5 We consider that, as a matter of principle, it is preferable to look to market mechanisms to promote the efficient use of resources rather than regulatory intervention, unless the case for such intervention is clear. In relation to our spectrum awards to date we have not identified a general need to recover spectrum at the end of the initial term.
- 7.6 We consider that there are likely to be a number of other advantages to adopting the general approach proposed above. In particular, reassignment by the regulator typically takes significant time and resource. The spectrum may also lie idle for a period as the regulator prepares for reassignment. While it may be possible to reduce this problem through the use of overlay auctions, the approach of an indefinite term together with spectrum trading seem likely to offer a simpler and less costly way of ensuring the spectrum is used efficiently.
- 7.7 The inclusion of an initial term in the licence is desirable in order to give sufficient certainty to investors to incur the necessary costs to put the spectrum into use. Without an initial term there is a risk that this may not occur and so the spectrum would not be used efficiently.
- 7.8 We therefore favour offering licences with an indefinite duration for the 800 MHz and 2.6 GHz bands. The retention of powers to revoke on spectrum management grounds provides a mechanism allowing regulatory intervention if this is justified in particular cases. Consistent with the above general policy framework, we propose that the auctioned licences should:
- have an indefinite duration, subject to revocation as set out below;
 - have an initial term of a specified duration, as discussed below;
 - be revocable before the expiry of the initial term on the limited grounds set out below; and
 - be revocable from any point after the expiry of the initial term on the grounds set out below, but also for spectrum management reasons subject to us giving five years notice and such notice not being given in advance of the final five years of the initial term.

Rights to revoke licences during the initial term

- 7.9 The initial term is designed to provide licensees with a high security of tenure for investment planning purposes. During that period, we will not be able to revoke licences for spectrum management reasons and will only be able to do so in the particular circumstances described below.
- 7.10 During this initial term the licence may only be revoked for the following main reasons:
- with the consent of the licensee;
 - for non-payment or late payment of the relevant licence fee;
 - if there has been a breach of any of the terms of the licence;
 - if the licensee has not complied with any requirement of any relevant trading regulations;
 - if the licensee has not complied with the auction regulations under which the licence was awarded, including any financial provisions including guarantees;
 - we may at any time, by notice in writing, revoke or vary licence terms if it appears to us to be requisite or necessary or expedient to do so in the interests of national security, or for the purposes of complying with a Community obligation of the UK or with any international agreement or arrangements to which the UK is party; and
 - if it appears requisite or necessary or expedient to do so for the purpose of complying with a direction by the Secretary of State under Section 5 of the Communications Act 2003 or section 5 of the Wireless Telegraphy Act.
- 7.11 In paragraph 6.53 above we set out the possibility of including an additional licence condition that would allow us, during the initial term, to revoke use of some of the licensed frequencies in particular areas if their use was needed to deliver a specific public policy goal (such as the provision of rural broadband).

Additional conditions after the initial period

- 7.12 Once the initial period has expired, the licence will remain in force and continue to be held by the licensee. We propose that two additional conditions would then apply:
- one relating to additional licence fees that would then be payable; and
 - one providing that we may revoke the licence on spectrum management grounds on five years' notice.
- 7.13 Licensees will be liable to pay additional licence fees in respect of the licences if they continue to hold them after the end of the initial period. The level of these fees will depend on our general approach to fees for the use of spectrum at the time, and how that general approach relates to these licences and to our statutory duties at the time. The level of the fees cannot therefore be determined now. Note that we would expect to give prior notice of our specific proposals to charge fees, and to consult as appropriate, before fees are introduced.

7.14 Similarly, in line with our normal policy on indefinite licences, once the initial period has come to an end we will have the power to revoke the licences for spectrum management reasons on five years' notice. We consider that it is appropriate for us to have the power to revoke ~~or vary~~ the licences that are the subject of this award after the end of the initial term. This reflects the greater uncertainty that will exist in the more distant future about the conditions that will make for optimum use of spectrum. We consider that market mechanisms should promote efficient use of spectrum, and be more successful in this respect than widespread reliance on regulatory controls. The tradability and liberalisation of spectrum are key elements of a market-based approach. However, there may be circumstances in which additional intervention is justified in the public interest (for example, to overcome a specific market failure such as problems of co-ordination caused by high transaction costs). A power to take regulatory action, if justified, in relation to the use of the spectrum in the long term will be achieved by us having the power to revoke the licence on spectrum management grounds after the end of the initial term.

Duration of the initial term

7.15 As mentioned above, the initial term should be linked to a reasonable view of the period required to efficiently earn an appropriate return on the investment anticipated for efficient use(s) of the spectrum. We have considered the relevant period that might provide a reasonable chance for the businesses that might be most likely to operate in the bands to make an appropriate return on efficient investment without unnecessary regulatory risk.

7.16 Analysis already undertaken in connection with previous awards suggests that the minimum operational term of a licence supporting substantial new investment in a network would need to be in the region of 20 years. Without a degree of certainty that they will be able to offer services for at least this sort of period of time, licensees are unlikely to be willing to make the investments necessary to efficiently exploit this spectrum.

7.17 We have considered what the duration of the initial term should be for 800 MHz and 2.6 GHz licences and from what date the initial term should run. If licensees are to have a reasonable prospect of earning a commercial return on their investments we consider they will need a reasonable degree of certainty that they will be able to continue offering service for a period of 20 years.

7.18 We will issue licences soon after the conclusion of the auction, when winning bidders have made any outstanding payments to cover their licence fees. However, we consider the initial period should begin at a later date because use of the both 800 MHz and 2.6 GHz bands will be restricted, at least in some parts of the UK, for a period after licence issue. As some operators may use both 800 MHz and 2.6 GHz in their networks we consider licences for both bands should have a common start date for the initial term. Spectrum in the 800 MHz band will be available from the completion of DSO in late 2012, though with restricted access until the band has been cleared of DTT. The 2.6 GHz band is unoccupied in the UK but, as discussed in section 4, its use will be restricted until the close of the London 2012 Games and completion of the 2.7 GHz radar modification programme.

7.19 Taking these factors into account we propose that the initial term for the new licences to be awarded for 800 MHz and 2.6 GHz licences should be for 20 years from 1 January 2013.

Question 7.1: Do you have any comments on the proposals relating to the duration of the initial licence period, our rights to revoke the licence during this period, the charging of licence fees after the end of the initial period and our additional revocation powers following the initial period?

Territorial extent of licences

7.20 The licences will permit use within the United Kingdom of Great Britain and Northern Ireland. They will not permit use in the Channel Islands and the Isle of Man.

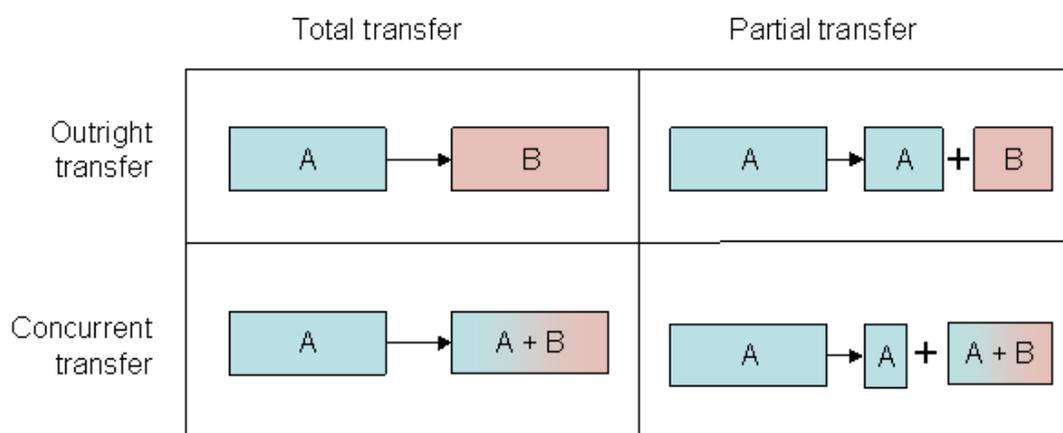
Spectrum trading

7.21 We began the implementation of spectrum trading for selected licence classes in 2004, through the Wireless Telegraphy (Spectrum Trading) Regulations 2004. The changes, described in the Spectrum Trading Statement, published in August 2004, introduced the possibility for licensees in specific classes to carry out:

- outright total transfers, i.e. transfers of all of the rights and obligations arising under a licence to a third party;
- concurrent total transfers, i.e. transfers of all of the rights and obligations arising under a licence to a third party which result in a concurrent holding of those rights and obligations by the transferor and the transferee(s);
- outright partial transfers, i.e. outright transfers of some of the rights and obligations arising under a licence to a third party; and
- concurrent partial transfers, i.e. transfers of some of the rights and obligations arising under a licence to a third party which results in a concurrent holding of those partial rights and obligations by the transferor and the transferee(s).

7.22 Figure 7.1 illustrates these four generic types of transfer.

Figure 7.1 Illustration of some possible types of transfer



Source: *Spectrum Trading Guidance Notes* - <http://www.ofcom.org.uk/radiocomms/ifi/trading/tradingguide/>

7.23 We describe this process as ‘transfer’ because the spectrum access rights are transferred by the grant of a new licence.

Simplifying spectrum trading

7.24 On 22 September 2009 we published a consultation⁷¹ on proposals to streamline the spectrum trading process by:

- removing the need to obtain our consent to transfer spectrum rights; and
- introducing a new type of trading, called 'spectrum leasing' in which spectrum could be accessed by entering into a lease with a licensee without obtaining a new licence from us. In leasing, the licence remains in the hands of the original holder.

7.25 We acknowledged in the document that our proposals might not be suitable for all licence classes and sought views on where there would need to be exceptions. Responses were broadly favourable but H3G and T-Mobile expressed concern about the application of our proposals to spectrum that could be used for mobile cellular services. We published an interim statement on 15 April 2010⁷² to inform stakeholders that we had decided in principle to proceed with our proposals for the generality of licence classes but agreed there would be a need to give further consideration to their application to bands used for GSM or 3G services.

7.26 Before spectrum leasing can be undertaken, we need to make regulations to specify the details of the new procedure, including the frequency bands in which leasing is to be permitted. Our timetable for this is largely determined by the Government's implementation of the revised EU Regulatory Framework and whether this makes the necessary amendment to the Wireless Telegraphy Act. We expect to publish in the near future a more detailed statement on our plans on leasing.

Spectrum trading regulations in the 800 MHz and 2.6 GHz bands

7.27 The current Spectrum Trading Regulations do not extend to the 900 MHz, 1800 MHz and 2100 MHz bands. The Direction requires us to vary the Regulations to include these bands. We published a notice⁷³ (the trading notice) on 2 February 2011 setting out how we proposed to do this and sought responses by 17 March 2011. We proposed that all types of transfer would be permitted. We also proposed providing in the varied Regulations for us to be able, before consenting to a transfer, to undertake an *ex ante* competition check where we considered this appropriate. We said we would give spectrum leasing further consideration in 2011, assuming the revisions to the EU Regulatory Framework have been implemented.

7.28 We consider it would be consistent to take a similar line for 800 MHz and 2.6 GHz licences and so we propose for these licences:

- Wireless Telegraphy licence rights and obligations will be tradable;
- all types of transfer will be permitted;
- our consent will be required for a transfer;
- before giving consent we may undertake an *ex ante* competition check.

⁷¹ <http://stakeholders.ofcom.org.uk/binaries/consultations/simplify/summary/simplify.pdf>

⁷² <http://stakeholders.ofcom.org.uk/binaries/consultations/simplify/statement/statement.pdf>

⁷³ <http://stakeholders.ofcom.org.uk/consultations/trading-900-1800-2100/>

- 7.29 Subject to responses to our consultation on the inclusion of a competition check before we consent to a spectrum trade of mobile spectrum and responses to this consultation, we propose that the trading regulations we make in relation to mobile spectrum licences should be amended to apply to the auctioned licences in the 800 MHz and 2.6 GHz bands.
- 7.30 We will consider further whether to introduce leasing for auctioned licences in the 800 MHz and 2.6 GHz bands and consult on this if the revisions to the EU Regulatory Framework have been implemented.
- 7.31 We consider that the position should be slightly different for licences that we may propose to award for shared low-power use in the 2.6 GHz band (see paragraphs 4.48 to 4.53). If we implemented such a proposal, several licensees would have non-exclusive access to the spectrum. They would hold distinct licences, but with identical rights and obligations for the concurrent use of identical frequencies nationally.
- 7.32 In these circumstances we propose not to allow transfers that would increase the number of 2.6 GHz low-power licensees, i.e.
- concurrent total transfers, i.e. transfers of all of the rights and obligations arising under a licence, to a third party which result in a concurrent holding of those rights and obligations by the transferor and the transferee(s);
 - outright partial transfers, i.e. outright transfers of some of the rights and obligations arising under a licence to a third party; and
 - concurrent partial transfers, i.e. transfers of some of the rights and obligations arising under a licence to a third party that results in a concurrent holding of those partial rights and obligations by the transferor and the transferee(s).

The concern with these three types of transfer is that they would allow one licensee unilaterally to increase the number of licensees and so the number of parties with whom all the other licensees would have to coordinate and hence their engineering coordination costs. However, we will keep the position under review.

- 7.33 Note that this is similar to the position on trading that we adopted for the licences we awarded for the DECT guard band (1781.7-1785 MHz paired with 1876.7-1880 MHz), which also allow concurrent low-power use.

Question 7.2: Do you have any comments on the proposal to amend the spectrum Trading Regulations to apply to the auctioned licences in the 800 MHz and 2.6 GHz bands, to include a competition check before we consent to a spectrum trade of mobile spectrum and not to allow transfers that would increase the number of 2.6 GHz low-power licensees?

Non-technical restrictions on use

- 7.34 We do not propose to impose any non-technical restrictions on the use to which the spectrum could be put in the licences (such as specifying the type of service that should be offered, the technology that should be deployed or the equipment that should be used), apart from an obligation on mobile broadband coverage described in the next paragraph.

Service obligations

- 7.35 For reasons explained in section 6 above, we propose to include in one of the 800 MHz licences an obligation to provide a mobile broadband service to 95% of the UK population. The service might be specified in the licence as follows:
- the provision of an electronic communications network that is capable of providing mobile telecommunications services with a sustained downlink speed of not less than 2Mbps;
 - with a 90% probability of indoor reception;
 - to an area within which at least 95% of the UK population lives.

Provision of information to facilitate optimal spectrum use.

- 7.36 In line with our duty to manage the spectrum efficiently, we propose to include a condition in the licences to require licensees to provide us on request with general information regarding their equipment and use of frequencies, or the roll-out of their network. From time to time, we may publish information received on the number of base stations and frequency use in areas throughout the UK. This could help interested parties who do not have access to this spectrum to identify areas where they might provide additional services. It would be open to them to gain access to spectrum in those areas by trading with licensees. This would help secure optimal use of the spectrum.
- 7.37 We consider that this approach is objectively justified to fulfil our statutory duties and objectives, transparent, proportionate and does not discriminate between licensees.
- 7.38 We are particularly interested in the views of stakeholders on what information they think would help to facilitate efficient use of spectrum and secondary trading, and on the impact of the disclosure of this information might have on licence holders.

Question 7.3: We welcome views on the merits of the proposed approach to information provision; in particular concerning the type of information that may be helpful and any impacts that publication of information might have both on licence holders and the wider spectrum market.

Provisional conclusions

- 7.39 The main specific non-technical conditions that we are currently proposing to include in the Wireless Telegraphy licences to be granted as a result of the combined award are:
- licence term – indefinite, with an initial term lasting 20 years from 1 January 2013 during which we will have limited rights of revocation;
 - licence fees – provision to charge licence fees, if appropriate, after expiry of the initial term;
 - rights to revoke - provisions for us to revoke a licence on spectrum management grounds on any date after expiry of the initial term, subject to five years' notice,

- spectrum trading – the licences to be tradable, with all legal forms of trading to be permitted subject to Ofcom’s consent, but only total outright transfers to be allowed for low-power 2.6 GHz licences;
- non-technical restrictions on use – the licences to not restrict the service to be offered or the technology or type of equipment to be used (other than the minimum technical restrictions necessary to control harmful interference);
- service obligations - one 800 MHz licence will include an obligation to provide a mobile broadband service to 95% of the UK population by the end of 2017; and
- provision of information - licensees will be required to provide us on request information on their equipment and use of frequencies, or roll out of their network.

Section 8

Spectrum packaging proposals for the 800 MHz and 2.6 GHz award

- 8.1 This section sets out our proposals for the packaging of the spectrum available in the combined award, i.e. how many different types of lots will be available, what their different properties are and how bidders can aggregate individual lots to achieve larger spectrum holdings.
- 8.2 We first describe the main factors relevant to spectrum packaging and how we are proposing to approach each of them at a high level.
- 8.3 We then review the circumstances of each band and our resulting packaging proposals for the 800 MHz and 2.6 GHz bands. We also consider the 900 MHz and 1800 MHz bands for completeness, although we are not proposing to allow relinquishment from these bands into the auction. We are also not proposing to allow relinquishment of 2.1 GHz spectrum. For each band that will be or might be available, we consider:
- a) the band plan;
 - b) the size of lots; and
 - c) different types of use, interference conditions, specific obligations and therefore the number of different categories of lots.
- 8.4 We also set out our proposals for reserve prices and conclude the section with a summary of the proposals it covers.

Main factors relevant to packaging approach

- 8.5 There are four main factors that are relevant to the decision of how to package spectrum that is available in a band:
- a) organisation of the lots - band plans;
 - b) size of each lot in a given category;
 - c) number of categories of generic lots and relinquishment of spectrum into the auction;
 - d) contiguity of lots; and
 - e) geographical reach of lots – UK-wide lots or regional lots.
- 8.6 There are European Commission⁷⁴ decisions that apply to the 800 MHz⁷⁴, 900 MHz and 1800 MHz⁷⁵ and 2.6 GHz⁷⁶ bands. In all cases, our spectrum packaging proposals need to be consistent with these decisions.

⁷⁴ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010D0267:EN:HTML>

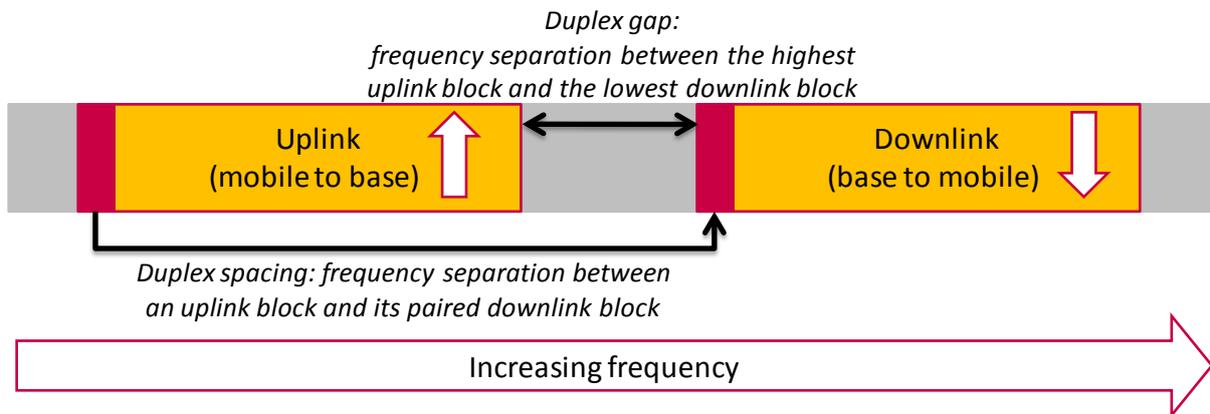
Organisation of the lots - band plans

8.7 Band plans are a function of most likely uses and corresponding international harmonisation. In this case, all bands are harmonised and most likely to be used for mobile services. The key question for the purpose of selecting a band plan is determining the balance between the two main forms of spectrum use for mobile services: paired use involving FDD technologies and unpaired use involving TDD.

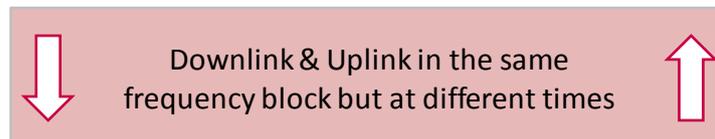
8.8 Figure 8.1 below illustrates the structural differences between the two types of uses.

Figure 8.1: Differences in spectrum use between paired (FDD) and unpaired (TDD)

FDD technology – Frequency Division Duplex – where signals from the handset to the base station (uplink) are transmitted on a different frequency from those from the base station to the handset (downlink) – so requires **paired** frequencies



TDD technology – Time Division Duplex – where signals from the handset to the base station and from the base station to the handset are transmitted on the same frequency but at different times – so can operate with **unpaired** frequencies



8.9 In principle, the band plan for a given set of mobile frequencies can be fixed or flexible. Where a band plan is fixed, there is a pre-defined amount set aside for paired (FDD) use and a pre-defined amount set aside for unpaired (TDD) use. Where a band plan is flexible, the amounts of frequencies for paired and unpaired use can take a range of values; it may then be possible to use a market-based process to identify the most appropriate value within the possible range. The choice between a fixed or flexible band plan depends on the scope for consumer benefits under each option. In turn, this depends largely on the approach achieved in standardisation bodies for the relevant technologies, which may be a fixed approach or a flexible approach, and on whether there is any significant industry interest in an approach that is different from that in relevant technical standards.

8.10 As illustrated in Figure 8.1, for reasons of interference management, there needs to be a separation, referred to as a duplex gap, between the two parts of paired use (downlink and uplink). The circumstances of each band, including propagation

⁷⁵ Commission Decision 2009/766/EC available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009D0766:EN:NOT>

⁷⁶ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:163:0037:0041:EN:PDF>

characteristics and size of this gap, and capabilities of the relevant technologies determine how the gap may be used for unpaired applications while allowing coexistence with paired use.

Size of each lot in a given category

- 8.11 The relevant size for lots in a given band depends on the size of the building blocks necessary for likely technologies to make use of the frequencies, how potential users may want to combine those building blocks and what minimum requirements might be relevant to productive use of a particular band.
- 8.12 Our approach is to strike a balance for each band between providing flexibility to the market (which suggests small lot sizes to maximise the variety of combinations that potential users might make) and managing the complexity that comes with very high numbers of possible combinations (which suggests lots sizes that are no smaller than is necessary for the purpose of allowing realistic, productive uses).
- 8.13 By way of example, we consider that the most likely technology for paired use at 800 MHz and 2.6 GHz is LTE. This technology has been standardised for a number of channel sizes, from 2x1.4 MHz to 2x20 MHz. However, we are not aware of any market interest in such small channel sizes as 2x1.4 MHz in the UK and we would therefore not propose to use this as the building block for packages in the auction. A larger size seems more appropriate, as it would be highly unlikely to constrain potential bidders in practice and it would reduce the complexity of the auction and the computational load involved in processing bids to identify winners and prices.

Number of categories of generic lots – restrictions due to adjacent uses, specific obligations, types of use and relinquishment

- 8.14 We have seen above that there are two structurally different types of uses: paired (FDD) and unpaired (TDD). Each involves a specific type of technology and may facilitate different focuses on certain mobile applications. Therefore a bidder seeking to acquire rights to use spectrum at auction will want to be able to distinguish between these two types when bidding. The need for such a distinction logically underpins two different broad categories of lots within a band: paired lots and unpaired lots.
- 8.15 There are other sources of differences within each category that relate to a further distinction in the type of potential uses, coverage obligations, the technical conditions to which it is subject, including conditions to prevent or minimise interference, and the time of availability of each lot.
- a) There are two types of licences that, subject to responses on other proposals in this consultation, we are envisaging for the award. The first type covers individual licences with technical conditions that allow high power use. This licence type allows a single licensee to use frequencies and to do so with power limits that are relatively high and similar to those that currently apply in mobile licences for the 900 MHz, 1800 MHz and 2.1 GHz bands. The second type covers concurrent licences, where several licensees have the same rights to use a single set of frequencies and need to put in place a degree of technical coordination to manage interference risks specific to such concurrent access to spectrum. Concurrent licences involve relatively low-power limits, as part of the provisions to manage interference, similar to the levels in place in the so called DECT guard band spectrum just above the 1800 MHz band.

- b) As discussed in section 6, we are proposing to include a coverage obligation on one licence in the 800 MHz band. This obligation is likely to have specific costs for the licensee concerned such that the licence is likely to be distinct from other licences in the 800 MHz band. There is a potential for the difference to be sufficiently large that it may create risks for the efficiency of the auction if we left it to the assignment stage to resolve who, out of bidders who were willing to buy licences for the 800 MHz band, would receive the lot with the coverage obligation. Some bidders may attach sufficiently high differences in value between a lot with the obligation and a lot without the obligation that they could bid on the basis of their lowest valuation for a generic lot that may have the obligation. This could result in those bidders not winning any 800 MHz lots in an auction, when it may be efficient for them to win lots without the obligation. Creating a category for the lot with the coverage obligation allows bidders to decide whether to bid for that lot.
 - c) The need to coexist with existing adjacent emissions and to manage the risk of interference into adjacent receivers can place potentially material restrictions on the use of certain blocks of spectrum. This might involve reductions on the power that a licensee can transmit in certain areas or in certain circumstances that could affect the cost of deploying networks and/or the scope for providing certain services in some areas. This seems likely to be relevant in the case of the 800 MHz band, where specific technical restrictions seem likely to apply to spectrum at the bottom end of the band (in respect of DTT).
 - d) Differences in the timing of availability of each block of spectrum may also justify creating corresponding lot categories, particularly if those differences combine with other specificities such as technical restrictions. Differences in timing of availability between blocks of spectrum in a given band might be relevant to lots in the 800 MHz band as a result of Digital Switchover for terrestrial TV broadcasting and the clearance of existing uses in the band. If these differences were not likely to be material, we would propose to include lots different principally because of date of availability in the same category (and let the assignment stage decide who gets which specific frequencies). If difference were likely to be material, we would propose to include lots with different availability times in different categories.
- 8.16 The combined effects of some of the obligations and restrictions that are likely to apply to some parts of the 800 MHz band may be relatively material. As a result, it could be risky to consider that these parts of the band are suitable to support a credible national wholesale competitor. We set out in section 5 and Annex 6 our provisional view that a minimum spectrum portfolio for such a competitor needs to include 2x5 MHz of sub-1 GHz spectrum. If that minimum quantity was made up of a block of 800 MHz with relatively stringent technical restrictions or potentially large delays in availability, then the licensee for that lot may not be able to compete effectively in future mobile markets. We therefore anticipate that some blocks in the 800 MHz band may not be suitable to count towards the minimum spectrum portfolio for national wholesale competitors.

Relinquishment of spectrum into the auction by existing mobile licensees

- 8.17 In light of the proposed spectrum caps (see section 5), we do not believe that there would be real efficiency or consumer benefits from allowing bidders to relinquish spectrum in the auction. Existing licensees would be able to win amounts of spectrum in the 800 MHz and 2.6 GHz band in the auction that are sufficiently large

that they would be unlikely to prefer to relinquish some of their existing spectrum in order to win more spectrum at 800 MHz and/or 2.6 GHz.

- 8.18 Without any relinquishment, under our proposed caps-
- a) O2 and Vodafone could each win up to 2x10 MHz at 800 MHz and up to 2x40 MHz (Vodafone) or 2x45 MHz (O2) at 2.6 GHz;
 - b) Everything Everywhere could win up to 2x20 MHz at 800 MHz and up to 2x20 MHz at 2.6 GHz; and
 - c) H3G could win up to 2x20 MHz at 800 MHz and up to 2x70 MHz at 2.6 GHz.
- 8.19 There are also practical complexities that would arise from allowing relinquishment. It would be necessary to specify in detail the terms of relinquishment, such as the date of availability of relinquished spectrum (and potentially whether geographical variations in dates might be suitable), which specific frequencies would be involved or whether relinquished spectrum should be contiguous. These points would require careful consideration for benefits that would likely be small. During the award process, we would also need to finalise the lots available, contiguity restrictions and other parameters and might only be able to do so once the final relinquishment situation was known. This would require some time, including to adjust the auction software and to give bidders time to consider the resulting provisions, which would have an impact on the timeline of the award.
- 8.20 We therefore consider that it is unlikely to be necessary or proportionate to include provisions in the auction to allow relinquishment.
- 8.21 However, in case it became apparent as part of this consultation that it may be beneficial to allow relinquishment of 900 MHz and/or 1800 MHz spectrum, we set out in this section how we would expect to package relinquished spectrum.
- 8.22 If any relinquishment were to be permitted, we expect that we would require licensees to commit to relinquishment of a specified amount of spectrum, without receiving any payment for it and within a given timeframe at the time of application for the award process, subject to qualifying as bidders. Following qualification to bid and by the last opportunity to withdraw, licensees' commitment to relinquish would become unconditional and the corresponding spectrum would be available in the auction. A relinquisher's rights to use relinquished spectrum would end at the date specified in the application and qualification commitments. The new licence for the relinquished spectrum won in the auction would start the day after that date. A relinquisher would be able to bid for the spectrum relinquished on the same basis as any other bidder, without a guarantee of winning spectrum in the auction additional to that of any other bidder. If a relinquisher won back any spectrum blocks it relinquished prior to the auction, then these spectrum blocks would be awarded to the operator under the same licence conditions and payment terms that would apply if these spectrum blocks were awarded to an alternative, non-relinquishing bidder. For example, the winner would be required to pay a one-off auction price for the spectrum blocks won, rather than Annual Licence Fees (discussed in section 10).

Contiguity of lots

- 8.23 Within a given band, the blocks of spectrum that a given licensee holds rights to may be contiguous or fragmented. We consider that there are real advantages to holding contiguous lots. For example, contiguity offers licensees the scope to aggregate

frequencies to form large channels. These large channels are necessary to achieve the highest performance that the most recent mobile technologies such as LTE or WiMAX can offer. A second important advantage is the reduction in the number of adjacencies between different licensees in a band, and therefore a reduction in the costs of technical coordination and interference risks between those parties. A fragmented band plan may also create risks for the future use of the band, for example by increasing the complexity of the scope of trading. Finally, ensuring contiguity reduces the combinatorial complexity of the auction, which has benefits for both bidders and the auctioneer.

- 8.24 The cost of enforcing contiguity is a restriction on the potential preferences that bidders can express for certain combinations of lots and, in principle, a potential reduction in the scope for some parties to win spectrum (e.g. if someone was willing to use only the bottom and top lots of 2x5 MHz of the band). However, the scope for these risks to have a material impact and to outweigh the benefits of contiguity seems limited.
- 8.25 Our approach is to ensure contiguity of lots won for each licensee in each band unless there are strong reasons not to do so.
- 8.26 Ensuring contiguity is relatively straightforward in new bands such as 800 MHz and 2.6 GHz. This involves ensuring that bids are compatible with a contiguity requirement in each band in both the principal stage and assignment stage of the auction. This applies first to bids in the principal stage: only bids that are compatible with the contiguity requirement would be possible (e.g. to bid for a total 2x10 MHz at 800 MHz, it would not be possible to bid for one lot of 2x5 MHz in the category at the bottom of the band and one lot of 2x5 MHz in the category at the top of the band, as these two lots could not be contiguous). This then applies to the options available in the assignment stage in which winning bidders bid on specific frequencies: only options that are consistent with the requirement would be available to each bidder (e.g. the winner of 2x10 MHz in the 2.6 GHz band would not have the option to bid for those 2x10 MHz to be 2x5 MHz at the bottom of the band and 2x5 MHz in the middle of the band). Section 9 provides more information on the proposed structure of the auction and its different stages.
- 8.27 As mentioned above, we are not proposing to permit any relinquishment of lots from mobile bands that are currently licensed. However, if we were to permit any relinquishment, then it would likely be more difficult to ensure contiguity of lots. This is because the 900 MHz is currently fragmented, with its 2x34.4 MHz split into six paired blocks of variable sizes from 2x4.8 to 2x7.6 MHz, licensed to O2 and Vodafone. Any contiguity requirement in this case would risk being inconsistent with the preferences or needs of the current licensees in light of their existing use. This may unnecessarily restrict the options for supply and demand in the auction (or this would require forcing a complex reorganisation of the band). Similarly at 1800 MHz, there is a degree of fragmentation, with O2 and Vodafone each holding a small amount (2x5.8 MHz each), the Everything Everywhere merger divestment spectrum covering 2x15 MHz and Everything Everywhere holding a large amount (2x45 MHz). With any relinquishment coming from O2, Vodafone and/or Everything Everywhere's holdings, contiguity across several lots of 2x5 MHz may require a reorganisation of the band, which would likely require a specific process and careful consideration. The licensees involved may be best placed to design such a process and it would seem disproportionate to seek to design it as part of the award process, for the sole purpose of implementing contiguity rules, when relinquishment is unlikely.

Geographical reach of lots – UK-wide lots or regional lots

- 8.28 Each lot available in the auction could in principle be either a single lot for the whole of the UK, or a number of lots for distinct geographical sub-divisions of the UK.
- 8.29 The main arguments in favour of regional lots are they may stimulate better services for consumers in certain geographies, if operators were to win spectrum rights in a particular region while not being interested in providing UK-wide services. This may also provide additional competition in those regions where new competitors emerge. However, there might also be some transitional downsides to the emergence of regional operators for mobile services. This is because of potential risk of delay in the availability of services for customers of a regional operator when they roam into other parts of the UK, until roaming agreements are in place between all regional operators.
- 8.30 There are also a number of arguments against offering regional licences. First, it would be very difficult to identify relevant regional areas. If there were any potential plans for regional services, their areas might overlap and it would be challenging to identify an optimal partition. Second, this would increase the risk of unsold licences in respect of areas that offer more limited commercial prospects, typically less densely populated areas. Unsold licences might delay the provision of services in those parts of the UK, as it would be necessary to go through a new award process. Third, there are potential losses in spectral efficiency from regional licences. This is because there would need to be restrictions on use at the boundaries between regions for users of the same frequencies in order to manage the risk of interference. (Northern Ireland is different in this respect in that it is geographically separated from Great Britain.) Fourth, offering regional lots increases the number of lots available. This in turn increases the complexity of the auction, in particular the computational load and in the extreme, it may make identifying winners and prices impractical.
- 8.31 We also note that, post award, spectrum trading and leasing would offer some scope for regional operators to emerge.
- 8.32 We are therefore proposing to use UK-wide lots for all categories of lot in the award, not regional lots.
- 8.33 In the remainder of this section, we review the first four factors above for each of the mobile bands and propose a resulting set of packaging measures.

Question 8.1: Do you agree with the way in which we are taking account of the main factors relevant to spectrum packaging and why?

Question 8.2: Are there other factors that we should consider to develop our approach to packaging? If so which ones and why?

Packaging proposals for the 800 MHz band

Available spectrum and band plan

- 8.34 There are 2x30 MHz of spectrum available in the 800 MHz band, as shown in Figure 8.2. The band plan set out there is consistent with the 800 MHz Decision and with relevant equipment standards. There is no unpaired spectrum available in the band and no equipment standards for TDD use, so there is no need to consider potential band plan flexibility for relative amounts of paired and unpaired spectrum.

- 8.35 We are not proposing to make the centre gap at 821-832 MHz available in this award. We plan to consider separately and at a later stage which future uses might be appropriate for this part of the band and therefore how to make it available.

Figure 8.2: Band plan for the 800 MHz band



Size of each lot in a given category

- 8.36 The 800 MHz Decision refers to assigned block sizes of multiples of 5 MHz. Our understanding of likely demand is that potential users have an interest in blocks of spectrum of 2x5 MHz, 2x10 MHz, 2x15 MHz or 2x20 MHz. This suggests using a lot size of 2x5 MHz which bidders will be able to aggregate to form larger blocks.
- 8.37 A minimum size of 2x5 MHz is also consistent with our spectrum floors proposal and a minimum of 2x5 MHz of sub-1 GHz spectrum for at least four bidders.

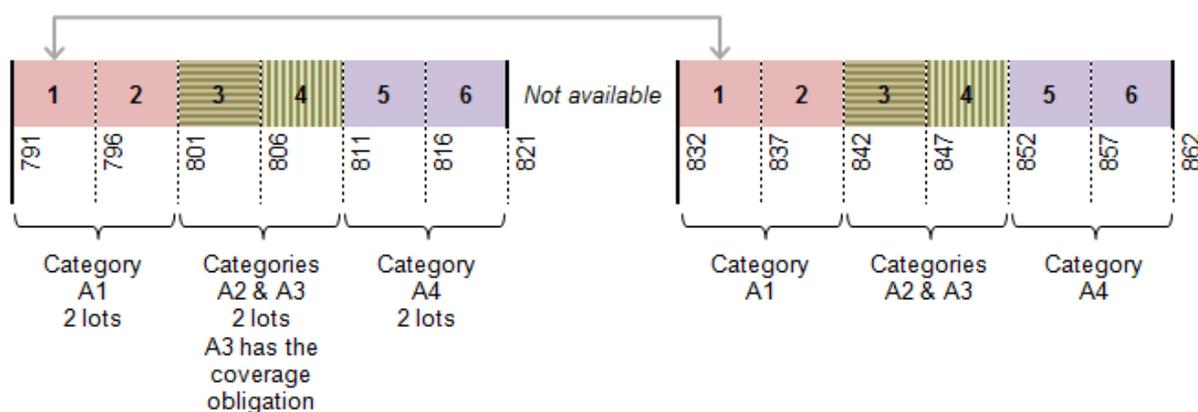
Number of categories of generic lots

- 8.38 As explained in section 4, we are in the process of carrying out significant technical work to consider the technical conditions that should apply in adjacent bands and in the 800 MHz band following the award. This work is on-going and we are not yet in a position to set out detailed proposals for the implications of technical coexistence issues with neighbouring uses.
- 8.39 However, it seems likely that there will be sufficiently large technical differences to justify a number of categories of lots in the 800 MHz band. At a high level, we expect some blocks to be particularly affected by requirements at the adjacency with DTT. There may be an interference issue at the adjacency with short range devices and other services above 862 MHz, however our current view is that this is unlikely to result in on-going technical restrictions on the use of the 800 MHz band (see paragraphs 4.16 to 4.23). It also seems plausible that some blocks in the middle of the band may only require limited restrictions in respect of adjacent uses.
- 8.40 At this stage, we propose to illustrate the implications of technical conditions, on the basis of our current understanding of the information available. This is for illustration only and is subject to on-going technical work. This illustration assumes that blocks affected by technical coexistence issues below 791 MHz are all affected in a similar way and that blocks affected by technical coexistence issues above 862 MHz are all affected in a similar way.
- 8.41 As explained in section 4 paragraph 4.8, our current assessment is that all of the UK apart from Scotland will be cleared of DTT use by the end of 2013, with Scotland being cleared by October 2014. For the purposes of packaging the 800 MHz spectrum, our current assessment is that any differences in timing of availability of different lots in the band are unlikely to be material. If further technical analysis or developments suggest that differences might be significant, then we would consider

the case for creating additional categories of lots in the band that would reflect where differences were material.

- 8.42 In section 6, we set out our approach to coverage obligations for this award. We are proposing to attach a coverage obligation to a single licence that includes frequencies in the 800 MHz band. This means that one of the lots in the band would have a coverage obligation. As discussed at paragraph 8.15, we consider that this requirement introduces a sufficiently important difference compared to other lots that we are proposing to create a specific category of lot with the proposed coverage obligation.
- 8.43 In order to facilitate the achievement of the coverage obligation, we are proposing that the lot with the obligation should have interference conditions that are not likely to impede coverage in a significant way relative to other available lots. We therefore propose that the obligation should relate to one of the lots in the middle of the band.
- 8.44 In light of these circumstances, our illustration of packaging for the 800 MHz bands includes six lots of 2x5 MHz in four categories (A1, A2, A3 and A4). Figure 8.3 sets out the corresponding band plan, where lots of paired blocks are numbered from one to six.
- 8.45 Categories A1 and A4 each include two generic lots. Categories A2 and A3 are single-lot categories. However, they are not associated with specific lots so as to facilitate contiguity. For example, it would be possible for a bidder to win the lot in category A3 (with coverage obligation) and one lot in category A4 by winning lots 4 and 5, or for a bidder to win the lot in category A3 (with coverage obligation) and a lot in category A1 by winning lots 2 and 3.

Figure 8.3: Band plan for the 800 MHz band with illustrative lot categories



Contiguity of lots

- 8.46 As discussed at paragraphs 8.23 to 8.27, we propose to ensure that the lots that a bidder wins in each band are as contiguous as possible, unless there are good reasons not to. We are not aware of any particular reason why the potential costs of a contiguity requirement would likely exceed the benefits for this band.
- 8.47 In the 800 MHz band, it is possible to ensure that each winning bidder's assignment is contiguous and we therefore propose to do so. This means implementing restrictions to prevent bids that are not consistent with a full contiguity requirement for each bidder. For example, it would not be possible to bid for a package that includes only lots in categories A1 and A4 in the band. The options for a three-lot

package would be: 2 lots from A1 and A2; 1 lot from each of A1, A2 and A3; A2, A3 and 1 lot from A4; and A3 and 2 lots from A4.

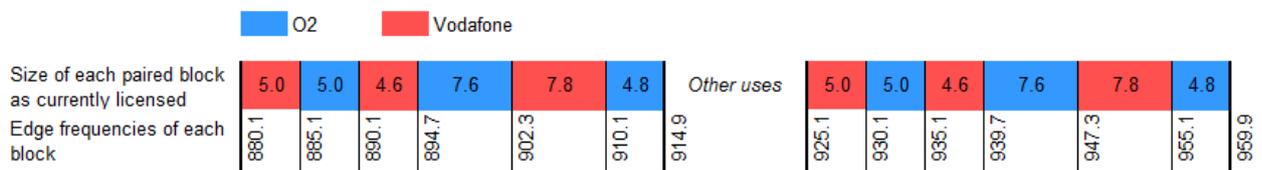
Question 8.3: Do you agree with our packaging proposals for the 800 MHz band? Please give reasons for your answer.

Packaging proposals for the 900 MHz band

Available spectrum and band plan

- 8.48 We are not proposing to permit any relinquishment of 900 MHz spectrum ahead of the auction. Therefore we do not expect to have lots for 900 MHz.
- 8.49 However, if we were to permit any 900 MHz spectrum to be relinquished such that it was available in the auction, then it would be for the relinquishing licensee to identify relevant frequencies and to ensure that they would comply with the requirements regarding size, adjacency conditions and timing of availability that we set out below.
- 8.50 Figure 8.4 below illustrates the current band plan at 900 MHz which includes 2x34.8 MHz of paired spectrum (880.1 to 914.9 MHz suitable for FDD uplink and 925.1 to 959.9 MHz suitable for FDD downlink). If one or both licensees sought to relinquish spectrum in the auction, they may reach an agreement for an updated band plan. However, it is not clear how likely or difficult this would be. This is a constraining factor on the scope for contiguity of any relinquished lots (if relinquishment were permitted).

Figure 8.4: Current band plan at 900 MHz



Size of each lot in a given category

- 8.51 The case for relinquishment would be that it would enable a 900 MHz licensee to reduce its sub-1 GHz holding in order to be able to win 800 MHz spectrum and still comply with the proposed sub-1 GHz cap. For this to work, and for our policy on sub-1 GHz floors to work, any relinquished spectrum would need to be in units that are equivalent to other 800 MHz lots.
- 8.52 The likely technologies for the 900 MHz band operate in channel sizes that are multiples of 5 MHz. Therefore, we are proposing to require any relinquished 900 MHz lot to be such that 2x5 MHz would be useable for technologies such as UMTS or LTE.
- 8.53 Commission Decision 2009/766/EC on the 900 MHz and 1800 MHz bands includes specific requirements regarding frequency separation between carriers depending on the technologies used in two adjacent blocks. This means that a block that is suitable for the use of 2x5 MHz (or multiples of 2x5 MHz for multiple lots) may be either:

- a) a 2x5 MHz block for which the relinquisher has secured a suitable agreement from adjacent user(s) for the carrier separation to be reduced consistently with that block size; or
- b) a larger block of up to 2x5.4 MHz that does not require further agreement of adjacent users for the operation of a UMTS or LTE channel of 2x5 MHz.

Number of categories of generic lots

- 8.54 In a scenario where relinquishment were possible, we would expect to make it a requirement that relinquished lots would be available for use by their winner in the auction by a pre-specified date that would be the same for all lots. Seeking to consider different relinquishment dates for different lots risks being impractical and increasing the complexity of the auction while it may bring any material benefits in practice (in the sense that any incentives for relinquishment are likely to be low even if different and longer timescales made technically easier to clear existing use more blocks). This single deadline for availability should be such that it is realistic for a relinquisher to free up the frequencies from their current GSM use and negotiate any necessary agreement with the adjacent user, while also being comparable to the date of availability of other lots in the auction. Our current understanding is that if any relinquishment were to happen, then a time of the order of 18 months between our decision on the policy for the award and the required availability of relinquished lots would seem appropriate.
- 8.55 We also believe that there would be no significant technical differences between relinquished lots in the 900 MHz band. Our analysis of adjacency conditions at the edge of the band indicates that provisions to accommodate adjacent use of GSM-R (below 880 MHz and 925 MHz) and military and aeronautical uses (above 915 MHz and 960 MHz) are likely to be modest. Our proposed requirement on lot size set out above also underpins equivalent properties for all relinquished lots in respect of intra-band interference risks.
- 8.56 We therefore consider that, if any 900 MHz lots were relinquished, they should all be part of the same category.

Contiguity of lots

- 8.57 In light of the current fragmentation of the 900 MHz band (see Figure 8.4), it would seem potentially very difficult for licensees willing to relinquish 900 MHz lots to ensure contiguity of relinquished lots and at the same time to minimise disruption to their existing services in the bands (using GSM and potentially UMTS technology).
- 8.58 A contiguity requirement in this case would seem likely to deter relinquishment, given the current band plan which would require significant changes, or to risk an inconsistency with other proposed requirements such as the timing of availability of any 900 MHz lot.
- 8.59 A downside to not requiring contiguity would be the risk that a bidder might win fragmented spectrum when they were seeking to achieve a large channel. For example, a bidder seeking 2x10 MHz of sub-1 GHz spectrum might in principle win two non-contiguous lots of 2x5 MHz in the 900 MHz band.
- 8.60 However, the issue is limited, in the sense that bidder would know in advance which lots were available in the 900 MHz band and could therefore bid knowing whether an assignment in the band would be non-contiguous. Bidders would have the choice to

bid for 800 MHz lots only and avoid the risk of fragmented assignment or to include 900 MHz lots in their bids and accept the risk of fragmented assignment. In addition, the risk that this would occur seems particularly low. First, as explained above, we do not expect any relinquishment to take place. Bidders would therefore be unlikely to face this risk in practice. In the unlikely event that relinquishment occurred at 900 MHz, it seems likely that the amount would be one lot of 2x5 MHz, in which case the risk would not exist either.

- 8.61 On balance, we propose not to require contiguity of 900 MHz lots if any were relinquished ahead of the auction.

Question 8.4: Do you agree with our proposal not to allow relinquishment of 900 MHz spectrum and why? Do you have any other comments regarding our packaging proposals for the 900 MHz band?

Packaging proposals for the 1800 MHz band

Available spectrum and band plan

- 8.62 In principle, there could be two reasons for 1800 MHz spectrum to be available in the auction:

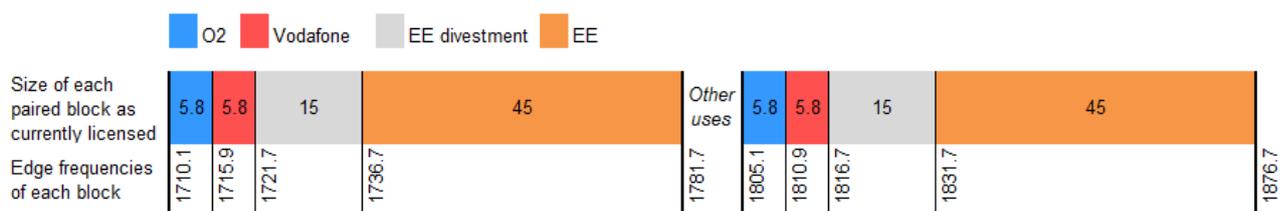
- a) Everything Everywhere may not have traded its rights for the 2x15 MHz block that they must divest as part of the undertakings that they gave to the European Commission in respect of the Orange/T-Mobile merger;
- b) An 1800 MHz licensee may relinquish some spectrum in order to increase the amount of spectrum it may win in other bands in light of the overall spectrum cap.

- 8.63 There is a possibility that Everything Everywhere's 2x15 MHz divestment may be available in the auction and we are therefore covering this possibility.

- 8.64 As with the 900 MHz band, we are not proposing to permit any relinquishment of 1800 MHz spectrum given the flexibility that bidders would have under the proposed spectrum caps. However, if any 1800 MHz spectrum relinquishment were permitted in the auction, then current licensing arrangements would dictate relinquishment options.

- 8.65 Figure 8.5 below illustrates the current band plan at 1800 MHz, which includes 2x71.6 MHz of paired spectrum (1710.7 to 1781.7 MHz suitable for FDD uplink and 1806.1 to 1876.7 MHz suitable for FDD downlink). O2 and Vodafone would only be able to relinquish the block they each currently hold. There is a choice as to which frequencies Everything Everywhere might relinquish from their retained holdings at 1736.7 to 1781.7 MHz paired with 1831.7 to 1876.7 MHz.

Figure 8.5: Current band plan at 1800 MHz



Size of each lot in a given category

- 8.66 Everything Everywhere undertook to divest a single block of spectrum of 2x15 MHz and its specific frequencies are 1721.7 to 1736.7 MHz paired with 1816.7 to 1831.7 MHz.⁷⁷
- 8.67 Similarly to 900 MHz, the case for relinquishment would be that it would enable an 1800 MHz licensee to reduce its total holdings in order to be able to win 800 MHz or 2.6 GHz spectrum and still comply with the proposed overall cap. For this to work, and for our policy on spectrum floors to work, any relinquished spectrum would need to be in units that are equivalent to other lots in the auction at 800 MHz and 2.6 GHz.
- 8.68 Given the lot sizes in these bands and likely uses, relinquished blocks of 1800 MHz would need to provide multiples of 2x5 MHz of spectrum that is effectively useable for mobile technologies such as UMTS and LTE.
- 8.69 In this case too, Commission Decision 2009/766/EC on the 900 MHz and 1800 MHz bands includes specific requirements regarding frequency separation between carriers depending on the technologies used in two adjacent blocks. This means that a block that is suitable for the use of 2x5 MHz (or multiples of 2x5 MHz for multiple lots) may be either:
- a) a 2x5 MHz block for which the relinquisher has secured a suitable agreement from adjacent user(s) for the frequency separation to be reduced consistently with that block size; or
 - b) a larger block of up to 2x5.4 MHz that does not require further agreement of adjacent users for the operation of a UMTS or LTE channel of 2x5 MHz.
- 8.70 Given the size of O2 and Vodafone's holdings in this band, we propose to require that any relinquishment they make is of 2x5.8 MHz. This would avoid any further fragmentation of the band.

Number of categories of generic lots

- 8.71 The EC decision on the Everything Everywhere merger imposes a 2x15 MHz size for the divestment. It also requires that the block be made available according to the following timeline: a first tranche of 2x10 MHz must be available no later than 30 months after the end of the 800 MHz and 2.6 GHz auction and no later than 30 September 2013, whichever is the earliest; the second tranche of 2x5 MHz needs to be available no later than 30 September 2015. These requirements effectively dictate that we use a specific category for the divestment.
- 8.72 For any relinquished 1800 MHz spectrum, we propose to apply the same principles as for any relinquished 900 MHz spectrum. Our proposal is therefore to require that relinquished lots would be available for use by their winner in the auction by a pre-specified time that would be the same for all relinquished lots. This time should be such that it is realistic for a relinquisher to free up the frequencies from their current GSM use and negotiate any necessary agreement with the adjacent user, while also being comparable to the date of availability of other sub-1 GHz lots. Our current understanding is that if any relinquishment were to happen, then a time of the order

⁷⁷ See the EC's decision published on 1 March 2010 on Case No COMP/M.5650 - T-MOBILE/ORANGE at http://ec.europa.eu/competition/mergers/cases/decisions/M5650_20100301_20212_247214_EN.pdf

of 18 months between our decision on the policy for the award and the required availability of relinquished lots would seem appropriate to meet these two criteria.

- 8.73 Our assessment suggests that any relinquished lots, whether O2's or Vodafone's 2x5.8 MHz holdings or portions of Everything Everywhere's 2x45 MHz, would have similar technical circumstances. There are no significant issues likely to arise either at the adjacencies with users below 1710 MHz (fixed, land mobile and meteorological applications) and 1805 MHz (military space operations and technology neutral licensed use in Northern Ireland), or intra-band because of the relevant EC decision and our proposed approach to lot sizes.
- 8.74 We therefore consider that, if any 1800 MHz lots were relinquished, they should all be part of the same category (but a category that is different from that for the Everything Everywhere divestment of 2x15 MHz).

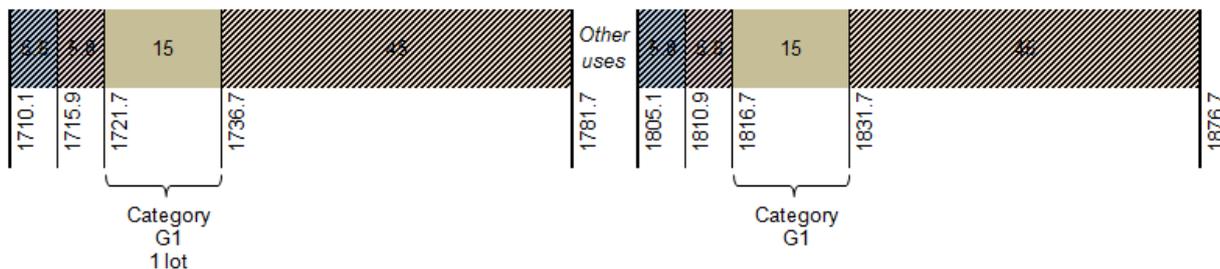
Contiguity of lots

- 8.75 The existing band plan creates some limitations to the scope for contiguity in the band. O2 and Vodafone could only relinquish their specific lots. Each of them could only be sold as a single, separate 2x 5 MHz lot if it was the only lot that a bidder won in that band. However, if both O2 and Vodafone relinquished their 1800 MHz lot and if a bidder won 2x10 MHz in the band, we would expect to require that bidder to win both these lots. The only other potential place where a bidder could win 2x10 MHz would be from Everything Everywhere's current holding if it relinquished enough spectrum. A bidder could not win exactly 2x10 MHz from Everything Everywhere's divestment if it were available in the auction, as it would need to be available as a 2x15 MHz lot as a result of Everything Everywhere's undertakings to the EC in the context of the Orange-T-Mobile merger.
- 8.76 Because of the possibility that the Everything Everywhere divestment could be available in the auction, we also propose that any spectrum that Everything Everywhere might relinquish would need to be contiguous with the divestment, and in contiguous lots of 2x5 MHz. This would allow a bidder to combine the 2x15 MHz of the divestment with such relinquished spectrum to form larger channels. If the Everything Everywhere divestment was not available in the auction, then we would still be minded to ensure that any lots Everything Everywhere relinquished were directly adjacent to it. This is because this would offer the possibility to the acquirer of the divestment to win more contiguous spectrum and it would also make it unnecessary for Everything Everywhere to be involved in any subsequent trade of spectrum that might be used to rearrange the spectrum holdings of different licensees to defragment the band.
- 8.77 We consider that these proposals help minimise fragmentation of the band and facilitating the creation of large channels, while not introducing any significant costs by way of reductions on bidding options.
- 8.78 Figure 8.6 below provides illustrations of the categories of lots that would be available in the auction in two cases. The first case is the likely scenario where none of O2, Vodafone or Everything Everywhere relinquishes any of their 1800 MHz spectrum. The second case relates to the unlikely scenario in which there is some relinquishment and, for purely illustrative purposes, we use an example where O2 and Vodafone both relinquish their lot and Everything Everywhere relinquish two lots. In both cases, for the same illustrative purposes, we include the Everything Everywhere divestment as a category of available spectrum, as it may be available in the auction.

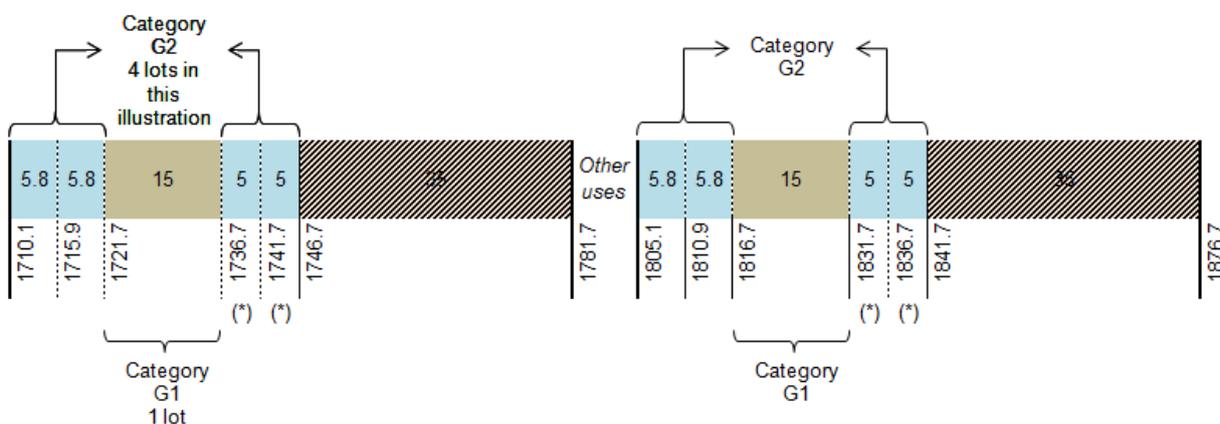
Figure 8.6: Band plan for the 800 MHz band with lot categories in two illustrative cases (with and without relinquishment)

 Not available in the auction

Case 1 - no relinquishment but EE divestment assumed to be available in auction



Case 2 - some relinquishment (O2 and Vodafone lots; 2 EE lots) and EE divestment assumed to be available in auction



(*) assumes that lot size is 2x5MHz i.e. EE secures necessary agreement with adjacent users

Question 8.5: Do you agree with our proposal not to allow relinquishment of 1800 MHz spectrum and why? Do you have any other comments regarding our packaging proposals for the 1800 MHz band?

Packaging proposals for the 2.1 GHz band

- 8.79 It seems highly unlikely that any current licensee would seek to relinquish paired spectrum from the 2.1 GHz band. Paired spectrum in this band plays an essential role in the delivery of 3G mobile services today. It is in intensive use and this is likely to continue for the foreseeable future. Unpaired spectrum in this band is not currently in use, with no clear plans to roll-out services, such as this spectrum is unlikely to be a good substitute or complement to other available mobile spectrum.
- 8.80 We are not therefore considering the possibility of relinquishment any further and we are not proposing to facilitate relinquishment of 2.1 GHz spectrum for the purpose of the auction.

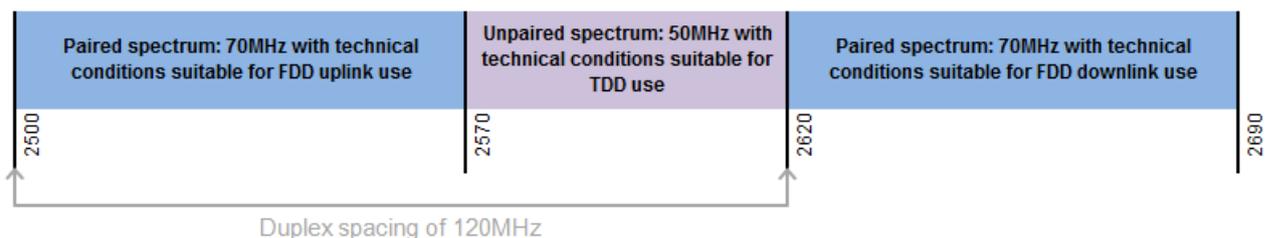
Question 8.6: Do you agree with our proposal not to make provisions to include 2.1 GHz spectrum in this auction and why?

Packaging proposals for the 2.6 GHz band

Available spectrum and band plan

- 8.81 There are 190 MHz available in the 2.6 GHz band, with potential for both paired and unpaired use. When we previously developed proposals for the award of this band on a stand-alone basis, circumstances were different and led us to approach the structure of the band plan in a particular way. At the time, there was significant interest in unpaired use of this band, with some scope for entry for one or more competitors using the TDD WiMAX technology. Previous standardisation discussions in CEPT had put forward a non-binding fixed band plan that identified 50 MHz at 2570 to 2620 MHz for unpaired use and a duplex spacing of 120 MHz. However, in the UK context as well as in other Member States, it was unclear then how much spectrum in the band should go to paired or unpaired use. We adopted a flexible band plan approach, leaving it to the auction process to resolve the balance between paired and unpaired spectrum in the band, while guaranteeing a duplex spacing of 120 MHz. As discussed in section 2, we withdrew the corresponding decision in 2009 as a result of developments in European and UK policy.
- 8.82 Since then, the interest in use of WiMAX technology has diminished and there is no clear demand for an increase in the supply of unpaired spectrum at 2.6 GHz over the default amount of 50 MHz put forward in CEPT. Other potential technologies are relevant to unpaired use in this band, in particular TD-LTE. We are not aware of any clear demand to increase the supply of unpaired spectrum to facilitate use of such other technologies. There also remain some uncertainties regarding the characteristics and timing of availability of TD-LTE equipment for this band, in particular user equipment such as smart phones or tablets.
- 8.83 The introduction of band plan flexibility also creates challenges for the auction design and implementation. These were manageable in the case of the auction of the 2.6 GHz band on its own. The proposed combined auction of 800 MHz and 2.6 GHz has a different degree of complexity absent band plan flexibility, with more categories of lots, more scope for substitution and complementarities, proposals for specific provisions such as competition constraints. Including band plan flexibility would create risks for both bidders and the auctioneer with a material increase in complexity given the context.
- 8.84 As a result, we are proposing to use a fixed band plan that is consistent with the default configuration envisaged in the 2.6 GHz Decision, and consistent with relevant technical standards for this band. This involves 2x70 MHz of paired spectrum with a 120 MHz duplex spacing and 50 MHz of unpaired spectrum (including restricted blocks to manage the risk of interference between paired and unpaired use). Figure 8.7 illustrates the proposed band plan.

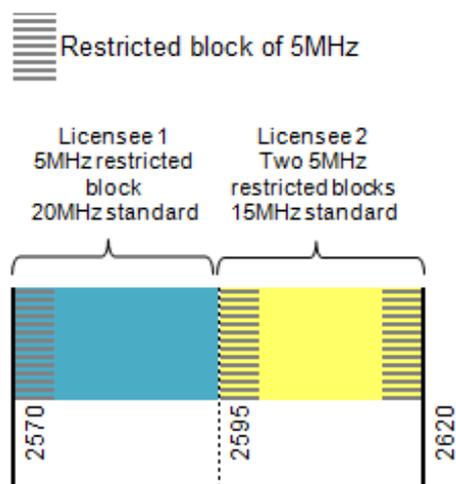
Figure 8.7: Proposed fixed band plan for the 2.6 GHz band



Size of each lot in a given category

- 8.85 In light of potential uses for the paired spectrum at 2.6 GHz, we see two main options for lot sizes. We could use either a 2x5 MHz lot size or a 2x10 MHz lot size. Using a 2x5 MHz size has the advantage of offering a greater range of choice for bidders, including channels of 2x5 MHz and 2x15 MHz in addition to those of 2x10 MHz and 2x20 MHz. However, it contributes to auction complexity by increasing the combinatorial options and the computational challenge of the winner determination and pricing algorithms. In addition, it is not clear that potential bidders would be likely to associate significant values to a single block of 2x5 MHz at 2.6 GHz and it is not clear either that having the option to bid on 2x15 MHz adds significant value when it is possible to bid for 2x10 MHz and 2x20 MHz.
- 8.86 On balance, we propose to select the simpler option of using paired lots of 2x10 MHz.
- 8.87 There is also a choice in respect of the unpaired part of the band. In principle, it could be a single lot of 50 MHz, or there could be multiple lots for bidders to aggregate according to their preferences. The technical conditions for unpaired use are such that there needs to be two restricted blocks of 5 MHz each at the top and bottom of the 50 MHz block, to manage interference between paired and unpaired use. This leaves up to 40 MHz for use at standard high powers. There also needs to be a restricted block between adjacent unpaired users, if there were two or more unpaired licensees. Therefore, with two unpaired licensees, there would be three restricted blocks of 5 MHz each (at the bottom of the block, between the two licensees and at the top) and 35 MHz with standard high power limits to be split between the two licensees. Figure 8.8 illustrates this case where one licensee holds rights to 20 MHz with standard power levels (plus a restricted block) and the other to 15 MHz (plus two restricted blocks).

Figure 8.8: Example of 2.6 GHz unpaired band plan with multiple licensees



- 8.88 Our assessment is that having more than two licensees in the band creates a strong risk that the quantity of spectrum available to at least two of them is so small as to severely restrict the scope for productive use. We do not think that such an outcome would be likely to meet our duty to secure the optimal use of the spectrum.
- 8.89 The case where there are two licensees also raises potential issues. It is not clear that unpaired blocks of 20 MHz or 15 MHz would promote efficient use of the spectrum, when compared to other blocks in high frequency bands, such as the 2x15

MHz divestment at 1800 MHz and 2x10 MHz or 2x20 MHz lots in the paired section of the band. This is because we anticipate that services using unpaired spectrum are likely to be similar to and compete, at least to some extent, with those using paired spectrum (and possibly some fixed broadband services), and therefore smaller amounts of spectrum would risk making potential service quality with unpaired spectrum comparatively weak. We received several submissions during our preparations for the stand-alone award of the 2.6 GHz band in 2006 to 2008 indicating that a new entrant would need a minimum of 30 MHz of unpaired spectrum (excluding restricted blocks) to develop a competitive service in terms of costs and quality. This was related to use of WiMAX technology. However, it seems that the broad idea regarding spectrum requirements is likely to remain relevant, as the latest TDD technologies operate in similar ways and offer similar performance.

- 8.90 We are aware that some existing mobile operators have won rights to parts of the centre part of the band in other European countries, for example in Germany and Denmark. This includes instances of operators winning amounts as small as 10 MHz or even 5 MHz of unpaired spectrum including restricted block(s). However, it is possible that this may have been in some cases as a result of bidding incentives under the specific auction rules (e.g. retaining eligibility by bidding on lots that are not necessarily very important). In addition, in Germany, those operators who won some unpaired spectrum also won larger amounts of paired spectrum and placed significantly higher values on paired spectrum. In the auction of the 2.6 GHz band that took place in Finland at the end of 2009, bidders could bid for up to 2x25 MHz of paired spectrum or the whole of the centre gap (50 MHz including restricted blocks). The three existing national operators won paired spectrum, not unpaired spectrum. Of course, any additional mobile spectrum capacity is likely to have value to existing mobile operators, but this may be principally option value as an addition to their core focus on paired spectrum.
- 8.91 As above in respect of the size of paired lots, having fewer unpaired lots has the advantage of reducing complexity for the auction. It may also have the effect of promoting participation in the auction, competition and entry by guaranteeing the winner 40 MHz of spectrum with standard power rights. This would be more directly comparable with the channels of 2x20 MHz that we expect bidders to seek at higher frequencies.
- 8.92 We are therefore proposing to award the centre gap at 2.6 GHz as a single lot.

Number of categories of generic lots

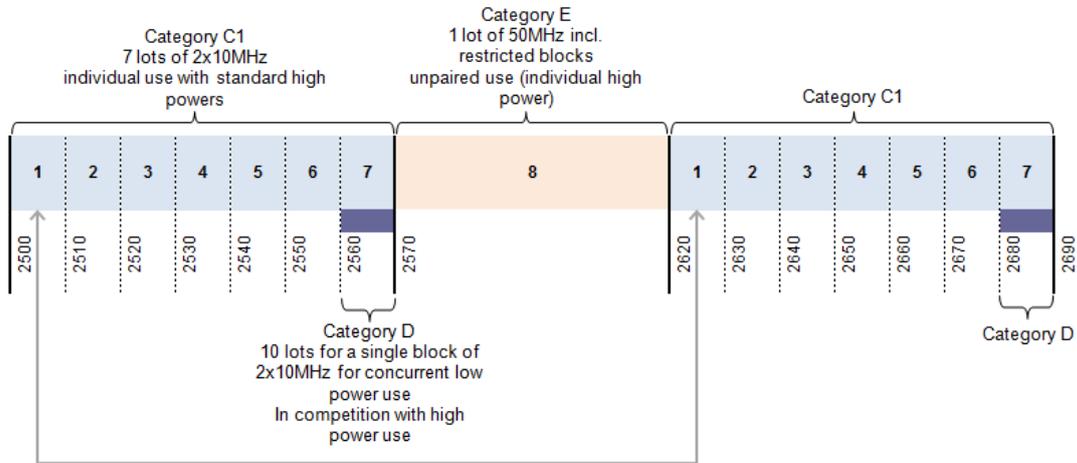
- 8.93 Our technical analysis, as set out in the statement of April 2008⁷⁸, was that all paired lots are sufficiently similar to be treated generically in the main stage of the auction. One development since that statement has been the issue of coexistence with radars that operate in the 2.7 GHz band. We set out in section 4 our current understanding of the position (see paragraphs 4.34 to 4.41). We believe that the issue affects all blocks of spectrum in the 2.6 GHz band in a broadly similar way.
- 8.94 We are therefore proposing to have a single category of lots for paired use with individual high power rights and another category for the single unpaired lot.

⁷⁸ Statement published on 4 April 2008, available at <http://stakeholders.ofcom.org.uk/consultations/2ghzrules/statement/>. We have since withdrawn this statement. However, the analysis on the question of generic treatment of lots in the band remains relevant.

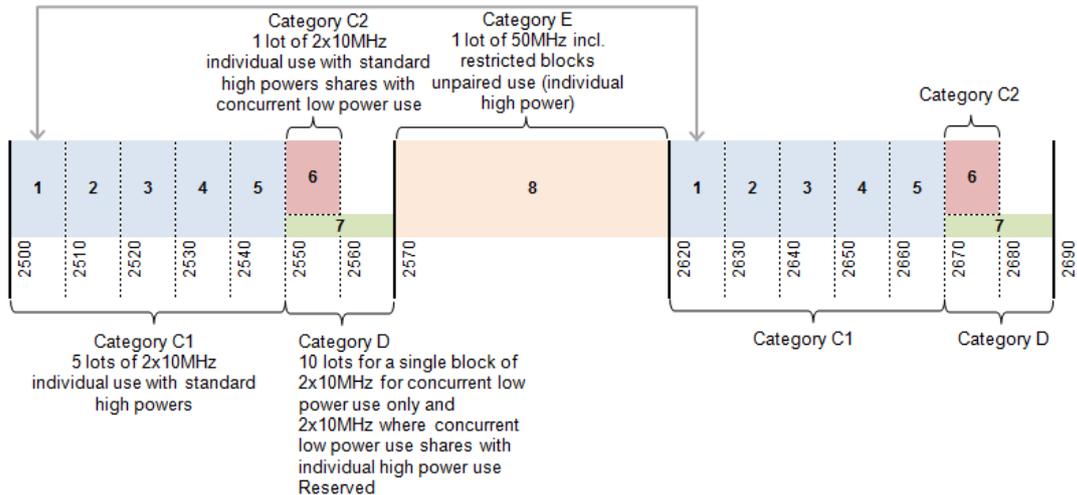
- 8.95 In section 5 and Annex 6, we also set out potential options to facilitate concurrent use of some paired spectrum at low powers. Subject to consultation responses and further analysis, there are several options that may be suitable to the circumstances of the award to facilitate concurrent low-power use. As a minimum, we would expect to design the auction in such a way that bidders for concurrent low-power use could compete with bidders for individual high power use over a fixed quantity of spectrum (2x10 MHz or 2x20 MHz). Other options include reserving some spectrum for concurrent low-power use (2x10 MHz or 2x20 MHz for concurrent low-power use only; specific lot of 2x20 MHz for low-power use, where half of the frequencies would be for concurrent low-power users only and the other half would be shared with an individual high power user). We set out these options in more detail in Annex 6. The report by Real Wireless published alongside this consultation also includes more information on how an individual high power licensee and concurrent low-power licensees might share the joint 2x10 MHz from a technical perspective in the case of the option with an underlay.
- 8.96 For the purpose of our proposals on packaging, we seek to illustrate this range of options in the case where we do not reserve any spectrum as well as in the case where we reserve some spectrum for low-power use. We are therefore considering in more detail the following three options:
- a) designing the award in order to let concurrent low-power users compete with high power users over 2x10 MHz;
 - b) reserving 2x20 MHz for concurrent low-power use where 2x10 MHz are for low-power use only and 2x10 MHz are for high power use with low-power use as an underlay; and
 - c) reserving 2x10 MHz for concurrent low-power use only.
- 8.97 Figure 8.9 shows the band plans with lot categories for these three potential options. The position of the low-power blocks within the band is for illustration only.

Figure 8.9: Illustrations of possible band plans for the 2.6 GHz band with lot categories

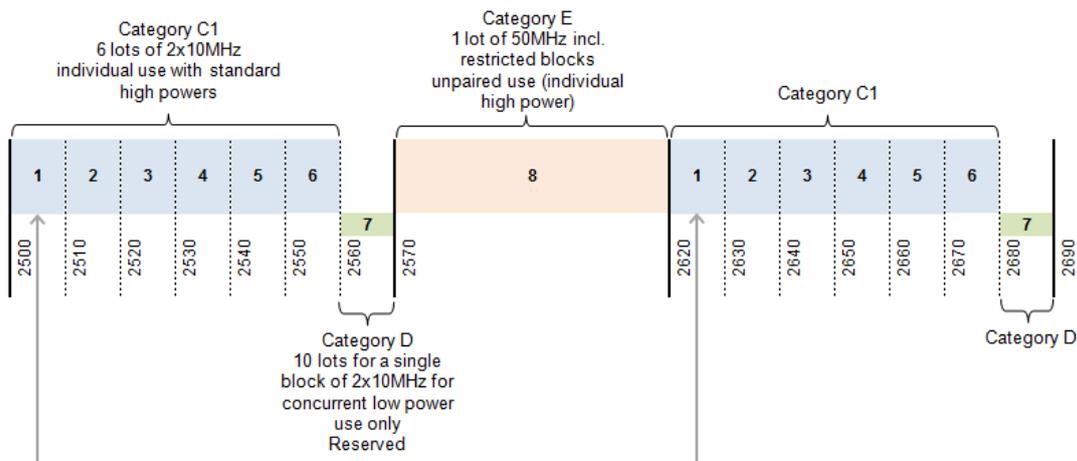
Option with competition between concurrent low power and high power use over 2x10MHz



Option with concurrent low power underlay in a 2x10MHz block shared with individual high power use



Option with reservation of 2x10MHz for concurrent low power use



Contiguity of lots

- 8.98 As discussed at paragraphs 8.23 to 8.27, we propose to ensure that the lots that a bidder wins in each band are as contiguous as possible, unless there are good reasons for this not to be the case.
- 8.99 We are not aware of any reason not to seek to impose contiguity for paired lots with individual high power rights, as we had originally decided in April 2008. It remains simple to implement.
- 8.100 In the case of the lot structure option and approach to concurrent low-power use where there is a 2x10 MHz block that individual higher power use and concurrent low-power use share, there would be an added requirement that any other lot won by the winner of the specific high power lot with the low-power underlay would have to be contiguous and adjacent to this lot. This would mean that the winner of the shared high power lot would be automatically assigned all of their lots from the top of the band (not including the shared low-power lot), with other winners of high power lots fitting in below that. This would not increase complexity in the auction and provide benefits from contiguity.

Question 8.7: Which aspects of our packaging proposals for the 2.6 GHz band do you agree with and why?

Eligibility for each lot type

- 8.101 Annex 9 sets out the detailed rules for the proposed auction design, This includes a description of eligibility points. These are the means to ensure that bidders' activity is conducive to efficient price revelation.
- 8.102 Eligibility points are a means to ensure that bidders do not increase the amount of spectrum they bid on from one round to the next and that switching from one category to another is broadly consistent with the expected relative values of these categories. More specifically, bidders will not be able to bid for a package with an associated eligibility that is greater than the eligibility of its bid in the previous round.
- 8.103 It is clearly difficult to identify in advance of the auction a precise set of relative values for the categories. However, for the purpose of incentivising auction participants to bid truthfully, it is not necessary to identify relative values precisely. It is sufficient to establish relative values that are within a reasonable range of the likely outcome.
- 8.104 Analysing the results of similar auctions, taking account of their specificities (e.g. in terms of auction design or bidding strategies) is likely to be particularly helpful for this purpose. We have developed a set of provisional eligibility point values for each band on the basis of information that is currently available from other countries. This only includes information from the 2010 German and 2011 Swedish auctions in respect of 800 MHz and we are considering the calculations below in Table 8.1 with caution as a result, as we extrapolate relative values for 800 MHz from these two results for other countries. We expect to revisit these nearer the time of the UK auction, as other similar auctions are likely to have taken place, for example in Ireland, Spain or Switzerland.

Table 8.1: Eligibility point information for each lot category based on recent auctions

Country	Approximate UK equivalent prices per lot using prices/MHz/pop (£m) (*)			Inferred eligibility points (rounded)			
	800 MHz (2x5 MHz lot)	2.6 GHz paired (2x10 MHz lot)	2.6 GHz unpaired (50 MHz lot)	800 MHz Germany (**)	800 MHz Sweden (**)	2.6 GHz paired	2.6 GHz unpaired
Austria	n/a	25	50	14	8	1	2
Germany	380	23	54	16	n/a	1	2
Denmark	n/a	133	267	3	2	1	2
Finland	n/a	3	11	114	68	1	4
Sweden (800 MHz)	220	n/a	n/a	n/a	n/a	n/a	n/a
Sweden (2.6 GHz)	n/a	154	119	3	2	2	1
Norway	n/a	26	111	14	8	1	4

(*) values per lot for Austria and Denmark established from overall band value on a pro rata basis per MHz assuming 40 MHz of fully useable spectrum in the 2.6 GHz unpaired lot

(**) values in italic indicate values for 800 MHz eligibility extrapolated from German and Swedish auction prices for indicative purposes

8.105 On balance, in light of these data, our provisional set of eligibility points, for the purpose of this consultation is:

- a) 800 MHz (any lot of 2x5 MHz in categories A1, A2, A3, A4): 30 points per lot;
- b) 2.6 GHz paired (any lot of 2x10 MHz in category C1 and in category C2 for individual high power use if there are provisions in respect of concurrent low-power use): 10 points per lot;
- c) 2.6 GHz paired (potential concurrent low-power lots of 2x10 MHz or 2x20 MHz in category D): one point if the lots covers 2x10 MHz or two points if the lots cover 2x20 MHz, for each of the 10 lots;
- d) 2.6 GHz unpaired (single lot of 50 MHz in category E): 20 points for the lot;
- e) Any other lot of paired sub-1 GHz frequencies in case of relinquishment: 30 points per lot of 2x5 MHz;
- f) Any other lot of paired frequencies above 1 GHz in case of relinquishment: 10 points per lot of 2x10 MHz. The Everything Everywhere divestment of 2x15 MHz would have 15 points.

Question 8.8: Do you agree with our proposed approach for eligibility points and why?

Reserve prices

- 8.106 Our approach to reserve prices in the past has been to set them at a level that was sufficient to deter frivolous bidding but that was likely to be relatively low compared to the value of the spectrum. By way of illustration, such reserve prices might have been of the order of £100,000 for a 20-year licence covering 2x5 MHz of spectrum.
- 8.107 In the context of the proposed auction, there may be reasons to consider alternative approaches.
- 8.108 It may be helpful for the purpose of achieving efficient use of the spectrum to use reserve prices, in addition to the auction rules, as a way to manage the risk of strategic behaviour that might occur during or prior to the auction aimed at reducing competition for spectrum (such as bidders reducing their demand to decrease significantly the price they pay). By having material reserve prices, this would likely reduce the maximum potential pay-off that any bidder could receive from bidding strategically. This would be likely to reduce the incentives on any bidder to seek to execute such a strategy.⁷⁹
- 8.109 This may also help with the auction process in that it would reduce the time necessary to reach price levels close to the eventual value of the spectrum (although there are other ways than adjusting reserve prices to achieve this, e.g. by adjusting bidding increments).
- 8.110 Another reason might be to strengthen incentives for stakeholders to engage in the regulatory process by sharing the best possible information with Ofcom in the context of consultations on decisions regarding spectrum use. In the case of the 800 MHz band and the 2.6 GHz band, we reached decisions to clear these bands of existing uses (analogue and digital terrestrial TV, including reorganisation of multiplexes to achieve a harmonised band plan for the digital dividend; PMSE and modification of adjacent radar uses). This was based on an analysis of likely relative values of competing uses, with significant input from stakeholders. For the purpose of managing incentives in regulatory engagement and overall to maximise the benefits of spectrum management, it may be desirable and proportionate to seek to expose mobile users of the spectrum to at least the cost of the clearance activities.
- 8.111 We also discuss below some specific risks that are likely to arise from the pro-competitive measures we are proposing to use in the auction, with spectrum floors. We consider the efficiency arguments in favour of using reserve prices that are close to market value for those lots that are effectively reserved for a certain number of bidders that do not already have minimum spectrum portfolios.
- 8.112 However, higher reserve prices create risks. They may deter participation, reduce the scope for entry, distort the outcome of the auction and, in the extreme, lead to unsold spectrum. These effects are likely to be more pronounced as reserve prices get higher and closer to the likely value of the spectrum.
- 8.113 We consider three options for setting material reserve prices:

⁷⁹ On the issue of reserve prices and strategic demand reduction, see for example Peter Cramton, Simultaneous Ascending Auctions, 8 August 2004, p.13 (<http://www.cramton.umd.edu/papers2000-2004/cramton-simultaneous-ascending-auction.pdf>) or Paul Klemperer, What really matters in auction design, August 2001, p.8 (<http://www.nuff.ox.ac.uk/users/klemperer/papers.html>).

- a) a level that would be unlikely to be (too) close to the value of the spectrum but would also be likely to cover at least the forecast costs of the on-going programmes of spectrum clearance;
- b) a level that is based on an estimate of likely value of the spectrum (probably with a mark-down); or
- c) an option that combines the two above, where the spectrum that is effectively reserved under the spectrum floor approach has a reserve price based on an estimate of the likely value of the spectrum (as under (b) and where the spectrum that is subject to full competitive bidding has a reserve price likely to cover at least the forecast clearance costs (as under (a)).

8.114 We see some merits in using reserve prices that would be likely to cover at least clearance costs, but unlikely to be close to the full value of the spectrum. The size of the risks involved for the efficiency of the auction, efficient use of the spectrum following the auction and, in time, for consumers seem modest. However, this may create desirable effects in three areas. This would be likely to strengthen incentives for high-quality regulatory engagement and the sharing of information between stakeholders and Ofcom. Such reserve prices may also lead to some reduction in the incentives for strategic bidding, because the maximum pay-offs from a strategy designed to win spectrum at low price would be bounded by higher reserve prices. Finally, this would help with the efficiency of the award process, as it would likely take less time to reach market clearing prices for the available spectrum (although there are other options for doing this with lower reserve prices, e.g. by having larger increments in round prices).

8.115 The table below provides an illustration of potential reserve price levels following this approach. This illustration assumes that there are lots specifically designed to facilitate low-power use at 2.6 GHz. If that was not the case, all 2.6 GHz lots would have individual high power rights and would have the same reserve price (£10,000,000 in this illustration).

Table 8.2: Illustration of potential reserve prices that would be material but unlikely to be close to likely spectrum values

Band and category	Lot size	Reserve price per lot (£)
A1: 800 MHz (bottom 2 lots, generic)	2x5 MHz	30,000,000
A2: 800 MHz (middle lot – no coverage obligation, generic as to frequency)	2x5 MHz	30,000,000
A3: 800 MHz (middle lot – WITH coverage obligation, generic as to frequency)	2x5 MHz	30,000,000
A4: 800 MHz (top two lots, generic)	2x5 MHz	30,000,000
B: 1800 MHz divestment (1 lot, specific, or no lot)	2x15 MHz	15,000,000
C1: 2.6 GHz FDD for individual high power use (5 lots, or 6 lots or 7 lots, all generic)	2x10 MHz	10,000,000
C2: 2.6 GHz FDD for individual high power use, possibly with shared low-power underlay (1 lot, specific, or no lot)	2x10 MHz with concurrent low-power underlay	10,000,000
D: 2.6 GHz FDD for shared low-power use – reserved for shared low-power if provision included, possibly with part underlay (1 lot, specific, or no lot)	2x10 MHz (concurrent) or 2x20 MHz (concurrent) with high power overlay over 2x10 MHz	1,000,000 if 2x10 MHz lot 2,000,000 if 2x20 MHz lot
E: 2.6 GHz TDD for individual high power use (1 lot, specific)	50 MHz	20,000,000

- 8.116 There may also be some efficiency reasons to support higher reserve prices in respect of certain lots. These lots are those that are effectively reserved for bidders that do not currently have a portfolio consistent with the minimum requirements for a national wholesale provider that we have identified in our competition assessment. As we require four winners to meet these essential requirements following the auction, competition for these lots may be weak or non-existent.
- 8.117 This would not be a problem if we could be certain that the winning bidders for these lots would in all cases have the resources, know-how and intention to be effective competitors in the relevant mobile markets. There is however a risk, for example if a number of the parties that might be effective competitors proved to be disinterested in bidding for this spectrum. That one or more of the winning bidders would not have the capability, or perhaps even the intention, to be an effective competitor. If the reserve price were low they might also be significantly less efficient users of the spectrum. There may therefore be a risk of failure fully to achieve the intended purpose of the competition constraint (as discussed in Section 5).
- 8.118 An option to deal with these risks is to use reserve prices that are likely to be closer to the market value of the spectrum, to maximise the probability that the winners are willing and able to invest in the spectrum and its use, and that their willingness to pay is at a level that is likely to be close to that of efficient competitors. An additional

advantage of such reserve prices would be to mitigate any potential risk that one or more competitors might gain an advantage that could affect investment incentives from asymmetric profits shocks if they were able to win reserved spectrum for close to the reserve price⁸⁰.

- 8.119 We would expect to use information such as international benchmarks to identify such a value. This would involve a degree of caution reflecting the uncertainties involved in extrapolating such data and the risks that reserve prices that are too high create for participation in the auction and efficiency.
- 8.120 We would be keen to hear the views of stakeholders on the risks that such reserve prices might create, in particular in respect of likely participation in the auction and the potential for entry.
- 8.121 On the basis of current information, from the auctions referred to in Table 8.1, the order of reserve prices that may be a suitable estimate of market prices for such purposes might be:
- a) £200,000,000 per lot of 2x5 MHz at 800 MHz; and
 - b) £40,000,000 per lot of 2x10 MHz at 2.6 GHz (and at 1800 MHz if frequencies in this band are available in the auction).
- 8.122 We reiterate it is not our objective to raise revenue for the Exchequer, nor is this a consideration we can take into account, given our statutory duties.

Question 8.9: Which approach to reserve prices do you think would be most appropriate to secure optimal spectrum use in the interests of citizens and consumers, and why?

Summary of packaging proposals

- 8.123 The table below provides a summary of our proposals for the packaging of the available spectrum for the auction of the 800 MHz and 2.6 GHz bands.

⁸⁰ See paragraphs 5.102 and A8.107 to A8.114 of <http://stakeholders.ofcom.org.uk/binaries/consultations/spectrumlib/annexes/annex8.pdf>

Table 8.31: Summary of packaging proposals including illustrative 800 MHz lot structure, inclusion of a concurrent low-power lot at 2.6 GHz and illustrative reserve prices

Band and lot category	Type	Lot size	Competition Constraints				Possible eligibility per lot	Possible reserve price per lot (£) (*)
			Count towards min portfolio as sub-1 GHz	Count towards min portfolio as >1 GHz	Count towards sub-1 GHz cap	Count towards overall cap		
A1: 800 MHz (bottom 2 lots)	Generic	2x5 MHz	No	Yes	Yes	Yes	30	30,000,000
A2: 800 MHz (middle lot – no coverage obligation)	Generic as to frequency	2x5 MHz	Yes	Yes	Yes	Yes	30	30,000,000 [Or 200,000,000]
A3: 800 MHz (middle lot – WITH coverage obligation)	Generic as to frequency	2x5 MHz	Yes	Yes	Yes	Yes	30	30,000,000 [Or 200,000,000]
A4: 800 MHz (top two lots)	Generic	2x5 MHz	Yes	Yes	Yes	Yes	30	30,000,000 [Or 200,000,000]
B: 1800 MHz (divested prior to auction as per EC merger requirements, 1 lot or no lot)	Specific	2x15 MHz	No	Yes	No	Yes	15	15,000,000 [Or 60,000,000]
C1: 2.6 GHz Paired for individual high power use (5 lots or 6 lots or all 7 lots)	Generic	2x10 MHz	No	Yes	No	Yes	10	10,000,000 [Or 40,000,000]
C2: 2.6 GHz Paired for individual high power use, possibly with shared low-power underlay (1 lot or no lot)	Specific	2x10 MHz with concurrent low-power underlay	No	Yes	No	Yes	10	10,000,000 [Or 40,000,000]
D: 2.6 GHz Paired for concurrent low-power use – if reservation included, possibly with part underlay (10 lots or no lots)	Specific	2x10 MHz Or 2x20 MHz with high power overlay over 2x10 MHz	No	No	No	No	1 if 2x10 MHz lot 2 if 2x20 MHz lot	1,000,000 if 2x10 MHz lot 2,000,000 if 2x20 MHz lot
E: 2.6 GHz Unpaired for individual high power use (1 lot)	Specific	50 MHz	No	No	No	Yes	20	20,000,000

(*) potential reserve prices in square brackets are only for spectrum that is “reserved” as a result of proposed minimum spectrum portfolios

Section 9

Auction design and rules proposals for the combined award

Introduction

- 9.1 The Direction requires us to hold an auction for the award of frequencies in the 800 MHz and 2.6 GHz bands and any other frequency bands that we think appropriate.⁸¹
- 9.2 In the previous section, we put forward proposals for the packaging of the spectrum, i.e. what would actually be offered for sale in the auction in terms of lot types and the properties of the individual lots.
- 9.3 This section takes the proposals on packaging as an input and sets out our proposals for how the spectrum should be sold, i.e. the choice of auction format. We explain our objectives for the auction and consider which auction format is likely to be best at meeting these objectives.
- 9.4 This section also details the key policy choices for the detailed auction design, given our preferred auction format.
- 9.5 We set out separately, in Annex 9, a proposal for the specific auction rules which describes in detail how each stage of the auction would work, and the requirements with which bidders would have to comply in the auction. In Annex 10, we also discuss in detail our approach to determining the prices (licence fees) that successful bidders in the auction will pay.

Objectives for the auction

- 9.6 We consider that our principal duty to further the interests of citizens and consumers, where appropriate by promoting competition, is of principal importance to this award. In fulfilling this duty, we consider that our duties to secure optimal use of spectrum, promote innovation, and secure the availability of a wide range of electronic communications services throughout the UK are also of particular significance.
- 9.7 We consider that an objective to achieve an outcome that awards spectrum to those that are most likely to use it in an optimal way irrespective of technology or use, is likely to be in the interests of citizens and consumers. We are also mindful of the requirement of the Direction that we should, where we think fit, put in place appropriate and proportionate measures, including potentially in the rules governing the auction, to promote competition in mobile markets after the auction.
- 9.8 In light of these duties we have set out a number of specific objectives for the auction. These are:
- a) To implement our policy proposals to promote future competition, as set out in section 5 and Annex 6, in a way that maximises auction efficiency: the design

⁸¹ We consider the arguments for allowing licence holders to “relinquish” existing mobile spectrum (i.e. to return spectrum to Ofcom for sale in this auction) and also the possibility that the 1800 MHz spectrum that Everything Everywhere has to divest as a condition of the merger may be included in this auction in section 8.

should include practical provisions to deliver our competition policy goals, while achieving a good balance on the other factors below.

- b) To let bidders make bids for spectrum packages they value: the design should enable bidders to express their valuations for the packages they would be happy to win. An auction design that only allows bidders to express a narrower set of bids than those they would be willing to make creates risks for the efficiency of the outcome.
- c) To address aggregation risks for bidders: the design should mitigate risks that bidders acquire some spectrum but not enough to meet their needs, or that spectrum is awarded in a manner which is insufficiently contiguous resulting in the sterilisation of some lots.
- d) More generally to facilitate the reduction in common value uncertainty: bidders are likely to be seeking to serve the same mobile broadband services market and are therefore likely to be valuing spectrum for similar purposes. Being able to validate their own estimates of value against the bidding decisions of other bidders should allow information relevant to the valuation of spectrum to be aggregated across bidders and improve economic efficiency.
- e) To encourage truthful bidding: the auction design should encourage bidders to submit bids on all packages on which they are interested, but not on those which they do not wish to win. The design should create incentives for bids to reflect the true valuation that bidders place on each package. This is important for a number of reasons, in particular to achieve an efficient outcome (to ensure we identify winners on the basis of bids that reflect true valuations), for the purpose of reducing common value uncertainty and for the purpose of running an efficient process in which there are as few opportunities as possible for bidders to extend the process unnecessarily.
- f) To reduce the opportunities for strategic bidding behaviour: the auction rules and procedures should make it difficult for bidders to follow a bidding strategy intended to exclude other bidders from winning spectrum or to seek to win smaller quantities of spectrum than would otherwise be efficient with a view to paying significantly less.
- g) To limit barriers to participation as far as possible: the auction should not unreasonably deter participation by any type of prospective bidder, including smaller bidders as well as large, sophisticated bidders. This implies that participating in the auction should be relatively simple, relatively low cost and low risk for bidders.
- h) To design an auction that is practical to implement: the level of complexity in the auction should not be so great that it becomes impractical to implement in the software required to run the auction or in the regulations required to give legal effect to the award design. Equally, the design should avoid being so complex for bidders to understand or participate in that they risk making material bidding mistakes.

9.9 We note that some of these objectives could conflict with certain aspects of the auction design. For example, the objective of facilitating a reduction in common value uncertainty could conflict with the aim of reducing the opportunities for strategic bidding behaviour. Where aspects of these objectives may conflict, we consider which approach is likely best to achieve the overall objective of awarding the

spectrum to those that can create greatest value (economic or otherwise) from its use for citizens and consumers.

Assessment of potential auction formats in light of our objectives

Single or multiple lots

- 9.10 There are two main options to package a given quantity of spectrum. The first is to award spectrum in pre-defined lots, restricting each bidder to winning a single lot, as was done in the 2000 3G auction in the UK for example. The second option is to define lots as “unit blocks”, of a size consistent with minimum needs, that bidders can seek to aggregate to form larger holdings according to their own specific needs and valuations. There can be limits to the aggregation options, for example for competition reasons.
- 9.11 We think that multiple lots would best promote our objective for securing optimal use of the spectrum because bidders’ demands for spectrum may well be different, especially given that their existing holdings of spectrum may differ. We also set out in section 5 our proposals for constraints on the amount of spectrum bidders can win for the purpose of promoting competition.

Simultaneous or sequential award of lots

- 9.12 If there is substitutability and/or complementarity between the available lots, a sequential auction would introduce significant substitution risks (as participants must bid for one or more lots without knowing what the price of other substitute lots will be) and aggregation risks (bidders do not know whether they will be successful in winning complementary lots).
- 9.13 A simultaneous approach can allow bidders to manage aggregation and substitution risk across lots.
- 9.14 We think that a simultaneous award would best promote our objectives for optimal use of the spectrum because it is likely there will be significant substitutability and complementarity between lots.

Single round (sealed bid) or multiple rounds (ascending bids)

- 9.15 If there were some degree of common value uncertainty for the 800 MHz and 2.6 GHz bands, i.e. bidders would face similar uncertainties over the value of this spectrum, uncertainty could be reduced by using an ascending bid format, with provision of information on bids in each rounds to bidders. This would allow bidders to learn from each others’ valuations and could thereby reduce common value uncertainty.
- 9.16 A multiple round ascending bid format which allows bidders to switch their demand to different lots in response to changes in relative prices can also enable bidders to reduce substitution risks while taking account of value information from other bidders. For example, if bidders were not able to switch demand to different lots in light of other bidders’ decisions, they could end up paying a high price for some lots when substitute lots could have been purchased at a lower price.
- 9.17 Another benefit of a multi-round process, in the context of a combinatorial auction, is to offer scope for simplifying bidders’ choices during the auction. This is because a multi-round process allows bidders to identify the packages (combinations) of

spectrum that they are in practice likely to have a chance of winning, and hence to focus their valuation and bidding efforts on these packages (rather than having to value and bid for every package that might be of interest to them – which could be a very large number).

- 9.18 On the other hand, if common value uncertainty is low, there may be no need for a multiple round process. Single round processes offer potential advantages in terms of simplicity and speed.
- 9.19 We think that a multiple round ascending bid process is likely to be necessary to secure the optimal use of the spectrum because of the benefits described above that are relevant to the circumstances of the combined award (and outweigh any advantages of a single round process in this case).
- 9.20 The specific auction format we are proposing also includes a single round of bidding (supplementary bids round) after multiple rounds (primary bid rounds), i.e. once bidders have had an opportunity to learn from each other to reduce common value uncertainty. The purpose of this single round of sealed bids is to complement the bids made in the earlier rounds with bids for packages that bidders are interested in but did not choose to bid on in the earlier rounds. We discuss this further later in this section and in Annex 9.

Separate bids on individual lots or combinatorial (package) bidding

- 9.21 In auctions with multiple lots, bidders seeking combinations or packages of lots may face aggregation risks as, when bidding for complementary lots, those bidders may have to bid separately for each lot without certainty over whether, and at what price, they might win the complementary lots.
- 9.22 A partial solution to manage their aggregation risks would be to allow bidders flexibility to shift demand across lots in response to changes in prices. However, there is always a risk that, as demand for lots diminishes towards the end of an auction, bidders may become stranded with unwanted lots.
- 9.23 The most effective solution to this risk is to allow bidders to make “package bids” (or combinatorial bids), i.e. linked bids for multiple lots that are accepted or rejected in their entirety. The downside of allowing combinatorial bidding is that facilitating aggregation for larger bidders needs to be balanced against the risk that smaller bidders, who might want only individual lots or relatively few lots, may be unable to coordinate their demand adequately to displace such larger bidders.
- 9.24 Linked to this, there is also a risk that there is often an incentive for individual small bidders in any ad hoc group that is effectively bidding against a large bidder to bid untruthfully by “free riding” on the other members of the coalition (that is, to bid conservatively in the hope that the other members of the ad hoc coalition will pick up a larger share of the cost). In the extreme, this could result in all members of the ad hoc coalition collectively bidding less aggressively than a single, large bidder and, therefore, not winning the spectrum even when it would be efficient for them to do so.
- 9.25 This “free-rider” risk can be addressed by the use of a second price rule which encourages bidders to bid their full value and by a policy to release only sufficient information for bidders to understand the level of aggregate demand (i.e. not releasing full information on bids made).

- 9.26 Using combinatorial bidding is clearly preferable as far as bidders for larger packages are concerned. Even in the case of bidders for smaller packages, the risks that relate to the establishment of switching strategies to respond to changes are a potential source of inefficiency. In the context of combinatorial bidding with limited information release and a second-price rule, the potential risks relating to “free-riding” and inefficient bidding for coalitions of smaller bidders are largely reduced or even eliminated. In addition, any remaining risk is unlikely to be greater than in a setting with bids on individual lots (because of likely complexities and risks where smaller bidders need to respond to switching from larger bidders and the pricing rule associated with such processes).
- 9.27 We consider that combinatorial bidding is likely to play an essential part in managing some key risks to the efficiency of the auction outcome and to make it simple for bidders to express their preferences in response to price changes. We are therefore proposing to use combinatorial bidding.

Generic or specific lots

- 9.28 With generic lots, a bidder is offered the choice to bid on, for example, a lot of 2x10 MHz in the 2.6 GHz band, without knowing at that stage which exact frequencies it would receive if it won that lot; a subsequent process would turn generic lots into specific frequencies. With specific lots, the bidder would know from the outset that it was bidding on, for example, the frequencies 2510 to 2520 MHz paired with 2630 to 2640 MHz.
- 9.29 If some lots were perfect substitutes, i.e. they could be used in exactly the same ways and to the exact same effects, then a bidder should be unconcerned about which ones of these lots they win (provided that they get a contiguous assignment if that is important to them). In such a case, there would be no need to identify specific lots. If, to the contrary, some lots were not good substitutes, then it would be important for efficiency that bidders were able to say specifically which ones they want and were not faced with risks such as winning lots they did not want. For the combined award, we find that there are several groups of spectrum blocks that are sufficiently good substitutes that they can be treated generically, as discussed in section 8.
- 9.30 Where bidders are likely to be interested in packages of more than one lot and where contiguous spectrum is important, generic lots also provide a benefit for “packing” winners into the available spectrum. This is because the auctioneer can guarantee that most (if not all) bidders will receive contiguous frequencies. Maximising the scope for individual bidders to receive contiguous frequencies is consistent with optimal use of spectrum by reducing the number of restricted blocks that are needed between winners’ assignments; it is also consistent with interested parties’ preferences and requirements. We consider the issue of contiguity of assignments in more detail in section 8.
- 9.31 Using generic lots also simplifies the auction. This is because it effectively separates two questions: how much spectrum each bidder should win in each available category and which specific frequencies each winner should receive a licence for. Resolving these questions in turn rather than at the same time makes each stage simpler and less vulnerable to inefficiencies and risks of strategic behaviour.
- 9.32 Specific lots rather than generic lots enable bidders to express differences in their valuations of different lots where these are not perfect substitutes. In light of the circumstances of the available spectrum, we are proposing to reflect this through having several categories of lots in a given band, where proportionate, as described

in section 8. However, we do not consider that the potential benefit of going further by having specific lots would be large, especially when compared to the additional complexity and aggregation risks that the use of specific lots would introduce to the auction. If potential bidders were concerned about the use of a proposed number of categories of generic lots, then it is likely that adapting the nature and number of lot categories would address the underlying issue better than considering specific lots across all available spectrum. In addition, an assignment stage (which always has to follow the auction of generic lots) can be designed so as to provide an opportunity for bidders to express preferences across specific frequencies.

- 9.33 We are keen to use generic lots as much as possible in this case, to benefit from the strategic simplification that they bring to the auction and the much improved scope for contiguous assignment. The 2.6 GHz paired lots, which have similar technical properties, lend themselves particularly well to this approach. However, we also recognise that there are differences between the available lots in the 800 MHz band in particular, as noted in section 8. We are therefore proposing to use generic categories of lots wherever suitable, but to treat carefully the nature and extent of potential differences between lots to determine the exact number of generic categories in each band.

Clock prices or bidder nominated prices

- 9.34 Clock prices are prices that the auctioneer sets in each round for each lot category; bidders respond to this by selecting how many lots in each category they wish to buy at the clock prices. Bidder nominated prices are prices that bidders bid at their discretion (subject to prices being at least equal to those in the previous round and possibly subject to a limit) for each lot or category of lot while also selecting which lots they wish to buy.
- 9.35 A clock approach has a number of significant advantages compared to allowing bidders to nominate prices for lots or packages of lots, under the following circumstances.
- Package bidding is important to avoid aggregation risk because there are complementarities between lots.
 - Generic lots can be used to some extent in the auction because the value of all or a group of lots is expected to be similar.
- 9.36 In these conditions, a clock auction simplifies the bidder's task very significantly since bidders only need to express demand for their preferred package of lots in each round, rather than having to express different prices for a number of alternate packages in which they might be interested. Furthermore, it reduces complexity in the auction rules and algorithms compared to a standard Simultaneous Multiple Round Ascending auction (SMRA) because in an SMRA, the auctioneer needs to establish the identity of the (provisional) winning bids at the end of each round and the minimum prices for individual lots in the next round. Clock prices with package bidding also remove the complexity for bidders in deciding the level at which to set their price in light of the possibility of being the highest bidder for lots and winning too much (when they were simply trying to mitigate the risks associated with bidding on individual lots). These considerations are beneficial to all bidders but make the clock price approach particularly helpful for smaller bidders.
- 9.37 We think that using clock prices with package bidding and lots that are as generic as possible is the best option in light of our objectives.

Activity rule

- 9.38 During the open rounds (the primary bid rounds), a bidder can only bid on a package that has the same or less eligibility points associated with it as the bid it made in the previous round, not more. This rule is designed to encourage truthful bidding and help with efficient price discovery in the auction. It avoids scenarios such as one in which a bidder would bid for small amounts of spectrum for most of the open rounds and would increase the amount of spectrum it bids on much later in the auction.

Constraint on supplementary bids

- 9.39 In the context of our work in preparation for the award of the 2.6 GHz band previously, we carried out significant work to consider what rules for the relationship between primary bids (made in the first phase with open rounds) and supplementary bids (subsequent bids made in a single round sealed bid phase) would best promote efficiency and truthful bidding. Those rules are set out in the following documents published in 2008: Update on the cap on supplementary bids for the 2.6 GHz award,⁸² our proposals to introduce the relative cap⁸³ and some slides summarising these proposals.⁸⁴
- 9.40 That analysis is directly relevant to the present circumstances here and we are therefore proposing to use in the combined auction what we identified in those documents as the relative cap. This relative cap limits the amount of any supplementary bids by reference to bids made in the primary rounds when a bidder was last eligible to bid for the package of interest. (The application of the cap is slightly simpler as the issue of “split bids” for the 2.6 GHz band is not applicable to this award.)

First or second price rule

- 9.41 A first price rule is such that bidders pay the full amount of their bid. A second price rule requires bidders to pay an amount that is just sufficient to ensure that no other bidder or coalition of bidders was prepared to pay more than them.
- 9.42 The key advantage of a second price rule, as opposed to a first price rule, is that it encourages truthful bidding and so is likely to lead to a more efficient outcome. In particular, under a first price rule, there is an incentive for bidders to reduce the value of their bids to less than their full valuation in order to pay as close as possible to the minimum necessary to beat other bidders (bid shading). By doing so, they risk not winning at all when it would be efficient for them to do so.
- 9.43 The disadvantage of a second price rule is that bidders do not know until the end of the auction what they will pay and, at the end of the auction, it may not be immediately apparent why they pay what they do. However, a bidder can only be required to pay as much as its bid or less, never more, and in the open multiple rounds of the auction (i.e. the first part of the bidding process), the level that the clock prices reach will give bidders some feel for the potential outcome where lots are strongly contested.

⁸² Published in December 2008 at http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-awards/awards-in-preparation/2008/Update_on_the_cap_on_supple1.pdf

⁸³ Published in October 2008 at <http://stakeholders.ofcom.org.uk/binaries/consultations/relativecap/summary/main.pdf>

⁸⁴ Published in November 2008 at http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-awards/awards-in-preparation/2008/Proposed_relative_cap_on_ba1.pdf

- 9.44 Our proposal is to use a second price rule, because of the compelling benefits in respect of bid shading risks.
- 9.45 In Annex 10, we consider options for the exact specification of a second price rule for this award.

Complexity in the auction

- 9.46 The auction will include a large amount of spectrum with a number of different lot categories and measures to promote competition. The demand from potential bidders is also likely to cover a range of different combinations of lots with potentially large spreads in valuations. This effectively imposes a certain level of complexity on the auction.
- 9.47 We are proposing to use a combinatorial clock auction (CCA), i.e. an auction in which the auctioneer sets prices in open rounds, bidders bid in these open rounds for packages of lots (both generic and specific) which they can only win in their entirety and they have an opportunity to make additional bids (principally for packages they have not yet bid on) in a single subsequent sealed bid round. Overall, we consider that our auction design proposals strike an appropriate balance between our different objectives, such as letting bidders express the range of their valuations in full, reducing common value uncertainty and limiting the opportunities for strategic behaviour.
- 9.48 Another important aspect of the proposals is that they simplify many aspects of the auction compared to other standard formats for spectrum auctions. The main alternative format is the SMRA in which there is a provisional winner for each lot considered separately at the end of each round. This approach is not compatible with combinatorial bidding (where bidders are guaranteed to win a package only in its entirety) and therefore creates risks and complexity for bidders. There are options to try to remediate some weaknesses of the structure of SMRA auction with added rules. However, these additions bring problems of their own without necessarily solving the initial problems completely. An advantage of the CCA is that it starts from a different structure and avoids having to add rules to solve these initial problems.
- 9.49 Our proposed approach also includes some potentially complex aspects as explained above, in particular the winner determination and pricing rules. It may be relatively difficult for a bidder to anticipate with full accuracy which one of its bids is likely to be part of the winning combination and how much of its bid value it would then pay. However, bidders are guaranteed to pay no more than their bid and no more than the next highest bidder or coalition of bidders is prepared to pay. These provisions effectively reduce bidders' need to assess exact spectrum and price outcomes in order to make bidding decisions. We have also organised a workshop in the past to help interested parties explore potential options to develop bidding strategies, for example where a bidder has a budget constraint.⁸⁵ We plan to carry out a range of activities before the auction to help bidders understand the proposed auction format and rules, including seminars, software demonstrations and mock auctions. We also plan to make available a version of the winner determination and pricing software, so that interested parties can carry out their own experiments.

⁸⁵ See material prepared by DotEcon in the context of the stand-alone award of the 2.6 GHz band at http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-awards/awards-in-preparation/757738/516_Bidding_under_the_relat1.pdf.

- 9.50 We consider that the degree of complexity is proportionate to achieving our objectives set out above, and is no more complex than other alternative designs would need to be to meet our objectives.

Summary view on the proposed auction format

- 9.51 We think that a CCA is likely to be the most appropriate format for this auction, because it is most likely to meet our objectives given the key issues set out above. There is considerable support for this view from academic research into auction design, for the type of supply and demand environment relevant to this auction.
- 9.52 There are no alternative auction design formats that would, in our view, be likely to strike a better balance between our various objectives for the award. We see comparatively material advantages to a CCA over an SMRA format for this type of award, with potential downsides for example in terms of the richness of bids that participants could make or of the risk that bidders could win more or less spectrum than would be efficient or the creation of opportunities for strategic bidding.
- 9.53 We are confident that the efficiency risks and process risks of implementing such an auction are low for the following reasons.
- We have used the CCA format successfully in other auctions – L-Band and 10 to 40 GHz.⁸⁶ Other Member States, for example Denmark and Austria, have used the same auction format for their awards of the 2.6 GHz band in 2010. (The Netherlands had also decided to use this format for their 2.6 GHz award in 2010, although in the circumstances with specific caps on the amount of spectrum that bidders could win, there was no need for a bidding process.)
 - It is the auction format we originally proposed for the auction of 2.6 GHz in 2008, following a detailed consultation process and a number of seminars and mock auctions.
 - We have received extensive specialist advice from DotEcon to develop our proposals.
 - Professor Peter Cramton, a leading auction theory academic, provided detailed advice for the development of these proposals.
 - We have carried out a first series of tests of this specific CCA design and of a software implementation, including experimental testing, and we plan to complete further testing in advance of the auction.
- 9.54 We therefore think that, subject to consultation responses, the proposed design is likely to be best suited to our objectives for the award and to be a practical solution for the circumstances.

Question 9.1: Do you agree with our proposals for the auction design and why?

⁸⁶ Our website provides feedback from auction participants and independent reviews for both auctions at http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/completed-awards/award_1452/extrep/ and <http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/completed-awards/1040award/extrep/>.

Short description of the auction process for our preferred format – the combinatorial clock auction

- 9.55 A CCA process would proceed in five stages, as described below. Annex 9 provides a fuller description of the proposed rules. These rules assume, for the purpose of illustration only, that the approach taken in respect of concurrent low-power use is to allow that use to compete with high power use over one paired lot of 2x10 MHz.

Application Stage

- 9.56 Prospective bidders submit an application to participate in the award process, including an initial deposit.

Qualification Stage

- 9.57 We determine which applicants are qualified to bid. The determination is based on a check of the applications and initial deposits, and assessment of bidder groups (to check that they are “independent” of each other). We announce the number and identity of the qualified applicants. Those qualified applicants then have an opportunity to withdraw from the process by a date that we will specify. The remaining participants after the last day for withdrawal are bidders and are committed to accepting a licence at the reserve price, subject to the outcome of the auction. We announce the number and identity of the bidders. If there is only one bidder, the bidder will be entitled to select the frequency lots it wishes to purchase (subject to such restrictions as any spectrum caps) and the award will then progress directly to the Grant Stage. If there is more than one bidder, then a bidding process is required.

Principal Stage

- 9.58 The Principal Stage of the auction determines the identity of the winning bidders and the number of lots of each type that they will receive.
- 9.59 The available lots are described in Table 8.3 in section 8.
- 9.60 The Principal Stage is divided into two phases. The first phase is the **primary bid rounds** which follow a clock auction format. Bidders make a single bid in each round for a package of lots in response to a set of prices that we notify to them (one price per lot for each category of spectrum). The prices in the first round will be pre-specified in the auction regulations. The prices in the subsequent rounds will be determined by Ofcom, with prices increasing for those categories of lot where demand exceeds the available supply and prices remaining the same for those categories of lot where demand is no greater than the available supply.
- 9.61 In the 2.6 GHz band the round price per lot for each low-power lot will be $1/10^{\text{th}}$ of the price per lot for each high power lot, or if fewer than 10 bidders included a low-power lot in their bid in the previous round the price per lot will be the new price per lot for each high power lot divided by that number of bidders.
- 9.62 Bidders will not be permitted to submit a bid that would exceed the spectrum caps that we are proposing to use as a result of our competition analysis.
- 9.63 The primary bid rounds continue until there is no excess demand in any category. During the primary bid rounds, bidders may be required to top up their deposits in order to continue bidding in subsequent primary bid rounds.

- 9.64 The second phase is the **supplementary bids round**, which always follows the primary bid rounds. This is a single round sealed bid process, in which bidders have the opportunity to make multiple, mutually exclusive bids for packages of lots, subject to constraints created by their primary round bids. At the same time, bidders must top up their deposits, for example such that they have on deposit a specified proportion of their highest bid made across both the primary bid rounds and the supplementary bids round.
- 9.65 The same restrictions as in the primary bid rounds apply on bids in respect of spectrum caps.
- 9.66 We then identify the highest value combination of bids that can be accommodated subject to conforming to the competition constraints placed on the outcome as described in Annexes 6 and 9, and subject to having either 7 lots in category C1 and none in category D, or 6 lots in category C1 and up to 10 lots in category D, drawing on all valid bids from the primary and supplementary bids rounds taking at most one bid from each bidder. This determines the number of lots in each category that each bidder will win and whether there is any concurrent low-power use. A 'base price' for each winning bid is also calculated according to a second price rule. The outcome determines the allocation of generic lots (800 MHz paired; 2.6 GHz paired) and specific lots (potential Everything Everywhere divestment at 1800 MHz; potential 2.6 GHz paired lot for concurrent low-power use; 2.6 GHz unpaired lot) to each bidder. Given restrictions on contiguity, this may also identify the assignment of specific frequencies to bidders for some generic lots in the 800 MHz band.
- 9.67 Winning bidders may need to top-up their deposit to match the base price of their winning bid.

Assignment Stage

- 9.68 The Assignment Stage determines how the available frequencies are distributed amongst the winning bidders from the Principal Stage for those lots that are not frequency specific in the Principal Stage outcome. This will involve at least some of the 2.6 GHz paired lots and may involve paired lots in other bands subject to the effect of contiguity requirements. Bidders participate in a sealed bid auction for each band in which generic paired lots need to be matched to specific frequencies. Bidders can make 'assignment round bids' for particular ranges of frequencies compatible with the number and category of lots that they won in the Principal Stage.
- 9.69 We then identify the highest value combination of bids that can be accommodated separately for each band, subject to all paired lots being awarded in accordance with contiguity requirements. A final price for each bidder is also calculated, which combines the base price and any additional prices arising from the Assignment Stage. Assignment Stage prices, which are additional to base prices, are calculated using a second price rule.

Grant Stage

- 9.70 After the conclusion of the Assignment Stage, the award progresses to the Grant Stage, in which winning bidders need to make any outstanding payment to cover their licence fee, licences are granted and the auction results are published.

Specific policy choices for the auction rules

Measures to promote competition - outcome restrictions vs. caps

- 9.71 In section 5 and Annex 6, we consider how best to promote competition and set out our proposal that restrictions on the outcome of the auction are preferable to using spectrum caps on their own. In this section, we consider which form the outcome restrictions might take and their implications for the auction design.
- 9.72 There are three main options to implement outcome restrictions.
- The first option is a “hard” constraint, i.e. a strict requirement that, as a result of the auction, at least four competitors hold sufficient amounts of spectrum sub-1 GHz and overall. This has the advantage of being a simple implementation of the policy and it does not require much adjustment to the rules. However, it presents a significant issue. It would provide a clear opportunity for parties that do not already meet the spectrum floors at the start of the auction to leverage the requirement that they win spectrum to secure a larger amount of spectrum at a potentially low price. Bidders that are effectively essential to meeting the requirement would be able to bid only for quantities that are greater than would otherwise be efficient, in the knowledge that one of their bids needs to be included in the winning outcome to meet the constraint. This would create significant risks to the efficiency of the outcome.
 - The second option is a “soft” constraint, i.e. an amount of loss in value that we would accept in order to achieve our competition objectives. In this case, if C_1 was the combination of bids with the highest value V_1 but it did not meet the competition constraint, then a combination of bids C_2 with a lower value V_2 would win if it met two conditions: i) that C_2 was the highest value combination that met the competition constraint and ii) that $V_2 \geq V_1 + VR$, where VR is the amount of reduction in value we would be prepared to accept. The implementation of this option is slightly more complex than the hard constraint, but it remains relatively simple. It also addresses to an extent the leveraging issue which is particularly problematic with the hard constraint. However, it still provides some opportunity for strategic bidding for bidders that may be essential to meet the competition constraint, within the bounds of the pre-identified value reduction, and at the same time would give other bidders the opportunity to undermine the achievement of our competition objectives. A further difficulty with this approach is the selection of an amount of value loss that we would accept. This would be a particularly subjective process and would carry a large risk of regulatory failure. For example, an amount that would be likely to minimise the risk of leveraging strategy would also be likely to be low and thereby risk failing to implement our competition proposals properly.
 - The third option is to reserve spectrum for those bidders that do not already hold a minimum portfolio of spectrum to be a credible national wholesaler and elect to compete to win enough spectrum to hold such a minimum spectrum portfolio, on condition that they make a reserve price bid for each and every package of spectrum that would be just sufficient for them to hold one of the minimum spectrum portfolios. The reservation would be such that enough of those bidders who elected to compete to hold a minimum spectrum portfolio would be certain to win, such that at least four licensees would hold at least a minimum spectrum portfolio after the auction (unless insufficient bidders elected to compete for a minimum spectrum portfolio, in which case all that did so elect would be certain to

win). Those bidders that were eligible and elected to compete to hold a minimum spectrum portfolio would compete against each other for the reserved spectrum (to the extent that there were more such bidders than the reservation could accommodate), and with all other bidders for any additional spectrum over and above the reserved spectrum. Those bidders that already hold a minimum spectrum portfolio and those who do not elect to compete to hold a minimum spectrum portfolio would compete for the spectrum that was not reserved. Requiring reserve price bids from those who wish to compete to benefit from the spectrum reservation addresses the risk that bidders may leverage the competition constraint to win additional spectrum cheaply. Annex 9 provides more information on this approach.

- 9.73 We think that the third option, where we reserve spectrum in order to satisfy the competition constraint, is the most appropriate to implement outcome restrictions efficiently. This is principally because of the size of the risks to the outcome of the auction under the alternative options. In comparison, the potential downsides of this proposed approach seem limited. They relate to auction complexity and the potential for bidder errors when they exercising their choice about bidding for reserved spectrum. However, we consider that the complexity of this option is relatively modest and that, with appropriate preparation, bidders are likely to be able to make efficient choices in light of their circumstances. There is also risk of regulatory failure, which relates to the risk that we do not identify the right minimum spectrum portfolios. This is a function of the pro-competition measure per se, rather than any specific implementation, and we therefore consider this risk in our competition assessment at Annex 6.

Determining the winners' prices

- 9.74 We are proposing to use the same principles as for previous auctions to determine the prices (licence fees) that winning bidders will pay. The first key principle here is that winners pay a sufficient amount (both individually and collectively) so that losers cannot argue, on the basis of the bids they made, that they were willing to pay more (both individually or collectively). This will typically define a space of potential prices and we need additional rules to identify a unique set of prices (one for each winning bidder). The second key principle is that the winning bidders should pay the minimum amount necessary (in total) to comply with the first condition. Again, this may not necessarily generate a single set of prices, so additional conditions may be necessary.
- 9.75 The approach we have used in the past to identify unique prices is to use a reference point, and then select those prices that are closest to this reference point. The reference point we have used in the past is the set of Vickrey prices, i.e. the unique set of prices that are the opportunity cost that each individual winning bidder imposes on others by virtue of winning. We refer to this approach as the Vickrey-nearest rule.
- 9.76 This pricing approach is a potential option for this award.
- 9.77 There are however reasons to consider alternative options. The first reason is that recent academic literature has highlighted that, in certain cases, there may be incentives on bidders to reduce their bids and influence resulting prices when using this rule. We think that these concerns are relatively unlikely to materialise in practice in this auction, but never the less this could be a concern.
- 9.78 The second reason is the requirement in the Direction to revise the level of annual licence fees that apply to 900 MHz and 1800 MHz licences so that they reflect full

market value, and to do so by having particular regard to the sums bid for licences in this auction. As discussed in section 10 and Annex 11, we believe this requirement pushes us towards the estimation of an average price per lot for each category of spectrum available in the auction. The Vickrey-nearest rule provides us with no information in this regard, as it identifies prices that are specific to packages, not to categories of spectrum.

- 9.79 We have therefore developed an alternative rule, which replaces Vickrey prices as the reference point for the identification of unique prices as set out in paragraph 9.42, by a particular set of linear lot prices. This alternative rule involves identifying linear lot prices which are closest to market clearing prices for the winning outcome (and if there is more than one such set of linear lot prices, to select those that are closest to the reserve prices in relative terms). These linear lot prices can then also be used as estimates of the value of different categories of spectrum as revealed by the auction, as an input to the required revision of annual licence fees for 900 MHz and 1800 MHz spectrum.
- 9.80 This approach has other benefits, in addition to providing a basis for annual licence fee calculations consistent with the Direction. In particular, it ensures that winners of spectrum in particular categories will be more likely to pay the same price per lot for that spectrum than might be the case under the Vickrey-nearest rule.
- 9.81 We are keen to receive comments from stakeholders on the relative merits of these alternative approaches.
- 9.82 Annex 10 sets out these proposals in more detail.

Information policy in the auction

- 9.83 There are several points during the award process at which we have a choice about what information to share with bidders and/or publish about the auction. These are:
- a) at the time of application, so that applicants and stakeholders at large can consider whether there are overlaps between applicant groups;
 - b) at the time of qualification, to confirm which applicants become bidders;
 - c) during the primary bid rounds, so that bidders can learn from each other and reduce common value uncertainty and so that interested stakeholders can follow developments in the auction;
 - d) at the end of the Principal Stage, to announce winners, amounts of spectrum won and base prices;
 - e) at the end of the Assignment Stage, to announce specific frequencies won and final licence fees (including assignment stage prices) and to make available all bids made in the auction.
- 9.84 We considered the question of information release in detail in relation to the 2.6 GHz award.⁸⁷ We believe that that analysis is relevant here as well, with the key issue being to strike a balance between reduction in common value uncertainties (which suggests providing more information on bids during the open rounds) and

⁸⁷ See section 7 of our April 2008 statement at <http://stakeholders.ofcom.org.uk/consultations/2ghzrules/statement/>.

opportunities for strategic behaviours such as signalling or retaliation (which suggests providing less information on bids during the open rounds).

- 9.85 We remain of the view that the options to reveal more information than aggregate demand per category of lot (e.g. anonymised bids) would create risks of strategic behaviour, including potential entry deterrence, that are likely to outweigh potential advantages. We are therefore proposing to release to bidders aggregated bid information only. We may publish some or all of this information on our website during the auction, for example at the end of each day of bidding in the primary rounds.
- 9.86 We also consider that it is important for the purpose of avoiding overlaps between bidder groups to publish the names of the applicants ahead of qualification. However, we do not think that we need to publish details of the bidder groups of each applicant and that making that information available to other applicants is sufficient to allow them to check for potential overlaps of bidder groups. Having published applicants' names, there would be no reason to delay publication of the qualified bidders' names.
- 9.87 We plan to publish information about winners, spectrum won and prices at the end of the Principal Stage and at the end of the Assignment Stage.
- 9.88 We also plan to publish at the end of the auction, all bids made in the auction. This is both for transparency purposes and to allow all interested parties to carry out their own verification of the results. In the context of our consultation on the 2.6 GHz award, a respondent was of the view that publication of all bids might put bidders seeking to participate in other auctions in Europe at a disadvantage by revealing their UK valuations. We remain of the view that it is preferable to be as transparent as possible and to publish all bids shortly after the conclusion of the auction. Some factors mitigate the risks to bidders who may participate in other auctions for the same spectrum internationally, such as the difficulty for observers in establishing which aspects of valuations and bidding strategies are country-specific.

Bidder association policy and other requirements of the award process

- 9.89 For past auctions, we used our standard process for dealing with the risk of distortion of the auction from potential flow of confidential information between bidders, e.g. as a result of overlaps in shareholdings between companies. A simple summary of this standard process is as follows. To consider the exact process used in previous awards, as well as other aspects such as requirements for applications or deposits, interested parties should review the Statutory Instruments setting out the auction rules for these awards.⁸⁸

- a) To prevent the flow of confidential information between separate applicants or bidders, applicants and bidders are required to identify their "bidder group", i.e. those organisations or persons that have a material interest in them (by way of shareholding or rights to determine the conduct of their business) or to whom they have disclosed confidential information. We can then assess whether

⁸⁸ See for example statutory instrument 2008 No. 686 used for the L-band auction, "The Wireless Telegraphy (Licence Award) Regulations 2008" available at <http://www.legislation.gov.uk/uksi/2008/686/contents/made>. The corresponding Information Memorandum may also be helpful to the consideration of the issues. It is available at http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/completed-awards/award_1452/keydocs/1452im/.

confidential information may have been passed between groups and investigate what the nature of that information may be. A provider of finance may be in receipt of confidential information from several applicants or bidders. However, we would consider any transmission of such confidential information by a provider of finance to another group to be against the requirements relevant to qualification to become a bidder (including the scope for distortion of the award process) and activity rules designed to prevent coordinated behaviour.

- b) For bidder groups, one of the tests used to determine whether an organisation or person has a material interest in an applicant or bidder is whether that organisation or person has any interest in shares carrying more than 25% of the votes entitled to be cast at a general meeting of the applicant or bidder.
- c) There should be no overlap between bidder groups of the applicants and, if there are overlaps at the time of application, then there is a period between application and a deadline by which any changes in bidder groups must have taken place. We use our determination on qualification to address any remaining overlaps.

9.90 In the context of the stand-alone 2.6 GHz award, we received representations from a stakeholder to adapt these rules to the circumstances of that award. This had the effect of making the rules more complex, in order to account for “passive shareholders”. Under these modifications, it was possible for shareholders with shares carrying more than 25% of general meeting votes, but not more than 50% (and not able to appoint or remove a majority of the board of directors), and who are not in receipt of confidential information, to be part of more than one bidder group.

9.91 For the purposes of this auction, we are not aware of any reason to follow such a more complex approach.

9.92 We would welcome stakeholders’ comments on the suitability of this standard approach for the combined award.

Deposits and licence fees

9.93 We plan to require bidders to provide deposits and to top these up in a way that is commensurate to their bid amounts during the auction. This is to protect Ofcom against credit risk and to protect the efficiency of the auction against invalid bids and unsold spectrum. We therefore plan to use material deposits, sufficient to deter default. We would also seek to minimise costs on bidders, given the possibility that they might not win, to promote participation in the auction.

9.94 We would therefore welcome views on what deposit levels might be sensible during the Principal Stage. A helpful starting point for consideration is the approach we developed for the stand-alone 2.6 GHz award, which we can summarise as follows.

- a) Application deposit of £100,000.
- b) Initial auction deposit equal to the reserve price for the desired eligibility. For this award, the amount may depend on whether a bidder is eligible to win “reserved” spectrum as discussed in section 8 in relation to reserve prices.
- c) Primary rounds deposit to be topped up at regular intervals such that bidders have on deposit a specified proportion (not required to be greater than 50%) of their highest bid.

d) Deposit to be topped up in supplementary bids round such that bidders have on deposit a specified proportion (not required to be greater than 50%) of their highest bid across the primary rounds and supplementary bids round.

9.95 We also plan to consider the practicalities of licence fee payments, as these fees might reach potentially large amounts. There may be benefits to staging payments of licence fees over a few days or weeks following the completion of the Principal Stage, in order to manage the sums involved.

Question 9.2: Do you have any comments on the proposed auction rules as explained in section 9, Annex 9 and Annex 10?

Question 9.3: Do you have any comments on how we should approach the payment of deposits and licence fees?

Next steps

9.96 We plan to engage with stakeholders to facilitate a productive consultation dialogue on these proposals, as discussed in section 11. We also plan to provide interested parties with opportunities to experience the auction software and take part in mock auctions ahead of the publication of the policy statement and Information Memorandum for this award.

9.97 We would be interested more generally in hearing from interested parties regarding what we might do to assist them in their consideration of auction design issues.

Section 10

Revising annual licence fees for 900 MHz and 1800 MHz proposals

10.1 The Direction requires Ofcom, after the completion of the auction, to revise the annual licence fees paid for 900 MHz and 1800 MHz spectrum. This section sets out our initial proposals for how we intend to do this. Annex 12 contains further details.

The Direction's requirements

10.2 Article 6 (1) and (2) of the Direction sets out respectively the following requirements.

After completion of the auction Ofcom must revise the sums prescribed by regulations under section 12 of the Wireless Telegraphy Act for 900 MHz and 1800 MHz licences so that they reflect the full market value of the frequencies in those bands.

In revising the sums prescribed Ofcom must have particular regard to the sums bid for licences in the auction.

High level approach

- 10.3 We consider that full market value is the price that would arise in a well functioning spectrum market. This would be the market clearing price when supply equals demand.
- 10.4 We interpret the term “full market value” to mean that we do not discount our estimate of the price that would occur in a well functioning market, nor do we set it conservatively compared with the available market information.
- 10.5 We have identified a number of different sources of information that could be used to determine the full market value of the 900 MHz and 1800 MHz spectrum. These are:
- a) bids made and licence fees paid in the auction for 800 MHz and 2.6 GHz spectrum;
 - b) licence fees paid in auctions in other countries for the same or similar spectrum;
 - c) estimates derived from technical and cost modelling; and
 - d) information derived from spectrum trades for 900 MHz and 1800 MHz spectrum in the UK or potentially in other countries.
- 10.6 We have considered the strengths and weakness of each of these sources of information. Annex 11 sets out our detailed consideration of each of them. Our provisional conclusion is that the use of the amounts bid and licence fees paid in the auction are likely to provide the most reliable basis on which we can determine the full market value of 900 MHz and 1800 MHz spectrum. This is because, we consider that in the specific circumstances of this award there are significant difficulties in using estimates from technical and cost modelling or from spectrum trades. Moreover, if the auction is sufficiently competitive, the licence fees paid are likely to

reflect the prices that would emerge in a well functioning market. Therefore, provided the spectrum auctioned is reasonably comparable to 900 MHz and 1800 MHz spectrum then we believe that using information derived from the auction is likely to be more reliable than other ways for estimating the full market value. If for some reason we judged that the auction information revealed by the auction was not reliable then we expect that it is likely that we would rely on information from auctions for similar or the same spectrum in other countries as the next best alternative.

- 10.7 We recognise that this provisional conclusion will have to be reviewed after the auction when we will be able to judge properly whether the information revealed by the auction does indeed provide the most reliable basis for revising annual licence fees. We will consult again on this question after the auction but believe that it is likely to be helpful for stakeholders to understand in advance of the auction our possible approach and therefore have included a discussion in this consultation.
- 10.8 In the rest of this section we explain our proposed approach to revising annual licence fees on the assumption that we base those fees on information extracted from the auction.

Implementation

- 10.9 We propose to implement the above high level approach in three key steps as set out below.
- a) First we propose to derive average (linear) price information for each lot category in the auction using the methodology described in Annex 11.
 - b) Second we will consider how best to use this information, and whether any adjustments are necessary, for example to reflect differences between spectrum bands, to estimate the market value of 900 MHz and 1800 MHz spectrum.
 - c) Third we will convert the lump sum information we have derived from the auction into annual licence fees.

Deriving average price information from the auction

- 10.10 We propose to use the methodology set out in Annex 11 to derive average price information for each lot category in the auction. This will provide a useful set of information which we can use to estimate the full market value of 900 MHz and 1800 MHz spectrum.

Relating the price information derived from the auction to 900 MHz and 1800 MHz spectrum

- 10.11 As explained in section 5 we do not propose to allow relinquishment of 900 MHz and 1800 MHz spectrum in the auction. This would mean that price information derived from the auction will be for 800 MHz and 2.6 GHz spectrum and therefore we need to consider how this information can be used to estimate the full market value of 900 MHz and 1800 MHz spectrum. It should be noted that it is possible, as explained in section 8 that the 1800 MHz spectrum which Everything Everywhere has committed to divest may be sold through the auction and if this did occur then we would have specific price information for 1800 MHz. However, as this is not within our control we do not consider that possibility further at this stage.

900 MHz spectrum

- 10.12 As explained in section 8 we expect there to be a number of different lot categories within the 800 MHz band. Table 8.3 in section 8 provides an illustration of the likely categories based on our understanding of the position at present. There are four categories listed in that table. We will derive an average price per MHz for each of these categories as explained above. The question is therefore how best to use this information to estimate the full market value of 900 MHz spectrum.
- 10.13 Our understanding of the technical characteristics of 800 MHz and 900 MHz spectrum suggests that they may be regarded as highly comparable. Nonetheless we recognize that licences in these bands may differ, for example because of specific technical licence conditions necessary to avoid interference and additional licence conditions such as a coverage obligation. We have proposed in section 8 that only three of the categories of 800 MHz lot would count towards the minimum spectrum portfolios for the purposes of the competition constraint, recognising the possible limitations on the lots in the other category to reduce interference into adjacent DTT use. We suggest that the same three categories be used to estimate the full market value of 900 MHz spectrum. We propose to average the price per MHz across these three categories to produce a single price per MHz that we will then use as our estimate of the full market value of 900 MHz spectrum.

Question 10.1: Do you have any comments on our proposal to use 800 MHz price information as derived from the auction to estimate the full market value of 900 MHz spectrum?

1800 MHz spectrum

- 10.14 The position regarding 1800 MHz spectrum is more difficult in our view than 900 MHz spectrum. This is because neither 800 MHz nor 2.6 GHz spectrum is as close a substitute for 1800 MHz spectrum as 800 MHz spectrum is to 900 MHz spectrum.
- 10.15 Our technical analysis (see Annex 8 for details) suggests that 1800 MHz spectrum may have advantages over 2.6 GHz spectrum in terms of the quality and coverage of the services that can be offered. This may be the case even when the 1800 MHz and 2.6 GHz frequencies are used in combination with sub-1 GHz spectrum. Our analysis also suggests that 800 MHz spectrum has significant advantages over 1800 MHz spectrum. Given our understanding of the technical work, we consider that prices for 2.6 GHz spectrum are likely to understate the value of 1800 MHz whereas 800 MHz would overstate the value.
- 10.16 We have identified five possible approaches:
- a) use 2.6 GHz price information derived from the auction without adjustment;
 - b) use 800 MHz price information derived from the auction without adjustment;
 - c) use 2.6 GHz price information derived from the auction with an uplift;
 - d) use 800 MHz price information derived from the auction with a discount;
 - e) use an average of 800 MHz and 2.6 GHz price information derived from the auction

- 10.17 Under the options c) and d) the challenge is to find a reliable basis for determining the uplift or discount. We could base the adjustment on some relatively basic estimate derived from technical modelling of the differences between the frequency bands or possibly using information on the differences between prices paid between the two bands in auctions in other countries. However we have some concerns about the reliability of doing this due to the difficulty first in accurately estimating the difference in technical capability and second and more importantly interpreting these in terms of differences in monetary value. The relative difference in prices paid in other auctions might provide a simpler basis for adjusting values, but there is only one source of information we are aware of⁸⁹ and it is hard to know how accurately that information might reflect the difference between the bands in the UK.
- 10.18 Option e) seems to us to be the best approach in the circumstances. This reflects our understanding of the technical characteristics of the bands which suggests that 1800 MHz lies between 800 MHz and 2.6 GHz and it avoids the risks of regulatory failure associated with deriving adjustment values which could be considerable. We propose to estimate the full market value of 1800 MHz as follows:
- calculate average price per MHz for lots in the 2.6 GHz FDD for high power use category (category C1 in our packaging proposals in section 8);
 - calculate the average price per MHz for 800 MHz lots as explained above;
 - then calculate a simple average of those two prices to give an average per MHz price that would be our estimate of the full market value of 1800 MHz.

Question 10.2: Do you have any comments on our proposal to use an average of 800 MHz and 2.6 GHz price information as derived from the auction to estimate the full market value of 1800 MHz spectrum?

Converting upfront payments to annual payments

- 10.19 The third step is to convert the upfront price information we have extracted from the auction into annual payments.⁹⁰
- 10.20 We propose to calculate the annual licence fees as an annuity whose present value is equivalent to the lump sum amount derived from the auction. The period over which we propose to spread the amount derived from the auction will be the initial term of the licence from which the full market value was derived (see section 7, paragraphs 7.21ff for details). The interest rate that we propose to use to convert the lump sum amounts into annual payments is the real pre tax cost of capital as defined in the most recent Mobile Call Termination analysis at the time we determine the annual licence fees (see Annex 12 paragraphs 11.30 to 11.42 for details of why that rate is proposed). We propose to set the fees as constant real fees until their revision since, in the absence of specific information on the profile of the value of spectrum over time, assuming a constant real profile appears to be a reasonable approach.

⁸⁹ 1800 MHz and 2.6 GHz spectrum were both sold in the recent German auction. We understand that there is consideration of auction proposals in the case of Ireland, Spain and Switzerland where this could also arise.

⁹⁰ We note that also some other sources of information, as international data, may be expressed as lump sums amounts and therefore require the same operation of converting the lump sum amount into annual payments.

- 10.21 We expect that revised annual licence fee level will start when the relevant Fees regulations come into force.

Question 10.3: Do you have any comments on the proposed approach to convert lump sum amounts into annual payment?

Subsequent changes to annual licence fees (ALF)

- 10.22 We propose that once we have revised the ALF for 900 MHz and 1800 MHz spectrum, we would only be likely to conduct revisions in the case of clear evidence of significant changes in long term circumstances that suggested that the value of this spectrum had varied materially and we were able to define a more reliable estimate.
- 10.23 In particular, we do not plan to use information from any trades of the spectrum in question or similar spectrum. This is principally because using information from trades to change ALF may distort trade incentives.

Next steps

- 10.24 Our proposal is to review the overall approach for the implementation of article 6(1) and 6(2) of the Direction in light of responses to this consultation and set out our views on these matters in our statement ahead of the combined award.
- 10.25 Soon after the end of the auction, we expect to conduct a review of the auction to determine whether an approach based on using the data derived from the auction is appropriate for the purpose of setting annual licence fees. Our position will be then be set out in a further consultation document which we will follow with a statement and the necessary regulations.

Section 11

Next steps

Analysis of responses

- 11.1 We will analyse all responses received by the closing date for this consultation of 31 May 2011 and, in finalising the award process, consider them against our statutory duties.

Stakeholder events

- 11.2 We plan to hold one or more seminars during the consultation period to present our proposals and receive early feedback from stakeholders.

Further consultations

- 11.3 We are also planning to publish one or more consultations in the next few months relating to:
- detailed proposals relating to the technical issues regarding the coexistence of future mobile services with the adjacent DTT use; and
 - proposals for the technical conditions for use of the 800 MHz and 2.6 GHz bands, including a review of adjacency conditions, (and covering technical conditions for lots at 900 MHz and 1800 MHz in case of relinquishment).

Publication of statement, information memorandum and draft auction regulations

- 11.4 Following the consultations, and subject to stakeholders' comments, we plan to issue a statement in the autumn setting out our conclusions which will be given effect to by regulations.
- 11.5 Alongside this statement we plan to publish an information memorandum for the award. This will be designed to give bidders as much information as necessary for them to decide whether to enter the auction and how they would prepare for participation. It may be modified or complemented by the publication of updates and answers to specific questions.
- 11.6 At the same time we plan to publish draft auction regulations for consultation. These regulations will give effect to our conclusions and provide the legal basis for the auction and contain detailed and comprehensive rules and procedures for its running. The regulations are made by means of a statutory instrument. They must be published in draft with a minimum of one month allowed for comments. When all comments have been considered and necessary amendments made the regulations are made in final form; they come into force approximately one month after being made.
- 11.7 According to our provisional timetable, the final version of the regulations would be made to allow the auction process to begin, with the submission of applications, in the first quarter of 2012.

Other regulations and documents for publication

11.8 As part of the preparations for the award and before prospective bidders are invited to consider participating in the award process, we will publish new regulatory documents and amend existing regulations to incorporate the conclusions of this consultation where appropriate. This will include:

- amending the spectrum trading regulations (Statutory Instrument 2004 No. 3154) before the award process to cover the 800 MHz and 2.6 GHz bands;
- publishing an interface requirements for the bands before the award process to reflect the technical conditions to be adopted for the licences;
- amending the order limiting the number of licences for certain categories (Statutory Instrument 2003 No. 1902) at the next relevant regular update;
- amending the UK Frequency Allocation Table at the next relevant regular update and UK Frequency Allocation Plan after the award to include the new assignments for the bands.