making communications work for everyone

Award of the 2.3 and 3.4 GHz spectrum bands

Competition issues and auction regulations

Consultation

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About this document

This document sets out proposals on competition issues for the forthcoming auction of spectrum in the 2.3 and 3.4 GHz bands.

The 2.3 and 3.4 GHz spectrum is needed to provide additional capacity to meet growing consumer demand for mobile broadband. It is important that the frequencies are made available as quickly as possible for the benefit of consumers and industry.

We have already consulted on other aspects of this award and the matters discussed in this document therefore represent the last issues on which we need to conclude before the auction can proceed.

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Section 1

Executive summary

1.1 It is Ofcom's aim to ensure that everyone in the UK can enjoy the benefits of fast and reliable mobile broadband. The radio spectrum we manage is fundamental to achieving that aim.

1.2 This consultation sets out proposals on competition issues for the forthcoming auction of spectrum in the 2.3 and 3.4 GHz bands. A total of 190 MHz of spectrum in those bands has been released to Ofcom by the Ministry of Defence as part of the Government's Public Sector Spectrum Release (PSSR) programme.

1.3 Our approach to this auction is driven by two policy objectives. Firstly, we want to make this spectrum available in a timely fashion, in order to meet consumer demand for mobile broadband services with higher speeds and greater capacity. Secondly, we want to ensure that consumers and businesses continue to benefit from a competitive market in the provision of mobile services.

1.4 We see these specific policy objectives as the means by which we fulfil our principal duty to further the interests of citizens in relation to communications matters; and to further the interests of consumers in relevant markets, where appropriate by promoting competition. It also fulfils our duty to secure the optimal use of spectrum.

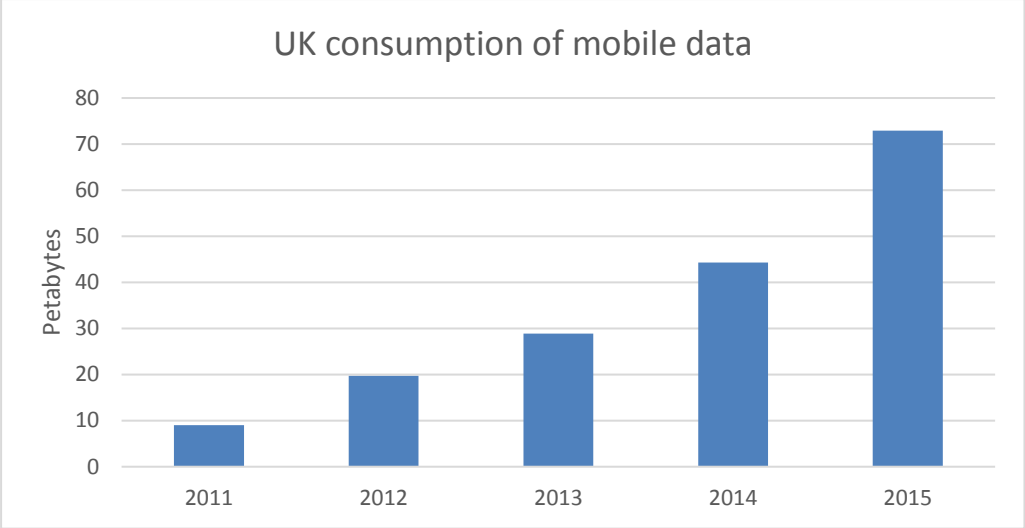
1.5 We have considered whether we should also use this auction to further a third important policy objective, which is to improve the availability of mobile services in the UK (e.g. in rural areas and other 'not spots'). We might try to do this by attaching coverage obligations to the spectrum we are auctioning.

1.6 However, the technical characteristics of the 2.3 and 3.4 GHz spectrum mean that it is suited to adding capacity, but is not an effective means of extending existing levels of mobile coverage. We do not therefore intend it to be used for this purpose. We will return to the question of mobile coverage obligations in future awards - in particular the award of 700 MHz spectrum band, which we expect to conduct in 2018/19.

Meeting the demand for mobile data

1.7 Over the last few years we have seen substantial growth in the amount of data carried over UK mobile networks, from 9 Petabytes in 2011 to 73 Petabytes in 2015[1]. This represents a cumulative annual growth rate of around 70% (as illustrated below).

[1] Ref Connected Nations 2015. 1 Petabyte equals 1 million Gigabytes.



1.8 This growth has been driven by a greater availability of mobile services offering a wider range of content - and an associated growth in the take-up of mobile devices which can be used to access this content. 71% of UK adults now own a smartphone, and 59% of UK households report having at least one tablet computer. [2]

1.9 We expect this growth to continue. Although projections of future growth are uncertain, there is a broad consensus that mobile data consumption will increase by 1-2 orders of magnitude over the next decade.

1.10 There are three main ways in which mobile operators can meet this increased demand; they can increase the amount of spectrum which they use to provide mobile services; they can increase the efficiency with which they use existing spectrum; or they can increase the number of sites from which they provide mobile services. Our view is that they will need to do all three in order to meet increasing demand.

1.11 Although making more spectrum available is not the only means of supporting growth in mobile data, it is of fundamental importance and is a mechanism under the direct control of Ofcom. In that context, the spectrum we are making available in this auction is particularly important. It will increase the total amount of spectrum available to mobile operators by 190 MHz, from 647 MHz to 837 MHz – an increase of 29% in the total mobile spectrum available.

1.12 However, it is important to note that the 2.3 and 3.4 GHz spectrum bands are different, and are likely to be important for increasing mobile capacity at different points in time:

- The auction will make available 40MHz of spectrum in the **2.3 GHz band**. This spectrum can be used immediately, since it is already supported by mainstream mobile devices such as the Apple iPhone;

- The auction will make available 150 MHz of spectrum in the **3.4 GHz band**. This band is *not* currently supported by most devices, but is likely to become useful in around two or three years. Additionally, the 3.4 GHz band is being seen as one of the bands likely to support the initial deployment of 5G mobile services. For example, the European Radio Spectrum Policy Group recently set out its view

[2] Communications Market Review 2016
https://www.ofcom.org.uk/__data/assets/pdf_file/0024/26826/cmr_uk_2016.pdf

that this is likely to be the primary band suitable for the introduction of 5G services across Europe, potentially before 2020.

A competitive mobile market for consumers and businesses

1.13 The UK mobile market is currently working well for consumers and businesses, with strong competition between mobile network operators (MNOs). The UK enjoys relatively low prices, whilst at the same time seeing significant levels of investment in new products and services.

1.14 There are currently four MNOs serving the market – BT/EE, H3G (operating as Three), O2 (owned by Telefonica) and Vodafone. These are supplemented by a number of Mobile Virtual Network Operators (MVNOs) which each have access to an MNO's network through a commercial agreement, and offer their own mix of services.

1.15 We set out in our Strategic Review of Digital Communications the importance that we continue to attach to real competition between four national network providers. We noted in particular that this competition is the best means of driving investment in new products and services, including those based on 5G technologies.

1.16 However, there is a risk that the current level of competition will reduce as consumer demand for mobile services increases. This is because there is an asymmetry in the amount of spectrum held by different operators. It means that some operators may be better placed to respond to increased demand than others. Of the total amount of mobile spectrum that is currently useable, BT/EE holds 45%; Vodafone holds 28%; O2 holds 15%; and H3G holds 12%.

1.17 We have considered competition issues related to our current spectrum award in a number of previous documents, including earlier consultations. However, it is important for us to now reassess those issues in light of recent market developments.

1.18 Of particular relevance are the decisions of the Competition and Markets Authority (CMA) in January 2016 to approve the acquisition of EE by BT, which has increased the total amount of spectrum held by the largest operator (the combined BT/EE entity); and the decision of the European Commission (EC) in May 2016 to block the proposed acquisition of O2 by H3G's parent company CK Hutchison.

1.19 We have considered potential competition concerns from two perspectives:

- Firstly, we have considered whether the outcome of this auction might result in any of the existing operators no longer being credible as a national supplier of mobile services. This was the primary competition concern which governed the design of our 2013 4G auction. However, for this award we believe it to be a less important consideration. We consider it unlikely that any of the four MNOs would cease to be credible in the next few years even if they did not obtain any spectrum in this award. Additionally, there will be more spectrum available for mobile services in future, including at 700 MHz and proposed at 3.6-3.8 GHz.

- Secondly, we have considered whether competition amongst the four national operators might be weakened because they have very asymmetric spectrum holdings. This is our primary concern for this auction.

Risk to competition through very asymmetric spectrum holdings

1.20 We note that the different mobile operators already have very different spectrum holdings and that this will clearly affect the way in which they respond to increased levels of consumer demand.

1.21 However, an uneven distribution of spectrum is not necessarily a barrier to strong competition among operators. As noted, companies can add capacity through network investment rather than deploying additional spectrum and anyway do not need to have the same capacity for competition to be strong (different companies may have different market shares or different commercial strategies). This is illustrated by the fact that competition is currently working well for consumers, despite the current degree of asymmetry.

1.22 Nevertheless, a *very* asymmetric distribution may give rise to competition concerns. For example, having a relatively large spectrum portfolio may enable an operator to offer a range of services - or a quality of service - that cannot be matched by credible competitors with smaller holdings. Conversely, an operator that is a credible competitor but has a small spectrum holding relative to others may struggle to compete in some segments of the market or in the provision of some services.

1.23 If BT/EE was to win all the 2.3 GHz spectrum that is available in this auction, that would increase its share of spectrum which is immediately useable from 45% to nearly half (49%). In other words, this one operator would have the almost same amount of spectrum as all the other operators put together. Our judgement is that this would create a significant risk to competition.

1.24 The MNOs with smaller shares of spectrum have an opportunity to bid for the 2.3 GHz spectrum themselves. However, operators with large spectrum shares may have a higher valuation for the spectrum not because they would use it more effectively, but because competition in the mobile market would be weaker if they acquired it. The fact that there is only a relatively small amount of spectrum in the 2.3 GHz band may make this kind of strategic investment more likely.

1.25 However, we believe there may be some incentives for operators who do not actually need additional spectrum immediately to nonetheless acquire it in the auction in order to weaken the competition they face in the mobile market. The fact that there is only a relatively small amount of spectrum in the 2.3 GHz band may make it easier to succeed in this kind of strategic investment.

1.26 In considering strategic investment in this way, we are not supposing that bidders, individually or collectively, will act in a manner prohibited either in the auction or more generally under competition law. Our concern is to consider whether strategic investment by one or more bidders, in pursuit of rational commercial goals, might result in an outcome that made the market less competitive. It is, however, also possible that very asymmetric distribution of spectrum could arise even if bidding was not for strategic reasons, which could be against consumers' interests.

1.27 We are less concerned about the risks associated with the 3.4 GHz spectrum. This spectrum is not immediately useable, and by the time it is we believe there are a variety of means by which operators will be able to adapt their strategies to meet consumer demand. Over these longer timescales, we expect other spectrum to become available - and operators also have the option of adopting different approaches to network deployment, including those based on 'small cells'.

1.28 We are also mindful of the potential unintended consequences associated with an intervention in relation to 3.4 GHz spectrum. As noted above, we expect this band to be an important enabler of 5G deployment, and it is possible that 5G networks will require access to large blocks of contiguous spectrum. Exactly how operators deploy 5G networks is currently uncertain, but we believe there to be a material risk that over specifying limitations on spectrum holdings at this point might constrain an operator's ability to innovate.

1.29 Taking all these factors into account, and having considered the views of stakeholders expressed in responses to previous consultations and in subsequent submissions provided to us by interested parties prior to this consultation, we now propose to impose a cap on immediately useable spectrum (i.e. spectrum useable now and in the transitional period before the 3.4 GHz frequencies are brought into use). We propose to impose no cap on the 3.4 GHz spectrum.

1.30 We propose to set the cap on immediately useable spectrum at 255 MHz, which represents 42% of such spectrum and is at the level of BT/EE's current mobile spectrum holdings. This cap will prevent a worsening of the current extent of asymmetry in immediately useable spectrum. This proposal has been incorporated into draft auction regulations, which are published alongside this consultation.

1.31 We have considered a range of other options. If we were to impose no cap, then there is an immediate and significant risk to competition. At the same time, if we were to go further and impose more restrictive competition measures we believe this would be disproportionate. We note in that context, that the effect of a tighter cap, for example, would be to constrain Vodafone, the operator with the second largest spectrum holdings. However, even if Vodafone were to win all the 2.3 GHz spectrum that is available in this auction, it would still have less spectrum than BT/EE.

Auction regulations

1.32 In addition to the competition issues, this document also addresses some matters concerning the auction regulations. In particular, we are proposing changes to the rules set out in our October 2015 draft regulations governing the withdrawal of bids made during the principal stage of the auction.

1.33 The rules made bidders liable, in some circumstances, to pay a sum equivalent to the amount of the withdrawn bid (or bids) without actually being offered any spectrum in return. This was to deter bidders from using withdrawals in order to manipulate the bidding process to the detriment of auction efficiency.

1.34 We are now proposing alternative rules for the withdrawals to achieve a similar objective:

- First, we propose to allow only partial standing high bidders to withdraw the standing high bid status of their bids. Partial standing high bidders are those that hold standing high bids on fewer lots than they actually bid for. This category of bidder is more likely to have a legitimate reason for wanting to withdraw.

- Second, we propose that lots which would otherwise remain unsold as a consequence of a withdrawal should be offered to the bidder who withdrew, at twice the price level of the withdrawn bids. If the bidder rejects the offer, the amount payable will then be equivalent to the level of the withdrawn bids for which it is liable. We consider this to be fair and proportionate and likely to lead to an efficient outcome.

1.35 We also address some other minor changes to the auction regulations and provide additional clarification on some points raised in our previous consultation.

1.36 As noted above, the draft auction regulations also now incorporate our proposed spectrum cap.

Section 2

Introduction

2.1 This document is a further consultation about the auction of spectrum in the 2.3 and 3.4 GHz frequency bands.

2.2 The auction is likely to attract the interest of mobile network operators (MNOs)[3] looking to meet growing demand from consumers and industry for mobile data services. This document focuses primarily on the question of whether, in the absence of any competition measures in the auction, the award could result in a weakening of competition in the mobile market. It contains proposals on how to address the competition concerns we have identified.

2.3 In addition to addressing competition issues, this document also sets out revised proposals on some details of the regulations that will be applied to the auction – particularly the rules governing withdrawal of bids. A notice of our intention to publish auction regulations – including the full regulations in draft form – is published alongside this document.[4] This consultation accompanies and forms part of the consultation exercise set out in that notice.

The importance of mobile spectrum

2.4 Radio frequencies (forming part of the radio spectrum) are a scarce resource. The spectrum itself is a major asset to the UK economy and society because it is the means by which all wireless communications devices operate. It is critical to areas such as cellular telephony, mobile multimedia, radio and television broadcasting, air travel, emergency services, and public utilities.

2.5 Responsibility for managing spectrum in the UK lies with Ofcom. This includes the 190 MHz of spectrum in the 2.3 and 3.4 GHz bands which has been released to Ofcom by the Ministry of Defence (MOD) as part of the Government's Public Sector Spectrum Release (PSSR) programme.

2.6 At any given time, the amount of spectrum available to UK users is limited. We therefore consider it very important to make any new spectrum released to the market available for use as soon as practical. It is not an efficient use of spectrum if frequencies that are available for use are left unassigned.

2.7 The 2.3 and 3.4 GHz bands we are auctioning are likely to be of particular interest to MNOs looking to increase their capacity in order to meet increasing demand for mobile data from consumers and industry. The mobile industry is evolving rapidly and consumer demand for mobile data applications is growing significantly. Mobile data traffic has been increasing at a rate of around 70% a year[5], driven by the increasing use of smartphones, tablets and laptops. 71% of UK adults now own a smartphone,

[3] In our July 2012 statement we used the term 'national wholesaler' to mean what we here refer to as MNO. The way we use MNO in this consultation excludes those operators that have mobile networks that only cover specific areas rather than providing national coverage, which we have sometimes called 'sub-national RAN operators'.
[4] https://www.ofcom.org.uk/consultations-and-statements/category-1/award-of-the-spectrum-bands/
[5] This is the cumulative annual growth rate over the last 4 years https://www.ofcom.org.uk/__data/assets/pdf_file/0028/69634/connected_nations2015.pdf

and 59% of UK households report having at least one tablet computer. [6] We expect the growth in demand to continue.

2.8 The characteristics of the 2.3 and 3.4 GHz bands in terms of propagation and the penetration of signals make them especially suitable for increasing the capacity available to meet consumer demand for more mobile data services. However, the two bands are different:

- The 2.3 GHz spectrum has propagation characteristics very similar to the 2.6 GHz band already used for LTE. It is supported by many mobile devices which consumers already own, and could be brought into use immediately.
- The 3.4 GHz band is not yet supported by mainstream mobile devices but may provide additional capacity for network operators in the future when it is supported by mainstream devices. Additionally, it is expected that the band will be used to support the development of future 5G mobile services.

Our policy objectives

2.9 In managing mobile spectrum it is Ofcom's objective to ensure that everyone in the UK can enjoy fast and reliable mobile broadband services.

2.10 Technological developments in both handsets and mobile applications are allowing consumers to carry out ever more activities wirelessly - including data heavy functions such as video downloads. Our auction will help operators to make use of the 2.3 and 3.4 GHz frequencies to maintain and enhance the services they currently offer. This will bring significant benefits to UK consumers and industry.

2.11 Our Mobile Data Strategy[7] document of June 2016 identified the 2.3 and 3.4 GHz bands as important priorities for meeting growing consumer demand for mobile broadband. We are therefore looking to make these bands available in a timely fashion.

2.12 There is also increasing interest in 5G services, which will bring new services and faster versions of existing services to consumers. The Mobile Data Strategy also explained our aim to ensure that a lack of suitable spectrum will not inhibit the rollout of 5G in the UK, and that the benefits of these new technologies can reach everyone. In this regard, we note that the Radio Spectrum Policy Group (RSPG), the high-level advisory group that assists the EC in the development of radio spectrum policy,[8] recently identified the wider 3.4-3.8 GHz band as the *"primary band suitable for the introduction of 5G use in Europe even before 2020"*.

Spectrum to be awarded

2.13 The full award frequencies to be released in this award comprise 40 MHz of spectrum within the 2.3 GHz band (2350-2390 MHz) and 150 MHz of spectrum within the 3.4 GHz band (at 3410-3480 MHz and 3500-3580 MHz). A further 40 MHz of spectrum in the 3.4 GHz band is currently held by UK Broadband Limited (3480-3500 MHz and 3580-3600 MHz). If UK Broadband chooses to participate in the auction

[6] Communications Market Review 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0024/26826/cmr_uk_2016.pdf

[7] https://www.ofcom.org.uk/consultations-and-statements/category-1/mobile-data-strategy/statement (Updated 2016: https://www.ofcom.org.uk/__data/assets/pdf_file/0033/79584/update-strategy-mobile-spectrum.pdf)

[8] http://rspg-spectrum.eu/

and to apply for a replacement licence, the frequencies making up its current holding will change to enable all users of the 3.4 GHz band to have contiguous spectrum holdings.

2.14 The 2.3 GHz spectrum will be made available for new uses throughout Great Britain (i.e. in England, Scotland[9] and Wales, but not in Northern Ireland). The 3.4 GHz spectrum will be made available throughout the whole of the UK.

2.15 Both of the award bands will be offered fully cleared of existing uses, apart from in a very few specific areas where there will be continued MOD use. There may also be some very limited use of the award spectrum for Programme Making and Special Events (PMSE), primarily for wireless cameras.

2.16 Both bands are harmonised throughout Europe for mobile services. Although high power mobile services seems the most likely use of the spectrum, alternative uses will not be precluded if winning bidders have other plans (subject to compliance with technical parameters and licence conditions). In that respect it is possible the auction could attract new entrants into the market – perhaps a sub-national operator or an existing fixed link or Wi-Fi provider looking to add additional mobile services.

2.17 We have considered whether this spectrum could be used to improve the *availability* of mobile services in the UK i.e. by increasing coverage. However, the technical characteristics of the spectrum mean it is suited to adding capacity and is not an effective means of extending existing levels of mobile coverage.

Our principal statutory duties and auction objectives

2.18 Ofcom's principal duties under Section 3 of the Communications Act 2003 are:

- to further the interests of citizens in relation to communications matters; and
- to further the interests of consumers in relevant markets, where appropriate, by promoting competition.

2.19 In doing so, we have a duty to secure the optimal use of spectrum (Section 3(2)(a)); and a duty to take account of the different needs and interests of all current or potential users of the frequencies (Section 3(4)(f)).

2.20 In performing our duties, we are also required under Section 3(3) to have regard in all cases to the principles under which regulatory activities should be transparent, accountable, proportionate, consistent and targeted only at cases in which action is needed.

2.21 The Wireless Telegraphy Act 2006 (WTA) also sets out a number of core statutory duties for Ofcom relating to the optimal use of spectrum. These include the duty to have regard, in carrying out our radio spectrum functions, to the demand for use of the spectrum for wireless telegraphy, and the demand that is likely to arise in future for the use of the spectrum for wireless telegraphy (Sections 3(1)(b) and (c)).

2.22 We consider that our principal duties are achieved by designing the auction in a way that enables the allocation of the spectrum to those bidders most likely to put it to the most efficient use and deliver the highest possible value to society. This should in turn fulfil our duties to secure the optimal use of the spectrum and enable us to

[9] There are restrictions to availability in the Outer Hebrides, the Isle of Skye and the Small Isles

achieve our policy objective that everyone in the UK can enjoy fast and reliable mobile broadband services.

2.23 Our statutory duties are more likely to be achieved through the following additional objectives for the auction:

- The auction should be simple where possible, without unduly compromising the efficient outcome of the auction.
- The outcome should be perceived by all participants and stakeholders as fair and legitimate, and bidders should not feel that they would have bid differently when they see the final result.

The current mobile market and spectrum allocations

2.24 The current UK market for mobile services includes four national mobile network operators – BT/EE, H3G, O2 and Vodafone. These are supplemented by a number of Mobile Virtual Network Operators (MVNOs) which have access to the networks operated by the four MNOs through commercial arrangements.

2.25 The market is operating well for consumers at present, with strong competition between suppliers, relatively low prices for UK consumers, and continued investment in new services. This is despite the allocation of mobile spectrum in the UK currently being asymmetric; BT/EE holds 42% of all mobile spectrum; Vodafone holds 29%; H3G holds 15%; and O2 holds 14%.[10] The current state of the UK mobile market is discussed in more detail in section 3 and annex 7.

Competition concerns related to the auction of 2.3 and 3.4 GHz spectrum

2.26 We recognise that whilst the mobile market is operating well at present, this may not be the case in future. The development of new technologies and applications is continuing to drive increasing demand from consumers. In order to remain competitive we expect MNOs will need to add mobile capacity to meet this demand.

2.27 We would be concerned, in particular, if the 2.3 and 3.4 GHz spectrum award could result in an allocation of spectrum to bidders that is not consistent with our auction objective and which would risk a weakening of competition in the mobile market.

2.28 We have already addressed competition issues in two previous consultations and in an earlier statement[11]. However, we have decided it is right for us to reassess these issues in light of recent changes in the market.

2.29 Since we last considered competition matters the CMA has approved the acquisition of EE by BT, including the consolidation of the two companies' spectrum holdings. On the other hand, a proposed acquisition of O2 by CK Hutchison (H3G's owner) was blocked in May 2016 by the European Commission[12]. These decisions mean there is now greater certainty about market structure than was previously the case. Importantly, there remain four MNOs with national coverage in the UK, namely BT/EE, H3G, O2 and Vodafone.

[10] Vodafone's and H3G's holdings include spectrum at 1400 MHz that is not currently useable.
[11] See annex 9 for a summary of previous documents we have published on the 2.3 and 3.4 GHz award
[12] We note that the EC decision to block the acquisition is now the subject of an appeal.

2.30 In the course of our own reassessment of competition issues, we have taken account of stakeholder responses to our earlier consultations and our own further analysis. We have also received a number of confidential further submissions from stakeholders about competition matters, and we have had meetings with a number of those stakeholders where they have explained in detail their particular views and positions.

2.31 We have considered and taken account of all these submissions and representations in formulating the further proposals contained in this document. However, we would welcome any further submissions in response to this consultation.

2.32 We are concerned in particular that a very asymmetric distribution of spectrum could result in weaker competition, even with four MNOs having spectrum portfolios that enable them to be credible competitors. For example, an operator with a relatively large spectrum portfolio may be able to offer a range of services - or a quality of service - that cannot be matched by credible competitors with smaller holdings. Conversely, MNOs that are credible competitors but have small spectrum holdings relative to their competitors may struggle to add enough capacity to remain strong competitors, at least for certain services or for certain customer segments.

2.33 This could mean some MNOs, whilst still being credible competitors overall, are less able - relative to other companies in the market - to provide some of the services that some customers are increasingly looking for. This reduction in competition could be harmful to consumers and lead to higher prices and/or lower quality of service.

2.34 We are particularly concerned about asymmetry in immediately useable spectrum that can be deployed before the 3.4 GHz band becomes useable, and other spectrum is made available – such as at 700 MHz and proposed at 3.6-3.8 GHz. MNOs with large reserves of spectrum are more able to add capacity quickly than those with smaller holdings who may need to add additional sites.

Auction regulations

2.35 In addition to addressing competition issues, this document also considers outstanding matters concerned with the regulations we will apply in the auction. In accordance with Section 14 of the WTA Ofcom may grant licences in accordance with procedures prescribed in regulations made by Ofcom.

2.36 Where Ofcom decides to award licences by auction, it makes specific regulations for those purposes, in accordance with Section 14 of the WTA. As noted above, the draft regulations in respect to the 2.3 and 3.4 GHz award are published in a separate document accompanying this consultation[13]. These regulations are also subject to consultation.

2.37 The draft regulations have been drawn up to reflect some adjustments to previous proposals. In particular, we are proposing changes to the rules set out in our October 2015 draft regulations governing the withdrawal of bids made during the principal stage of the auction (see sections 5 and 6). The draft regulations also incorporate draft rules covering the competition proposals set out in this document.

[13] https://www.ofcom.org.uk/consultations-and-statements/category-1/award-of-the-spectrum-bands/

Impact Assessment

2.38 This document represents an impact assessment as defined in Section 7 of the Communications Act. Impact assessments provide a valuable way of assessing different options for regulation. They form part of best practice policy-making.

2.39 In preparing this document we have considered the citizen and consumer interests in respect to our overall policy objectives. We have also considered the impact on mobile network operators; other service providers; and on users of mobile devices and applications.

2.40 Any comments about our assessment of the impact of our proposals should be sent to us by the closing date for this consultation. We will consider all comments before deciding whether to implement our proposals. For further information about our approach to impact assessments, see the guidelines: *Better policy-making: Ofcom's approach to impact assessment*, which are on our website: http://www.ofcom.org.uk/consult/policy_making/guidelines.pdf.

Equality Impact Assessment

2.41 Ofcom is separately required by statute to assess the potential impact of all our functions, policies, projects and practices on race, disability and gender equality. Equality Impact Assessments (EIAs) also assist us in making sure that we are meeting our principal duty of furthering the interests of citizens and consumers regardless of their background or identity.

2.42 In our view, our consideration of competition issues for the 2.3 and 3.4 GHz award is not likely to have a particular impact on one group of stakeholders as opposed to another. Assessments of the impact of other aspects the award in respect to equality have been made separately[14].

Structure of the consultation

2.43 The rest of this document is set out as follows:

- **Section 3** provides details on the mobile market in the UK, including the current state of competition and the current allocation of mobile spectrum.
- **Section 4** presents our analysis of the competition issues for the auction of the 2.3 and 3.4 GHz spectrum. We consider whether there is a case for applying competition measures in the auction due to competition concerns and, if so, what concerns we would seek to address by applying any such measures.
- **Section 5** then discusses the options available to us for addressing competition concerns, including the option of applying no competition measures at all. We then set out our proposals in light of our analysis.
- **Section 6** sets out a revised proposal on the rules governing the withdrawal of bids in the auction.

[14] We are currently re-evaluating an earlier assessment of the co-existence of mobile services with assistive listening devices and conducting some further technical analysis. We will publish our findings separately in due course.

- **Section 7** sets out proposals on other aspects of the auction rules.

- **Section 8** considers our next steps ahead of auctioning the 2.3 and 3.4 GHz spectrum. It notes that we will publish an update to the auction Information Memorandum we published in October 2015 and lists some changes that have already been determined in light of developments since this initial publication.

2.44 In some places in this document and in the annexes we draw on commercially sensitive evidence supplied to us in confidence. This evidence is redacted in the published version of this document. Where we have redacted passages of text or illustrations it is indicated by the ✂ symbol.

Section 3

Current state of the UK mobile market

3.1 As explained in section 2, we would be concerned if the award of 2.3 and 3.4 GHz spectrum could result in an allocation of spectrum to bidders that is not consistent with our auction objective and which could result in a weakening of mobile competition.

3.2 In order to determine if there is such a risk, or that it is appropriate for us to actively promote competition, we must first understand the UK mobile market. In this section, we therefore consider the current state of competition, as well as the current allocation of mobile spectrum.

Current state of competition

3.3 Retail competition in mobile services today is characterised by competition between both MNOs and MVNOs. Competition amongst these MNOs enables MVNOs to obtain wholesale access commercially, without regulation.

3.4 There are currently four MNOs: BT/EE, H3G, O2 and Vodafone. We believe that the existence of at least four credible MNOs is important for the UK mobile market. This is consistent with our views in previous documents and is a position maintained by the EC's recent decision to block the proposed merger of H3G and O2, which would have reduced the number of MNOs to three. We agree with the EC's conclusions.

3.5 With the benefit of this competition, the market appears to be operating well at present, with strong competition between suppliers, relatively low prices for UK consumers, and continued investment in new services. This is despite the fact that, as discussed below, the allocation of mobile spectrum between the four MNOs is currently asymmetric. The current state of the UK mobile market is described in more detail in annex 7 of this document.

Current allocation of mobile spectrum

3.6 As Figure 3.1 below shows, the allocation of mobile spectrum between the four MNOs is currently asymmetric.

Figure 3.1: MNOs' current spectrum holdings[15]

Spectrum Band	Type	BT/EE	Vodafone	O2	H3G	Total
800 MHz	FDD	10	20	20	10.0	60.0
900MHz	FDD	0	34.8	34.8	0	69.6
1452-1492 MHz[16]	SDL	0	20	0	20	40.0
1800 MHz	FDD	90	11.6	11.6	30	143.2
2100 MHz	FDD	40	29.6	20	29.5	119.1
2.6 GHz (paired)	FDD	100	40	0	0	140.0
2.6 GHz (unpaired)	TDD	15	20	0	0	35.0
Total holdings		**255**	**176.0**	**86.4**	**89.5**	**606.9**
Share of spectrum		**42%**	**29%**	**14%**	**15%**	

3.7 Further, of the *spectrum useable immediately* for mobile (i.e. excluding spectrum at 1400 MHz that is not currently supported by mobile devices) BT/EE holds 45%; Vodafone holds 28%; O2 holds 15%; and H3G holds 12%.

3.8 The current asymmetric distribution of spectrum has arisen for historic reasons – its evolution is illustrated at Figure 3.2.

3.9 Before 2010 there were four larger operators all with shares of spectrum around 20% or slightly above (O2, Orange, T-Mobile and Vodafone) plus a fifth operator (H3G) with a further 9%. The 2010 merger of Orange and T-Mobile to form EE meant that the spectrum distribution became more asymmetric - although the competition authorities determined that the combined entity should divest some spectrum frequencies. These frequencies were eventually acquired by H3G, which raised its share of mobile spectrum to 18%, with EE retaining 39%; Vodafone 23% and O2 20%.

3.10 The 2013 auction of frequencies in the 800 MHz and 2.6 GHz frequencies (widely known as the 4G auction) substantially increased the amount of available mobile spectrum by about 70%. Even so, there was still an asymmetric distribution of spectrum after the 2013 auction. Ofcom applied competition measures in the auction to ensure the maintenance of an effective market of at least four credible network operators, including a reservation of some spectrum that could only be acquired by H3G or a new entrant and a cap of 37% on the total amount of spectrum a single operator could hold. Given these competition measures, the auction bidding left EE with 37% (the maximum allowed) and with Vodafone holding 28%; O2 with 15% and H3G with 12%.[17]

3.11 More mobile spectrum became available in 2015 when Qualcomm sold 40 MHz of frequencies it held in the 1400 MHz band – although these frequencies are not

[15] We describe why we regard these bands as relevant and not others (such as 1900 MHz) in annex 5. We have not included all 50 MHz of the unpaired 2.6 GHz spectrum in the table, or in our analysis. This is because the top 5 MHz of the 2.6 GHz band (held by BT/EE) and the lowest 5 MHz of any individual company's holding in the unpaired 2.6 GHz band are restricted to 25dBm. This is to manage the risk of interference between two users of unpaired spectrum as well as between users of unpaired spectrum and users of paired spectrum. For the purpose of this competition assessment and possible competition measures, we therefore count BT/EE's holdings at 2595-2620 MHz as representing only 15 MHz of unrestricted mobile spectrum and Vodafone's holdings at 2570-2595 MHz as representing only 20 MHz of unrestricted mobile spectrum. For more explanation of the treatment of the unpaired 2.6 GHz in the overall spectrum cap in the 2013 award, see paragraphs 6.67 and 6.68 and Section 10 of our July 2012 statement.

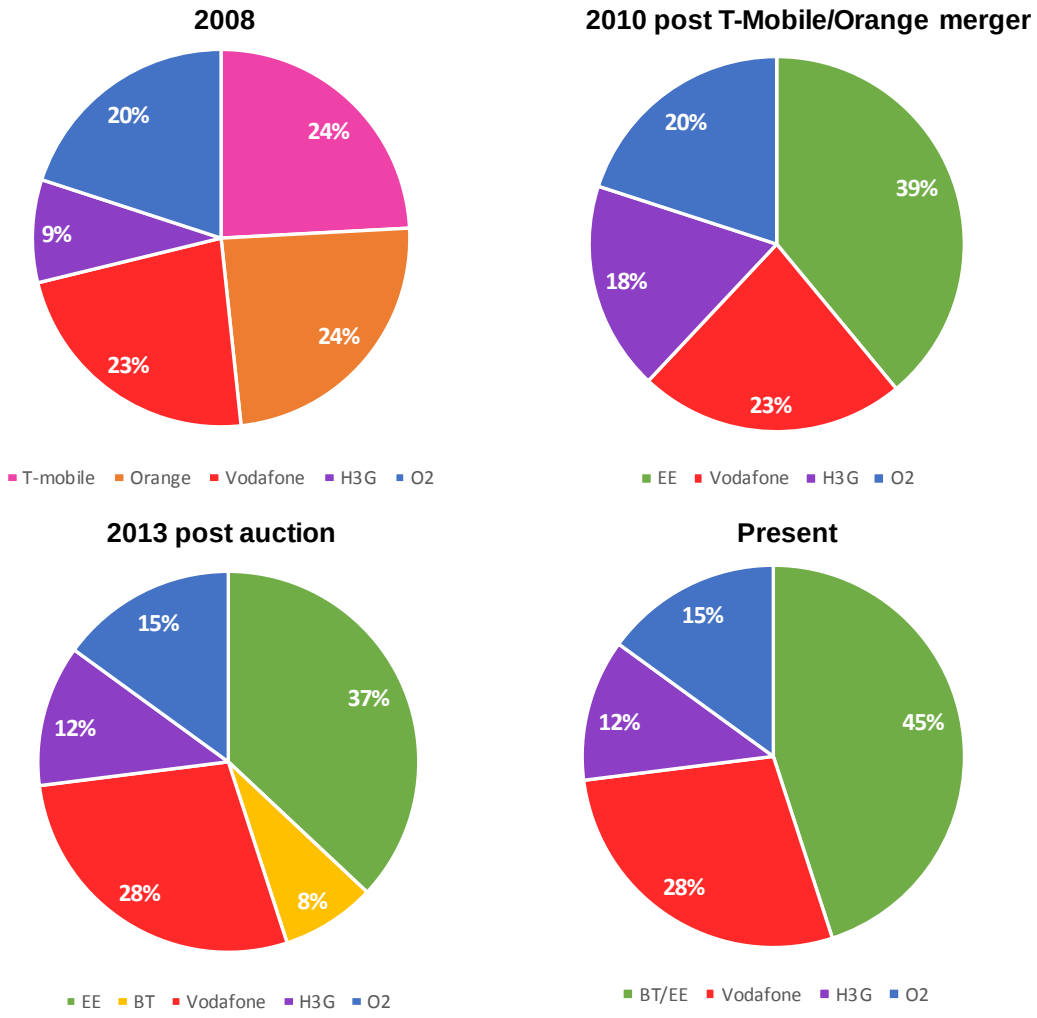
[16] Spectrum at 1452-1492 MHz is not currently in use because it is not currently supported by mainstream mobile devices.

[17] The remaining spectrum was held by BT

currently included in most mobile devices and so are not useable immediately. The frequencies were bought by Vodafone and H3G.

3.12 The current distribution of spectrum among the four MNOs arose after the acquisition of EE by BT, which was approved by the Competition and Markets Authority (CMA) in January 2016. Although BT had not previously operated as an MNO, it had obtained frequencies in the 2.6 GHz band in the 2013 4G auction. The combined BT/EE holding therefore rose to 42% of all currently available mobile spectrum, or 45% of the currently useable spectrum.

Figure 3.2 Evolution of useable spectrum shares



3.13 A proposed acquisition of O2 by H3G's parent company CK Hutchison would have reduced the number of UK MNOs from four to three, and allowed the combined H3G/O2 entity to also consolidate their spectrum holdings. It would have left the three remaining operators with a more even distribution of spectrum than at present.

3.14 However, in May 2016, the merger was blocked by the EC on competition grounds.[18] As noted above, Ofcom supports that conclusion, which is also consistent with the policy we set out ahead of our 2013 4G auction that competition in the UK market is best served by there being four credible MNOs.

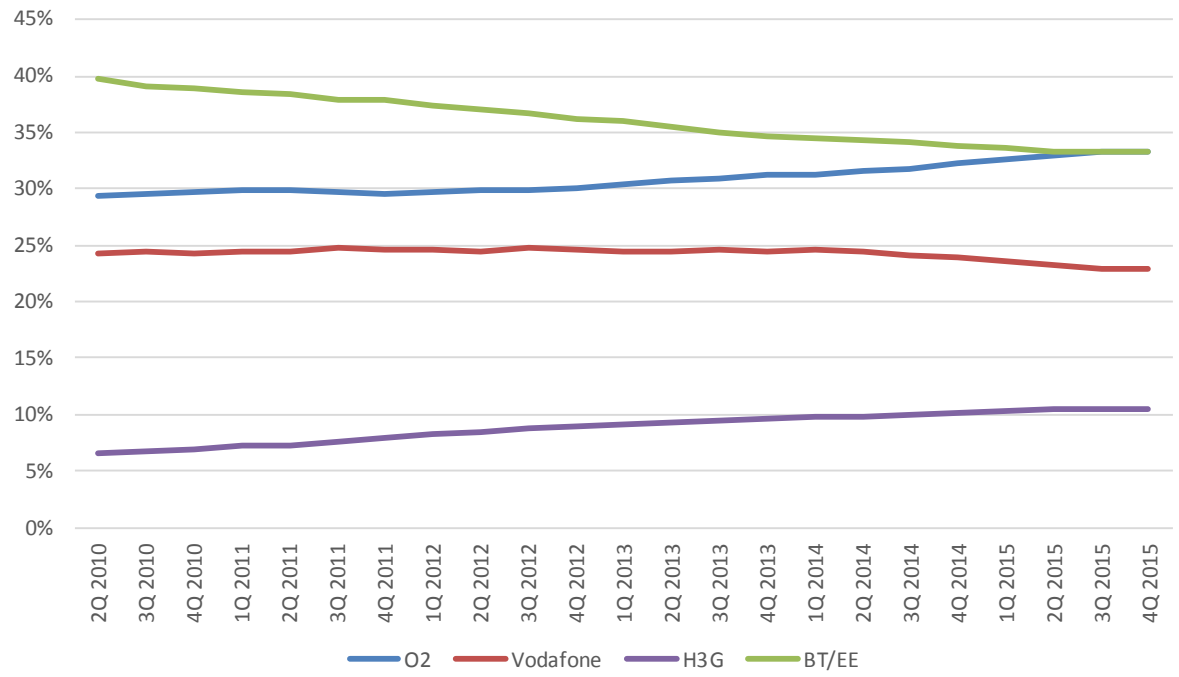
[18] We note that the EC decision to block the acquisition is now the subject of an appeal.

To date, asymmetric spectrum shares do not appear to have weakened competition

3.15 It appears that the ability of MNOs to compete and to increase their market shares to date has not been driven purely by their share of spectrum holdings. H3G and O2 are the two MNOs generally to have increased their market share of network subscribers in recent years (including the subscribers of hosted MVNOs). This is illustrated in Figures 3.3a and 3.3b below, using data from operators and Analysys Mason respectively.[19] In contrast, BT/EE and Vodafone have lost subscribers in recent years

[✂] REDACTED

Figure 3.3b: Subscriber market shares by network (including own subscribers and hosted MVNOs' subscribers) – Analysys Mason data



Source: Analysys Mason

3.16 While H3G has the lowest share of subscribers, it has the highest share of mobile data traffic, as shown in column B of Figures 3.4a and 3.4b[20] below.[21] Column D shows that H3G has higher data traffic per MHz of spectrum than the other

[19] Our analysis for this consultation has been based on data provided by the operators to Ofcom as part of their regular information submissions to us. However, as we cannot publish this information, we are also including market share data based on Analysys Mason data. [✂] REDACTED

[20] As mentioned above, we have based our analysis on data provided by operators but also present the same analysis using non-confidential data from Analysys Mason.

[21] The spectrum shares set out in Figures 3.3 and in later figures assume different bands are all equivalent in terms of their usefulness in adding capacity. In reality the large differences in frequency between some of the different bands (for example, between the 800 MHz band and the 3.4 GHz band) puts greater strain on an analysis using simple shares of total spectrum. However, as we describe below, we expect the 3.4 GHz spectrum to be sufficiently substitutable for the 2.3 GHz spectrum (and other mobile bands) in terms of adding capacity in the longer term.

operators. Column E shows that O2 has the highest ratio of subscribers per unit of spectrum.[22]

[✂] REDACTED

Figure 3.4b: Shares of spectrum, data and subscribers, and related ratios – Analysys Mason data

	A	B	C	D	E	F
	Share of spectrum (excl 1400)	Share of mobile data traffic	Share of network subscribers	Data share/ spectrum share ratio	Subscriber share/ spectrum share ratio	Data share/ subscriber share ratio
BT/EE	45%	33%	33%	1.5	1.0	1.9
O2	15%	17%	33%	2.4	2.9	1.0
Vodafone	28%	13%	23%	1.0	1.1	1.1
H3G	12%	37%	11%	6.3	1.2	6.8

Sources: The shares of mobile data traffic are taken from Enders Analysis' *UK mobile market Q2 2016 – Future uncertain*, 5 September 2016 (slide 11). The shares of network subscribers are from Analysys Mason data and include the subscribers of hosted MVNOs, and are for Q4 2015. Note: 1400 MHz is excluded from the spectrum shares shown above because it is not currently in user devices.

Provisional conclusion

3.17 Although the UK mobile market is currently working well, with four credible MNOs and a range of MVNOs supporting strong retail competition, we would be concerned if the award of 2.3 and 3.4 GHz spectrum risked weakening competition.

3.18 Specifically, we consider it is important that we do not lose four credible MNOs. Further, whilst the current level of asymmetry in mobile spectrum shares does not appear to have distorted competition to date, this does not mean that it will not do so in the future. We would therefore also be concerned if the allocation of spectrum shares following the auction were so asymmetric that it resulted in a weakening of mobile competition.

3.19 In Section 4, we therefore consider the likelihood of either of these risks occurring if we do not impose any competition measures in the auction, as well as the extent of any consumer harm which would result from such a reduction in competition.

[22] The ratios in columns D, E and F are calculated so that the MNO with the smallest ratio is normalised to one. This means that the units in these columns are not meaningful, but the comparison between MNOs can be seen in each column.

Section 4

Competition assessment

4.1 As explained in section 3 above, the UK mobile market is currently working well, with four credible MNOs and a range of MVNOs supporting strong retail competition. This is despite the fact that the existing spectrum holdings of the four MNOs are currently asymmetric.

4.2 However, this does not mean that asymmetric spectrums shares will not become a problem in the future, nor that we can assume there will remain four credible MNOs. Technological innovation and the continuing rapid take-up of consumer devices and applications means UK mobile data use will continue to grow significantly in the future. One important way of meeting this demand is by MNOs deploying more spectrum. As explained earlier, mobile spectrum is a valuable and finite national resource and there is high demand from MNOs when new frequencies become available.

4.3 In this section, we therefore discuss whether there are any competition concerns arising from the 2.3 and 3.4 GHz spectrum auction and, if there are, what the consequences might be if we did not adopt measures to address them. In section 5, we then go on to consider whether it would be appropriate and proportionate, in light of our provisional assessment in this section, to impose measures in the auction to address our competition concerns and ensure the optimal use of spectrum.

Competition concerns

4.4 In considering the impact of the 2.3 and 3.4 GHz award on competition, we have considered the likelihood of two specific competition concerns arising. These concerns reflect our view that, especially given the high barriers to entry to becoming a new MNO, competition is affected both by the number of effective competitors and the strength of competition between them.

4.5 In particular, as explained in Section 3, we think it is important that competition in the retail mobile market is not weakened as a result of the award of 2.3 and 3.4 GHz spectrum. We think it is important that there remain at least four credible MNOs and that competition amongst those MNOs is not weakened as a result of very asymmetric mobile spectrum shares. This is consistent with our competition assessment for both our spectrum award of 2013[23] (which enabled the expansion of 4G services) and our November 2014 consultation on this award.

4.6 In this Section, we therefore consider :

- **The likelihood of there ceasing to be four credible MNOs as a result of the auction.** As explained in Section 3, there are currently four credible MNOs in the

[23] See paragraphs 4.25-4.30 in *Assessment of future mobile competition and award of 800 MHz and 2.6 GHz Statement*, Ofcom, 24 July 2012 (which we subsequently refer to this as our "July 2012 statement"), https://ofcom-build.squiz.co.uk/__data/assets/pdf_file/0031/46489/statement.pdf
We noted that an MNO could be a credible competitor even though it is not in a strong position in some dimensions of service, or in delivering particular services or to particular customers. For example, a MNO might be credible if it were able to provide good quality of service (such as high data rates and latency) in most indoor locations, even if it could not compete as strongly for customers that particularly valued having a connection in the most difficult to serve locations.

UK and we would be very concerned if spectrum holdings after the auction were such that there was a reduction in the number of effective MNOs. That is, if one of the existing MNOs would have such weak spectrum holdings relative to its rivals that it ceased to be 'credible'. By credible we mean that a competitor is able to exert an effective constraint on its rivals - in terms of factors such as the provision of high quality services, competitive prices, choice and innovation - and so contribute to the overall competitiveness of the market.

- **The likelihood of very asymmetric mobile spectrum shares weakening competition even if there are four credible MNOs.** Clearly, retaining four credible MNOs is an important contributor to competition – but it is not enough on its own to ensure the market is as competitive as it might be. Even if there are four credible MNOs, competition could be weaker from a very asymmetric distribution of spectrum if some operators would struggle to compete strongly across certain services or for certain customer segments - or temporarily over some period of time. In particular, we consider three different asymmetry scenarios (asymmetry in overall mobile spectrum shares, asymmetry in immediately useable mobile spectrum shares, and asymmetry in shares of 3.4 GHz spectrum).

4.7 Given their importance to competition in mobile services, most of our assessment in this document relates to MNOs. However, we also welcome other types of competition and recognise that a new entrant may find innovative ways of using spectrum in the future, in a way that provides benefits to citizens and consumers.[24]

4.8 The competition concern on which we place most weight in this case relates to one aspect of the risk that the distribution of mobile spectrum holdings will become very asymmetric as a result of this auction and that - in some cases - this could harm competition and consumers. We therefore start this section by considering whether and, if so, in what circumstances, competition would be weaker if spectrum holdings were very asymmetric after the auction. For that reason we refer to the risk of very asymmetric spectrum holdings as **Competition Concern 1.**

4.9 As explained below, the aspect of Competition Concern 1 we are most concerned about is the impact of very asymmetric holdings of *immediately useable* spectrum after the auction, which might, for example, adversely affect those high value consumers who demand consistently high data speeds. For these customers and over the next two to three years, we are particularly concerned that competition may be weaker than it might otherwise be.

4.10 This is because, as explained in section 2 above and in more detail below, MNOs with large spectrum holdings may have advantages that competitors cannot replicate; or MNOs with relatively small spectrum holdings, whilst still being credible competitors overall, may struggle to add enough capacity to remain strong competitors, at least for certain services or for certain customer segments.

[24] For example, in the future, it is possible that new business models may become important involving operators other than MNOs acquiring spectrum to provide services themselves in particular locations, while still relying on an access agreement with an MNO to provide national coverage. By way of example, TalkTalk mentions in its 2016 annual report a plan to implement an inside-out fixed-mobile network that consists in the roll-out of femto cells across their existing fixed line base, thereby allowing the operator to offload mobile traffic that would otherwise be provided as part of its MVNO deal with Telefónica. Over time, TalkTalk notes that there will be further opportunities to drive down data costs across this inside-out network, potentially by building a larger small-cell network combined with suitable high frequency spectrum. Report available at https://www.talktalkgroup.com/dam/jcr:3ae87c83-4e84-4464-a9df-06dd76eb293d/TalkTalk%20Telecom%20Group%20PLC%20Annual%20Report%202016.pdf

4.11 This concern focuses on the transitional period of the next few years and so the allocation of 2.3 GHz spectrum, but not 3.4 GHz spectrum. We do however also consider asymmetry in overall spectrum shares more generally and in 3.4 GHz spectrum - although we place less weight on these, for the reasons set out below.

4.12 After discussing this asymmetry risk, we turn to our other potential competition concern, related to the likelihood of there ceasing to be four credible MNOs as a result of the auction. We refer to this as **Competition Concern 2.**

4.13 For the reasons set out later in this section, we consider it unlikely that any of the four MNOs would cease to be credible in the next few years even if they did not obtain any spectrum in this award, and that in the longer term there will be other opportunities for them to obtain spectrum to remain credible. We therefore consider the risk of there ceasing to be four credible MNOs as a result of this award is not high.

4.14 Finally in this section, we consider the likelihood of those auction outcomes that might weaken competition actually arising in the absence of competition measures through bids on the basis of intrinsic valuations or strategic investment. We are most concerned that such an outcome might arise because of strategic investment.

Competition Concern 1: Risk of very asymmetric mobile spectrum shares

4.15 We first consider why, in principle, asymmetric spectrum shares could give rise to competition concerns and the degree of asymmetry which could give rise to competition concerns and risk undermining our auction objective.

4.16 We then consider the specific circumstances in the UK mobile market. In doing so, we consider the potential implications of very asymmetric holdings resulting from the auction having regard to the following:

- Asymmetry in overall mobile spectrum shares - Competition Concern 1(i);
- Asymmetry in mobile spectrum which is useable immediately after the award (which includes 2.3 GHz spectrum, but excludes 3.4 GHz spectrum) – Competition Concern 1(ii); and
- Asymmetry in 3.4 GHz spectrum specifically – Competition Concern 1(iii).

4.17 For the reasons set out below, our main concern is that shares of immediately useable mobile spectrum may become very asymmetric as a result of the auction of spectrum in the 2.3 GHz band. Our provisional view is that such an outcome would be detrimental to competition over the next two to three years.

4.18 Whilst we recognise that overall mobile spectrum shares and shares of 3.4 GHz spectrum could also become very asymmetric as a result of the auction, our provisional view is that it is less likely that this would result in competition concerns.

General concerns about very asymmetric spectrum shares

4.19 In order to remain competitive, we expect all MNOs will need to add capacity in the future to meet strong growth in mobile data demand. Having sufficient capacity is important as the amount of capacity (for a given number of users of a network) determines the average data speeds those users receive. Average data speeds are

one dimension in which MNOs compete. Using additional spectrum is an important way of adding capacity, and hence either increasing average data speeds or serving more customers.

4.20 If the distribution of spectrum between MNOs becomes very asymmetric, the market could develop in a way that reduces competition for some services or customers (even though there remain four credible MNOs)[25]. It is appropriate to consider the *share* of total mobile spectrum an MNO has (rather than just the absolute amount of spectrum), because competition is influenced by a *relative* comparison of one MNO compared to its rivals.[26]

4.21 A very asymmetric spectrum distribution that weakens competition, even where there are four credible MNOs, can be characterised by:

- One or more MNOs with a very high share of spectrum compared with other companies in the market; and/or
- One or more MNOs with a relatively low share of spectrum compared with other companies in the market (whilst still having sufficient spectrum to enable them to be credible).

4.22 These are inherently inter-related. If one or more MNOs has a very high share of spectrum, there will necessarily be less for other MNOs, making it more likely that one will have a relatively low share that gives rise to a competition concern (even if that MNO has enough spectrum to enable it to be credible). We consider each of these inter-related effects below.

Competition may be weaker if one or more MNOs has a very high share of spectrum

4.23 One example of how competition could be weaker if one MNO has a very high share of spectrum is that it is able to offer such superior services that rivals are unable to replicate them. This could weaken competition, at least in terms of supplying some services, some customers, or over a temporary period. Competitors could lose their ability to compete as strongly and customers may switch suppliers as a result.

4.24 While there may be benefits to some consumers from a company with a high share of spectrum offering such services, if competition were weakened, this could ultimately be against consumers' interests in general.

4.25 Another example is that an MNO with a high spectrum share may make limited use of any additional spectrum it wins in an auction (at least in the short term), but

[25] We are interested in spectrum shares from the perspective of comparing MNOs' ability to add capacity. While we focus on comparing spectrum shares that are calculated by aggregating spectrum in different bands, we recognise that different spectrum bands can have different characteristics and different values. That different bands have different values does not necessarily undermine considering shares of spectrum. To the extent that differences in values are due to different deployment costs, they may not be relevant to our consideration of spectrum shares for capacity.
For example, if two different bands are deployed to provide the same services, but one is more expensive to deploy than the other, we might expect this to be reflected in the cost of acquiring the spectrum. In this case, it is reasonable to regard the bands as equivalent when considering the shares of spectrum for adding capacity, even though one is more valuable than another.
However, it could be that the cost of deployment with one band is so expensive that it would not be deployed to the same extent as another band. In that case, differences between bands might be more significant for our competition assessment, and considering simple spectrum shares less meaningful. In this case, we assume that the differences between bands are not so extreme as to undermine consideration of shares of spectrum overall.
[26] See from paragraph A3.164 of Annex 3 of our July 2012 statement for more explanation of this. https://ofcom-build.squiz.co.uk/__data/assets/pdf_file/0029/47387/annexes1-6.pdf

acquiring it denies that spectrum to its competitors, and thereby weakens competition potentially in the longer term as well as the short term. The competitors might compete more strongly if they had instead acquired the auctioned spectrum.

4.26 A further possibility is that an MNO with a high spectrum share - and likely some spectrum lightly used - could become a leader in setting relatively high prices for some services or customer segments. It could pose a credible threat to competition by being able to respond with aggressive price cuts if rivals seek to grow their market share of different services or customer segments through lower prices. This could lead to a softening of competition for some services.

Competition may be weaker if one or more MNOs have a relatively low share of spectrum

4.27 MNOs with small spectrum holdings will tend to have higher marginal costs of adding capacity than operators with a high spectrum holding. This is because they would need to build significantly more sites to increase capacity (whereas the operator with a high spectrum share could, for example, deploy additional spectrum on its existing sites). As a result they could have reduced incentives to compete aggressively for new customers given the investment in sites that would be required to serve additional customers. Competition could be stronger, therefore, if they had a higher share of spectrum.

4.28 As well as facing the higher marginal costs of adding capacity, there may also be practical constraints on the speed of adding capacity through means other than additional spectrum, as discussed below. For example, building new sites in some locations can be challenging, due in part to a lack of suitable sites in the right locations and to planning restrictions, and there may be practical constraints on re-farming spectrum rapidly. This means some of these other solutions to adding capacity may not be very effective over a short period, especially over the very short term of one to two years, and that competition may therefore be weaker as a result of those competitors having relatively low spectrum shares.

But symmetrical spectrum shares are not necessary

4.29 Notwithstanding the above concerns about very asymmetric spectrum distributions, operators do not need to have the same, or close to the same, shares of spectrum in order for there to be strong competition. This is because:

- There is no reason to expect rivals in any market to need the same *capacity* in order for competition to be strong. MNOs can have different market shares, may have compensating strengths in other areas (e.g. customer service), or may still be able to deliver services to many consumers by choosing commercial strategies that make best use of their capacity.[27] For example, if one competitor offers a more attractive consumer proposition than its rivals and wins a particular type of customer from them, it may need more capacity while its rivals need less.

- Spectrum is not the only way of adding capacity. As we describe in more detail in annex 8, capacity can also be added by using existing spectrum more effectively. For example, capacity can also be added by a) densifying the network topology by increasing the number of cells (e.g. switching from a 3-sector to a 6-sector configuration) and/or increasing the number of sites (e.g. adding new micro or

[27] However, we recognise that if very restrictive commercial strategies are adopted to cope with limited capacity, then competition for some users may become weaker.

macro sites or deploying small cell sites within macro sites); and b) moving to more efficient technologies (spectral efficiency can be improved with newer technology such as re-farming 2G and 3G spectrum bands and use of higher orders of MIMO technology and other LTE–Advanced techniques). It may also be possible to use licence exempt spectrum (such as the 5 GHz bands) to provide additional capacity in particular locations.

- A certain degree of asymmetry in spectrum holdings may reflect differences in operators' commercial strategies and expectations about the future. Such asymmetries may give rise to consumer benefits. For example, an operator that already has a high share of spectrum may use additional spectrum in an innovative way, and an operator that has a lower share of spectrum may find innovative ways of attracting consumers to compensate for its lower share of spectrum e.g. targeting particular consumer or business segments, or offering higher quality in other aspects of service.

Provisional conclusion on the degree of asymmetry that, in principle, raises concerns

4.30 In a market where there are four credible MNOs holding all the spectrum, then symmetric holdings would imply each having 25% of spectrum. For the reasons set out above, we would not be concerned about MNOs having spectrum shares that varied some way above or below 25%. However, at some degree of asymmetry competition may weaken (even where there are four credible MNOs). There is a difficult judgement about when spectrum distributions become so asymmetric they may begin to harm competition.

4.31 We have previously taken the view that, if one MNO had more than around 40% of spectrum, competition may weaken. This is partly because one operator may have so much spectrum relative to its competitors that the concerns set out above may arise - but also because there would be less spectrum available for other operators who may be weaker competitors as a result.[28]

4.32 We note that one MNO (i.e. BT/EE) already has more than 40% of spectrum and the market appears to be working well for consumers currently. Nevertheless, as MNOs need to continue adding capacity in the future to meet growing consumer demand, we remain of the view that there is a risk that competition may be weakened if any single operator has more than 40% of spectrum.[29]

4.33 As to when a spectrum holding is too low relative to its rivals to promote competition, despite the MNO having enough spectrum to be a credible competitor, a useful

[28] The precise level of any cap set in an auction is a matter of judgement, taking into account the applicable circumstances. For example, in the 2013 auction we set an overall spectrum cap at 2x105 MHz (or 210 MHz of spectrum), which allowed the operator with the largest spectrum share (EE) to obtain at most 2x40 MHz of spectrum in the auction. This cap of 210 MHz prevented any operator obtaining more than 37% of the 567 MHz of spectrum that we considered relevant for mobile competition in that award (taking account of the exclusion of some of the unpaired 2.6 GHz spectrum for reasons set out below). The sub 1 GHz cap in the 2013 auction was set at 42% of the sub 1 GHz spectrum available. It was set at 2 x 27.5 MHz of sub 1 GHz spectrum so as to allow the two operators with large pre-existing holdings of sub 1 GHz spectrum to each acquire at most an additional 2x10 MHz of sub 1 GHz spectrum.

[29] We also note that, of the other European countries we have considered with four operators in Annex 6, the UK is almost unique in having an MNO with over 40% of useable spectrum. The European countries that have four operators that we have considered are Denmark, France, Italy, the Netherlands, Slovenia, Spain and Sweden. Slovenia might have an even more asymmetric distribution of spectrum, as there are two operators with around 40% and two operators with much smaller shares. However, it may not be correct to describe Slovenia as having four credible MNOs, as we understand that the operator with the smallest spectrum share has a very low share of subscribers and may not be a strong constraint on rivals, and has filed for bankruptcy.

reference point is our view about the minimum requirements for an MNO to be credible. As we discuss later, there is a material risk of an MNO not having sufficient spectrum to be credible if it holds less than 10-15% of spectrum. However, it is possible that if an MNO only holds this minimum amount, whilst still being credible, it may not be as strong a competitor as it otherwise could be with more spectrum, such as competing less strongly for some customer segments.[30]

4.34 This is why it might promote competition for a credible operator with a share of spectrum in the 10-15% range to obtain a greater share. But this is not always the case. It will depend, amongst other things, on how well that operator can add capacity in other ways and on its market performance relative to that of rivals. For example, if that operator does not offer very attractive services to consumers and has a low market share, it would probably not strengthen competition if it obtained a higher spectrum share and competition could instead even be weakened.

4.35 We consider on a case-by-case basis whether additional spectrum for credible MNOs with smaller spectrum shares might strengthen competition. In doing so, we use as a reference point our view on the minimum spectrum requirements to enable an MNO to be credible, such as where MNOs have spectrum shares close to the minimum. But this is not a mechanical exercise and we make judgments about the strength of an MNO's spectrum portfolio in the round, taking account of a range of relevant circumstances.

4.36 For example, for the short term of the next few years, we also take into account considerations that may take time to change, such as the speed of re-farming spectrum from an older technology to the latest version, or the MNO's current market position. In the longer term, such considerations are less relevant as there is more opportunity for them to be implemented, evolve or change substantially, and we place our emphasis on the spectrum holdings themselves.

Competition Concern 1(i): The risk of very asymmetric *overall* spectrum shares

Very asymmetric spectrum allocations are possible immediately after the auction

4.37 Figure 4.1 below illustrates some potential extremes of spectrum holdings possible immediately following the auction in the absence of competition measures. It shows the outcomes where one of the four MNOs obtains all the spectrum in the auction. The most asymmetric distribution involves one MNO having more than 50% of spectrum.

Figure 4.1: Spectrum shares if MNOs win all/no additional spectrum[31]

	BT/EE	Vodafone	O2	H3G	UK B
BT/EE wins all 2.3 GHz & 3.4 GHz spectrum	**53%**	21%	10%	11%	5%
Vodafone wins all 2.3 GHz & 3.4 GHz spectrum	30%	**44%**	10%	11%	5%
O2 wins all 2.3 GHz & 3.4 GHz spectrum	30%	21%	**33%**	11%	5%
H3G wins all 2.3 GHz & 3.4 GHz spectrum	30%	21%	10%	**33%**	5%

[30] We note that in the other European countries we considered in Annex 6, it is unusual for a market with four or more MNOs to have two operators with less than 15% of the useable spectrum. Slovenia and the Netherlands both have two operators with less than 15% of the share. However, our understanding is that the operators with the smallest shares in each market (Ziggo in the Netherlands and T-2 in Slovenia) may not be what we would regard as credible MNOs.

[31] This table shows the possible holdings when the following bands are included 800 MHz, 900 MHz, 1400 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz, 2.6 GHz (paired and unpaired) and 3.4 GHz spectrum. This table excludes the 700 MHz and 3.6-3.8 GHz spectrum.

4.38 Such asymmetric distributions of spectrum would normally raise significant competition concerns for the reasons discussed above. However Figure 4.1 shows all the spectrum that will be allocated immediately after the auction, but does not take into account that some of that spectrum will not be useable immediately. As described further in annex 5, there are currently no mobile user devices capable of using the 1400 MHz spectrum already allocated to Vodafone and H3G. Similarly, the 3.4 GHz spectrum is not expected to be useable for at least two to three years after the auction due to a lack of suitable user devices.

4.39 For this assessment we identify a 'transitional period' from immediately after the 2.3 and 3.4 GHz auction until the time when the 3.4 GHz spectrum is useful for mobile services because it is in the handsets of a sufficient proportion of the customer base.[32] During this transitional period the 2.3 GHz spectrum is useable but the 3.4 GHz spectrum is not. We expect the transitional period to last for at least two to three years. We refer to the 'longer term' as meaning the period from the end of this transitional period up to 5-10 years after the auction. The whole period from immediately after the auction to 5-10 years into the future is the timeframe we consider for this competition assessment.

4.40 Importantly, when the 3.4 GHz spectrum does become useable, we expect other mobile spectrum to also be useable, and Figure 4.1 does not include this other spectrum.

Other mobile spectrum will be useable in the longer term

4.41 In annex 5 we assess what spectrum bands are likely to be used for mobile services in the future. Drawing on the conclusions in that annex, Figure 4.2 shows when future spectrum may be useable, taking account of both when particular spectrum is likely to become available and when the bands are likely to be included in mainstream user devices.[33]

4.42 The 'faded' nature of some of the bars in this table is to reflect the uncertainty on when, or if, the spectrum will become useable for mobile services. We have not included in this table all possible spectrum that may become useable over this time period - such as at 1427-1452 and 1492-1518 MHz and the lower 2.3 GHz spectrum - since there is more uncertainty over when and if these bands may become useable in the UK. The right hand side of the table shows the changing spectrum shares for MNOs as more spectrum is included, on the assumption that they do not acquire any of the additional spectrum.

4.43 In annex 8 we also set out the shares of downlink spectrum only. There is an argument that downlink spectrum shares are more relevant than spectrum overall given the asymmetric nature of traffic (with downlink traffic being many times greater than uplink traffic). However, we note that uplink constraints in a network can also be important given the relative performance of the uplink with lower power devices compared to the downlink, and so we have retained our focus on total overall spectrum. We do not consider that our analysis or proposals would be fundamentally changed by considering only downlink spectrum.

[32] We consider that spectrum can be useful for adding capacity even when it is in only a minority of user devices. This is because traffic can be offloaded from those devices that can use the spectrum, freeing up other bands for those devices that cannot use the spectrum.

[33] For the spectrum that will be auctioned in the future, such as the confirmed 700 MHz award and proposed 3.6-3.8 GHz award, we assume that it is auctioned sufficiently in advance that it would be possible to deploy it as soon as it is available and there are sufficient handsets.

Figure 4.2: Spectrum shares as more mobile spectrum available

Possible timescales for when spectrum may be useable / **Spectrum shares as more bands included**

Commentary on spectrum bands	2016	2017	2018	2019	2020	2021	BT	Voda	O2	H3G	UKB	To be auctioned	Total spectrum (MHz)
These bands already allocated and useable	567 MHz at 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz and 2.6 GHz						45%	28%	15%	12%			567
2.3 GHz in some important handsets now and useable as soon as can be deployed after auction		40 MHz at 2.3 GHz					42%	26%	14%	11%		7%	607
1452-1492 MHz already allocated, but currently not in handsets			40 MHz at 1400 MHz (20 MHz each held by VF and H3G)				39%	27%	13%	14%		6%	647
3.4 GHz currently not in handsets and may take longer than 1400 MHz to appear in handsets				190 MHz at 3.4 GHz (40 MHz held by UKB)			30%	21%	10%	11%	5%	23%	837
Paired 700 MHz likely to be in handsets and useable as soon as spectrum available					60 MHz at 700 MHz		28%	20%	10%	10%	4%	28%	897
Centre gap at 700 MHz available at same time as paired 700 MHz, but less certain will be in handsets then					20 MHz at 700 MHz		28%	19%	9%	10%	4%	29%	917
3.6-3.8 GHz likely to be in handsets at similar time as 3.4 GHz, but may be some restrictions on use and no decision to make the part not already allocated to UK Broadband available for mobile use				200 MHz at 3.6-3.8 GHz (84 MHz held by UKB)			23%	16%	8%	8%	11%	35%	1117

4.44 Figure 4.3 below shows what the spectrum shares would be in the extreme case of one of the four MNOs obtaining all the spectrum in this auction, when the 700 MHz and 3.6-3.8 GHz spectrum bands are also included.

Figure 4.3: Spectrum shares if operators win all/no additional spectrum when future spectrum included[34]

	BT/EE	Vodafone	O2	H3G	UK B	700 MHz and 3.6-3.8 GHz
BT/EE wins all 2.3 GHz & 3.4 GHz spectrum	**40%**	16%	8%	8%	11%	18%
Vodafone wins all 2.3 GHz & 3.4 GHz spectrum	23%	**33%**	8%	8%	11%	18%
O2 wins all 2.3 GHz & 3.4 GHz spectrum	23%	16%	**25%**	8%	11%	18%
H3G wins all 2.3 GHz & 3.4 GHz spectrum	23%	16%	8%	**25%**	11%	18%

4.45 If we award the remaining spectrum at 3.6-3.8 GHz with few restrictions on it, then even in the extreme outcome of BT/EE obtaining all the spectrum in this award, it would only have obtained around 40% of mobile spectrum available in the longer term.

4.46 Moreover, it will be Ofcom that will design the confirmed 700 MHz auction and proposed 3.6-3.8 GHz auctions. We would have the ability to impose competition measures in future auctions that are appropriate and proportionate to address any competition concerns that we might have at that point.

Degree of certainty about other spectrum being useable in the future

4.47 The degree of certainty about other spectrum being available and useable in the future is an important difference between our assessment of competition issues now and our assessment for the 2013 auction.

4.48 In that previous assessment, we considered a timeframe up to 5-10 years into the future. During that timeframe, we concluded that we should not rely on other potential spectrum releases for enabling an MNO to be credible. This was because of the uncertainties about the timing of release of spectrum, and also about the availability of user devices.[35] For this award, while there is uncertainty about the precise timing of the releases of bands and the availability of user devices, it is now more certain that other bands will be made available and also that there will be user devices available.

4.49 In particular, the release of the 700 MHz band is now clearer. We have decided to make the 2x30 MHz and the 20 MHz centre gap of the 700 MHz band available and to bring forward its release, so as to complete clearance in Q2 2020.[36] If there is a period when the 3.4 GHz spectrum is useable and the 700 MHz band is not, we expect it to be very short. Also, the availability of user devices for bands other than 700 MHz, particularly in the 3.4–3.8 GHz band, is now more certain than it was in 2012.

[34] UK Broadband's share of spectrum in this table includes its 84 MHz in the 3.6-3.8 GHz band (as well as its 40 MHz at 3.4 GHz). The 700 MHz spectrum includes the 20 MHz of unpaired 700 MHz.
[35] See paragraph A2.80 to A2.84 of Annex 2 of our July 2012 statement.
[36] *Maximising the benefits of 700MHz clearance*, statement, Ofcom, 17 October 2016, https://www.ofcom.org.uk/consultations-and-statements/category-1/maximising-benefits-700mhz-clearance#

4.50 While the release of more spectrum at 3.6-3.8 GHz for mobile use is not as certain as at 700 MHz, we are currently proposing to make 116 MHz of spectrum in that band available for mobile services.[37]

4.51 This spectrum is of high priority for mobile use, particularly given its potential to be used for 5G. We believe this band could be available within a similar timeframe as 3.4 GHz because it is already harmonised for mobile use in Europe and there is momentum in industry for the wider 3.4-3.8 GHz band for 5G.

4.52 We are aware of existing equipment operating in the 3.6-3.8 GHz band and understand that at least some chipsets cover the wider 3.4–3.8 GHz band, thus enabling products to operate in 3.6-3.8 GHz on the same timescale as the 3.4 GHz band.

4.53 We recognise in the 3.6-3.8 GHz consultation there are different options to make this band available including retaining existing user's authorisations, or removing them. Each policy option will entail different timelines for availability and constraints on use. When deciding on what policy option to follow, we will naturally take utmost account of the importance of this band for competition and consumers.

Provisional conclusion on Competition Concern 1(i) (the likelihood of very asymmetric *overall* spectrum shares distorting competition)

4.54 We recognise that a very asymmetric distribution of spectrum may, in principle, weaken competition and that as a result of the auction overall mobile spectrum shares could become very asymmetric. However, the 3.4 GHz band is not useable immediately and by the time it becomes useable, other spectrum will have become available. This significantly limits our concern about competition being weakened due to the distribution of overall spectrum holdings immediately after this auction.

4.55 As there is a possibility that the timeframe for availability of 3.6-3.8 GHz is later than for 3.4 GHz, when we consider possible competition measures in section 4, we consider options that take account of this possibility.

Competition Concern 1(ii): The risk of very asymmetric holdings of *immediately useable* spectrum

4.56 In our November 2014 consultation we did not consider the award of the 2.3 GHz spectrum raised any specific issues, such that it should be considered separately from the 3.4 GHz spectrum. While we recognised that there was a better selection of user devices for the 2.3 GHz spectrum than the 3.4 GHz spectrum, our provisional view was that this did not raise any significant competition concerns. This was because we took the view that all MNOs had sufficient spectrum to be credible competitors in the short term, and there would be a reasonable selection of user devices for 3.4 GHz in the longer term.[38]

4.57 Some stakeholders who responded to the November 2014 consultation strongly disagreed with our view that the frequencies were sufficiently substitutable. Between them, they argued there were a number of distinctions between the two bands which

[37] *Improving consumer access to mobile services at 3.6 to 3.8 GHz*, Ofcom, 6 October 2016, https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz
[38] See in particular paragraphs 7.80 to 7.82 of the November 2014 consultation.

meant, they said, that we should treat them differently for the purposes of our competition assessment. They argued:

- The handset and network **equipment ecosystem** for 3.4 GHz is much less developed than for the 2.3 GHz spectrum;
- The 3.4 GHz spectrum has inferior **propagation characteristics** compared to the 2.3 GHz band; and
- The 3.4 GHz spectrum is less compatible with existing network infrastructure which will affect the **speed/ease of deployment**.

4.58 We have reconsidered whether there may be any competition concern in the transitional period when there is not a sufficiently developed ecosystem for the 3.4 GHz spectrum. For the reasons set out below, our provisional assessment is that there is a significant risk that competition could be weaker during this transitional period if there are increasingly asymmetric spectrum holdings.[39]

4.59 The adverse effect of any such weakening in competition may be significant. However, there are some limits to the extent of consumer harm. This is because there will be other spectrum that will be useable in the longer term, which operators with low spectrum holdings would be able to acquire, including the 3.4 GHz spectrum and the 700 MHz spectrum. The effect is therefore likely to be temporary. Additionally, the impact is likely to be most relevant to some customer segments rather than all customers. We take into account these points on the likely scale of consumer detriment in considering the weight we should place on this competition concern (this is relevant to our assessment of proportionality of competition measures in section 5).

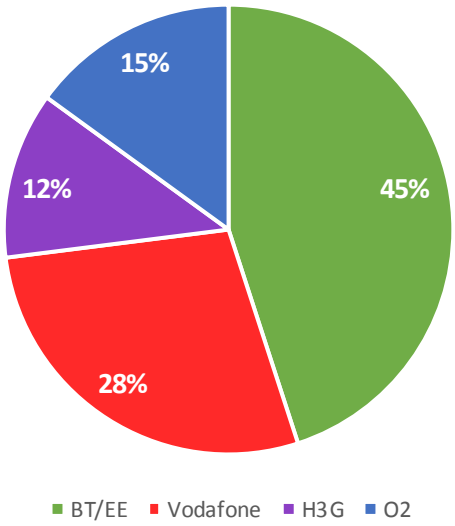
4.60 We also consider below the arguments raised by stakeholders about why the 3.4 GHz spectrum may not be sufficiently substitutable even after the transitional period. Whilst our provisional view is that 3.4 GHz spectrum will be sufficiently substitutable after the end of the transitional period, we acknowledge that, if it were not, this would be likely to make the consumer harm from very asymmetric holdings of immediately useable spectrum more enduring.

Distribution of immediately useable (rather than overall) spectrum could become increasingly asymmetric

4.61 If we consider the immediately useable spectrum, and so exclude the 1400 MHz spectrum and 3.4 GHz spectrum[40], then the distribution of the currently allocated spectrum is as shown in the pie chart in Figure 4.4 below.

[39] The key changes in our assessment now compared to that at November 2014 are that (1) immediately useable spectrum is now more concentrated as a result of the merger of BT and EE and (2) we recognise that there is a risk that at least one MNO may encounter difficulties adding capacity to meet demand.
[40] UK Broadband currently uses 40 MHz of 3.4 GHz spectrum for fixed wireless broadband only and therefore we do not consider it as immediately useable for mobile uses.

Figure 4.4: Current allocation of immediately useable spectrum (including 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz and 2.6 GHz)



4.62 The distribution of immediately useable spectrum in the UK became more concentrated as a result of the merger between BT and EE. In the 2013 auction, EE won the maximum amount it was permitted to acquire and held 37% of mobile spectrum. When EE's spectrum was combined with BT's holdings of 8%, the combined BT/EE holdings became 45%. The combined holdings of BT/EE are therefore above the overall spectrum cap we set in the 2013 auction (we discuss the CMA's merger assessment below)

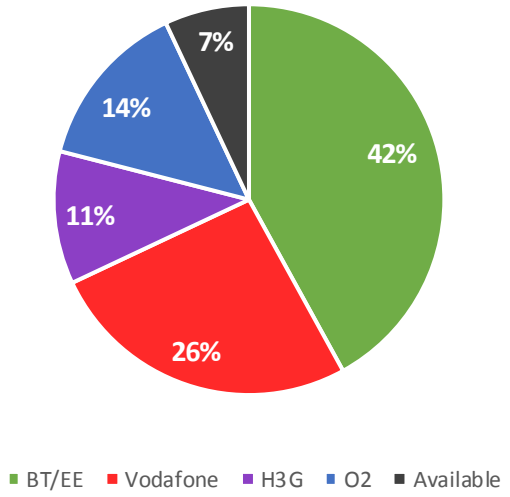
4.63 While we did not consider that BT could become an MNO with only its holdings of spectrum at 2.6 GHz, in our November 2014 consultation we considered that BT's independent holdings of spectrum could be positive for mobile competition. With the merger between BT and EE, that is no longer relevant.[41]

4.64 As we describe in annex 6, when we compare the current asymmetry of spectrum held by MNOs in the UK with that in other European countries where there are four credible MNOs, we find the UK has one of the most asymmetric spectrum distributions.[42] Although the summary statistics in annex 6, such as the Gini coefficient cannot capture all aspects of the spectrum distributions, they provide an illustration of the comparative degree of asymmetry.

4.65 Given that the 2.3 GHz spectrum will also be immediately useable after the auction, in our view it is more meaningful to consider shares of spectrum also including the 2.3 GHz spectrum. Figure 4.5 below therefore shows all the spectrum that will be useable immediately after the award, including the 2.3 GHz spectrum. It shows that the 2.3 GHz spectrum represents around 7% of such spectrum. It also shows that BT/EE will have 42% of immediately useable spectrum after the award, if it does not obtain any 2.3 GHz spectrum.

[41] See paragraphs 7.83 to 7.86 of the November 2014 consultation for more explanation of the potential relevance of BT and UK Broadband. Since BT merged with EE, this discussion is only now relevant for UK Broadband.
[42] Slovenia has an even more asymmetric distribution of spectrum. However, it may not be correct to describe Slovenia as having four credible MNOs, as we understand that the operator with the smallest spectrum share has a very low share of subscribers and may not be a strong constraint on rivals, and has filed for bankruptcy.

Figure 4.5: Immediately useable spectrum after auction, including 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz, 2.6 GHz plus 2.3 GHz



4.66 If BT/EE were to obtain all 40 MHz of 2.3 GHz spectrum, its share of immediately useable spectrum would rise from 42% to nearly half (49%). In contrast H3G would only have 11% (before the 1400 MHz is useable) and O2 would have 14%, with Vodafone having 26%. Such a very asymmetric distribution of immediately useable spectrum raises significant concerns about competition being weaker than it might otherwise be in the transitional period.

Very asymmetric holdings of immediately useable spectrum could weaken competition in the transitional period

4.67 We recognise that the current degree of asymmetry does not appear to have led to a significant competition problem for mobile consumers overall up to now. For example, the two MNOs with the smallest spectrum shares, H3G and O2, have generally gained overall subscribers in recent years while prices have remained competitive compared to international benchmarks, as we discuss in annex 7.[43]

4.68 However, during the transitional period, we are concerned that competition could become weaker, as mobile data use continues to grow and MNOs need to continue to add capacity to be able to compete effectively. MNOs with much smaller useable spectrum shares may not be able to add capacity as cost effectively as the operator with the highest share, which may tend to weaken competition for some customers over the transitional period.

4.69 Our concern that a very asymmetric distribution of immediately useable spectrum may weaken competition is increased because there is a risk that at least one MNO may encounter difficulties adding sufficient spectrum capacity to meet demand in the transitional period without 2.3 GHz spectrum, as we discuss in the next sub-section.

[43] [✂] REDACTED In Annex 7 we also note that H3G's share of traffic has fallen. However, H3G continues to provide a share of data traffic well in excess of its share of subscribers, and that its share of subscribers and its cashflows have continued to grow even as its traffic share has declined. The fall in H3G's traffic share does not necessarily mean that competition is weakening.

Assessment of MNOs' network capacity in transitional period

4.70 As we have already noted, in addition to using more spectrum, capacity can also be added by densifying the network topology (such as increasing the number of cells); moving to more efficient technologies; or using licence exempt spectrum (such as the 5 GHz bands) to provide additional capacity.

4.71 In annex 8, we consider the ability of an MNO to add capacity in the transitional period and the longer term as well as the impact of user speeds. When we consider if MNOs may struggle to add sufficient capacity to meet growing demand in the transitional period, we focus on O2 and H3G, as they have lower shares of spectrum. In contrast, both BT/EE and Vodafone have higher shares of spectrum, and currently carry the least data per MHz of spectrum they hold, as shown in Figure 3.4 above. In addition, BT/EE achieves the highest average 4G speeds in performance tests, as set out in annex 7.

4.72 We consider that in the longer term many of the ways listed above will provide an ability to add network capacity to varying degrees. However, we recognise that some of these options are not available in the short term and can only feasibly be implemented in a longer timeframe (e.g. by adding sites in high-dense urban areas).[44]

4.73 Our provisional conclusion on potential capacity constraints is that [✂] REDACTED. We have taken into account this provisional conclusion on the assessment of the available evidence on capacity constraints in our policy proposals.

CMA's assessment of the merger between BT and EE

4.74 In submissions to the CMA in late 2015 in the context of the BT/EE merger, various operators raised concerns about capacity constraints in the future.[45] For example, H3G said that it will face capacity constraints in the coming years.[46]

4.75 The CMA considered in detail whether the merger would lead to a substantial lessening of competition in the retail mobile market because other operators faced capacity constraints:

> *The CMA "considered whether the competitiveness of the retail mobile market was likely to decline absent the merger, due to possible capacity constraints of some operators, and whether BT would therefore have become a more important competitor. We considered capacity constraints in detail and our view is that, although some MNOs face challenges, it is unlikely that they would individually or in combination be sufficiently and enduringly*

[44] We are interested in the extent capacity can be added in the transitional period (i.e. before the 3.4 GHz spectrum is useable) without additional immediately useable spectrum. The further into the transitional period (and the longer the transitional period), the more we might expect network MNOs to be able to add network capacity in other ways.
[45] See section 14 of the *BT Group plc and EE Limited: A report on the anticipated acquisition by BT Group plc of EE Limited*, CMA, 15 January 2016, https://assets.publishing.service.gov.uk/media/56992242ed915d4747000026/BT_EE_final_report.pdf
See also paragraphs 28 to 32, Appendix G, *BT Group plc and EE Limited: A report on the anticipated acquisition by BT Group plc of EE Limited*, CMA, 15 January 2016, https://assets.publishing.service.gov.uk/media/56991ae4ed915d468c00002b/FR-Appendices_and_Glossary.pdf
[46] Paragraph 14.70, *BT Group plc and EE Limited: A report on the anticipated acquisition by BT Group plc of EE Limited*, CMA, 15 January 2016.

weakened by any potential capacity constraints to the extent that the loss of BT from the retail mobile market is expected to lead to a substantial lessening of competition."[47]

4.76 The CMA's conclusion was partly based on evidence that, without the merger, BT (as an MVNO) would have provided limited additional competition to MNOs, and that BT was not currently a strong competitor in retail mobile and that its market share forecasts were modest.[48] Because the CMA did not consider that BT was currently a strong competitor in retail mobile, it focussed its assessment of the merger on mobile competition in the medium to long term, after operators could obtain new spectrum, rather than on competition in the next few years.[49]

4.77 We are not considering whether, without the BT/EE merger, BT would have been a strong competitor in mobile in the transitional period. Rather we are considering whether a further concentration of useable spectrum may weaken mobile competition, at least for some temporary period of time. There is therefore no tension between the CMA's finding that BT would have added little to retail mobile competition in the short term and our concern that a further concentration of immediately useable spectrum may harm mobile competition.[50]

Provisional conclusion on Competition Concern 1(ii) (the risk of very asymmetric holdings of immediately useable spectrum)

4.78 If BT/EE obtained 2.3 GHz spectrum, the distribution of immediately useable spectrum would become increasingly asymmetric. In the extreme, if BT/EE obtained all the 2.3 GHz spectrum, only half (51%) would be available for other operators. We are concerned that a further concentration of immediately useable spectrum would mean that competition would be weaker than it would otherwise be for the reasons discussed above.

4.79 The adverse effect of any such weakening in competition may be significant. In particular, it may lead operators with small spectrum shares to compete less strongly, especially for specific customer segments, such as those high value consumers who demand consistently high data speeds. This could result in increased prices for those customers to moderate the increase in data traffic of such operators.

4.80 However, there are some limits to the extent of consumer harm. This is because, as discussed below, there will be other spectrum that will be useable in the longer term, which operators with low spectrum holdings would be able to acquire. This includes

[47] Paragraph 18, *BT Group plc and EE Limited: A report on the anticipated acquisition by BT Group plc of EE Limited*, CMA, 15 January 2016.
[48] Paragraph 11.81, *BT Group plc and EE Limited: A report on the anticipated acquisition by BT Group plc of EE Limited*, CMA, 15 January 2016.
[49] The CMA said "The theories of harm we are assessing involve potential effects on competition from the merger that would not arise for several years – that is, over time as BT potentially grew as a mobile retailer; and in future when the MVNO contracts of Sky, TalkTalk and Virgin become subject to new negotiations. For that reason, we consider it appropriate to consider MNOs' capacity in the medium to long term, including how it may be affected by the deployment of new spectrum." Paragraph 71, Appendix G, *BT Group plc and EE Limited: A report on the anticipated acquisition by BT Group plc of EE Limited*, CMA, 15 January 2016, https://www.gov.uk/cma-cases/bt-ee-merger-inquiry
[50] In our submission of 31 July 2015 to the CMA on the BT/EE merger, we did not consider that other MNOs would be capacity constrained in the longer term, as all MNOs would have a reasonable opportunity to increase capacity, including through the acquisition of spectrum in auctions. It was therefore only in the shorter term that there could be a question over whether other MNOs may be unable to increase capacity sufficiently to keep pace with increasing demand. See paragraphs 1.14 and 3.28 to 3.45, https://assets.digital.cabinet-office.gov.uk/media/55cc79abe5274a547300002f/Ofcom_Phase_2_submission.pdf

the 3.4 GHz spectrum and the 700 MHz spectrum. The effect is therefore likely to be temporary.

4.81 There is also a risk that at least one of [✂] REDACTED may encounter difficulties adding sufficient capacity to meet deamnd in the transitional period if it does not obtain 2.3 GHz spectrum. This increases our concern about a very asymmetric distribution of spectrum in the transitional period.

4.82 We therefore consider in section 5 competition measures that would prevent an increasingly asymmetric distribution of immediately useable spectrum, alongside other options for competition measures.

4.83 Moreover, if at least one of [✂] REDACTED is capacity constrained [✂] REDACTED. We also consider such options in section 5.

4.84 However, [✂] REDACTED. For example, even if some MNOs were capacity constrained, it might still strengthen competition if operators with a higher spectrum share gained additional spectrum, or if new entrants gained spectrum, *if* those operators could use that spectrum in a way that was very attractive to consumers. In this context, we note that both O2 and H3G have generally increased their share of subscribers over recent years, suggesting they are strong competitors, despite having smaller shares of spectrum than BT/EE and Vodafone.

4.85 We give most weight to this concern about the distribution of immediately useable spectrum when we consider possible competition measures in section 5 of this document. This reflects the evidence about the greater likelihood that it would arise compared to other competition concerns (and despite the limitations on the scale of the adverse effect, discussed above).

Concerns about the allocation of 2.3 GHz spectrum in the longer term

3.4 GHz spectrum should be a substitute for 2.3 GHz in the longer term

4.86 After the transitional period, there will be mobile user devices that can use the 3.4 GHz spectrum. However, some stakeholders have argued that the higher frequency of the 3.4 GHz band means its propagation characteristics are inferior to 2.3 GHz spectrum and other mobile bands in terms of indoor penetration. Some respondents to earlier consultations told us that the 3.4 GHz band may be more relevant for small cell deployment, rather than macro cells. However, we note that UK Broadband uses 3.4 GHz spectrum on macro cells.

4.87 One stakeholder has also argued that the 3.4 GHz spectrum will be more difficult and costly to deploy than the 2.3 GHz band, because it is more suitable for small cells.

4.88 Even if the 3.4 GHz spectrum were only used for small cells, we note that small cells are likely to be of growing importance in the future as a means to increase mobile capacity in congested areas - and the propagation characteristics of the 3.4 GHz frequencies means that cells can achieve greater isolation which could perform even better than 2.3 GHz in a small cell network. This could mean that the 2.3 and 3.4 GHz spectrum may be regarded as substitutable to some extent even if the 3.4 GHz were only used mainly for small cells.

4.89 Despite these potentially different ways of using the spectrum, on balance, we remain of the view that the 3.4 GHz spectrum is likely to be sufficiently substitutable for the 2.3 GHz spectrum (and other mobile bands) in terms of adding capacity in the

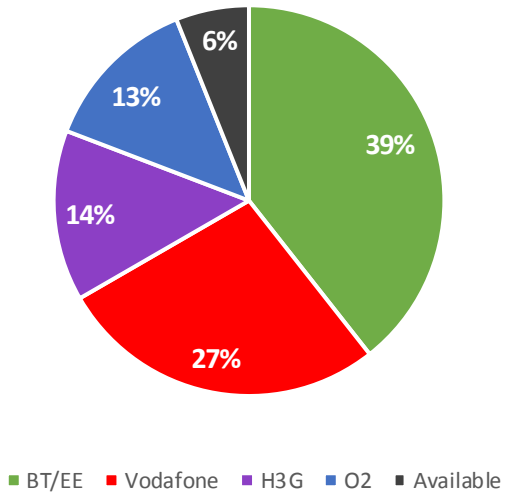
longer term. This is particularly so in areas of high congestion where additional capacity is likely to be most needed.

Risk of enduring competition concerns if 3.4 GHz spectrum is insufficiently substitutable

4.90 While we consider the 3.4 GHz spectrum will be a sufficient substitute for other mobile bands to add capacity in the longer term, there is some risk it may not be. There is therefore the possibility that the competition concerns in the transitional period that are discussed above in relation to the allocation of the 2.3 GHz spectrum could be more enduring.

4.91 In the longer term, we expect the 1400 MHz spectrum to be sufficiently substitutable for other mobile bands (even if the 3.4 GHz is not). When we include the 1400 MHz spectrum, H3G's and Vodafone's shares of spectrum increase. Figure 4.6 below shows the distribution when the 1400 MHz spectrum is included, but the 3.4 GHz spectrum is not.

Figure 4.6: Future mobile spectrum, including 1400 MHz, excluding 3.4 GHz (800 MHz, 900 MHz, 1400 MHz, 1800 MHz, 2.1 GHz 2.3 GHz and 2.6 GHz)



4.92 The illustration ignores other spectrum that will be available in the future, such as the 700 MHz spectrum, which we have noted we aim to make available in Q2 2020.[51] The availability of the 700 MHz spectrum could mitigate longer term concerns about the allocation of the 2.3 GHz spectrum.

Even if 3.4 GHz becomes sufficiently substitutable, there is still some risk that competition concerns relating to 2.3 GHz may be enduring

4.93 If there are operators who are competitively disadvantaged during the transitional period, they will have the opportunity to compete more strongly as that disadvantage diminishes. For example, if an operator is unable to serve a particular type of customer during the transitional period - and as a result loses some of those

[51] BT/EE's currently holdings of 255 MHz would represent 35% of total mobile holdings if the 700 MHz spectrum were also included (and the 3.4 GHz spectrum excluded).

customers - it will be able to compete to regain them after the transitional period as its disadvantage reduces.

4.94 However, it seems likely that it will take some time for customers to be regained. This might be because:

- If the MNO obtains a reputation for being a weak competitor during the transitional period for some customer segments, it may take time for this to be reversed;
- The pace of consumers switching providers may be constrained if they face contractual and non-contractual costs associated with switching, such as being in a 2-year contract. In addition, there may be some inertia that limits how quickly consumers churn to other operators as retail prices change.

4.95 On the other hand, the mobile market is highly dynamic, with rapid changes of technology and consumer preferences. We have also made proposals to improve the switching process for mobile consumers.[52] This makes it less likely that effects such as the ones described would be long lasting.

4.96 So while we would expect the effects of a reduction in competition in the transitional period to erode over time, we recognise the risk that this process could take some time.[53]

Competition Concern 1(iii): The risk of very asymmetric shares of 3.4 GHz spectrum

4.97 The possibility of 3.4 GHz spectrum being used for new 5G mobile services - as part of a larger block of spectrum between 3.4 and 3.8 GHz - has increased since the publication of our earlier consultations. For example, the RSPG, the high-level advisory group that assists the EC in the development of radio spectrum policy,[54] recently identified the wider 3.4-3.8 GHz band as the *"primary band suitable for the introduction of 5G use in Europe even before 2020".*[55] We also note that this band could be re-farmed from early 4G use to subsequent 5G use if necessary.

4.98 Also, a manifesto signed by many large companies in the mobile industry identified the potential for 5G in the 3.4-3.8 GHz band when it called for it to be licensed across the EU in time to enable 5G deployment before 2020 alongside other bands.[56]

4.99 It is not yet clear what the optimum channel size for 5G will be, but there are views that large contiguous blocks of spectrum – perhaps with channels of 40-100 MHz wide may be desirable. It is therefore possible that there might be interest from some

[52] In March this year we consulted on proposals to improve the mobile switching process for consumers. In July, we outlined further proposals specifically to address the difficulties that consumers face when they switch mobile services where they need to give notice to terminate their existing service. These documents can be found at the following links:
https://www.ofcom.org.uk/consultations-and-statements/category-2/mobile-switching-jul16
https://www.ofcom.org.uk/consultations-and-statements/category-1/consumer-switching-mobile

[53] This is consistent with the analysis in our August 2012 decision to vary Everything Everywhere's 1800 MHz spectrum licences to allow use of LTE and WiMax technologies – see pp32-33 in
https://www.ofcom.org.uk/__data/assets/pdf_file/0021/74307/statement.pdf

[54] http://rspg-spectrum.eu/

[55] *Public consultation on the Draft RSPG Opinion on spectrum related aspects for next-generation wireless systems (5G),* June 2016, https://circabc.europa.eu/d/a/workspace/SpacesStore/1a40dd19-c8a8-4ed0-bc9c-6cc5a7755f7d/RSPG16-031Final_Opinion_5G_for_public_consultation.pdf

[56] *5G Manifesto for timely deployment of 5G in Europe,* July 2016,
http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=16579

operators in acquiring a large block of the 3.4 GHz spectrum with a view to using it for 5G services in the future.

4.100 If the 3.4 GHz spectrum were to become important for launching 5G services and it was more difficult to launch 5G services with existing mobile bands, then competition in the provision of 5G might be weaker if only some of the operators had 3.4 GHz spectrum and could offer such services.

4.101 However, there are various mitigations that suggest that competition might not necessarily be weaker even if only one or two operators obtain the 3.4 GHz spectrum in the auction:

- UK Broadband already holds 40 MHz of 3.4 GHz spectrum and 84 MHz at 3.6-3.8 GHz.[57]
- Other spectrum may be available in the future which would be suitable for 5G, including at 3.6-3.8 GHz[58] and at 700 MHz[59].
- There is uncertainty over whether the 3.4 GHz spectrum will be important for the launch of 5G services and whether it will be difficult to launch 5G with existing bands. There is also uncertainty over the incremental value that consumers might put on 5G services relative to 4G services.

4.102 Because of these mitigations and uncertainties, we place lower weight on competition concerns relating specifically to 3.4 GHz spectrum.

Competition Concern 2: Risk of there ceasing to be four credible MNOs

4.103 As explained in section 3, the UK mobile market is currently made up of four MNOs: BT/EE, Vodafone, O2 and H3G, together with a range of MVNOs.

4.104 We remain of the view that it is in consumers' interests for there to be at least four credible MNOs.[60] The existence of four MNOs supports competition both directly and indirectly. It supports retail competition directly because MNOs are major competitors in supplying retail mobile services to consumers. It also supports retail competition

[57] While it is theoretically possible that UK Broadband could itself obtain all 150 MHz of the 3.4 GHz spectrum in the award, given that UK Broadband is not a significant competitive constraint in the mobile market currently, this could strengthen rather than weaken mobile competition in general.
[58] We note that if we consider together the 190 MHz of the 3.4 GHz spectrum and the 200 MHz of 3.6-3.8 GHz spectrum that may be available in the future, then the 150 MHz of 3.4 GHz spectrum that is available in the auction represents around 40% of the 3.4-3.8 GHz spectrum. In this context, if one MNO obtained all 150 MHz of 3.4 GHz spectrum in this auction, this may not raise competition concerns, provided the 3.6-3.8 GHz spectrum is made available in a timely way without material restrictions.
[59] The RSPG believes that "5G will need to be deployed also in bands already harmonised below 1 GHz, including particularly the 700 MHz band". See *Public consultation on the Draft RSPG Opinion on spectrum related aspects for next-generation wireless systems (5G),* June 2016, https://circabc.europa.eu/d/a/workspace/SpacesStore/1a40dd19-c8a8-4ed0-bc9c-6cc5a7755f7d/RSPG16-031Final_Opinion_5G_for_public_consultation.pdf
[60] For a longer explanation of our reasons for favouring a market with at least four MNOs see paragraphs 7.24 to 7.34 of the November 2014 consultation, https://www.ofcom.org.uk/__data/assets/pdf_file/0025/78055/Public_Sector_Spectrum_Release_2-3_and_3-4_ghz_award.pdf

indirectly because the MNOs can compete in terms of providing wholesale access to MVNOs.

4.105 All four MNOs currently provide wholesale access, although they may not all tender for all contracts or provide all services (e.g. some MNOs do not include 4G services in all of their wholesale offers).[61] We consider that wholesale access provided through strong competition between MNOs is likely to lead to better outcomes than if regulation were needed to require wholesale access because competition were not sufficient.

4.106 While a potential disadvantage of having four - rather than fewer - MNOs is that total industry costs may be higher as a result of the large fixed costs involved with a mobile network, this can be mitigated by the ability to share some assets, for example through network sharing arrangements.

4.107 Our views regarding the desirability of retaining four credible MNOs in the UK are consistent with the recent decision of the European Commission to block the proposed acquisition of O2 by H3G, which we support.[62]

Framework for assessing credible spectrum portfolios

4.108 In our competition assessment for the 2013 auction, we compared the spectrum holdings of the existing four MNOs against a framework of what might be sufficient to ensure each MNO was capable of being a credible competitor in the future. We adopt a similar approach here.

4.109 Below we describe the framework we used for the 2013 auction and then update it. Figure 4.7 sets out the conclusions we reached in the 2013 auction on the four quality dimensions we considered when assessing whether a spectrum portfolio would be sufficient to allow an MNO to be credible.[63]

[61] Even if one of the four MNOs ceased to offer MVNO access, the presence of four MNOs competing strongly in the retail market will support competition in providing wholesale access. This is because an MNO that does not offer wholesale access to MVNOs will still exert an indirect constraint on the wholesale access pricing of those MNOs that do offer wholesale access, because of switching in the downstream retail market. An MNO offering wholesale access faces some constraint on raising prices to an MVNO which it supplies because, even if the MVNO does not switch to a different MNO, it is likely to pass the price increase on to its customers, some of whom may respond by switching to the MNO that does not provide access, which could make the price rise unprofitable.

[62] http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=2_M_7612

[63] The table is reproduced from Figure 4.2 in our July 2012 statement.

Figure 4.7: Conclusions on dimensions of capability (each considered in isolation) and spectrum for credibility from 2013 auction assessment

Quality dimension	Necessary condition for credibility?	Important for helping provide sufficient capability for credibility?
Capacity and average data rates	**Necessary** to have enough capacity to deliver a competitive average data rate. Not necessary to have 25% of paired spectrum, partly because there are other ways of providing capacity. There is a **material risk of not achieving the necessary minimum if hold less than 10-15%** of paired spectrum after the Auction.	**Greater spectrum share than 10-15%** increases capability. A much larger holding than this is an **important capability strength**.
Quality of coverage	**Necessary** to have enough quality of coverage. **Sub 1 GHz spectrum is unlikely to be necessary**, given alternative ways of providing good quality coverage. **Greater risk of not having the necessary minimum quality of coverage the higher the frequency** on which the national wholesaler is relying for coverage.	While unlikely to be necessary, **sub 1 GHz spectrum** is likely to give some advantage and so is an **important capability strength**.
Highest peak data rates	**Unlikely to be necessary** to deliver highest peak data rates for credibility. So unlikely that access to 2x15 MHz or 2x20 MHz contiguous block of 800 MHz, 1800 MHz or 2.6 GHz spectrum is necessary to be credible.	Ability to deliver highest peak data rates may be a source of capability strength, but it is **unclear** how important this is as a contribution to credibility.
Other LTE advantages (e.g. better latency)	**Unclear** that it is necessary to deliver services with other LTE advantages, such as better latency, in the near term. So unclear that access to 800 MHz, 1800 MHz or 2.6 GHz spectrum is necessary to be credible. However, providing LTE services **is more likely to be necessary longer term** to be credible. In the longer term 900 MHz spectrum is likely to provide a route to LTE.	Other LTE advantages may be a source of capability strength, but it is **unclear** how important as a contribution to credibility. Longer term, the **importance of this strength is likely to grow**, and 900 MHz spectrum is likely to provide a route to LTE.

4.110 **Capacity and average data rates:** We consider it remains necessary to have sufficient spectrum for *capacity* to deliver a competitive average data rate to customers. We reconsider below the conclusion from the 2013 auction assessment about the appropriate share of spectrum required.

4.111 **Quality of coverage:** We also consider that spectrum for sufficient *coverage* is necessary. As discussed in paragraphs below, all four MNOs currently have at least the minimum spectrum necessary for coverage. The technical characteristics of the spectrum which we are auctioning also mean that it is not an effective means of extending existing levels of mobile coverage.

4.112 **Highest peak data rates**: We note that it is now possible to offer much higher peak data rates[64] than at the time of the 2013 auction through the use of carrier aggregation with LTE-Advanced technology. This newer technology allows carriers to be aggregated across different spectrum bands and so reduces the benefits of having *contiguous* spectrum. However, our view on the importance of peak data rates is unchanged. We continue to consider it unlikely to be necessary for an MNO to deliver the highest peak data rates in order to be credible. It is average data rates that are more important for consumers' experience than peak data rates. The ability to deliver the highest peak data rates may be a source of capability strength, but it is unclear how important this is as a contribution to credibility. It might be argued that our view is inconsistent with the emphasis that BT/EE places on speed in its marketing. However, much of BT/EE's marketing relates to a particular measure of *average* speeds rather than peak speeds.[65] We also note that there are few mobile applications that can make use of the very high peak speeds of over 300 Mbps, meaning that there would be little direct value for consumers in having the highest peak data rates.

4.113 **Other LTE advantages:** The last quality dimension we considered for the 2013 auction no longer appears relevant as a distinction between MNOs, as all four MNOs are deploying LTE. We also note that there are now user devices that can use LTE with a wide range of spectrum bands (including 900 MHz and 2.1 GHz), and not just 800 MHz, 1800 MHz and 2.6 GHz.

4.114 We have also considered whether any new quality dimensions may be relevant. In particular, whether having an early route to deploying 5G services may be important. This is potentially relevant given the role that the 3.4 GHz band may play in providing 5G services. At this time we consider it unlikely that an early route to 5G will be a necessary requirement to having a credible spectrum portfolio in the next few years. However, within the timeframe we are considering for this competition assessment (i.e. the next 5-10 years), MNOs are likely to need a route to 5G. As we describe below, the 3.4 GHz band is likely to provide one such route, as would other spectrum in the 3.6-3.8 GHz band. The 700 MHz band may also be used for 5G services. In addition, there may be new spectrum bands made available for 5G. It is currently unclear whether, and in what timeframe, the mobile bands that have already been allocated might be used for 5G services.

4.115 To summarise, for at least the next few years, we consider it is only in terms of capacity and coverage that there are necessary minimum components which an MNO will need to be credible. Longer term, a route to 5G might also be important to credibility, but it is unclear what spectrum bands might be sufficient to achieve this.

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[64] The peak data rate is the data rate that can be delivered under ideal signal conditions and without contention between users (i.e. a single user occupying all of the resources of one cell and very close to the base station). This is distinct from the average data rate which is what users actually experience on average under realistic conditions in a network shared with other users, which we consider under capacity.

[65] For example, EE's advertising that its network is "50% faster" than all other networks relates to *average* 4G download speeds based on information from OOkla speed tests by users (which we discuss further in Annex 8). http://ee.co.uk/why-ee
While EE does also refer to its 'real-world' peak data rate of over 360Mbps at Wembley Stadium, this is a less prominent part of its advertising, http://newsroom.ee.co.uk/ee-launches-next-phase-of-4g-for-the-worlds-fastest-smartphones/

But having only the bare minimum in each of the coverage and capacity dimensions may not be sufficient – an MNO might need to have more capability in at least one dimension to be credible.

4.116 For example, one MNO may have the necessary components together with much more than the necessary minimum capability in capacity, while another may have the necessary requirements and much more capability in terms of coverage. Alternatively, sufficient overall capability might be achieved through having only a little more than the minimum necessary in each of these two dimensions.

4.117 Another way of viewing this is in terms of risk. If an MNO does not have the necessary minimum capability in coverage or capacity, it is unlikely to be capable of being credible. However, it is not straightforward to specify these necessary minimum requirements with precision. We make a judgement in the light of the available evidence in the form of a range rather than a single threshold figure. Taking into account the uncertainty associated with our judgement, we consider that if an MNO is towards the lower end of the range in either capacity or coverage capabilities, there is a risk that it would not be capable of being credible.

4.118 If an MNO is weaker in both the capacity and coverage dimensions, the risk is greater. For example, even if an MNO meets the necessary minimum requirements for both coverage and capacity, this may not be sufficient capability to be credible in the round. This is because an MNO that has only the minimum capability in each dimension may well struggle in reality to compete against competitors that have a materially greater capability in one or both of the key dimensions taken in the round.

Minimum share of spectrum required for capacity

4.119 We have reviewed whether there are any reasons to revise our 2013 assessment of the minimum share of spectrum needed to be credible.

4.120 We note first that, during a period when they have had a share of spectrum in the 10-15% range, the performance of O2 and H3G to date (as described above) seems consistent with them being credible MNOs. However, we recognise it is possible this could change in the future if sufficient capacity cannot be added by other means. The fact that they may have been credible competitors to date whilst having a share of spectrum in the 10-15% range does not remove the risk that they may lose their credibility in the future.

Very low spectrum shares may undermine the credibility of an MNO

4.121 As already noted, in a market where there are four MNOs holding all the spectrum, then symmetric holdings would imply each having 25% of spectrum. Because MNOs do not need to have the same capacity and because there is scope to trade off network investment and spectrum in terms of adding capacity, we consider that an MNO could have a substantially lower share than this and be a credible competitor.

4.122 However, if an operator's spectrum holdings were too low, it may struggle to add sufficient capacity to be a credible competitor. It would tend to have higher marginal costs of adding capacity than an operator with a high spectrum holding, thereby limiting its capacity to constrain rivals, or jeopardizing its financial viability.

4.123 In our competition assessment for the 2013 auction, we did not consider that having a share of spectrum at or below the 10-15% range automatically meant that an operator was not a credible MNO. We recognised that share of spectrum was a

simple measure that does not take into account the differences in spectrum of different frequencies and other factors. However, our judgement was that there was a material risk of an MNO not having sufficient spectrum to be credible if it held less than 10-15% of paired spectrum.[66]

4.124 Taking into account our updated analysis above and in annex 8 of the different ways to add capacity, we have not identified clear reasons to depart from this judgement apart from including unpaired as well as paired spectrum.[67]

International comparisons of minimum shares of spectrum to be credible

4.125 In our competition assessment for the 2013 auction we noted that our analysis was consistent with evidence from other countries. This showed that while the shares of spectrum held by MNOs vary considerably, in general, it was unusual for an MNO to hold a share of paired spectrum amounting to less than 10%.[68]

4.126 We have reviewed the recent evolution of international spectrum shares in annex 6 and, in some cases, contrasted these with the evolution of market shares. As in our previous assessment, we have focussed mainly on other western European countries which have four MNOs, as we consider these to be most comparable to the UK market.

4.127 Annex 6 shows that there are now fewer MNOs in Europe than previously that have shares of less than 10-15% of the spectrum useable for mobile services.[69] This is in part due to the mergers that have taken place in recent years, and also because some operators that previously had low shares have since obtained a higher share of spectrum.[70]

4.128 In the countries we have examined, the only MNOs that have spectrum shares in the 10-15% range or below are Tele2 (11%) and Ziggo (7%) in the Netherlands; T-2 (5.5%) and Telemach (14%) in Slovenia; and Yoigo in Spain (11%)[71] - with Free in France only increasing its spectrum share beyond 15% in May 2016 (it previously had 11-14%).

[66] See, in particular, paragraphs 4.69 to 4.73 of our July 2012 statement.

[67] In our competition assessment for the 2013 auction we included only *paired* spectrum when calculating spectrum shares. This was because we considered it uncertain at that time whether sufficient devices would be available for unpaired 2.6 GHz spectrum. We now consider that there are sufficient devices for the unpaired 2.6 GHz spectrum to be useful for adding capacity, and that this is also the case for the unpaired 2.3 GHz spectrum. As discussed, we expect there to be a sufficient ecosystem for the 3.4 GHz spectrum in the future. We therefore consider that we should now consider unpaired spectrum in the denominator when calculating shares of spectrum, tending to increase the absolute amount of spectrum that any operator needs to be credible.

[68] Paragraph 4.73 of our July 2012 statement, and also Figure A2.28 of Annex 2 to the July 2012 statement and paragraphs A2.182 to A2.259.

[69] Including 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz paired, 2.6 GHz unpaired and 2.6 GHz paired bands. We now include unpaired 2.6 GHz spectrum despite excluding it in our previous assessment. Unlike in 2012, we now consider the unpaired 2.6 GHz spectrum can be considered as mainstream mobile spectrum. We have assumed that all spectrum awarded in these bands in other countries is for high power use.

[70] For example, Free (Iliad) had a spectrum share of 11.6% at the time of our previous assessment in 2012, but today has a spectrum share of 16.4%.

[71] We have not included Tele2 and Telenor in Sweden as they have access to the 28% of the spectrum held by the joint venture Net4Mobility. We have also excluded the infrastructure company TT- Netværket owned by Telia and Telenor, which holds 4.5% of the spectrum in Denmark. We also excluded Ukko mobile in Finland, which does not provide traditional mobile services, for example, it does not offer voice services.

4.129 Merger activity could be interpreted as an indication that a share of spectrum in the 10-15% range makes it more difficult for an MNO to be credible in the longer term, but this is not necessarily the case.[72] Furthermore, some of the recent mergers - such as the recently approved merger between H3G and Wind in Italy - are not between operators with small spectrum holdings.

4.130 Our updated comparison indicates that there are European operators within the 10-15% spectrum range which have apparently been able to compete, as they have increased their market shares. For example, Free in France (which was in this range until May 2016) and Telemach in Slovenia have been able to grow their market shares despite formerly having relatively low shares of spectrum (Free has almost become the third operator in France).

4.131 Yoigo in Spain may be an example of an MNO with a 10-15% spectrum share that has not been a credible competitor. However, it is unclear whether a lack of spectrum has been the main obstacle to this. We note that the Spanish regulator has put in place competition measures in spectrum auctions which should have made it easier for Yoigo to acquire additional spectrum if it was required – but it failed to do so, effectively leaving some spectrum unsold.

4.132 It is worth noting that the recently approved[73] merger in Italy between H3G and VimpelCom (Wind) included spectrum divestment remedies (in addition to infrastructure sharing and national roaming agreements) which will lead to the creation of a new fourth MNO. The spectrum divested to the new entrant amounts to 70 MHz across various bands, so that it will start operations with the equivalent of 13%[74] of the useable spectrum available (see annex 6 for further details).

4.133 The EC considered this was sufficient to enable the new MNO to develop and roll out its own mobile network and operate as an MNO, and that this would fully address the EC's concerns about the elimination of competition from the merger of two strong competitors. Iliad of France has already agreed to take these assets to become the fourth national operator after the merger.[75]

4.134 The international comparisons also suggest that fairly symmetric spectrum distributions do not necessarily lead to more even market shares. For example, markets in Denmark, Sweden and Italy have significant differences in subscriber market shares despite relatively symmetric distribution in spectrum.

4.135 It is clear that other factors affect the viability and market performance of an operator beyond spectrum holdings.

Provisional conclusion on share of spectrum necessary to be credible

4.136 We have not found clear evidence through any of our updated analysis to change the judgement reached for the competition assessment for the 2013 auction that there is

[72] For example, H3G Austria merged with Orange Austria in January 2013. Before the merger, H3G Austria had a spectrum share in the 10-15% range. In its assessment of this merger in December 2012, the European Commission noted that H3G Austria was an important competitive force without the merger, and that H3G Austria was not claimed to be a failing firm, http://ec.europa.eu/competition/mergers/cases/decisions/m6497_20121212_20600_3210969_EN.pdf

[73] See http://europa.eu/rapid/press-release_IP-16-2932_en.htm

[74] This is calculated excluding the 1400 MHz holdings of Telecom Italia and Vodafone. The new entrants share of spectrum would be around 12% when calculated including the 1400 MHz spectrum that we expect to be useable in the future.

[75] See http://www.iliad.fr/presse/2016/CP_050716_Eng_.pdf

a material risk of an MNO not having sufficient spectrum to be credible if it holds less than 10-15% of spectrum.

4.137 But this does not mean that an operator with 10-15% of spectrum will necessarily be able to have a leading market position. While we consider there is some trade-off between spectrum and other ways of adding capacity, that trade-off is not perfect. An operator with a low share of spectrum may have lower capacity than other operators, and may not be able to sustain a very high share of subscribers, or to compete strongly for all customer segments. But we would still regard such an operator as being credible provided it was able to exert an effective constraint on rivals and so contribute to the overall competitiveness of the market, and provided it could do this in a way that allowed it to be sustainable and financial viable.

Assessment of future credibility of MNOs

BT/EE and Vodafone already have strong spectrum portfolios

4.138 In terms of coverage spectrum, BT/EE has more than the minimum necessary, with a small amount (2x5MHz) of sub 1 GHz spectrum and a large amount of 1800 MHz spectrum.

4.139 In terms of spectrum for sufficient capacity, BT/EE has a very large amount of spectrum - 255 MHz or 42% of current spectrum (including 1400 MHz), significantly in excess of the minimum necessary.

4.140 Given its advantages in terms of such a high share of spectrum, we consider BT/EE's spectrum portfolio overall would be sufficient for it to be credible even if it did not obtain spectrum in this auction. As shown in Figure 4.6 above, it will still have 30% of mobile spectrum if we included the 2.3 and 3.4 GHz spectrum in the calculations (but excluded other future mobile spectrum, such as at 700 MHz).

4.141 Vodafone has more than the minimum required to be credible in terms of both coverage and capacity. It has a large amount of sub 1 GHz spectrum (2x27.4 MHz) providing good spectrum for coverage, allowing it to provide good capacity even in hard to reach places, such as indoors. For capacity in general, it has a fairly large amount of spectrum overall - 176 MHz, representing 29% of current spectrum (including 1400 MHz).

4.142 As shown in Figure 4.6, Vodafone would still have 21% of mobile spectrum if we include the 2.3 and 3.4 GHz and it did not obtain any of those frequencies. As with BT/EE, we therefore consider Vodafone's spectrum portfolio as a whole would be sufficient for it to remain a credible competitor if the only additional spectrum we consider is at 2.3 GHz and 3.4 GHz. Even if we were to also include spectrum at 700 MHz and 3.6-3.8 GHz, Vodafone's existing holdings would represent 16% of spectrum.

4.143 In summary, we do not consider that BT/EE or Vodafone need to obtain spectrum in this award to retain credible spectrum portfolios. If significantly more spectrum were to become available in the future, or a route to 5G were to become important and their existing holdings were not suitable for this, then at some point BT/EE and Vodafone may need to obtain additional spectrum, but they will have the option of obtaining it in those future awards.

O2 and H3G likely to remain credible in the transitional period without additional spectrum

4.144 Considering the evidence above and in annex 7 on the current state of competition, the performance of O2 and H3G to date seems consistent with them being credible MNOs currently. This is with both operators having a share of spectrum in the 10-15% range. We also note that H3G and O2 are now both strongly cash-flow positive.

4.145 During the transitional period, if O2 did not acquire any 2.3 GHz spectrum, its spectrum portfolio would represent 14% of mobile spectrum (falling to 13% when the 1400 MHz band becomes useable). It includes 2x27.4 MHz of sub 1 GHz spectrum giving it an important strength in terms of coverage, as it is able to provide good capacity even in hard to reach areas, such as deep indoors. The size and composition of this portfolio suggests O2 should have sufficient spectrum to be credible during the transitional period.

4.146 We recognise that a significant proportion of O2's spectrum is currently being used for 2G services (which is less spectrally efficient). While this reflects O2's commercial decisions on how it chooses to use its spectrum, there may be practical constraints on how quickly O2 can add capacity through re-farming. If it is unable to re-farm quickly enough, this may affect O2's ability to compete in the transitional period, at least for some customers.

4.147 Given O2's strong position in the market currently (with more than 30% of network subscribers), and that the transitional period is not indefinite (being expected to last for a few years after the auction); we consider it unlikely that O2 would cease to be credible in the transitional period. This does not rely on O2 necessarily retaining its current market position as it could still be a credible competitor with a smaller market share.

4.148 H3G has 11% of spectrum during the transitional period, rising to 14% when the 1400 MHz spectrum becomes useable. It has more than the minimum necessary for coverage with 2x5 MHz of 800 MHz spectrum, and 1800 MHz spectrum. It uses all of its spectrum for 3G and 4G services, carrying a high (albeit declining) share of data compared to other MNOs.

4.149 Its subscriber market share has shown a steady upward trend over recent years. Its cash-flows have improved over time and it now has the highest EBITDA[76] margin of all the MNOs (see annex 7). Given H3G's spectrum portfolio and position in the market currently, we consider it unlikely that H3G would cease to be credible in the transitional period.

4.150 In summary, we believe it is unlikely that O2 or H3G would cease to be credible MNOs in the transitional period if they failed to obtain any additional spectrum. However, as we discussed above, even if O2 and H3G remain credible, if they were to struggle to add sufficient capacity to compete strongly for some customers in the transitional period, competition for some customer segments might be weaker than it could otherwise be.

O2 and H3G may need more spectrum to remain credible in the longer term

4.151 In the longer term, when considering credibility, we attach less weight to current market position, as this can change over time. We therefore focus on the spectrum

[76] **EBITDA** earnings before interest, tax, depreciation and amortisation

portfolios and what MNOs can achieve with those portfolios. We consider these portfolios and the capabilities they provide in the round.

4.152 In considering whether the spectrum portfolios of O2 and H3G would enable them to be credible MNOs in the longer term if they do not obtain any spectrum in this award, we take account of only the *minimum* portfolio of spectrum needed. As noted, this is distinct from our other aim of ensuring there is strong competition for all customers even where there are four credible MNOs.

4.153 O2 would have 10% of spectrum in the longer term if it obtained no spectrum in this award. This is calculated including the 3.4 GHz spectrum, but excluding the 700 MHz and 3.6-3.8 GHz spectrum.[77] The capability of its portfolio is strengthened by its large amount of sub 1 GHz spectrum. Nevertheless, with such a low share of spectrum, there would be a risk to O2's credibility.

4.154 H3G would have 11% of spectrum in the longer term if it obtained no spectrum in this award, calculated as described for O2 above. When the 1400 MHz spectrum becomes useable, it is likely to become valuable coverage spectrum given its relatively low frequency and the ability to use it at higher power than some other bands. Therefore, H3G will become reasonably strong in terms of coverage (with 800 MHz, 1400 MHz and 1800 MHz), in the sense of being able to provide sufficient capacity in hard to reach areas, but not as strong as O2.

4.155 Such low shares of spectrum would involve a risk to credibility for both O2 and H3G since they would be at the bottom of the 10-15% range below which we consider there is a material risk. O2 and H3G may therefore need more spectrum to remain credible in the longer term. If a route to 5G were to become important to credibility, and their existing spectrum was not suitable for this, then O2 and H3G may also need spectrum that would enable them to offer 5G services.

<u>But more spectrum will be available in the longer term</u>

4.156 However, the 2.3 and 3.4 GHz in the auction is not the only opportunity to obtain spectrum in the future:

- **700 MHz**: this band is likely to be high value spectrum (because it provides good coverage) and may not be as suitable for adding capacity as cost effectively as higher frequency spectrum. Nevertheless, if O2 or H3G each obtained 2x10 MHz of this spectrum for example, they would be more likely to be credible in the

[77] While we expect the 3.4 GHz spectrum to be a sufficient substitute for other bands as regards capacity in the longer term, there is some risk that it will not be. If less weight were attached to the large amount of 3.4 GHz spectrum (and similarly to the 3.6-3.8 GHz spectrum), because of its higher frequency, the relative importance of the current holdings of O2, and also H3G, would tend to rise. As an illustration, in the extreme, if we attach no weight to the 3.4 GHz spectrum (and assuming neither obtained any 2.3 GHz spectrum in the auction), then O2's share of relevant spectrum would be 13% (of which a large part would be the high value sub 1 GHz spectrum), and H3G's share would increase to 14%. These percentages are calculated assuming that only 800 MHz, 900 MHz, 1400 MHz, 1800 MHz, 2100 MHz, 2.3 GHz and 2.6 GHz spectrum are regarded as being relevant mobile spectrum. If less weight is attached to 3.4 GHz spectrum, H3G and O2 are therefore less likely to need additional spectrum in the longer term to remain credible. Moreover, the 700 MHz spectrum would have greater significance in this scenario, with more scope for it to increase the share of spectrum that O2 and H3G have.

longer term.[78] We have also decided to make available 20 MHz of the 'centre gap' of the 700 MHz band available for mobile use.

- **UK Broadband's spectrum**: When the 3.4 GHz spectrum becomes useful for adding mobile capacity, some useable mobile spectrum may then still be held by an entity other than the four MNOs. UK Broadband holds 40 MHz of 3.4 GHz spectrum, which will represent 5% of total mobile spectrum (calculated excluding the 3.6-3.8 GHz spectrum). Depending on UK Broadband's approach, this potentially gives O2 or H3G another option in terms of increasing their capacity, for example through buying wholesale capacity or by acquiring UK Broadband's licence for this spectrum. This tends to reduce our competition concerns about O2 and H3G having low shares of spectrum.[79] In addition to the 3.4 GHz spectrum, UK Broadband also holds a licence for access to 84 MHz in the 3.6-3.8 GHz band[80], which may become useable for mobile services at the same time as the 3.4 GHz spectrum as devices becomes more widely available.

- **3.6-3.8 GHz spectrum**: We are proposing to award 116 MHz of the 3.6-3.8 GHz band for mobile use, as already discussed above.

- We have also identified other spectrum as a priority in terms of making it available for mobile data use, including 1492-1518 MHz, 1427–1452 MHz and the lower 2.3 GHz band (2300–2350 MHz).

4.157 We would have the ability to impose measures in future awards of spectrum that are appropriate and proportionate to address competition concerns that arose in the meantime. This reduces the risk that O2 and H3G would cease to be credible in the longer term.

Provisional conclusion on the risk of O2 and H3G ceasing to be credible

4.158 We have considered the spectrum portfolios of O2 and H3G - and the capabilities they provide - in the round. We consider it unlikely that either O2 or H3G would cease to be credible MNOs in the transitional period even if they did not obtain spectrum in this award. O2 has 13%-14% of spectrum, with a large amount of sub 1 GHz spectrum. It also has a strong position in the market currently (with more than 30% of subscribers). H3G has 11% of spectrum during the transitional period, rising to 14% when the 1400 MHz spectrum becomes useable. It has sufficient spectrum for coverage, but does not benefit from having a large amount of sub 1 GHz spectrum. Its subscriber market share has shown a steady upward trend over recent years.

4.159 However, in the longer term, O2 and H3G may need more spectrum to remain credible. They would both have a low share of spectrum, of around 10%, if they did not obtain any in this auction. But this award will not be the only opportunity for them

[78] For example, O2 and H3G would each have 12% of total mobile spectrum if they obtain no spectrum in the PSSR award but obtained 2x10 MHz in the 700 MHz award (this is calculated including the 3.4 GHz spectrum, but excluding 3.6-3.8 GHz spectrum).
[79] For a longer explanation of the potential relevance of operators other than the four MNOs having mobile spectrum see paragraphs 7.83 to 7.86 of the November 2014 consultation, though as BT and EE have merged, it is now only UK Broadband that remains relevant.
[80] UK Broadband holds a licence for spectrum access in 2 x 84 MHz at 3605 MHz to 3689 MHz and 3925 MHz to 4009 MHz where its deployments are subject to coordination with satellite earth stations and fixed links by Ofcom on a first come first served basis.

to obtain spectrum in the longer term. For example, there is a confirmed award at 700 MHz and proposed award at 3.6-3.8 GHz.

Likelihood of Competition Concerns 1 and 2 arising in the absence of competition measures

4.160 We turn now to our assessment of the likelihood of competition concerns actually arising if we were to propose no competition measures in the auction (either through bidding at intrinsic value or through strategic investment).

Drivers of allocation of spectrum in the auction

4.161 The allocation of spectrum in the auction, both in terms of the amount and the location within each band (frequency), will be determined by the relative bids that participants make. This in turn is likely to be determined by their expected difference in profits from supplying wholesale and retail services with and without the spectrum.

4.162 We distinguish between two sources of value (i.e. profits) for operators in bidding for spectrum[81]:

- **Intrinsic value** – The present value of additional profits a bidder expects to earn when holding the spectrum compared to not holding it - in the absence of any strategic considerations to obtain spectrum that reduces competition in mobile services from the existing level.

- **Strategic investment value** – The present value of additional expected profits earned from bids that affect the future structure of competition in mobile services by depriving one or more competitors of spectrum.

4.163 Even if operators do not necessarily make this distinction in an explicit way when formulating their own valuation of spectrum, it is relevant for our analysis because of the differential effect on competition between these two sources of value.

Likelihood of competition concerns occurring if bidding is based only on intrinsic value

4.164 We would be concerned if there was a risk that one or more MNOs would cease to be credible if they failed to acquire sufficient spectrum in this award, even if all bidders were to bid strictly on the basis of their intrinsic valuations. However, as we noted previously, in our view O2 and H3G would remain credible in the transitional period and, while we consider that they might need more spectrum in the long term to remain credible, this will not be the only opportunity for them to obtain spectrum.

4.165 There could also be a concern that a very asymmetric distribution of spectrum arising from intrinsic value bidding would weaken competition, which could harm consumers' interests. We acknowledge, however, that there is a trade-off between the risk of an adverse effect on competition and the risk that preventing the operator that has the highest intrinsic value for the spectrum from obtaining the frequencies may not be in

[81] In the US, the terms 'use value' and 'foreclosure value' have been used, which we understand to be similar in meaning to what we mean by intrinsic value and strategic investment value. See for example, page 10 and 11 of the US Department of Justice's submission to the Federal Communications Commission, *In the matter of policies regarding mobile spectrum holdings*, April 2013, http://www.justice.gov/atr/public/comments/295780.pdf

consumers' interests. That operator might have the highest intrinsic value because it would use the spectrum to offer the most attractive services to consumers.

4.166 In general, we would expect the value each MNO places on additional spectrum to reduce as it obtains more frequencies. This means that those operators with small spectrum holdings will tend to have higher values for additional spectrum than operators with high spectrum holdings. In turn, this may reduce the likelihood of this award resulting in a significantly more asymmetric distribution of spectrum because of differences in intrinsic value. We recognise, however, that there are many additional considerations that can affect the value of specific spectrum to different operators, such that this general tendency is not always the most important factor.

4.167 Additionally, our auction design helps to reduce common value uncertainty by allowing for a process of price discovery, where bidders may adapt their expectations by observing some information about other bidders' behaviour. This reduces the chance that bidders bid on the basis of overly optimistic expectations about the evolution of variables that affect all operators. In turn, that will tend to reduce the chances of a very asymmetric outcome.

4.168 On balance, whilst recognising the trade-off involved, there is a concern that a very asymmetric distribution of spectrum arising from bidding based on intrinsic values could be against consumers' interests.

Likelihood of competition concerns occurring as a result of strategic investment

4.169 Strategic investment is where a bidder bids in excess of its own intrinsic value for an amount of spectrum, which denies use of that spectrum to its competitors - thereby weakening competition in the downstream market. Strategic investment can be attempted unilaterally, by a single strategic investor, or with tacit coordination between two or more strategic investors.

4.170 In considering strategic investment in this way, we are not supposing that bidders, individually or collectively, will act in a manner prohibited either in the auction or more generally under competition law. Our concern is to consider whether strategic investment by one or more bidders, in pursuit of rational commercial goals, might result in an outcome that made the market less competitive.

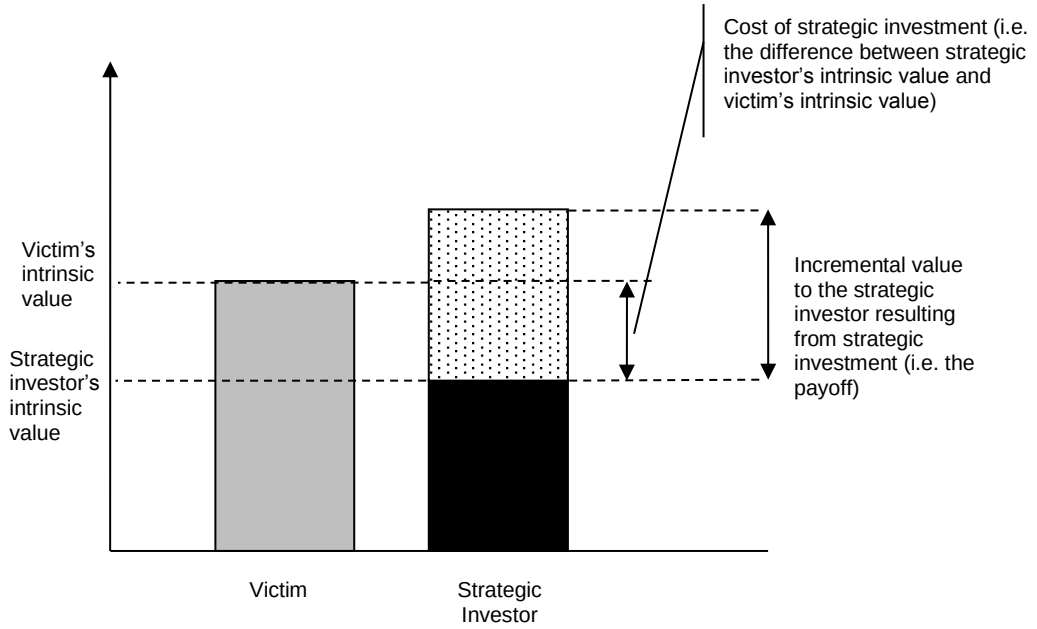
4.171 The pay-off from engaging in strategic investment is the increase in profits arising from weakening competition in the market as a result of denying spectrum to one or more rivals. In Figure 4.8 below, the payoff from strategic investment is illustrated by the dotted area above the black area.

4.172 To succeed, the strategic bidder will need to outbid the potential 'victims' of strategic investment in the auction. The difference between the victim's intrinsic value (the grey area) and the strategic investor's intrinsic value (the black area) represents the cost of strategic investment. This is because the strategic investor would need to pay at least the intrinsic value of the victim[82] in order to succeed in acquiring the spectrum.

[82] Given the nature of the auction design we chose for this award, the strategic investor might need to pay the victims' intrinsic value plus a price increment.

4.173 The higher the victims' intrinsic value for the spectrum, the higher the cost of strategic investment. Likewise, the higher the strategic investor's intrinsic value, the lower the cost of strategic investment.

Figure 4.8: Illustration of cost of strategic investment and expected payoff



4.174 In the paragraphs below we look first at the risk of strategic investment in the 2.3 GHz band alone. We then go on to consider the risk of strategic investment in both bands. Finally, we assess the risk of strategic investment in the 3.4 GHz band alone.

4.175 Our assessment of the risk of strategic investment is ultimately a judgement based on an analysis of a) the incentives for bidders to engage in it and b) the likelihood of those incentives materialising in actual bidding behaviour. It is reasonable to assume that, all else constant, the stronger the incentives, the more *likely* it is that those incentives will materialise.

4.176 The incentives of bidders to engage in strategic investment in turn depend on the expected 'pay-off' for this strategy when compared to the cost involved. This will determine whether such investment would represent a profitable strategy overall - in which case the potential strategic investor may have an incentive to engage in such behaviour.

4.177 Both the pay-off and the cost are dependent on evidence which we take as given for the purposes of this analysis. This includes the detail of the auction design adopted in the 2.3 GHz and 3.4 GHz award, the amount and type of spectrum available in each of the 2.3 GHz and 3.4 GHz bands, and the competition concerns identified above.

The risk of strategic investment related specifically to 2.3 GHz spectrum - Competition Concern 1(ii)

4.178 We have identified three main hypothetical scenarios under which one or more bidders may deny 2.3 GHz spectrum to rivals through strategic bidding – noting that

these scenarios do not exhaust all other possible means by which bidders could bid strategically and deny spectrum to their competitors:

- Scenario 1: A unilateral strategic investor acquiring 30 or all 40 MHz, which denies a 20 MHz block to any of its competitors.

- Scenario 2: A unilateral strategic investor acquiring 10 or 20 MHz which denies a 20 MHz block to more than one of its competitors.

- Scenario 3: Two tacitly coordinating strategic investors, each acquiring 20 MHz, which denies any 2.3 GHz spectrum to the other two MNOs (or new entrants).

Potential pay-off from engaging in strategic investment in 2.3 GHz spectrum

4.179 We have already noted two main competition concerns specifically related to the acquisition of 2.3 GHz spectrum.

4.180 The **first** might arise during the transitional period if the auction led to a very asymmetric distribution of useable spectrum, such that competition would be weaker than it otherwise might be. This concern is given extra weight by our view that [✂] REDACTED.

4.181 The **second** might arise if our view that 3.4 GHz is likely to become sufficiently substitutable for the 2.3 GHz spectrum in terms of adding capacity in the longer term proves to be wrong. We recognised that if that happens, then there is a possibility that competition concerns in the transitional period could be more enduring.

4.182 By denying 2.3 GHz spectrum to competitors, strategic investors may be depriving rivals of spectrum in the transitional period, in the longer term, or both.

4.183 We take the view that the pay-off a strategic investor might be able to extract by denying 2.3 GHz spectrum to its rivals in the *longer* term is likely to be limited, as more spectrum is made available in the future. However, the pay-off associated with denying 2.3 GHz spectrum during the transitional period (first concern) might be clearer because:

- There is a relatively well-defined time frame within which operators will have limited ability to compensate for a lack of useable spectrum;

- The strategic investor may have an expectation that, if these operators are denied useable spectrum and have no relevant mitigations available to them during the transitional period, they may - at least for some customers - compete less aggressively and/or increase prices to reduce the rate of growth in demand they would otherwise face;

- There may also be an expectation that this will benefit the operator that engages in strategic investment, either because it will capture some or all of the demand lost by the victim or victims of strategic investment, or because it will be less constrained by price competition, or a combination of the two.

4.184 While it is plausible that some operators may benefit from engaging in strategic investment to exploit this concern, there is a risk to those operators that any of the assumptions presented above may be incorrect.

4.185 We expect the potential pay-off from weakening rivals would be temporary, as we believe that in due course the 3.4 GHz or other spectrum could be used to add capacity to serve consumers. There is however a risk that even if 3.4 GHz spectrum becomes an effective substitute for other mobile spectrum, a reduction in competition during the transitional period could take some time to erode.

4.186 Operators with more currently unused (or under-used) spectrum available to them would tend to have more to gain from engaging in strategic investment as they would tend to have a higher ability to serve a larger proportion of the customers lost by their competitors. Likewise, operators with higher market shares would benefit more from a relaxation in price competition as they would be able to extract more surplus from their existing client base.

4.187 As noted, the pay-off associated with strategic investment is the weakening of competition in the downstream market. Provided it occurs and is successful, the pay-off to the operators that benefit from the strategic investment will be the same, irrespective of whether the strategic investment came about unilaterally or through coordination. This means that a bidder engaging in unilateral strategic investment incurs all the cost but only a share of the pay-off. With coordinated strategic investment, the cost is shared between the strategic bidders but they have to overcome difficulties in tacitly coordinating (as discussed further below).

4.188 We expect the risk of strategic investment causing harm to competition to be higher under our hypothetical scenarios 1 and 3 than under scenario 2, because more spectrum is denied to competitors. In fact, under scenario 2 the bidder who engages in the unilateral strategic investment is uncertain about who is actually being denied the spectrum.

Cost of engaging in strategic investment in 2.3 GHz spectrum

Unilateral strategic investment

4.189 Under hypothetical scenarios 1 and 2, a single bidder acquires spectrum which denies it to other bidders (ranging from 10 MHz to 40 MHz). The smaller the amount of spectrum acquired, the lower the underlying costs will tend to be. However, while the cost of strategic investment under scenario 2 is likely to be smaller compared to scenario 1, it is also less likely to be effective.

4.190 The acquisition of 40 MHz for strategic purposes would involve fully outbidding all the other bidders (or, in the case of 30 MHz, it would involve outbidding all the other bidders except on 10 MHz).

4.191 If some operators believe themselves to be capacity constrained in the transitional period without the 2.3 GHz spectrum, they would tend to have a high intrinsic value for this type of spectrum. It follows that the price at which these bidders might be outbid could be high, therefore increasing the costs of strategic investment.

4.192 In addition, if strategic investors have sufficient or close to sufficient capacity spectrum for their needs, their intrinsic valuation for 2.3 GHz spectrum will tend to be relatively small, which also increases their cost of strategic investment. This may be a particular disincentive if the strategic bidder incurs the cost of acquiring an indefinite licence only to gain value during the transitional period from weakening competition.

4.193 However, while a high intrinsic value of other bidders raises the potential cost of strategic investment, it may also be indicative of its underlying pay-off.

4.194 Additionally, it is possible that some of the operators which might have an interest in engaging in strategic investment would also have some intrinsic value for the spectrum themselves, thereby reducing the cost. Even if their intrinsic value based on using the spectrum in the transitional period is relatively small, it may increase over time.

4.195 Finally, even if the cost of strategic investment *per lot* is high, the quantities of spectrum involved in scenario 1 are relatively small when compared to the overall 190 MHz available in the auction. Therefore, the absolute cost of strategic investment may not be high.

4.196 We note there are a number of features included in the auction design which may increase the cost or difficulties of strategic investment. The nature of these features and their likely effectiveness in addressing strategic investment are discussed in 'text box' form (Figure 4.9) at the end of this section.

Co-ordinated strategic investment

4.197 We now consider coordinated strategic investment, and in particular scenario 3. This scenario denies the same, or close to the same, amount of spectrum to victims as scenario 1, but does so while allowing the strategic investors to share the potential cost associated with strategic investment. This makes the potential costs lower to each strategic investor than with unilateral strategic investment.

4.198 In practice it may be difficult to tacitly coordinate strategic investment. One reason is that while the benefits from successful strategic investment will be captured by an operator irrespective of whether it participates or not, the costs will only be incurred if it does so. A bidder might as a consequence have an incentive to *free ride,* or in other words to let other bidders incur the costs of strategic investment while it enjoys the benefits, if the latter succeeds.

4.199 For example, in scenario 3 strategic investor A may choose to bid on 10 MHz under the expectation that strategic investor B will bid on 20 MHz, which would result in them jointly succeeding in denying a block of 20 MHz to another bidder. By bidding on 10 MHz, instead of 20 MHz, strategic investor A would partly free ride and let strategic investor B incur a higher cost. However, if both strategic investors bid on the same expectation – i.e. each bidding on 10 MHz - they may both be unsuccessful in denying a 20 MHz block to another bidder.

4.200 Additionally, the information policy we have adopted for the auction, as well as posing a challenge to bidders who wish to engage in unilateral strategic investment, also makes tacit coordination between bidders more difficult to achieve.

4.201 For example, strategic bidder A would not know if strategic bidder B was bidding in a way that was consistent with its assumed strategic investment approach. Therefore, an attempt by bidder A to engage in strategic investment could result in it incurring the costs of bidding above its intrinsic valuations and yet failing to prevent the intended victim(s) from acquiring spectrum - and so there would be no payoff as there would not be a reduction in downstream competition. In such a case, bidder A would incur a loss from its failed attempt at strategic investment. The prospect of such losses tends to increase the costs to potential strategic bidders of engaging in coordinated strategic investment.

4.202 The extent to which both the scope for free-riding and the lack of information available during the auction can be effective in deterring strategic investment specifically for the 2.3 GHz spectrum alone is uncertain. Tacit coordination may be facilitated by the existence of a clear focal point for the division of spectrum in the auction between the operators with high spectrum shares currently. This might be 20 MHz each for Vodafone and BT/EE.

4.203 The existence of a clear focal point may make free riding less appealing as a strategy. However, it will not necessarily be clear to strategic investor B that strategic investor A is pursuing a coordinated rather than a unilateral strategy, given that it cannot directly observe its bids. A lack of certainty about this could make free riding more attractive to strategic investor B. Although, the clearer the division of spectrum, the less need strategic investors will have of clear information during the auction.

Provisional conclusion on the risk of strategic investment in 2.3 GHz alone

4.204 There is a possibility that denying 2.3 GHz spectrum to particular operators may reduce competition for some groups of consumers during the transitional period. Some bidders may therefore see a discernible pay-off from engaging in strategic investment.

4.205 There is a risk that the cost and the risk involved with engaging in strategic investment are insufficient to deter it in this band. This could be either unilateral strategic investment by one bidder, or tacitly coordinated investment between two strategic bidders (which seems to be facilitated by the existence of a clear division of spectrum amongst the two operators with the highest spectrum shares)[83].

4.206 Our conclusion is that the possibility of strategic investment in the 2.3 GHz band is a significant concern.

Risk of strategic investment for 2.3 GHz and 3.4 GHz spectrum together - Competition Concerns 1(i) and 2

4.207 We now discuss the potential for strategic investment related to the whole of 2.3 GHz and 3.4 GHz spectrum in the auction. In order to deny a relevant amount of spectrum to other bidders in the 2.3 and 3.4 GHz auction, strategic investment would potentially need to involve the acquisition of a large amount of spectrum.

4.208 By means of illustration, we provide three possible scenarios of strategic investment when the whole 190 MHz in the auction is considered.

- Scenario 1: A unilateral strategic investor acquiring at least 175 MHz, which denies a 20 MHz block to any of its competitors

[83] Last year, Qualcomm traded 20 MHz of 1400 MHz spectrum to each of Vodafone and H3G – see https://www.ofcom.org.uk/__data/assets/pdf_file/0022/81670/trade-of-frequencies-statement.pdf. This is the same amount of spectrum as that available at 2.3 GHz in our award. It could be argued that the fact that H3G acquired 20 MHz of 1400 MHz spectrum is evidence against our view of the risk of strategic investment for 2.3 GHz spectrum. However, there are a number of differences in circumstances which may make such an argument unreliable. The trade was concluded while the merger between BT and EE was being assessed by the CMA and the proposed merger between H3G and O2 was being assessed by the European Commission. This meant that there was significant uncertainty about the future industry structure for all potential bidders and also on the demand for spectrum for most of the parties involved. Also, the sources of intrinsic value for 1400 MHz may be different than for 2.3 GHz, e.g. the 1400 MHz band may be used for coverage and, unlike 2.3 GHz spectrum, is not immediately useable for capacity.

- Scenario 2: A unilateral strategic investor acquiring at least 155 MHz, which denies a 20 MHz block to more than one of its competitors[84]

- Scenario 3: Two tacitly coordinating strategic investors jointly acquiring the whole 190 MHz which denies any spectrum to the other MNOs (or new entrants)

4.209 After discussing these three scenarios, we consider the implications if bidders' preferences exhibit strong value complementarities for 40 MHz blocks in the 3.4 GHz band and 20 MHz blocks in the 2.3 GHz band – and, as a result, there is a perception that there are six blocks of spectrum available in the auction.

4.210 As with our analysis for the 2.3 GHz band we look at the potential pay-off and cost of engaging in strategic investment related to the 2.3 and 3.4 GHz bands together.

Potential pay-off from engaging in strategic investment for all the spectrum available

4.211 We identified earlier two main competition concerns related to particular operators failing to acquire any spectrum in the auction. The potential pay-off from engaging in strategic investment for all the spectrum available in the auction is the flipside of these two competition concerns.

4.212 The **first** is related to the potential impact of an increasingly asymmetric distribution of overall spectrum, Competition Concern 1(i). The **second** concern is that one or more operators would cease to be credible MNOs if they failed to acquire spectrum in this auction, Competition Concern 2. Should this concern materialise, it would result in a significant reduction in competition.

4.213 In respect to Competition Concern 1(i), the likely availability of significant spectrum in the future also makes it less likely that competition would weaken for some customers because of an increasingly asymmetric distribution of overall spectrum immediately after the auction (rather than only that useable in the transitional period).

4.214 In respect to Competition Concern 2, the second concern, we considered that the risk that O2 and H3G would cease to be credible operators if they did not obtain any spectrum was not high, due to the availability of other spectrum in the future. BT/EE and Vodafone already have strong spectrum holdings, sufficient for them to remain credible competitors even if they do not obtain any spectrum in this award.

4.215 We have also noted that we would have the ability to impose competition measures in future auctions to address competition concerns if they arose in the meantime. If one or more bidders failed to acquire spectrum in the auction because the final price was exceptionally high - and unlikely to be explainable by bidders bidding on the basis of intrinsic value alone - this would tend to increase the case for taking competition measures in future auctions.

4.216 On balance, we believe the advantages from engaging in strategic investment for the whole spectrum available in the auction are uncertain.

[84] If the intended victim(s) of the strategic investment needed 40 MHz to avoid being weakened as competitor(s), the amounts a unilateral strategic investor would need to acquire in scenarios 1 and 2 would be 155 MHz and 115 MHz respectively.

Cost of engaging in strategic investment for all the spectrum available

4.217 While the potential gain seems unclear, the cost and the risk associated with acquiring all or almost all of the spectrum available in the 2.3 and 3.4 GHz auction is likely to be high.

4.218 The 2.3 and 3.4 GHz auction will include 190 MHz of mobile spectrum (40 MHz at 2.3 GHz and 150 MHz at 3.4 GHz). This represents more than 20% of total mobile spectrum (of 836.9 MHz).

Unilateral strategic investment

4.219 Given the amount of spectrum available, a unilateral strategic investor would need to pay not only above its own intrinsic valuation, but also above the market value, for a large amount of excess spectrum it would possibly not actually need. For example, under scenario 1, the strategic investor acting on its own would need to acquire at least 175 MHz, and, even under scenario 2, at least 155 MHz.

4.220 As we noted when we looked at the cost of strategic investment specifically for the 2.3 GHz band, if one or more operators require capacity spectrum to remain strong competitors, their intrinsic value is likely to be high relative to other operators.

4.221 Therefore, the large volume of spectrum in the 2.3 and 3.4 GHz award - and the potentially high intrinsic value of other bidders - both tend to increase the cost to any bidder engaging in strategic investment

4.222 While this would tend to be the case with any auction format, the specific features of the auction format we chose for the 2.3 and 3.4 GHz auction tend to increase both the cost and the risk associated with strategic investment when all the spectrum available in the auction is considered, as opposed to only the 2.3 GHz band. Three features of the auction design are relevant in particular (see also Figure 4.9 below):

- The **first** is related to the way prices are set within each band. The quantity of spectrum for which the strategic bidder may have a high intrinsic value is likely to be small compared to the overall spectrum available. By bidding for a large quantity of spectrum, like in scenario 1 or 2, the bidder is likely to be pushing up the price in both bands and in the process reduce the gains it would otherwise enjoy from a lower price. However, the 3.4 GHz band may in future be used for 5G. There is uncertainty about likely 5G spectrum requirements, but it is currently expected that it may involve relatively large blocks. Bidders bidding under that expectation may want to acquire a large amount of the spectrum in 3.4 GHz in any case.

- The **second** feature is related to the nature of bidding in the auction. Because the strategic bidder would potentially need to bid in both bands simultaneously, the risk of being stuck as a standing high bidder at a price that exceeds its intrinsic valuation, when it would like to stop bidding, is higher than if the bidder was bidding in a single band.

- The **third** is related to the information available during the auction. The limited amount of information will make it riskier to engage in strategic investment. In particular, strategic investors will not know for sure in which band the intended victims would be bidding.

4.223 These features do not rule out the possibility of strategic investment, but they are relevant because they tend to reduce the likelihood of it occurring.

Co-ordinated strategic investment

4.224 We now look at the possibility of coordinating strategic investment (such as in scenario 3). We believe coordination would be difficult to achieve when all the spectrum is considered for four reasons:

- The pay-off that the two operators would jointly extract from denying spectrum to other bidders is the same as the one that applies to unilateral strategic investment which, as noted above, is uncertain.
- As noted in relation to 2.3 GHz spectrum in isolation, the information policy will make coordination difficult, and more so when all the spectrum is considered.
- When all the spectrum is considered, there does not seem to be a clear way in which two operators might divide the spectrum. This is particularly the case in the 150 MHz of 3.4 GHz spectrum. While 2.3 GHz spectrum on its own may have a clear focal point of splitting the band between two strategic investors, by combining it with 3.4 GHz frequencies the focal point is less obvious
- Even if there were a clear focal point for the division of the spectrum, it might still involve a substantial cost to the bidders engaging in coordinated strategic investment. If for example BT/EE acquired 85 MHz of spectrum and Vodafone another 85 MHz, the former would increase its holdings by 33% and the latter by almost 50%.

Strategic investment in the presence of strong value complementarity for large blocks

4.225 It might be argued that strategic investment would be easier if there were strong value complementarities for large blocks of spectrum. Value complementarity occurs when the value placed on a certain amount of spectrum is higher than the sum of the values placed on the individual parts of that amount. For example, if the value assigned by an individual bidder to 40 MHz of 3.4 GHz spectrum is more than twice the value assigned to 20 MHz of the same type of spectrum, there is value complementarity for 40 MHz.

4.226 If there are strong preferences for large blocks of spectrum, due to value complementarity, then there might be a natural division of the 3.4 GHz spectrum in blocks of 40 MHz, which would effectively mean there were four units or less of 3.4 GHz spectrum in the auction: for example, three units of 40 MHz each and one smaller unit of 30 MHz. We do not consider this is necessarily the case. In the context of the discussions in previous documents about the auction design for this award, based on the evidence available to us at that time, we explicitly assumed that the most important source of value complementarity occurred in the first 20 MHz in each band.[85] Nevertheless we consider below the implications of such a scenario of units of 40 MHz in the 3.4 GHz band.

4.227 If we also consider that the 2.3 GHz spectrum might be acquired in two blocks of 20 MHz, this would mean there would effectively be six units of spectrum in the auction, two at 2.3 GHz and four at 3.4 GHz (or acquisition of a single 40 MHz block at 2.3

[85] See for instance the May 2015 Statement (page 88)

GHz would imply five units of spectrum in the auction). The advantages from engaging in strategic investment for the whole spectrum would still be uncertain for the reasons set out above.

4.228 Unilateral strategic investment that excludes one operator would require acquiring more than four of the six units, which would represent a significant amount of spectrum. Having larger blocks of spectrum within each unit does not change this.

4.229 It might be argued that the presence of strong value complementarities may reduce or even neutralise the effect of the first feature of the auction design (the way prices are set in the auction), discussed above. Bidders may be less tempted to reduce demand in order to gain less spectrum, at a lower price, if they have strong values for large amounts of spectrum.

4.230 The mitigating effect of the other two features of the auction design, described above, still apply in the presence of strong value complementarities. All in all, we are of the view that the possible presence of strong value complementarities does not make unilateral strategic investment significantly more likely.

4.231 There could be a difference in terms of changing the focal point for coordinated strategic investment. For example, if two operators were to coordinate, there would be a focal point of three units each, and if three operators were to coordinate, there would be a focal point of two units each. However, having two different types of lot (i.e. 2.3 GHz spectrum and 3.4 GHz spectrum), combined with the limited information available during the auction, would complicate any arrangement. There could be uncertainty between those engaging in strategic investment in terms of who was bidding for 2.3 GHz and who was bidding for 3.4 GHz spectrum, and the cost and risk may not fall evenly on them.

4.232 The intended coordinated strategic investment would only be successful if all the strategic bidders followed through. Each one of the strategic investors would therefore need to take the risk of making a loss, because even if it did its part and bid above its intrinsic value for the two or three units of spectrum, one of the other strategic bidders on which it is relying might not do so, meaning that the weakening of downstream competition was not achieved. Assuming the potential victim has high intrinsic value for the spectrum, the costs and risks of engaging in strategic investment would still be high.

4.233 Other possibilities for the nature of value complementarities further increase the risks to strategic investors:

- For example, we noted above that the most important source of value complementarity could be for the first 20 MHz in each band. This would imply a larger cost of strategic investment in acquiring a 40 MHz block. It might also mean a greater risk that one or more of the strategic investors would revert to bidding for only 20 MHz, making the coordinated strategic investment unsuccessful, but still costly for those strategic investors that did their part and acquired spectrum at prices above their intrinsic value.

- We have also noted above that an operator might wish for reasons of intrinsic value to acquire a large block for 5G in the 3.4 GHz band. In addition, there is uncertainty about exactly how large such a block might be, e.g. 60, 80 or 100 MHz. If it was certain that one specific operator was going to acquire a large block of known size, this could fit with coordinated strategic investment, potentially involving fewer strategic investors (such as two: one acquiring 100

MHz and another acquiring 40 MHz at 3.4 GHz and both acquiring 20 MHz at 2.3 GHz). However, in practice, there is likely to be material uncertainty about whether an operator would acquire a large block and the size of the block. For example, if strategic investor A acquired a 40 MHz block in the expectation that operator B would acquire 100 MHz, but B in practice only acquired 60 MHz, then there would still be 50 MHz available in the 3.4 GHz band for others and the strategic investment could be wholly or largely unsuccessful.

- In general, a lack of certainty about the nature of complementarities, which could be different for different bidders, and the range of possibilities involving block sizes both larger and smaller than 40 MHz, make the focal point for any intended coordinated strategic investment less clear-cut.

Provisional conclusion on the risk of strategic investment in 2.3 GHz and 3.4 GHz spectrum together

4.234 When the specific effect of denying 2.3 GHz spectrum to competitors during the transitional period is ignored, we consider it is unlikely that a single bidder would have the incentive to engage in unilateral strategic investment in relation to all or almost all of the spectrum available in the auction in order to weaken competition. This is because the pay-off is uncertain while the costs and risk of failure are likely to be high.

4.235 While coordination may allow bidders to reduce the individual costs of strategic investment, the pay-off would still be uncertain. In addition, whilst more than one bidder may wish to acquire a large quantity of spectrum, e.g. as a consequence of value complementarities, tacit coordination is made difficult because of the lack of a clear focal point for the division of spectrum, and because the individual costs associated with it are likely to be high.

The risk of strategic investment specifically for 3.4 GHz spectrum - Competition Concern 1(iii)

4.236 We noted earlier in the document that the 3.4 GHz band has the potential to be used for 5G. Some bidders might as a result target specifically the 3.4 GHz band which denies competitors access to a 5G band.

4.237 The potential pay-off from such a strategy is uncertain. At this stage, there is uncertainty about what the technical requirements for 5G will be, about what bands will be primarily used for it, and about the cost savings or incremental value that consumers may place on 5G rather than 4G.

4.238 In addition, the proposed availability of 3.6-3.8 GHz in the future, as well as UK Broadband already holding 40 MHz of 3.4 GHz spectrum and 84 MHz of 3.6-3.8 GHz spectrum, mitigate gains a bidder might otherwise enjoy from acquiring this spectrum and denying it to other bidders.

4.239 While the pay-off - if any - is uncertain, the cost involved in strategic investment would be potentially high, in particular due to the amount of spectrum available. All in all, we consider unilateral strategic investment in 3.4 GHz specifically is unlikely.

4.240 Coordinated strategic investment would face similar costs and risks as discussed above, such as about the absence of a clear focal point and the risk of acquiring 3.4 GHz at a price above intrinsic value but failing to weaken downstream competition by other strategic investor(s) not following through.

Provisional conclusions on likelihood of weaker competition without measures in auction

Likely to remain four credible MNOs without competition measures (Competition Concern 2)

4.241 BT/EE and Vodafone already have strong spectrum holdings which we consider are sufficient for them to remain credible competitors in the future. While the spectrum holdings of O2 and H3G are considerably smaller, even if we imposed no competition measures in the auction, the risk of O2 or H3G ceasing to be a credible competitor in the future is not high, because:

- Even if O2 or H3G did not obtain any spectrum in this auction, there will be other opportunities to obtain spectrum in the future, including in awards of spectrum by Ofcom; and
- If they do believe they need spectrum to be credible, they should be able to obtain a sufficient amount even without any competition measures, because they would have a high intrinsic valuation for such spectrum and because of the high cost that other bidders would incur if they tried to compete for all or most of the spectrum available. Even if O2 and/or H3G failed to acquire 2.3 GHz spectrum, they would be likely to be able to acquire 3.4 GHz.

4.242 While we consider the risk that there would cease to be four credible MNOs is not high even without competition measures, if this were to happen, we expect the adverse impact on consumers would be substantial. We take this into account in our assessment of options in section 5.

However, competition even with four credible MNOs might be weaker without competition measures (Competition Concern 1)

4.243 As explained above, our main concern is that there is a significant risk that increased asymmetry of immediately useable spectrum would weaken competition in the transitional period (Competition Concern 1(ii)).

4.244 We are most concerned that such an outcome might arise from strategic investment, which we consider to be a significant concern. We are nevertheless concerned that this could still be against consumers' interests if it arose without strategic investment.

4.245 We consider that the risk of very asymmetric distributions of spectrum overall and 3.4 GHz spectrum specifically (Competition Concern 1(i) and 1(iii)) weakening competition is lower, because other spectrum will be available in the future through awards by Ofcom. Moreover, in our view, strategic investment is unlikely for spectrum overall and for 3.4 GHz specifically.

Figure 4.9: Auction design features and their effectiveness in addressing the incentives to engage in strategic investment

The first feature that could make strategic investment more costly is related to the way prices in each band are set in the auction. In our auction design the final price for lots within each band will be the same (or separated by at most one increment). In order to fully outbid all the other bidders in a given band, the bidder would need to keep on bidding on all of the lots available in that band until there was no demand from other bidders. This in turn would have the effect of increasing the price for all the lots available in the band.

If the strategic bidder does not have any intrinsic value for any spectrum in the band, when the price in the band exceeds its strategic value, the bidder just stops bidding. If it is subsequently fully outbid by other bidders, the strategic bidder is not made worse-off by having decided to bid on the basis of strategic investment. If however the bidder has an intrinsic value for some spectrum in the band, the decision to have bid for a larger amount of spectrum than it would want to buy for its own use may make it worse-off, if it fails in its strategic investment objective. It would also be worse off if by having bid for a large amount of spectrum it raised the price on the smaller amount of spectrum for which it has some intrinsic value. This applies even in the circumstance the bidder gets fully outbid, as by having instead bid on a smaller amount of spectrum, it might have been able to acquire it at a price lower than its intrinsic value.

However, in 2.3 GHz alone the difference between how much spectrum the bidder would wish to acquire for its own use – if any - and the total amount of spectrum available in the band is likely to be small. Therefore, the impact on the final price of bidding for an additional small amount of spectrum, compared to bidding only for the spectrum the bidder wished to acquire for its own use, is likely to be limited.

The second feature is related to the nature of bidding in the auction. Bidding in the 2.3 and 3.4 GHz auction will not be for packages of spectrum but for individual lots (with a lot size of 10 MHz for the 2.3 GHz band). This means that, whilst a bidder can place bids for multiple lots within each band, it is possible that it will win some of the lots it bids for but not all of them. This is a difference from the combinatorial clock auction which we used for the 2013 auction.

As the auction progresses the price for all the spectrum available in the auction may be such that it exceeds the bidder's strategic investment value (plus intrinsic value). As we noted previously, at that point the bidder would like to stop bidding and abandon the attempt at strategic investment. But in our auction design standing high bids are assigned at the end of each round. It could be that the bidder is assigned standing high bids in one or both bands. If in future rounds the strategic bidder is not outbid on all of its standing high bids, it would still win and be liable to pay for those bids at a price which potentially exceeds its intrinsic value for the spectrum.

In such a situation the strategic bidder would have paid more than its intrinsic value for the spectrum (so incurring a loss) without achieving the effect of foreclosing competition.

The extent to which this risk is a serious deterrent to engaging in strategic investment specifically in 2.3 GHz is however uncertain. On one hand, the amount of spectrum the bidder might end up winning at a loss is likely to be small, due to the fact that there is a small amount available in total. On the other hand, the price at which the bidder may acquire the unwanted spectrum could outweigh the fact that the amount acquired is small.

The third feature is related to the information we will make available to bidders during the auction. The information policy we have decided to adopt is that, during the principal stage, bidders are provided with limited information about the bids made by other bidders. A bidder will not see information on any of the specific bids made by other bidders and instead it will only receive approximate aggregated information.

The limited information available to bidders makes some aspects of strategic investment much more difficult.

In particular, it is difficult for the strategic bidder to target particular competitors, because it does not see any specific bids being made by other bidders. For example, it might be that the strategic bidder believes that only particular competitors are vulnerable to strategic investment (because others competitors' alternative plans without the 2.3/3.4 GHz spectrum would be effective). However, the strategic bidder would not know for sure whether it was bidding against the competitor it wants to target or another bidder. The strategic bidder would face the risk that it would continue to bid when the competitor it wants to target had already dropped out. In this case, the cost to the potential strategic bidder of engaging in strategic investment would be higher (than if it could target particular competitors).

With regards to 2.3 GHz alone, while bidders do not know who they are bidding against, if some bidders are particularly capacity constrained in the short term, they will tend to have high intrinsic valuations for this spectrum. Therefore, a bidder engaging in strategic investment may take the view that it is likely that it will be bidding against those bidders

Consultation question

Question 1: Do you agree that we have identified the right competition concerns?

Question 2: Do you agree with our assessment and provisional conclusions in respect to:

Competition Concern 1 (the risk of very asymmetric spectrum shares and in particular Competition Concerns 1(i), 1(ii), and 1(iii)).

Competition Concern 2 (the risk of there ceasing to be four credible MNOs?

If not, please give your reasons and set out the evidence that supports your view.

Section 5

Options for addressing competition concerns

5.1 Having assessed the possible competition concerns in the previous section, this section considers the options available to us for addressing those concerns – including the option of applying no competition measures at all.

5.2 We begin by setting out a framework for assessing the proportionality of different options for promoting competition. We then consider those options, starting with taking no competition measures in the auction and then considering progressively more interventionist options.

Framework for assessing proportionality of options

5.3 The framework we use for assessing the proportionality of the various options is based on the following principles:[86]

- The measure must be effective to achieve the legitimate aim in question (appropriate);
- The measure must be no more onerous than is required to achieve that aim (necessary);
- The measure must be the least onerous, if there is a choice of equally effective measures; and
- In any event, the measure must not produce adverse effects which are disproportionate to the aim pursued.

5.4 In assessing proportionality, we also take into account the relative weight we place on the different competition concerns that the options mitigate. The relative weight reflects a combination of seriousness of the concern in adversely affecting competition and consumers, and the likelihood of the concern arising.

5.5 As noted in the previous section, our competition concerns focus on the likelihood of there ceasing to be four credible MNOs as a result of the auction; and the likelihood of very asymmetric mobile spectrum shares arising as a result of the auction which have the effect of weakening competition.

5.6 We place most weight on the concern relating to weaker competition in the transitional period due to a very asymmetric distribution of immediately useable spectrum (Competition Concern 1(ii)), because of its much greater likelihood of arising. We also take account of the other competition concerns on which we place less weight for this award: the risk that there ceases to be four credible MNOs in the future; and the risk arising from asymmetric distributions of spectrum overall (including both 2.3 GHz and 3.4 GHz spectrum) and about 3.4 GHz specifically.

[86] These principles were considered by the Competition Commission in the case of *Tesco v Competition Commission* (2009) CAT 6. See, in particular, from paragraph 136 of this judgment. http://www.catribunal.org.uk/files/Judg_1104_Tesco_04032009.pdf

5.7 In considering the effectiveness and potential downsides of the different options, we need to recognise the uncertainty that is an inevitable aspect of the competition assessment for this award. There are uncertainties over the likelihood of competition concerns arising without competition measures, and over whether competition measures might unintentionally lead to a worse outcome for consumers. For example, we are not certain when, or indeed if, the 3.4 GHz spectrum will be a sufficient substitute for other mobile bands.

5.8 These uncertainties mean that making decisions on the proportionality of the different options involves a measure of judgement. We need to apply the proportionality principles in the context of these inevitable uncertainties.

5.9 Below we first consider the option of taking no measures. We then consider five other options involving intervention. For each we assess its effectiveness at addressing our different competition concerns, the first criterion above, and the risk of producing adverse effects, which covers both the second and fourth criteria above. We do not consider that the third criterion is relevant, as we have not identified any two options that are equally effective.

General risks of adverse effects with intervention

5.10 In our assessment below we take account of both general and specific risks of adverse effects of competition measures. Here we outline the general risks, whilst the specific risks are discussed below for each option.

5.11 The likelihood and scale of the risk of unintentionally harming consumers' interests are related to the degree of intervention. The greater the intervention, in general, the greater the likelihood and scale of detrimental effects from unintended consequences. It may be the case that it is appropriate to accept a greater risk of detrimental consequences in order to address a serious and likely competition issue. If the concern is smaller, then our tolerance to detrimental effects would be lower.

5.12 Competition measures may unintentionally harm consumers' interests if they prevent an outcome that would be beneficial. For example, interventions that cap the overall amount of spectrum any operator can hold may increase that operator's costs or reduce the quality of its services, which could be detrimental to consumers. In particular, if competition measures mean that spectrum is not allocated to operators that have the highest intrinsic value, it risks being against consumers' interests.

5.13 Asymmetric spectrum holdings may help to encourage innovation by those with small spectrum shares. For example, if operators with relatively small spectrum shares are unable or unwilling to outbid operators with larger spectrum shares, they may develop other innovative ways of increasing their capacity (for example, through greater use of licence exempt spectrum) or find other ways of offering services that are attractive to consumers.

5.14 If there is a spectrum cap but those eligible to bid are not prepared to pay the reserve prices (suggesting they would obtain little value from the spectrum), then caps can result in unsold spectrum. This could lead to the necessity of holding another auction without the caps and a delay in the spectrum being released - potentially delaying

benefits to consumers. There are examples internationally of spectrum being unsold due to spectrum caps.[87]

5.15 There is also a risk that operators may choose to bid less than their intrinsic values in this award, in the hope of influencing Ofcom's decisions about future spectrum awards. For example, operators with small amounts of spectrum may assume that if they fail to obtain spectrum in this auction, Ofcom is more likely to take measures in future auctions. This could lead to inefficient spectrum allocations that are not in consumers' interests. This risk is made more relevant by the proximity of the auction for the 700 MHz spectrum, which we anticipate to be highly valuable spectrum, and the proposed award of 116 MHz within the 3.6-3.8 GHz band.

5.16 To some extent, this risk exists whether or not there are competition measures in this auction. However, in general, we believe that the more interventionist we are in this auction, the more likely operators are to expect us to be interventionist in the future - and the greater the risk that they will try to unduly influence our future decisions. This tends to make us more cautious about imposing interventionist competition measures in this auction.

Taking no measures does not address our main competition concern

5.17 The first option we consider is taking no competition measures in the auction. However, this would not address our main concern of weaker competition as a result of the very asymmetric distribution of immediately useable spectrum (Competition Concern 1(ii)) and we therefore think that it is appropriate to impose some form of competition measure specifically in order to address this concern. We therefore consider options involving competition measures, and their proportionality, below.

Main options for competition measures

5.18 We consider five main options for intervention below. These start with the least interventionist option we have considered, and then consider other options that are more interventionist.

- Option A - a cap of 255 MHz (about 42%) applied only to immediately useable spectrum, which would have the effect of excluding BT/EE from acquiring 2.3 GHz spectrum (but would permit it to acquire 3.4 GHz spectrum);
- Option B - a cap of 150 MHz (about 25%) of immediately useable spectrum, which would have the effect of excluding both BT/EE and Vodafone from acquiring 2.3 GHz spectrum (but would allow both to acquire 3.4 GHz spectrum);
- Option C – a cap of 255 MHz applied only to immediately useable spectrum (as in option A) combined with an overall spectrum cap set at 340 MHz (around 37% of the sum of currently held spectrum, the spectrum in this award and 700 MHz spectrum), which would have the effect of excluding BT/EE from acquiring 2.3

[87] For example, nobody acquired any of the 2.6 GHz unpaired spectrum in the auctions held in the Netherlands (2010) and Spain (second award in 2011). In the Netherlands this spectrum was eventually sold in 2012 while in Spain a third award in 2011 with revised caps led to the sale of most of the leftover spectrum. See Annex 8 of Ofcom's Statement on "*Annual licence fees for 900 MHz and 1800 MHz spectrum*", 24 September 2015, http://stakeholders.ofcom.org.uk/consultations/annual-licence-fees-further-consultation/statement/

GHz spectrum and limiting it to 85 MHz of 3.4 GHz spectrum. This option would also place a small constraint on Vodafone's total spectrum acquisitions;

- Option D - reserving two lots, each of 20 MHz of 2.3 GHz spectrum, for operators with smaller spectrum holdings (e.g. less than 90 MHz) or new entrants, which would exclude BT/EE and Vodafone (the two MNOs with the largest current spectrum holdings) from acquiring 2.3 GHz spectrum; and

- Option E – a tight overall spectrum cap of 255 MHz, about 30% of mobile spectrum, which would have the effect of excluding BT/EE from acquiring any spectrum in this award.

5.19 Option A is the least interventionist option, because, in emphasising our main concern relating to a very asymmetric distribution of immediately useable spectrum, it imposes limits only on one band and only has the effect of restricting one operator, BT/EE, from obtaining 2.3 GHz spectrum (albeit that it prevents that operator from acquiring any spectrum in this band). Option B goes further as it would have the effect of excluding both BT/EE and Vodafone from obtaining 2.3 GHz spectrum.

5.20 Option C is more interventionist than option A because it includes an additional restriction in the form of an overall spectrum cap (that is a looser version of what we favoured in our November 2014 consultation, taking account of subsequent developments). Option E is much more interventionist because, although it only includes an overall spectrum cap, that cap is set at a much more restrictive level.

5.21 Option D would ensure 2.3 GHz spectrum is allocated to two different entities other than BT/EE and Vodafone, and in that sense is a highly interventionist option.

5.22 Options D and B are similar in that both prevent BT/EE and Vodafone from acquiring 2.3 GHz spectrum. But they are different in that option D would prevent one operator (such as O2 or H3G) from acquiring all 40 MHz of the 2.3 GHz spectrum, while option B would allow this.

5.23 Below we describe in more detail and assess in turn each of options A to E, including what spectrum any caps include and the implications for different operators. We also consider some variations of these main options.

5.24 Below we also consider the possibility of making any competition measures contingent on the auction price reaching a threshold price. This could apply to any of options A to E, and would be aimed at reducing the risk of adverse effects.

Option A: cap on immediately useable spectrum

5.25 Option A involves a cap on the amount of immediately useable spectrum any company could have. This would address our main concern relating to a very asymmetric distribution of immediately useable spectrum.

5.26 As explained in section 4, we are concerned that there is a risk that competition may be weakened if any single operator has more than about 40% of spectrum. We have considered a cap set at 255 MHz, which would represent 42% of the immediately useable spectrum, and would prevent BT/EE from increasing its holdings of immediately useable spectrum. BT/EE would only be able to obtain 2.3 GHz spectrum in the award if it sold some of its existing spectrum in advance. Before taking account of the 2.3 GHz band, BT/EE's share of immediately useable spectrum is 45%. The cap would therefore have the effect of reducing its share of immediately

useable spectrum after the auction (i.e. after taking account of 2.3 GHz spectrum) to 42%. The cap would not restrict any other bidders in terms of purchasing 2.3 GHz spectrum.

5.27 The cap would apply to the spectrum we expect to be immediately useable after the auction, namely spectrum at 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz. Importantly, this cap would exclude the 3.4 GHz spectrum, as well as spectrum in the 1400 MHz band.[88]

5.28 We have considered whether it would be appropriate to go further in terms of capping BT/EE's share of useable spectrum in the transitional period. One option might be to prevent BT/EE from obtaining any of the 3.4 GHz spectrum unless it divested some of its existing spectrum prior to the auction to comply with a lower share of immediately useable spectrum.

5.29 However, such a restriction would not fit well with the competition problem it aimed to address. Barriers on BT/EE obtaining 3.4 GHz spectrum would not directly help promote competition in the transitional period. Moreover, we consider that requiring BT/EE to divest spectrum it already holds (and may be planning to use) is a significantly greater intervention than preventing it from acquiring new spectrum. We do not consider the potential benefits from promoting competition in this way are sufficient for this to be proportionate.

Effectiveness of option A at addressing competition concerns

Effectiveness at promoting competition during the transitional period - Competition Concern 1(ii)

5.30 This option would prevent the current asymmetry of immediately useable spectrum from worsening and it would decrease the share held by the operator with the largest such holdings. It is therefore effective in addressing our main competition concern in this auction.

Effectiveness at addressing other potential competition concerns

5.31 We have other competition concerns, some of which this option mitigates to a limited extent. We attach lower weight to these concerns for the reasons discussed in section 4.

5.32 We have a concern about there ceasing to be four credible MNOs in the future. As BT/EE and Vodafone already have sufficiently strong spectrum holdings to remain credible, the potential issue for credibility relates to spectrum being obtained by O2 or H3G. Option A limits what BT/EE can win, making it more likely that O2, H3G or a new entrant will obtain spectrum - but this option imposes no restrictions on the spectrum Vodafone can acquire. Option A therefore does not guarantee that O2 or H3G acquires spectrum. But even without competition measures, we consider that the risk of O2 or H3G failing to remain credible is not high.

[88] We expect the 1400 MHz spectrum to be useful before the 3.4 GHz spectrum, so there might be an argument for including the 1400 MHz spectrum in the frequencies covered by the cap. However, given that the cap only bites on BT/EE, this change would make no difference in practice (as BT/EE does not hold 1400 MHz spectrum). We note that if the 1400 MHz spectrum were included in the denominator, then BT/EE's 255 MHz of spectrum would represent 39% of the total.

5.33 Other potential concerns about weaker competition relate to asymmetric distributions of spectrum overall (including both 2.3 GHz and 3.4 GHz spectrum) and about 3.4 GHz specifically. This option does not directly address the latter concern about 3.4 GHz spectrum, as it does not impose a restriction on 3.4 GHz spectrum.

5.34 However, this option contributes to a limited extent in avoiding very asymmetric distributions in overall spectrum, as it prevents BT/EE from obtaining 2.3 GHz spectrum. However, there could still be a large degree of asymmetry in total mobile spectrum holdings immediately after the auction. At the most extreme, BT/EE would still be able to obtain all 150 MHz of the 3.4 GHz spectrum in the auction if it outbid all other operators for the entirety of the available spectrum in the band. This extreme outcome would mean it could have 405 MHz of mobile access spectrum, which represents 48% of allocated spectrum immediately after the award.

5.35 We consider it less likely that very asymmetric distributions of spectrum overall and 3.4 GHz spectrum specifically would cause competition concerns, because other spectrum will be available in the future through awards by Ofcom.[89] This mitigation is more important because the 3.4 GHz will not be useable for at least two to three years after the auction. Moreover, strategic investment is unlikely when all the 2.3 GHz and 3.4 GHz spectrum is considered together and for 3.4 GHz specifically.

Risks of Option A producing adverse effects

5.36 This option could only produce adverse effects and harm consumers' interests if BT/EE had the highest intrinsic value for the 2.3 GHz spectrum. If that were the case, whether this option actually harmed consumers' interests would depend on a trade-off, as discussed in section 4. The trade-off would be between the potential adverse effect on competition from BT/EE obtaining it, and potential consumer harm due to the operator with the highest intrinsic value not being able to use the spectrum when it might offer the most attractive services to consumers.

5.37 However, we consider this unlikely because:

- BT/EE already has a large amount of useable mobile spectrum - 255 MHz. This represents 42% of immediately useable spectrum after the award;
- BT/EE's current holdings include a large amount of paired spectrum and some unpaired spectrum. It has 15 MHz of unpaired spectrum in the 2.6 GHz band, and under this option would not be prevented from acquiring more unpaired spectrum in the 3.4 GHz band;
- BT/EE combines this high share of spectrum with a large network of sites (around 18,000);
- BT/EE is not currently deploying all of its existing spectrum widely. It has deployed 2x20 MHz of 2.6 GHz spectrum, with an additional 2x15 MHz deployed on a number of sites in Central London, and at Wembley. BT/EE has also told us that it has recently begun small scale deployment of the 2.6 GHz spectrum held by BT prior to the acquisition of EE. The 2.6 GHz spectrum held by BT prior to

[89] If BT acquired all the 3.4 GHz spectrum (but no 2.3 GHz spectrum), this would represent 44% if we also include in the denominator the 700 MHz band but not the 3.6-3.8 GHz spectrum, or 36% including the 3.6-3.8 GHz spectrum as well.

the merger in total represents 45 MHz of its 2.6 GHz spectrum (or 7% of immediately useable spectrum after the award); and

- We would not be preventing BT/EE from buying a large amount of 3.4 GHz spectrum, which we believe will be a sufficient substitute for other mobile spectrum in terms of adding capacity in the longer term, and might be used for 5G services in the future.

5.38 Even though the risk of harm from preventing BT/EE obtaining 2.3 GHz spectrum seems low, we recognise that there is some risk. For example, it is not impossible that BT/EE might prefer to add capacity in the longer term by using 2.3 GHz spectrum rather than 3.4 GHz spectrum because the 2.3 GHz spectrum fits better with its existing network configuration. Also it may have plans to deploy all of its current spectrum in the near future.

5.39 A specific concern with this option is that it could increase Vodafone's incentive to engage in strategic investment against O2 or H3G, compared to if there were no competition measures.

5.40 Without any intervention, Vodafone would not know whether it was bidding against BT/EE (and so increasing the price it has to pay without any benefit for Vodafone in terms of weakening rivals with smaller spectrum holdings) or whether by bidding higher it was squeezing out weaker rivals. This would tend to reduce the attractiveness of engaging in strategic investment, as it makes the potential benefits more uncertain.

5.41 In contrast, with option A, BT/EE is prevented from bidding for 2.3 GHz spectrum, so Vodafone would know it was not bidding against BT/EE and would instead be bidding against rivals with smaller spectrum holdings. This tends to make strategic investment more attractive to Vodafone compared to if no competition measures were taken.

5.42 However, Vodafone's incentive to engage in strategic investment may not be as great as BT/EE's would be. If Vodafone wished to engage in strategic bidding, with BT/EE not being allowed to bid for 2.3 GHz spectrum, the cost of strategic investment would fall entirely on Vodafone. However, if BT/EE was allowed to bid for this spectrum in the auction, there might be a clear focal point that would allow the two companies to split the cost of denying spectrum to other bidders. This would be achieved by bidding for 20 MHz each.

5.43 Vodafone has a lower market share than BT/EE (21% compared to 34% of subscribers), tending to reduce the gains it would obtain from any general increase in prices. Also, BT/EE has more spectrum than Vodafone, which means that it might have more capacity to acquire and serve new customers from other operators (although, on the other hand, we also note that Vodafone's current ratio of data to spectrum is lower than BT/EE's).

5.44 If BT/EE combined has a stronger retail position after the merger than EE's in isolation, it might now have more to gain from a weakening of competitors (in terms of acquiring switching customers).[90]

[90] This point was noted by the CMA in paragraph 12.37 in the *BT Group plc and EE Limited: A report on the anticipated acquisition by BT Group plc of EE Limited*, CMA, 15 January 2016.

Provisional conclusion on Option A

5.45 This option would prevent the current asymmetry of immediately useable spectrum from worsening and it would decrease the share held by the operator with the largest such holdings. It is therefore effective in addressing our main competition concern in this auction.

5.46 By preventing BT/EE from obtaining all the spectrum in the auction, this option also provides some small mitigation to the other potential competition concerns we have identified, such as a very asymmetric spectrum distribution in the longer term and maintaining at least four credible MNOs.

5.47 There are some risks of producing adverse effects with option A, but we consider these to be relatively low. This is mainly because BT/EE is unlikely to have a higher intrinsic value than other operators for the 2.3 GHz spectrum, and this option does not place any restriction on BT/EE acquiring a large block of 3.4 GHz spectrum.

5.48 If the 3.6-3.8 GHz spectrum were not available for mobile services in a similar timeframe to the 3.4 GHz spectrum, then we would be more concerned about a large degree of asymmetry in total mobile spectrum holdings immediately after the auction. This may mean this option is less effective at addressing our competition concerns and strengthens the case for an additional constraint on overall spectrum holdings, as discussed below under option C.

5.49 Given the assessment above, we consider option A is proportionate. Overall, we consider option A would be effective in achieving our aim of avoiding an increasingly asymmetric distribution of immediately useable spectrum during the transitional period. Further, whilst other measures (considered below) may also be effective in achieving our aim of promoting competition, our provisional view is that they would be more onerous and therefore disproportionate.

Option B: tighter cap on immediately useable spectrum

5.50 We next consider a tighter cap on immediately useable spectrum, namely a cap that would prevent operators with holdings of more than 150 MHz (about 25%) of immediately useable spectrum from acquiring 2.3 GHz spectrum. This would have the effect of excluding both BT/EE and Vodafone from acquiring 2.3 GHz spectrum.

5.51 This option aims to address our main competition concern of spectrum asymmetries in immediately useable spectrum by ensuring that only operators with currently small spectrum shares (including H3G, O2 and a new entrant) are able to obtain 2.3 GHz spectrum.[91]

5.52 A variant of this option would be to set a cap that would prevent BT/EE from obtaining any 2.3 GHz spectrum, but to allow Vodafone to acquire up to 20 MHz of the 40 MHz in the band. This would be the effect of a cap at 180 MHz (about 30%) of immediately useable spectrum.

[91] This option is the same in its effect as an option suggested to us by a stakeholder involving a reservation of the 2.3 GHz spectrum for operators with less than 120 MHz of sub 3 GHz spectrum.

Effectiveness of option B at addressing competition concerns

Effectiveness at promoting competition during the transitional period - Competition Concern 1(ii)

5.53 This option goes further than option A in reducing asymmetry of immediately useable spectrum by ensuring the 2.3 GHz spectrum is obtained by operators with small holdings of such spectrum[92]. It may therefore be more effective than option A at promoting competition in the transitional period, which is our main competition concern for this award.

Effectiveness at addressing other potential competition concerns

5.54 This option also mitigates some of our other competition concerns to a limited extent.

5.55 It has the effect of preventing BT/EE and Vodafone from bidding for any 2.3 GHz spectrum, thereby ensuring the spectrum is allocated to those with a small share currently (O2 or H3G) or a new entrant[93]. In this way, it tends to reduce the risk that there ceases to be four credible MNOs in the future. As discussed under option A, we consider this risk to be not high even without competition measures.

5.56 It also tends to reduce asymmetry in total spectrum holdings to some limited extent. As discussed under option A, this concern about overall spectrum asymmetry is anyway mitigated by other opportunities to obtain mobile spectrum in the future. Like option A, this option does not directly affect the distribution of 3.4 GHz spectrum.

Risks of Option B producing adverse effects

5.57 Option B prevents both BT/EE and Vodafone from obtaining 2.3 GHz spectrum. We have discussed above the general risks of intervention, and under option A the risks involved with preventing BT/EE from obtaining 2.3 GHz spectrum. Here we therefore focus on the additional risks of preventing Vodafone from obtaining 2.3 GHz spectrum.

5.58 This option could produce adverse effects and harm consumers' interests if Vodafone had the highest intrinsic value for the 2.3 GHz spectrum, though there would be a trade-off as discussed for option A.

Preventing Vodafone obtaining 2.3 GHz spectrum may lead to an inefficient spectrum distribution

5.59 Based on Vodafone's current holding of spectrum, blocking it from acquiring any 2.3 GHz spectrum would mean preventing it from obtaining more than 26% of immediately useable spectrum.[94] This is very restrictive in a market with four MNOs, where completely symmetric shares (and no other competitors) would imply 25%

[92] Provided demand for the spectrum is expressed by those operators at least at the reserve price set by Ofcom.
[93] Again, provided those bidders have an interest to acquire the spectrum at least at the reserve price
[94] Vodafone's share of useable spectrum of 26% is calculated excluding the 1400 MHz spectrum. If we also consider the 1400 MHz spectrum, then Vodafone would have 27% of spectrum currently.

each. It would prevent Vodafone from reducing the gap to BT/EE's amount of immediately useable spectrum.[95]

5.60 We recognise that currently Vodafone has a low share of data traffic and a lower ratio of data carried/MHz of spectrum than other operators. Moreover, like BT/EE, Vodafone is not currently deploying all of its 2.6 GHz spectrum widely. It has deployed its paired 2.6 GHz spectrum (of which it has 2x20 MHz) on only a small proportion of total sites [✂] REDACTED, and is currently trialling the use of its unpaired 2.6 GHz spectrum.

5.61 Its unpaired 2.6 GHz spectrum represents 3% of immediately useable spectrum after the auction. While this could suggest Vodafone would have a low intrinsic value for additional spectrum, such metrics are only crude indicators of the potential value Vodafone currently obtains from its spectrum. Moreover, what matters in terms of an efficient distribution of spectrum in the auction is how operators value incremental spectrum for future use. This could be affected by, for example, their choices on the services they offer, future growth and their re-farming plans.

5.62 We also note that Vodafone is smaller than O2 in terms of share of subscribers, and has lost market share in recent years, while O2 and H3G have generally gained market share. There are likely to be many different factors contributing to Vodafone's falling market share, but it is not impossible that additional spectrum could make Vodafone a more effective competitor.

5.63 Any potential harm from preventing Vodafone from acquiring 2.3 GHz spectrum would be mitigated by its ability to acquire 3.4 GHz spectrum, which we expect will be sufficiently substitutable for other mobile spectrum in the longer term. But the 3.4 GHz spectrum may be more costly for operators to deploy than the 2.3 GHz spectrum, and Vodafone may need additional spectrum before the 3.4 GHz spectrum is useable.[96]

Risk of O2 and H3G strategically reducing demand for 2.3 GHz spectrum

5.64 A specific risk with option B is that O2 and H3G may have an incentive to reduce demand for 2.3 GHz spectrum strategically, with each aiming to win 20 MHz at the reserve price, even though their intrinsic values may imply that an efficient outcome would involve a larger amount of spectrum being acquired by one of them.

5.65 The one with the higher intrinsic value may find it more profitable to settle for 20 MHz of 2.3 GHz spectrum at a lower price, rather than win 30 or 40 MHz at a higher price. If one had a higher intrinsic value for 30 MHz or all 40 MHz of 2.3 GHz spectrum, this would probably not be in consumers' interests.[97] This risk might potentially be

[95] We recognise that Vodafone has a much greater amount of high value low frequency spectrum compared to BT/EE. Specifically, Vodafone has 2 x 27.4 of 800 and 900 MHz spectrum, as well as 20 MHz of 1400 MHz spectrum. In contrast, BT/EE only has 2 x 5 of 800 MHz spectrum. However, we are interested in the additional benefit of spectrum holdings at 2.3 GHz, and it is not obvious that Vodafone's high share of low frequency spectrum has a significant impact on that.

[96] If the 3.4 GHz spectrum were not a sufficient substitute for other bands in the longer term, then option B would impose a more significant constraint on Vodafone, increasing the risk of adverse effects with option B.

[97] We note that if O2 and H3G were to engage in such strategic demand reduction, the outcome would be the same as under option D (reservation of two lots of 2.3 GHz spectrum). An advantage of option B over option D is that if one of O2 or H3G had a much higher intrinsic value for all of the 2.3 GHz spectrum, it could obtain that, if this outweighed its gain from strategic demand reduction.

reduced if a threshold price level were used before the competition measure had effect, provided that a threshold price could be set at an appropriate level.

Variant of allowing Vodafone to only acquire 20 MHz of 2.3 GHz spectrum

5.66 If we allowed Vodafone to acquire only 20 MHz of 2.3 GHz spectrum, this would mean it could acquire up to 29% of immediately useable spectrum. This would still prevent Vodafone from reducing the gap to the amount of the spectrum held by BT/EE. While this variant would reduce the risk of adverse effects with this option, it would not remove it.

Provisional conclusion on Option B

5.67 While option A would be effective in addressing the risk of weaker competition through very asymmetric holdings in the transitional period, our provisional view is that option B would be more effective. This is because it would also prevent Vodafone (in addition to BT/EE) from acquiring any 2.3 GHz spectrum.

5.68 However, we are concerned about a greater risk of adverse effects from option B given that it would represent a greater level of intervention. As discussed above, preventing Vodafone (whose current spectrum holdings are materially smaller than BT/EE's) from obtaining 2.3 GHz spectrum may lead to an inefficient spectrum distribution. It could also risk incentivising strategic demand reduction by O2 and H3G.

5.69 On balance, while we recognise that this option may better address our main competition concern than option A, we consider that it is more onerous and risks producing adverse effects which are disproportionate to our aim. We therefore consider it is disproportionate.

Option C: caps on immediately useable spectrum combined with an overall spectrum cap

5.70 This option involves two caps:

- A cap on immediately useable spectrum as with option A above; and
- A cap on overall spectrum, where we specifically consider a cap set at 340 MHz.

5.71 The purpose of the first cap would be to address our main competition concern about very asymmetric spectrum holdings of immediately useable spectrum. The second cap would address a longer term concern about a very asymmetric distribution of spectrum overall, when the 3.4 GHz spectrum becomes useable.

5.72 An overall cap was our preferred option in our November 2014 consultation. We now consider that an overall cap on its own would be ineffective. It would not address our main competition concern relating to the very asymmetric distribution of immediately useable spectrum, which could weaken competition in the transitional period.

5.73 However, having an overall spectrum cap in addition to the cap on immediately useable spectrum has some merit. We previously proposed an overall spectrum cap at 310 MHz, which was derived by multiplying the same percentage we used for the overall spectrum cap in the 2013 award (37%) by the total amount of spectrum already allocated plus the 2.3 and 3.4 GHz spectrum in the award. As this cap was

set at a relatively high level, we previously considered that this option was not overly onerous.

5.74 However, in the specific circumstances of the 2.3 GHz and 3.4 GHz award, the case for an overall spectrum cap at this level is significantly weakened by the following:

- BT/EE would be prevented from acquiring a large block of 3.4 GHz spectrum (since it would be limited to acquisition of 55 MHz). The 3.4 GHz band may be used to launch 5G services, and blocking BT/EE from obtaining a large block could be detrimental to consumers if BT/EE needed 3.4 GHz spectrum to deploy 5G services early, and was better positioned than its competitors to do so.

- Other mobile spectrum will be awarded that will be useable at a similar time to the 3.4 GHz spectrum.

5.75 Because we expect other spectrum to be available when the 3.4 GHz spectrum becomes useable, we are less concerned about asymmetry in spectrum overall. In particular, we expect 700 MHz and potentially 3.6-3.8 GHz to be useable. This means that even if BT/EE acquired all the 150 MHz of 3.4 GHz of spectrum in the auction, it would have only 36% of the spectrum that would be useable in the longer term.

5.76 However, as discussed in section 4, there is more uncertainty about whether the 3.6-3.8 GHz spectrum will be useable in the same timeframe as the 3.4 GHz and 700 MHz spectrum. We have therefore considered a cap of 340 MHz which represents around 37% of the sum of currently held spectrum, the spectrum in this award and 700 MHz spectrum (including the 700 MHz centre gap). This excludes the 3.6-3.8 GHz spectrum. An overall spectrum cap at this level (combined with the separate cap on 2.3 GHz spectrum) would imply the following restrictions (based on current spectrum holdings):

- **BT/EE** would be prevented from obtaining any 2.3 GHz spectrum and more than 85 MHz of 3.4 GHz spectrum; and

- **Vodafone** would be prevented from obtaining more than 160 MHz of any combination of the 40 MHz of 2.3 GHz and 150 MHz of 3.4 GHz spectrum.

5.77 The caps in this option would not restrict any other bidders in terms of purchasing 2.3 GHz or 3.4 GHz spectrum.

Variants of option C

<u>Combining an overall spectrum cap with the cap in option B</u>

5.78 One variant of this option would be to combine an overall cap on spectrum (for example, set at 340 MHz) with the cap on immediately useable spectrum set out in option B above. If we were to consider option B proportionate, there might be some merit in combining it with an overall cap on spectrum. However, given our provisional view that option B is not proportionate we do not consider this variant further.

<u>Higher level for overall cap</u>

5.79 The overall spectrum cap could also be set at a higher level. There is uncertainty over just how large the blocks desirable for 5G services might be. A cap at 340 MHz would prevent BT/EE from obtaining more than 85 MHz of 3.4 GHz spectrum. A

higher cap, for example set at 355 MHz, would allow BT/EE to obtain 100 MHz of contiguous 3.4 GHz spectrum (assuming UK Broadband participates in the 2.3/3,4 GHz auction and applies for a replacement licence – if not, there would not be more than 80 MHz of contiguous spectrum).[98] However, our provisional view is that this variant is not proportionate for similar reasons to those set out below in relation to option C more generally.

Having a cap on 3.4 GHz spectrum specifically rather than an overall cap

5.80 Another variant of this option would be to replace the second cap (which relates to overall spectrum holdings) with a cap specifically on the amount of 3.4 GHz spectrum any company could obtain. Because of the possibility that large blocks of 3.4 GHz spectrum may be optimal for 5G services and our desire not to prevent innovation in this area, we would set such a cap at a high level, e.g. 80 to 100 MHz of 3.4 GHz spectrum.

5.81 Such a cap could have benefits in terms of promoting competition by ensuring that at least two operators obtained 3.4 GHz spectrum in the auction. It would prevent any operator, including BT/EE and Vodafone, from individually obtaining all of the 3.4 GHz spectrum, and could also promote competition in terms of mitigating the risk of a very asymmetric distribution of spectrum overall.

5.82 However, we attach lower weight to concerns about very asymmetric holdings of 3.4 GHz spectrum specifically, for the reasons explained in section 4. Also, given we are not certain just how large the blocks desirable for 5G services might be, there is a risk that if we were to set a cap, we may set it at a level which is too restrictive, especially if the cap is set at a lower level than 100 MHz. This might slow deployment of 5G services in the UK, which may not be in consumers' interests. On balance, we do not consider that it is proportionate to impose a separate cap on the 3.4 GHz spectrum, and therefore don't consider this variant further.

Effectiveness of option C at addressing competition concerns

Effectiveness at promoting competition during the transitional period

5.83 This option is the same as option A in terms of its effectiveness at addressing our main competition concern about asymmetry of immediately useable spectrum (Competition Concern 1(ii)).

Effectiveness at addressing other potential competition concerns

5.84 This option is also effective in addressing the risk of very asymmetric total spectrum distributions (Competition Concern 1(i)). As discussed under option A, this concern is anyway mitigated by other opportunities to obtain mobile spectrum in the future. But there is some risk that the 3.6-3.8 GHz spectrum will not be as useful as soon as other spectrum, and may therefore not mitigate a very asymmetric distribution resulting from this auction. If the usability of the 3.6-3.8 GHz spectrum were materially later than the 3.4 GHz spectrum, the overall cap in this option would be effective in avoiding a very asymmetric distribution of spectrum.

[98] A cap at 355 MHz would represent a cap of around 39% of the spectrum already allocated plus the spectrum in this auction and also the 700 MHz spectrum. This is calculated excluding the 3.6-3.8 GHz spectrum. It would represent 32% of total spectrum if the 3.6-3.8 GHz were also included in the denominator.

5.85 In terms of our concern about 3.4 GHz spectrum specifically, this option prevents BT/EE from obtaining all the 3.4 GHz spectrum. But it does not prevent other operators from acquiring all of the 3.4 GHz spectrum, so may not necessarily be effective in ensuring a number of operators would be able to launch future 5G services with 3.4 GHz spectrum. We therefore do not consider this variant further.

5.86 The two caps together reduce the risk that there would cease to be four credible MNOs in the future, but they do not ensure that O2 or H3G will obtain spectrum. But we anyway consider it likely that there will remain four credible MNOs in the future.

Risks of Option C producing adverse effects

5.87 The risks with the cap on immediately useable spectrum are the same as discussed under option A above.

5.88 In terms of the overall spectrum cap, a specific concern is that it reduces the ability of BT/EE to obtain a very large block of spectrum, which may be important for it to offer 5G services, as discussed above. This could delay or reduce the deployment and availability of 5G services. However, option C would still permit BT/EE to acquire a block up to a bandwidth of 85 MHz. Whilst there is uncertainty about the most efficient block size for 5G, we do not currently have evidence that a contiguous block of 100 MHz has important advantages for 5G deployment over, for example, an 80 MHz block.

5.89 As the cap would allow BT/EE to obtain 85 MHz of 3.4 GHz spectrum and there will be other spectrum becoming available in the future that could be used for 5G services[99], we do not consider this to be a large risk.[100] But there is some risk.

5.90 We also note that there could be an interaction with expectations about the 700 MHz auction, especially as the calculation of the cap of 340 MHz, as described above, uses a pool of relevant mobile spectrum that includes the 700 MHz band. Whilst competition measures in the future 700 MHz action are a matter we will decide in the process for that award, BT/EE may be cautious of obtaining a large block of 3.4 GHz (such as 80 MHz), even if it is allowed to do so, if it were concerned this might mean it would be precluded from also obtaining 700 MHz spectrum. This risk would be reduced if the level of the overall spectrum cap were raised.

Provisional conclusion on Option C

5.91 We see some merit in combining a cap on immediately useable spectrum (option A) with an overall cap on spectrum, which could be set at a higher level in recognition of other spectrum becoming available in the longer term. Such a combined set of measures would avoid an increasingly asymmetric distribution of spectrum in both the transitional period and the longer term and would therefore be effective in addressing Competition Concerns 1(i) and (ii).

[99] For example, the proposed award of 3.6-3.8 GHz spectrum would allow any operator that was prevented from launching 5G services with 3.4 GHz spectrum due to competition measures in this auction to obtain other spectrum in the future, with which it could launch 5G services.

[100] We also note that if BT/EE greatly valued having a large block of 3.4 GHz spectrum, it could sell some of its existing spectrum before the auction. This could allow it to bid for a large block of 3.4 GHz spectrum without being constrained by an overall spectrum cap. However, BT/EE would need to sell its existing spectrum before knowing the price of a large block of 3.4 GHz spectrum in the auction, which it may be reluctant to do.

5.92 However, as with any competition measures, there is a risk that this option prevents an outcome that is in consumers' interests or distorts operators' bidding incentives. Both these general risks are greater with this option compared to option A because this option is more interventionist.

5.93 On balance, we consider that it is not proportionate to impose a cap on overall spectrum in addition to a cap on immediately useable spectrum. In particular, it is more onerous than option A and risks producing adverse effects which are disproportionate to our aim.

5.94 The case for this option being proportionate would be stronger if there were evidence that having very large blocks of 3.4 GHz spectrum was unlikely to be important for 5G services and if the 3.6-3.8 GHz spectrum was likely to be useable materially later than the 3.4 GHz spectrum.

Option D: reservation of two lots of 2.3 GHz spectrum

5.95 This option involves reserving two lots of 20 MHz of 2.3 GHz spectrum for operators with smaller spectrum holdings (e.g. less than 90 MHz) or a new entrant. This would exclude BT/EE and Vodafone (the two MNOs with the largest current spectrum holdings) from acquiring 2.3 GHz spectrum, because they already have a large amount of immediately useable spectrum. O2, H3G or new entrants would each be able to obtain one of the two reserved lots.

5.96 This option would prevent one of O2, H3G or a new entrant obtaining all of the 40 MHz of 2.3 GHz spectrum. This is the distinction between this option and option B.

5.97 A variant of this option would be to reserve a larger amount of spectrum, such as an additional 40 MHz in the 3.4 GHz band. However, since 3.4 GHz spectrum is not useable in the transitional period, it would not assist the promotion of competition in the short term. As to credibility, if, for example, O2 and H3G were each to win 20 MHz of 2.3 GHz, this would take each of their shares of spectrum from at or near the bottom of the 10-15% range to above the middle of this range at about 13%.[101] A further 20 MHz each would increase their shares to just over 15%. We consider that reservation of 3.4 GHz spectrum as well would be unwarranted in light of the competition concerns identified previously. We therefore don't consider this option further.

Effectiveness of option D at addressing competition concerns

Effectiveness at promoting competition during the transitional period - Competition Concern 1(ii)

5.98 Like option B, this option goes further than option A in reducing asymmetry of immediately useable spectrum by ensuring the 2.3 GHz spectrum is obtained by operators with small holdings of such spectrum or a new entrant. It may therefore be

[101] The denominator for these percentages includes all mobile spectrum allocated immediately after the 2.3 GHz / 3.4 GHz auction: 800 MHz, 900 MHz, 1400 MHz, 1800 MHz, 2.1 GHz, paired and unpaired 2.6 GHz plus 2.3 GHz and 3.4 GHz.

more effective than option A at addressing our competition concern in the transitional period, which is our main competition concern for this award.[102]

Effectiveness at addressing other potential competition concerns

5.99 This option also mitigates some of our other competition concerns to some extent. By ensuring that the 2.3 GHz spectrum is obtained b*y two* operators with small shares (which could be O2, H3G or a new entrant), this option reduces the risk that there cease to be four credible MNOs in the future[103] and reduces overall spectrum asymmetry. However, there could still be a large degree of asymmetry in total mobile spectrum holdings immediately after the auction. As discussed for other options, this concern about overall spectrum asymmetry is mitigated by other opportunities to obtain mobile spectrum in the future.

5.100 Like option A, this option does not directly affect the distribution of 3.4 GHz spectrum.

Risks of option D producing adverse effects

5.101 This option would have the effect of preventing both BT/EE and Vodafone from obtaining any 2.3 GHz spectrum. We have discussed the risks of producing adverse effects from preventing BT/EE from acquiring any 2.3 GHz spectrum under option A (cap on spectrum useable in transitional period) above and the risk of preventing Vodafone from acquiring 2.3 GHz under option B (prevention of operators with more than 150 MHz of immediately useable spectrum from acquiring 2.3 GHz spectrum) above.

5.102 Option D goes further than option B and also prevents any one operator obtaining all of the 2.3 GHz spectrum. If competition would be stronger if one operator (such as one of O2 or H3G) acquired all 40 MHz of the 2.3 GHz spectrum, this option could make competition weaker than other options (including weaker than with no measures). Option D also mandates that the 2.3 GHz is sold in 20 MHz blocks. It is a significant intervention and there is a greater risk of producing adverse effects than other less restrictive options.

Provisional conclusion on Option D

5.103 While option D is more effective in addressing our competition concerns than some other options, it is more onerous than option A and would represent a significant intervention with material risks of producing adverse effects. It not only prevents BT/EE and Vodafone from obtaining any 2.3 GHz spectrum, it also prevents one of O2 and H3G from obtaining all 40 MHz of the 2.3 GHz spectrum. This option could

[102] It is unclear which of options B and D would be more effective at promoting competition during the transitional period. If competition would be stronger if one operator (such as one of O2 or H3G) acquired all 40 MHz of the 2.3 GHz spectrum (rather than two operators obtaining 20 MHz each), then option D would be less effective than option B. On the other hand, option D would prevent one of O2 or H3G acquiring all of the 2.3 GHz spectrum in order to deliberately weaken the other, whereas option B does not prevent this.

[103] This option also allows an operator other than O2 or H3G to obtain one of the reserved lots of 20 MHz spectrum – for simplicity, we refer to such an operator as being a new entrant. This might be interpreted as reducing the effectiveness of this option at safeguarding four credible MNOs. However, if a new entrant were prepared to pay more for this spectrum than O2 or H3G it may promote competition. New entrants face significant barriers to entry, and for such an operator to outbid O2 and H3G (who are established operators) would tend to suggest that it had a strong business case, which may suggest it could contribute materially to competition.

even weaken competition in the transitional period if competition would be stronger if one of O2 or H3G acquired all 40 MHz of the 2.3 GHz spectrum.

5.104 Given the significant risks of adverse effects and the uncertain benefits, our provisional view is that option D is disproportionate given the other options that involve more limited intervention.

Option E: tight overall spectrum cap

5.105 This option aims to promote competition by constraining the asymmetry of overall spectrum holdings, but involves a cap set at a tight level. Specifically, we consider an overall spectrum cap of 255 MHz, which represents about 30% of mobile spectrum (including 2.3 GHz and 3.4 GHz, but excluding 700 MHz spectrum).

5.106 Given the block sizes in the auction, this option would imply restrictions on the following operators (based on current spectrum holdings):

- **BT/EE** would be prevented from obtaining any spectrum in this award;
- **Vodafone** would be prevented from obtaining more than 75 MHz of additional mobile spectrum; and
- **O2** and **H3G** would each be prevented from obtaining more than 165 MHz of additional mobile spectrum.

5.107 BT/EE would therefore not be allowed to participate in the auction at all unless it divested spectrum in advance.

Effectiveness of option E at addressing competition concerns

Effectiveness at promoting competition during the transitional period - Competition Concern 1(ii)

5.108 Option E is as effective as option A at promoting competition in the transitional period, as it prevents BT/EE (which already has a high share of immediately useable spectrum) from obtaining any of the 2.3 GHz spectrum. But it does not go as far as options D and B, in that it does not prevent Vodafone obtaining the 2.3 GHz spectrum (and Vodafone has the second highest share of immediately useable spectrum).

Effectiveness at addressing other potential competition concerns

5.109 This is the most effective option at promoting competition by avoiding very asymmetric distributions in overall spectrum, as it significantly restricts the amount of spectrum those with the largest spectrum shares currently can obtain.

5.110 In terms of maintaining four credible MNOs, while option E does not ensure that spectrum is obtained by *two* operators other than BT/EE and Vodafone,[104] it would make this much more likely, as there would be 115 MHz of spectrum that BT/EE and Vodafone would be prevented from acquiring (based on their current holdings).

[104] For example, it would be possible for Vodafone and O2 together to obtain all 190 MHz of spectrum in the auction.

5.111 In terms of our concern about 3.4 GHz spectrum specifically, this option prevents BT/EE from acquiring any 3.4 GHz spectrum and imposes constraints on other MNOs (especially Vodafone). However, it would not prevent O2, H3G or a new entrant from acquiring all of the 3.4 GHz spectrum, so may not necessarily be effective in ensuring a number of operators are able to launch future 5G services with 3.4 GHz spectrum.

Risks of Option E producing adverse effects

5.112 Option E is very restrictive. In particular, BT/EE would be prevented from obtaining *any* 2.3 GHz or 3.4 GHz spectrum - unless it first divested some of its existing holdings. It would also impose significant constraints on Vodafone. Because this option is so restrictive, there would be a significant risk that it may produce adverse effects.

5.113 BT/EE would not have the option of obtaining even a modest block of 3.4 GHz spectrum. The 3.4 GHz spectrum may be important for launching 5G services, and having a large block of it may be highly desirable for 5G services. If BT/EE were the operator most interested in or best placed to rapidly develop 5G services, then preventing it from obtaining a large block of 3.4 GHz spectrum could harm consumers. It might reduce the speed of deployment and availability of 5G services more generally, given that a deployment by BT/EE might pressure other operators to also deploy 5G. This risk has grown since our November 2014 consultation, as momentum for the 3.4 GHz spectrum being an important candidate band for 5G services has increased recently. While this risk is mitigated by the possibility that BT/EE might be able to use its existing spectrum holdings for 5G and the future availability of other spectrum, there could still be some risk if BT/EE were particularly interested in pursuing 5G services with 3.4 GHz spectrum specifically.

Provisional conclusion on Option E

5.114 Option E is very restrictive. Whilst it would be effective in addressing our competition concerns it would be more onerous than option A and there would be a significant risk that it may produce adverse effects. We therefore do not consider option E to be proportionate.

Use of a threshold price before competition measures apply

5.115 It would be possible with options A to E for the competition measures to only apply once the round price in the principal stage of the auction had risen to a ‘threshold price’, set above the reserve price. Until the threshold price was reached, there would be no restrictions on any operator.

5.116 The rationale for using a threshold price would be to try to strike a balance in terms of reducing the risk of adverse effects without substantially reducing the effectiveness of the competition measure. The aim would be to set the threshold price at the intrinsic value of those operators who would be excluded from being able to obtain spectrum by the competition measures. If this could be done, it would mean that those operators would be prevented from engaging in strategic investment while being able to obtain the spectrum at their intrinsic value, if this was higher than the value placed on the spectrum by other bidders.

5.117 Below we first consider in more detail how a threshold price would apply. We then turn to the challenges of setting an appropriate level for the threshold price, and we describe in more detail in annex 8 how we might go about setting the threshold. For

ease of reference, in the discussion below and in annex 8, we use the following terminology:

a) 'always-eligible' bidders are those who are permitted to bid for spectrum both below and above the threshold price; and

b) 'constrained' bidders are those who are affected by the competition measure above the threshold price.

Threshold price for competition measures related only to 2.3 GHz spectrum

5.118 We first discuss how the threshold price would work for the options that would only impose restrictions on who could obtain 2.3 GHz spectrum, namely options A, B, and D.

5.119 For option D (reservation of two lots of 2.3 GHz spectrum), once the threshold price level was reached, the constrained bidders (BT/EE and Vodafone in this option) would not be allowed to submit new bids for spectrum of that type. If there were only two always-eligible bidders remaining at that point, and they both bid at the threshold price, they would each be awarded one of the 20 MHz lots at the threshold price. If there were more than two always-eligible bidders remaining, those bidders would continue bidding until the price rose sufficiently so that there were only two always-eligible companies, and each would obtain the 20 MHz of 2.3 GHz spectrum at that higher price.[105]

5.120 Options A and B would be similar. On the basis of existing spectrum holdings, for option A the only constrained bidder would be BT/EE, while both BT/EE and Vodafone would be constrained bidders with option B. If there were 40 MHz or more of demand from always-eligible bidders when the threshold price was reached, then the constrained bidders would no longer be eligible.

Threshold prices for overall spectrum cap

5.121 In the context of an overall spectrum cap (option E and part of option C), there would be two separate threshold prices for 2.3 GHz spectrum and 3.4 GHz spectrum. While round prices in both bands were below the threshold prices, all bidders would be allowed to bid without the constraint of a cap.

5.122 Once the round price in a band reached the threshold price for that band, any new bids made in that band would count towards the overall cap. Conversely, bids made at a round price lower than the threshold price would not count towards the cap.

Setting the threshold price at an appropriate level

5.123 An obvious difficulty with the adoption of a threshold price approach would be to determine the appropriate value(s) for the threshold price(s).[106] In annex 8 we

[105] If at the threshold price, there was only one always-eligible bidder remaining, then only one 20 MHz lot of the 2.3 GHz spectrum would be reserved. The constrained bidders (BT/EE and Vodafone) would be eligible to continue bidding for the other lot.

[106] The FCC's current incentive auction involves a threshold that distinguishes between reserved and unreserved spectrum. However, in that auction the amount of spectrum sold to mobile operators in the forward auction and the amounts of spectrum that are reserved and unreserved are determined endogenously within the auction (given the linkage between the reverse and forward auctions and between the stages within the auction, and the constraint that the forward auction should raise

illustrate how we might approach setting a threshold price by considering how it might be set for option D. Similar methodology and evidence would apply to other options as regards the 2.3 GHz band. Competition measures in options C and E in addition involve the 3.4 GHz band, via an overall spectrum cap, and so would require a threshold price level to be set for that band as well.

5.124 There would be risks in setting the threshold price either too low or too high. If we set it too low, then it would do little to mitigate the risk of adverse effects (e.g. excluding bidders even when it is efficient for them to win the spectrum). If we set it too high, it may make the intended competition measure ineffective and so fail to promote competition, as it might allow strategic investment to occur that would exclude operators with smaller spectrum shares.

5.125 The balance between these risks of setting the threshold price too low or too high depends on the option for competition measures with which it is combined. For example, with option A we consider below that the risk of adverse effects is low. This implies that we should place more weight on the alternative risk of setting the threshold price too high. In turn, this suggests that, in the face of uncertainty on the right level for the threshold price, we should set it so that it is more likely to be too low than too high. On this basis, and in light of the discussion in annex 8 of the available evidence, there is a question whether we have a reliable basis to set the threshold price for option A materially above the reserve price.

5.126 The difficulty in setting the threshold price at an appropriate level is linked to the reason why Ofcom chose to assign this spectrum by means of an auction and allow bidding between operators to determine the outcome. Fundamentally, bidders (both constrained and other) have better information on their respective intrinsic values of this type of spectrum than Ofcom.

Potential concerns with the specific implementation of the threshold price

5.127 The threshold price approach described above is a novel feature. It might increase the level of strategic complexity to bidders and may have unintended consequences, especially given the difficulties in setting appropriate threshold prices. For instance, with the overall cap in options C and E, constrained bidders might have an incentive to bid more strongly in the band whose round price is farther away from the threshold price, in order to alleviate the constraint, even if this means a departure from their relative intrinsic values. Or, if the round price in a band has already reached the threshold level, the constrained bidders might bid more strongly in the band whose price is below the threshold level. This might distort price signals during the principal stage and might result in a less efficient outcome (if the constrained bidders end up winning more spectrum in a band than suggested by their relative intrinsic values).

5.128 In addition, it might expose constrained bidders to risks. For instance, in most options we might be subjecting the constrained bidders to increased aggregation risk.

5.129 Aggregation risk refers to the risk of winning some, but not all of the spectrum required by a bidder to realise complementarities in their value. If the demand from always-eligible bidders at the threshold price in a given band was less than the available supply, the constrained bidders might be assigned standing high bid status

sufficient revenue to pay broadcasters for spectrum in the reverse auction). For further details, see https://www.fcc.gov/article/fcc-15-78a1. In contrast, if we were to use a threshold price, there is no such endogenous mechanism in the PSSR award to determine its level. Therefore, we would need to derive an appropriate level and specify it in advance of the auction.

on some of their bids in the band. It might be however that the amount of standing high bids held would be for less than the amount of spectrum they wished to acquire (i.e. a partial standing high bidder).

5.130 An unconstrained bidder would have the option to subsequently bid back for a larger quantity of spectrum at a higher price. However, the constrained bidders would be prevented from placing new bids for a larger quantity of spectrum. They could as a consequence end up winning the smaller amount of spectrum at a price above their intrinsic value (due to a failure to win enough spectrum to realise complementarities). While the constrained bidders could withdraw their standing high bids, under the proposed withdrawal rules they would still be liable for a payment at the end of the principal stage of the auction if the spectrum was not subsequently taken up by the eligible bidders.

5.131 An alternative option would be to allow bidders in the circumstance described above to withdraw their standing high bids at no cost to them. However, under this rule, constrained bidders might bid with the sole intention of pushing up the price paid by the always-eligible bidders, expecting to be able to withdraw once the price reached the threshold price.

Conclusion on threshold price

5.132 In principle, a threshold price has some attractions of reducing the risk of adverse effects without substantially reducing the effectiveness of competition measures. We note however that this would not prevent asymmetric spectrum holdings due to differences in intrinsic value (which, as noted above, may still cause consumer detriment). Also, this relies on being able to set the threshold price at an appropriate level. On balance, in the absence of reliable evidence to set the threshold price, we do not consider that the potential benefits of introducing it would be sufficient to outweigh the additional concerns that might arise about of its practical implementation.

Provisional conclusion and our proposal

5.133 We have described above the potential effectiveness of the five options that involve intervention, and also the risks of producing adverse effects. In considering whether any of them are proportionate, we have considered their effectiveness at addressing our competition concerns, and the relative weight we place on those competition concerns. As discussed above, the relative weights reflect a combination of the seriousness of the concern in adversely affecting competition and consumers, and the likelihood of the concern arising.

5.134 Any measures must be no more onerous than is required to achieve the aim and must also not produce adverse effects which are disproportionate to that aim. While some options are more effective at dealing with some concerns than others, they may also be more onerous than others. Judgement is needed to determine which is proportionate, if any.

5.135 The option of having no measures would be the most attractive if we considered the benefits from promoting competition to be relatively low compared to concerns about the risks of intervention. However, as explained above, we consider that there is a high risk following the auction (and in the absence of any competition measures) of very asymmetric holdings of immediately useable spectrum. This would mean that competition would be weaker than it would otherwise be, leading to significant consumer detriment in the transitional period, and potentially beyond.

5.136 Taking into account this concern, and our views above on the proportionality of the different options, **our provisional conclusion is that it would be appropriate and proportionate to adopt option A. That is, to cap immediately useable spectrum - with the level of the cap set so BT/EE is unable to obtain any 2.3 GHz spectrum (unless it divests some of its existing spectrum holdings)**.

5.137 We consider that the other options we have identified would however be disproportionate.

5.138 In light of our provisional conclusion, we have incorporated option A into the auction regulations that have been published in draft form alongside this consultation. We are also seeking views on those draft regulations.

Consultation questions

Question 3: Do you agree we have identified the right options to address our competition concerns?

Question 4: Do you agree with our assessment of the options we have identified for promoting competition in the auction? If not, please describe what measures you consider would be appropriate, providing as much evidence as possible to support your preferred approach.

Question 5: Do you have any further comments on our proposals on competition measures?

Section 6

Auction regulations – withdrawal rules

6.1 We first published draft regulations in October 2015[107] alongside the Information Memorandum and our earlier statement on the award. In light of stakeholder responses and our own further analysis of the issues involved, we are now proposing some changes to the draft regulations (in addition to the changes resulting from the proposed competition measure).

6.2 In this section, we set out proposed new rules affecting the withdrawal of bids during the principal stage. In the following section (section 6), we set out proposals for some adjustments to other aspects of the auction rules.

Background and summary

6.3 During the principal stage, bidders have the choice to 'cancel' - or withdraw – the standing high bids they make. The rules set out in the October 2015 document specified circumstances in which bidders would be liable to pay a sum equivalent to the amount of the withdrawn bid (or bids) without actually acquiring any spectrum in return. The rules aimed at providing a deterrent against using withdrawals for 'illegitimate' reasons e.g. to 'game' the bidding process to the detriment of other bidders.

6.4 However, we have recognised that applying these rules could result in spectrum going unsold; and/or individual bidders becoming liable to pay for more spectrum than their withdrawal causes to go unsold; and/or multiple bidders being liable to pay for the same unsold spectrum.

6.5 We have therefore decided to revisit our proposals to improve on some of these potential outcomes. In summary:

1. We propose that only partial standing high bidders will be allowed to withdraw the standing high bid status of their bids i.e. those bidders who hold standing high bids on fewer lots than they actually bid for. This category of bidder is more likely to have a legitimate reason for wishing to withdraw standing high bids;

2. We propose that lots which would otherwise remain unsold as a consequence of a withdrawn bid should instead be offered to the bidder who placed the bid. In order to mitigate incentives to use withdrawals for gaming purposes, the offer price will be equivalent to twice the level of the withdrawn bids. However, the bidder will be entitled to decline the offer at the grant stage and, if it does this, the amount payable by that bidder will be equivalent to the original level of the withdrawn bids for which it is liable (i.e. the single round price). This reflects the value of the spectrum denied to other bidders by having bid and then withdrawn. The difference between the cost of accepting or rejecting the spectrum licence is approximate to the economic value of the spectrum which the bidder is acquiring. We consider this to be fair and proportionate.

[107] http://stakeholders.ofcom.org.uk/binaries/consultations/notice-2.3-3.4-ghz-spectrum/summary/notice.pdf

6.6 In the following sub-sections we set out our rationale for arriving at these new proposals.

Concern with our previous proposals

6.7 Under our previous proposals, any standing high bidder could subsequently withdraw the standing high bid status of its bids – although there were limits to how many times it could do so. If Ofcom then failed to allocate all the lots in that band through bidding in a following round, a bidder who withdrew would be required to pay the *totality* of their withdrawn bids in that band.

6.8 As a result, there was no direct link between the withdrawal payment and the amount of the spectrum which would be left unsold as a consequence of the withdrawal. Individual bidders could be required to pay more than the cost of the unsold spectrum, and multiple bidders could be simultaneously liable for payments related to the same unsold spectrum.

6.9 Additionally, by not offering the spectrum to the bidders who were liable for withdrawal payments, the proposed rules increased the chances of spectrum remaining unsold at the end of the auction, and therefore unused.

6.10 Concern about these shortcomings was expressed by some of the stakeholders who responded to previous consultations. As a result of their observations and our own re-evaluation of the issues, we have looked at ways to improve the rules to make them fairer while still resulting in an efficient auction.

Our revised proposals

Only partial standing high bidders will be allowed to withdraw

6.11 We propose that only *partial* standing high bidders should be allowed to withdraw the standing high bid status of their bids. Partial standing high bidders are those who hold bids with standing high bid status on lots in a particular band – but hold them on fewer lots than they bid for in the last round in which they submitted bids.

6.12 We propose that *full* standing high bidders will not be allowed to withdraw. Full standing high bidders are those bidders who hold a number of standing high bids in a particular band equal to the number of bids submitted in the last round in which they bid.

6.13 Due to the way we assign standing high bid status, there can be at most one partial standing high bidder in each band. As a consequence, there will be at most one bidder accountable for withdrawals in each band – ruling out the possibility of multiple bidders being liable for the same unallocated spectrum.

Partial standing high bidders

6.14 Withdrawals may play an important role in aiding partial standing high bidders to express their preferences during the principal stage. In particular, they may be helpful in facilitating ‘switching’ i.e. moving demand from one spectrum band to another in response to changes in price.

6.15 Let us suppose a bidder wishes to acquire spectrum in either band, but has identified a minimum amount of spectrum in each band it wishes to acquire. As relative prices change, this bidder might wish to move its demand from one band to the other in an

attempt to secure the amount of spectrum it wants. It will move to the band which, at any given time, offers the highest value compared to its price.

6.16 There remains some risk that moving demand in this way can lead to a bidder becoming 'stuck' between the two bands. This could occur if a bidder was to be partially outbid in one band, and as a result chose to move its freed up eligibility to the other band. If the bidder is not then fully outbid in the band it wishes to move away from it can be left as a standing high bidder in that band - and potentially the other band too, depending on subsequent bidding. It may therefore end up winning a quantity of spectrum in both bands that is of little or no use to it.

6.17 We are of the view that a circumstance such as the one described is relatively unlikely to materialise because bidders have a number of ways to protect themselves against such a risk. For example, a bidder who has been partially outbid may request that its eligibility limit be carried forward to the next round, which allows it to 'sit out' a round to see whether it is fully outbid before committing to move its freed up eligibility to another band[108]. The risk may be avoided altogether if a partial standing high bidder in one band simply chooses to bid again for the same number of lots in the band - at a higher price - instead of attempting to move away from the band.

6.18 However, should the circumstance described occur, the impact on efficiency might be material. This would in particular be the case if the bidder failed to acquire a minimum amount of spectrum it can use effectively - even though it valued it sufficiently highly to acquire it - and as a result offered either a worse service to consumers, or at a higher price. For that reason, we are proposing to allow partial standing high bidders to withdraw their bids.

Full standing high bidders

6.19 In our May 2015 Statement and Further Consultation, we recognised that under some circumstances full standing high bidders might wish to withdraw the standing high bid status of their bids[109]. We said we did not see any reasons why we should not allow them to do so, given the fact that the withdrawal rule, in the terms we proposed, held the bidder sufficiently liable for withdrawals to prevent them from using that option for the wrong reasons[110].

6.20 We have now reconsidered our assessment. We believe there may be two reasons why a standing high bidder may wish to withdraw.

6.21 Firstly, a bidder may wish to withdraw its demand in one band in order to expand its demand in the alternative band. However, we believe it is unlikely that a bidder would choose to act in such a way unless its bidding strategy was based on factors other than its true intrinsic valuation of the spectrum.

6.22 If a full standing high bidder had placed bids in accordance with its true intrinsic valuations, it should prefer to hold the lots making up its standing high bids rather than other lots in the alternative band. This is because the price of lots in the alternative band must have either remained the same or increased compared to when the bidder placed the initial bid in the first band. If it had bid sooner, it may have been able to bid for more lots more cheaply.

[108] More information about waivers is available for instance in § A 5.62, in the May 2015 Statement and Consultation
[109] § A4.105 of our May 2015 Statement and Further Consultation
[110] § A4.106

6.23 Second, a full standing high bidder may have a genuine reason for wanting to reduce demand for reasons unrelated to moving demand elsewhere. In particular, it could be that a bidder wishes to acquire spectrum in one band only if it can also acquire spectrum in the other band. This is known as cross-band value complementarity. In these circumstances, a bidder may wish to reduce demand in the band where it is a full standing high bidder because it realises the chances of acquiring the amount of spectrum it wishes to obtain in the other band are lower than it previously thought.

6.24 It is not possible to distinguish this motivation from other more tactical motivations during the auction process. In any case, we have limited evidence of cross-band value complementarities being relevant in the context of this auction. We therefore propose to prevent full standing bidders from withdrawing bids.

6.25 We believe the option of not allowing full standing high bidders to withdraw the standing high bid status of their bids is unlikely to have a harmful impact on the efficiency of the auction outcome. We are therefore proposing to proceed on that basis[111].

Licence offered for unallocated spectrum

6.26 We are proposing to offer bidders a licence to use any spectrum that would otherwise remain unsold as a consequence of their withdrawals. We will refer to this spectrum as 'unallocated spectrum'[112].

6.27 One important consequence of offering such a bidder the unallocated spectrum is that withdrawal alone does not allow a bidder to reduce its commitment in the auction. This is because the bidder remains liable for any spectrum unallocated as a consequence of its withdrawal until some other bidder, or bidders, place alternative bids.

6.28 Because bidders cannot reduce their commitment in the auction by withdrawing alone, they have more of an incentive to withdraw only when they truly wish to move demand across bands.

Sum payable for unallocated spectrum if the bidder rejects the licence

6.29 If a bidder who is offered a licence for the unallocated spectrum chooses to reject the offer, we propose that it should pay the opportunity cost of the bids that, by having been withdrawn, generated the unsold spectrum in the first place. We use the level of a bid as an approximation of that opportunity cost.

6.30 By having bid at a given price and then becoming a standing high bidder on one or more lots, the bidder would have denied other bidders the chance of acquiring those lots at a lower price. In an ascending price auction, like the one we are implementing

[111] Nevertheless, our revised proposal, which we expand on below, means that a full standing high bidder will have only the same or a smaller financial exposure than under our previous proposals because:

- If the full standing high bidder is fully outbid subsequently it is no longer liable to pay for the spectrum (as before);
- If the full standing high bidder is not subsequently outbid – or only partially outbid - it will end up winning the spectrum, but paying either the same amount as it would have paid if it had withdrawn (if not outbid) or a smaller amount (if partially outbid).

[112] This is to reflect the fact that the spectrum is not unsold, but rather it is not allocated any standing high bids by Ofcom at the end of the last principal stage round.

for the principal stage of the 2.3 and 3.4 GHz award, the bid level is therefore a good approximation for the opportunity cost of its bid.

6.31 We therefore propose that if the bidder rejects the licence, it will be required to pay a sum equivalent to the number of unsold lots multiplied by the price of the withdrawn bids.

Price of unallocated spectrum if the bidder accepts a spectrum licence

6.32 We consider it appropriate that a bidder who accepts a licence for unallocated spectrum is asked to pay more to acquire the frequencies than it would otherwise pay if it rejected the licence. We propose that the appropriate level should amount to twice the price of the bidder's withdrawn bids.

6.33 It is sensible and makes good economic sense that the difference between accepting and rejecting the licence is the value of the licence itself. This licence contains a value which the operator may realise by, for example, trading in the secondary market.

Other possible levels for the heightened fee

6.34 We recognise that the exact fee at which we should offer the unallocated spectrum to the bidder who withdraws is a matter of judgement and there is a range of possible levels.

6.35 The lowest price at which the spectrum should be offered is the price of the withdrawn bids. This therefore sets a lower bound for the range. However, we have serious concerns about setting the heightened fee for accepting a licence at, or close to, this lower bound. We believe it could create incentives for bidders to attempt to game the auction, with potentially detrimental impact on its efficiency and fairness.

6.36 To understand why, it is important to note that by offering a bidder the chance to acquire the unallocated spectrum, we are allowing a de-facto violation of the eligibility rule. The eligibility rule determines that bidders cannot increase their demand measured by eligibility points from one round to the next[113].

6.37 By accepting a licence for the unallocated spectrum, bidders might be able to acquire a quantity of spectrum which exceeds their eligibility limit in the last round of the principal stage. In other words, these bidders would be able to increase demand towards the end of the principal stage.

6.38 If the price at which we offer the unallocated spectrum to the bidder is sufficiently low, the bidder may have an incentive to try and expand demand in the way described above. We set out below a non-exhaustive list of why it may wish to do so.

- To distort price signals: By hiding demand during the principal stage, the bidder may succeed in conveying the wrong information to the other bidders, who will receive an indication of the level of aggregate demand in each band. This may in turn let other bidders unduly discount their expectations about the value of the spectrum in one or other of the two bands, and reduce demand – and therefore the level of competition – accordingly.

[113] The exception to this is when a bidder's eligibility limit is carried forward to the next round (referred to in the proposed regulations as an 'eligibility event').

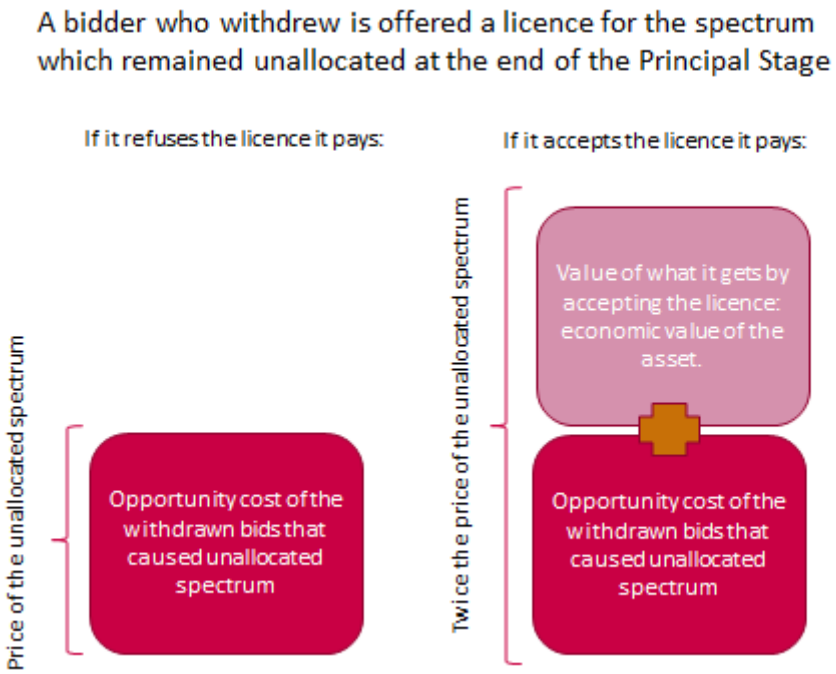
- To buy spectrum cheaply: A bidder may wish to reduce its own demand in an attempt to bring the auction to an early end. Let us suppose at some point in the principal stage there is competition in one band, whilst the other band has no new bids. At this stage, a bidder may wish to withdraw from the band which is more contested in an attempt to reduce competition. If successful, this could cause some spectrum to remain unallocated and therefore be offered to the bidder who withdrew. While this could be achieved simply by placing no new bids and waiting to be outbid, by withdrawing the bidder is able to move all the freed up eligibility points to the band where there is less competition, potentially succeeding in buying spectrum in both bands at a relatively low price.

- Signal and test tacit collusion: By withdrawing and placing bids in the alternative band, such as in the example described above, a bidder may also attempt to test whether a tacit collusive outcome is stable. If the other bidders bid in a way which is consistent with the bidder's expectations, the auction would come to an end. If not, by switching demand to another band the bidder may have retained enough eligibility to allow it to bid back on the band from which it withdrew.

6.39 We believe that the closer the fee is to the lower bound suggested by us, the stronger the above incentives will be. In any event, it creates undesirable strategic complexity which may adversely affect the efficiency of the auction.

6.40 Our revised proposals are illustrated at Figure 5.1 below.

Figure 5.1: Illustration of our new proposals



Nature of the licence being offered to the bidder

6.41 We propose that any licence for unallocated spectrum which is offered to the bidder would be separate from any licence for spectrum which the bidder won in the normal course i.e. by bids being assigned standing high bid status at the end of the last principal stage round. Therefore, the choice to accept or reject the licence for

unallocated spectrum is independent from the acquisition of any other spectrum won by the bidder.

6.42 However, the unallocated spectrum and the spectrum won by the bidder in the normal course are considered together for the purpose of the assignment stage. Therefore, if the bidder were to acquire both unallocated spectrum and spectrum won in the normal course in the same band, the bidder would receive one contiguous block of spectrum in that band[114]. We propose that the unallocated spectrum would be located at the bottom of the total range assigned to the bidder in that band in the assignment stage.

6.43 The licence for unallocated spectrum would be offered to the bidder after the end of the assignment stage.

Minimum requirement

6.44 Under our draft auction regulations, bidders in the 2.3 and 3.4 GHz auction may set a 'minimum requirement' for the amount of spectrum they wish to obtain in the 3.4 GHz band of up to 20 MHz. If, at the end of the last principal stage round, a bidder becomes standing high bidder on less than its minimum requirement[115], such standing high bids will not become winning bids. However, we propose that if a bidder chooses to withdraw, it may still be liable for the spectrum even if it is for a quantity which is smaller than the minimum requirement.

6.45 Our auction rules previously provided that if, during the principal stage, a bidder was standing high bidder on less than its minimum requirement, those standing high bids would still hold. That is, should the bidder in those circumstances wish to withdraw, it might still be liable for withdrawal payment[116].

6.46 We propose to apply the same principle in our new proposals. If a bidder is standing high bidder on less than its minimum requirement in 3.4 GHz, withdraws its standing high bids in the band, and as a result generates unallocated spectrum, the latter will be offered it at twice its price even though it is below the minimum requirement set up by the bidder.

6.47 If it rejects the licence, it will be asked to pay the full sum bid for the unallocated spectrum.

Other features of the withdrawal rule

6.48 For the sake of clarity, the following features of the withdrawal rules proposed in our October 2015 document will still apply, as the changes we propose have no bearing on these:

[114] Subject to the rules relating to the participation of UK Broadband and the revocation of the pre-existing licence.

[115] A combination of two different rules in the auction guarantees that there is at most one bidder in this situation. On one hand, no bidder can place bids for less than their minimum requirement. On the other hand, the ranking rule to assign standing high bid status is such that at most one bidder is partial standing high bidder.

[116] § A 4.96-4.104, in the May 2015 Statement and Consultation. The rationale for our policy was to avoid a bidder setting a minimum requirement to make it easier for it to free itself from any responsibilities during the auction, by withdrawing

- In a given round, bidders cannot simultaneously withdraw and place new bids in the same band;
- Also, in a given round, bidders cannot simultaneously withdraw and request that their eligibility limit is carried forward to the next round;
- There is a maximum number of five rounds in which bidders can withdraw the standing high bid status of their bids;
- Bidders can only withdraw the standing high bid status of all the bids they hold in a band (and not any lesser proportion of them);
- Bidders cannot withdraw a second time from a band unless the round price in that band has increased, relative to the first time the bidder withdrew.

Consultation question

Question 6: Do you agree with our revised proposal on the withdrawal of bids in the auction?

Section 7

Auction regulations – other issues

7.1 This section of the document addresses other issues raised by stakeholders following publication of our draft auction regulations in October 2015.

7.2 Some comments were related to the detailed drafting of the regulations. We have incorporated suggestions into the revised draft regulations wherever we considered it appropriate to do so. We have also made a number of other changes to the drafting, aimed at simplifying the regulations and making them clearer. Such changes do not affect the substance of the rules.

7.3 Additionally, some submissions from stakeholders raised points relating to the policies which underlie the auction regulations. We think it is worth clarifying some of these matters.

Process for assigning standing high bid status

7.4 One respondent commented that the auction regulations appeared to suggest that the ranking of bidders is determined every round, such that the rank order of two bidders who have standing high bids from a previous round could change in the next round.

7.5 The ranking of bidder is in effect determined at the end of each round. This means that the order of bidders who submitted bids at the same price and who were ranked at the end of a round may change at the end of the following round.

Use of software to implement 'randomness'

7.6 We will use an Electronic Auction System (EAS) to conduct the principal and the assignment stages of the auction. The EAS will be coded to ensure the processes which require randomness are well implemented.

7.7 In the principal stage, this applies to the way we will rank bidders within category one, and within category two (regulation 32).

7.8 In the assignment stage, this applies to the way we would break ties as part of the winner determination process (regulations 72 and 78).

7.9 We aim to provide detailed information on the software as part of a Guidance for Bidders document we will publish closer to the start of the auction.

Price increments

7.10 As we noted in our October Statement[117], we decided not to restrict our ability to set price increments in the auction regulations. However, we will set price increments carefully and will look at a number of indicators when doing so.

[117] § 4.8 to 4.15

7.11 We will provide an illustration of the indicators we will be looking at when setting price increments as part of the Guidance for Bidders which we will publish closer to the start of the auction.

Indication of the level of excess demand during the principal stage

7.12 The level of excess demand which we will disclose to bidders during the principal stage will be indicated in multiples of 20 MHz. The smallest possible amount indicated will be 20 MHz. This means that if the level of excess demand is negative or zero, it will be indicated as being less than 20 MHz.

7.13 One of the risks involved in indicating the actual level of excess demand is that bidders may use it to bring the auction to an early end. This risk is exacerbated by indicating a very low or negative level of excess demand.

7.14 We believe an indication that the level of excess demand is less than 20 MHz is sufficient to aid bidders for the intended purpose of conducting an efficient auction.

Assignment stage

7.15 A respondent noted that the auction regulations suggested it was a possibility that a bidder might be assigned 3.4 GHz spectrum in two blocks, one of which could be an isolated lot.

7.16 We confirm that under regulation 76 - i.e. in circumstances where the pre-existing licence holder in 3.4 GHz (UK Broadband) does not apply for a replacement licence or does not participate in the assignment stage (and paragraphs 2 and 3 do not apply) - Ofcom may consider assignment stage plans that involve individual bidders being assigned blocks of spectrum which are smaller than 20 MHz (e.g. a winning bidder could be assigned a block of spectrum of 5 MHz or 10 MHz).

7.17 We believe such an outcome is unlikely. For it to occur, Ofcom would need to fail to find at least one assignment stage plan where all bidders would be assigned contiguous spectrum and, failing that, at least one assignment stage plan where no bidder who acquired at least 40 MHz is left with a contiguous block including less than that.

Refund of the deposit

7.18 Regulation 107 sets out how we will proceed with refunding deposits provided by bidders which are in excess of the licence fees.

7.19 While we do not commit to a specific deadline by which to instruct our bank to proceed with the refund, we will seek to do so within 3 working days of the grant of the licences.

Section 8

Additional matters and next steps

8.1 In this final section of the document we look at how we intend to proceed with preparations for our auction of the 2.3 and 3.4 GHz spectrum following this consultation.

Consideration of responses and publication of statement

8.2 The consultation closes on **30 January 2017**. After the closing date, we will consider all the responses we receive from stakeholders and others. We will then publish a statement setting out our final decisions on competition issues.

8.3 The statement will also finalise our position on the auction rules discussed in this document, in particular the rules on withdrawal of bids. The final auction regulations will be published alongside the statement.

Publication of update to Information Memorandum

8.4 In October 2015 we published an Information Memorandum[118] in connection with the 2.3 and 3.4 GHz auction. The document sets out information which may be of interest to potential bidders. In summary, the Memorandum:

- Describes the characteristics of the bands for which licences are to be awarded;
- Explains some factors that may affect licensees' use of the bands;
- Summarises some of the principal terms of the licences that will be issued following completion of the Award Process, and provides at annex 1 and 2 draft templates of the licences that will be issued for the 2.3 and 3.4 GHz bands respectively;
- Sets out the spectrum lots that will be available in the Award Process and the reserve price for each lot;
- Provides certain information in relation to the Award Process; and
- Provides information on a range of other associated issues.

8.5 The document notes that information contained in the Memorandum is subject to updating, revision and/or amendment before the auction. Accordingly, it is our intention to publish a notice of those factors that have changed in the months following first publication of the Memorandum. We will do so alongside our final statement in respect to this consultation.

[118] https://www.ofcom.org.uk/__data/assets/pdf_file/0030/81579/info-memorandum.pdf

8.6 In the meantime, we are taking this opportunity to inform potential bidders of the more significant changes that will be included in the Information Memorandum update. They include:

- The publication in October 2016 of a consultation on future use of the 3.6-3.8 GHz band, which lies adjacent to the 3.4 GHz spectrum we are auctioning[119].
- Acknowledgement of possible future changes of use across the whole of the broader 3.6-4.2 GHz range. As noted elsewhere in this document, this band has been identified by the European advisory body, the Radio Spectrum Policy Group, as the *"primary band suitable for the introduction of 5G use in Europe"* – although no final decisions have been taken.
- Notification that we have published proposals to make additional spectrum in the 5 GHz band available for Wi-Fi[120]. This could be used as an alternative to continued use of the 2.4 GHz band, which lies close to the 2.3 GHz band we are auctioning.
- Confirmation that the Ministry of Defence has determined that coordination requirements around the 13 airborne locations using frequencies affecting deployment of new services in the 3.4 GHz band will expire at the end of 2018.

8.7 The notice of updates to the Information Memorandum will also include a number of lesser, technical alterations to the original document.

Preparations for the auction

8.8 It is our intention to proceed with the auction of the 2.3 and 3.4 GHz spectrum as soon as practical after the publication of our final statement on the award.

8.9 We will publish on our website a notice of invitation to apply. This will set out the process for application alongside details of how potential bidders will subsequently qualify to participate. It will include details of the initial deposit we will require to be lodged in our account.

8.10 Following submission of applications and payment of initial deposits, Ofcom will provide details of how applicants may access a training version of the electronic auction software we will be using in the auction, together with bidder and auctioneer manuals setting out instructions on use of the software. This will enable applicants to familiarise themselves with the bidding process and to conduct internal mock auctions and training with full autonomy (that is, without intervention from Ofcom).

8.11 In addition to this self-training, we intend to offer applicants some optional individual training during the qualification phase of the auction process to give potential bidders the opportunity to clarify any aspects related to the use of the software. We also plan to run mock auctions during those individual sessions. We will provide applicants with further details about the timing and content of the bidder training nearer the time.

[119] *Improving consumer access to mobile services at 3.6 to 3.8 GHz*, Ofcom, 6 October 2016, https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz
[120] https://www.ofcom.org.uk/__data/assets/pdf_file/0037/79777/improving-spectrum-access-consumers-5ghz.pdf

Annex 1

Responding to this consultation

How to respond

A1.1 Ofcom would like to receive views and comments on the issues raised in this document, **by 5pm on 30 January 2017.**

A1.2 We strongly prefer to receive responses via the online form at = https://www.ofcom.org.uk/consultations-and-statements/category-1/award-of-the-spectrum-bands/. We also provide a cover sheet (http://stakeholders.ofcom.org.uk/consultations/consultation-response-coversheet/) for responses sent by email or post; please fill this in, as it helps us to maintain your confidentiality, and speeds up our work You do not need to do this if you respond using the online form.

A1.3 If your response is a large file, or has supporting charts, tables or other data, please email it to pssr.award@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet (http://stakeholders.ofcom.org.uk/consultations/consultation-response-coversheet/). This email address is for this consultation only.

A1.4 Responses may alternatively be posted to the address below, marked with the title of the consultation.

Robert Emson,
Floor 3
Spectrum Group
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 If you would like to submit your response in an alternative format (e.g. a video or audio file), please contact Robert Emson on 020 7783 4375 or email Robert.Emson@ofcom.org.uk.

A1.6 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt if your response is submitted via the online web form, but not otherwise.

A1.7 You do not have to answer all the questions in the consultation if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A1.8 It would be helpful if your response could include direct answers to the questions asked in the consultation document. The questions are listed at Annex 4. It would also help if you could explain why you hold your views, and what you think the effect of Ofcom's proposals would be.

Confidentiality

A1.9 Consultations are more effective if we publish the responses before the consultation period closes. In particular, this can help people and organisations with limited

resources or familiarity with the issues to respond in a more informed way. So, in the interests of transparency and good regulatory practice, and because we believe it is important that everyone who is interested in an issue can see other respondents' views, we usually publish all responses on our website, www.ofcom.org.uk, as soon as we receive them.

A1.10 If you think your response should be kept confidential, please specify which part(s) this applies to, and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we don't have to edit your response.

A1.11 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.12 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further at http://www.ofcom.org.uk/terms-of-use/

Next steps

A1.13 Following this consultation period, Ofcom plans to publish a statement.

A1.14 If you wish, you can register to receive mail updates alerting you to new Ofcom publications; for more details please see http://www.ofcom.org.uk/email-updates/

Ofcom's consultation processes

A1.15 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in Annex 2.

A1.16 If you have any comments or suggestions on how we manage our consultations, please call our consultation helpdesk on 020 7981 3003 or email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact Steve Gettings, Ofcom's consultation champion:

Steve Gettings
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA

Tel: 020 7981 3601
Email steve.gettings@ofcom.org.uk

Annex 2

Ofcom's consultation principles

Ofcom has seven principles that it follows for every public written consultation:

Before the consultation

A2.1 Wherever possible, we will hold informal talks with people and organisations before announcing a big consultation, to find out whether we are thinking along the right lines. If we do not have enough time to do this, we will hold an open meeting to explain our proposals, shortly after announcing the consultation.

During the consultation

A2.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A2.3 We will make the consultation document as short and simple as possible, with a summary of no more than two pages. We will try to make it as easy as possible for people to give us a written response. If the consultation is complicated, we may provide a short Plain English / Cymraeg Clir guide, to help smaller organisations or individuals who would not otherwise be able to spare the time to share their views.

A2.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A2.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and aim to reach the largest possible number of people and organisations who may be interested in the outcome of our decisions. Ofcom's Consultation Champion is the main person to contact if you have views on the way we run our consultations.

A2.6 If we are not able to follow any of these seven principles, we will explain why.

After the consultation

A2.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish all the responses on our website as soon as we receive them. After the consultation we will make our decisions and publish a statement explaining what we are going to do, and why, showing how respondents' views helped to shape these decisions.

Annex 3

Consultation response cover sheet

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

Please tick below what part of your response you consider is confidential, giving your reasons why

Nothing	☐	Name/contact details/job title	☐
Whole response	☐	Organisation	☐
Part of the response	☐	If there is no separate annex, which parts?	

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here.

Name Signed (if hard copy)

Annex 4

Consultation questions

A4.1 This consultation seeks responses to the following questions:

Question 1: *Do you agree that we have identified the right competition concerns?*

Question 2: *Do you agree with our assessment and provisional conclusions in respect to:*

Competition Concern 1 *(the risk of very asymmetric spectrum shares and in particular Competition Concerns 1(i), 1(ii), and 1(iii)).*

Competition Concern 2 *(the risk of there ceasing to be four credible MNOs?*

If not, please give your reasons and set out the evidence that supports your view.

Question 3: *Do you agree we have identified the right options to address our competition concerns?*

Question 4: *Do you agree with our assessment of the options we have identified for promoting competition in the auction? If not, please describe what measures you consider would be appropriate, providing as much evidence as possible to support your preferred approach.*

Question 5: *Do you have any further comments on our proposals on competition measures?*

Question 6: *Do you agree with our revised proposal on the withdrawal of bids in the auction?*

A4.2 A notice of our intention to publish auction regulations – including the full regulations in draft form – is published separately alongside this document and can be found at [1] https://www.ofcom.org.uk/consultations-and-statements/category-1/award-of-the-spectrum-bands/. This consultation accompanies and forms part of the consultation exercise set out in that notice.

Annex 5

Mobile spectrum bands

A5.1 In this annex we assess what spectrum bands are likely to be used for mobile services in the future.

800 MHz, 900 MHz, 1800 MHz, 2100 MHz and 2.6 GHz

A5.2 In our assessment of the overall spectrum cap for the 2013 auction and in our November 2014 consultation, we identified the spectrum at 800 MHz, 900 MHz, 1800 MHz, 2100 MHz and 2.6 GHz (paired and unpaired) as the main bands of current importance for mobile access. We see no reason to revise our assessment that these bands should be considered in this competition assessment.

2.3 GHz spectrum

A5.3 There is already a wide range of user devices available globally that can use 2.3 GHz. The Global mobile Suppliers Association (GSA) reports there were 1,604 devices available worldwide that can use 2.3 GHz spectrum for LTE as at June 2016.[121] A number of these devices are already in the UK market, including some popular mobile phones such as the iPhone 6 and 6+ and Samsung Galaxy S7.

A5.4 The 2.3 GHz spectrum is likely to be used for mobile broadband shortly after it is awarded. Our view that the 2.3 GHz spectrum can be used rapidly is consistent with the CMA's decision in the BT/EE merger.[122]

A5.5 We discuss the possibility of the lower 2.3 GHz band (2300 – 2350 MHz) becoming available in the future in paragraph A5.26 below.

1400 MHz spectrum[123]

A5.6 We are not aware of any devices available currently that can use 1400 MHz, but we expect these to be developed in the near future. The case for device makers to include this band within their devices will be strengthened by there now being a number of operators licensed to use this spectrum for mobile service in several large European countries, namely Germany, Italy and the UK. The price paid for this spectrum in the auctions in Germany and Italy, where it was acquired by MNOs for €330m and €460m respectively, is also consistent with an expectation of significant device development.

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[121] *Status of the LTE Ecosystem*, GSA, June 24, 2016, http://gsacom.com/paper/status-lte-ecosystem-report-5614-lte-devices-announced-455-suppliers/

[122] The CMA found that: "The evidence therefore suggests that the 2.3 GHz spectrum may become useful in a substantial proportion of devices (and therefore allow significant offload) by 2017", paragraph 78, https://assets.digital.cabinet-office.gov.uk/media/56991ae4ed915d468c00002b/FR-Appendices_and_Glossary.pdf

[123] More specifically, we are referring to the frequencies at 1452-1492 MHz. In 2015, 40 MHz of 1400 MHz spectrum was traded by Qualcomm to Vodafone (in respect to 1452-1472 MHz frequencies) and to H3G (in respect to 1472-1492 MHz frequencies). Ofcom's consent was needed for this trade, which we granted in this decision: http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-trading-regs-apr-15/statement/trade-of-frequencies-statement.pdf

A5.7 The 1400 MHz spectrum is also likely to be used for mobile access in more European countries[124], and potentially outside Europe. The development of devices may also be helped by the role of Qualcomm, which is a major chipset manufacturer and promotes the Supplemental Downlink standard, including at these frequencies.

A5.8 We expect the 1400 MHz spectrum to be included in devices on a similar timetable to, or shortly before, the 3.4 GHz spectrum. We understand it is easier to incorporate the 1400 MHz spectrum into existing component design within handsets than the 3.4 GHz spectrum.

3.4 GHz spectrum[125]

A5.9 Although we are auctioning the 3.4 GHz spectrum at the same time as the 2.3 GHz spectrum, it is likely to take longer to bring the 3.4 GHz frequencies into use than the 2.3 GHz frequencies. This is because the 3.4 GHz ecosystem is lagging some years behind that of the 2.3 GHz band. At present, we are not aware of any major handsets which incorporate the 3.4 GHz band. According to the GSA, there are a total of 82 devices that can use parts of the wider 3.4 GHz to 3.8 GHz band for TD-LTE as at June 2016.[126] However, we note that the 3.4 GHz spectrum is now incorporated into some chipsets for mobile devices e.g. in Qualcomm's Snapdragon chipset.[127]

A5.10 Following WRC-15, the 3.4 GHz spectrum has a primary mobile allocation across Europe, the Middle East and Africa, the Americas and some countries in Asia/Pacific.

A5.11 It is being deployed in various countries. For example, in Japan three major networks (KDDI, NTT Docomo and SoftBank) are reported to be planning large scale deployments in the 3.4 GHz band by the end of 2016, driven by conditions put in place at the time the frequencies were awarded. This may generate momentum for the development of the ecosystem – although wide adoption may still take some time. In its assessment for the BT/EE merger, the CMA concluded that a substantial proportion of devices are likely to be available for the 3.4 GHz band by 2020.[128]

700 MHz spectrum

A5.12 At the time of our November 2014 consultation, we noted that the 700 MHz band could be freed up for mobile services across the UK by the beginning of 2022, and potentially sooner. However, we have recently decided to aim to bring forward the

[124] In March 2015, the European Commission made a mandatory decision to harmonise the 1452-1492 MHz band for terrestrial systems capable of providing electronic services in the European Union.
[125] What we refer to as the 3.4 GHz spectrum is band 42, covering frequencies from 3400 MHz to 3600 MHz. This spectrum is also known internationally as the 3.5 GHz band or the 3.4-3.6 GHz band.
[126] *Status of the LTE Ecosystem*, GSA, June 24, 2016, http://gsacom.com/paper/status-lte-ecosystem-report-5614-lte-devices-announced-455-suppliers/
[127] https://www.qualcomm.com/news/releases/2016/02/11/qualcomm-announces-mobile-industrys-first-gigabit-class-lte-modem
[128] Paragraph 12.47 https://assets.digital.cabinet-office.gov.uk/media/56992242ed915d4747000026/BT_EE_final_report.pdf
And Table 8 and paragraphs 75 to 78 of Appendix G, https://assets.digital.cabinet-office.gov.uk/media/56991ae4ed915d468c00002b/FR-Appendices_and_Glossary.pdf

when the spectrum is available in Q2 2020.[129] We plan to auction the 700 MHz spectrum in advance of it being available.

A5.13 User devices capable of using 700 MHz spectrum are already in use in the UK and the proportion of such devices will grow over time. We expect MNOs to be able to make use of the 700 MHz spectrum as soon as it is available.

A5.14 In addition to the 2x30 MHz of paired spectrum at 700 MHz, we have also decided to auction 20 MHz of the 'centre gap' of 700 MHz for mobile use.[130]

3.6–3.8 GHz spectrum

A5.15 The characteristics of the 3.6-3.8 GHz spectrum make it suitable for a range of mobile applications, including for increasing data capacity, and we have identified this spectrum as a high priority band for mobile. It is likely that when there are devices that can use 3.4 GHz spectrum, they will also be able to use the 3.6–3.8 GHz band.

A5.16 However, at present, this band is used for fixed link services, satellite services, and for UK Broadband's fixed/mobile broadband service, as described below. We are currently proposing to make more of the 3.6 GHz to 3.8 GHz band available for mobile services through an award of 116 MHz of additional spectrum.[131]

A5.17 In addition to the 116 MHz that we may award in the 3.6-3.8 GHz band, UK Broadband already holds 84 MHz of spectrum at 3605-3689 MHz. In combination with its 3.4 GHz spectrum, it uses this to offer its 'Relish' LTE mobile broadband service. 'Relish' uses both indoor and outdoor Broadband Wireless Access (BWA) devices to offer services to consumers and businesses in central London, with plans for roll-out in other cities. UK Broadband has stated that it intends to offer mobile broadband services in the future.[132]

A5.18 It is likely that the spectrum at 3.6-3.8 GHz will be used for mobile services in the future, even if it may be subject to restrictions on its use to avoid interference with other uses in the band.

1900 MHz spectrum not relevant

A5.19 We do not consider the unpaired 1900 MHz spectrum is relevant to mobile competition in our analysis. It is not currently being used for mobile access and is unlikely to be able to be used for high power macro sites in practice due to the compatibility with the adjacent uplink band of the 2.1 GHz paired spectrum. Of this spectrum, EE has 10 MHz, O2 has 5 MHz and H3G has 5 MHz.

[129] Section 3, *Maximising the benefits of 700MHz clearance*, statement, Ofcom, 17 October 2016, https://www.ofcom.org.uk/consultations-and-statements/category-1/maximising-benefits-700mhz-clearance#
[130] Section 4, *Maximising the benefits of 700MHz clearance*, statement, Ofcom, 17 October 2016.
[131] *Improving consumer access to mobile services at 3.6 to 3.8 GHz*, Ofcom, 6 October 2016, https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz
[132] See paragraph 1.3, *Variation of UK Broadband's 3.4 GHz licence*, Ofcom, June 2014 http://stakeholders.ofcom.org.uk/binaries/consultations/uk-broadband-licence/summary/condoc.pdf

A5.20 EE recently requested a licence variation to allow it to use its 1900 MHz spectrum for LTE in support of delivery of the emergency services network, and we are currently consulting on this.[133] Our preliminary view which we published in the consultation is to grant EE's request so as to allow LTE in EE's 1900 MHz spectrum, subject to technical conditions consistent with CEPT Report 39. We note that these technical conditions, if applied to all 1900 MHz spectrum, would allow different power levels in different 5 MHz blocks of the 20 MHz of 1900 MHz spectrum.

A5.21 Specifically, BT/EE's lowest 5 MHz block (1900-1905 MHz) would be permitted to operate at up to 43 dBm, BT/EE's next 5 MHz block (1905-1910 MHz) would be permitted to operate up to 30 dBm, O2's 5 MHz block (1910-1915 MHz) and H3G's 5 MHz block (1915-1920 MHz) would be permitted to operate up to 20 dBm. There might be an argument that the higher permissible power for BT/EE's lowest 5 MHz (or even all of its 10 MHz) means that this spectrum could be used to support mainstream mobile services on microcells, even though the 1900 MHz spectrum of O2 and H3G could not. We note that there are already many global mobile handsets available that cover this spectrum as part of a wider band and this band is included in many handsets available to UK consumers.

A5.22 However, it is not clear that even at 43 dBm it would be useful for mainstream mobile services. As far as we are aware, it is not used elsewhere in Europe for mainstream mobile services, despite the CEPT Report 39 dating from 2010.

A5.23 Even if we were to include all or some of the 10 MHz of EE's 1900 MHz as immediately useable spectrum, we do not consider that it would undermine our preferred policy option. Rather, it would tend to strengthen the case for the option we propose, of capping the spectrum immediately useable after the award. This is because if BT/EE's 1900 MHz spectrum were included, the current distribution of immediately useable spectrum would be even more asymmetric, with BT/EE's current share of immediately useable spectrum increasing to 46%. After the auction, BT/EE's share would fall to 43%.

Other potential future mobile spectrum

A5.24 There are a number of other frequencies that may become useful for mobile access in the future. We published an update to our mobile data strategy in June 2016.[134] This described some changes to our priorities for future mobile spectrum release, including making the release of spectrum at 1427-1452 and 1492-1518 MHz a high priority, as well as spectrum at 5725-5850 MHz and the mmWave bands. We continue to attach high priority to the 3.6-3.8 GHz spectrum, as described above.

A5.25 The award of the 2.3 and 3.4 GHz bands is part of the Government's Public Sector Spectrum Release (PSSR) programme. In April 2016, the Central Management Unit (part of UK Government Investments) proposed a new target (reported in the March 2016 Budget): "750MHz of valuable public sector spectrum in bands under 10GHz

[133] The consultation on EE's requested licence variation is here: https://www.ofcom.org.uk/consultations-and-statements/category-2/EE-licence-variation-1990-1920MHz

[134] *Mobile Data Strategy, Update on our strategy for mobile spectrum*, Ofcom, 30 June 2016, http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/update-strategy-mobile-spectrum.pdf

will be made available by 2022, of which 500MHz will be made available by 2020."[135]

A5.26 In addition to the current release of cleared spectrum, the PSSR programme involves plans to make further public sector spectrum available for civil users. The lower 2.3 GHz band (2300–2350 MHz) was noted as a priority band for investigation as part of the CMU update. We are therefore currently working with MOD and other government departments to explore the potential to make available additional spectrum for civil users in the lower 2.3 GHz range. This may be on a time limited basis and/or in limited geographic areas. Such opportunities remain uncertain at this stage and in any case will not be available for some years.

135 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/518303/enabling_uk_growth_pssr_programme_annual_report.pdf

Annex 6

International benchmark of spectrum holdings

Introduction

A6.1 This annex presents the spectrum holdings of different operators in several Western European countries. We have focused on countries where there are at least four MNOs, namely Denmark, France, Italy, the Netherlands, Slovenia, Spain and Sweden, as these are better UK comparators[136].

A6.2 Therefore, we have not included Austria, Belgium and Germany, which were discussed in our 2012 Assessment of future mobile competition and award of 800MHz and 2.6 GHz Statement, but which now only have three MNOs.[137] In Austria and Germany there are now only three MNOs because two of them merged. In Belgium, while a fourth operator obtained spectrum in 2011, it did not launch services and returned the spectrum rights in 2014.[138]

A6.3 The analysis in this section is based on spectrum holdings in bands which are currently useable by mobile operators, namely 800 MHz, 900 MHz, 1800 MHz, paired 2.1 GHz and paired and unpaired 2.6 GHz. We present a time-series of total spectrum holdings over the past five years.

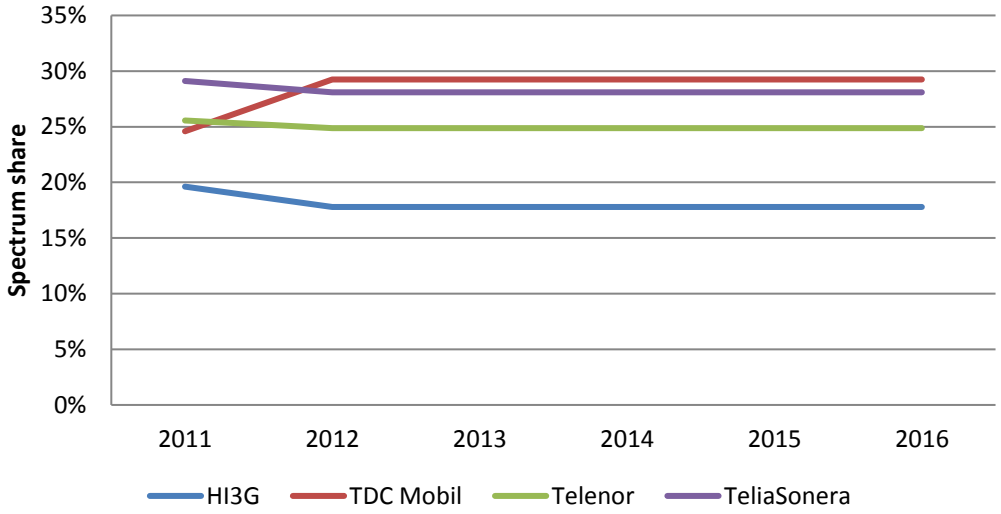
A6.4 We compare this evolution of spectrum shares with the evolution of market shares[139] in order to assess how MNOs have performed. We are mindful that spectrum is not the only resource on which the credibility of an MNO hinges nor that market shares are an absolute indication of this. Nonetheless, it does give an indication of the effectiveness of an operator to compete in the market.

Denmark

A6.5 Spectrum allocations in Denmark have remained stable since 2012, with the four MNOs having spectrum shares between ca. 18-29% each.[140]

[136] We have excluded Finland from our analysis as the fourth holder of spectrum -Ukko mobile- does not provide traditional mobile services, for example, it does not offer voice services.
[137] For our earlier assessment see paragraphs A2.182 to A2.259 in Annex 2 of our July 2012 statement.
[138] See the discussion under 'mobile telephony' on page 10 of Telenet's 2014 Annual Report, http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9Mjc5MDYyfENoaWxkSUQ9LTF8VHlwZT0z&t=1
[139] Source: Analysys Mason Telecom Market Matrix – April 2016, except for Slovenia
[140] We have assumed that each of the spectrum holdings of TeliaSonera and Telenor include 50% of the spectrum holdings of TT Netværket, which is a joint venture of Telenor and TeliaSonera, holding 2x10 MHz of 800 MHz spectrum. TT Netværket does not operate as an MNO on its own but rather as the infrastructure company of Telenor and TeliaSonera in Denmark. See http://www.tt-network.dk/

Figure A6.1: Spectrum shares in Denmark



Source: Cullen international

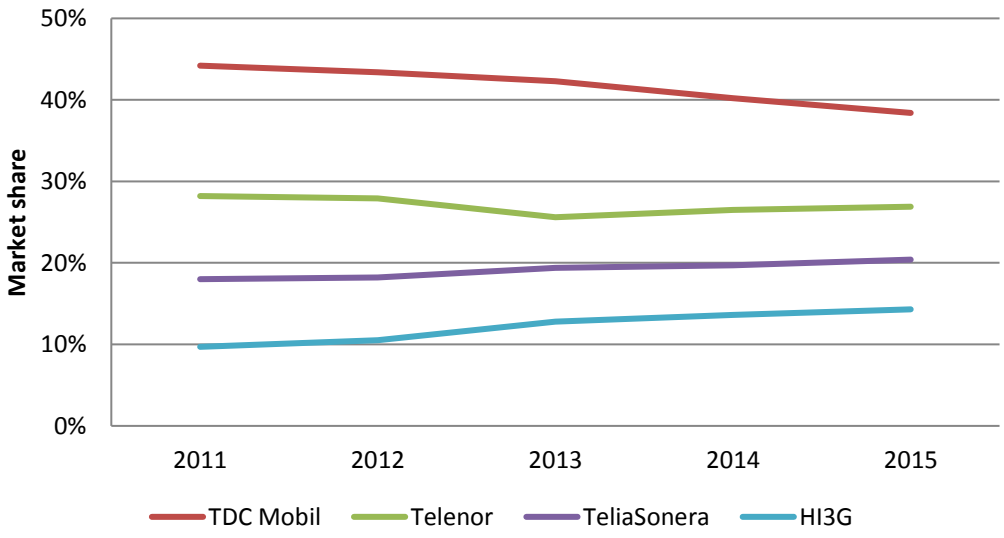
Figure A6.2: Spectrum holdings in Denmark – 2016 (MHz)

	800 MHz	900 MHz	1800 MHz	2.1 GHz (Paired)	2.6 GHz (Paired)	2.6 GHz (Un-paired)	Total
TDC Mobil	40	18	43.6	31	40	0	172.6
Telenor	10	18	38.8	30	40	10	146.8
TeliaSonera	10	23.6	47.2	30	40	15	165.8
HI3G	0	10	20	30	20	25	105

Source: Cullen international

A6.6 The three smaller operators in Denmark have increased their subscriber market share at the expense of the largest operator (TDC), with the exception of a dip by Telenor between 2011 and 2013.

Figure A6.3: Subscriber market share in Denmark



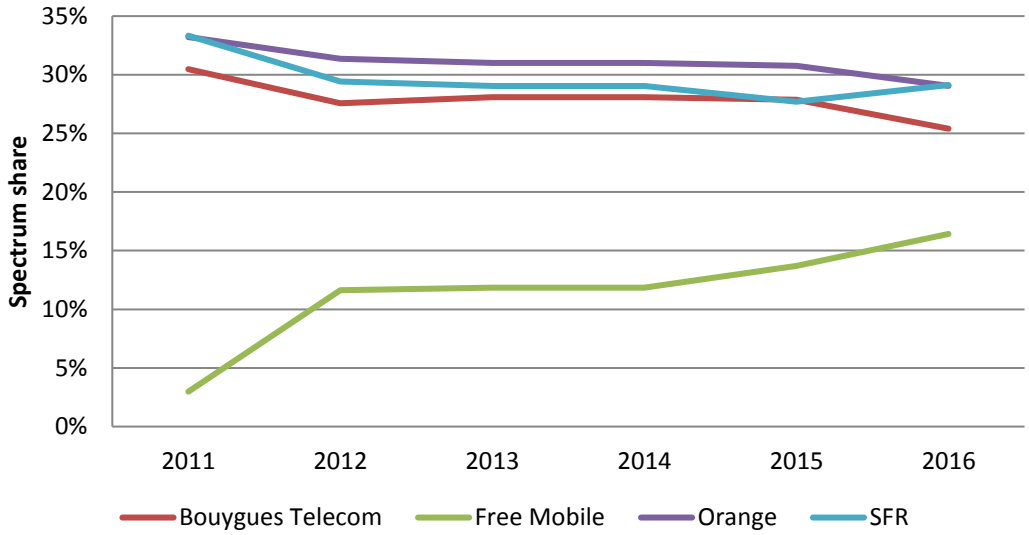
Source: Analysys Mason

A6.7 There is a larger dispersion of subscriber market shares in Denmark than spectrum shares. TDC's subscriber market share is larger than its spectrum share, but it has consistently lost market share to competitors over the period. TeliaSonera has a slightly lower share of spectrum than TDC but a significantly lower subscriber share (albeit rising over time). HI3G's subscriber share has increased over time but remains lower than its share of spectrum.

France

A6.8 In France there are currently four operators with the largest three having relatively similar spectrum holdings between ca. 25-30%, while the fourth operator -Free - now holds just over 15%:

Figure A6.4 Spectrum shares in France



Source: Cullen international / ARCEP

Figure A6.5: Spectrum holdings in France – 2016 (MHz)

	800 MHz	900 MHz	1800 MHz	2.1 GHz (Paired)	2.6 GHz (Paired)	2.6 GHz (Un-paired)	Total
Orange	20	20	40	39.2	40	0	159.2
SFR	20	20	40	49.6	30	0	159.6
Bouygues Telecom	20	19.6	40	29.6	30	0	139.2
Free Mobile	0	10	30	10	40	0	90

Source: Cullen international / ARCEP

A6.9 Free, which launched its service in 2012, currently holds a total of 90 MHz of paired spectrum in the 900 MHz, 1800 MHz, 2.1 GHz and 2.6 GHz.

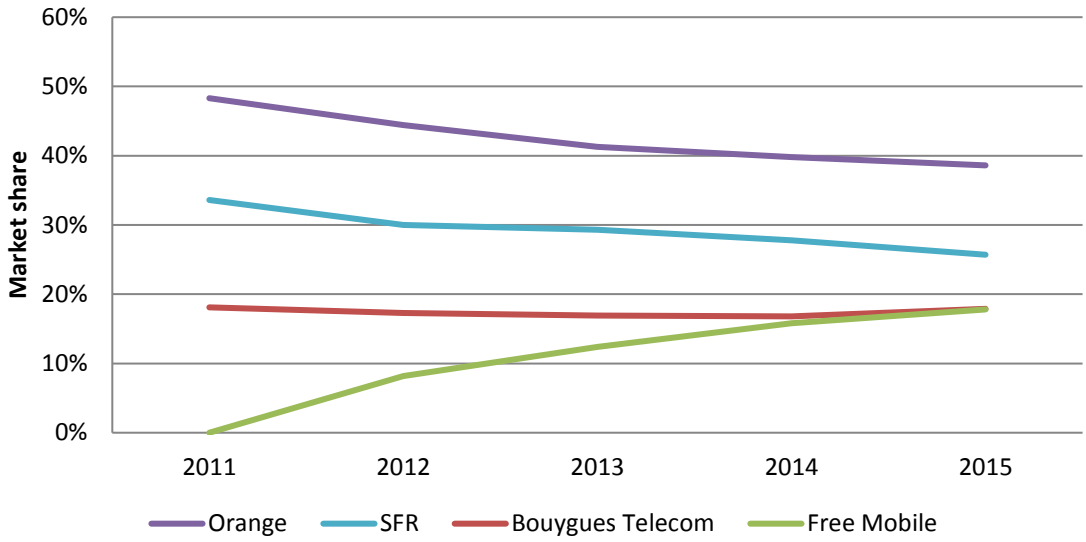
A6.10 Current spectrum holdings include 2x15 MHz that it was assigned as a result of the re-farming of the 1800 MHz band by Arcep.[141] In this re-farming process each of the

[141] See http://www.arcep.fr/index.php?id=8571&tx_gsactualite_pi1[uid]=1771&tx_gsactualite_pi1[annee]=&tx_

other three operators relinquished 2x5 MHz of 1800 MHz spectrum, which was then awarded to Free, in exchange for authorisation to use this band for 4G services.[142]

A6.11 Despite its significantly smaller spectrum share, Free has been very effective at increasing its subscriber base and is now poised to become the third operator by number of subscribers.

Figure A6.6: Subscriber market share in France



Source: Analysys Mason

A6.12 Since its entry into the market Free has been consistently increasing its market share, even when it held just under 12% of the total spectrum share. For example, in 2014 it had almost 16% of the subscriber market share with 11.8% of the spectrum share.

A6.13 It should be noted that Free currently has a national roaming agreement with France Telecom (FT) which was signed in 2012 and was expected to last until 2018. In 2013 the competition authority prevented this agreement from being extended beyond the original date.[143] In 2016 it was agreed that the roaming agreement will start to be phased out from January 2017, coming to a complete end by 2020. We do not have information on how much of Free's current traffic is carried over Orange's network.

A6.14 In 2015 France carried out the auction for 2x30 MHz of 700 MHz spectrum, which is expected to be cleared by mid-2019.[144] As a result of the auction 2x5 MHz were

gsactualite_pi1[theme]=&tx_gsactualite_pi1[motscle]=&tx_gsactualite_pi1[backID]=26&cHash=c871b5f7f09a340df41c676b07559218&L=1

142 http://www.arcep.fr/index.php?id=8571&tx_gsactualite_pi1%5Buid%5D=1766&tx_gsactualite_pi1%5Bannee%5D=&tx_gsactualite_pi1%5Btheme%5D=&tx_gsactualite_pi1%5Bmotscle%5D=&tx_gsactualite_pi1%5BbackID%5D=26&cHash=9b7d91056645812f50705838413cb4f4&L=1

143 See http://www.autoritedelaconcurrence.fr/user/standard.php?id_rub=482&id_article=2061

144 http://www.arcep.fr/index.php?id=8571&no_cache=1&L=0&tx_gsactualite_pi1%5Buid%5D=1754&tx_

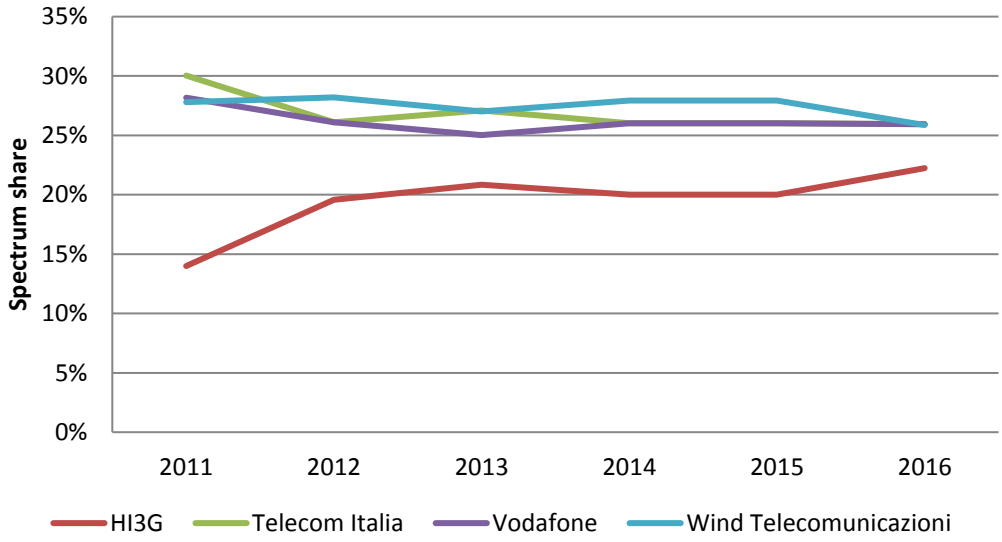
awarded to each of SFR and Bouygues while Orange and Free each won 2x10 MHz.[145]

A6.15 For this auction ARCEP put in place a cap of 2x15 MHz for any operator in this band as well as a cap of 2x30MHz on sub 1 GHz spectrum holdings.[146]

Italy

A6.16 Before the merger between H3G and Wind, which we discuss below, all four operators in Italy had relatively similar spectrum holdings of roughly a quarter each, with no more than a 4% difference between MNOs.

Figure A6.7: Spectrum shares in Italy



Source: Cullen international

Figure A6.8: Spectrum holdings in Italy – 2016 (MHz)

	800 MHz	900 MHz	1800 MHz	2.1 GHz (Paired)	2.6 GHz (Paired)	2.6 GHz (Un-paired)	Total
Telecom Italia	20	20	40	30	30	0	140
Vodafone	20	20	40	30	30	0	140
Wind	20	19.6	30	30	40	0	139.6
HI3G	0	10	30	30	20	30	120

Source: Cullen international

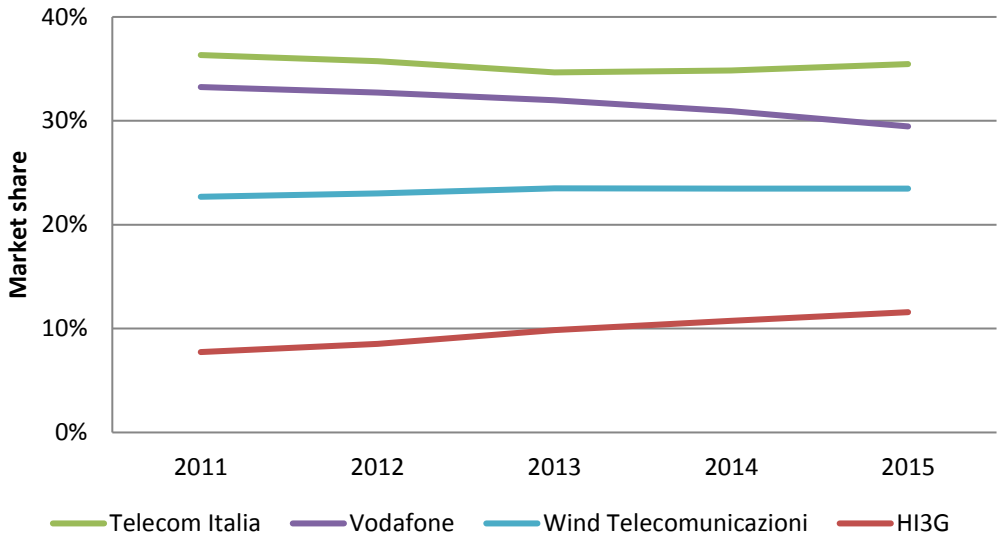
gsactualite_pi1%5Bannee%5D=&tx_gsactualite_pi1%5Btheme%5D=&tx_gsactualite_pi1%5Bmotscle%5D=&tx_gsactualite_pi1%5BbackID%5D=26&cHash=81da221e448ecb894f8a4f7b6fc5a742

145 http://www.arcep.fr/index.php?id=8571&L=0&tx_gsactualite_pi1[uid]=1806&tx_gsactualite_pi1[annee]=&tx_gsactualite_pi1[theme]=&tx_gsactualite_pi1[motscle]=&tx_gsactualite_pi1[backID]=26&cHash=7e1d824a1659bb2e7723a117bffbff80

146 http://www.arcep.fr/index.php?id=8571&no_cache=1&L=0&tx_gsactualite_pi1%5Buid%5D=1754&tx_gsactualite_pi1%5Bannee%5D=&tx_gsactualite_pi1%5Btheme%5D=&tx_gsactualite_pi1%5Bmotscle%5D=&tx_gsactualite_pi1%5BbackID%5D=26&cHash=81da221e448ecb894f8a4f7b6fc5a742

A6.17 Despite relatively stable and symmetric spectrum shares, there are significant differences in subscriber market shares between the different operators.

Figure A6.9: Subscriber market share in Italy



Source: Analysys Mason

A6.18 For example, H3G's spectrum share is relatively close to its competitors whilst its market share is growing but remains significantly below its spectrum share.[147]

A6.19 H3G and Wind (Vimplecom) agreed to merge, pending approval from the European Commission (EC). The merger was notified on the 5th of February 2016[148], with the Commission approving the merger on the 1st of September 2016.

A6.20 In order to address the EC's competition concerns the merging parties offered remedies aimed at allowing the creation of a new fourth MNO.[149] These remedies included:

- Divestment by the merged entity of spectrum in different bands.
- An infrastructure sharing agreement with the new MNO giving it access to the base stations of the merged entity.
- A transitional national roaming agreement allowing the new MNO to use the merged entity's network to provide nation-wide 2G, 3G and 4G services while the new operator builds its own network.

A6.21 Before the agreement was cleared by the EC, the merging parties reached an agreement with Iliad of France (owners of the French MNO Free) to acquire the assets which constituted this proposed remedy.[150] The agreement included the

[147] H3G has spectrum in the 900 MHz, 1800 MHz, 2.1 GHz, and 2.6 GHz (paired and unpaired) bands.
[148] See http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=2_M_7758
[149] http://europa.eu/rapid/press-release_IP-16-2932_en.htm
[150] See http://www.iliad.fr/presse/2016/CP_050716_Eng_.pdf
See also slide 18 of http://www.iliad.fr/finances/2016/slideshow_S1_2016_310816.pdf

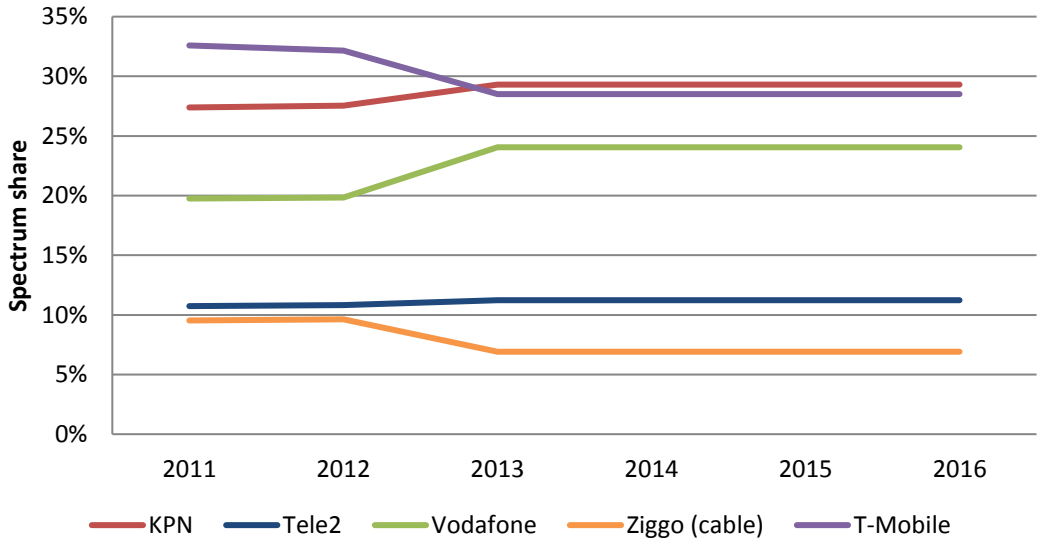
transfer of a total of 2x35 MHz of spectrum in the 900 MHz (2x5 MHz), 1800 MHz (2x10 MHz), 2.1 GHz (2x10 MHz) and 2.6 GHz bands (2x10 MHz).

A6.22 This agreement means that the merged entity will control ca. 35% of the usable spectrum once it divests the agreed spectrum into the new MNO. This new MNO will therefore begin operation with the equivalent of 13%[151] of the total spectrum.

The Netherlands

A6.23 At present there are five companies in the Netherlands with mobile spectrum, including two which have only recently launched services (Tele2 and Ziggo).

Figure A6:10. Spectrum shares in the Netherlands



Source: Cullen international

Figure A6.11: Spectrum holdings in the Netherlands – 2016 (MHz)

	800 MHz	900 MHz	1800 MHz	2.1 GHz (Paired)	2.6 GHz (Paired)	2.6 GHz (Un-paired)	Total
KPN	20	20	40	39.6	20	30	169.6
Vodafone	20	20	40	39.2	20	0	139.2
T-Mobile	0	30	60	40	10	25	165
Tele2	20	0	0	0	40	5	65
Ziggo	0	0	0	0	40	0	40

Source: Cullen international

A6.24 While Tele2 had been allocated spectrum in the 2.6 GHz band since 2011, with a further award in the 800 MHz band in 2013, it only launched its own 4G-based mobile service in November of 2015. Until then, it had been providing service as an MVNO using T-Mobile's network.

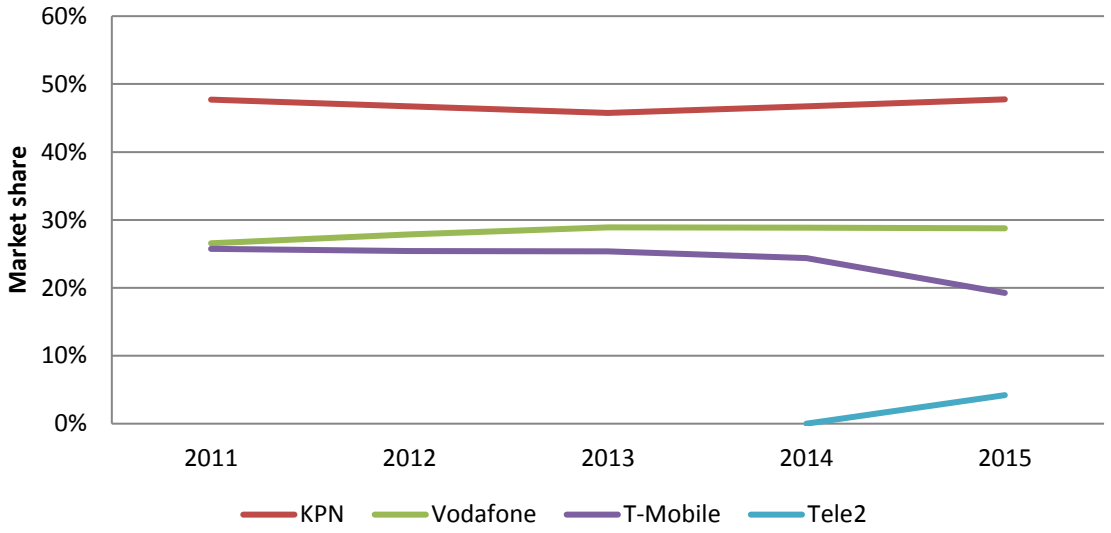
[151] If the 40MHz of 1400 MHz spectrum currently held by Telecom Italia and Vodafone is taken into account, the spectrum share of the new MNO would be just over 12%

A6.25 In spite of now running its own network, Tele2 is reported to be continuing its MVNO agreement with T-Mobile for 2G and 3G services for at least five years, in addition to signing an infrastructure sharing agreement with them.[152]

A6.26 On the other hand, Ziggo (Liberty Global), which had originally started to provide mobile services as an MVNO using Vodafone's network[153], has now received approval to merge with Vodafone.[154] As a result, the Dutch MNO market will likely shrink to four mobile operators, with Vodafone effectively controlling just under 32% of the total spectrum in the country, including the 2x20 MHz of 2.6 GHz spectrum currently held by Ziggo.

A6.27 At present Tele2 has 4% of the subscriber share.[155] However, as it has only recently made the transition from MVNO to MNO, it is too early to draw any conclusions on how its spectrum holdings affect its ability to compete in the market. We do not have information available on Ziggo's number of subscribers.

Figure A6.12: Subscriber market share in the Netherlands



Source: Analysys Mason

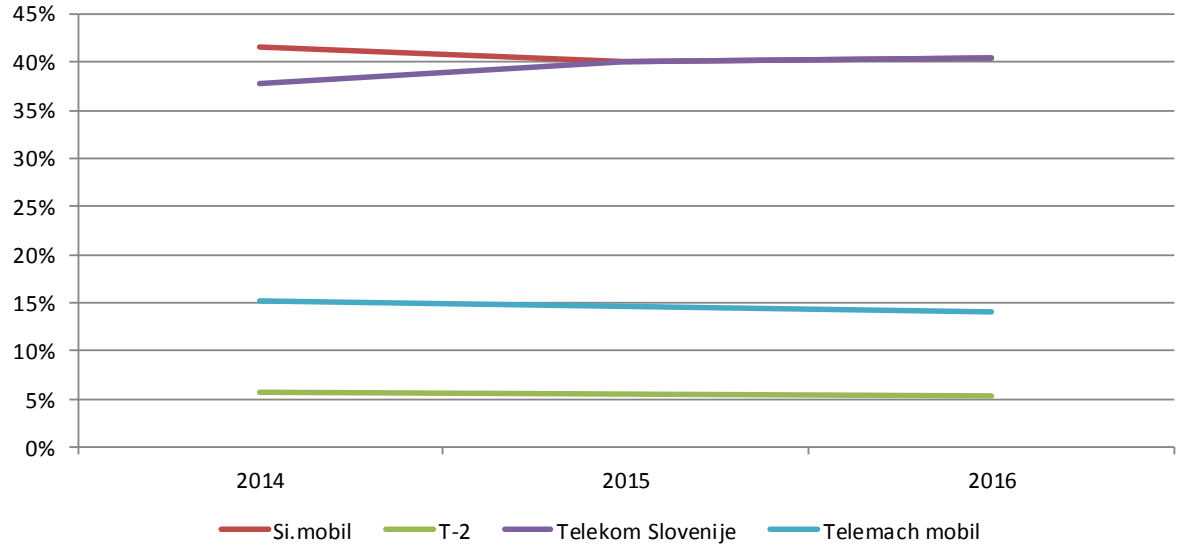
A6.28 KPN has been able to maintain a market share close to 50% despite having relatively similar spectrum holdings to T-Mobile, which has only managed around 25%, with a significant decrease in subscriber share to below 20% between 2014 and 2015.

Slovenia

A6.29 There are significant differences in the spectrum holdings in Slovenia with the two main operators holding around 40% of the total spectrum each, with the other two smaller operators sharing the remaining 20% as the chart below shows.

[152] See http://www.totaltele.com/view.aspx?ID=482816
[153] See https://www.telegeography.com/products/commsupdate/articles/2013/09/18/ziggo-launches-voicedata-mvno-service/
[154] See http://europa.eu/rapid/press-release_IP-16-2711_en.htm
[155] We do not have subscriber market share data for Tele2 for years earlier than 2015, so have only shown the 2015 figure. In reality its subscriber growth may have been more gradual that is shown here as it probably includes the subscribers it already had as an MVNO.

Figure A6:13 Slovenian spectrum shares



Source: Cullen international

Figure A6.14: Spectrum holdings in Slovenia – 2016 (MHz)

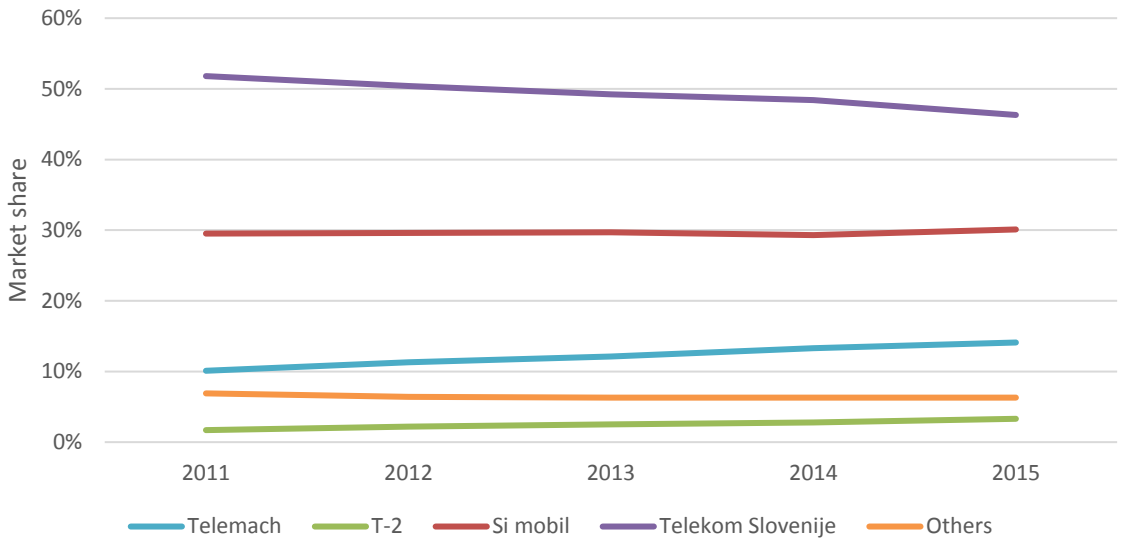
	800 MHz	900 MHz	1800 MHz	2.1 GHz (Paired)	2.6 GHz (Paired)	2.6 GHz (Un-paired)	Total
Si.mobil	20	24.8	60	30	70	25	229.8
T-2	0	0	0	30	0	0	30
Telekom Slovenije	20	24.8	50	40	70	25	229.8
Telemach mobil	20	20	30.4	10	0	0	80.4

Source: Cullen international

A6.30 Telekom Slovenije and Si.mobile have similar spectrum shares and materially different subscriber shares, whilst being the largest two operators by spectrum and subscribers. Telemach mobil's growing share of subscribers is now similar to its share of spectrum. T2, which is reported to have recently filed for bankruptcy[156], only had ca. 3% share of the market and 5% share of spectrum.[157]

[156] See https://www.telegeography.com/products/commsupdate/articles/2016/03/08/slovenias-t-2-forced-back-into-bankruptcy/
[157] Source: http://www.telekom.si/o-podjetju/Annual-Report-of-the-TSG-and-TS-for-2015.PDF

Figure A6:15 Subscriber market share in Slovenia[158]



Source: Telekom Slovenije Group Annual Report 2015

A6.31 In 2014 the Slovenian regulator carried out an auction for spectrum in the 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz (paired and unpaired) and 2.6 GHz (paired and unpaired) bands. For this auction it placed a number of caps on specific bands, namely a cap of 2x15 MHz for the 900 MHz band and 2x30 MHz for the 1800 MHz band. It also put in place more general caps of 2x3 MHz on sub 1 GHz spectrum and a cap on total spectrum of 2x105 MHz.[159]

A6.32 In addition to these caps, it reserved 2x10 MHz out of the total 2x30 MHz of 800 MHz spectrum for operators with less than 15% of market share, effectively ruling out Si.Mobil and Telekom Slovenije, both of whom won 2x10 MHz each of the unreserved spectrum. This reserved spectrum was won by Telemach (then Tusmobil), which was the only operator other than the two incumbents who participated in the auction. It also won 2x5 MHz of 900 MHz spectrum that was left over as both Si.Mobil and Telekom Slovenije reached their cap in this band in addition to 2x10 MHz of 1800 MHz spectrum.[160]

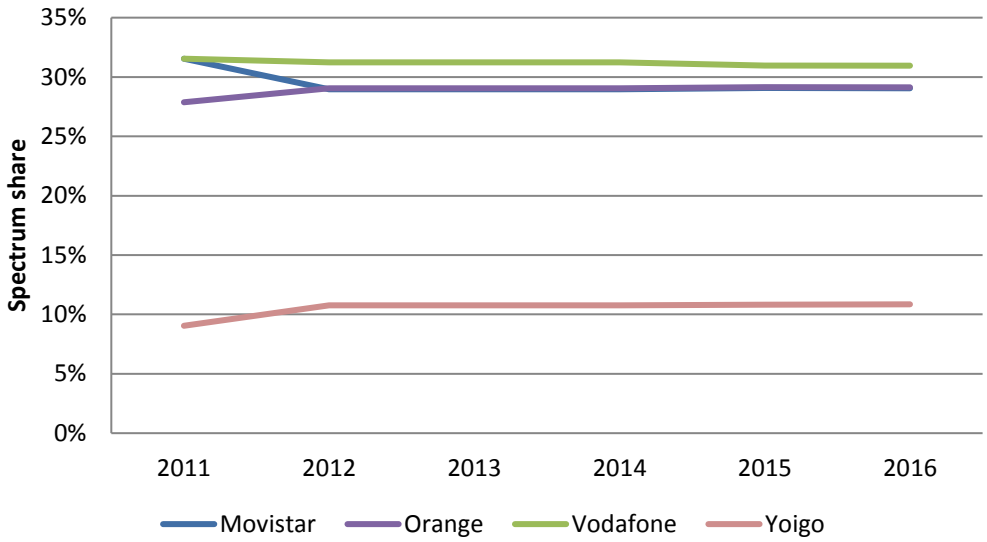
A6.33 The national regulatory authority, AKOS, explained why it had put in place competition measures as follows *"Because of the extreme asymmetry of operators in the Slovenian market agency had reserved up to two 2 x 5 MHz blocks of 800 MHz spectrum that only new entrants or existing operators with a market share of active end users of at most 15% could acquire. The goal was to maintain and develop effective competition in the markets for mobile electronic communication services."*[161]

[158] "Others" include Izi mobil and Debitel
[159] See annex 8 of the "Annual licence fees for 900 MHz and 1800 MHz spectrum" statement by Ofcom at http://stakeholders.ofcom.org.uk/consultations/annual-licence-fees-further-consultation/statement/
[160] Si.Mobil reached the 1800MHz cap
[161] http://www.akos-rs.si/public-tender-with-a-public-auction-for-assigning-radio-frequencies-for-the-provision-of-public-communication-services-successfully-concluded

Spain

A6.34 In Spain there is a significant difference in spectrum distributions between the largest three operators, which each hold around 30% of the total spectrum, and the fourth operator (Yoigo), which holds just over 11%.

Figure A6:16 Spanish spectrum shares



Source: Cullen International

Figure A6.17: Spectrum holdings in Spain – 2016 (MHz)

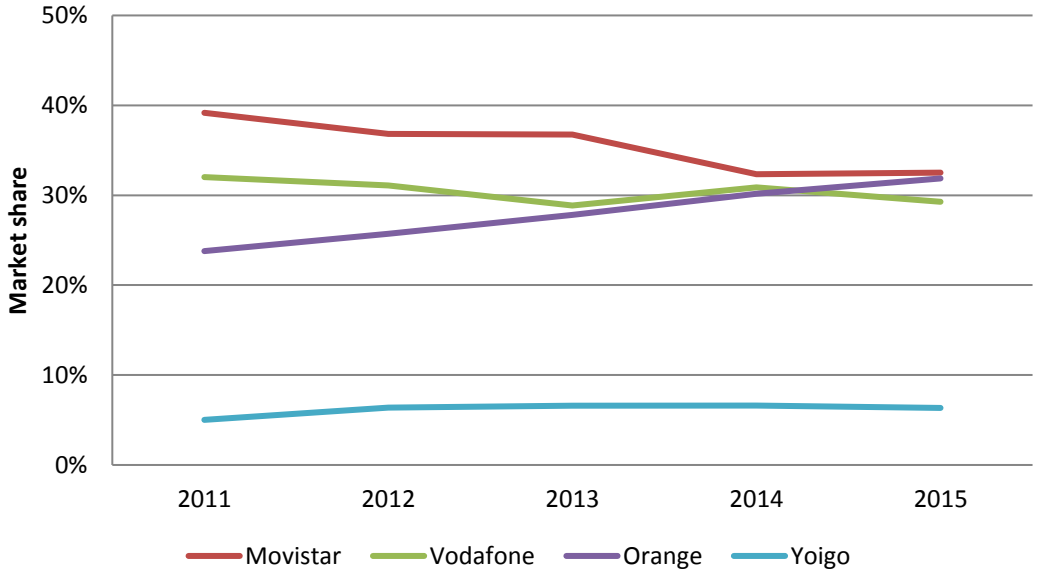
	800 MHz	900 MHz	1800 MHz	2.1 GHz (Paired)	2.6 GHz (Paired)	2.6 GHz (Un-paired)	Total
Movistar	20	19.6	40	30	40	0	159.6
Vodafone	20	20	40	30	40	20	170
Orange	20	10	40	30	40	10	160
Yoigo	0	0	29.6	30	0	0	59.6

Source: Cullen international

A6.35 Although Yoigo is reported to have a 2G/3G roaming agreement with Telefonica[162] in addition to its own spectrum holdings, it has failed to grow beyond ca. 6% market share since its launch. It is Orange which has been most effective at increasing its market share, having achieved the second largest subscriber share, marginally below that of Movistar (Telefonica).

[162] http://tecnologia.elpais.com/tecnologia/2008/03/11/actualidad/1205227683_850215.html

Figure A6.18: Subscriber market share in Spain



Source: Analysys Mason

A6.36 Yoigo has had the opportunity to acquire more spectrum. In 2011 Spain carried out a total of three spectrum awards. In the first award – a beauty contest - Yoigo was awarded 2x15 MHz of 1800 MHz spectrum. The second award of the year was an auction for spectrum in the 800 MHz, 900 MHz and 2.6 GHz (paired and unpaired) bands. Two caps were in place for this auction: 2x20 MHz cap on sub 1 GHz spectrum and a limit of 115 MHz on joint 1800 MHz, 2.1 GHz and 2.6 GHz spectrum.

A6.37 Despite the caps in place, Yoigo was not awarded any spectrum in this auction. Furthermore, the caps meant that 2x5 MHz of 900 MHz spectrum remained unsold thereby requiring a third award process where the caps were raised and Telefonica acquired the 900 MHz that was left.

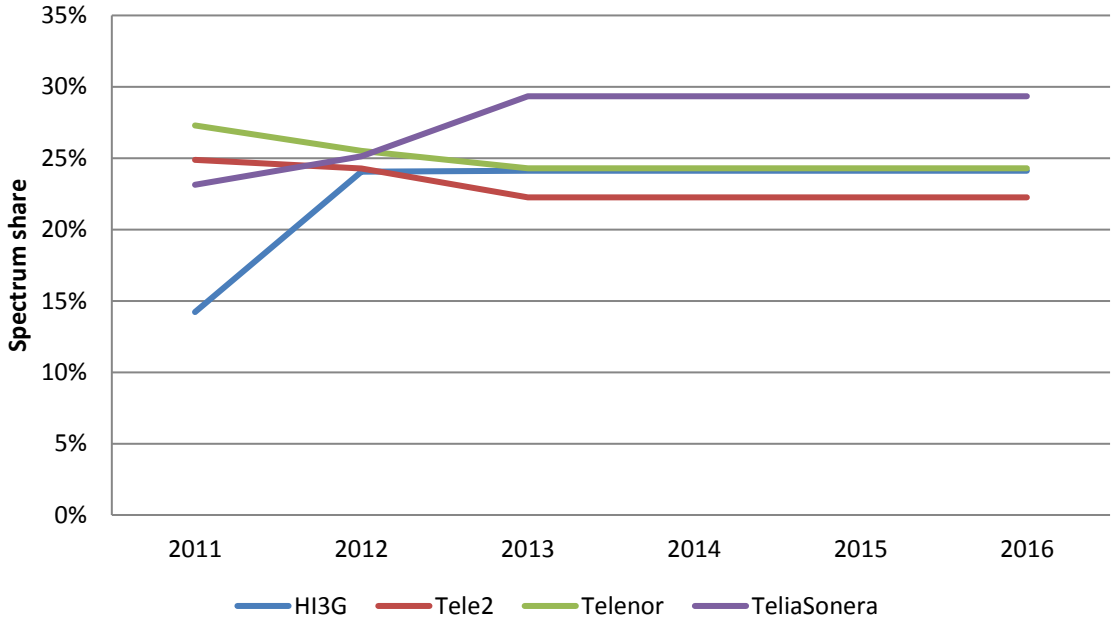
A6.38 In 2016 Yoigo was sold by TeliaSonera and is now part of the Spanish telecommunications group MASMOVIL.

Sweden

A6.39 In Sweden spectrum shares by the different operators are relatively even (22% to 29%) when taking into account the spectrum holdings of joint ventures.[163]

[163] Telenor and Tele2 are part of the Net4Mobility joint venture, which holds around 30% of the total spectrum in the country. Furthermore, Svenska UMT-licens AB is a 50:50 joint venture between TeliaSonera and Tele2. While we do not have the detailed agreements of these joint ventures, we have assumed that each member has access to half of the spectrum of the JV. See https://www.telenor.com/investors/company-facts/business-description/telenor-sweden/ and http://www.tele2.com/media/press-releases/2002/tele2-abs-umts-joint-venture-in-sweden-is-fully-funded-on-signing-sek-11-billion-credit-facility/

Figure A6:19: Spectrum shares in Sweden



Source: Cullen International

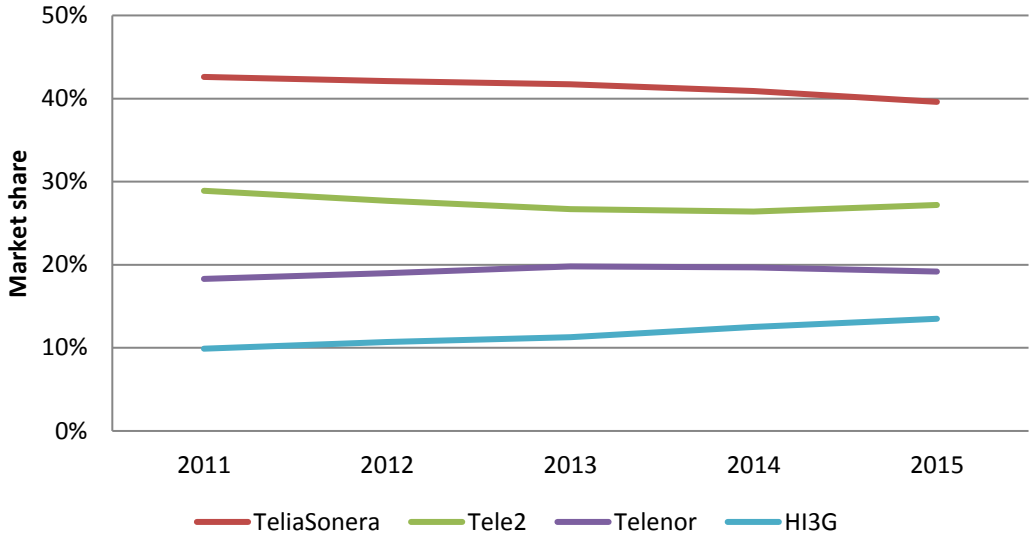
Figure A6.20: Spectrum holdings in Sweden – 2016 (MHz)

	800 MHz	900 MHz	1800 MHz	2.1 GHz (Paired)	2.6 GHz (Paired)	2.6 GHz (Un-paired)	Total
TeliaSonera	20	20	70	19.8	40	0	169.8
Tele2	10	24	35	19.8	40	0	128.8
Telenor	10	16	35	39.6	40	0	140.6
HI3G	20	10	0	39.6	20	50	139.6

Source: Cullen international

A6.40 There is much more variation in subscriber shares than spectrum shares. For example, despite holding ca. 25% of the spectrum available, H3G has the lowest subscriber market share in the country with a gradual upward trend.

Figure A6.21: Swedish subscriber market share



Source: Analysys Mason

International comparison of concentration and spectrum distribution

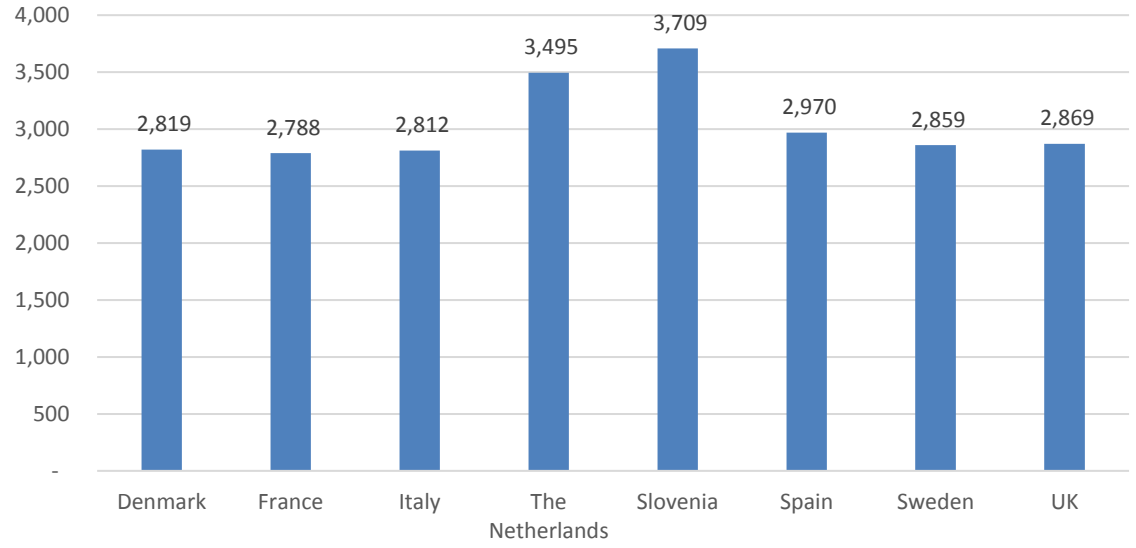
A6.41 We have carried out an analysis to compare the concentration levels in terms of the market (i.e. subscribers) as well as spectrum for the different countries in our sample, including the UK[164].

A6.42 We first estimated the level of market concentration of the different countries using the Herfindahl-Hirschman Index (HHI). This index is estimated by taking the absolute value of the market share of each firm in the industry (e.g. 25 if the market share is 25%) and then squaring this number. The sum of these values for all firms is the HHI and can theoretically range from close to zero for a market with a large number of firms, all with little market share (e.g. less than 1%), to 10,000 for a market with one operator with 100% market share.

A6.43 In our sample the highest levels of market concentration are in the Netherlands and Slovenia, both with HHIs well above 3,500. The UK has concentration levels relatively similar to those of the rest of the sample, which has HHIs ranging from 2,788 for France to 2,970 for Spain.

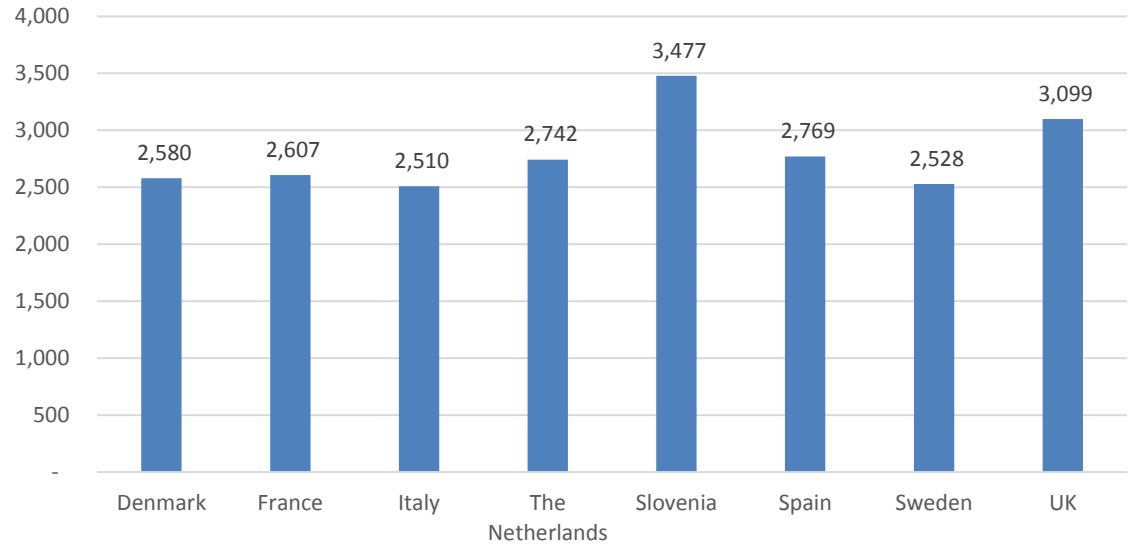
[164] For the UK wholesale market shares have been used, i.e. MNO's own subscribers and those of hosted MVNOs.

Figure A6.22: Market HHI indices for different countries[165]



A6.44 The same approach can be used to compare the levels of spectrum concentration between the different countries, i.e. using spectrum shares rather than subscriber shares. Using this measure, the highest levels of spectrum concentration are in Slovenia and the UK, with spectrum HHI indices of 3,477 and 3,099 respectively. Concentration levels of other countries are relatively similar between 2,510 and 2,769.

Figure A6.23: Spectrum HHI indices for different countries

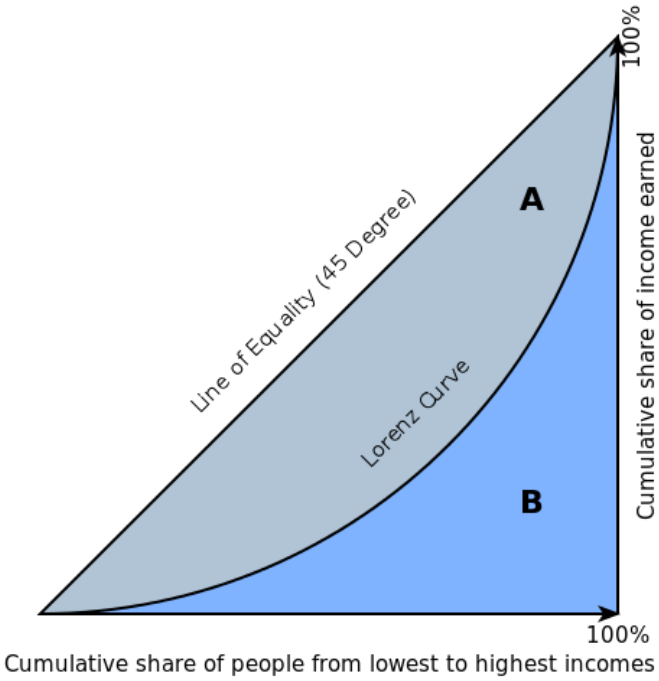


A6.45 An alternative method to estimate potential asymmetry in the allocation of spectrum is to use the Gini coefficient. The Gini coefficient is generally used to estimate how unequally wealth or income are distributed throughout a country[166] by comparing actual distribution to a scenario where there is full equality. In the figure below the

[165] HHIs estimated using own and hosted subscribers, i.e. excluding MVNO market share for which we don't have data for other countries.
[166] See: http://www.intmath.com/blog/mathematics/the-gini-coefficient-of-wealth-distribution-4187

Gini coefficient corresponds to the ratio between the area A and the sum of A+B. The relative sizes of these areas depends on the Lorenz curve, which shows the cumulative percentage of total national income (or spectrum) plotted against the cumulative percentage of the corresponding population. The Gini coefficient therefore ranges between 0 when A=0 (i.e. full equality, where everyone has the same level of income) and 1 when B=0 (i.e. full inequality where one person has all the income).

Figure A6.24: Gini coefficient calculation elements



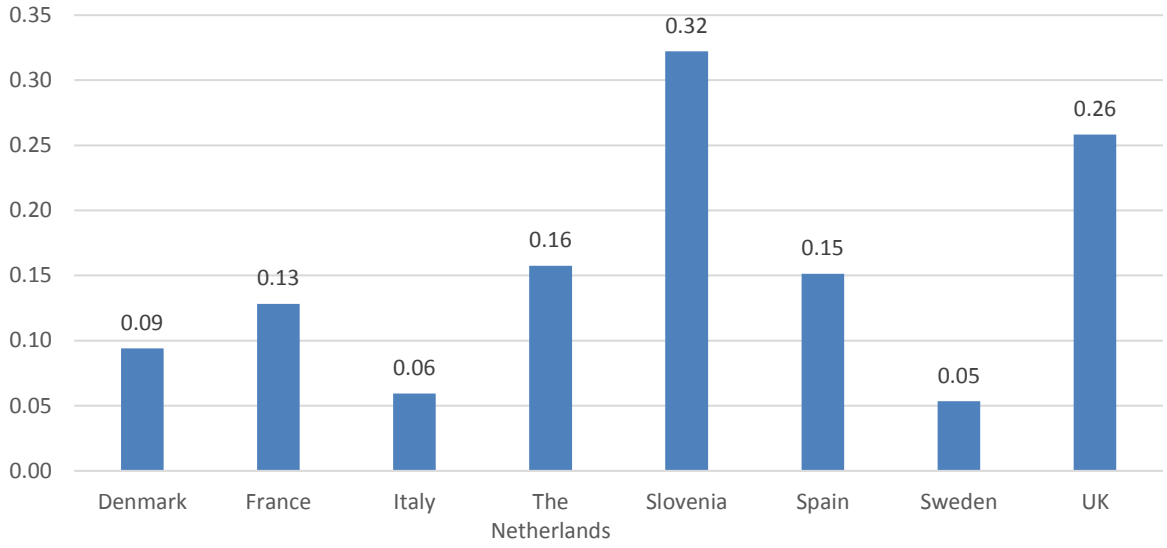
Source: https://commons.wikimedia.org/w/index.php?curid=7114030

A6.46 In the case of spectrum, we can estimate the Gini coefficient by assuming that in the Line of Equality (LOE) each operator has 1/n of the spectrum, where n is the number of MNOs in the country[167].

A6.47 Under this approach Slovenia and the UK have the highest levels of asymmetry in the spectrum distribution with Italy and Sweden having the lowest levels. Given that the Gini coefficient measures deviations from equal distribution, it is unsurprising that Italy and Sweden have the lowest coefficients as operators in these countries have ca. 25% of the total spectrum each.

[167] To build the Lorenz curve each MNO would be evenly spaced in the X-axis and the cumulative spectrum shares would give the coordinates in the Y-axis. The operators have to be arranged from the lowest to the highest spectrum share to derive the Y-axis coordinates so that the slope of the Lorenz curve is always increasing.

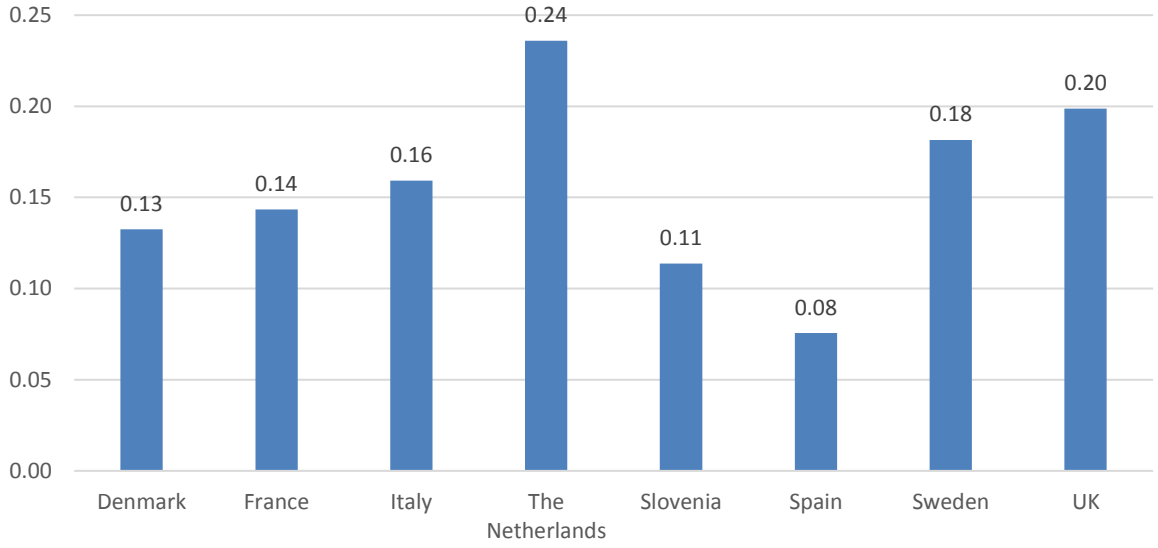
Figure A6.25: Gini coefficient with LOE where each MNO has 1/n of total spectrum



A6.48 However, the line of equality could be specified in different ways. For example, an alternate approach is to take into account subscriber shares for the estimation of the Gini coefficient, i.e. assuming that the line of equality is one where each subscriber has access to the same amount of spectrum, regardless of its MNO[168]. In this case the Gini coefficient of the UK is still the second highest, but at a lower level than that in figure A6.24 and closer to that of Sweden. Furthermore, the highest Gini coefficient is now that of the Netherlands, with Slovenia, which had the highest Gini in figure A6.54, now having the second lowest Gini.

[168] In this case the coordinates in the X axis would be given by the subscriber shares of each operator. The slope of each segment of the Lorenz curve would therefore be a function of the market share and spectrum share of each operator. As in the previous case, the operators have to be arranged in such a way as to have a strictly increasing slope in the Lorenz curve.

Figure A6.26: Gini coefficient with LOE where each subscriber has the same spectrum



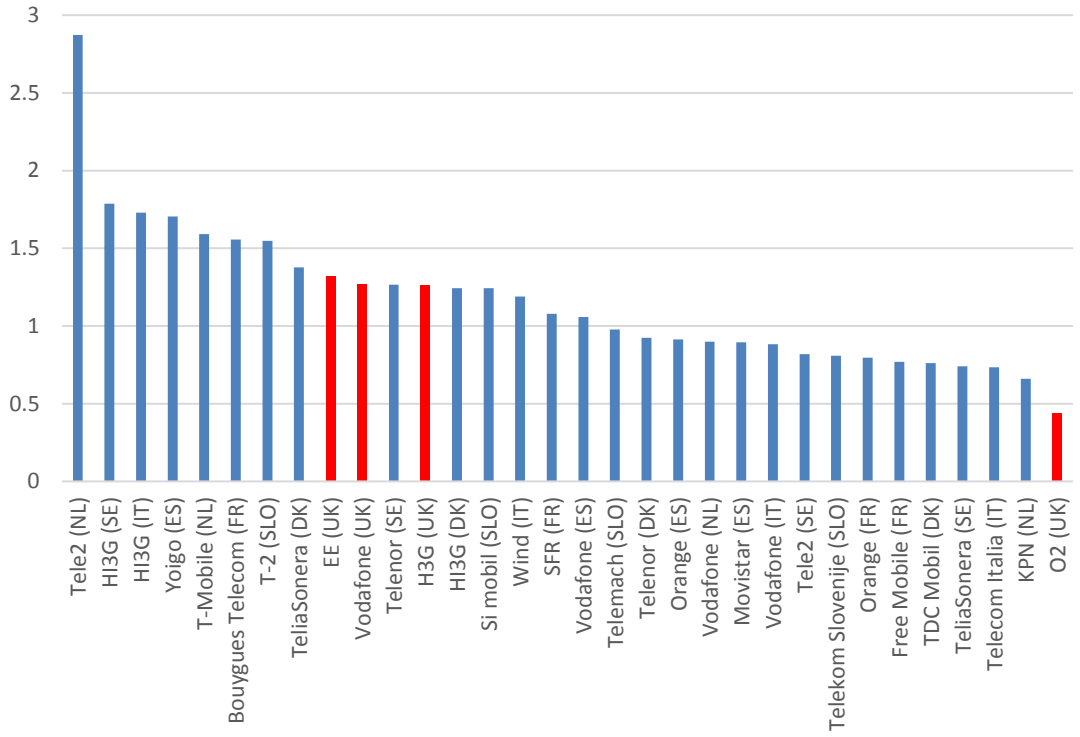
A6.49 The measure of spectrum inequality is therefore highly dependent on the way in which the LOE is specified[169]. While the analysis presented here gives useful insight, it is important to bear in mind that the Gini coefficient measures deviations from a very specific scenario, which may not necessarily reflect an optimal outcome.

A6.50 There are other ways to analyse and compare the distribution of spectrum to subscribers. For example, for each of the operators in our sample, we have estimated the ratio of spectrum shares to subscriber shares. Much like our second Gini estimation, this ratio allows us to compare the spectrum distribution from a subscriber point of view.

A6.51 In our sample of 32 operators across eight countries, O2 has the lowest ratio of spectrum to subscriber share ratio while EE, Vodafone and H3G are placed 9th, 10th and 12th respectively with relatively similar ratios.

[169] For example, a third way to specify it is by using data traffic instead of subscribers, i.e. assume that full equality means that each MB carried has access to the same amount of spectrum, regardless of the MNO that carries it.

Figure A6.27. Spectrum share to subscriber share ratios for different European MNOs



A6.52 Much in the same way as different LOEs can be specified for the Gini analysis, it is possible to specify other ratios that assess spectrum distribution against different variables. For example, spectrum share to data traffic share potentially provides an estimate of actual spectrum usage. However, we do not have the data traffic by operator for other countries to carry out this calculation.

A6.53 But we have conducted this calculation for the UK – we show the relative ratios of data traffic to spectrum for the four UK MNOs in section 3 (alongside their relative ratios of subscribers to spectrum). We note that the relative ratios of operators using this measure of traffic to spectrum share are materially different from the relative ratios for the UK MNOs using the measure of subscribers to spectrum, e.g. because H3G carried significantly more data traffic per MHz of spectrum than the three other MNOs. This suggests that in an international comparison we could also see material differences in the relative ratios, depending on the measure being used.

Annex 7

Current state of the UK mobile market

Introduction

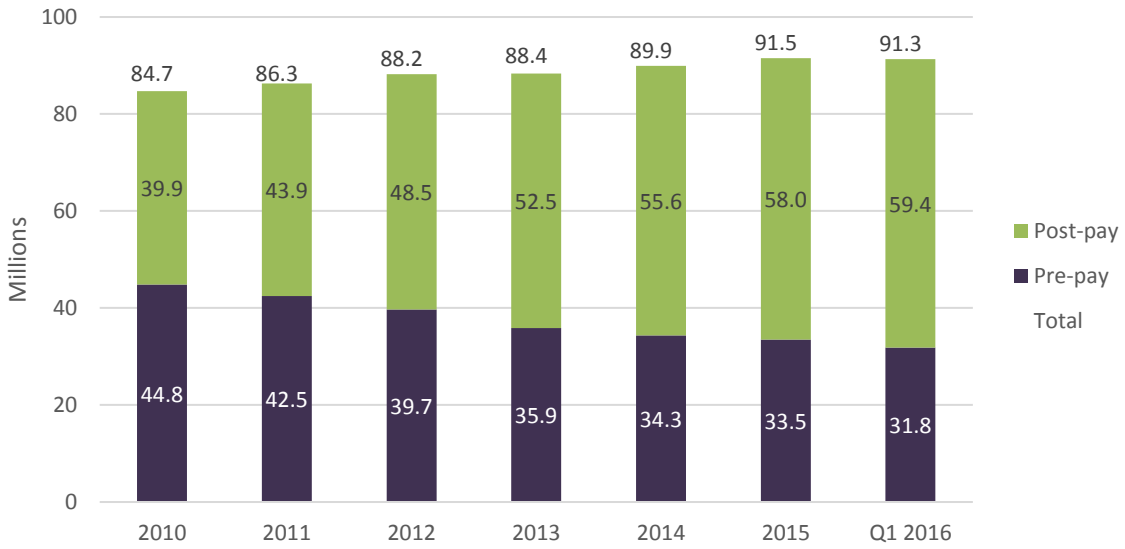
A7.1 This annex presents a general overview of the UK mobile market focusing on aspects such as subscriber growth, market shares, pricing trends and the current state of the UK mobile networks, among others.

A7.2 The purpose of this annex is to provide factual information that supports some of the arguments that have been made in this consultation and is not intended to be an exhaustive description of the current state of competition in the mobile sector in the UK.

General state of the market

A7.3 The number of mobile subscribers in the UK had grown continuously in recent years, going from 84.7m subscribers in 2010 to 91.5m subscribers in 2015. However, there has been a slight decrease as of Q1 2016 to 91.3m.

Figure A7.1: Mobile subscriptions, by pre-pay and post-pay



Source: Ofcom/operators

Note: Includes M2M

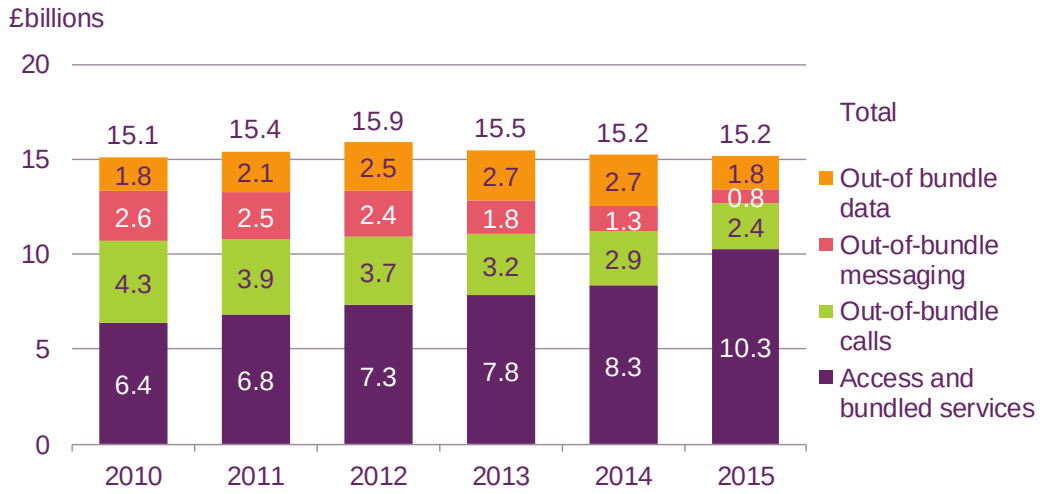
A7.4 As the figure above shows, there has been a significant change in the pre-pay / post-pay split.[170] Whereas in 2010 53% of subscriptions were pre-pay, by Q1 2016

[170] The distinction between post-pay and pre-pay tariffs may not always be strong. For example, some pre-pay tariffs involve subscribers making regular monthly payments for minutes and data that must be used in the following month, which are similar in form to post pay tariffs. There are also some post-pay tariffs with very short termination periods that are not unlike some pre-pay tariffs. For more on the blurring of the distinction between pre-pay and post-pay see paragraphs 14 to 18 of Appendix B of the CMA's decision on BT/EE merger,

this share had fallen to 25%. As a result, despite the overall fall in subscribers in Q1 2016, post-pay subscribers grew by ca. 1.4m between 2015 and Q1 2016.

A7.5 Mobile retail revenue remained fairly stable between 2014 and 2015 after experiencing a decrease between 2012 and 2014.

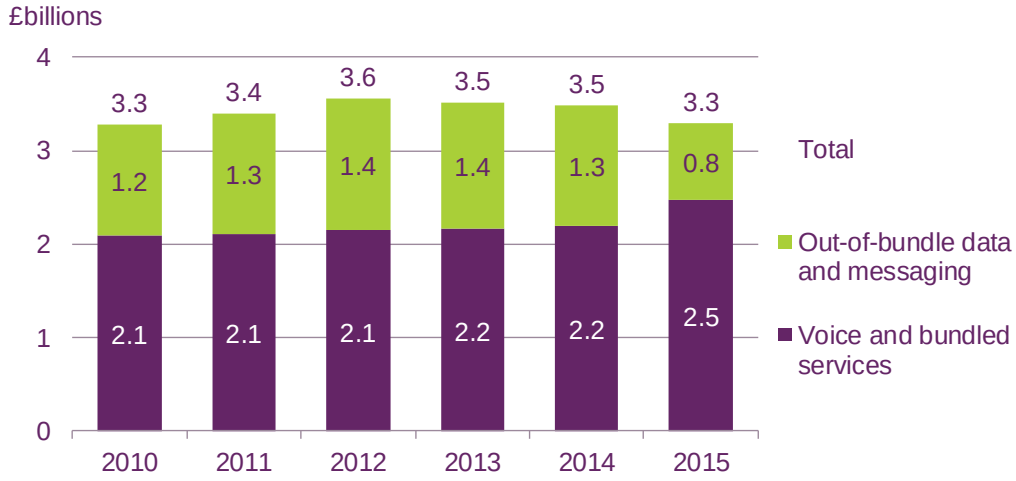
Figure A7.2: Mobile retail revenue by service



Source: Ofcom CMR 2016

A7.6 On the other hand, total and business mobile revenues have been declining since 2012 after an increase in the period between 2010 and 2012. Between 2015 and 2016 there was a significant increase in the revenues from voice and bundled services. Nonetheless, for business revenue this increase was more than offset by a sharp drop in the out-of-bundle revenues.

Figure A7.3: Business mobile revenues



Source: Ofcom CMR 2016

A7.7 Total mobile retail revenue fell slightly by £63.9m (0.4%) in 2015 (although still at £15.2bn when rounded, as in 2014 – see Figure A7.2). in contrast to the 0.1%

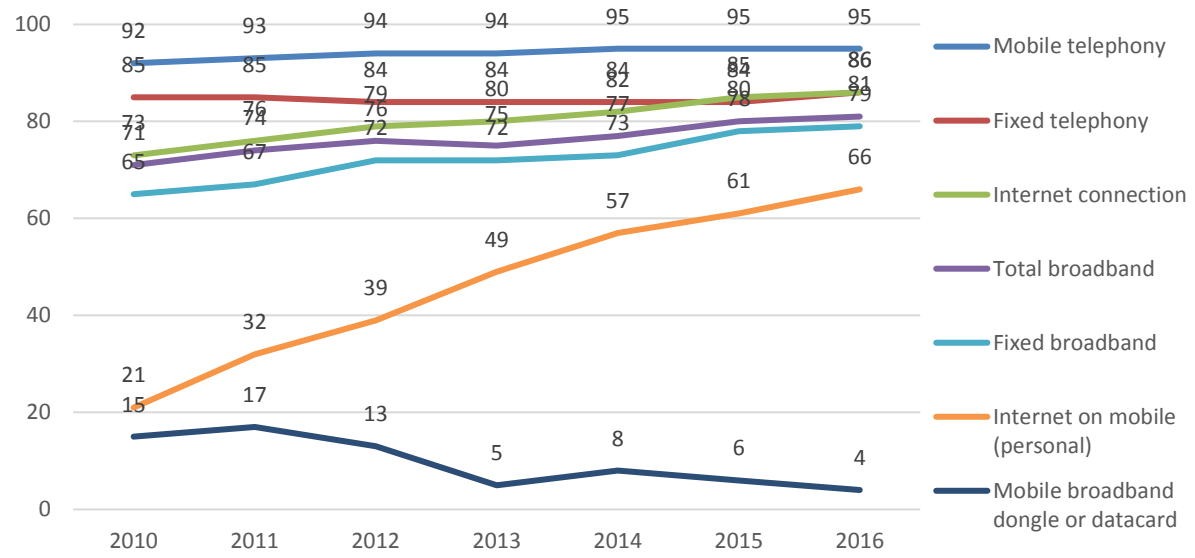
https://assets.publishing.service.gov.uk/media/56991ae4ed915d468c00002b/FR-Appendices_and_Glossary.pdf

average annual growth rate over the five years to 2015. Along with prices and declining SMS and MMS use, a key reason for falling average revenues may be the migration of higher-use pre-pay customers onto post-pay services during the year[171]. As mobile data volumes increase, the proportion of connections that are post-pay may also increase, as it is typically expensive to consume larger quantities of data on pre-pay tariffs.

A7.8 In terms of usage, data services, including internet on mobile devices has increased rapidly in recent years. As a result, whereas in 2010 only 21% of adults had access to the internet on their mobile, by 2016 this figure had increased to 66%.

Figure A7.4: Take-up of key telecoms technologies

Proportion of households/adults (%)



Source: Ofcom CMR 2016

A7.9 It is also worth noting that access to mobile broadband using dongles and datacards has decreased from a peak of 17% in 2011 to just 4% by 2016.

A7.10 The increased internet access on phones is a reflection of the increased penetration of smartphones in the UK, which is among the highest in Europe. For example, at present 71% of adults in the UK own a smartphone up from 66% in 2015.[172] This is higher than penetration rates in other European countries such as France, Germany and Italy which had penetration rates of 49%, 60% and 60% respectively for Spring 2015.[173]

A7.11 4G has experienced rapid growth in the UK. In Q4 2015 4G accounted for almost half of all mobile subscriptions (46%), and 4G take-up increased across all ages, genders and socio-economic groups in 2016. The availability of 4G mobile services has also increased, with the UK having 97.8% outdoor premises coverage by at

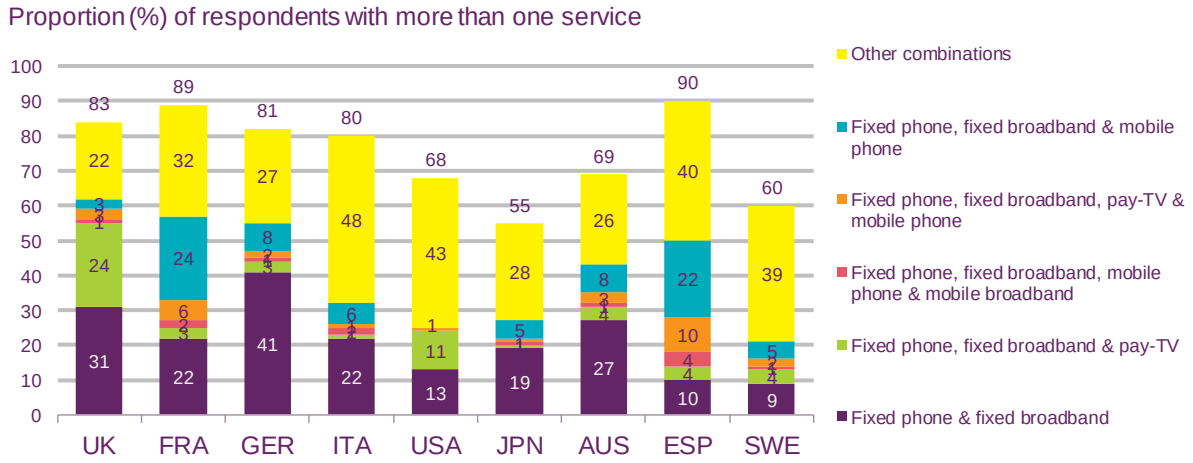
[171] Source: Ofcom CMR 2016
[172] Source: Ofcom CMR 2016
[173] See http://www.pewglobal.org/2016/02/22/smartphone-ownership-and-internet-usage-continues-to-climb-in-emerging-economies/ . the UK smartphone penetration rate for this period was 68% in this survey

least one operator in May 2016. The number of M2M connections has also been growing (up 7% to 6.7 million in 2015), as Internet of Things (IoT) devices begin to enter the market.[174]

A7.12 As a result, 4G subscriptions have grown from just 1.3 million in Q3 2013 to almost 42 million by Q1 2016.[175]

A7.13 Bundled fixed/mobile packages by fixed broadband operators have increased slightly in recent years. However, these bundles still have a relatively small share of the household provision market broadband compared to other countries. For example, while in the UK only ca. 7% of respondents acquire mobile services as part of a fixed bundle, ca. 32% do so in France and 36% in Spain.[176]

Figure A7.5: Proportion of consumers buying more than one communications service from the same provider

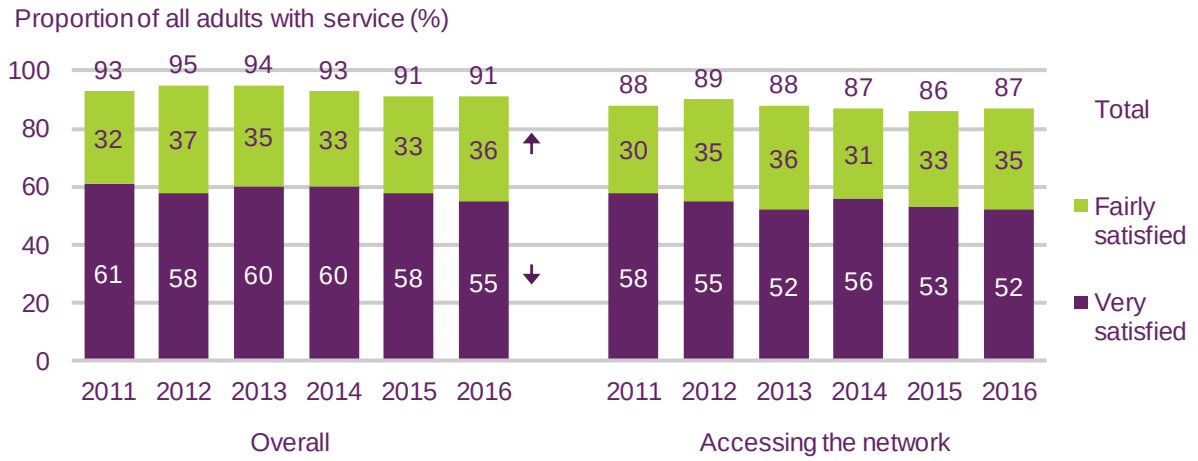


Source: International Communications Market Report 2015

A7.14 Consumer satisfaction with mobile services has remained fairly stable with 91% of subscribers expressing that they are fairly or very satisfied with their service.[177]

[174] Source: Ofcom CMR 2016
[175] Source: CMR 2016 and updated data from operators / Ofcom
[176] *Source:* International Communications Market Report 2015
http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr15/icmr15/icmr_2015.pdf
[177] Source: CMR 2016

Figure A7.6: Satisfaction of aspects with mobile service



Source: Ofcom CMR 2016

A7.15 As part of the Digital Communications Review (DCR) we commissioned a study by WIK to assess the drivers of investment and consumer welfare in mobile communications. This WIK study found there was no general relationship between competition and investment that can be expected to hold across all markets. It also found that over the last decade, the UK's capex / revenues ratio was broadly comparable to those in a number of other EU and international mobile markets.[178]

Recent changes to the structure of the market

A7.16 In 2010 Deutsche Telekom and France Telecom agreed to merge their UK mobile operations into Everything Everywhere (now EE), thereby reducing the number of MNO's in the UK market from five to four.

A7.17 In 2012 Vodafone acquired Cable and Wireless' (C&W) global operations including those in the UK.[179]

A7.18 In 2015 BT agreed to acquire EE, with the merger being completed in 2016 after receiving clearance from the CMA.[180]

A7.19 Before the BT/EE merger there was an expectation that BT was going to use its own spectrum to launch its own mobile service, albeit one largely reliant for national coverage on access as an MVNO.

A7.20 Finally, in 2015 H3G agreed to acquire O2's UK mobile operation, which would have reduced the number of MNOs in the UK to three. However, this proposed merger was blocked by the European Commission in 2016.[181]

[178] WIK-Consult, *Competition & investment: An analysis of the drivers of investment and consumer welfare in mobile telecommunications*, July 2015, p.41: http://stakeholders.ofcom.org.uk/binaries/consultations/dcr_discussion/annexes/Competition_and_investment_mobile.pdf
[179] http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=2_M_6584
[180] https://www.gov.uk/cma-cases/bt-ee-merger-inquiry
[181] http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=2_M_7612

Competitive state of the market

Market shares

A7.21 In principle, market shares can be measured in a range of ways based on subscriber numbers, revenue, volume of (data) traffic etc. Most of the evidence set out below is for shares of subscribers (which is the information most easily obtained on a comparable basis across operators). We also include some evidence on shares of data traffic.

A7.22 We have not included market share comparisons in terms of revenues because of the difficulties in making such comparisons meaningful and accurate, including due to the effect of handset revenues, potential differences in accounting treatment (e.g. potential inclusion of non-mobile related revenues), and challenges in the treatment of MVNOs.

A7.23 H3G[182] and MVNOs have increased their retail market share of subscribers over the past few years, mostly at the expense of BT/EE and Vodafone.

[✂] REDACTED

A7.24 In terms of usage, we note that MVNOs tend to account for a larger share of voice minutes than data. In our Strategic Review of Digital Communications discussion document, we described how the proportion of voice minutes used by MVNO customers has not changed since 2011, at 16% of total mobile voice minutes (calculated including Tesco mobile). However, the proportion of total mobile data used by MVNO customers has fallen to 7% (from 14% in 2011). We said that this suggests that MVNO networks are more targeted at voice call markets, or that their service propositions lead to a higher proportion of such. We explained that this may be influenced by the terms available from mobile operators for MVNOs (e.g. whether 4G services are made available) or availability of high end, data focussed handsets.[183]

A7.25 The difference between the market shares in the figure above and those presented elsewhere highlights the effect of hosting MVNOs. For example, when hosted MVNOs are taken into account, O2's market share is almost on par with EE's at ca. 35%.

A7.26 The market is still relatively concentrated, particularly since the merger of T-Mobile and Orange, when the HHI for the market was ca. 1,750. After the T-Mobile and Orange merger these concentration indices increased to ca. 2,317 but the rising market share of H3G and other MVNOs have led to a decrease in concentration indicators as illustrated in the table below.

[182] In Figure A7.7 and other charts below, H3G is shown as "Three".

[183] Ofcom, Strategic Review of Digital Communications: Discussion document, 16 July 2015, paragraph 4.29, http://stakeholders.ofcom.org.uk/binaries/consultations/dcr_discussion/summary/digital-comms-review.pdf

Figure A7.8: HHI index for the UK retail mobile market[184]

	2009	2010	2011	2012	2013	2014	2015	Q1 2016	Delta 2010-Q1 2016
HHI	1,749	2,317	2,245	2,152	2,109	2,089	2,054	1,990	- 327

A7.27 As shown in Figure A7.9 below, in the pre-pay segment, Vodafone and EE have lost a significant number of subscribers since 2011. Only H3G has seen a continuous growth in the number of pre-pay subscribers.

[✂] REDACTED

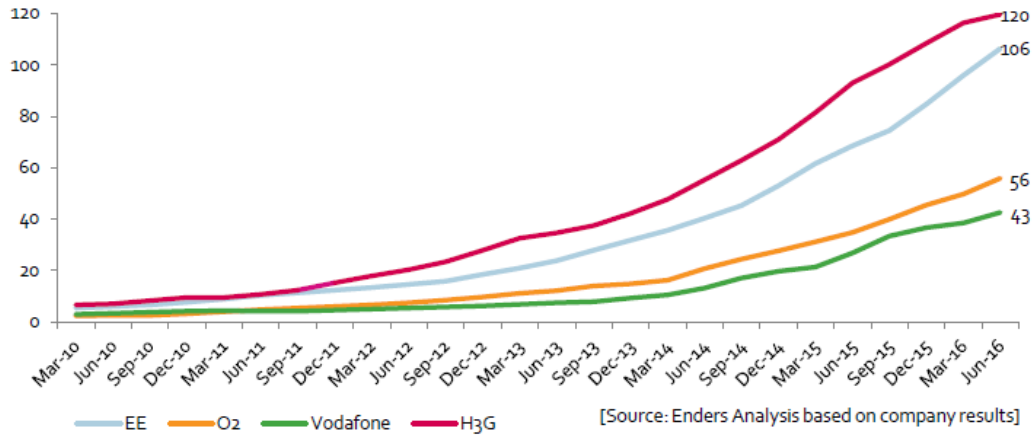
A7.28 In the post-pay segment, shares have remained relatively stable with variations of 1-3% in shares for each MNO over the last five-year period. Nonetheless, all MNOs and MVNOs who offer post-pay plans have seen significant growth in their absolute numbers of post-pay subscribers.

[✂] REDCATED

A7.29 As we discussed in our 2016 Consumer Switching consultation document[185], about 6.6 million subscribers had switched mobile phone provider in the 18 months prior to the consultation. Therefore, on average, ca. 5% of total subscribers switched mobile phone providers per year.

A7.30 The share of data carried by the networks of the four MNO is very different to their subscriber shares. As shown in Figure A7.13, H3G carries the most data (37% of total data), though its share has declined recently as its rate of growth has moderated.

Figure A7.13: Data traffic on MNOs networks (quarterly mobile data traffic, PB)



Source: Enders analysis

[184] Unlike the HHI presented in Annex 6, this table takes into account the market shares of MVNOs as well as MNOs.
[185] See paragraph 4.9 of https://ofcom-build.squiz.co.uk/__data/assets/pdf_file/0025/82636/consumer-switching-mobile-consultation.pdf

Pricing

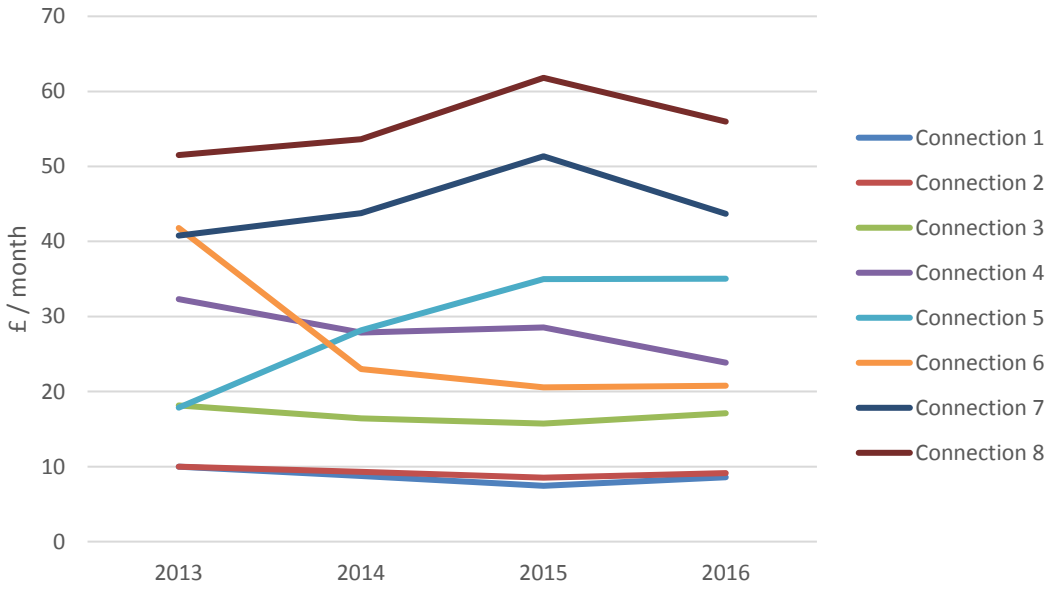
A7.31 To assess pricing trends, we have compared the tariffs of the different UK operators based on the following representative service connections, which follow the same methodology that we used in our 2015 International Communications Market Report (ICMR)[186].

Figure A7.14: Composition of service baskets

	Handset type	Outbound voice minutes per month	Outbound SMS per month	Data use per month
Connection 1	Basic	50	None	None
Connection 2	Basic	50	25	100MB
Connection 3	Intermediate	150	200	300MB
Connection 4	Intermediate	250	100	400MB
Connection 5	Premium	200	50	500MB
Connection 6	Intermediate	100	250	2GB
Connection 7	Premium	300	150	1GB
Connection 8	Premium	500	200	5GB

A7.32 Comparing the average of the best prices available from all operators for plans that include handsets, there had been a continuous decrease between 2013 and 2015 for all but connections 5, 7 and 8. However, in 2016 the high-end connections 7 and 8 had a sizeable decrease in prices while low-end connections 1, 2 and 3 as well as connections 5 and 6 showed a slight increase in prices.

Figure A7.15: Weighted average of best prices available from all operators



[186] See http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr15/icmr15/icmr_2015.pdf for a detailed explanation of the determination of the baskets

Source: Ofcom, using data supplied by Teligen

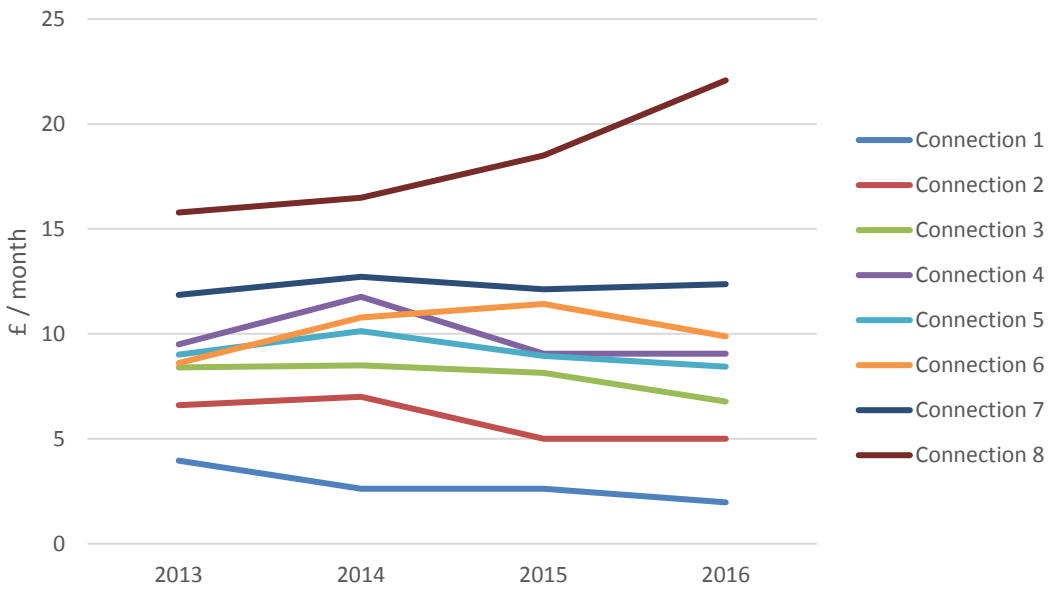
Note: Nominal prices

A7.33 It is likely that this increase in tariffs over the 2013-2015 period was a reflection of the increase in the price of premium handsets as well as the additional cost on 4G packages shortly after they were launched. In the figure above, the connections that have increased in prices over this period were 5, 7 and 8, all of which have premium handsets. Of the connections with an intermediate or basic handset only connection four marginally increased in price over that period. Nonetheless, over the past year the connections with premium handsets have decreased in price or had marginal increases (connection 5).

A7.34 In order to isolate the effect of handset prices from mobile service pricing, we have also looked at the lowest available stand-alone tariff for SIM-only plans. Over the past year only connections 7 and 8 have increased in price, with other connection types either decreasing or remaining stable. Connection 8 is the only type which has increased continuously over the 2013-2016 period.

A7.35 Over the 2013-2016 period connections 1, 2, 3, 4 and 5 have had an overall decrease in prices of 50%, 24%, 19%, 5% and 6% respectively. On the other hand, over this same period connections 6, 7 and 8 have increased in price by 15%, 4% and 40% respectively.

Figure A7.16: 'Lowest available' stand-alone mobile pricing (SIM-only)

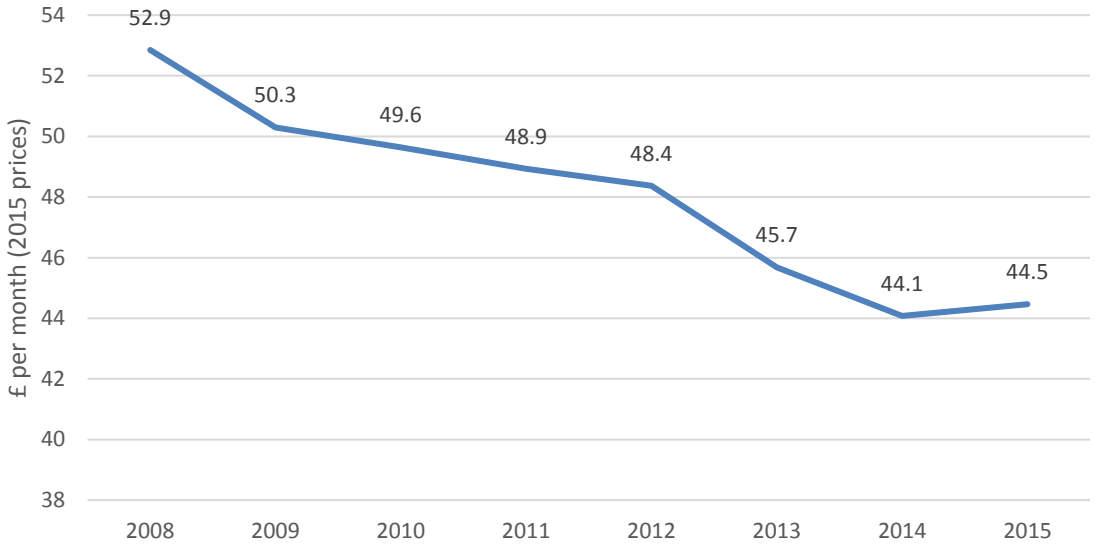


Source: Ofcom, using data supplied by Teligen

Note: Nominal prices

A7.36 Average monthly spend on mobile services had decreased continuously until 2014. In 2015 there was an increase in household spend on mobile of ca. £0.40 per month.

Figure A7.17: Average monthly spend on mobile services



Source: Ofcom CMR 2016

A7.37 For large data users, we have compared the size and price of the largest mobile data packages offered currently. We have done this for SIM-only offers, to avoid difficulties in comparing different handsets.

A7.38 Figure A7.18 shows the packages offered in mid-September 2016. We recognise that offers change frequently, and that some of the tariffs included in this table were time-limited promotional offers. Figure A7.18 therefore only provides a snap shot of tariffs available at a particular point in time, and is not necessarily representative of what operators offer at other times.

Figure A7.18: Largest data packages, SIM only post-pay offers, September 2016

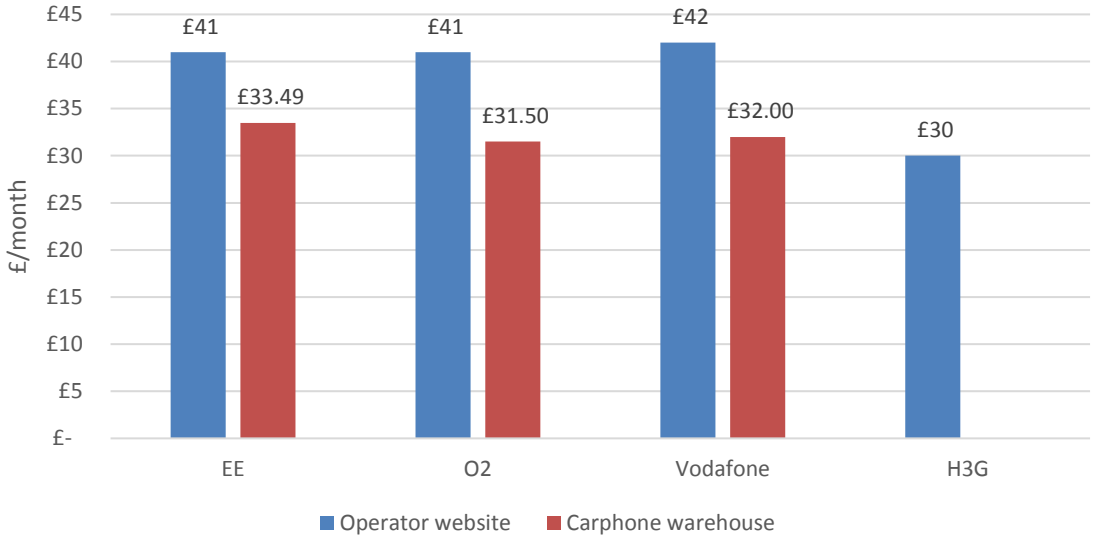
Operator	Monthly charge	Data (GB per month)	Minutes	Texts
H3G	£33	Unlimited	Unlimited	Unlimited
H3G	£28	Unlimited	600	Unlimited
H3G *	£24	30	Unlimited	Unlimited
H3G	£27	12	Unlimited	Unlimited
Vodafone *	£25	25	Unlimited	Unlimited
Vodafone *	£20	20	Unlimited	Unlimited
Tesco mobile	£30	20	750	5000
EE	£34.99	16	Unlimited	Unlimited
O2 *	£28.90	16	Unlimited	Unlimited
BT	£25	15	Unlimited	Unlimited
Virgin media	£23	10	5000	Unlimited
iD	£25	10	2000	5000

Notes: Largest SIM-only data packages offered in mid-September 2016. We do not describe all aspects of the different packages and may not have shown all large SIM-only packages available. Packages are mostly for a 12-month contract (shorter contracts generally being more expensive).
** indicates a promotional offer, and may only have been available for a short period*

A7.39 While some other operators have previously offered unlimited data plans, we understand that only H3G still offers unlimited SIM-only post pay packages.[187]

A7.40 Figure A7.18 also shows that H3G prices for large data packages are competitive relative to other operators. This is also consistent what Enders Analysis publishes on pricing for what it describes as the 'sweet spot' bundle with the iPhone 6s.[188] As of June 2016 H3G was offering the price for this package of all MNOs, including resale through Carphone Warehouse.[189]

Figure A7.19: 'Sweet spot' iPhone 6S pricing

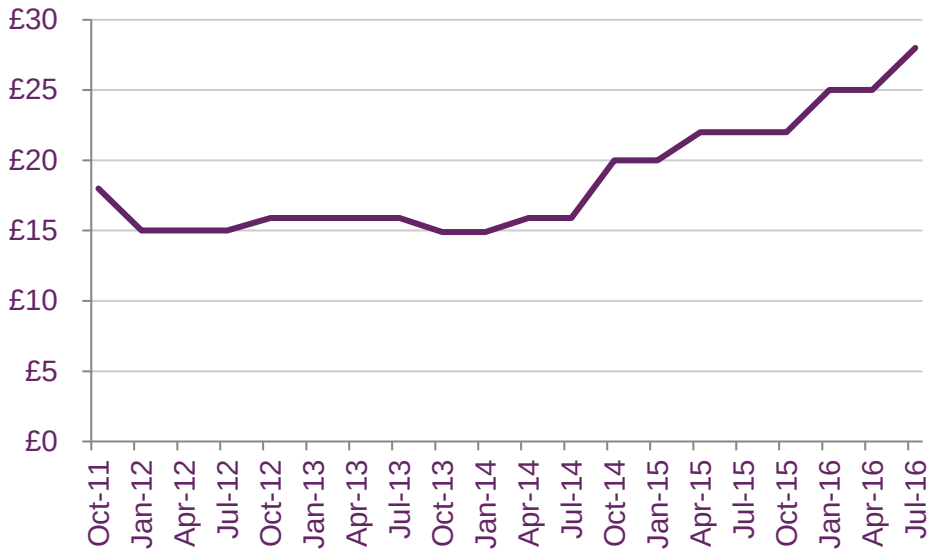


Source: Enders analysis

A7.41 Despite still pricing competitively relative to other MNOs, H3G has increased its prices for some large data packages considerably over the last couple of years. This increase is illustrated in Figure A7.20 below, which shows the price for one unlimited data package offered by H3G.

Figure A7.20: H3G's SIM-only unlimited data, 600 minutes, 12 month contract

[187] We note that some pre-pay tariffs are similar in form to post pay tariffs and that Giffgaff (owned by O2) offers unlimited data plans for £20 per month on a prepay basis. However, this package is not comparable to the ones in Figure A7.18 as the speed the subscriber receives is reduced to 256 kbps from 8am to midnight after the subscriber reach 6 GB.
[188] 24 month contract with at least 1GB of data, unlimited texts and 2,000 minutes or more per month. One-off handset fee under £100 and 16GB iPhone 6S as handset.
[189] From UK Mobile Market Q2 2016, Enders Analysis, 5 September 2016



Source: Pure pricing

A7.42 While increasing prices for its large data packages, H3G has significantly reduced its pre-pay prices. Figure A7.21 below shows the prices before and after H3G's launch of its '321' pre-pay plan in July 2013. Before this, prices per minute, text and MB had been constant for some time, and have been constant at the reduced prices since July 2013.

Figure A7.21: H3G's pre pay prices

	Before July 2013	Since July 2013
Voice (ppm)	26p	3p
Text	11p	2p
Data (p per MB)	11p	1p

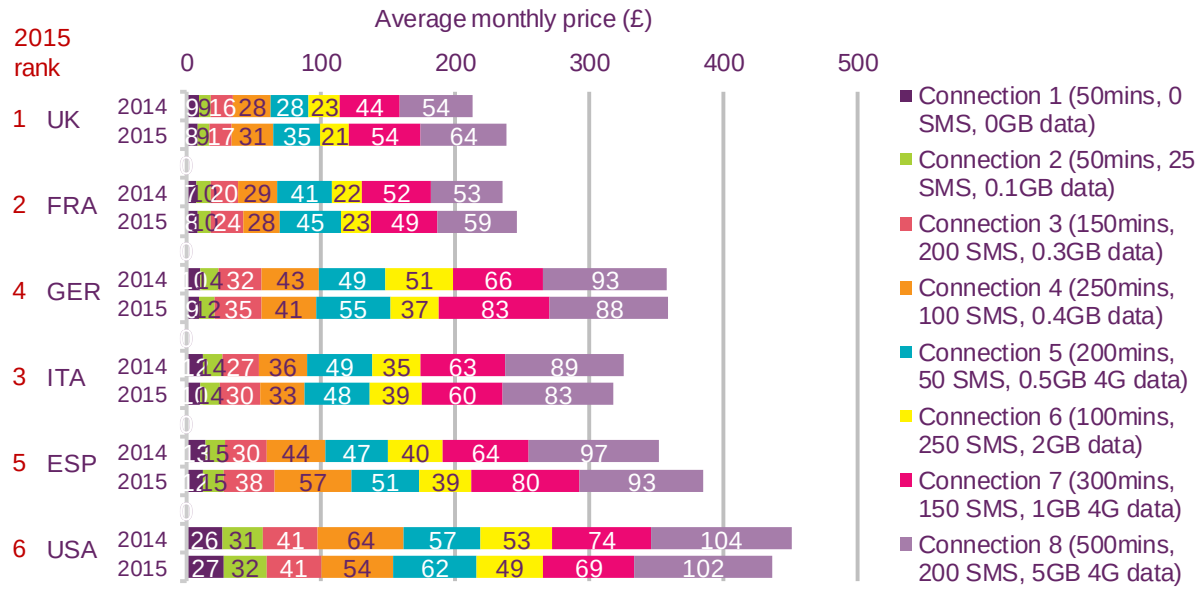
Source: Pure pricing

A7.43 As shown in Figures A7.10 and A7.11 earlier, H3G's market share as well as total number of pre-pay subscribers has grown in recent years, presumably as a result of this reduction in prices.

A7.44 An international comparison of the UK's mobile pricing[190] with other large EU countries and the USA showed that, in 2014 and 2015, the UK had the lowest total 'weighted average' stand-alone price for the eight mobile connections. However, France and the UK, as well as Spain, experienced an increase in this indicator between 2014 and 2015. Nonetheless, the UK's 'weighted average' stand-alone price is still significantly below that of most other comparator countries for which we have data.

[190] As per Ofcom's 2015 ICMR

Figure A7.22: 'Weighted average' stand-alone mobile pricing

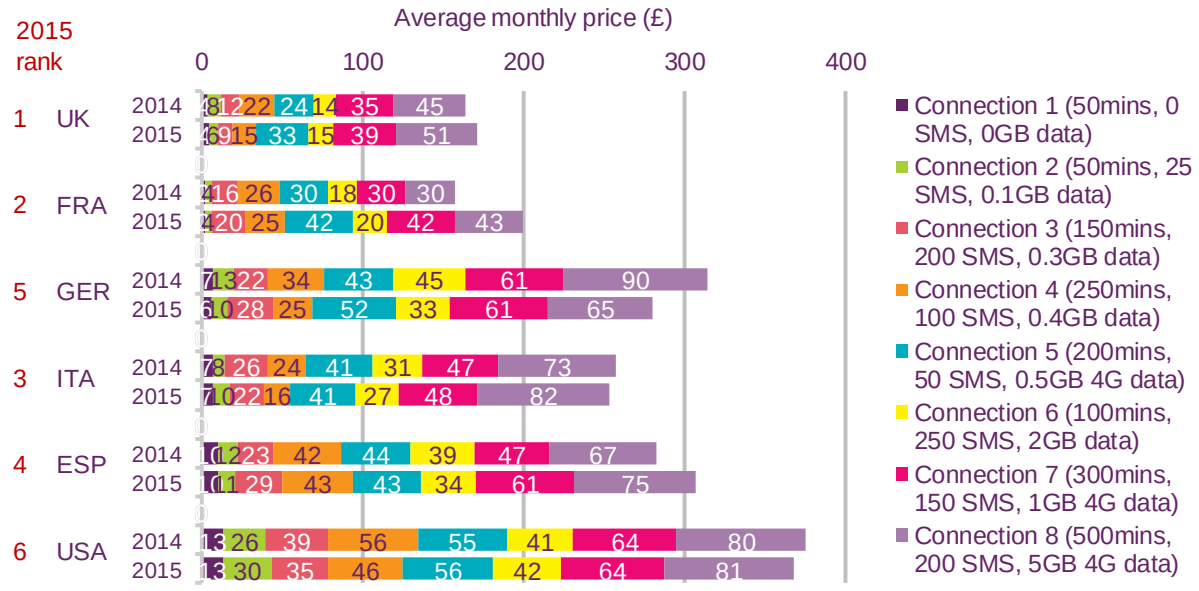


Source: Ofcom using data supplied by Teligen

Note: 'Weighted average' of best-value tariff from each of the largest operators by market share in each country; July 2014 and July 2015; PPP adjusted.

A7.45 Furthermore, in 2015 the UK had the lowest total 'lowest available' stand-alone prices for eight representative mobile baskets while it had the second lowest in 2014.

Figure A7:23: 'Lowest available' stand-alone mobile pricing



Source: Ofcom using data supplied by Teligen

Note: July 2014 and July 2015; PPP adjusted.

A7.46 In our 2015 ICMR report we also found that UK users of 4G services had the highest satisfaction with the price paid for the mobile services among our comparator countries. 81% of the UK subscribers were satisfied with the price,

followed by the USA with 76% and Italy with 75%, while only 46% of subscribers in Sweden were satisfied with the price[191] .

A7.47 The Mobile Broadband Prices in Europe 2016 report, recently published by the EC, compares mobile broadband prices across the EU's member states as well as non-EU countries including the USA, Japan, South Korea, Norway, Iceland and Turkey[192]. The report compares handset mobile broadband price plans as well as those for tablets and laptops.

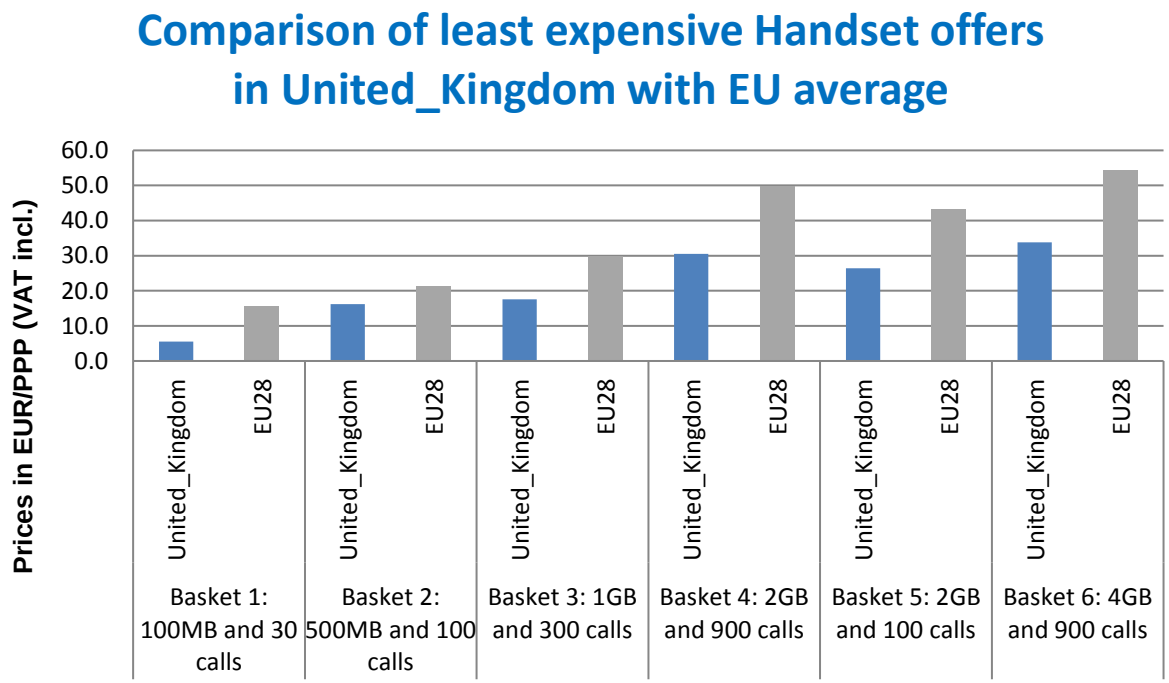
A7.48 The approach used for this report was the 2012 OECD methodology for mobile broadband which calculates the total price of different baskets in order to identify the cheapest offers. It divides the offers into three types of mobile devices (handsets, tablets and laptops) and six usage baskets for each type of device.

A7.49 The baskets used in the report have relatively low usage allowances. For example, the lowest basket for handset use included 100MB of data plus 30 calls, while the highest basket included 4GB of data and 900 calls. Laptop allowances ranged from 500MB and 20GB and for tablet between 250MB and 10GB.

A7.50 The report finds that the UK performs well compared to other EU countries with regards to handset plans. The UK is in the cluster of countries with the cheapest plans for all but the second basket, where it is in the second cheapest cluster (of four clusters).

A7.51 Compared to the average of the 28 EU member countries, the UK handset plan prices are between 24%-64% cheaper.

Figure A7.24. Comparison of the least expensive handset offers UK vs. EU average



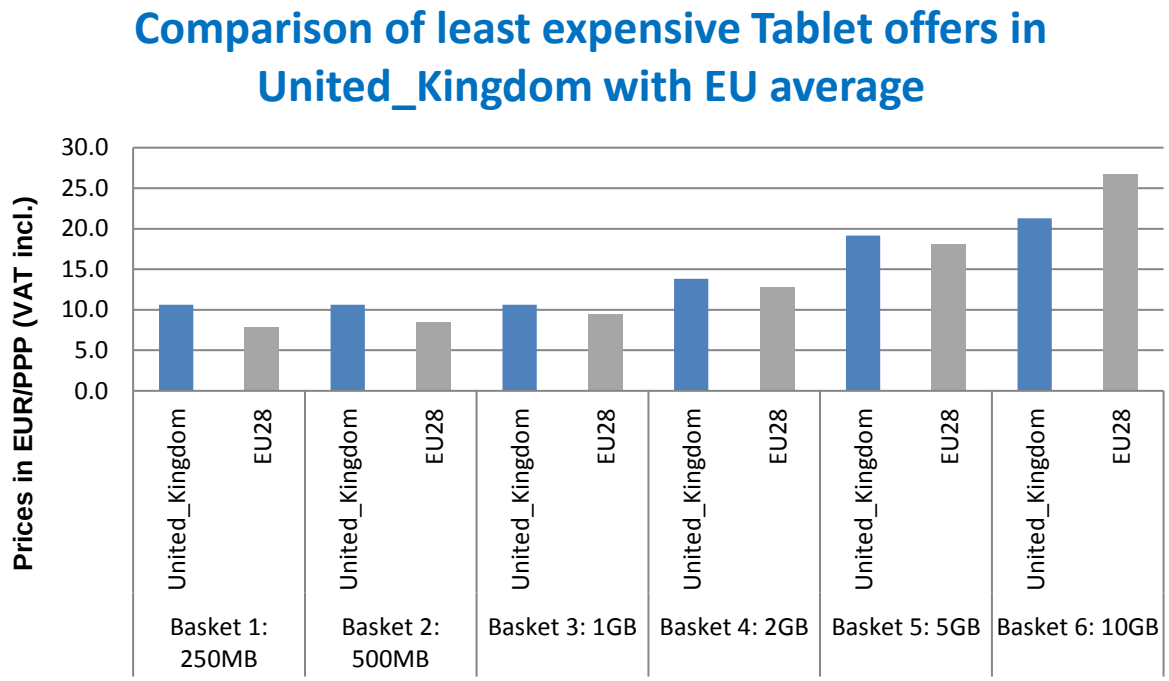
[191] See figure 1.37 of 2015 ICMR
[192] See https://ec.europa.eu/digital-single-market/en/news/mobile-broadband-prices-europe-2016

Source: EC Mobile Broadband Prices in Europe 2016 report – Simulation tool[193]

A7.52 With regards to laptop and tablet plans the UK is in the fourth cluster with the most expensive countries for the baskets with data allowances between 256MB and 512MB, in the third cluster for baskets with data allowances between 1GB and 5GB and in the second cluster (i.e. second cheapest) for allowances between 10GB and 20GB.

A7.53 For tablet plans, the UK is up to 35% more expensive than the EU average for all baskets except for basket 6, which is 20% cheaper.

Figure A7.25. Comparison of the least expensive tablet offers UK vs. EU average

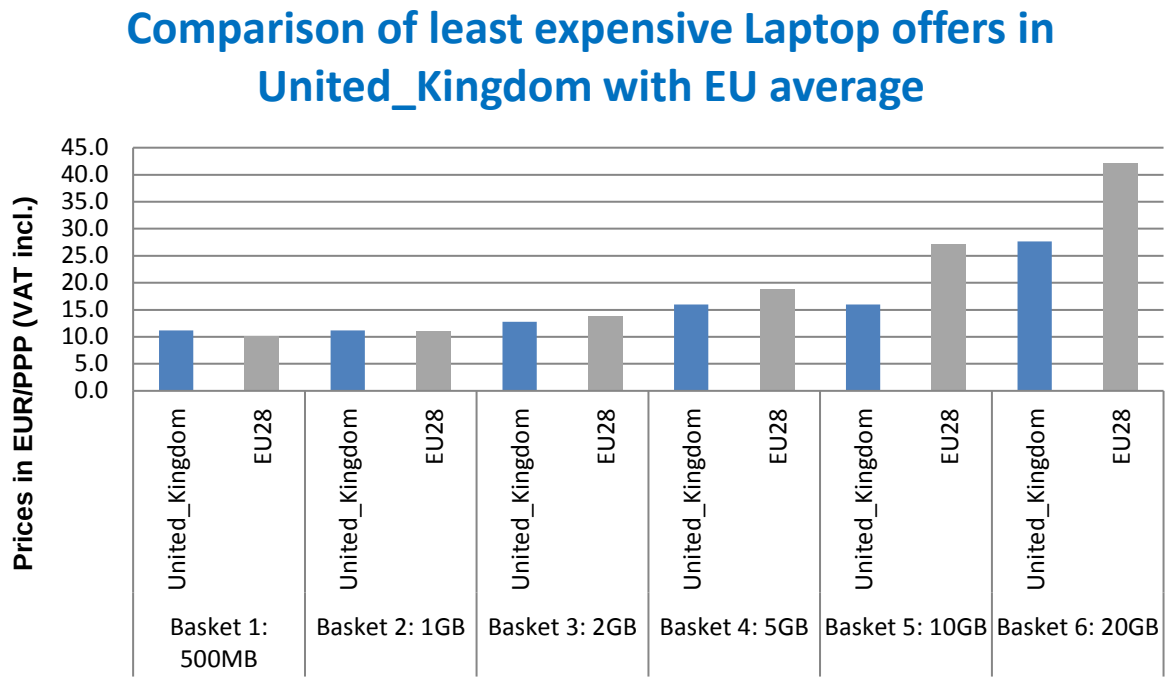


Source: EC Mobile Broadband Prices in Europe 2016 report – Simulation tool

A7.54 The UK's laptop plans are more expensive for the two baskets with the lowest allowance (between 2%-11%) but cheaper for the other four (between 7%-41%).

[193] See http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=18584

Figure A7.26. Comparison of the least expensive laptop offers UK vs. EU average



Source: EC Mobile Broadband Prices in Europe 2016 report – Simulation tool

A7.55 The report also found that, compared to 2015, prices of UK handset plans have increased by an average of 4% between 2015 and 2016 compared to a 7% decrease on average across EU member countries.

A7.56 Tablet and laptop plans with low data allowances also increased significantly, with 256MB price plans almost doubling and 512MB and 1GB plans increasing by almost a third between 2015 and 2016. However, higher usage plans had price decreases of 7% on average over the same period. Across the EU prices of tablet and laptop plans decreased on average by 3%.

A7.57 The report also compares the proportion of income spent on each of the devices between the different EU countries. It finds that handset plans in the UK are among the cheapest in EU when compared to income. Tablet plans are just above the EU average while laptop plans are below the average.

A7.58 According to the report H3G and Vodafone offer the cheapest mobile broadband plans with some significant differences compared to EE. It also found that Vodafone offers the best handset-based plans and it's also the cheapest for laptop plans, except for 20GB where H3G and EE are cheaper. However, it should be noted that the report did not include O2 in the analysis.

A7.59 Compared with other non-EU countries, the EU's average handset plans are comparable to those of the USA with other countries and baskets being between 18% cheaper and 14% more expensive than the EU average.

A7.60 For laptop and tablet plans the EU is the cheapest for the baskets with low data allowance but South Korea is cheaper for the plans with higher allowances.

Revenues

A7.61 There are differences in the average retail revenue per subscriber between the different operators.

[✂] REDACTED

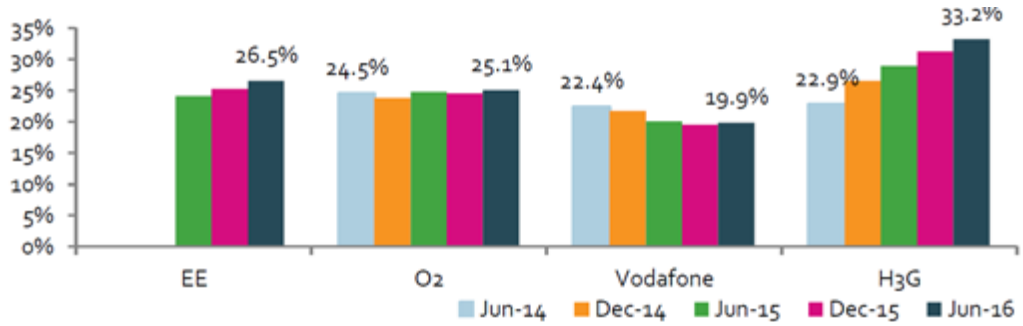
A7.62 Average post-pay retail revenue per customer trends are different between the different operators. The average revenues of EE have remained largely stable at just under £ [✂] REDACTED per month, on average. On the other hand, the average revenues of the other operators have decreased over time. For H3G, whilst there has been an overall decline in average revenue per post-pay customer over the period, it increased between 2013 and 2015 by [✂] REDACTED and then again for Q1 2016 [✂]REDACTED. Despite these increases and the continued decrease in average revenues of its competitors, H3G's average revenue per post-pay subscriber remains as the lowest of all MNOs.

[✂] REDACTED

A7.63 Overall, average monthly retail revenue for both prepaid and post-paid customers has continued to decrease with a CAGR of -4.7% for post-paid and -5.3% for pre-paid over the last five years.[194]

A7.64 The overall increase in revenues per customer by H3G is likely to have contributed to its recent improved EBITDA margin. Enders Analysis reports that H3G's EBITDA margin is on target to be the highest among the UK's four MNOs.

Figure A7.29: EBITDA margin by operator last 12 months



Source: Enders analysis

Additional competition considerations

A7.65 One important consideration in the state of competition in the UK mobile sector is the presence of large independent specialist retailers such as Carphone Warehouse and the now defunct Phones 4U. These have played an important role in retail sales of UK mobile services. High street retail is still responsible for around 60% of post pay handset sales and 90% of pre-pay handset sales, and the last remaining large specialist independent retailer in the UK, Carphone Warehouse has a significant share of those handset sales.[195]

[194] Source: Ofcom CMR 2016
[195] Source: Enders Analysis, UK mobile user survey 2014, January 2015, page 32.

A7.66 It is also worth noting that, in terms of wholesale access competition, at present all MNOs host MVNO operators. For example, EE hosts Virgin Mobile, O2 hosts Talk Talk, Vodafone hosts Lebara and H3G hosts iD.

A7.67 Nonetheless, as presented previously in this annex, Virgin and Tesco have thus far been the only MVNOs which has been able to acquire a subscriber market share of more than 3% of the retail market.

A7.68 There has also been continued innovation in the UK market. This has included innovations by the smallest MNO, H3G, which was also the last MNO to enter the market. For example, some of the innovations that H3G introduced included being the first operator to offer All You Can Eat data plans, to scrap roaming charges for certain locations and to offer free calls to 0800 numbers from mobiles.

A7.69 Nonetheless, innovations have not been limited to H3G. For example, to name a few, Vodafone launched the "Rural Open Sure Signal programme", which provided 100 rural communities in the UK with 3G coverage for the first time and rolled out High Definition voice in 2014[196]. EE has introduced services which emphasise data security (in conjunction with MobileIron) and launched EE connect, which offers a platform for M2M services[197]. O2 offers benefits to their subscribers through their Priority programme including access to concert ticket presale and discounts in selected shops and restaurants. Furthermore, O2 was the first MNO to launch a plan whereby users could upgrade their handsets early if they so wished (O2 Refresh).

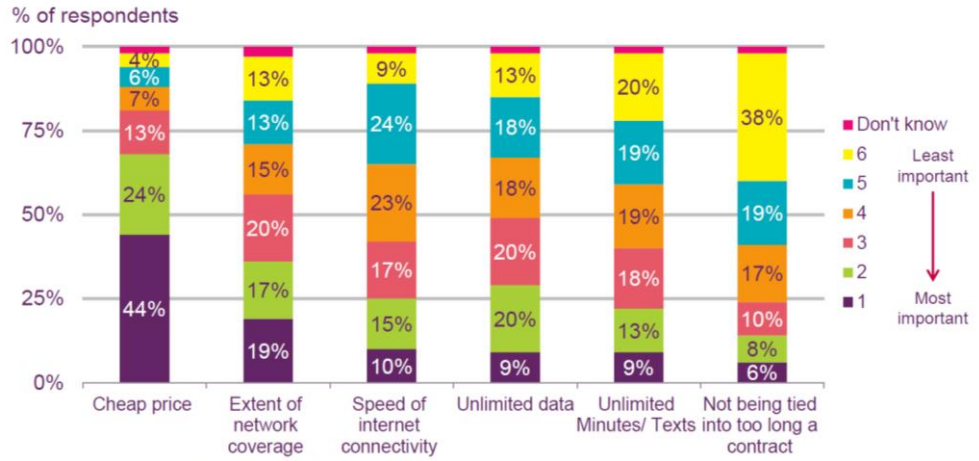
Performance and quality of UK mobile networks

A7.70 Network performance is one of the factors that a consumer is likely to take into account when choosing a mobile phone service. Other factors include price, customer service, handset choice and contract terms.

A7.71 Figure A7.30 below shows the importance of different factors in consumers' decision on whether to take up a 4G plan. Price is most frequently reported as the most important factor. Other factors include coverage, speed and contract terms. This seems consistent with network performance being an important factor in consumers' choices, even if it is not necessarily the most important factor.

[196] Source: http://www.vodafone.co.uk/about-us/company-history/
[197] Source: http://ee.co.uk/business/large/innovation

Figure A7.30: Importance of factors when deciding to take up a 4G plan[198]



Source: YouGov, 4G tariffs 22-28 May 2015
Base: Online UK adults 16+ who do not currently have 4G (388)
Q40. Which of these would be most important when deciding which 4G plan to take up? Please put in rank order of 1-6 where 1 = most important and 6 = least important.

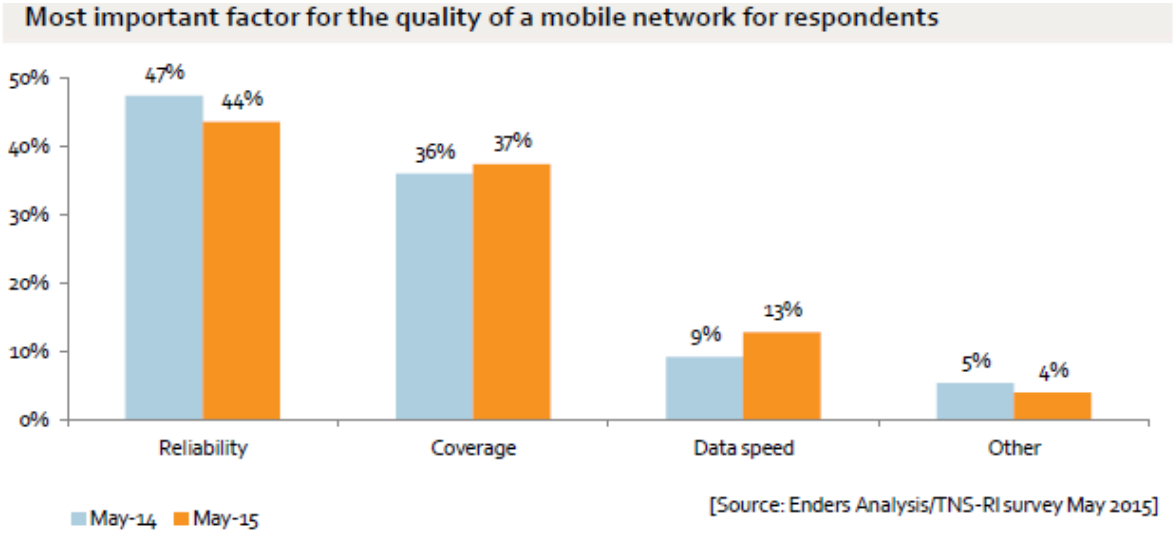
A7.72 In assessing the proposed merger of O2 and H3G, the EC investigated the relative importance of different parameters of competition in the retail mobile market, drawing on various sources, included a survey of retail customers. It found that while price is a primary parameter of competition (in particular as regards data allowances), network performance related criteria were second in terms of importance.[199]

A7.73 Network performance or network quality is a broad concept, which includes several aspects valued by consumers such as network reliability, network coverage, download and upload speeds, latency, jitter, webpage browsing times, call quality and call success rate, etc. These metrics are not just related to the performance of the radio access network but also depend on the performance of the core and backhaul networks as well as other aspects. For example, web browsing times depend on download speeds as well as how quickly the network can identify the location of the website. Some of these parameters are also interrelated. Both coverage (network availability) and download speed for instance are important for consumers to qualify a network as "reliable".

A7.74 In May 2015, Enders Analysis reported that reliability is still the most important factor for consumers when considering the quality of a mobile network, followed by coverage and data speed. Compared to results from previous year though, reliability has decreased in importance from 47% to 44% of respondents whereas data speed has increased from 9% to 13%.

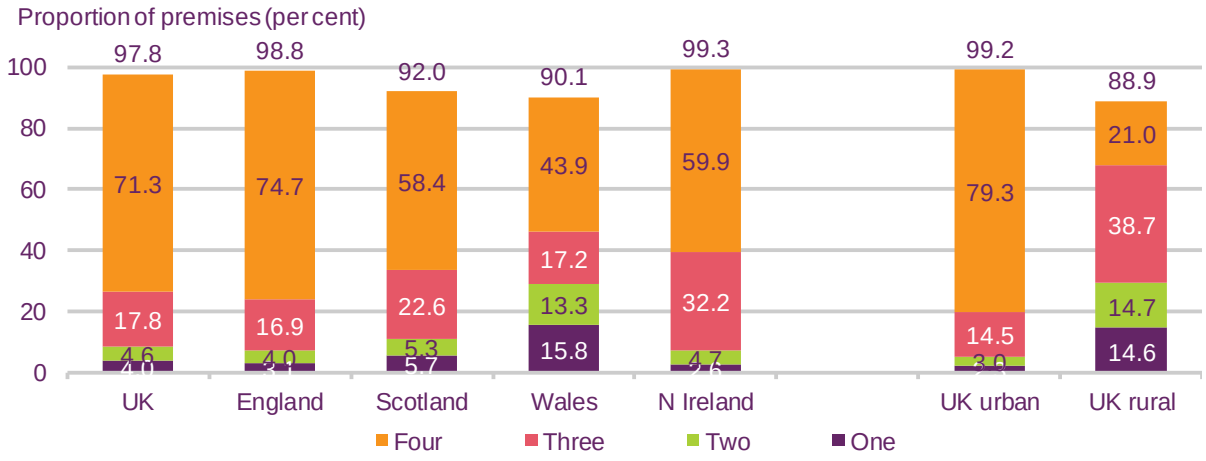
[198] Reproduced from Figure 4.7 of the Ofcom's 2015 Communications Market Report, http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr15/CMR_UK_2015.pdf
[199] See from recital 214, EC Decision of 11 May 2016 declaring a concentration to be incompatible with the internal market (Case M.7612 - HUTCHISON 3G UK / TELEFONICA UK), http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=2_M_7612

Figure A7.31: Enders Analysis - network quality according to consumers



A7.75 In relation to network coverage, Ofcom data reports that by May 2016, 97.8% of UK premises were in areas with outdoor 4G coverage, with 71.3% benefitting from similar coverage from all four mobile network operators and fewer than 10% of premises being covered by one or two operators. Coverage varied significantly between urban and rural areas of the UK, with 99.2 % of premises in urban UK areas having outdoor 4G coverage, and 79.3% covered by all four operators compared to 88.9% of rural premises having outdoor 4G coverage from at least one operator, and just 21.0% having coverage from all four operators.[200]

Figure A7.32: Outdoor 4G premises mobile coverage, by number of operators



Source: Ofcom / operators, May 2016 data

Note: Coverage is based on 100m2 pixels covering the UK

A7.76 In terms of geographic coverage of land area, voice coverage in June 2015 ranged between 68% and 78%, with data coverage being as low as 47% for O2 while EE, with 75%, had the highest geographic data coverage.

[200] Source: Ofcom CMR 2016

Figure A7.33: UK coverage for mobile voice services, based on combined 2G and 3G coverage[201]

	O_2	Vodafone	EE	Three
Outdoor coverage				
Premises	98%	98%	99%	98%
Geographic	72%	77%	78%	68%
Indoor/In-car* coverage				
Premises	93%	92%	94%	93%
Motorways	97%	97%	99%	98%
A & B Roads	67%	73%	81%	73%

** For in-car coverage we assume that the phone is used within the vehicle. Coverage would be better if a car kit with an external antenna were used.*

Source: Ofcom analysis of operator data

Figure A7.34: UK coverage for mobile data services, based on combined 3G and 4G coverage[202]

	O2	Vodafone	EE	Three
Outdoor coverage				
Premises	92%	92%	98%	98%
Geographic	47%	49%	75%	68%
Indoor/In-car* coverage				
Premises	86%	83%	94%	93%
Motorways	83%	83%	99%	98%
A & B Roads	49%	48%	79%	73%

** For in-car coverage we assume that the phone is used within the vehicle. Coverage would be better if a car kit with an external antenna were used.*

Source: Ofcom analysis of operator data

A7.77 There are a number of studies regularly performed and occasionally published which measure the performance of UK mobile networks with specific focus on mobile broadband and smartphone performance. These include Ofcom's Smartphone cities study published in March 2016[203], Rootmetrics biannual report[204] and OOkla speed tests.[205] UK MNOs also rely on consumer surveys to understand how the services offered on their network are perceived by consumers. The YouGov survey SMIX (Smartphone, Mobile Internet eXperience) is one of such examples.[206]

[201] Reproduced from Figure 20 of Ofcom's Connected Nations 2015 report, http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2015/downloads/connected_nations2015.pdf
[202] Reproduced from Figure 21 of Ofcom's Connected Nations 2015 report.
[203] Ofcom, "Smartphone cities", March 2016, http://stakeholders.ofcom.org.uk/binaries/research/broadband-research/smartphone-cities/smartphone_cities.pdf
[204] Rootmetrics, "Mobile Network Performance in the UK: A Special Report", September 2016 http://www.rootmetrics.com/en-GB/content/mobile-network-performance-in-the-uk
[205] http://www.speedtest.net/awards/gb/carrier/2015
[206] https://reports.yougov.com/services/smix/

A7.78 Measuring network performance is not a straightforward exercise and, as recognised by those performing such tests, each methodology is likely to have limitations. However, results can provide an indication of the likely customers' experience on mobile networks.

A7.79 The latest Rootmetrics research published on 1 September 2016 rates MNOs across 6 performance categories: overall performance, reliability, speed, data, call and text performance. The test looks at performance across the breadth of the UK, in each of the four nations, and within the 16 most populous metro areas. As shown in Figure A7.35 below, EE is found to outperform all other MNOs in each of the six test categories winning the UK Overall RootScore Award for the sixth consecutive time, i.e. for three consecutive years as the tests are run every half year.

Figure A7.35: Rootmetrics results in % for first half of 2016

	BT/EE	O2	H3G	Vodafone
Overall	92.1	77.7	85.3	81.3
Reliability	93.5	78.1	90.0	82.0
Speed	89.9	76.9	74.8	79.4
Data	93.5	77.8	87.2	80.9
Call	89.7	76.0	81.7	80.4
Text	96.3	90.6	92.3	93.1

Source: Rootmetrics

A7.80 O2's results across the UK-wide testing were similar to what was found in the second half of 2015. O2's rankings remained identical in the categories of overall performance, reliability, speed, and data performance with the exception of text and calls where O2's rankings decreased from second in the previous round of testing to fourth in the first half of 2016. It was also found that if O2 expands its 4G services beyond metropolitan areas, O2's performance could show improvement at the UK and nation levels.

A7.81 H3G, which was awarded the Network Reliability RootScore award at the end of 2015 ranked second in the same category. According to Rootmetrics, the change in rank does not necessarily mean that H3G's reliability results at the UK-wide level were worse than those from second-half 2015 testing. Rather, EE's reliability performance improved while that of H3G remained consistent across both test periods. H3G finished generally strong in the UK-wide testing, ranking second in the categories of overall performance, network reliability, data performance, call performance, and text performance. Rootmetrics reports that while H3G ranked fourth in the network speed category, H3G has been relatively slow to deploy its 4G network across the UK. If H3G expands its 4G services, its speeds could improve and the operator's strong results in our UK-wide testing could get even stronger.

A7.82 Consistently with previous results, Vodafone ranks third in the categories of overall performance, network reliability and data performance. It has however improved its call and text results at the metro level and UK-wide testing, e.g. in the call performance category it improved from fourth into a two-way tie with H3G in second place. In the network speed category, Vodafone ranks second behind EE for the third consecutive test period. Rootmetrics is of the view that as Vodafone continues to expand its 4G presence across the UK, Vodafone could soon narrow the gap with the best performers.

A7.83 The Smartphone cities report from Ofcom tested the performance of 4G and 3G networks of the four MNOs in November-December 2015 in five cities across the UK: Cardiff, Edinburgh, Liverpool, London and Norwich.

A7.84 The overall performance is shown in Figure A7.36 where EE achieved the fastest average download speeds, at 20Mbit/s on average across all five cities. There are very small differences in relation to average web browsing speeds across the four MNOs but the proportion of successful downloading varies from 91% (O2) to 98% (EE).

Figure A7.36: Smartphone cities report scorecard

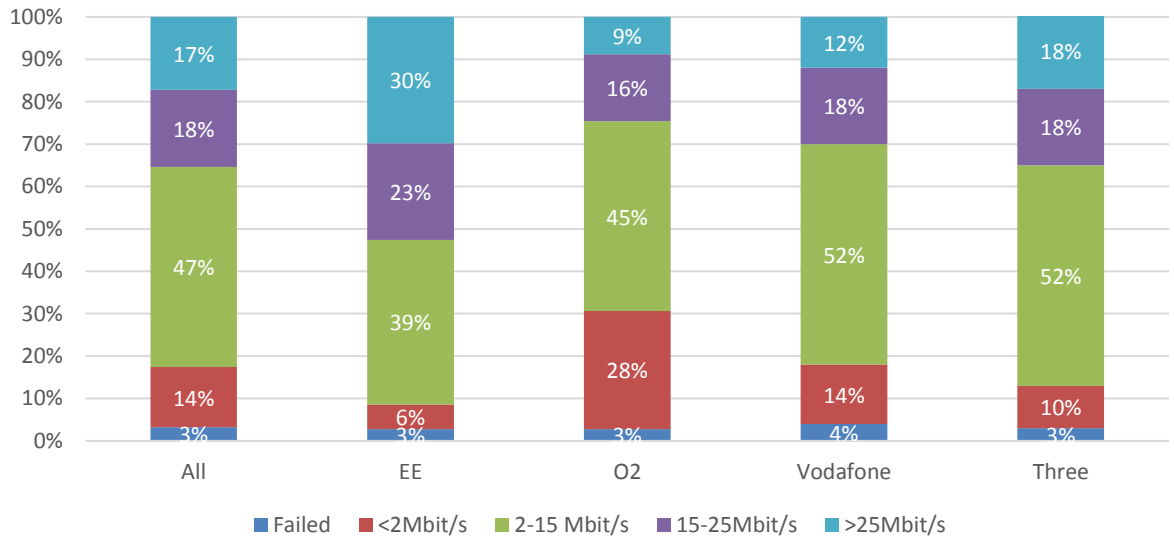
	Web browsing speed		Download speed	
	Average speed	Successful loading	Average speed	Speeds over 2Mbit/s
EE	5 seconds	98%	20Mbit/s	92%
O2	6 seconds	89%	10Mbit/s	69%
Three	6 seconds	95%	15Mbit/s	87%
Vodafone	6 seconds	91%	12Mbit/s	82%

Source: Ofcom mobile broadband measurements, fieldwork November and December 2015.
Note: Average (mean) of all tests gathered, with 4G as the best bearer.

A7.85 An average speed metric will indicate how fast a service is on average, but it does not reveal how frequently that service fails. In order to gauge the consistency of a mobile network's performance, the report looked at the distribution of results, displayed in Figure A7.37 below.

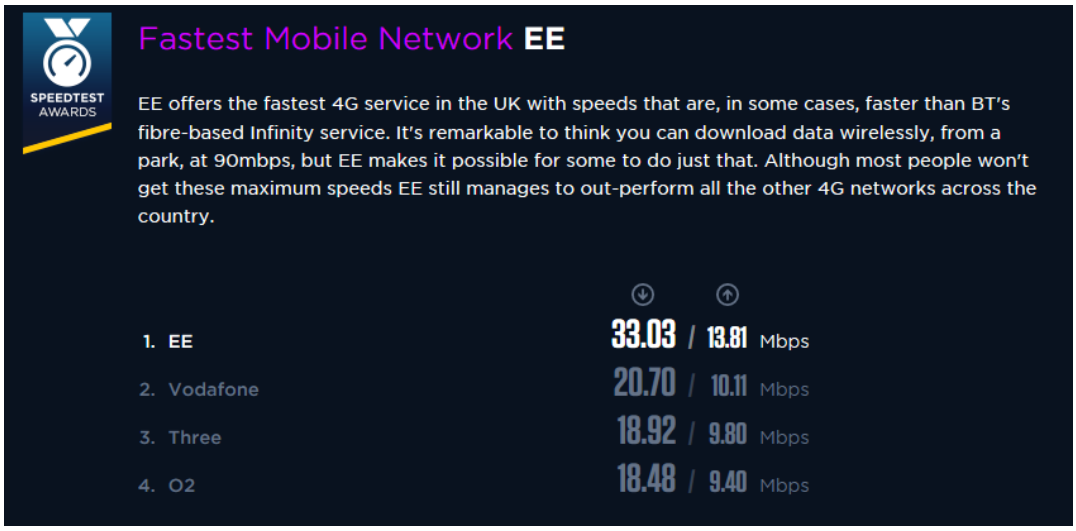
A7.86 The proportion of downloads with speeds of >2Mbit/s varied significantly across operators, accounting for 92% of downloads attempted on EE's network – the highest proportion of all operators. In contrast, O2 had the lowest proportion of test samples with speeds of over 2Mbit/s, at 69% across all cities.

Figure A7.37: Smartphone cities report - 4G speeds



A7.87 Somewhat consistently with all the other performance tests, the OOkla tests also show that EE is the fastest UK network.[207] The results published on the OOkla website are shown in the figure below.

Figure A7.38: OOkla test results



A7.88 Recent tests performed by TwinPrime in the US, Europe and India show that even though average 4G data speeds in highly dense urban areas in the US are decreasing, network response times have improved by 20% and retransmit rates are much lower (0% in many cities), improving overall network experience. [208] [209] For example, New York has fallen from first place to seventh in the US metropolitan rankings for LTE speeds, compared to the previous six months. Network quality (referring to network response times and retransmission ratio as proxy for packet loss), in TwinPrime's view however is getting better. The research also shows that EE is the best performing carrier in terms of LTE speeds in England. It is unclear whether this refers to England only or the overall UK.

A7.89 Somewhat in line with the above findings, London has the best 4G coverage in the UK but also the slowest speeds, according to the latest OpenSignal report.[210]

A7.90 All performance tests consistently show EE achieving the highest average 4G speed. In general, however, there is not a predetermined download speed below which customers experience a poor service. Typically, it depends on the type of service they are requesting from the network. There may be certain download

[207] We note that, differently from Rootmetrics which plans the tests and collect samples to provide a consistent and reliable picture of the UK network performance during the busiest hour in the network, OOkla tests are generated by collecting users' tests, randomly performed by users across the country. There is therefore lower control of the location and time of these tests.
[208] TwinPrime, State of Mobile Performance, H1 2016 edition, available at http://go.twinprime.com/p/resources/state-of-mobile-performance-2016h1?gclid=CO-k2qSvyM8CFYgYGwodmBAA2Q
[209] Network response time is the time it takes for the device to establish a connection. Retransmit rate is the ratio of bytes retransmitted due to packet loss or other network quality issues, against the total bytes transferred over the network. It is a close approximation of packet loss.
[210] OpenSignal App, State of UK Mobile networks, April 2016, https://opensignal.com/reports/2016/10/uk/state-of-the-mobile-network/?report=2016/09/uk/state-of-the-mobile-network/

speeds below which customers perceive that the service is not acceptable, and certain download speeds above which the service is perceived as good.

A7.91 As noted above, having the fastest speed does not necessarily mean offering the best customer experience. That typically depends on a number of factors. The importance of speed may increase in the future although the extent of any potential increase remains uncertain. Speeds matter to the extent that they significantly improve the customer's experience. For example, in the past switching from 2G-based technologies which offer up to a few hundred kbps to speeds of the order of Mbps offered by 3G+ and 4G networks was a substantial improvement of customer experience. It is possible that in the future customers will value increased speeds more than they currently do.

Annex 8

Additional analysis

Introduction

A8.1 This annex presents supporting analysis for a few specific issues that we draw on in the main text. It sets out:

- Shares of spectrum when only considering downlink spectrum.
- How we might approach setting the level of a threshold price for competition measures.
- Ways in which MNOs can add capacity in the future.

Downlink spectrum

A8.2 There is an argument that as downlink traffic is much greater than uplink traffic the amount of spectrum available for downlink is most relevant for adding capacity. We have therefore considered the current distribution of downlink spectrum. To do this, we have assumed that the ratio of downlink/uplink for TDD spectrum was 3:1[211], which means that we have counted 75% of TDD spectrum as being for downlink. We include 50% of paired (FDD) spectrum and 100% of SDL spectrum.

A8.3 In Figure A8.1 below, we show the current holdings and future availability of downlink spectrum. The shares of spectrum for the different MNOs in terms of downlink spectrum are broadly similar to that shown in section 3 when we consider total spectrum (including downlink and uplink), though there are some differences. The 2.3 GHz and 3.4 GHz spectrum represent a larger share of the total available downlink spectrum (at 28%, excluding 700 MHz and 3.6-3.8 GHz) compared to the share of total spectrum they represent when both uplink and downlink are included (at 23%, excluding 700 MHz and 3.6-3.8 GHz).

[211] This is consistent with the “preferred” LTE frame structure specified in technical licence conditions, although under certain circumstances other frame configurations with different downlink/uplink ratios are possible for the 3.4 GHz band

Figure A8.1: Current holdings of downlink spectrum and future availability

Spectrum Band	Type	BT/EE	Voda-fone	O2	H3G	UK B'band	To be auct'ed	Total
Useable now (all in MHz)								
800 MHz	FDD	5	10	10	5			30
900MHz	FDD		17.4	17.4				34.8
1800 MHz	FDD	45	5.8	5.8	15			71.6
2100 MHz	FDD	20	14.8	10	14.6			59.4
2.6 GHz (paired)	FDD	50	20					70
2.6 GHz (unpaired)	TDD	11.25	15					26.25
Sub-total of above bands		**131.25**	**83**	**43.2**	**34.6**			**292.05**
Share of above bands		**45%**	**28%**	**15%**	**12%**			
2.3 GHz	TDD						30	30
Sub-total with 2.3 GHz		**131.25**	**83**	**43.2**	**34.6**		**30**	**322.05**
Share with 2.3 GHz		**41%**	**26%**	**13%**	**11%**		**9%**	
Likely to be useable in the future (all in MHz)								
1452-1492 MHz	SDL		20		20			40
Sub-total with 1452-1492 MHz		**131.25**	**103**	**43.2**	**54.6**		**30**	**362.05**
Share with 1452-1492 MHz		**36%**	**28%**	**12%**	**15%**		**8%**	
3.4 GHz	TDD					30	112.5	142.5
Sub-total with 3.4 GHz		**131.25**	**103**	**43.2**	**54.6**	**30**	**142.5**	**504.55**
Share with 3.4 GHz		**26%**	**20%**	**9%**	**11%**	**6%**	**28%**	
700 MHz (only paired)	FDD						30	30
Sub-total with FDD 700 MHz		**131.25**	**103**	**43.2**	**54.6**	**30**	**172.5**	**534.55**
Share with FDD 700 MHz		**25%**	**19%**	**8%**	**10%**	**6%**	**32%**	
700 MHz centre gap	SDL						20	20
Sub-total with SDL 700 MHz		**131.25**	**103**	**43.2**	**54.6**	**30**	**192.5**	**554.55**
Share with SDL 700 MHz		**24%**	**19%**	**8%**	**10%**	**5%**	**35%**	
3.6-3.8 GHz	TDD					63	87	150
Sub-total with 3.6-3.8 GHz		**131.25**	**103**	**43.2**	**54.6**	**93**	**279.5**	**704.55**
Share with 3.6-3.8 GHz		**19%**	**15%**	**6%**	**8%**	**13%**	**40%**	

A8.4 We note that uplink constraints in a network can also be important and we have retained our focus on total overall spectrum in the main analysis. We do not consider that our analysis would be fundamentally changed by considering only downlink spectrum.

Methodology and evidence to set threshold price level

A8.5 Below we illustrate how we might approach setting a threshold price by considering how it might be set for option D. Similar methodology and evidence would apply to other options as regards the 2.3 GHz band. Competition measures in options C and E also involve the 3.4 GHz band, via an overall spectrum cap and so would require a threshold price level to be set for that band as well.

A8.6 In the case of option D, there would be no reserved spectrum before the round price of the 2.3 GHz band reached the threshold price. In option D, BT/EE and Vodafone

would be constrained bidders and all other operators would be always-eligible bidders. Therefore, above the threshold price BT/EE and Vodafone would no longer be able to make new bids for 2.3 GHz spectrum.

Methodology and relevant evidence

A8.7 As noted above, the logic of the threshold price is that ideally we would set it at the intrinsic value of the constrained bidders. We have considered the available evidence from which we could derive a suitable threshold price for the 2.3 GHz band. We do not directly observe the intrinsic value of the constrained bidders (BT/EE and Vodafone for option D). However, we have considered whether we could adopt a similar methodology as we used to derive lump-sum values when we set annual licence fees (ALF) for 900 MHz and 1800 MHz spectrum.[212] The primary evidence we used for ALF was:

a) Market value of bands in the UK 2013 auction (800 MHz and FDD (i.e. paired) 2.6 GHz); and

b) Relative value benchmarks from auctions in European countries since the beginning of 2010, i.e. in each benchmark country, the value of ALF bands (900 MHz and 1800 MHz) relative to 800 MHz and 2.6 GHz bands.

A8.8 For example, to derive the lump-sum value of 900 MHz spectrum of £18m per MHz, in effect, we applied to the UK value of 800 MHz (£33m per MHz) a ratio of the value of 900 MHz to 800 MHz (54.5%) which we derived from relative value international benchmarks.

A8.9 The most comparable spectrum to 2.3 GHz in the 2013 auction was the TDD (i.e. unpaired) 2.6 GHz band. We consider below the available evidence from bids for TDD 2.6 GHz spectrum (taking into account the different role of the threshold price in the 2.3 GHz and 3.4 GHz award, compared to market value for ALF).

A8.10 This information could potentially be combined with relative value benchmarks on the value in other European countries of 2.3 GHz to TDD 2.6 GHz spectrum. However, we are not aware of any auctions of 2.3 GHz spectrum in Europe since 2010.[213] Unlike when we set ALF, we do not therefore have similar relative value benchmarks to convert figures for TDD 2.6 GHz to values of 2.3 GHz. In the absence of such evidence, we assume in the discussion below that bidders' per-MHz value of 2.3 GHz is similar to TDD 2.6 GHz.

A8.11 In the November 2014 consultation (paragraph 6.166), in the context of reserve prices, we said that the propagation characteristics of both the 2.3 GHz and the 2.6 GHz bands are similar, they are both internationally harmonised and they are both for TDD use. However, we also noted that there is wider equipment availability for the 2.3 GHz band than there was for the TDD 2.6 GHz spectrum at the time of the 2013 auction. We considered it quite possible, therefore, that the 2.3 GHz band is

[212] Annual licence fees for 900 MHz and 1800 MHz spectrum, Statement, September 2015 ("ALF statement"): http://stakeholders.ofcom.org.uk/consultations/annual-licence-fees-further-consultation/statement/

[213] There was an auction of 2.3 GHz in Norway but it was ten years ago in 2006. We note that DotEcon have produced reserve price benchmarking reports for ComReg in Ireland in the context of ComReg's auction of 3.4-3.8 GHz spectrum. These benchmarking reports have included results for auctions of 2.3 GHz spectrum, and do not identify any recent auctions of 2.3 GHz spectrum in Europe. The latest DotEcon update was in August 2016, https://www.comreg.ie/?dlm_download=3-6-ghz-band-spectrum-award-benchmarking-update-dotecon

more valuable than the TDD 2.6 GHz band in the 2013 auction. In addition, we also took into account the reference point of the FDD 2.6 GHz band, although we recognised that FDD duplexing is significantly more widely used in the UK than TDD, which may translate into the 2.3 GHz band being only a proportion of the value of FDD 2.6 GHz spectrum.

A8.12 Since November 2014 the ecosystem for 2.3 GHz and TDD spectrum in general has continued to develop, probably at a faster pace than might have been expected in 2013. We note that unexpected changes in market conditions, such as a faster pace of growth in demand, might also increase the value of spectrum. On the other hand, as we recognised when setting ALFs, there might be greater certainty now about the availability of more mobile spectrum than at the time of the 2013 auction, which could suggest lower spectrum values.

A8.13 Given these considerations, the assumption of similar value for 2.3 GHz as for TDD 2.6 GHz spectrum may lead to understated or overstated estimates of threshold prices. On balance, we consider it more likely that the value of TDD spectrum has increased since 2013 due to the development of TDD ecosystems. However, in the absence of sound evidence on the relative value of these two bands or on changes in value since the 2013 auction, we have not identified a reliable basis to make a quantified adjustment to values of TDD 2.6 GHz in the 2013 auction, when estimating the current forward-looking value of 2.3 GHz spectrum.

Bids in the 2013 auction relating to 2.6 GHz spectrum

A8.14 We first consider the available evidence on the intrinsic value for TDD 2.6 GHz spectrum of BT/EE and Vodafone, the constrained bidders in the 2.3 GHz and 3.4 GHz award under option D. The 2013 auction took place before the BT/EE merger. BT and EE therefore bid separately in the 2013 auction, and BT's bids were presumably on the basis of a business plan as a new entrant (sub-national) mobile operator.

A8.15 The most relevant information to inform intrinsic value for 2.3 GHz is BT's, EE's and Vodafone's losing bids[214] for TDD 2.6 GHz spectrum, as this represents their expressed value[215] for additional TDD spectrum (by "additional" we mean in addition to their pre-existing holdings and the spectrum they won in the 2013 auction).

A8.16 The values in BT's bids[216] for additional TDD 2.6 GHz spectrum were £1m for an additional 5 MHz and £0.25m for each further 5 MHz.[217]. These mean, for example, values of £1.25m and £1.75m for an additional 10 MHz and 20 MHz respectively. Given the very different basis on which BT may have bid in 2013 compared to its spectrum and market position in the 2.3 GHz and 3.4 GHz award after the merger

[214] All bids are taken from the Supplementary Bids Round, which determined the outcome and prices in the principal stage of the 2013 auction.
[215] The values expressed in bids could differ from intrinsic value due to budget constraints or strategic bidding. For example, if there were budget constraints on bidders in the 2013 auction which will not apply to a similar extent in the PSSR award, the evidence from bids in the 2013 auction might understate the appropriate threshold price. We discussed budget constraints in paragraphs 2.184-2.185 in the ALF statement.
[216] These are incremental bid values (IBVs), e.g. the difference in bid value between BT's winning bid (which was for a package including 20 MHz of TDD 2.6 GHz spectrum) and its bid for a larger package also including additional TDD 2.6 GHz spectrum.
[217] These are much lower than the IBV of £30m in BT's winning bid for 20 MHz (which allowing for a restricted lot of 5 MHz implies an average value of £10m per 5 MHz).

with EE, these values may not be very informative for the purpose of threshold prices in the 2.3 GHz and 3.4 GHz award. In any case, we note that they are significantly lower than the reserve price we have set for the 2.3 GHz band of £10m per 10 MHz lot.

A8.17 There were no values for EE in the 2013 auction for additional TDD 2.6 GHz spectrum. This is because EE won spectrum in the auction up to the limit of the overall cap in that auction and so was not permitted to bid for further spectrum.

A8.18 The values in Vodafone's bids for additional TDD 2.6 GHz spectrum were £1.2m for each 5 MHz (or £2.4m per 10 MHz).[218] As for BT, these values are well below the reserve price for the 2.3 GHz band.

A8.19 For the reference point of FDD 2.6 GHz spectrum, values for additional spectrum in the 2013 auction were as follows:

a) BT bid £14.6m *less* for an additional 2x5 MHz (than for the 2x15 MHz which it won in the auction);

b) There were no bids by EE for additional spectrum; and

c) Vodafone's bids for each additional 2x5 MHz were £25.226m, £53.7m, £53.7m and £29.53m respectively. Whilst these values on a per-MHz basis exceed the reserve price for the 2.3 GHz band, they might not provide reliable indicators of Vodafone's current intrinsic values of TDD spectrum.

A8.20 Overall, therefore, we do not consider that the evidence from the 2013 auction that in principle is most relevant to informing the level of a threshold price for 2.3 GHz spectrum provides a reliable basis to set the threshold price at a different level than the reserve price.

A8.21 Another possible perspective on the threshold price would be bids in the 2013 auction by bidders that would be always-eligible bidders in the 2.3 GHz and 3.4 GHz award, such as H3G and O2. The logic of the threshold price suggests that its level should be *below* the intrinsic value of the always-eligible bidders (if they would be the efficient winners of the spectrum) – otherwise the threshold price would frustrate the intention of the competition measure to prevent strategic investment by constrained bidders.

A8.22 The values of H3G and O2 in the 2013 auction for additional TDD 2.6 GHz spectrum were as follows:

a) For TDD 2.6 GHz, H3G bid £22m for 20 MHz, £8m for a further 5 MHz and £30m for the next 20 MHz. After allowing for 5 MHz of restricted spectrum, this gives values of £30m for 20 MHz and £60m for 40 MHz (or £15m per 10 MHz on average).

b) O2 made no bids for additional TDD 2.6 GHz spectrum.[219]

A8.23 H3G's values in the 2013 auction are on average £5m per 10 MHz above the reserve price for 2.3 GHz. This provides a possible basis to set the threshold price

[218] As for BT, these are much lower than the IBV in Vodafone's winning bid for 25 MHz of £73.2m for the first 15 MHz (which allowing for a restricted lot of 5 MHz implies an average value of £36.6m per 5 MHz), then £9.844m and £2m for the next two 5 MHz lots respectively.
[219] For FDD 2.6 GHz, H3G bid £100m and O2 £128m for 2x10 MHz.

at £15m per 10 MHz (also taking into account that values of TDD spectrum today are likely to be higher than in 2013, which tends to offset the argument that the threshold price level should be set below the values of always-eligible bidders).

A8.24 However, we discuss in section 5 the implication of the risks of setting the threshold price too low or too high for the relevant competition measure option. For example, if we consider that we should set the threshold price so that it is more likely to be too low than too high, it is questionable that we have a reliable basis to set the threshold price materially above the reserve price.

Network capacity

A8.25 In this section we assess the:

a) ability to add capacity to a network in the short term

b) ability to add capacity to a network in the longer term

c) impact of capacity on speed of the network

A8.26 Operators with lower shares of licensed spectrum than rivals may be able to deliver comparable levels of capacity by relying on other approaches than additional spectrum to adding capacity. However, there are differences between the various approaches, in terms of overall performance and timeliness.

A8.27 We noted in Section 3 that there will be other spectrum that will be useable in the longer term, which operators with low spectrum holdings may be able to acquire, including the 3.6-3.8 GHz spectrum and the 700 MHz spectrum. In addition to using more spectrum, however, capacity can also be added by:

a) densifying the network topology, such as increasing the number of cells (e.g. switching from a 3-sector to a 6-sector configuration) and/or increasing the number of sites (e.g. adding new micro or macro sites or deploying small cell sites within macro sites); and

b) moving to more efficient technologies. Spectral efficiency can be improved with newer technology such as re-farming 2G and 3G spectrum bands and use of higher orders of MIMO technology and other LTE–Advanced techniques.

c) it may also be possible to use licence exempt spectrum (such as the 5 GHz bands) to provide additional capacity.

A8.28 We also recognise that the timings and practicality associated with different ways of addressing capacity will vary significantly.

Short term capacity

A8.29 As the transitional period is likely to be relatively short (perhaps 2 to 3 years after the auction), we consider it informative to consider the market position of the MNOs and their ability to add capacity to meet expected demand.

A8.30 In considering whether any MNOs may struggle to add sufficient capacity to meet growing demand in the transitional period, we focus on O2 and H3G, as they have lower shares of spectrum. In contrast, both BT and Vodafone have higher shares of spectrum, and currently carry the least data per MHz of spectrum they hold, as

discussed in section 3 above[220]. In addition, EE achieves the highest average 4G speeds in performance tests, as set out in Annex 7.

A8.31 We consider O2 first, before turning to H3G [✂] REDACTED We considered in detail a range of evidence submitted by O2

[✂] REDACTED

A8.32 [✂] REDACTED

A8.33 [✂] REDACTED

A8.34 [✂] REDACTED

A8.35 [✂] REDACTED

A8.36 [✂] REDCATED As set out in Annex 7, O2's network offers a good quality of service to its customers, as confirmed by its customer satisfaction, by O2's recent increases in market share and that O2 is likely to continue to compete effectively for the provision of mobile services in the UK.[221] [✂] REDACTED [222]

A8.37 [✂] REDACTED

A8.38 [✂] REDACTED

A8.39 [✂] REDACTED

A8.40 [✂] REDACTED

A8.41 Turning our attention to H3G, it is striking that it carries a very high share of data traffic, at 37%, with only 12% of the currently useable spectrum that has already been allocated (i.e. excluding 1400 MHz which is not yet useable). One factor making it easier for H3G to carry a high share of data is that all of its spectrum is used for 3G or 4G technologies, with none being used for the much less spectrally efficient 2G (in contrast to the other three MNOs).

A8.42 As shown in Figure [3.4], H3G's network subscriber share is broadly in line with its share of spectrum[223], which means that it has about the same spectrum per subscriber as the average for the industry as a whole. Its high share of data is therefore due to its subscribers having much higher average use than subscribers of other MNOs.

A8.43 In part, H3G's high usage per subscriber is likely to reflect its choices about the tariffs it currently or has previously offered. For example, we understand that only H3G still offers unlimited SIM-only post pay packages. If it needs to, H3G is probably able to change its commercial strategy to reduce usage by very heavy

[220] Average speeds achievable by a user are related to the local capacity available
[221] Annex 7, section on performance and quality of UK mobile networks, A7.70 - A7.91.
[222] In Annex 7, we show O2's performance in relation to network reliability, coverage speeds etc. according to a number of empirical studies measuring performance of UK mobile networks. O2 may not be ranking first in the various studies but has offered consistently good performance in 2015 and 2016 to his customers and has web downloading times in line with other MNOs according to Ofcom's Smartphone cities study.
[223] This is when its share of spectrum is calculated in terms of useable spectrum, that is, excluding the 1400 MHz spectrum.

data users, so as to make more capacity available for other users. To some extent it may already be doing this, as it has increased its prices for 'All-You-Can-Eat' packages while remaining price competitive and competing strongly for pre-pay consumers (who have lower usage), as described in more detail in Annex 7. However, we recognise that if very restrictive commercial strategies were adopted to cope with limited capacity, then competition for some segments of users may weaken.

A8.44 We have not undertaken a detailed assessment of whether H3G may struggle to add sufficient capacity to meet demand during in the next few years. However, we note that the EC concluded that, "*based on the available evidence in its file, it could not be reasonably predicted that H3G's ability to compete would materially deteriorate due to capacity constraints in the next two to three years.*"[224]

Long term capacity

A8.45 As set out above, we believe that there are a number of options for MNOs to increase capacity in the longer term, such as site densification, small cell deployments and 6-sector upgrades, more aggressive re-farming plans, LTE-Advanced technical improvements, use of carrier aggregation, enhanced MIMO, interference cancellation mechanisms, self-optimising networks (SON), etc. In addition, as noted elsewhere in this document, there will be other spectrum that will be useable in the longer term, which operators with low spectrum holdings would be able to acquire, including the 3.6-3.8 GHz spectrum and the 700 MHz spectrum.

A8.46 The viability and benefit of some of these approaches has been questioned by stakeholders in some cases. For example, [✂] REDACTED

A8.47 [✂] REDACTED

A8.48 Mobile operators report to us that acquiring and deploying macro or small cells takes significant time with the acquisition phase of sites being one of the most difficult, particularly in urban areas where demand is highest. Some landlords do not want to negotiate or allow their properties to be used for base stations and the logistics of getting power and backhaul to many small cells is significant. [✂] REDACTED. Deployment of MIMO can also lead to lengthy negotiations with landlords depending on the terms of the original site access arrangement.

A8.49 Whilst we recognise these points, we also note that alternative creative solutions are feasible for finding suitable sites. For example, Vodafone signed a deal with JCDecaux at the end of 2014 gaining it access to the latter's street furniture and billboard assets for deployment of small cells[225].

A8.50 In addition, we consider that some of the changes proposed in the Digital Economy Bill and changes to the Electronics Communications Code may help MNOs acquire and build sites more quickly. Secondary legislation changing planning rules in England to allow taller mobile masts have been laid before Parliament and will come into force on 24 November[226]., although we accept that these changes have not yet come into force and are currently subject to debate in Parliament.

[224] Recital 775, EC merger decision on the O2/Three merger, available online at http://ec.europa.eu/competition/mergers/cases/decisions/m7612_6415_10.pdf
[225] http://www.vodafone.com/content/index/media/vodafone-group-releases/2014/jcdecaux.html
[226] The regulations can be found at: http://www.legislation.gov.uk/uksi/2016/1040/note/made

A8.51 The development of carrier aggregation technology brings another dimension to network planning. It enables multiple LTE signals on different frequencies to be combined to increase data rates and improve network performance. The capacity increase however is highly dependent on the loading on the network and the number of carriers aggregated. It is made possible predominantly from efficiencies in signalling and scheduling of traffic within the network[227].

A8.52 Other LTE-Advanced technologies will bring incremental capacity improvements but are currently in their infancy so the exact extent of the benefits in real networks that will be realisable is a little uncertain at this stage, although we expect algorithms and benefits to increase over time.

A8.53 However, whilst some of these alternatives may not realise capacity benefits immediately, we consider that with time they are credible alternatives to additional spectrum to a considerable extent. We therefore do not agree with the view, [✂] REDACTED.

The impact on speed

A8.54 Site densification is likely to be able to deliver capacity resulting in similar average speeds in heavily loaded networks to those achievable from using additional spectrum. In contrast, in lightly loaded cells – particularly where carrier aggregation is deployed – a significantly higher number of sites would be needed in order to match performance.[228] [✂] REDACTED

A8.55 Carrier aggregation may also facilitate greater peak speeds to an individual user, particularly when the network is lightly loaded. However, in a heavily loaded network the benefits of carrier aggregation will be less. The effect of carrier aggregation on the capacity and performance of a network is likely to be rather limited in more capacity constrained, and therefore heavily loaded, networks.

A8.56 Speed is anyway not the only dimension of network performance that consumers value. As we describe from paragraph A7.70 in Annex 7, network performance is a broad concept, which also includes, for example, network reliability and latency. In line with this, some recent research conducted by TwinPrime[229] shows that even though average 4G data speeds in highly dense urban areas in the US are decreasing, network response times have improved by 20% and retransmit rates are much lower (0% in many cities), improving overall network experience.[230]

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[227] As multiple bands are simultaneously used to transmit data to a user, the signalling overhead is reduced resulting in more network resources being available for user data. Additionally, some efficiencies in scheduling of data transmission can be realised. Supermarket queues provide a simple illustration: one supermarket has multiple checkouts but a single queue that serves them all (carrier aggregation) whereas another has multiple queues, with one queue for each checkout. The single queue minimises the amount of time any checkout is idle but there is still an unserved customer.

[228] In very lightly loaded cells with a small number of users it may never be possible to meet the data speeds achievable with more spectrum. However, we expect that very light loading will not occur very often in practice.

[229] TwinPrime, State of Mobile Performance, H1 2016 edition, available at http://go.twinprime.com/p/resources/state-of-mobile-performance-2016h1?gclid=CO-k2qSvyM8CFYgYGwodmBAA2Q

[230] Network response time is the time it takes for the device to establish a connection. Retransmit rate is the ratio of bytes retransmitted due to packet loss or other network quality issues, against the total bytes transferred over the network. It is a close approximation of packet loss.

A8.57 This is supported by one mobile operator who noted that customer satisfaction is more commonly driven by the avoidance of negative experiences rather than the occurrence of positive ones [✂] REDACTED

A8.58 This suggests that the experience in heavily loaded cells is more relevant than in lightly loaded cells. In any case, the saved costs of densification will be reflected in the intrinsic value an operator has for additional spectrum. Such saved costs are likely to be higher where an operator considers that highest speeds in lightly loaded cells are more important – including those achieved from carrier aggregation of new spectrum.

A8.59 Similarly, we do not consider that carrier aggregation has a significant bearing when considering the degree of asymmetry of spectrum that gives rise to a competition concern or on considering the credibility of MNOs.

Annex 9

Previous documents

A9.1 This consultation follows the publication of a number of earlier documents through which we established our approach to various aspects of the award (N.B. this list does not include the Information Memorandum which is discussed in section 9):

- In October 2013, we consulted on a band plan for the 3.4 GHz spectrum and issued a 'Call for Inputs' to stakeholders on a range of issues including auction design; spectrum packaging; competition issues; coverage obligations; and 'use-it-or-lose-it' clauses[231].

- In February 2014, we consulted on proposals for addressing the coexistence of LTE with users of adjacent spectrum bands[232]. In particular, we assessed the potential for interference between 2.3 GHz LTE and users of the licence exempt 2.4 GHz band (2400-2483.5 MHz) including Wi-Fi. We also considered other coexistence issues for the 2.3 and 3.4 GHz award, including issues for medical devices, satellites and radar. The technical analysis supporting our proposals was updated in a further document published in December 2014[233]. The February 2014 consultation also confirmed that band plans for both the 2.3 and 3.4 GHz spectrum would be consistent with time division duplex (TDD) arrangements[234].

- In November 2014 we consulted further on a range of issues, including more detailed proposals on auction design and process, and on the technical and non-technical licence conditions[235] we would apply. The November consultation also included our first assessment of competition issues. It proposed setting a cap of 310 MHz on the total volume of mobile spectrum a single mobile network operator could hold.

- In May 2015 we published a document which was both a statement on some issues, and a further consultation on others[236]. The statement element set out our decisions on the auction design and process; the coexistence of new uses of the frequencies alongside existing uses in neighbouring bands; and the technical and non-technical licence conditions. The further consultation set out proposals for an alternative approach to competition issues in the light of market uncertainty stemming from the proposed acquisition of EE by BT and of O2 by CK Hutchison (H3G). This included the proposal to give ourselves the option of withholding some of the 2.3 and/or 3.4 GHz spectrum from the auction.

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[231] https://www.ofcom.org.uk/consultations-and-statements/category-2/2.3-3.4-ghz
[232] https://www.ofcom.org.uk/consultations-and-statements/category-1/pssr-2014
[233] https://www.ofcom.org.uk/__data/assets/pdf_file/0019/36037/updated-analysis.pdf

[234] Time division duplex is used to separate the outward and return mobile signals in the same frequency channel by time, rather than by use of different frequencies (frequency division duplex).
[235] https://www.ofcom.org.uk/__data/assets/pdf_file/0025/78055/Public_Sector_Spectrum_Release_2-3_and_3-4_ghz_award.pdf
[236] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/68337/Public_Sector_Spectrum_Release_statement.pdf

- In October 2015 we published a statement setting out our intention to proceed with an auction of the 2.3 and 3.4 GHz spectrum as soon as possible, and without waiting for the outcome of either the BT takeover of EE or the proposed H3G/O2 merger. We said we would award the spectrum without applying a cap because – on balance – that was the approach best suited to a wide range of possible market scenarios. One of these scenarios was if proposed market consolidations were approved and spectrum holdings were more evenly distributed as a result - in which case a cap could prove to be both overly restrictive and unnecessary as a competition measure. We also published an Information Memorandum[237] and our proposed Auction Regulations[238]. However, in December 2015 we decided to put the auction on hold until the outcome of an EC inquiry into the H3G/O2 deal was decided.

[237] https://www.ofcom.org.uk/__data/assets/pdf_file/0030/81579/info-memorandum.pdf
[238] https://www.ofcom.org.uk/consultations-and-statements/category-3/notice-2.3-3.4-ghz-spectrum

Annex 10

Glossary of terms

4G	Fourth generation mobile phone standards and technology
AIP	Administrative Incentive Pricing
ALF	Annual Licence Fees
BT/EE	A UK Mobile Network Operator (MNO)
CEPT	The European Conference of Postal and Telecommunications Administrations
CFI	Call for Inputs
CK Hutchison	Parent company of H3G
Communications Act	The Communications Act 2003
CMA	Competition and Mergers Authority
CPI	The Consumer Price Index (CPI) is a measure of inflation. It measures the changes in the price level of consumer goods and services purchased by households. The most significant item excluded in the CPI, but included in the RPI, is mortgage interest rate payments.
EAS	Electronic Auction System
EC	European Commission
ECC	Electronic Communications Committee – One of the three business committees of the European conference of Postal and Telecommunications.
EIA	Equality Impact Assessment
EU	European Union
FDD	Frequency Division Duplex – a technology that deals with traffic asymmetry between uplink and downlink where separate frequency bands are used for send and receive operations in paired spectrum
GHz	Gigahertz. 1,000,000,000 (or 10^9) oscillations per second.
H3G	Hutchinson 3G UK Ltd – trading as Three - an MNO.
ITU	International Telecommunications Union - Part of the United Nations with a membership of 193 countries and over 700 private-

	sector entities and academic institutions. ITU's headquarters are in Geneva, Switzerland.
LSA	Licence shared access of radio spectrum
LTE	Long Term Evolution. Part of the development of 4G mobile systems that started with 2G and 3G networks. Aims to achieve an upgraded version of 3G services having up to 100 Mbps downlink speeds and 50 Mbps uplink speeds.
MHz	Megahertz. A unit of frequency of one million cycles per second.
MNO	Mobile network operator. We use this term to mean a mobile operator that controls access to a radio area networks covering the large majority of the UK population. We use this term to exclude those operators that have mobile networks that only cover specific areas rather than providing national coverage
Mobile Trading Regulations	Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011
MOD	The Ministry of Defence
MVNO	Mobile virtual network operator
NAO	National Audit Office
NRA	National Regulatory Authority. The relevant communications regulatory body for each country in the EU. Ofcom is the NRA for the United Kingdom.
O2	A UK MNO
Ofcom	The Office of Communications
PSSR	Public Sector Spectrum Release
RAN	Radio Access Network
RED	Radio Equipment Directive – a new EU Directive with requirements for radio transmitters and receivers
RF	Radio Frequency
RSPG	Radio Spectrum Policy Group - European advisory body on spectrum issues.
SDL	Supplementary Down Link – where unpaired spectrum is used for downlink transmission only
TDD	Time Division Duplex – a technology that deals with traffic asymmetry where the uplink is separated from the downlink by the allocation of different time slots in the same frequency band in unpaired spectrum.

TD-LTE	Time Division Long Term Evolution. Sometimes referred to as Long Term Evolution Time-Division Duplex.
UK Broadband	A UK supplier of mobile services with spectrum holdings in the 3.4 GHz band