Annual licence fees for 900 MHz and 1800 MHz spectrum

Provisional decision and further consultation

Consultation

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About this document

The Government directed Ofcom in 2010 to revise the fees for 900 MHz and 1800 MHz spectrum licences to reflect the full market value of those frequencies. The fees are paid by the mobile operators (EE, H3G, Telefónica and Vodafone) who use some of the spectrum to provide 2G and 3G services, including voice calls, and some for 4G mobile services.

This document sets out our provisional decision on those fees and consults on whether, and if so how, the geographic coverage commitment made by the mobile operators should impact those fees.

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Section 1

Executive Summary and Introduction

Summary

1.1 Ofcom was directed by the Government to revise the annual licence fees (ALFs) to be paid by the holders of licences to use radio spectrum in the 900 MHz and 1800 MHz bands (the "ALF spectrum") to reflect full market value, after completion of the UK 4G auction. We have been consulting on revising ALFs under the Government Direction[1], including in particular our consultation in October 2013 ("the October 2013 consultation") and a further consultation in August 2014 ("the August 2014 consultation").

1.2 Following the above consultations, and having taken account of responses we received, we had towards the end of 2014 reached a provisional decision on future ALFs, subject to final internal confirmation and approvals.

1.3 On 17 December 2014, the Government and the Mobile Network Operators (MNOs) – EE, H3G, Telefónica and Vodafone – signed a Statement of Commitment in which each MNO agreed to implement 90% geographic voice coverage throughout the UK by no later than 31 December 2017. That commitment has been given legal effect through the variation of each of the MNOs' 900 MHz and 1800 MHz licences to include a new coverage obligation to this effect. This is referred to in this document as the "geographic coverage obligation".[2]

1.4 As a result of this agreement, we confirmed in an exchange of letters with the Secretary of State of 17 December 2014 our view that all interested parties should be given a reasonable opportunity to comment on whether they consider that the geographic coverage obligation, taking account of the associated incremental costs incurred by the MNOs, should impact future ALFs.[3]

1.5 This consultation is intended to afford all interested parties that opportunity to comment. We think that the clearest way of doing this is to set out the position that we had reached on the revised levels of ALF before considering the impact of the geographic coverage obligation, as well as our initial views on whether, and if so how, the geographic coverage obligation affects the market value of the ALF spectrum.

1.6 In this document, we therefore set out our provisional decision on the level of ALF and we consult on the impact of the geographic coverage obligation on ALF. We set out below our view that the impact of the geographic coverage obligation should be considered as part of the analysis that results in the derivation of a lump-sum value for the ALF spectrum, before that lump sum is annualised and implemented.

[1] The Wireless Telegraphy Act 2006 (Directions to OFCOM) Order 2010 (S. I. 2010 No. 3024).

[2] There is also a different coverage obligation in the 800 MHz spectrum licence acquired in the 4G auction by Telefónica.

[3] http://media.ofcom.org.uk/news/2015/mno-variations/

ALFs for 900 MHz and 1800 MHz before considering the impact of the geographic coverage obligation

1.7 In summary, the position we had reached, subject to final internal confirmation and approvals, was to set the new base ALFs (using the analytical framework shown at Figure 1.1) as follows.[4]

1.8 **Step 1**: **UK market value of spectrum in the 4G auction**

a) **800 MHz:** we consider that an appropriate forward-looking market value for the 800 MHz band for the purpose of ALF, net of expected DTT co-existence costs, is £30m per MHz (compared to £32.63m per MHz in the August 2014 consultation). The corresponding value gross of expected DTT co-existence costs is **£33m per MHz** (compared to £35.63m per MHz in the August 2014 consultation).

b) **2.6 GHz:** we consider that an appropriate market value for the 2.6 GHz band for the purpose of ALF is **£5.5m per MHz** (which is the same as our proposal in the August 2014 consultation).

1.9 **Step 2**: **Lump-sum values of ALF spectrum**

a) **900 MHz:** we consider that an appropriate lump-sum value for 900 MHz spectrum for the purpose of ALF is **£23m per MHz** (which is the same value as in the August 2014 consultation).

Our assessment of the ratio of 900:800 MHz from the international benchmark analysis is now 70% (as compared to 65% in the August 2014 consultation, which has the effect of offsetting the reduction in the UK market value of 800 MHz referred to above).

b) **1800 MHz:** we consider that an appropriate lump-sum value for 1800 MHz spectrum for the purpose of ALF is **£13m per MHz** (compared to £14m in the August 2014 consultation).

From the international benchmark analysis our assessment of the "Y/X ratio" for 1800 MHz – the difference in value between 1800 MHz and 2.6 GHz ("Y"), divided by the difference in value between 800 MHz and 2.6 GHz ("X"), expressed as a percentage – is now 27% (as compared to 28% in the August 2014 consultation).

1.10 **Step 3**: **Discount Rate**

a) We apply a discount rate of 2.0% to convert the above lump-sum values into an equivalent annual rate (as compared with a discount rate of 2.6% in the August 2014 consultation).

b) This reflects two main changes from the August 2014 consultation. First, we use current market rates (yield to maturity) as the basis for the debt rate. Second, we make an adjustment to reflect the potential for future reviews of ALF and the ability of licensees to relinquish spectrum in circumstances where the market

[4] References to "Steps" correspond to the steps set out in Figure 1.1 in this section below.

value of the spectrum fell. These mean that the Government bears a share of the risk of changes in the value of spectrum over time.

1.11 **Step 4**: **ALF** - applying the above framework, our provisional decision would be to set new base ALF levels as follows (expressed in March 2013 prices, the date of the completion of the 4G auction):

a) **900 MHz**: **£1.48m per MHz per annum**

b) **1800 MHz**: **£0.84m per MHz per annum**

Impact of the geographic coverage obligation (step 2b)

1.12 In our view the impact of the geographic coverage obligation should be considered as part of the analysis that results in the derivation of lump-sum values for the ALF spectrum. We describe this as step 2b in the overall framework we set out below at Figure 1.1.

1.13 We have considered this question using the same approach to market value, based on opportunity cost, as in the rest of this document (and as in previous consultations). The analytical approach we put forward recognises that the MNOs may incur incremental costs to meet the geographic coverage obligation. However, under our proposed approach these incremental costs would not in themselves necessarily lead to an impact on market value. In summary, the reasons for this are as follows:

a) Under our proposed approach to assessing the impact on ALF of the geographic coverage obligation, the market value of spectrum for the purpose of ALF depends on the value to the marginal operator, this being the highest-value operator that does *not* hold that specific spectrum, since this determines the opportunity cost.

b) Each MNO has the geographic coverage obligation regardless of whether or not it acquires additional ALF spectrum.

1.14 In light of the above, we consider that any impact of the incremental costs of meeting the geographic coverage obligation on market values of spectrum would depend on the difference in the marginal operator's incremental costs of meeting the coverage obligation with and without additional ALF spectrum. Under our proposed approach the marginal operator's existing spectrum holdings are also relevant, as they are likely to affect this difference in incremental costs (e.g. the difference may not be large if the marginal operator already holds spectrum that provides similar voice coverage capabilities to the additional ALF spectrum).

1.15 There could also be an impact on the value of additional ALF spectrum to the marginal operator due to the effect of the geographic coverage obligation on other operators against which it is competing, such as a change in voice coverage competition.

1.16 Applying this proposed approach to the ALF spectrum, our initial view is that the geographic coverage obligation is unlikely to have a material effect on the market value of either 900 MHz or 1800 MHz spectrum for the purpose of ALF:

a) We consider it unlikely that additional 900 MHz or 1800 MHz spectrum would confer a material capability, in relation to the marginal operator's incremental cost

of meeting the geographic coverage obligation, that it could not obtain using its existing spectrum holdings.

b) For similar reasons, it seems unlikely to us that the marginal operator's competitive position in voice coverage would be a significant factor in its additional value of 900 MHz or 1800 MHz spectrum.

1.17 We have also considered whether the incremental costs to the MNOs of meeting the geographic coverage obligation would have a direct impact in reducing ALF. In our view, for this to be the case a significantly different approach would need to be relevant, such as:

a) If market value were to depend on the private value of the ALF spectrum to the licensee. In our view, it would not be appropriate to change the definition of "market value" in this way, to relate to the private value instead of the opportunity cost; and

b) If the geographic coverage obligation were causally related only to the operators' holdings of ALF spectrum.

1.18 Accordingly, we propose not to amend the lump-sum values for either 900 MHz or 1800 MHz as a result of the geographic coverage obligation.

1.19 In consulting on the impact of the geographic coverage obligation, we invite stakeholders' views on both the approach we put forward and our initial view on the impact of the geographic coverage obligation on ALF.

Implementation of revised ALFs

1.20 Our position on implementation of revised ALFs remains as we set out in the August 2014 consultation. We consider that the revised ALFs should take effect from the same common effective date (CED) for all licensees. We are minded to set the CED to be the earliest date practicable after the new fees regulations are made implementing the revised ALFs. Our provisional decision is that the revised ALFs should be phased-in in two steps with one half of the increase coming into effect on the CED, and the second half of the increase becoming effective exactly one year following the CED. From this point (i.e. one year following the CED) all licensees should pay ALFs on the same actual payment date.

Introduction

Ofcom's task

1.21 Under the Government Direction, Ofcom is required to revise the level of ALFs for the 900 MHz and 1800 MHz Public Wireless Networks licences so that they reflect full market value. In doing so, the Government Direction requires us to have particular regard to the sums bid in the UK 4G auction. The UK 4G auction concluded in March 2013. Our approach has been to define full market value for the purpose of ALF as the market-clearing price in a well-functioning market, or the forward-looking marginal opportunity cost of the spectrum.

1.22 In accordance with the Government Direction, we set out proposals for revised ALFs in the October 2013 consultation.[5] We received responses from EE, H3G, Telefónica

[5] http://stakeholders.ofcom.org.uk/consultations/900-1800-mhz-fees/

and Vodafone. These MNOs all hold Public Wireless Networks licences in one or both of the 900 MHz and 1800 MHz bands and so have a direct interest in the relevant ALF. We also received responses from BT, GSMA, Enders Analysis, the Scottish Government and Prospect.

1.23 In April 2014 we published a further consultation on the methodology to derive a discount rate consistent with CPI inflation.[6] This discount rate is used in our methodology to convert lump-sum values for the 900 MHz and 1800 MHz bands into annual fees. The MNOs, but no other stakeholders, responded to this further consultation.

1.24 In May 2014 we published an update, and invited comments, on European auctions that had taken place since the time of the October 2013 consultation.[7] The results of European spectrum auctions for the 800 MHz, 900 MHz, 1800 MHz and 2.6 GHz bands are used to inform our estimates of the lump-sum values for the 900 MHz and 1800 MHz bands in the UK. The MNOs, but no other stakeholders, submitted comments on this update.

1.25 In August 2014, we published a further consultation setting out our revised proposals, focusing on those areas which had changed from the October 2013 consultation. We received responses from the MNOs, BT and the Scottish Government.

1.26 Non-confidential versions of the responses that we received to these consultations are available on our website.

1.27 In response to our October 2013 consultation, a number of stakeholders said that we should carry out a full impact assessment of our proposals for revising ALFs. In essence, their view was that we should not revise ALFs to reflect full market value unless we could demonstrate that taking this approach to setting ALFs (and the specific levels of ALF that we proposed) was necessary to promote efficient use of spectrum, and that the potential benefits in terms of spectrum efficiency would outweigh any potential adverse effects on consumer prices, investment in infrastructure, innovation and competition. They considered that unless we carried out such an impact assessment any decision we made would be unlawful.

1.28 In the August 2014 consultation, we made a statement for the purposes of section 7(3)(b) of the Communications Act 2003, setting out that we considered it was unnecessary for us to carry out an impact assessment of the type argued for by stakeholders. We explained that we considered it unnecessary because we did not have any discretion to decide whether or not to set ALFs at full market value since we had been directed by the Government to do so and we were required to implement that direction.

1.29 Notwithstanding that we set out our decision on this point in the August 2014 consultation, all of the licensees argued in their responses that we should conduct a full impact assessment, especially in relation to the impact on retail prices, investment and competition, and argued that unless we conduct such an impact assessment our decision on revising ALFs would be unlawful. They argued that we should assess the impacts on these matters of setting ALFs at different levels which could reasonably be said to reflect full market value. We consider that these comments do not contain any new arguments in addition to the arguments licensees

[6] http://stakeholders.ofcom.org.uk/consultations/900-1800-mhz-fees-cpi/

[7] http://stakeholders.ofcom.org.uk/consultations/900-1800-mhz-fees/update-note/

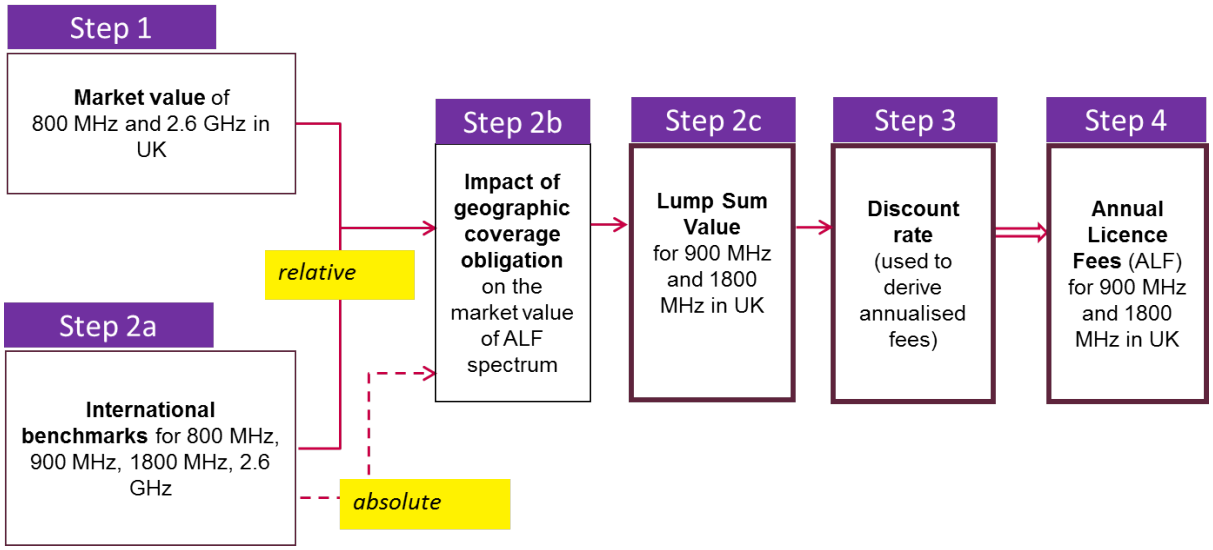
raised in their responses to the October 2013 consultation, and which we considered in reaching our decision on impact assessment set out in the August 2014 consultation.

Analytical framework

1.30 As we set out in the August 2014 consultation, we recognise that we have little direct relevant market evidence of the UK value of the specific spectrum bands for which we are setting revised licence fees, 900 MHz and 1800 MHz. For example, there has been no UK auction of spectrum in either of these bands. The available evidence is instead for the market value of *other bands* in the UK, or for these bands in *other countries* where they have been auctioned. Accordingly, we recognise there is therefore inherent uncertainty in deriving ALFs for the 900 MHz and 1800 MHz bands at full market value. Nevertheless, in order to implement the Government Direction we must conclude on an appropriate amount for ALFs.

1.31 Given the available evidence, the framework we use for deriving an appropriate level of ALF is illustrated in Figure 1.1. This builds on the framework that we used to develop the ALF proposals in the October 2013 consultation (where we explained the reasons for doing so)[8] and our revised proposals in the August 2014 consultation. None of the respondents disagreed with this high-level framework of analysis, although Vodafone argued that we should have put more weight on technical modelling (we discuss Vodafone's argument on technical modelling in Annex 9). The only modification we make to the analytical framework is to show where we propose that the assessment of the impact on ALF of the geographic coverage obligation should fit into our overall analytical framework.

Figure 1.1: Framework of steps 1 to 4



Source: Ofcom

1.32 There are two distinct aspects to our derivation of fees:

a) the derivation of the lump-sum value of spectrum in each of the 900 MHz and 1800 MHz bands in the UK; and

[8] See paragraphs 2.8 to 2.18 in the October 2013 consultation.

b) the conversion of those lump-sum values into annual fees.

1.33 As in the August 2014 consultation, we organise our analysis of these aspects into four analytical steps.

1.34 Steps 1 and 2 relate to the derivation of lump-sum values for the 900 MHz and 1800 MHz bands in the UK.

1.35 In **step 1** we estimate the UK market value of the 800 MHz and 2.6 GHz bands ("the auction bands"), based on analysis of the sums bid in the 4G auction (to which the Government Direction requires us to have particular regard).

1.36 In **step 2** we derive the lump-sum values of the 900 MHz and 1800 MHz bands ("the ALF bands").

a) In step 2a we use evidence on the *relative* value of the ALF bands, 900 MHz and 1800 MHz, to the auction bands, 800 MHz and 2.6 GHz. This includes, in particular, international benchmark evidence on auctions conducted in other European countries in recent years. We also consider the evidence of the *absolute* values of the ALF bands in the relevant benchmark countries. However, in line with the updated analysis presented in the August 2014 consultation, we place the primary emphasis on the relative values, as explained in Section 3.

b) As discussed above, we are consulting on the impact of the geographic coverage obligation on ALF. Our proposed approach to this is to consider the impact of the obligation on the market value of ALF spectrum as part of our analysis to derive the lump-sum values for the ALF spectrum, as shown as step 2b in Figure 1.1.

c) In step 2c we estimate lump-sum values by combining an analysis of the value of 900 MHz and 1800 MHz spectrum *relative* to the auction bands in the relevant benchmark countries (from step 2a) with our estimates (from step 1) of the market value for those auction bands in the UK. This is the point in our analytical steps where we would also expect to take into account the impact of the geographic coverage obligation (from step 2b).

1.37 In **step 3** we consider the choice of an appropriate discount rate to convert the lump-sum values for the 900 MHz and 1800 MHz bands in the UK into annual licence fees.

1.38 In **step 4** we set out the ALFs at full market value for 900 MHz and 1800 MHz spectrum using the analysis under steps 1, 2 and 3.

Approach to interpreting the available evidence

1.39 Where there are choices of methodology in steps 1, 2 and 3 in our analysis, we consider in each relevant section in this document which methodology, on balance, we are minded to prefer over the alternative(s).

1.40 We have applied our preferred methodologies to the available evidence, noting the challenges in interpreting some of that evidence, and exercising our regulatory judgment where necessary.

1.41 In the August 2014 consultation we said that we should exercise any necessary regulatory judgement by adopting a conservative approach when interpreting the evidence.[9] We said that this was for the following key reasons:

- Asymmetry of risk as between the effects on spectrum efficiency from inadvertently setting ALFs either above or below market value, given the uncertainty about the correct estimates for market value.

- Possibility that forward-looking market values today could be lower than at the time of the auctions from which we derive our key evidence, due to greater certainty of availability of mobile spectrum in the future, compared to expectations at the time of the 4G auction.

1.42 All the current licensees agreed in their responses to the August 2014 consultation that we should adopt a conservative approach when interpreting the evidence. BT did not disagree that we should adopt a conservative approach, but commented that "taking a conservative approach is not the same as deliberately setting ALF below Ofcom's view of the appropriate level". We agree with BT's comment.

1.43 All the current licensees argued that, in practice, we had not been conservative, or that we had not been sufficiently conservative. Telefónica said that there was a large range of plausible estimates for both 900 MHz and 1800 MHz and we should ultimately select ALFs based on the lower end of the estimates of full market value. EE, Telefónica and Vodafone argued that we should conduct a full impact assessment in order to ensure that we adopt a conservative approach. Vodafone also claimed that we need a framework to consider whether we are sufficiently conservative in our treatment of the evidence.

1.44 We consider that licensees have misunderstood what we mean by adopting a conservative approach when interpreting the evidence. We have always recognised that there is inherent uncertainty in deriving ALFs for the 900 MHz and 1800 MHz bands to reflect full market value. Nevertheless, in order to implement the Government Direction we must conclude on an appropriate amount for ALFs going forward, and that process necessarily involves us exercising regulatory judgement when considering the evidence.

1.45 Where there are alternative approaches to interpreting the available evidence that we consider could be appropriate for the purpose of deriving revised ALFs that reflect full market value, we will take into account whether the alternative approaches are more likely to understate full market value or to overstate it. We will generally prefer approaches which we consider are more likely to understate full market value than to overstate it, where such a choice arises.

[9] See paragraph 1.34 of the August 2014 consultation.

Section 2

UK market values of 800 MHz and 2.6 GHz spectrum for the purpose of ALF

Introduction

2.1 This section estimates the full market value for the purpose of ALF of the auction bands, 800 MHz and 2.6 GHz, using bids in the 4G auction. This is step 1 in the analytical framework we set out in Section 1. Supporting material for the issues discussed in this section is set out in Annex 6.

2.2 In the light of the responses to the August 2014 consultation we have made some modifications to our analysis and our view of the market value of the 800 MHz band. For the 2.6 GHz band the bulk of our analysis, and our view of market value, is the same as in the August 2014 consultation.

2.3 The rest of this section:

- provides an overview of our proposals in the August 2014 consultation and the stakeholder responses;
- introduces our analysis by outlining the key concepts, methods and complications to be addressed;
- derives the market value of each of the 800 MHz and 2.6 GHz bands for the purpose of ALF through analysis of:
  - auction prices;
  - opportunity costs in the 4G auction for the purpose of ALF (including the Additional Spectrum Methodology, ASM, and the decomposition method put forward by Vodafone);
  - Linear Reference Prices (LRPs); and
  - marginal bidder analysis;
- provides our comments on stakeholders' responses to the August 2014 consultation at the relevant points throughout our analysis; and
- summarises our view on the market values of the 800 MHz and 2.6 GHz spectrum bands for the purpose of ALF.

August 2014 consultation and stakeholder responses

Our analysis and proposals in the August 2014 consultation

2.4 In the August 2014 consultation we explained that, whilst the auction revenue was derived properly for the purpose of the 4G auction and appropriately reflected the bids made in the auction, for the related but different question of market value for the purpose of ALF, in our view it was too low. Therefore, we considered that the results

of the method of revenue-constrained LRPs, which attributes the auction revenue between the different bands in the auction, were also too low as a basis for ALF.

2.5 In summary our specific reasons were:

- the pricing rule in the auction for the reserved spectrum which was won by H3G intentionally resulted in an auction price below opportunity cost;
- EE's auction price at the reserve price was below opportunity cost for the purpose of ALF, because EE itself was the only losing bidder for 800 MHz spectrum; and
- the auction prices of Telefónica and Vodafone for 800 MHz were affected by a packing issue, which led to each operator's first 2x5 MHz being priced at the reserve price even though in general there was excess demand for the spectrum at the reserve price.

2.6 We considered the following three methods to estimate market value of 800 MHz and 2.6 GHz for the purpose of ALF:

- LRPs without revenue constraint;
- ASM; and
- marginal bidder analysis.[10]

2.7 Our preferred method was the marginal bidder analysis, for the following reasons:

a) The results of the method of LRPs without revenue constraint were reduced by bids that were constrained by the overall spectrum cap in the 4G auction. We considered that we should not treat the overall cap in the 4G auction as a binding constraint on a forward-looking basis.

b) The results of ASM involved effects in both directions which we considered were better removed for the purpose of ALF:

   - o package rearrangements which may not be achievable outside a multi-band auction; and
   - o treating the overall spectrum cap in the auction as a binding constraint.

c) We argued that these effects, which represented disadvantages of the two methods as described above, could be accounted for in the marginal bidder analysis, including through careful interpretation of the results. We considered spectrum increments of both 2x5 MHz and 2x10 MHz. On balance, for the 800 MHz band our view was that the market values using a 2x10 MHz increment were more appropriate as a basis for ALF, given the synergies in block size reflected in auction bids.

[10] For a high-level description of these methods, see paragraph 2.32 below. Further details are set out later in this section and in Annex 6.

2.8 Our preferred figures, which we suggested were conservative estimates of market values (net of expected DTT co-existence costs) derived from our marginal bidder analysis, were:

- 800 MHz band: £32.63m per MHz; and
- 2.6 GHz band: £5.5m per MHz.

Stakeholder responses

2.9 In this sub-section we set out a summary of the responses from stakeholders on our analysis and proposals in the August 2014 consultation. We provide our comments on these responses in the detailed discussion in later sub-sections (in some cases supplemented by additional material in Annex 6).

Sums paid in the auction provide a ceiling on market value

2.10 Stakeholders argued that the sums paid in the 4G auction provided a ceiling on the market value of that spectrum:

a) Vodafone[11] said that it is implausible that the value of spectrum is greater than the sums paid in the auction, unless there has been a material increase in the value of UK spectrum since the auction. It also argued[12] that setting ALFs too high created a risk that is not mirrored by the risk of setting them too low, which suggested putting no weight on any approach that gives results above the actual prices in the auction.

b) EE[13] said that reserve prices are very likely to overstate the market value and so the total revenue achieved in the auction must be seen as an upper bound of ALFs.

c) H3G[14] said that we should take account of the revenue equivalence theorem[15] and treat the auction revenue as an upper bound on estimates of market value. It also argued[16] that the auction prices were made artificially higher than full market value by the presence of spectrum reservation. Consequently, it suggested a downward adjustment needed to be made to the resulting value estimates to offset what it saw as the positive revenue effect of the spectrum reservation in the auction.

2.11 Vodafone[17] and Telefónica[18] suggested that there was no packing issue affecting the auction prices of 800 MHz spectrum if reserve prices were sufficiently low. They argued that the packing issue arose as a result of choices Ofcom made in the auction rules including setting relatively high reserve prices and applying those reserve

[11] Vodafone's response to the August 2014 consultation, p. 8.

[12] Vodafone's response to the August 2014 consultation, p. 12.

[13] EE's response to the August 2014 consultation, p. 15.

[14] H3G's response to the August 2014 consultation, Annex A (Power Auctions report), p. 5 and p. 8.

[15] See footnote 58 for a description of the revenue equivalence theorem.

[16] H3G's response to the August 2014 consultation, Annex A (Power Auctions report), p. 12.

[17] Vodafone's response to the August 2014 consultation, p. 10.

[18] Telefónica's response to the August 2014 consultation, p. 35, paragraph 83.

prices on a lot by lot basis. Telefónica[19] said that, even if there was a packing issue, it did not agree with the use of hypothetical bids to try to compensate for this issue. The possibility of lumpy outcomes reflected the inherent lumpiness of demand for spectrum in some bands.

2x5 MHz is the relevant increment for determining market value, not 2x10 MHz

2.12 Vodafone[20] considered it more likely that, when setting ALFs based on a larger marginal increment, Vodafone/Telefónica would inefficiently relinquish 2x5 MHz (or less), which it claimed could not be used more efficiently by EE. It said that there was no good technical reason to choose a 2x10 MHz increment. Also, it contended that choosing a marginal increment of 2x10 MHz was inconsistent with Ofcom's recognition in the August 2014 consultation that, in the face of uncertainty, it needed to act conservatively.

EE's bids were inflated by strategic bidding

2.13 Telefónica[21] claimed that EE's bid structure was not reflective of its true valuations. It contended that EE had little chance of winning the package of 2x20 MHz of 800 MHz and 2x20 MHz of 2.6 GHz (on which Ofcom's proposed value from the marginal bidder analysis was based). It would have required outbidding Telefónica or Vodafone on their 2x10 MHz in the 800 MHz band which was unlikely. Telefónica claimed that a bid for 2x15 MHz would have been more likely to win which is why EE did not submit a bid for it.

2.14 Telefónica also said that EE's bids included large synergies for incremental spectrum, in particular for large packages. It suggested that EE's small bids understated value and larger bids were inflated, so incremental values overstated market value.

2.15 H3G (Power Auctions report)[22] set out an analysis suggesting that EE had a small (or "near zero") chance of winning the package of 2x20 MHz of 800 MHz and 2x20 MHz of 2.6 GHz, and it claimed that EE only submitted a bid for this package to set prices paid by other bidders.

2.16 Vodafone[23] said that setting ALFs based on marginal values which potentially contained strategic premiums could result in inefficient re-allocations, potentially leading to spectrum being relinquished even though there is no higher value user. It claimed[24] that there was evidence that an element of strategic value (strategic premium) was reflected in EE's bidding as packages approached the spectrum cap. This was because bids for larger packages were more likely to be included in the price determination for other bidders.

[19] Telefónica's response to the August 2014 consultation, p. 35, paragraph 84.

[20] See Vodafone's response to our August 2014 consultation, p. 13-21, and Annex 1, p. 5-6.

[21] See Telefónica's response to the August 2014 consultation, p. 25.

[22] See p. 30-36 in Annex A, Power Auction's report as part of H3G's response to the August 2014 consultation.

[23] See Vodafone's response to the August 2014 consultation, p. 8.

[24] See Vodafone's response to the August 2014 consultation, Annex 1, p. 8, and Annex 1.1, p. 12-14.

Ofcom should take the overall cap in the 4G auction of 210 MHz as a binding constraint

2.17 Vodafone[25] argued that, *to depart from the overall cap in the auction, Ofcom would be pre-judging a competition assessment. It claimed that, in any case, we had failed to set out any competition assessment to support our approach that the overall cap should be treated as non-binding on a forward-looking basis.*

2.18 EE[26] said that Ofcom cannot dismiss the spectrum cap constraint upon EE when establishing marginal value. It also argued that, even if EE is not prevented from acquiring more 900 MHz spectrum due to the future release of spectrum that release itself drives spectrum values down due to greater availability of spectrum.

Ofcom's implementation of the marginal bidder approach included subjective decisions

2.19 H3G[27] said that our marginal bidder analysis omitted relevant information, in particular, because we limited our attention to paired 2.6 GHz spectrum (C lots) while ignoring bids for unpaired 2.6 GHz spectrum (E lots). It also criticised our reasoning in the August 2014 consultation for the selection of £32.63m per MHz as an estimate of the market value of the 800 MHz band in the marginal bidder analysis.

2.20 Telefónica[28] suggested that our analysis failed to take into account that the value of 900 MHz spectrum would not be inflated by the contiguity premium in the same way 800 MHz was in the 4G auction (even when looking at the value of a 2x10 MHz increment).

2.21 EE[29] argued that the marginal bidder analysis was highly subjective, extremely unreliable and overstated the market value of 800 MHz. It contended that the absence of information on how EE or other bidders would have bid for additional 800 MHz spectrum should in itself have been a signal that the adoption of the marginal bidder analysis was prone to significant error and unreliable results. EE also suggested that the marginal bidder analysis:

a) failed to provide market values of frequencies as a whole, as it ignores effects across bands;

b) focused on an arbitrary marginal increment of spectrum;

c) over-estimated the intrinsic value placed on additional 800 MHz spectrum given that EE's bids in the 4G auction contained significant complementarities (contiguity premium and complementarity premium); and

d) significantly weakened bidders' incentives to reveal their true opportunity cost in future auctions.

[25] See Vodafone's response to the August 2014 consultation, p. 17 and 21.

[26] See EE's response to the August 2014 consultation, p. 16-18.

[27] See p. 37-40 in Annex A, Power Auction's report as part of H3G's response to the August 2014 consultation.

[28] See p. 28-29 in Telefónica's response to the August 2014 consultation.

[29] See p. 5 in EE's response to the August 2014 consultation.

Stakeholders suggested different estimates of market value than proposed by Ofcom

2.22 BT agreed with our proposed market values. EE, H3G, Telefónica and Vodafone suggested different estimates. See Table 2.1 for a summary of preferred methods and suggested values by stakeholders.

2.23 EE said that the LRPs with revenue constraint was the most appropriate and reliable method.

Table 2.1: Summary of preferred methods and suggested values by stakeholders (in £m per MHz)

	BT	EE	H3G	Telefónica	Vodafone
Preferred method	Ofcom's August 2014 consultation (marginal bidder analysis)	LRP with revenue constraint	LRPs with revenue adjusted (below the auction revenue)	Broad assessment of all plausible methodologies	Marginal bidder analysis (with mean/median bid values)[30]
Suggested values for 800 MHz	£32.63m	£26.89m	£25.04m	£25m	£17.9m – £21.4m
Suggested values for 2.6 GHz	£5.5m	£4.99m	£3.57m	£4.95m	£5.5m

Source: Ofcom from responses to the August 2014 consultation

2.24 H3G derived its suggested values from a variation of LRPs with an adjusted, lower revenue constraint, and values by band reflecting pro-rating compared to the structure of LRPs without revenue constraint.

2.25 Telefónica[31] said that there were a number of plausible methodologies, each with strengths and weaknesses, and a reasonable approach was to look at these as a whole, and make a judgement based on a weighted assessment of these approaches.

2.26 Vodafone's preferred method was its marginal bidder analysis (which is materially different from Ofcom's) on the basis that it could separate intrinsic value from (contiguity and strategic) premium values. As a second choice, it supported the use of the decomposition approach, which decomposes by band the opportunity cost imposed by each bidder.[32]

[30] Vodafone proposed to use the same method and values as in its response to the October 2013 consultation.

[31] See Telefónica's response to the August 2014 consultation, p. 17.

[32] Vodafone (Annex 1, p. 9, response to the August 2014 consultation) said that a market value of £5.5m per MHz for 2.6 GHz spectrum was fairly reasonable for the reason that a market price cannot possibly exceed the highest price at which it is possible to sell all available lots. Also, it said that £5.5m per MHz was broadly in line with our claim of being conservative.

Key concepts, methods, and complications in our analysis of market value for the purpose of ALF

Market value and opportunity cost

2.27 We define full market value for the purpose of ALF as the market-clearing price in a well-functioning market, or the forward-looking marginal opportunity cost of the spectrum. This is the same as in the August 2014 consultation (paragraph 2.9), although we have added an explicit reference to the opportunity cost being forward-looking for the avoidance of doubt. It is also consistent with our definition of full market in the October 2013 consultation (and the earlier consultation documents preceding the 4G auction).[33] In this document we use the terms "full market value", "market value" and "marginal opportunity cost" interchangeably.

2.28 Taking Vodafone's holdings of 900 MHz as an example, we are not seeking to establish Vodafone's value of its 900 MHz licence. Instead it is the value that is denied to other operators by Vodafone continuing to hold this spectrum that is relevant to the opportunity cost. In particular, it is the value to the other operator that would gain the highest value if it were to acquire Vodafone's 900 MHz frequencies (or part of them).

2.29 When assessing the full market value of 800 MHz and 2.6 GHz spectrum in this context, we recognise that we are doing so for a specific purpose. We are deriving the market value to serve as a basis for the ALF of different spectrum bands, 900 MHz and 1800 MHz, when combined with the other steps in our analysis (such as benchmarking and annualisation). As explained below, this 'read-across' from the spectrum bands in the 4G auction (800 MHz and 2.6 GHz) to the ALF bands (900 MHz and 1800 MHz) has important implications for the relevant market values, especially of the 800 MHz band.

2.30 The auction prices in the 4G auction of 800 MHz and 2.6 GHz spectrum represent the starting point of our analysis, because they are a potential source of information on market value. Given the bids made in the auction, the auction prices for non-reserved spectrum were derived as the higher of the (i) reserve prices and (ii) highest losing bids for "additional spectrum" (i.e. for more spectrum than that bidder won in the auction), for (constituent elements of) the specific package of spectrum won by that winning bidder. Where the auction prices comprised losing auction bids, they reflected the opportunity cost in the 4G auction of that spectrum package to other bidders (i.e. to bidders other than the winning bidder whose price is being derived), relative to their own winning packages. To the extent that auction prices were based on reserve prices, they did not reflect a losing bid by a bidder, and so they may not provide the most relevant information on opportunity cost.

2.31 The winning spectrum packages reflect operators' existing, post-auction spectrum holdings. This means that the opportunity cost in the auction addresses the question of the value that bidders expressed in the auction for more spectrum in addition to

[33] See, for example, paragraph 2.8 in the October 2013 consultation, and paragraph 10.3 in the March 2011 consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, http://stakeholders.ofcom.org.uk/binaries/consultations/combined-award/summary/combined-award.pdf.

their existing, post-auction holdings.[34] This is especially relevant to ALF, as it informs the opportunity cost of the ALF spectrum, i.e. the value denied by the licensees of 900 MHz and 1800 MHz spectrum to the non-holders of that spectrum. The opportunity cost is the (highest) value that the non-holders could obtain by adding some of this ALF spectrum to their holdings.

High-level overview of methods

2.32 We provide in this sub-section a high-level comparison between the different methods which we use in our assessment of market value:

a) Prices in the 4G auction, which are based on opportunity cost of the spectrum, given the highest losing bids for additional spectrum (where they exceed the reserve price);

b) Opportunity costs in the 4G auction, which reflect highest losing bids for additional spectrum in the absence of reserve prices. For this analysis we use the Additional Spectrum Methodology and the decomposition method (put forward by Vodafone) to attribute amounts for multi-band packages between the constituent bands;

c) Linear Reference Prices, which seek to estimate the linear prices that are closest to market-clearing prices (by a linear price we mean the same price per MHz in a given band, such as 800 MHz, to all operators and for all block sizes); and

d) Marginal bidder analysis to analyse opportunity cost by assessing the bids of the highest losing bidder for additional spectrum.

2.33 We use these methods in our analysis of the market value of both 800 MHz and 2.6 GHz spectrum. In particular, we derive candidate value(s) from the opportunity costs in the auction,[35] which we compare against the LRPs, and we use the marginal bidder analysis either as a cross-check (in the case of 800 MHz) or to select the market value figure from within the range of candidate values (in the case of 2.6 GHz). The differences in the detail of our analytical steps for the 800 MHz and 2.6 GHz bands reflect differences in the circumstances, notably the absence for the 2.6 GHz band of most of the complications that arise in the analysis of the 800 MHz band.

2.34 Whilst the methods are not identical, they share a substantial degree of overlap and commonality. To compare and contrast the methods at a high level, it is helpful to consider their application to the 2.6 GHz band, for which the analysis is less complicated:

a) Prices for 2.6 GHz in the 4G auction are generally in the range between £5.1m and £5.7m per MHz, determined by the highest losing bids.

b) Opportunity costs in the 4G auction are between £5.1m and £5.7m, similar to the auction prices, because these prices were not set by the reserve price of 2.6 GHz spectrum.

[34] We note recent announcements about merger and acquisition activity involving particular MNOs. For the avoidance of doubt, our analysis throughout this document is based on the existing spectrum holdings of the MNOs.

[35] This is a modification in our analysis compared to the August 2014 consultation.

c) LRP with the revenue constraint set at the level of the auction revenue is £4.99m per MHz for the 2.6 GHz band, whilst the LRP without the revenue constraint is £5.7m per MHz. Since there is no linear price at which the market clears for any of the bands in the 4G auction, given the synergies in the bids made in the auction, both of these LRPs would involve excess demand or excess supply in the spectrum bands. The linear price that avoids excess supply and minimises excess demand is £5.5m per MHz.

d) A conservative interpretation of the evidence from the marginal bidder analysis is a market value of £5.5m per MHz.

2.35 It is not a coincidence that the figures derived from the range of methods are similar. They share a similar purpose: to assess opportunity cost. The evidence they use is the same: bids in the 4G auction. The way they assess this evidence is not identical, but in all of the methods the winning bids and packages are of central importance as reference points:

a) Prices in the 4G auction are determined as the higher of reserve prices and the incremental bid value[36] for additional spectrum in the highest losing bids compared to that bidder's winning package.

b) Opportunity costs in the auction are the incremental bid value for additional spectrum in the highest losing bids compared to the winning packages of the bidders submitting these highest losing bids.

c) LRPs are determined by the relevant constraining bids, which can include losing bids by all bidders. The choice of the constraining bids depends on their attractiveness to the bidder compared to its winning package at the linear prices.

d) The results of the marginal bidder analysis depend on the incremental bid value for additional spectrum in the highest losing bids (or lowest winning bid) of the marginal bidder compared to its winning package.

2.36 We consider it desirable that differences between bidders' losing bids and their winning bids play such a key role in the methods that we use. As set out above at paragraph 2.31, because the winning spectrum packages reflect the operators' existing, post-auction spectrum holdings, values for additional spectrum compared to the winning bids assess the most relevant opportunity cost for the purpose of ALF. Also, the winning packages themselves reflect the outcome of a competitive auction which cleared the market, matching demand to the available supply of spectrum.

2.37 Some stakeholders argued that a weakness of the marginal bidder analysis is that it depends on a single specified losing bid relative to the marginal bidder's winning bid, whereas LRPs are determined by a wider range of losing bids. Given the key role of winning bids and packages in all of the methods, we do not consider this to be a feature of the marginal bidder analysis that is of concern. For example, (in the

[36] The incremental bid value is the bidder's difference in bid value between two different packages for a specified increment of spectrum. For example, Telefónica made a bid of £1,219.003m for a package of 2x10 MHz of 800 MHz spectrum (with coverage obligation). It also made a bid of £1,347.003m for a larger package of 2x10 MHz of 800 MHz *plus* 2x10 MHz of 2.6 GHz spectrum. Therefore, the specified increment of spectrum between these two packages is 2x10 MHz of 2.6 GHz, and the incremental bid value is £128m or £6.4m per MHz. Furthermore, the smaller package described above was Telefónica's winning package, and the increment in the larger package was the highest losing bid in the auction for 2.6 GHz spectrum.

absence of rearrangements) the auction price of operator 1's winning package is similarly determined by a single losing bid from the highest losing bidder ("operator 2") relative to operator 2's winning bid (and this applies in respect of each component of operator 1's winning package) . Indeed, on the contrary, we consider the fact that LRPs are in practice influenced by the difference between two losing bids by a bidder, and not just by the difference to its winning bid, can be regarded as a disadvantage of the LRP method for the reasons set out above.[37]

2.38 We also note that some of the analysis proposed by stakeholders in their responses involves estimating opportunity cost relative to a different assumed allocation of spectrum in the 4G auction than the actual winning packages (e.g. H3G's analysis of market value in the absence of spectrum reservation). A disadvantage of such analysis is that it takes us away from the reference point of the existing, post-auction spectrum holdings.

2.39 The methods are not identical. In the 2.6 GHz band this is reflected in the results of the methods not being the same, even though they all lie within a fairly narrow range between £4.99m and £5.7m per MHz. But the sources of difference between the methods are much more prominent in the analysis of the 800 MHz band due to the greater importance of various complications than for the 2.6 GHz band. These complications, which are outlined below, lead to substantial differences between some of the results from the different methods for the 800 MHz band.

Complications in our analysis of market value for the purpose of ALF

2.40 Although we noted above that the 4G auction prices are the starting point for our analysis, various complications mean that it is not appropriate to take the auction prices themselves as the most appropriate estimates of market value for the purpose of ALF, especially for the 800 MHz band.

2.41 First, there is the effect on the auction prices for 800 MHz spectrum of **reserve prices** set by Ofcom:

a) Spectrum **reservation** for H3G meant that its auction price for 2x5 MHz in the 800 MHz band was set at the reserve price, below the opportunity cost of this spectrum as a deliberate consequence of the different pricing rule which applied to reserved spectrum.

b) The reserve price also affected the auction price of the 800 MHz spectrum won by EE, Telefónica and Vodafone.

2.42 Second, there are the implications for forward-looking opportunity cost of **changes in circumstances** since the 4G auction:

a) We consider that the **overall spectrum cap** of 210 MHz which applied in the 4G auction should be treated as **non-binding on a forward-looking basis**. This is because of the upcoming availability of additional mobile spectrum, including the 1.4 GHz, 2.3 GHz and 3.4 GHz bands. In our recent consultation on the forthcoming award of 2.3 GHz and 3.4 GHz bands we have also proposed an overall spectrum cap, but at the much higher level of 310 MHz. There is a significant implication for the market value of 800 MHz for the purpose of ALF, because the auction prices and opportunity costs of 800 MHz in the auction were

[37] See Annex 6 for details of the relevant constraints which characterise the LRPs in practice.

affected by the bids of EE whose winning package was at the overall cap. This meant that the opportunity costs in the auction of 800 MHz were reduced, compared to the forward-looking opportunity cost, by EE's value for additional spectrum, reflecting a trade-off between more 800 MHz spectrum and less 2.6 GHz spectrum.

b) We also take account of the possibility that forward-looking market values today are lower than at the time of the 4G auction in 2013 due to **greater certainty of availability** of mobile spectrum in the future, compared to expectations at the time of the auction. We take this into account as one of the possible reasons for our choice of the level of ALFs to be conservative when interpreting the evidence (see Section 1).[38]

2.43 Third, there are the implications for market value of **differences between 800 MHz spectrum in the 4G auction and 900 MHz**, given that our purpose is to derive a market value for 800 MHz to serve as a basis for the value of the 900 MHz band:

a) The pattern of value for additional 800 MHz spectrum may be different from the pattern for 900 MHz given the importance of synergies arising from technical efficiencies in contiguous blocks of 2x10 MHz and 2x20 MHz. In particular, the evidence suggests that EE's value in the auction for an additional 2x5 MHz in the 800 MHz band (to add to the 2x5 MHz it won) included a **contiguity premium**. However, EE has no current holdings of 900 MHz, which means that its value for 2x5 MHz of 900 MHz in addition to its existing spectrum holdings would be its first spectrum in that band to which it may be that no contiguity premium applies. Consequently, when deriving an opportunity cost for a 2x5 MHz increment of 800 MHz for the purpose of ALF, we exclude a contiguity premium.[39]

b) A further important implication is that the opportunity cost of **the 2x5 MHz of 800 MHz that EE won in the auction is not informative** for the purpose of ALF. In the 4G auction, EE was the only material losing bidder for additional 800 MHz spectrum. Telefónica and Vodafone were not permitted to bid for additional 800 MHz spectrum, given that they won 2x10 MHz taking them up to the level of the sub-1 GHz cap in the auction of 2x27.5 MHz (since each had pre-existing holdings of 2x17.4 MHz in the 900 MHz band). H3G chose not to place material bids in the auction for more 800 MHz spectrum than the 2x5 MHz it won. This meant that the opportunity cost of EE's 2x5 MHz of 800 MHz spectrum in the 4G auction to other bidders, i.e. from highest losing bids other than EE's, was very low (only £2.5m per MHz). However, for ALF we are seeking to derive the opportunity cost of the 900 MHz spectrum which is held by Telefónica and Vodafone. On the available evidence of the bids in the 4G auction, the opportunity cost for sub-1 GHz spectrum is set by EE. The opportunity cost in the auction of EE's 2x5 MHz of 800 MHz spectrum to other bidders excludes EE's own bids. As such, it excludes the most informative values for the opportunity cost of 900 MHz.

[38] It is not clear to us that there is a way to derive a sufficiently reliable quantified estimate of this specific effect.

[39] This approach might understate forward-looking opportunity cost because it does not take account of carrier aggregation, which might allow an operator to obtain a proportion of the contiguity premium with two non-contiguous blocks of 2x5 MHz. We explain this point in further detail in paragraph 2.145 below.

2.44 Fourth, there are the implications for opportunity cost of other differences in circumstances between the 4G auction and the ALF bands. The 4G auction was a package auction in which three different spectrum bands were available (800 MHz, paired 2.6 GHz and unpaired 2.6 GHz – for the avoidance of doubt, in this section we use the term "2.6 GHz" to refer to the paired band except when expressly stated). When deriving auction prices or the opportunity cost in the auction, the value derived typically includes the value of rearranging spectrum between bidders. The highest losing bid for additional spectrum might not exactly match the winning package whose price is being derived. For example, EE's highest losing bids for additional 800 MHz spectrum were for packages with less 2.6 GHz spectrum than in its own winning package. This raises two issues:

a) To derive a value for 800 MHz alone, we need to add back the value of this 'lost' 2.6 GHz spectrum.

b) For the auction prices and opportunity costs in the auction, we add back the value of rearrangements. The 2.6 GHz spectrum 'released' by EE (in its highest losing bid compared to its winning package) is rearranged to other bidders when identifying the combination of highest losing bids for the 800 MHz spectrum won in the auction by each of H3G, Telefónica and Vodafone (which we also refer to as the "price-setting combination of packages"). It is rearranged to the bidders (other than EE) who made losing bids for additional 2.6 GHz spectrum.

For the purpose of ALF, such rearrangements could require interdependent, multi-party trades which might be difficult to achieve, given that they would (now) have to take place outside a multi-band auction. Therefore, in the marginal bidder analysis we seek to estimate the opportunity cost of 800 MHz and 2.6 GHz for the purpose of ALF without the value of **rearrangements**.

2.45 Fifth, we are interested in the opportunity cost for the **relevant marginal increment** of spectrum:

a) For the 800 MHz band we consider increments of both 2x5 MHz and 2x10 MHz. These correspond to the blocks of 800 MHz spectrum won in the 4G auction.

b) For the 2.6 GHz band the two highest losing bids in the auction by Telefónica and H3G were both for 2x10 MHz (although in the marginal bidder analysis we also consider the lowest winning bid for 2x5 MHz at the margin). The blocks of 2.6 GHz spectrum won in the 4G auction were larger at 2x15 MHz (Niche), 2x20 MHz (Vodafone) and 2x35 MHz (EE).

2.46 Taking account of these complications, we now set out our analysis of the full market value for the purpose of ALF of, first, the 800 MHz band and, thereafter, the 2.6 GHz band. The complications mean that we derive our estimate of market value of 800 MHz spectrum using a range of methods and evidence, and by applying our regulatory judgement. For the 2.6 GHz band, we use the same range of methods and we also use our judgement, but the evidence is less varied because fewer of the complications are relevant.

Market value of the 800 MHz band for the purpose of ALF

Summary of our analysis

2.47 In this sub-section we summarise our analysis of the market value of the 800 MHz band for the purpose of ALF, which we then set out in greater detail in the

subsequent sub-sections. Except where expressly stated, all market value figures for 800 MHz spectrum in this section are expressed net of expected DTT co-existence costs, reflecting the observed bids in the 4G auction for 800 MHz spectrum. In the concluding sub-section at paragraph 2.184 we set out the market value which is gross of expected DTT co-existence costs. We consider in turn below each of the following analytical steps.

2.48 **Auction prices** for 800 MHz spectrum (£22.5m per MHz for EE and H3G, £27.5m per MHz for Telefónica, and £27.5m or £30.4m per MHz for Vodafone[40]).

2.49 **Opportunity cost in the 4G auction for the purpose of ALF** of 2x5 MHz and 2x10 MHz increments:

a) Initially, we examine the opportunity costs in the auction of the winning packages of H3G and Telefónica respectively. These packages only included 800 MHz spectrum, so there is no complication of needing to decompose a multi-band package amount between the constituent bands. We use these opportunity costs to derive a candidate market value of £30m per MHz as a weighted average of the opportunity costs of these increments: £38.4m per MHz for 2x5 MHz (H3G) and £26.45m per MHz for 2x10 MHz (Telefónica).

b) We also take into account other information on opportunity cost in the auction. We consider the opportunity cost in the auction of the 800 MHz spectrum won by EE (£2.5m per MHz) and decompositions for 800 MHz spectrum of the amount for the multi-band package of spectrum won in the auction by Vodafone (about £26m per MHz), using ASM and the decomposition method. The opportunity cost of EE's 2x5 MHz is not informative of the market value for the purpose of ALF (as discussed at paragraph 2.43b) above); and the opportunity cost of Vodafone's 2x10 MHz is consistent with our candidate value (when averaged with the higher marginal opportunity cost of H3G's 2x5 MHz increment).

2.50 **Linear Reference Prices.** In addition, we compare the candidate market value of £30m per MHz against the following LRPs for 800 MHz: (i) with the auction revenue as a constraint (£26.9m per MHz); (ii) without revenue constraint (£31.2m per MHz); and (iii) with a linear price which avoids excess supply and minimises excess demand (£31m per MHz). We consider that the revenue-constrained LRPs are too low for the purpose of ALF because the auction revenue understates the relevant forward-looking opportunity cost. Especially in these circumstances, we consider that the other LRPs, from (ii) and (iii), provide useful reference points. In our view the LRPs are broadly consistent with the candidate market value of £30m per MHz or suggest it might understate full market value.

2.51 **Differences in circumstances from the 4G auction, and the marginal bidder analysis**. We consider the implications for opportunity costs for the purpose of ALF of differences in circumstances from the 4G auction, specifically: (i) treating the overall cap in the 4G auction of 210 MHz as non-binding on a forward-looking basis; (ii) excluding a contiguity premium when estimating the opportunity cost of a 2x5 MHz increment; and (iii) excluding the value of rearrangements. The first factor, non-binding overall cap, implies higher opportunity cost for the purpose of ALF. The second factor, excluding a contiguity premium, implies lower opportunity cost. The

[40] We report multiple figures for Vodafone, because there is more than one way to decompose its multi-band package price between the constituent bands.

third factor, excluding rearrangements, on its own also implies lower opportunity cost:[41]

a) Our proposed market value for the 800 MHz band in the August 2014 consultation (£32.6m per MHz) was derived from the marginal bidder analysis. We continue to believe this method is informative of market value for the purpose of ALF and, in principle, it allows us to examine the implications of the differences in circumstances from the 4G auction. However, in the light of stakeholder responses on the difficulties in practice of obtaining sufficiently reliable estimates of market value from the marginal bidder analysis for the 800 MHz band, we do not now consider it appropriate to derive a specific quantified estimate from the marginal bidder analysis.

b) Instead we use the perspective of the marginal bidder analysis as a cross-check[42] on the candidate market value of £30m per MHz that we derive from our consideration of opportunity cost in the auction, considering both 2x5 MHz and 2x10 MHz increments. In our view the differences in circumstances from the 4G auction imply significant changes to the marginal opportunity costs of 2x5 MHz and 2x10 MHz increments:

   - For a 2x5 MHz increment (H3G's spectrum), the marginal bidder analysis suggests that the forward-looking marginal opportunity cost relevant to ALF is lower than the opportunity cost in the 4G auction of £38.4m per MHz (due to excluding a contiguity premium).

   - For a 2x10 MHz increment (Telefónica's spectrum) the marginal bidder analysis suggests that the forward-looking marginal opportunity cost relevant to ALF is higher than the opportunity cost in the 4G auction of £26.45m per MHz (due to the overall cap in the 4G auction of 210 MHz being non-binding on a forward-looking basis).

   Taking these implications into account, in our view the available evidence from the marginal bidder analysis suggests that £30m is a reasonable estimate of the market value of the 800 MHz band for the purpose of ALF or tends to suggest it might understate market value.

2.52 Taking account of the evidence and analysis in the preceding analytical steps and applying our regulatory judgement, our view is that an appropriate market value of the 800 MHz band for the purpose of ALF is £30m per MHz. In our view, this is more likely to understate market value than to overstate it (for reasons set out in detail

[41] By "on its own" we mean comparing the position with rearrangements with the position without rearrangements, holding constant other features such as the overall spectrum cap. We explain below that, in the price-setting combination, rearrangements of 2.6 GHz spectrum from EE to other bidders reduced the opportunity cost in the 4G auction compared to the forward-looking value, i.e. when the overall cap in the auction is treated as non-binding on a forward-looking basis (see paragraphs 2.103 to 2.105). But with the overall cap of 210 MHz binding, as in the auction, excluding rearrangements would reduce the opportunity cost.

[42] The nature of this cross-check is that we use a different perspective or method to analyse the same underlying evidence of bids in the 4G auction as we used in deriving the candidate market value (given that reliable, independent evidence which is informative of the market value is not available). Similarly, when we refer to a cross-check of the candidate market value against LRPs, we mean a comparison against a different method of analysing the same underlying evidence.

below and summarised in paragraph 2.186). We now consider each of the analytical steps in greater detail.

Auction prices

2.53 As explained in the preceding summary, our starting point is to consider the auction prices for spectrum acquired in the 800 MHz band. EE and H3G each won 2x5 MHz of 800 MHz spectrum in the 4G auction. Both paid an auction price for this spectrum at the reserve price of £225m (or £22.5m per MHz). Vodafone and Telefónica each won 2x10 MHz of 800 MHz spectrum in the auction:

a) Telefónica's auction price was £550m including a discount of £31m for the coverage obligation.[43] This implies a price without the discount for the coverage obligation of £581m (or £29.05m per MHz). All references to the coverage obligation in the UK in this section (and in Sections 3 to 4 and Annexes 6 to 8) mean the coverage obligation on the 2x10 MHz of 800 MHz spectrum won in the 4G auction by Telefónica (which we refer to in Section 6 as the "800 MHz coverage obligation").

b) Vodafone won a package of spectrum in all three bands in the auction, so its auction price for 800 MHz depends on how its package price is decomposed between the bands. There is no uniquely correct way to derive this decomposition and a range of figures can be derived using different approaches. In the August 2014 consultation we suggested two alternative decompositions with associated prices for 800 MHz as follows (see Annex 6):

   i) £608.5m (or £30.425m per MHz).

   ii) £550.5m (or £27.525m per MHz).[44]

2.54 The reserve price for 800 MHz of £22.5m per MHz influenced the auction prices of all four winners of 800 MHz spectrum – see Table 2.2. This table shows auction prices for Vodafone and Telefónica for each of the two 2x5 MHz amounts in the 2x10 MHz blocks they won in the auction (as in Table 2.3 in the August 2014 consultation).

2.55 The prices were affected by various rules which applied in the 4G auction:

a) The reserve price for 800 MHz of £225m per 2x5 MHz (or £22.5m per MHz).

b) Spectrum reservation for a fourth national wholesaler, which was the 2x5 MHz in the 800 MHz band obtained by H3G (as the only eligible operator that opted in to compete for reserved spectrum).

c) The cap on sub-1 GHz spectrum of 2x27.5 MHz, taking into account both pre-auction holdings and spectrum acquired in the auction. The 2x10 MHz of 800 MHz won by each of Vodafone and Telefónica took them up to the maximum level permitted under this cap, given that each also holds 2x17.4 MHz in the 900 MHz band (for which we are setting the level of ALF in this document).

[43] For the derivation of the discount for the 800 MHz coverage obligation, see paragraph 2.28 in the August 2014 consultation and paragraph A6.117 in Annex 6, the latter referring to the difference in LRPs between A1 and A2 as £31m.

[44] In Annex 6 we also set out a third decomposition of £27.113m per MHz.

d) The cap on overall holdings of mobile spectrum of 210 MHz ("the overall cap") taking into account both pre-auction holdings and spectrum acquired in the auction. The 80 MHz of spectrum won in the auction by EE (comprising 2x5 MHz of 800 MHz and 2x35 MHz of 2.6 GHz) took it up to the maximum permitted under this overall cap, given its holdings of 2x20 MHz in the 2.1 GHz band and 2x45 MHz in the 1800 MHz band (for which we are setting the level of ALF in this document).

Table 2.2: Auction price attributable to 800 MHz

	EE	H3G	Telefónica	Vodafone	Total / average per MHz
First 2x5 MHz	£225m	£225m	£225m	£225m	
Second 2x5 MHz	n/a	n/a	£325m	£383.5m*	
Auction price	£225m	£225m	£550m	£608.5m	£1608.5m
Amount of spectrum	2x5 MHz	2x5 MHz	2x10 MHz	2x10 MHz	2x30 MHz
Average	£22.5m per MHz	£22.5m per MHz	£27.5m^ per MHz	£30.425m per MHz	£26.81m per MHz

Source: Ofcom

* This figure is derived using ASM. With other decompositions of Vodafone's multi-band package price between bands, other amounts attributable to 800 MHz are possible.

^ This figure includes the discount for the coverage obligation – without the discount, the average price would be £29.05m per MHz.

2.56 At the relevant points in the discussion below we explain in more detail the implications of these auction rules for the opportunity cost for the purpose of ALF.

Opportunity costs in the 4G auction for the purpose of ALF

2.57 We now consider the underlying opportunity costs of 2x5 MHz and 2x10 MHz increments. We do so in a way which does not depend on the reserve price since the reserve price was a figure set by Ofcom, not by auction bids.

2.58 To do so, we focus initially on the opportunity cost of the 2x5 MHz of 800 MHz spectrum won by H3G and the 2x10 MHz won by Telefónica. The winning packages of these two bidders only included 800 MHz spectrum and do not raise the same complications that arise for the 800 MHz spectrum won by EE and Vodafone (which requires us to decompose amounts for multi-band packages between the constituent bands). We then consider some possible decompositions of the opportunity costs in the auction of EE's and Vodafone's spectrum. Further details of the derivation of these opportunity costs are set out in Annex 6. Thereafter we explain how we derive our candidate value for 800 MHz spectrum.

Opportunity cost in the 4G auction of H3G's 2x5 MHz of 800 MHz spectrum was £38.4m per MHz

2.59 The opportunity cost to other bidders of the 2x5 MHz of 800 MHz spectrum won in the 4G auction by H3G was £384m (or **£38.4m per MHz**). This opportunity cost comprised EE's value for additional 800 MHz spectrum (i.e. for more than the 2x5 MHz it won in the 4G auction) and the value of rearrangements of 2.6 GHz spectrum from EE to other bidders. The components of the opportunity cost were:

a) £310.5m – EE's incremental bid value (IBV)[45] for an additional 2x5 MHz of 800 MHz and 2x5 MHz less of 2.6 GHz compared to its winning package; plus

b) £128m – Telefónica's IBV for an additional 2x10 MHz of 2.6 GHz compared to its winning package; less

c) £52.5m – Niche's IBV for 2x5 MHz less of 2.6 GHz and an additional 5 MHz of unpaired 2.6 GHz compared to its winning package; less

d) £2m – Vodafone's IBV for 5 MHz less of unpaired 2.6 GHz compared to its winning package.

2.60 We now describe the reason that losing bids for 2.6 GHz spectrum are involved in determining the opportunity cost in the 4G auction of 800 MHz spectrum. Note that the description below relates not to bidders' actual winning packages, but to the price-setting combination (i.e. the packages that constitute the combination of highest losing bids for the 2x5 MHz of 800 MHz spectrum won in the auction by H3G):

a) EE made no losing bid for an additional 2x5 MHz of 800 MHz spectrum on its own. This is because its winning package (2x5 MHz of 800 MHz and 2x35 MHz of 2.6 GHz) was at the overall spectrum cap. Therefore, the driver of the opportunity cost of £384m is the losing bid by EE for a package with an additional 2x5 MHz of 800 MHz but also 2x5 MHz less of 2.6 GHz (i.e. a package of 2x10 MHz of 800 MHz and 2x30 MHz of 2.6 GHz) at an incremental bid value of £310.5m compared to its winning package. But £310.5m is an understatement of the opportunity cost of 800 MHz, because it is reduced by EE's lost value of 2x5 MHz of 2.6 GHz.

b) We need to find the highest losing bid for this 2x5 MHz of 2.6 GHz to add back the lost value of this spectrum and so obtain the opportunity cost of the 2x5 MHz of 800 MHz spectrum. The highest losing bid for 2.6 GHz spectrum is Telefónica's losing bid for 2x10 MHz, not 2x5 MHz, at an incremental bid value of £128m.

c) Therefore, we also need to find the lowest winning bidder to give up 2x5 MHz of 2.6 GHz to put together with the 2x5 MHz from EE and yield a supply of 2x10 MHz of 2.6 GHz to match the highest losing bid from Telefónica for 2x10 MHz. This bidder is Niche, but the smallest bid value is sacrificed by taking Niche's losing bid which involved an additional 5 MHz of unpaired 2.6 GHz as well as 2x5 MHz less of paired 2.6 GHz spectrum at an incremental bid value of £52.5m.

d) There is now a 'spare' 5 MHz of unpaired 2.6 GHz spectrum and the highest losing bidder for this is Vodafone at an incremental bid value of £2m.

2.61 H3G did not pay this opportunity cost of £384m as its auction price; instead, it paid the reserve price, which was £159m lower at £225m. This was because H3G benefited from the competition measure in the 4G auction of reserved spectrum for

[45] As noted above, the IBV is the bidder's difference in bid value between two different packages for a specified increment of spectrum. £310.5m is the IBV between EE's bids for the package of: (i) 2x10 MHz of 800 MHz and 2x30 MHz of 2.6 GHz (bid of £1,360m); and (ii) 2x5 MHz of 800 MHz and 2x35 MHz of 2.6 GHz (its winning package at a bid of £1,049.5m). The increment of spectrum is the difference in spectrum between these two packages, i.e. an additional 2x5 MHz of 800 MHz and 2x5 MHz less of 2.6 GHz.

which it was not required to pay the opportunity cost. There was a specific auction pricing rule that deliberately set a price below opportunity cost for reserved spectrum; and in practice, it was the reserve price.[46] For the purpose of ALF, it is the opportunity cost of H3G's spectrum which is relevant, not the reserve price.[47]

2.62 In contrast, in its response H3G argued that spectrum reservation made auction prices and opportunity costs artificially higher than full market value to other winners of 800 MHz spectrum by restricting the amount of spectrum available to them. By making assumptions about how H3G's bids would have been different in the absence of spectrum reservation (and assuming unchanged bids by other bidders), it argued that: (i) the auction outcome would have been different, with EE winning 2x10 MHz in the 800 MHz band and H3G not winning any 800 MHz spectrum; and (ii) opportunity cost-based auction prices would have been 12%-15% lower in the absence of reserved spectrum.[48]

2.63 However, in our view H3G's response is not addressing the relevant question:

a) First, for the purpose of ALF we are most interested in the opportunity cost relative to existing, post-auction spectrum holdings. By assuming a change in the auction outcome without spectrum reservation, H3G's estimates of new opportunity cost-based prices are not relative to current spectrum holdings. In particular, the opportunity cost in the hypothetical scenario put forward by H3G is relative to EE holding more 800 MHz spectrum than it actually has. This reduces the size of the opportunity cost. In contrast, our figures for the opportunity cost in the auction of 800 MHz are all relative to existing, post-auction spectrum holdings.

[46] The way that H3G chose to bid guaranteed it would win reserved spectrum at the reserve price (£22.5m per MHz), given the specific auction pricing rule. Further information on this point can be found in a paper written by Ofcom's Director of Competition Economics, Geoffrey Myers, in his personal capacity: "The innovative use of spectrum floors in the UK 4G auction to promote competition", Centre for the Analysis of Risk and Regulation, London School of Economics, Discussion Paper 74, November 2013, ISSN 2049-2718, http://www.lse.ac.uk/researchAndExpertise/units/CARR/pdf/DPs/DP74-Geoffrey-Myers.pdf.

[47] We note that in Figure A8.6 in the October 2013 consultation we reported Vodafone's decomposition approach (from its submission in June 2013) with nominal reserve prices (set at £1,000), which includes a figure for the opportunity cost of H3G's spectrum in the presence of the competition constraint (i.e. spectrum reservation) of £13.7m per MHz. However, for the avoidance of doubt, £13.7m per MHz is not the full opportunity cost to other bidders of the spectrum won by H3G. Instead, it is related to the choice of reserved spectrum (or "spectrum floor") won by H3G. As explained in the paper cited at footnote 46:

> "H3G won the spectrum floor of 1xA1 [2x5 MHz of 800 MHz] instead of 4xC [2x20 MHz of 2.6 GHz] because the incremental value in its bids of £165m exceeded the additional opportunity cost to other bidders of £107.156m. (This was an "additional" opportunity cost because it was additional to other bidders' loss in bid value of £276.844m from H3G winning 4xC instead of them winning that as well as all of the other spectrum in the auction.)" [page 19]

The figure of £13.7m per MHz is the core price (collective opportunity cost) related to the Vickrey price (individual opportunity cost) of £107.156m, or £10.7m per MHz, in the quotation above. For a further discussion of core and Vickrey prices in the context of the decomposition method, see Annex 6. The significant point, however, is that the full opportunity to other bidders of the spectrum won by H3G is the sum of the two figures in the quotation above, £107.156m plus £276.844m, i.e. £384m or £38.4m per MHz.

[48] See p. 12-29 in Annex A, Power Auction's report as part of H3G's response to the August 2014 consultation.

b) Second, we do not consider it appropriate for the purpose of ALF to estimate auction prices in the absence of spectrum reservation. Such reservation was an important competition measure in the 4G auction, imposed to promote competition. Whether or not the opportunity cost to other bidders is higher as a consequence, the relevant value for the purpose of ALF should be with the competition measure in place. In our view, therefore, the full market value of ALF spectrum should reflect opportunity cost in the presence of spectrum reservation in the auction, which meant in practice that bidders other than H3G only obtained 2x25 MHz in the 800 MHz band, not the entire band of 2x30 MHz.

2.64 As set out at paragraph 2.55 above, there were three competition measures in the auction: (i) spectrum reservation; (ii) sub-1 GHz cap; and (iii) overall cap. We noted above at paragraph 2.42 that in our view the overall cap of 210 MHz that applied in the auction should be treated as being non-binding on a forward-looking basis. This is because of a change in regulatory circumstances since the 4G auction, specifically the forthcoming availability of more mobile spectrum, such as in the 2.3 GHz and 3.4 GHz bands. This change in circumstances does not affect the rationale in the 4G auction for the other competition measures.[49] We used spectrum reservation because we considered that a fourth national wholesaler, which turned out to be H3G, needed a minimum spectrum holding to be a credible competitor. This is not invalidated by the forthcoming availability of more mobile spectrum. In addition, the further mobile spectrum is in bands that are above 1 GHz, so it does not change the reason we imposed the sub-1 GHz cap in the 4G auction.

Opportunity cost in the 4G auction of Telefónica's 2x10 MHz of 800 MHz spectrum can be estimated as at least £26.45m per MHz (without the discount for the coverage obligation)

2.65 The opportunity cost of Telefónica's 2x10 MHz of spectrum in the 4G auction in the absence of reserve prices can be estimated by deriving what the prices would have been if the reserve price had been set at zero and assuming the same bids as in the actual auction. This assumption of no change in the bids may lead to an underestimate of the opportunity cost, because it is possible that additional or different bids would have been made at incremental bid values below the actual reserve prices (whereas there was no point in making such bids in the actual auction as they could not have affected the winning allocation or prices). For example, purely for the purpose of illustration we note that, if EE had been willing to submit bids for 2x15 MHz of 800 MHz with an IBV for the third 2x5 MHz just below £225m, the results would have been similar to what we see with the reserve price.

2.66 Using this approach, we derive an opportunity cost in the 4G auction, including the discount for the coverage obligation, of at least £498m (or £24.9m per MHz). This is lower than Telefónica's actual auction price of £550m, because we are removing the effect of the reserve price (in the manner described above).

2.67 ALF spectrum is not subject to a coverage obligation similar to the 800 MHz coverage obligation which applies to the spectrum acquired in the auction by Telefónica. Therefore, we are interested for the purpose of ALF in a market value of 800 MHz spectrum in the absence of such a coverage obligation and so without the discount (we consider separately in Section 6 the impact of the geographic coverage

[49] See Assessment of future mobile competition and award of 800 MHz and 2.6 GHz, Statement, July 2012, http://stakeholders.ofcom.org.uk/consultations/award-800mhz-2.6ghz/statement/ ("July 2012 statement on 4G auction").

obligation). As set out at paragraph 2.53a) above, the discount for the coverage obligation in the auction was £31m. Adding this back, we derive an estimate of the opportunity cost in the auction of Telefónica's 2x10 MHz of at least £529m or at least **£26.45m per MHz**. When we discuss below the opportunity cost of Telefónica's 2x10 MHz of 800 MHz spectrum, we mean the value without the discount for the coverage obligation, except where expressly stated.

Other information on opportunity costs in the 4G auction, relating to EE's and Vodafone's 800 MHz spectrum, does not significantly change the estimates for 2x5 MHz and 2x10 MHz increments

2.68 One way to obtain the opportunity costs in the auction of the 800 MHz spectrum in the multi-band packages won by EE and Vodafone is to use ASM.[50] The results of ASM for the 800 MHz spectrum won by all four winners in the 4G auction are shown in Table 2.3. The figures shown are for the incremental value (except in the two rows labelled as averages). So, for example, the ASM results with Telefónica as the excluded bidder are £35.6m per MHz for the first 2x5 MHz and £17.3m for the second 2x5 MHz in the 2x10 MHz block acquired by Telefónica (with an average of these incremental values of £26.45m per MHz).

Table 2.3: ASM results for 800 MHz spectrum interpreted as opportunity costs in the 4G auction (in £m per MHz)

Excluded bidder	First 2x5 MHz	Second 2x5 MHz
EE	£2.499m	n/a
H3G	£38.4m	n/a
Telefónica - incremental	£35.6m	£17.3m
Telefónica – average (2x10 MHz)	£26.45m	
Vodafone - incremental	£38.35m	£14.5m
Vodafone – average (2x10 MHz)	£26.425m	

Source: Ofcom

2.69 The ASM results for H3G's and Telefónica's spectrum (i.e. when each is the "excluded bidder") are the same as the opportunity costs in the auction reported above: £38.4m and £26.45m per MHz respectively. We now discuss in turn the ASM results for EE and Vodafone.

[50] In the August 2014 consultation we described ASM as addressing the question of what would have happened, given the bids made in the auction, if hypothetically there had been more spectrum available in the auction. For example, in computing ASM with Vodafone as the excluded bidder, we excluded Vodafone's auction bids from the analysis and considered the value of additional 800 MHz to the other bidders. In this way ASM estimated a value that the other three bidders, but not Vodafone, placed on additional 800 MHz. In the August 2014 consultation we used ASM to derive a proxy for the value of the same amount of 900 MHz spectrum from Vodafone's holdings. However, another interpretation of the results for 2x10 MHz of 800 MHz with Vodafone as the excluded bidder is the value to other bidders of the spectrum won by Vodafone. This is the opportunity cost in the 4G auction of the 800 MHz spectrum won by Vodafone.

Very low opportunity cost to other bidders in the 4G auction of EE's 2x5 MHz of 800 MHz is not informative of market value for the purpose of ALF

2.70 The ASM result for EE as the excluded bidder in Table 2.3 suggests that the opportunity cost in the auction to other bidders of the 2x5 MHz of 800 MHz spectrum won by EE was very low at only £2.5m per MHz, given the bids made in the auction. This would also have been the price in the absence of reserve prices, assuming no change in the bids made.

2.71 The reason why this opportunity cost in the auction to other bidders - i.e. to bidders other than EE - is so low is that EE was the only material losing bidder for additional 800 MHz spectrum:

a) Telefónica and Vodafone were not permitted to bid in the auction for additional 800 MHz spectrum, i.e. more than the 2x10 MHz they each won (see paragraph 2.43b) above).

b) H3G chose not to place material bids in the auction for more 800 MHz spectrum than the 2x5 MHz it won. The opportunity cost in the auction of £2.5m per MHz reflects H3G's bid for the 2x10 MHz of 800 MHz with coverage obligation which was at a low incremental bid value of £25m (or £2.5m per MHz) compared to its winning package of 2x5 MHz of 800 MHz (without coverage obligation).[51]

2.72 As explained in paragraph 2.43b) above, the opportunity cost in the auction of EE's 2x5 MHz of 800 MHz spectrum to other bidders excludes EE's own bids (by definition) and as such it excludes the most informative value for the opportunity cost of sub-1 GHz spectrum. Therefore, we regard the opportunity cost to other bidders in the 4G auction of EE's 2x5 MHz in the 800 MHz band as not being informative of market value for the purpose of ALF.

Other appropriate decompositions of the package amount of Vodafone's spectrum won in the auction are similar to the opportunity cost in the auction of Telefónica's 2x10 MHz

2.73 The opportunity cost to other bidders of Vodafone's 2x10 MHz depends on the decomposition of the package amount by band, given that Vodafone won a multi-band package.

2.74 In its response Vodafone provided three decompositions for the 800 MHz spectrum in its winning package, using the decomposition method[52] which identifies what the auction prices would have been for smaller sub-packages of the winning package:[53]

a) £528.5m (or £26.425m per MHz).

[51] £25m was the difference in reserve prices between these packages (consistent with H3G's apparent bidding strategy – see the paper referred to in footnote 46 for further details). The opportunity cost in the auction shown in Table 2.3 also deducts the small incremental bid value of £0.001m per MHz of Telefónica between 2x10 MHz with and without coverage obligation. See Annex 6 for details.

[52] The calculation method consists in adding a sufficiently high extra hypothetical bid for a smaller sub-package of the winning package such that Vodafone would win the smaller sub-package. Then, we compare the opportunity cost of winning the smaller sub-package with the opportunity cost of winning a larger package which includes lots for an additional band. The difference corresponds to the opportunity cost of the lots in that additional band. Further details are set out in Annex 6.

[53] Annex 1.2, p. 19, in Vodafone's response.

b) £521.761m (or £26.088m per MHz).

c) £461.183m (or £23.059m per MHz).

2.75 The first decomposition is the same as the ASM result of £26.425m per MHz, shown in Table 2.3 above. It is very similar to the opportunity cost in the auction of the 2x10 MHz won by Telefónica of £26.45m per MHz.

2.76 The second decomposition of £26.088m per MHz, is similar to the ASM result of £26.425m per MHz as it is lower by only about 1%. It is similarly only about 1% lower than the opportunity cost in the auction of the 2x10 MHz won by Telefónica.

2.77 The third decomposition is materially lower than the ASM result, by about 13%. However, in our view this third decomposition is likely to understate market value. We have detailed concerns about the methodological basis on which it is derived, which we set out in Annex 6. As explained in Annex 6, once we adjust for these concerns, this third decomposition becomes the same as the ASM result (i.e. £26.425m per MHz).

2.78 Taking this into account, we consider that the appropriate decompositions of the opportunity cost in the auction of Vodafone's spectrum package for 2x10 MHz of 800 MHz spectrum are similar to the opportunity cost in the auction of the 2x10 MHz won by Telefónica (of £26.45m per MHz).

Average opportunity cost in the 4G auction of 2x5 MHz and 2x10 MHz increments provides a candidate market value of £30m per MHz

2.79 The opportunity costs of 2x5 MHz and 2x10 MHz increments discussed above reflect incremental value in addition to bidders' winning packages, i.e. their value for 800 MHz spectrum in addition to their existing, post-auction spectrum holdings. This makes them, in principle, relevant opportunity costs in the auction for the purpose of ALF (although we also need to assess the implications of relevant differences in circumstances from the 4G auction, which we consider in a later sub-section using the marginal bidder analysis).

2.80 One option would be to take as our range of candidate market values the range between the opportunity costs in the 4G auction of a 2x5 MHz increment (£38.4m per MHz) and a 2x10 MHz increment (about £26m per MHz). We could then assess this range as we undertake the further analytical steps outlined in the summary above, using such further information and analysis to inform our choice of market value from within this range (or as a basis to reject the candidate range). This is indeed the approach we adopt when we assess the market value of the 2.6 GHz band in a later sub-section.

2.81 However, given the complications in the analysis for the 800 MHz band, we do not consider this approach would be informative. First, the range between the opportunity cost in the auction of a 2x5 MHz and a 2x10 MHz increment is wide: the higher figure for a 2x5 MHz increment of £38.4m per MHz is about 45% and £12m per MHz above the lower figure of about £26m per MHz for a 2x10 MHz increment. Second, for reasons explained in greater detail below, the other information or analysis is either not sufficiently relevant or reliable to assist us in choosing an appropriate estimate of market value from within this wide range (e.g. we do not obtain a sufficiently reliable quantified estimate from our marginal bidder analysis).

2.82 A second option would be to take as our candidate value one or other of the opportunity costs in the auction, either for a 2x5 MHz or a 2x10 MHz increment.

2.83 However, we do not adopt this approach - instead we adopt the third option of taking an average of the opportunity costs in the 4G auction of 2x5 MHz and 2x10 MHz increments. In principle, we are interested in the marginal opportunity cost for the relevant increment, not an average. However, we develop a candidate market value using the average of these marginal opportunity costs for two reasons.

2.84 First, for the 800 MHz band, it is not clear whether 2x5 MHz or 2x10 MHz should be regarded as the more relevant marginal increment and there is a case for either. We discuss this issue in greater detail, including stakeholders' responses, in Annex 6. A more pragmatic approach in the circumstances is to consider the average of these marginal opportunity costs.

2.85 Our second reason is the implications of differences in circumstances from the 4G auction relevant to ALF. As set out in greater detail in a later sub-section, when we take account of these differences in circumstances using the marginal bidder analysis, we expect:

a) the opportunity cost of a 2x5 MHz increment to be significantly lower than £38.4m per MHz (due to excluding a contiguity premium); and

b) the forward-looking opportunity cost of a 2x10 MHz increment to be significantly higher than £26m per MHz (due to treating the overall cap in the 4G auction of 210 MHz as being non-binding on a forward-looking basis).

2.86 This means that, if we were to take the lower marginal opportunity cost in the 4G auction of about £26m per MHz for a 2x10 MHz increment as the candidate market value, we would reject it as being too low for the purpose of ALF when we take account of the relevant differences in circumstances from the 4G auction. Similarly, if we were to take the higher marginal opportunity cost in the 4G auction of £38.4m per MHz for a 2x5 MHz increment as the candidate market value, we would reject it as being too high for the purpose of ALF.

2.87 However, we consider that in neither case would we have a sufficiently reliable quantified estimate to use in place of the rejected market value figure. Therefore, in practice, the average opportunity cost in the auction of about £30m per MHz provides a better candidate market value than either of the marginal opportunity costs in the 4G auction.

2.88 To derive this average of £30m per MHz, we take the weighted average of the opportunity costs in the auction for a 2x5 MHz increment and a 2x10 MHz increment, placing twice as much weight on the per MHz figure for 2x10 MHz because it involves twice as much spectrum as 2x5 MHz. We set out above one figure for a 2x5 MHz increment (£38.4m per MHz for the spectrum won by H3G) and three alternative figures for a 2x10 MHz increment (£26.088m, £26.425m or £26.45m per MHz for the spectrum won by Vodafone or Telefónica). Using these alternative figures for a 2x10 MHz increment, the three corresponding alternative weighted averages of the opportunity costs in the auction of a 2x5 MHz increment and a 2x10 MHz increment are £30.19m, £30.42m and £30.43m per MHz. Given the complications in the analysis outlined above (at paragraphs 2.41 to 2.45), we round down to derive our candidate market value of the 800 MHz band for the purpose of ALF of **£30m per MHz**.

2.89 Below we consider this candidate value against the estimates and insights from the other parts of our analysis: initially the LRPs, and thereafter the marginal bidder analysis.

Linear reference prices

2.90 LRPs provide another method to analyse the market value of 800 MHz spectrum in the 4G auction. LRPs seek to provide the best estimates of linear market-clearing prices (i.e. the same per MHz price for all spectrum in a given band), using information on losing bids as well as winning bids. No linear market-clearing prices exist in the case of the 4G auction, because of the synergies in some of the bids, so the LRP method only provides an estimate of linear prices that are closest to market-clearing. Further details of the LRPs are set out in Annex 6.

Revenue-constrained LRPs

2.91 We consider first the revenue-constrained LRPs as they reflect the actual auction revenue which is decomposed into linear prices by band. This method yields an LRP for 800 MHz of £26.89m per MHz.

2.92 In effect, the revenue-constrained LRPs are a revenue attribution method, i.e. a way to decompose the auction revenue into amounts by band (such that multiplying the LRPs by the amount of spectrum in each band would give a total equal to the auction revenue). The revenue-constrained LRPs provide an alternative to the decomposition of auction prices discussed in paragraph 2.53 above. But, whereas that approach yielded multiple alternative figures (in the case of the spectrum won by Vodafone) and different figures for 800 MHz spectrum won by different operators, the revenue-constrained LRPs identify a single figure for each band. In the context of ALFs such an approach has some advantages in principle:

a) It decomposes auction revenue or opportunity cost into linear prices – ALFs will be applied as linear prices.

b) The decomposition into amounts by band identifies the closest linear prices to market-clearing, given the revenue constraint.[54]

c) There is also the potential advantage that the LRP takes account of a wider range of losing bids than other methods, as well as the winning bids, which may allow cross-band effects to be more fully reflected. However, as noted at paragraph 2.37 above, this could also be seen as a disadvantage.

2.93 In practice, in the specific circumstances of the 4G auction, we maintain the view we set out in the August 2014 consultation that these revenue-constrained LRPs are too

[54] In its response H3G said that the linear clearing prices will create revenue that is generally higher than the Vickrey revenue and so restricting clearing prices to generate Vickrey revenue and at the same time approximately clear as many markets as possible pushes the LRPs in some unknown direction. H3G argued that, by separating the two objectives, a pro-rating procedure can be carried out in a controlled way that preserves some of the desirable properties of the clearing prices while adjusting their absolute levels to satisfy the revenue constraint (see p. 41-45 in Annex A, Power Auction's report as part of H3G's response to the August 2014 consultation). We do not consider that H3G's pro-rating procedure is a better approach to derive linear prices when applying a revenue constraint than the LRP algorithm which takes into account losing bids, minimises the excursions and so provides an improved fit with the auction bids.

low as estimates of market value for the purpose of ALFs, because the auction revenue understates the opportunity cost relevant to ALF. This is for three reasons.

H3G's auction price is below market value for the purpose of ALF

2.94 First, H3G's auction price is substantially below market value for the purpose of ALF because it is the reserve price (£22.5m per MHz) for reserved spectrum, not the opportunity cost of that spectrum (£38.4m per MHz). We have discussed this issue above at paragraphs 2.59 to 2.64.

EE's auction price is not informative of market value

2.95 Second, EE's auction price or opportunity cost in the auction is not informative of the market value of 800 MHz for the purpose of ALF. We have discussed this issue above at paragraphs 2.43b) and 2.80 to 2.82.

Telefónica's and Vodafone's auction prices are similar to or below forward-looking market value

2.96 Third, we considered in the August 2014 consultation that Vodafone's and Telefónica's auction prices were below market value due to a packing issue. The packing issue was that EE made no bids in the auction for an additional 2x10 MHz of 800 MHz spectrum (i.e. for packages including 2x15 MHz of 800 MHz spectrum, given that its winning bid was for 2x5 MHz). But EE made bids well above the reserve price for an additional 2x5 MHz (packages including 2x10 MHz) and for an additional 2x15 MHz (packages including 2x20 MHz). This meant that part of the auction price of Vodafone and Telefónica was the reserve price, not a losing bid (see Table 2.2), even though in general there was excess demand for 800 MHz spectrum at the reserve price.

2.97 Some stakeholders argued that the absence of bids from EE was a reflection of EE's incremental value for a third 2x5 MHz of 800 MHz being lower than the reserve price. Telefónica and Vodafone argued that there was no packing issue, as without reserve prices the price-setting combination does not involve any unsold 800 MHz spectrum. Instead the opportunity cost reflects EE's value for an additional 2x15 MHz of 800 MHz spectrum, with 2x5 MHz being rearranged from H3G to EE (and 2x15 MHz in the 2.6 GHz band being rearranged from EE to other bidders plus rearrangements of other 2.6 GHz spectrum).

2.98 In our analysis of Vodafone's and Telefónica's auction prices we now distinguish more clearly between: (i) opportunity costs in the auction; and (ii) differences in circumstances from the 4G auction.

2.99 *Opportunity cost in the auction*. We agree that a reasonable inference from the available evidence is that EE's incremental bid value for a third 2x5 MHz of 800 MHz was below the reserve price. We set out above opportunity costs in the 4G auction of Vodafone's and Telefónica's 2x10 MHz in the 800 MHz band which are below the respective auction prices. For example, we can compare the opportunity costs in the 4G auction of £26.425m and £26.45m per MHz for Vodafone and Telefónica

respectively in Table 2.3 against the auction prices of £30.425m and £29.05m per MHz respectively in Table 2.2.[55]

2.100 In our view, the observation that these opportunity costs in the 4G auction are below the auction prices reflects the existence of the packing issue we described in the August 2014 consultation. In general, there was excess demand for 800 MHz at the reserve price. But the *pattern* of that excess demand from EE, for an additional 2x5 MHz or an additional 2x15 MHz, did not fit together well with the size of the 2x10 MHz blocks of 800 MHz spectrum won by each of Telefónica and Vodafone. This does not mean we should ignore the absence of bids from EE for an additional 2x10 MHz of 800 MHz spectrum (given the reserve price). But it does imply that careful interpretation is needed, in the factual context that the opportunity cost in the auction of 2x5 MHz and 2x15 MHz increments of 800 MHz spectrum are both significantly higher than for a 2x10 MHz increment. The opportunity cost in the auction of a 2x15 MHz increment is about £30m per MHz.[56]

2.101 *Differences in circumstances from the 4G auction*. We consider that the opportunity cost in the 4G auction of Vodafone and Telefónica is below market value for the purpose of ALF because, for the purpose of ALF, we treat the overall cap in the 4G auction of 210 MHz as being non-binding on a forward-looking basis.

2.102 The opportunity cost in the auction is determined by the highest losing bids for the specific package being considered. In essence, the opportunity cost in the 4G auction is reduced compared to the forward-looking value by EE's highest losing bid involving a trade-off between additional 800 MHz and less 2.6 GHz spectrum, because its winning package was at the overall cap in the auction of 210 MHz. This trade-off, when identifying the combination of highest losing bids, results in a significant reduction in value compared to the forward-looking opportunity cost, because the bids from EE for 2.6 GHz spectrum were significantly higher than from other bidders.

2.103 An illustration of the significance of this effect on opportunity cost is provided by a disaggregation of the opportunity cost in the auction of £38.4m per MHz for a 2x5 MHz increment into:

a) EE's incremental bid value for an additional 2x5 MHz of 800 MHz spectrum of £46.1m per MHz; less

b) lost bid value from rearrangements in the 2.6 GHz band due to EE's trade-off at the overall cap of £7.7m per MHz.[57]

[55] We refer here to the opportunity cost and auction price for Telefónica without the discount for the coverage obligation so it is a like-for-like comparison.

[56] See the ASM results reported in Table A6.8 in Annex 6: £30.72m per MHz for a 2x15 MHz increment with Vodafone as the excluded bidder; and £29.48m per MHz with Telefónica as the excluded bidder.

[57] EE's incremental bid value of £31.05m per MHz, which is a key component of the opportunity cost of £38.4m per MHz (see paragraph 2.59 above), can be disaggregated using observed bids into +£46.1m per MHz for an additional 2x5 MHz of 800 MHz spectrum and -£15.05m per MHz for a reduction of 2x5 MHz of 2.6 GHz spectrum. The figure of £46.1m per MHz is derived as EE's bid for the package in the price-setting combination of £1,360m (2x10 MHz of 800 MHz and 2x30 MHz of 2.6 GHz) less its bid of £899m for the package with 2x5 MHz less of 800 MHz; and the figure of -£15.05m per MHz is EE's bid for this package less the bid for its winning package of £1,049.5m which includes an additional 2x5 MHz of 2.6 GHz. The net incremental bid value to other bidders for 2x5 MHz of 2.6

2.104 In other words, on a forward-looking basis with the overall cap in the 4G auction treated as non-binding, EE would not face the trade-off which triggers the lost bid value from rearrangements in the 2.6 GHz band from EE to other bidders, and the opportunity cost of 800 MHz spectrum would be significantly higher. For a 2x10 MHz increment, as won by each of Telefónica and Vodafone, there is a greater amount of 2.6 GHz spectrum rearranged from EE to other bidders (2x15 MHz) in the price-setting combination. This means there is an even larger reduction in the opportunity cost of 800 MHz spectrum from rearrangements of 2.6 GHz spectrum than is the case for a 2x5 MHz increment compared to the forward-looking value (see also paragraphs 2.154 to 2.155 below).

2.105 In the marginal bidder analysis we treat the overall cap in the 4G auction of 210 MHz as being non-binding. In the context of the ALF bands this means that, on a forward-looking basis, EE does not have to face a stark trade-off between acquiring 900 MHz spectrum and giving up some of its existing spectrum holdings. When considering market value for 800 MHz and 2.6 GHz as a basis for the value of spectrum in the ALF bands, this corresponds to value-reducing rearrangement in the 2.6 GHz band being avoided when assessing the forward-looking opportunity cost relevant to ALF of 800 MHz spectrum. Instead the opportunity cost in the marginal bidder analysis reflects EE's value for additional 800 MHz on its own.

2.106 We explain below that the evidence from the marginal bidder analysis is consistent with a market value of a 2x10 MHz increment of £30m per MHz or tends to suggest that it may understate market value. This compares to Telefónica's auction price (without the discount for the coverage obligation) of £29.05m per MHz and Vodafone's auction price of £27.1m, £27.5m or £30.4m per MHz (depending on the decomposition, as set out above and in further detail in Annex 6). Therefore, based on the marginal bidder analysis, the forward-looking opportunity cost of 800 MHz spectrum for the purpose of ALF is likely to be similar or at least as high as the auction prices paid by Telefónica and Vodafone.

Our view on revenue-constrained LRPs

2.107 Overall, therefore, we consider that the 4G auction prices are below forward-looking market value when considered for the specific purpose of ALF. The consequence is that revenue-constrained LRPs are too low as estimates of market value for the purpose of ALF.

LRPs without revenue constraint

2.108 LRPs without revenue constraint seek to identify the best estimate of linear market-clearing prices, taking as given the bids made in the 4G auction (but not constraining the sum of the LRPs). The LRP without revenue constraint for the 800 MHz band is £31.2m per MHz.

2.109 H3G's response in effect argued that the relevant question for market value is the outcome in a uniform-price auction (in this context we use the terms "uniform price" and "linear price" interchangeably). It suggested that the LRPs without revenue constraint are inappropriate because it would not expect such prices to be achieved in a uniform-price auction. This is because the bids made in the 4G auction were dependent on the non-linear, second-price rule that applied. With the different pricing

GHz is £7.35m - see paragraphs 2.59b) to d). In this disaggregation, therefore, the lost bid value from rearrangements in the 2.6 GHz band is £7.35m less £15.05m per MHz, i.e. -£7.7m per MHz.

rule of linear (uniform) prices, H3G, drawing on the revenue equivalence theorem and the existing economic literature, argued we might expect bidders to have made different bids, in particular to have shaded their bids.

2.110 However, we do not consider that the LRPs without revenue constraint are an attempt to estimate the outcome of a linear (or uniform) price auction, as H3G suggested (nor is this our interpretation of full market value). Instead the conceptual underpinning for these LRPs is a competitive equilibrium in which all operators are price takers. Furthermore, we do not know how bidders would behave in a linear-price version of the 4G auction. For example, the conditions for the revenue equivalence theorem do not hold in the circumstances relevant to the 4G auction;[58] and the economic literature that H3G referred to does not consider the relevant circumstances of bidders with values that include synergies.

2.111 We do not consider that the LRP without revenue constraint is a definitive estimate of market value. But we maintain our view in the August 2014 consultation that it provides a useful reference point, especially in the specific circumstances of the 4G auction with revenue-constrained LRPs that understate market value for the purpose of ALFs. This LRP of £31.2m per MHz exceeds our candidate market value of £30m per MHz by £1.2m per MHz or 4%.

Linear price that avoids excess supply and minimises excess demand

2.112 We have also considered a variation of the LRPs without revenue constraint. As noted above, there are no linear market-clearing prices, and this means that the LRP method identifies linear prices that can involve excess demand or excess supply in each of the bands (see Annex 6 for further details). We have identified a set of linear prices that avoids excess supply in any band and minimises the excess demand. We describe this method and the derivation of the results in greater detail in Annex 6.

2.113 The linear price for the 800 MHz band with this method is £31m per MHz, which in our view also provides a useful reference point for a similar reason as for the LRP without revenue constraint.

2.114 This linear price of £31m per MHz exceeds our candidate market value of £30m per MHz by £1m per MHz or 3%.

Our view on cross-check of candidate value against LRPs

2.115 Given our further analysis, we now have three linear prices for the 800 MHz band relating to bids in the 4G auction:

a) LRP with revenue constraint of £26.89m per MHz;

b) LRP without revenue constraint of £31.2m per MHz; and

[58] The revenue equivalence theorem states that, under the specific assumptions of risk neutral bidders with independent valuations, the expected revenues from any Bayesian incentive compatible mechanism yielding efficient outcomes are the same. However, the bidders in the 4G auction may not have been risk neutral, nor had independent valuations. Furthermore, a uniform price version of the 4G auction would not have been an incentive compatible mechanism. Therefore, the revenue equivalence theorem does not apply.

c) Linear price that avoids excess supply and minimises excess demand of £31m per MHz.

2.116 In our view, the revenue-constrained LRP is below market value for the purpose of ALF. Especially in these circumstances, we consider that the latter two results provide useful reference points. We note that they both exceed our candidate market value of £30m per MHz. Therefore, we consider that the LRPs are broadly consistent with the candidate market value or suggest it may understate full market value.

Differences in circumstances from 4G auction, and marginal bidder analysis

Reasons for deviating from opportunity costs in 4G auction

2.117 There are specific reasons for deviating from the opportunity costs in the 4G auction due to differences in the circumstances applicable to ALF spectrum compared to the 4G auction.

Treating the overall cap in the 4G as non-binding on a forward-looking basis

2.118 First, the opportunity cost of 800 MHz spectrum in the 4G auction significantly understates the relevant forward-looking opportunity cost due to the impact of the overall cap on EE. This is relevant because of our view of the change in regulatory circumstances since the 4G auction, such that it is more appropriate to treat the overall cap as non-binding on a forward-looking basis, given the forthcoming availability of further mobile spectrum.

2.119 We explained in the August 2014 consultation that the overall spectrum cap of 210 MHz only formally applied at the time of the 4G auction. On a forward-looking basis as more mobile spectrum becomes available (e.g. 1.4 GHz, 2.3 GHz and 3.4 GHz bands), we would not expect EE to be precluded from acquiring some more spectrum. To put the point starkly, treating the overall spectrum cap in the 4G auction as binding on a forward-looking basis would imply that EE would not be permitted to acquire any spectrum in the auction for the 190 MHz of spectrum in the 2.3 GHz and 3.4 GHz bands planned for late 2015 or early 2016. Or, more directly relevant for this document, it would also imply that EE would not be permitted to acquire any 900 MHz spectrum (without also relinquishing an equal amount of spectrum in other bands of spectrum that it currently holds). In our view, it would not be a reasonable assumption for the purpose of ALF to restrict EE only to its current overall spectrum holdings, given that more spectrum will soon be available for mobile use (although our view is not dependent on the precise date of this award).

2.120 Consistent with this view, we recently published proposals on an overall spectrum cap to apply in the forthcoming award for 2.3 GHz and 3.4 GHz spectrum.[59] The proposed cap is 310 MHz, compared to the overall spectrum cap which applied in the 4G auction of 210 MHz.[60] Therefore, the proposals would permit EE to acquire up to

[59] Public Sector Spectrum Release, Award of the 2.3 GHz and 3.4 GHz bands, Consultation, 7 November 2014, http://stakeholders.ofcom.org.uk/binaries/consultations/2.3-3.4-ghz-auction-design/summary/2_3_and_3_4_GHz_award.pdf (the "PSSR award consultation").

[60] We explained why our competition assessment for the 4G auction did not rely on the 1.4 GHz, 2.3 GHz and 3.4 GHz bands in paragraphs A2.74-A2.76 and A2.80-A2.84 in the July 2012 Statement on 4G auction. The reasons why we consider these bands relevant for the purpose of the spectrum cap proposed in the forthcoming award are set out in paragraphs 7.53-7.63 in the PSSR award consultation.

100 MHz of spectrum in addition to its current holdings. In our marginal bidder analysis we consider EE being able to acquire a further 10 or 20 MHz of additional 800 MHz spectrum as a proxy for 900 MHz (reflecting increments of 2x5 MHz and 2x10 MHz respectively) without having to trade off this additional spectrum for less 2.6 GHz spectrum.[61]

2.121 Some respondents disagreed with our approach to the overall cap. For example, Vodafone argued that it pre-judged a competition analysis if EE were to acquire 900 MHz spectrum, and that in any case we had not set out any competition analysis to support our view.

2.122 However, as noted above, since the August 2014 consultation we have published the PSSR award consultation, in which we set out a competition analysis to support our proposal for an overall cap of 310 MHz.[62]

2.123 We discuss further below the implications for market value of the overall cap in the 4G auction of 210 MHz being treated as non-binding on a forward-looking basis.

Excluding a contiguity premium

2.124 Our second reason to deviate from the opportunity costs in the 4G auction arises because we are using our figure for the market value of 800 MHz to inform the market value of 900 MHz. This suggests that, for an increment of spectrum of 2x5 MHz, there is a case for a lower value which **excludes a contiguity premium** that is reflected in EE's value for additional 800 MHz spectrum in the 4G auction (see paragraph 2.43a) above).

Excluding the value of rearrangements

2.125 Third, we consider it is reasonable to exclude the value of **rearrangements** (see paragraph 2.44).

[61] One possible complication is that, by acquiring 2x5 MHz or 2x10 MHz of additional spectrum, EE could in future be constrained by any future spectrum caps which Ofcom might set in future spectrum awards. EE would be constrained if any such future caps proved to be a binding constraint on EE. If this were the case, then there might be an opportunity cost to EE of acquiring the additional spectrum. In the limit, for example, it could mean that EE would only be able to acquire an equivalent amount less of spectrum in the future award than it wished. In such circumstances, there could be a case to reduce the estimate of EE's value of the additional 800 MHz spectrum by the potentially lost value to EE of an equivalent amount of spectrum in the future award. However, first, it is not clear to us that the relevant circumstances necessarily apply for such a reduction in the estimate. Second, we do not consider that we have evidence to usefully quantify the size of any reduction.

[62] Consistent with our analysis of competition measures for the 4G auction, there are three types of competition concern regarding spectrum holdings, aligned with the three competition measures in the auction (see paragraphs 2.55 and 2.64 above): (i) spectrum reservation to seek to ensure minimum spectrum holdings for at least four credible national wholesalers; (ii) sub-1 GHz cap; and (iii) overall cap. The rationale for the two spectrum caps was to mitigate the risk of highly asymmetric holdings of respectively sub-1 GHz and overall spectrum after the auction leading to lower competitive intensity (see paragraph 1.10 in our July 2012 statement on 4G auction). In the PSSR award consultation we explicitly considered the first and third concerns. As to the distribution of sub-1 GHz spectrum, EE's existing holdings are only 2x5 MHz at 800 MHz, so if it were to acquire some 900 MHz spectrum: first, its holdings would still be well below the level of the sub-1 GHz cap; and second, there would tend to be a reduction in the asymmetry of sub-1 GHz spectrum holdings.

Marginal bidder analysis can take account of these differences in circumstances

2.126 In principle, the marginal bidder analysis allows us to take account of the differences in circumstances from the 4G auction identified above. The marginal bidder analysis involves examining the bids from bidders for more spectrum than they won in the auction. It focuses, in a band-by-band assessment, on the bidder that had the highest value for additional 800 MHz spectrum (EE) or additional 2.6 GHz spectrum (Telefónica) for which it was a losing bidder. As such, it uses information on highest losing bids.

2.127 Our starting point in the marginal bidder analysis is to consider the value bidders expressed for more spectrum in addition to their post-auction spectrum holdings, i.e. relative to their winning packages. This is especially relevant for the purpose of ALF as explained above (see paragraphs 2.31 and 2.36), Our discussion of the marginal bidder analysis is structured as follows:

a) First, we outline the significant practical difficulties in applying the marginal bidder analysis to the 800 MHz band.

b) Second, we discuss the suggestions made by stakeholders about strategic bidding by EE.

c) Third, we consider marginal opportunity costs for a 2x5 MHz increment.

d) Fourth, we consider marginal opportunity costs for a 2x10 MHz increment.

e) Thereafter, we assess the analysis put forward by Vodafone to suggest that treating the overall cap in the 4G auction of 210 MHz as being non-binding does not lead to higher market values.

f) Finally, we explain our view on using the marginal bidder analysis as a cross-check to the candidate market value of £30m per MHz.

2.128 We comment on stakeholder responses about the marginal bidder analysis at the relevant points in the discussion below (or, in some cases, our comments are set out in Annex 6).

Practical difficulties

2.129 We now outline the practical difficulties in applying the marginal bidder analysis to the 800 MHz band, which are discussed in greater detail in the later sub-sections below. Before describing these difficulties, we show in Table 2.4 the main evidence we use in the marginal bidder analysis. This table shows the demand for 800 MHz in the 4G auction of the highest losing bidder for additional 800 MHz spectrum, EE.

2.130 The figures in this table are EE's incremental bid values for different amounts of 800 MHz spectrum in packages with varying amounts of 2.6 GHz spectrum. For example, the first column shows EE's incremental bid values for 2x5 MHz of 800 MHz (with each row showing the bid value in a package also including the specified amount of 2.6 GHz spectrum). The second column shows the incremental bid value for a further 2x5 MHz (i.e. for a package including a contiguous block of 2x10 MHz of 800 MHz spectrum). EE made no bids for 2x15 MHz blocks in the third column, but it did bid for 2x20 MHz blocks in the fourth column. Table 2.4 shows the average incremental bid value for the third and fourth 2x5 MHz taken together in the 2x20 MHz block.

2.131 EE's winning package is shown in the bottom left-hand corner of Table 2.4. We are especially interested in EE's value to acquire additional 800 MHz spectrum, which are the neighbouring cells highlighted in the bottom row of Table 2.4 (bordered by a solid line).

Table 2.4: EE's demand (IBVs) for 800 MHz spectrum[63] in £m per MHz

Packages with:	First 2x5 MHz (1xA1)	Second 2x5 MHz (2xA1)	Third 2x5 MHz (3xA1)	Fourth 2x5 MHz (4xA1)
No 2.6 GHz (0xC)	£23.0m	£42.0m	£26.33m	
2x5 MHz of 2.6 GHz (1xC)	dnb	dnb	dnb	dnb
2x10 MHz of 2.6 GHz (2xC)	£23.0m	£60.5m	£29.02m	
2x15 MHz of 2.6 GHz (3xC)	£23.0m	£55.59m	£26.65m	
2x20 MHz of 2.6 GHz (4xC)	£23.0m	£50.55m	£32.63m	
2x25 MHz of 2.6 GHz (5xC)	£23.0m	£49.12m	dnb	np
2x30 MHz of 2.6 GHz (6xC)	£27.5m	£46.1m	np	np
2x35 MHz of 2.6 GHz (7xC)	£35.3m*	**np**	**np**	np

Source: Ofcom

dnb EE did not bid for this package
np EE was not permitted to bid for this package by the overall spectrum cap in the 4G auction of 210 MHz
* EE's winning package

2.132 The first practical difficulty is that the marginal bidder analysis may yield different figures for different marginal increments of 2x5 MHz and 2x10 MHz, and there is a case for using either increment. We discuss the choice of marginal increment in Annex 6, and in later sub-sections we consider the implications of the marginal bidder analysis for both increments of 2x5 MHz and 2x10 MHz.

2.133 Second, in practice, the marginal bidder analysis involves the use of proxies and assumptions, because the most relevant information is not directly observed. EE's winning package was at the overall spectrum cap that applied in the 4G auction. This cap meant that EE could acquire at most 2x40 MHz in the auction, i.e. no more than eight 2x5 MHz lots which could comprise any combination of 800 MHz and 2.6 GHz spectrum. The packages that, as a result of the cap, EE was not permitted to bid for are the cells showing "np" in the bottom right-hand section of Table 2.4, which are bordered by the dotted line. Therefore, in practice, the marginal bidder analysis involves using bid data to estimate proxies for bids that EE was not permitted to make in the auction, which (as noted above) are the highlighted cells in the final row of Table 2.4. Similarly, in practice to estimate the relevant value excluding a contiguity premium involves proxy estimates, not directly observed bids (as discussed in more detail below).

[63] Table 2.4 only shows EE's IBVs for 800 MHz spectrum without coverage obligation (lot category A1), not the IBVs for 800 MHz spectrum with coverage obligation (A2). It also only shows IBVs for packages including 800 MHz and paired 2.6 GHz (lot category C), as in EE's winning package, not packages with unpaired 2.6 GHz spectrum (E). In lot categories A1 and C, the size of each lot was 2x5 MHz.

2.134 Third, there is a range of drivers of bid values which complicates the interpretation of the available evidence (see the further discussion in paragraphs 2.160 to 2.166 below).

2.135 Some of these practical difficulties were emphasised by stakeholders in their responses. Taking account of responses (and in contrast to the August 2014 consultation) we no longer derive quantified estimates for the market value of 800 MHz from the marginal bidder analysis. The most important reasons for the difference in our approach compared to the August 2014 consultation, which we discuss further below, are as follows (reflecting the absence of directly observed bids):

a) We take account of the value of both 2x5 MHz and 2x10 MHz increments (whereas in the August 2014 consultation, we only relied on the 2x10 MHz increment). However, it is difficult to obtain a sufficiently reliable quantified estimate of a 2x5 MHz increment excluding a contiguity premium.

b) We now use a wider range of evidence to inform the value of a 2x10 MHz increment (whereas in the August 2014 consultation, we only used one specific EE incremental bid value).

2.136 Therefore, instead of a quantified analysis using the marginal bidder analysis, we use it to apply a cross-check. In particular, we consider whether the candidate market value of £30m per MHz derived above appears reasonable from the perspective of the marginal bidder analysis.

Suggestions about strategic bidding by EE

2.137 In their responses H3G, Telefónica and Vodafone suggested that EE's bids were inflated by strategic bidding and argued that this needed to be taken into account in the marginal bidder analysis (or that it provided a reason for not relying on this method).

2.138 We distinguish between stakeholders' arguments about strategic investment and price driving:

a) Strategic investment is where a bidder, with the aim of foreclosing downstream competition, bids above its intrinsic value of spectrum to prevent it being acquired by the bidder's downstream competitors.[64] A possibility for strategic investment, consistent with arguments put forward by Vodafone, relates to EE's incremental bid value of £35.3m per MHz in its winning bid for its first 2x5 MHz of 800 MHz in a package with 2x35 MHz of 2.6 GHz (see the first column in the bottom row of Table 2.4), which took EE up to the limit of the overall spectrum cap.

b) Price-driving is where a bidder overstates its true demand to raise the auction prices paid by other bidders. A suggestion of price driving put forward by H3G[65], Telefónica[66] and Vodafone[67] relates to EE's incremental bid value of £32.63m per MHz for a third and fourth 2x5 MHz lots of 800 MHz in addition to a package of

[64] We distinguish here between intrinsic value and strategic investment value to a bidder. Intrinsic value is the bidder's value of the spectrum in the absence of strategic considerations.

[65] See p. 10 of H3G's response to our August 2014 consultation.

[66] See p. 5 of Telefónica's response to our August 2014 consultation.

[67] See p. 8 of Vodafone's response to our August 2014 consultation.

> 2x10 MHz of 800 MHz and 2x20 MHz of 2.6 GHz (which we used as our proposed market value for the 800 MHz band in the August 2014 consultation). These respondents argued that EE had little or no chance of this being a winning bid and so it was inflated to increase prices paid by competitors (although we note that, in the event, it did not in fact set any auction prices).

2.139 We comment in Annex 6 on the detail of the arguments put forward by H3G, Telefónica and Vodafone, explaining why we do not agree with their suggestions.

2.140 We also asked EE to provide its response to these arguments. EE explained that it did not engage in strategic bidding:

> "… we can confirm that all of EE's bids made in the auction were within our valuation for the relevant spectrum, i.e. within what Ofcom refers to as "intrinsic value". Furthermore, our valuations did not incorporate any elements relating to the value of depriving other parties usage of the spectrum concerned (e.g. by weakening a competitor) nor to increasing the costs of our competitors"[68]

2.141 Bids at or below intrinsic value do not constitute price driving. Bids that do not include valuations relating to weakening competition do not constitute strategic investment.

2.142 Based on the available evidence, we do not consider that we should ignore or adjust EE's bids because of the suggestions about strategic bidding made by various stakeholders.

Marginal bidder analysis of opportunity cost of 2x5 MHz increment

2.143 The differences in circumstances relating to the overall cap, contiguity premium and rearrangements imply that the opportunity cost in the auction set out above for a 2x5 MHz increment of £38.4m per MHz is likely to be too high compared to the value of 2x5 MHz to serve as a basis for 900 MHz. Although there are effects in different directions, as explained below, the exclusion of a contiguity premium seems likely to lead on balance to a lower value, even taking into account the overall cap in the 4G auction being non-binding on a forward-looking basis.

2.144 For a 2x5 MHz increment, from the marginal bidder analysis we expect the market value of 800 MHz for the purpose of ALF to be somewhat below £35.3m per MHz to the extent there is a declining marginal value of spectrum. £35.3m per MHz is EE's incremental bid value for the 2x5 MHz of 800 MHz spectrum which it won in the auction. This is a relevant reference point, because it was EE's first acquisition of sub-1 GHz spectrum and, as such, does not include a contiguity premium. However, to the extent that there is a declining marginal value of spectrum[69] (and in the absence of other effects on value), we would expect the value of an additional 2x5 MHz without contiguity premium to be lower than £35.3m per MHz. The candidate market value of £30m is £5.3m per MHz (or 15%) lower than £35.3m. We consider this is a reasonable allowance for a declining marginal value of spectrum.

[68] EE's Letter to Ofcom, 13 November 2014 (responding to an Ofcom letter of 28 October 2014). http://stakeholders.ofcom.org.uk/binaries/consultations/annual-licence-fees-further-consultation/Letter_to_Ofcom_from_EE.pdf

[69] As explained in paragraph A6.69 of the August 2014 consultation, we include the "coverage premium" when discussing the underlying marginal value of sub-1 GHz spectrum.

2.145 In principle, the contiguity premium, or a proportion of it, might be obtained using carrier aggregation. This enables a network to operate a single carrier using spectrum from different frequency bands. For example, both EE and Vodafone have deployed carrier aggregation between respectively 1800 MHz / 2.6 GHz and 800 MHz / 2.6 GHz bands.[70] The relevant carrier aggregation in the context of ALF would be between two 2x5 MHz blocks from each of the 800 MHz and 900 MHz bands. With the current technology we would not expect such carrier aggregation to realise the same technical efficiencies as could be achieved with a contiguous 2x10 MHz block in the same band. But there would be the potential for at least a significant proportion of the contiguity premium to be realised, depending on these technical issues and the extent of availability of suitable handsets. By not reflecting this potential, our analysis of the value of a 2x5 MHz increment may understate full market value on a forward-looking basis.

Vodafone's marginal bidder analysis

2.146 Vodafone's marginal bidder analysis decomposed EE's incremental bid values for 800 MHz spectrum into two parts: (i) generic value and (ii) premium value (e.g. contiguity premium or a premium related to strategic bidding). In order to decompose the incremental bid values, Vodafone used two alternative methods. Both methods assumed that the generic value of spectrum declines linearly but that the premium value is constant going from 1 to 2 blocks, as going from 3 to 4 blocks. Method A assumed the premium is constant in *absolute* terms, whereas method B assumed it is a constant *proportion* of the total value. The rate of decline is measured between EE's values for its first and second 2x10 MHz blocks of 800 MHz.

2.147 We have concerns about the reliability of Vodafone's model (as we discuss further below from paragraph 2.169). Here we consider two issues: the value taken as the starting point, and the estimate of declining marginal value.

2.148 Vodafone's marginal bidder analysis[71] used as a starting point the average value for EE's first 2x5 MHz of 800 MHz in its various package bids (see the first column of Table 2.4), i.e. the mean of £24.9m or the median of £23m per MHz. This is the largest reason for the difference between our marginal bidder analysis and the figures that Vodafone obtained from its version of the marginal bidder analysis.

2.149 In our view, £35.3m per MHz provides a much more appropriate starting point to estimate the full market value of 800 MHz spectrum for the purpose of ALF than either the mean of £24.9m or the median of £23m per MHz, as used by Vodafone. The key difference is that £35.3m per MHz is the incremental bid value for 800 MHz spectrum in EE's winning bid in the auction. The mean or the median relate to values for 800 MHz spectrum on average in smaller packages, i.e. to less spectrum than EE actually holds. We have also addressed above the suggestion by Vodafone that this bid of £35.3m per MHz was inflated by strategic bidding.

2.150 We show in Table 2.5 the rate of decline in the marginal value of spectrum derived by applying Vodafone's approach of methods A and B, described above. Vodafone focused on the declining marginal value with mean and median values. We also show in the table the rate of declining marginal value, when methods A and B are applied to EE's bids for differing amounts of 800 MHz in packages with specific

[70] See paragraphs 5.100-5.102 in Ofcom's Infrastructure Report 2014, December 2014, http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2014/infrastructure-14.pdf.

[71] See Vodafone's response to August 2014 consultation, Annex 1.1.

amounts of 2.6 GHz spectrum. Since the method involves comparing the rate of decline between EE's values for its first and second 2x10 MHz blocks of 800 MHz, this cannot be applied to packages with more than 2x20 MHz of 2.6 GHz spectrum. In those packages there is an absence of bids by EE for a second 2x10 MHz block of 800 MHz (because the overall cap in the auction did not allow EE to make such bids). The figures for declining marginal value in Table 2.5 can be compared to the gap of £5.3m between our starting point of £35.3m and our candidate value of £30m per MHz.

Table 2.5: Declining marginal values (in £m per MHz) using Vodafone's methods A and B

	Method A	Method B
Mean	£5.4m	£3.5m
Median	£5.1m	£3.2m
Packages with no 2.6 GHz	£3.1m	£2.2m
Packages with 2x10 MHz of 2.6 GHz	£6.4m	£3.5m
Packages with 2x15 MHz of 2.6 GHz	£6.3m	£3.7m
Packages with 2x20 MHz of 2.6 GHz	£2.1m	£1.3m

Source: Ofcom using Vodafone's response to the August 2014 consultation

2.151 We need to exercise caution in interpreting the figures in Table 2.5, given our concerns about Vodafone's model. However, we note that most of the figures in Table 2.5 are significantly smaller than the £5.3m gap between our starting point of £35.3m and our candidate value of £30m per MHz.

Marginal bidder analysis of opportunity cost of 2x10 MHz increment

2.152 The opportunity cost in the auction set out above for a 2x10 MHz increment of about £26m per MHz is likely to be too low compared to the forward-looking market value of 2x10 MHz to serve as a basis for 900 MHz. This is because the overall cap in the 4G auction of 210 MHz being non-binding on a forward-looking basis implies a higher value.

2.153 As explained above at paragraphs 2.103 to 2.106, the auction prices and opportunity cost of 800 MHz spectrum in the 4G auction were reduced, compared to the forward-looking values, by EE's incremental values for additional 800 MHz spectrum reflecting a trade-off with less 2.6 GHz spectrum at the overall cap of 210 MHz.

2.154 In the discussion above we provided an illustration of the reduction in bid value for a 2x5 MHz increment. Here we provide an illustration for a 2x10 MHz increment. The opportunity cost in the 4G auction of Telefónica's 2x10 MHz in the 800 MHz band (excluding the discount for the coverage obligation) was £529m or £26.45m per MHz. This opportunity cost comprised EE's value for additional 800 MHz spectrum and the value of rearrangements of 2.6 GHz spectrum from EE to other bidders, as follows:

a) £748.5m – EE's IBV for an additional 2x15 MHz of 800 MHz and 2x15 MHz less of 2.6 GHz compared to its winning package; less

b) £165m – H3G's IBV for an additional 2x20 MHz of 2.6 GHz and 2x5 MHz less of 800 MHz compared to its winning package; less

c) £52.5m – Niche's IBV for 2x5 MHz less of 2.6 GHz and an additional 5 MHz of unpaired 2.6 GHz compared to its winning package; less

d) £2m – Vodafone's IBV for 5 MHz less of unpaired 2.6 GHz compared to its winning package.

2.155 To illustrate the amount of bid value that is lost, compared to the forward-looking value, by rearrangements due to EE's trade-off at the overall cap in the 4G auction, we can disaggregate EE's IBV of £748.5m into an IBV:

a) for an additional 2x15 MHz of 800 MHz spectrum (£1,158m); and

b) for a similar reduction in 2.6GHz spectrum (-£409.5m) due to a trade-off at the overall cap.[72]

This IBV for additional 800 MHz spectrum is £38.6m on a per MHz basis, much higher than the opportunity cost in the auction of £26.45m per MHz.[73]

2.156 Whilst we expect an increase in opportunity cost compared to that observed in the 4G auction, it is not straightforward to derive a reliable quantified estimate. For a 2x10 MHz increment, we now explain why we no longer consider that our estimate in the August 2014 consultation from the marginal bidder analysis of £32.63m per MHz is sufficiently reliable.

2.157 In particular, a reasonable representation of the value we are seeking to estimate is EE's incremental value for an additional 2x10 MHz of 800 MHz spectrum relative to its winning package which included 2x5 MHz. This is the average of the two highlighted (bordered) cells in the bottom row of Table 2.4. However, as shown in that table, EE did not make these bids in the 4G auction (indeed it was not permitted to do so, because of the overall cap of 210 MHz that applied in the auction). Therefore, there is an absence of directly observed bids for the relevant increment of spectrum of 2x10 MHz in addition to EE's winning package.

2.158 Evidence from directly observed bids is set out in Table 2.6 which shows the same information as in Table 2.4 but in a slightly different format. It sets out EE's directly observed bids for its first and second 2x10 MHz blocks in packages with different amounts of 2.6 GHz spectrum. The value we wish to estimate for the 2x10 MHz increment, additional to EE's winning package, is shown by the highlighted (bordered) cell in the bottom row of the table.

2.159 To the extent there is a declining marginal value of spectrum, we might expect EE's values for the first 2x10 MHz of 800 MHz to be above the value of the 2x10 MHz increment to EE's winning package; and the values for the second 2x10 MHz to be below the relevant opportunity cost.

[72] The IBV for 2x15 MHz of additional 800 MHz spectrum of £1,158m is the difference between EE's bid of £1,798m for the package of 2x20 MHz of 800 MHz and 2x20 MHz of 2.6 GHz and its bid of £640m for the package of 2x5 MHz of 800 MHz and 2x20 MHz of 2.6 GHz. The IBV for the reduction of 2x15 MHz of 2.6 GHz spectrum of -£409.5m is the difference between EE's bid of £640m for the latter package and its bid of £1,049.5m for its winning package of 2x5 MHz of 800 MHz and 2x35 MHz of 2.6 GHz.

[73] In this illustration of the value lost from rearrangements, the difference between £38.6m and £26.45m per MHz may reflect rearrangements in the 800 MHz band (from H3G to EE) as well as rearrangements in the 2.6 GHz band.

2.160 There are likely to be other relevant considerations, when interpreting the available evidence. For example, in the August 2014 consultation and in Annex 6 we suggest that cross-band effects and financial constraints might also be relevant to incremental bid values.

Table 2.6: EE's demand (IBVs) for 2x10 MHz blocks of 800 MHz spectrum in £m per MHz

Packages with:	First 2x5 MHz (1xA1)	Second 2x5 MHz (2xA1)	Third 2x5 MHz (3xA1)	Fourth 2x5 MHz (4xA1)
No 2.6 GHz (0xC)	£32.50m		£26.33m	
2x5 MHz of 2.6 GHz (1xC)	dnb		dnb	
2x10 MHz of 2.6 GHz (2xC)	£41.75m		£29.02m	
2x15 MHz of 2.6 GHz (3xC)	£39.30m		£26.65m	
2x20 MHz of 2.6 GHz (4xC)	£36.77m		£32.63m	
2x25 MHz of 2.6 GHz (5xC)	£36.06m		dnb	np
2x30 MHz of 2.6 GHz (6xC)	£36.80m		np	np
2x35 MHz of 2.6 GHz (7xC)	£35.3m*	**np**		np

Source: Ofcom

dnb EE did not bid for this package
np EE was not permitted to bid for this package by the overall spectrum cap in the 4G auction of 210 MHz
* EE's winning package

Cross-band effects

2.161 In its response EE[74] referred to a "complementarity premium" in its bids, which meant that the value of a larger package of both 800 MHz and 2.6 GHz spectrum was significantly higher than the sum of the values of the two corresponding smaller, single-band packages. This is a **cross-band effect**, in this case a synergy value between spectrum in different bands (although there can also be cross-band effects reflecting substitutability between bands). For example, using EE's definition of a complementarity premium, the bid for its winning package included such a premium of £123m, because it bid:

a) £1,049.5m for a multi-band package of 2x5 MHz of 800 MHz and 2x35 MHz of 2.6 GHz (EE's winning package), which is larger than the sum of:

b) £230m for a single-band package of 2x5 MHz of 800 MHz; and

c) £696.5m for a single-band package of 2x35 MHz of 2.6 GHz.

2.162 It is not straightforward reliably to derive the cross-band effect associated with the unobserved values we wish to estimate.

2.163 EE noted that we conducted the marginal bidder analysis on EE's bids by holding constant the number of lots of 2.6 GHz spectrum at four (i.e. 2x20 MHz). It said that

[74] EE's response to the August 2014 consultation, p. 24-28.

by doing so we were incorrectly assigning to the marginal 2x10 MHz of 800 MHz certain amounts of value (i.e. the complementarity premium) which relate to EE's valuation of the package as a whole. It claimed that this calculation is over and above EE's intrinsic value for the additional 800 MHz spectrum. Also, EE proposed three options to take into account the complementarity premium when estimating the value of 800 MHz for the purpose of ALF.

2.164 We disagree that a complementarity premium should be excluded when assessing the full market value of 800 MHz for the purpose of ALF. The complementarity premium we include in our marginal bidder analysis is an important feature in the spectrum value analysis given the pattern of bids in the 4G auction and it reflects observed cross-band effects. In our analysis we consider incremental bid values which include only complementarities that are causally related to (i.e. realised by) that spectrum increment. In our view, removing the complementarity premium from our analysis would understate full market value.

Budget constraints

2.165 We noted the evidence of **budget constraints** in the August 2014 consultation, and the consequent risk that some auction bids may understate the full market value of the spectrum (see paragraph 2.88 in that document). Since then, EE has also told us that its bids were influenced by a financial constraint ("budget cap").[75] In a combinatorial clock auction (the auction format used for the 4G auction), a bidder can respond to a budget cap in different ways. One way is to reduce the number of packages it bids for. Another is to include bids for packages in which it is interested, and avoid any bid that exceeds its financial constraint. If so, the bidder will express IBVs which differ from its true incremental values for the spectrum. For example, it may compress all IBVs below true values; or it may reduce IBVs for some packages by more than others, perhaps maintaining some IBVs at or close to true values.

2.166 The range of ways in which a bidder may respond to a budget cap complicates the interpretation of the available evidence and makes it more difficult reliably to derive the unobserved bid values we wish to estimate.

Our view from marginal bidder analysis of 2x10 MHz increment

2.167 Given the various issues discussed above, we have not derived a specific quantified estimate of EE's value for a 2x10 MHz increment of 800 MHz spectrum additional to its existing, post-auction holdings (reflecting its winning package) which we consider would be sufficiently reliable to serve as a basis for ALF.

2.168 However, we note that all EE's incremental bid values for 2x10 MHz blocks of 800 MHz in packages with larger amounts of 2.6 GHz of at least 2x20 MHz (compared to its winning package of 2x35 MHz) are significantly in excess of £30m per MHz – see Table 2.6. Therefore, we consider that the available evidence is consistent with our candidate market value of £30m per MHz or tends to suggest that it may understate full market value.

Vodafone's marginal bidder analysis

2.169 We noted in the August 2014 consultation that, if Vodafone's model is used to estimate the value of a 2x10 MHz increment, it implied a value between about £32m

[75] Letter from Inge Hansen of EE to Geoffrey Myers of Ofcom, 13 November 2014.

and £35m per MHz. The contiguity premium implied by Vodafone's model accounted for roughly half of this value (between 44% and 51%).

2.170 The results implied by Vodafone's model for a 2x10 MHz increment are therefore consistent with our candidate market value of £30m per MHz being an understatement. However, we do not place significant weight on this point because we have concerns about the reliability of Vodafone's model. We noted in the August 2014 consultation that, when Vodafone's model with its proposed parameter values (e.g. for the size of the contiguity premium) is compared to EEs actual bids, it provided an inaccurate prediction of those bids. This suggested to us either that the model and/or the parameter values were unreliable. For example, the model used by Vodafone might omit material drivers of bid values, such as cross-band effects or budget constraints; or the assumptions made by Vodafone in order to derive parameter values might be incorrect. We also noted that the size of the contiguity premium implied in Vodafone's model of more than £30m per MHz was especially inaccurate for some of EE's actual bids, e.g. it was significantly overstated for the largest packages which were most relevant for the purpose of ALF.

2.171 Vodafone[76] said that its model did not seek to predict each and every bid by EE. It argued that, most significantly, the model estimated usage value of generic spectrum, and excluded the separate elements associated with a contiguity premium or strategic bidding. Departures from the model were likely to occur in bids for the largest packages, which were most subject to strategic investment or price driving.

2.172 We remain concerned about the reliability of the model proposed by Vodafone, as illustrated by the errors when the model is use to predict EE's observed bids. We do not consider that Vodafone's suggestion that strategic bidding explains these errors addresses our concerns about omitted drivers of bid value or incorrect parameter values, especially given our assessment above of the evidence on strategic bidding by EE.

Overall cap and hypothetical analysis in Vodafone's response

2.173 Vodafone provided a hypothetical analysis of what might have happened if the overall cap in the 4G auction had been higher at 220 MHz or 230 MHz, by making assumptions about hypothetical bids by EE for larger packages. It argued this analysis showed that relaxing the overall cap makes no significant difference to the opportunity costs of 800 MHz spectrum.[77]

2.174 However, in our view, Vodafone's analysis poses the wrong question and consequently draws the wrong inference for the purpose of ALF. The relevant question is not what would have happened in the 4G auction had the overall cap been different. The overall cap was set at 210 MHz and we are not suggesting this was incorrect. Instead our view is that there has been a change in regulatory circumstances since the 4G auction with the forthcoming availability of additional mobile spectrum, such as at 1.4 GHz, 2.3 GHz and 3.4 GHz. This means that, *on a forward-looking basis*, an overall cap set as low as 210 MHz is no longer appropriate.

2.175 One issue, therefore, is that Vodafone's hypothetical analysis assumes a different outcome in the 4G auction than actually occurred, and then it assesses opportunity costs relative to the hypothetical winning packages in the auction, not the actual

[76] See Vodafone's response to the August 2014 consultation, Annex 1, p. 12.

[77] Annex 1.3 in Vodafone's response.

winning packages (which reflect existing post-auction spectrum holdings). For example, in Vodafone's hypothetical analysis (with an assumed overall cap at 230 MHz, 20 MHz higher than the actual cap in the 4G auction) EE is assumed to win a package of 2x5 MHz of 800 MHz and 2x45 MHz of 2.6 GHz spectrum. This is 2x10 MHz more of 2.6 GHz spectrum than EE actually won,.

2.176 The consequence is that, in Vodafone's hypothetical analysis, the opportunity costs still reflect EE making a trade-off between more 800 MHz and less 2.6 GHz spectrum, because EE's assumed winning package is at the level of the assumed overall cap of 230 MHz. In contrast, in our view the significance of the overall cap of 210 MHz being non-binding is that EE would not need to face this stark trade-off on a forward-looking basis (see paragraphs 2.119 to 2.120). Without the trade-off, using Vodafone's assumptions about EE's hypothetical bids, the opportunity cost is significantly higher at more than £30m per MHz, as we now explain.

2.177 Table 2.7 shows some of the hypothetical bids for EE which are assumed by Vodafone in its analysis (in italics and red font). If we apply the marginal bidder analysis, the opportunity costs of 2x5 MHz and 2x10 MHz increments relative to EE's actual winning package in the 4G auction (which reflects its current, post-auction holdings), are as follows as shown in the highlighted (bordered) cells:

a) 2x5 MHz increment: £43.425m per MHz

b) 2x10 MHz increment: (£43.425m + £22.5m) ÷ 2 = £32.96m per MHz

Table 2.7: Marginal bidder analysis including hypothetical bids for EE assumed in Vodafone's response (in £m per MHz)

Packages with:	First 2x5 MHz (1xA1)	Second 2x5 MHz (2xA1)	Third 2x5 MHz (3xA1)	Fourth 2x5 MHz (4xA1)
No 2.6 GHz (0xC)	£23.0m	£42.0m	*£22.5m*	*£30.162m^*
2x5 MHz of 2.6 GHz (1xC)	dnb	dnb	dnb	dnb
2x10 MHz of 2.6 GHz (2xC)	£23.0m	£60.5m	*£22.5m*	*£35.548m^*
2x15 MHz of 2.6 GHz (3xC)	£23.0m	£55.59m	*£22.5m*	*£30.8m^*
2x20 MHz of 2.6 GHz (4xC)	£23.0m	£50.55m	*£22.5m*	*£42.752m^*
2x25 MHz of 2.6 GHz (5xC)	£23.0m	£49.12m	*£22.5m*	*£49.487m*
2x30 MHz of 2.6 GHz (6xC)	£27.5m	£46.1m	*£22.5m*	*£52.369m*
2x35 MHz of 2.6 GHz (7xC)	£35.3m*	*£43.425m*	*£22.5m*	dnb
2x40 MHz of 2.6 GHz (8xC)	*£34.199m*	*£41.552m*	dnb	dnb
2x45 MHz of 2.6 GHz (9xC)	*£37.447m*	dnb	dnb	dnb

Source: Ofcom using Annex 1.3 of Vodafone's response

* EE's winning package
^ These IBVs are implied by actual bids by EE observed in the auction given the assumption about the hypothetical IBV for the third A1 (for which EE did not place any actual bids)
dnb EE did not bid for this package and no hypothetical bid is assumed by Vodafone

2.178 The opportunity cost of a 2x10 MHz increment (on which Vodafone focused) is about 10% higher than the candidate market value of £30m per MHz in this hypothetical analysis of EE's values for additional 800 MHz spectrum. The opportunity cost of a 2x5 MHz increment is substantially higher than £30m per MHz (by 45%), although this figure includes a contiguity premium.

2.179 Clearly there are limits to a hypothetical analysis of EE's value for additional 800 MHz spectrum (and Vodafone itself recognised limitations in its assumptions about EE's hypothetical bids). However, in our view, this exercise is consistent with our analysis of the implications of the overall cap of 210 MHz which applied in the 4G auction being non-binding on a forward-looking basis. It is not inconsistent with our candidate market value of £30m per MHz. Indeed, to the extent that such hypothetical analysis is informative, it tends to suggest that £30m per MHz may understate full market value for the purpose of ALF.

Our view on using the marginal bidder analysis as a cross-check on the candidate market value of £30m per MHz

2.180 In principle, the marginal bidder analysis allows us to take account of differences in circumstances from the 4G auction which are relevant to ALF spectrum: (i) treating the overall cap in the 4G auction of 210 MHz as non-binding on a forward-looking basis; (ii) excluding a contiguity premium when assessing the market value of a 2x5 MHz increment; and (iii) excluding the value of rearrangements. However, the practical difficulties, in particular the absence of directly observed bids by EE for the most relevant packages, mean that we do not derive sufficiently reliable quantified estimates from our marginal bidder analysis.

2.181 Nevertheless, we consider it is still informative to apply a cross-check on the reasonableness of our candidate market value of £30m per MHz using the perspective of the marginal bidder analysis for each of 2x5 MHz and 2x10 MHz increments:

a) 2x5 MHz increment: we expect the market value to be below £35.3m, allowing for a declining marginal value of spectrum. Our candidate value is £5.3m per MHz or 15% below this level, which we consider provides a reasonable allowance.

b) 2x10 MHz increment: EE's incremental bid values are significantly in excess of £30m per MHz for 2x10 MHz blocks of 800 MHz in packages with at least 2x20 MHz of 2.6 GHz spectrum (compared to its winning package of 2x35 MHz).

2.182 In our view, this cross-check using the marginal bidder analysis suggests that £30m per MHz is a reasonable figure for the market value of 800 MHz for the purpose of ALF or tends to suggest that it may understate market value.

Provisional decision on market value of the 800 MHz band for the purpose of ALF

2.183 For the reasons set out above (and summarised at paragraphs 2.47 to 2.51 above, we are minded to conclude that an appropriate market value of 800 MHz spectrum for the purpose of ALF is £30m per MHz.

2.184 This is an amount which is net of expected DTT co-existence costs, reflecting the observed bids in the 4G auction for 800 MHz spectrum. Such costs do not apply to the ALF bands, 900 MHz and 1800 MHz. Therefore, for the purpose of ALF we are interested in the market value of the 800 MHz band gross of expected DTT co-existence costs. As set out in detail in Annex 6, our view from the evidence is that the gross value is £3m per MHz higher than the net amount. This is because of the way that the marginal bidder for 800 MHz spectrum, EE, took account of expected DTT co-existence costs in its auction bids, which affect in a similar way each of the auction prices, opportunity costs in the auction, LRPs and marginal bidder analysis.

Our view, therefore, is that an appropriate market value of 800 MHz spectrum for the purpose of ALF, gross of expected DTT co-existence costs, is £33m per MHz.

2.185 We recognise that the analysis of the forward-looking market value of the 800 MHz band for the purpose of ALF involves significant complications, which we summarised above at paragraphs 2.41 to 2.45. One consequence of these complications is that some of the methods we examine (auction prices, opportunity costs in the auction and LRPs) do not take account of all the relevant considerations. Another is that, whilst in principle the marginal bidder analysis could take into account the relevant differences in circumstances from the 4G auction, the difficulties in practice mean that we do not derive a quantified estimate from our marginal bidder analysis that in our view is sufficiently reliable.

2.186 This means it is not straightforward to make a definitive assessment of the risk of understatement or overstatement in our market value figure of £30m per MHz (net of expected DTT co-existence costs). Nevertheless we consider there are a number of reasons why £30m per MHz is more likely to understate market value than to overstate it, including the following:[78]

a) Assuming zero reserve prices may yield an underestimate of the opportunity costs in the auction for Telefónica's and Vodafone's 2x10 MHz blocks - see paragraph 2.65 above.

b) £30m per MHz is below the LRP without revenue constraint (£31.2m per MHz) and the linear price that avoids excess supply and minimises excess demand (£31m per MHz) - see paragraphs 2.111 and 2.114 above.

c) We take no account of the potential for at least a proportion of the contiguity premium to be realised even with a 2x5 MHz increment through carrier aggregation between spectrum in the 800 MHz and 900 MHz bands - see paragraph 2.145 above.

d) For a 2x10 MHz increment, all EE's incremental bid values for 2x10 MHz of 800 MHz in packages with at least 2x20 MHz of 2.6 GHz are above £30m per MHz - see paragraph 2.168 above.

e) The evidence of budget constraints in the 4G auction suggests there is a risk that some auction bids, including those by EE (the marginal bidder for additional 800 MHz spectrum), may understate the full market value of the spectrum - see paragraph 2.165 above.

Market value of the 2.6 GHz band for the purpose of ALF

Summary of our analysis

2.187 To derive the market value of the 2.6 GHz band, we consider the same analytical steps as in our analysis of 800 MHz spectrum:

a) Auction prices for 2.6 GHz spectrum. These generally fall in the range of £5.1m to £5.7m per MHz (although there are decompositions of Vodafone's package auction price which are lower at £3.8m and £4.3m per MHz).

[78] A possible effect in the opposite direction is set out in footnote 61 above.

b) Opportunity cost in the auction for 2.6 GHz spectrum. We use these opportunity costs to derive a range of candidate market values of £5.1m to £5.7m per MHz.

c) Linear reference price for 2.6 GHz: (i) with the auction revenue as a constraint (£4.99m per MHz); (ii) without revenue constraint (£5.7m per MHz); and (iii) linear price which avoids excess supply and minimises excess demand (£5.5m per MHz). We compare the range of candidate market values against these LRPs, taking into account that the revenue-constrained LRPs understate opportunity costs in the 4G auction.

d) Differences in circumstances from the 4G auction. We use the marginal bidder analysis to consider the implications for marginal opportunity costs of the relevant marginal increment, and we exclude the value of rearrangements. As in the August 2014 consultation, when interpreting the evidence we derive a conservative estimate of £5.5m per MHz.

e) Taking account of the evidence and analysis in the preceding analytical steps, we are minded to conclude that an appropriate market value of the 2.6 GHz band for the purpose of ALF is £5.5m per MHz.

2.188 There are a couple of differences in the detail of how we apply these analytical steps for 2.6 GHz compared to 800 MHz spectrum. These reflect the absence for the 2.6 GHz band of most of the complications that arise in the analysis of 800 MHz set out above. For reasons set out in greater detail below:

a) We derive a range of candidate values from the opportunity costs in the auction (not a single candidate value); and

b) We derive sufficiently reliable quantified estimates from the marginal bidder analysis for the 2.6 GHz band, which we use to inform our choice of market value from within the range of candidate values.

Auction prices

2.189 There were three winners in the auction of 2.6 GHz spectrum: EE (2x35 MHz), Vodafone (2x20 MHz) and Niche (2x15 MHz). These bidders all won a multi-band package. We derive more than one figure for 2x20 MHz and 2x15 MHz blocks because there are alternative decompositions of Vodafone's and Niche's package prices by band.

2.190 The auction prices of this spectrum in £m per MHz were as follows (see Table A6.6 in Annex 6 for further details):

a) 2x15 MHz (Niche): £5.12m or £5.28m per MHz.

b) 2x20 MHz (Vodafone): £3.81m, £4.25m, £5.46m or £5.70m[79] per MHz.

c) 2x35 MHz (EE): £5.20m per MHz.

[79] The two highest losing bids for 2.6 GHz spectrum were for 2x10 MHz increments by Telefónica (£128m) and H3G (£100m). These two highest losing bids together constitute this decomposition of Vodafone's auction price for its 2x20 MHz block of 2.6 GHz spectrum (£228m or £5.70m per MHz).

Opportunity costs in the 4G auction

2.191 Unlike the 800 MHz band, auction prices for 2.6 GHz spectrum are also generally reflective of opportunity costs in the 4G auction, as they were not affected by the reserve price for the 2.6 GHz band. However, there are some differences of detail in the decompositions of the package amounts of Niche and Vodafone (which are affected by the reserve price for 800 MHz).

2.192 The opportunity costs in the auction were as follows (see Table A6.23 in Annex 6 for further details):

a) 2x15 MHz (Niche): £5.11m or £5.28m per MHz.

b) 2x20 MHz (Vodafone): £5.29m, £5.46m or £5.70m per MHz.

c) 2x35 MHz (EE): £5.20m per MHz.

Candidate market values

2.193 The first option to derive candidate market values is to take the range of opportunity costs in the 4G auction as the basis for our range of candidate market values; and then to assess this range against each of LRPs and the marginal bidder analysis, using that further analysis to inform our choice of market value. This is the approach we adopt for the 2.6 GHz band.

2.194 The second option would be to take one specific opportunity cost as the candidate market value. The third option would be to derive a candidate value by taking an average of different measures of opportunity cost. We used this third approach in the context of the 800 MHz band above.

2.195 The reasons we consider it appropriate to adopt the first approach for the 2.6 GHz band, despite rejecting it as not being informative for the 800 MHz band, reflect the material differences in circumstances between the analysis of market value for 2.6 GHz compared to 800 MHz spectrum:

a) Unlike the 800 MHz band, the range of the opportunity cost in the auction is relatively narrow, £5.1m to £5.7m per MHz.

b) For the 2.6 GHz band, again unlike the 800 MHz band, the further analysis, in particular the marginal bidder analysis, is sufficiently reliable for us to obtain a quantified estimate that assists us in deriving an appropriate estimate of market value from within this range.

2.196 Therefore, we take as our range of candidate values for the market value of the 2.6 GHz band the range given by the decompositions of opportunity costs in the auction of £5.1m to £5.7m per MHz.

Linear reference prices

2.197 The range of candidate values compares to LRPs as follows (see Annex 6 for further details of the derivation of these linear prices).

2.198 The revenue-constrained LRP (at actual auction revenue) is £4.99m per MHz. This is below our range of candidate market values, but we consider that the auction revenue, and hence also the revenue-constrained LRPs, understate opportunity cost

in the auction relevant to ALF (for the reasons set out above, when discussing the 800 MHz band at paragraphs 2.93 to 2.107). Consistent with this view, we note that the revenue-constrained LRP at £4.99m per MHz lies below nearly all of the other evidence we use, including the auction prices for 2.6 GHz spectrum.

2.199 Our view that the revenue-constrained LRPs understate opportunity cost in the auction is the key reason why we consider that the value of 2.6 GHz spectrum suggested by each of EE (£4.99m), Telefónica (£4.95m) and H3G (£3.57m) understates market value (see Table 2.1 above or Table 2.9 below for a summary of stakeholders' suggested values). EE derived its suggested value from the revenue-constrained LRP; Telefónica used it (in conjunction with the estimates from other approaches); and H3G derived its figure from an analysis using an even lower revenue constraint (we have explained our reasons for disagreeing with H3G's approach at paragraph 2.63 and footnote 54 above, in the context of the 800 MHz band).

2.200 The LRP without revenue constraint is £5.7m per MHz. This is at the top-end of our range of candidate values.

2.201 The linear price that avoids excess supply and minimises excess demand is £5.5m per MHz. This lies within our range of candidate values.

2.202 In our view the above cross-check against LRPs is consistent with our range of candidate market values.

Marginal bidder analysis

2.203 For the marginal bidder analysis, in contrast to the 800 MHz band, we can directly observe bids from the marginal bidders for 2.6 GHz for spectrum additional to their winning packages. This suggests that the practical difficulties which mean that we do not derive sufficiently reliable estimates from the marginal bidder analysis for 800 MHz do not apply to the same extent to the 2.6 GHz band. Furthermore, the marginal bidder analysis can explore the marginal opportunity cost of 2.6 GHz for the relevant marginal increment.

2.204 In our view the marginal bidder analysis of 2.6 GHz in the August 2014 consultation remains valid – see paragraphs 2.78 to 2.81 in that document, which are repeated below.

2.205 The highest losing bidder for the 2.6 GHz band was Telefónica at £6.4m per MHz for a 2x10 MHz block. This suggests that the marginal increment for 2.6 GHz is 2x10 MHz, not a smaller 2x5 MHz increment. The next highest losing bid was also for a 2x10 MHz block (by H3G at £5m per MHz).

2.206 It might also suggest that the market value of 2.6 GHz spectrum should be £6.4m per MHz, the highest losing bid. However, there is a material complication – there is no linear market-clearing price, given the bids made in the auction (as is also the case for the 800 MHz band).

2.207 A price below £6.4m per MHz would imply excess demand in the band, because it would fail to choke off the demand for 2x10 MHz by Telefónica, the highest losing bidder. But whilst a higher price would achieve that, it would also involve less demand than in the winning allocation by one of the winners, Niche, by 2x5 MHz, leading to excess supply in the band. This is because Niche's IBV for the last 2x5 MHz in the 2x15 MHz block it won in the auction was only £5.5m per MHz.

2.208 This means that any price above £5.5m per MHz would lead to this reduced demand by Niche of 2x5 MHz. Below £6.4m per MHz it would be more than offset by the extra demand for 2x10 MHz by Telefónica, leading to excess demand in the band (by 2x5 MHz). But a higher price than £6.4m per MHz would result in excess supply for the band (of 2x5 MHz).[80] Therefore, in our view, there is a risk that £5.5m per MHz may understate market value. Nevertheless we prefer this estimate because we consider that we should adopt a conservative approach when interpreting the evidence.

Provisional decision on market value of the 2.6 GHz MHz band for the purpose of ALF

2.209 The result of the marginal bidder analysis of £5.5m per MHz lies within our range of candidate values. We consider that the marginal bidder analysis is sufficiently reliable for 2.6 GHz spectrum. We are minded to conclude that an appropriate market value of the 2.6 GHz band for the purpose of ALF is £5.5m per MHz.

Provisional decision on market values of 800 MHz and 2.6 GHz for the purpose of ALF

2.210 Tables 2.8 and 2.9 provide a summary of the various estimates of market value of the 800 MHz and 2.6 GHz bands provided by stakeholders (see also Table 2.1 above), along with the figures from our analytical steps and the conclusions we are minded to reach (and, for comparison, our proposals in the August 2014 consultation).

2.211 For the reasons set out above (summarised in paragraphs 2.47 to 2.52), we are minded to conclude that an appropriate forward-looking market value for the 800 MHz band for the purpose of ALF, net of expected DTT co-existence costs, is £30m per MHz (compared to £32.63m per MHz in the August 2014 consultation). The corresponding value gross of expected DTT co-existence costs is £33m per MHz (compared to £35.63m per MHz in the August 2014 consultation).

2.212 For the reasons set out above (see paragraphs 2.187 to 2.209), we are minded to conclude that an appropriate market value for the 2.6 GHz band for the purpose of ALF is £5.5m per MHz (which is the same as our proposal in the August 2014 consultation).

2.213 We consider these estimates are more likely to understate than overstate market value for the reasons set out in paragraphs 2.186 and 2.208.

[80] A set of non-linear prices was needed to clear the market for the 2.6 GHz band, given the bids made in the 4G auction.

Table 2.8: Market value of 800 MHz spectrum in £m per MHz (net of expected DTT co-existence costs)[81]

	Provisional decision	August 2014 consultation	EE	H3G	Telefónica	Vodafone	BT
Proposals for 800 MHz	**£30m**	£32.63m	£26.89m	£25m	£25m	£17.9m - £21.4m	£32.63m
Spectrum won in 4G auction			2x5 MHz	2x5 MHz	2x10 MHz	2x10 MHz	n/a
4G auction prices for 800 MHz			£22.5m*	£22.5m*	£27.5m^	£27.1m, £27.5m or £30.4m	n/a
Opportunity cost in 4G auction	£30m~		£2.5m#	£38.4m	£26.45m	£26.1m or £26.4m	n/a
LRP with revenue constraint	£26.89m	£26.89m					
LRP without revenue constraint	£31.2m	£31.2m					
Linear price avoiding excess supply	£31.0m						

Source: Ofcom

* Reserve price
^ This figure includes the discount for the coverage obligation – without the discount, the average price would be £29.05m per MHz
~ Average of 2x5 MHz and 2x10 MHz increments
# We consider this opportunity cost is not informative for the purpose of ALF

Table 2.9: Market value of 2.6 GHz spectrum in £m per MHz

	Provisional decision	August 2014 consultation	EE	H3G	Telefónica	Vodafone	BT
Proposals for 2.6 GHz	**£5.5m**	£5.5m	£4.99m	£3.57m	£4.95m	£5.5m	
Spectrum won in 4G auction			2x35 MHz			2x20 MHz	2x15 MHz
4G auction prices for 2.6 GHz			£5.2m	n/a	n/a	£3.8m, £4.3m, £5.5m or £5.7m	£5.1m or £5.3m
Opportunity cost in 4G auction			£5.2m	n/a	n/a	£5.3m, £5.5m or £5.7m	£5.1m or £5.3m
LRP with revenue constraint	£4.99m	£4.99m					
LRP without revenue constraint	£5.7m	£5.7m					
Linear price avoiding excess supply	£5.5m						

Source: Ofcom

[81] For ease of comparison, Table 2.8 shows figures for the value of 800 MHz net of expected DTT co-existence costs because this is the basis on which stakeholders generally put forward their suggested values.

Section 3

Assessment of lump-sum values

Introduction

3.1 This section sets out the estimates of the lump-sum values of 900 MHz and 1800 MHz which we are minded to use as a basis for setting annual licence fees, before considering the impact of the geographic coverage obligation. This is step 2 in the analytical framework we set out in Section 1. Supporting material for the issues discussed in this section is in Annexes 7, 8 and 9.

3.2 The following assessment is consistent with the approach in our August 2014 consultation, although it differs in some detailed respects, reflecting consultation responses and some new evidence. Our estimate of the lump-sum value of 900 MHz (£23m per MHz) is the same as in that consultation. We have revised our estimate of the lump-sum value of 1800 MHz down from £14m per MHz to £13m per MHz.

3.3 The rest of this section:

a) provides an overview of our August 2014 consultation proposals, stakeholder responses to those proposals, and our view of these responses;

b) explains our approach to making a judgement on an appropriate lump-sum values of 900 MHz and 1800 MHz spectrum in the UK, drawing on the international benchmark evidence;

c) presents our assessment of the lump-sum value of 900 MHz spectrum in UK;

d) presents our assessment of the lump-sum value of 1800 MHz spectrum in UK;

e) sets out our cross-checks; and

f) summarises our provisional decisions.

August 2014 consultation and stakeholder responses

August 2014 consultation

3.4 In our August 2014 consultation we derived proposed lump-sum values for 900 MHz and 1800 MHz licences based on a notional licence with a 20-year initial term, and then used these lump-sum values to derive proposed annual licence fees. In deriving lump-sum values we considered the following evidence:

a) Bids in the UK 4G auction: these were discussed in Section 2 of the August 2014 consultation, and our revised view is in Section 2 of this document.

b) International auction prices: we considered evidence from 4G auctions in the EU from 2010 onwards, particularly as to the relative value of spectrum bands included in the UK 4G auction, and the spectrum bands for which we are setting annual licence fees.

c) Technical evidence: we noted the difficulties of using technical modelling to determine the value of spectrum to individual operators.

3.5 Our approach to estimating lump-sum values involved the following steps:

a) Calculate absolute values for each frequency band from European auctions in UK-equivalent terms.

b) Use these in combination with our estimates of the UK market value of the 800 MHz and 2.6 GHz to derive a set of relative value benchmarks for the value in the UK of 900 MHz (based on its value relative to 800 MHz) and 1800 MHz spectrum (based on the distance method, which we discuss below).

c) Use these benchmarks to derive an estimate of the lump-sum value for each of 900 MHz and 1800 MHz spectrum in the UK, by:

i) Grouping the benchmarks into tiers according to the quality of evidence we consider they provide to serve as a basis for ALF, placing more weight on benchmarks in higher tiers.

ii) Assessing the risk that benchmarks may understate or overstate UK market values.

iii) Reaching a view of the lump-sum value of 900 MHz and 1800 MHz spectrum by considering these benchmarks in the round.

iv) Applying cross-checks, such as absolute-value benchmarks.

3.6 Based on this approach, the proposals for lump-sum values that we set out in the August 2014 consultation were: £23m per MHz for the 900 MHz band; and £14m per MHz for the 1800 MHz band.

Stakeholder responses

3.7 Stakeholders commented in detail both on our approach to assessing lump-sum values, and also on the relevance and interpretation of specific benchmarks. We summarise their main points below.

Our approach

3.8 Stakeholders generally agreed that the approach described above included the correct elements, including:

a) The use of recent European auction data.

b) Our focus on relative benchmarks and, in particular, the use of the relative value of 900 MHz to 800 MHz for estimating 900 MHz value and the use of the distance method for estimating 1800 MHz value. EE, H3G, Telefónica and Vodafone supported our use of these relative values.[82] BT agreed that absolute values should not be used and said relative values were potentially relevant.

c) The use of tiering to differentiate country benchmarks based on their quality as evidence points.

[82]The distance method was proposed by EE and H3G in their responses to our October 2013 consultation.

3.9 However, some stakeholders argued that we should take account of non-benchmark evidence (technical and commercial evidence) as to the relative values of different bands.

a) Vodafone cited a technical model relating to the possible use of the 700 MHz band for mobile services,[83] and said this model showed that the present use and future value of 800 MHz spectrum must be considerably more than that of 900 MHz spectrum (based on the intensity of use of the two bands which the model assumed). In our August 2014 consultation we noted that this model was consistent with a wide range of possible values of 900 MHz spectrum. Vodafone argued that a purpose-built model for 900 MHz could generate a significantly narrower, and lower, range of values for 900 MHz.

b) In contrast to Vodafone's first point above, H3G[84] argued that a comparison of technical characteristics and commercial opportunities of 800 MHz and 900 MHz shows they are of almost identical value.

Data from European auctions and derivation of benchmarks

3.10 Stakeholders did not challenge the general approach we had used to convert European auction prices into UK-equivalent values for licences of similar duration to those awarded in the UK 4G auction. However, Telefónica[85] questioned some specific aspects of the calculations, including the use of PPP factors to convert values into £ sterling, the mechanics of the adjustments to reflect different licence durations and different dates of spectrum availability, including the use of a standard discount rate, and the averaging of lot prices. Telefónica also questioned the way we had taken account of DTT co-existence and coverage obligation costs when deriving the UK-equivalent benchmarks for 900 MHz and 1800 MHz from the auction prices in the country concerned.

3.11 Analysys Mason and Aetha (AM&A),[86] on behalf of EE and H3G, argued that the use of a proxy for the value of 2.6 GHz spectrum in Sweden appeared inappropriate given the availability of an auction price in that country (from 2008). Telefónica[87] agreed with the use of a proxy, but suggested taking an average of several possible measures.

3.12 EE[88] argued that for some benchmarks where we had used a straight average of lots sold, the calculation should reflect differences in the size of the lot and the population covered by each lot.

Definition and choice of tiers for benchmarks

3.13 Stakeholders' comments on our estimation of lump-sum values focused on our framework for assigning benchmarks to particular tiers, and on how we had applied this framework to a number of specific country benchmarks.

[83] This model was designed by Analysys Mason for Ofcom in the context of a separate project, on changing the use of the 700 MHz band to mobile broadband.
[84] H3G, response to our August 2014 consultation, page 3.
[85] Telefónica, response to our August 2014 consultation, pages 56 to 62.
[86] AM&A, Review of Ofcom"s determination of UK lump-sum values for 1800MHz and 900MHz spectrum to set annual licence fees, Final Report for EE and Three, page 2.
[87] Telefónica, response to our August 2014 consultation, pages 62 to 65.
[88] EE, response to our August 2014 consultation, page 38.

3.14 AM&A[89] (on behalf of EE and H3G) suggested that our framework to determine the tier for each benchmark was effectively a subjective country-by-country assessment. It argued that we seemed to look for reasons to exclude benchmarks and that, since Tier 3 benchmarks effectively carried no weight, we relied on a very small number of benchmarks.

3.15 It presented an alternative framework for deciding the tier and weight to attach to each benchmark, and placed all of the benchmarks in only two tiers (instead of the three tiers in our August 2014 consultation). AM&A categorised all 900 MHz benchmarks in our sample as Tier 2 (except Denmark, which it excluded), and for 1800 MHz it categorised Germany and Italy as Tier 1 and all others as Tier 2.

3.16 In contrast, Telefónica[90] said our approach of assessing each benchmark qualitatively had considerable merit. Telefónica presented econometric analysis from NERA[91] aimed at establishing whether some benchmarks were statistical outliers and should be moved to Tier 3 on those grounds.

3.17 All MNO responses presented their own analysis of the appropriate choice of tier for each country benchmark within their preferred framework (see Annex 7, paragraph A7.170, Table A7.10 and Table A7.11. There was broad agreement on the choice of tier for a number of countries as well as differences in a number of others.

3.18 There is only one benchmark country, Austria, where all MNO responses argued for a change to the choice of tier from the August 2014 consultation; they argued that both the 900 MHz and 1800 MHz benchmarks should be in Tier 2 or Tier 3 (as opposed to Tier 1 as in the August 2014 consultation).[92] The other main differences to the choice of tier in the August 2014 consultation related to:

a) Ireland, where AM&A[93] (for EE and H3G) argued that the benchmarks for both 900 MHz and 1800 MHz should be in a lower tier (as did NERA,[94] for Telefónica, in the case of the 1800 MHz benchmark, although both NERA and Frontier,[95] for Telefónica and Vodafone respectively, agreed that the Ireland 900 MHz benchmark should be Tier 1 as in the August 2014 consultation).

b) The German 1800 MHz benchmark, where AM&A[96] argued that it should be Tier 1 (although NERA[97] for Telefónica agreed with the Tier 2 ranking in the August 2014 consultation) while Frontier,[98] for Vodafone, considered Germany "not relevant";

[89] AM&A, pages 1 and 20.
[90] Telefónica, response to August 2014 consultation, pages 49 to 51.
[91] NERA: Review of country benchmarks used for setting lump sum values for UK 900 MHz and 1800 MHz – A Response to Ofcom's Further Consultation, Prepared by NERA Economic Consulting for Telefónica UK, 16 September 2014.
[92] Responses to our August 2014 consultation: AM&A Final report for EE and H3G, page C-1. Vodafone, page 24, Telefónica, page 6.
[93] AM&A, Final report for EE and H3G, page C-5.
[94] NERA, response to our August 2014 consultation, pages 5 and 16.
[95] Frontier, report for Vodafone, page 22.
[96] AM&A, Final report for EE and H3G, page C-4.
[97] NERA, response to our August 2014 consultation, page 18.
[98] Frontier, report for Vodafone, page 11.

c) The Spain 900 MHz benchmark and the Sweden 1800 MHz benchmark which Frontier, [99] for Vodafone, argued should be in Tier 1 rather than Tier 2.

Derivation of lump-sum values and sensitivity analysis

3.19 Stakeholders questioned how we had exercised our judgement when using the relative value benchmarks to arrive at our proposed lump-sum values for 900 MHz and 1800 MHz. MNOs proposed using a form of weighted averaging (assigning different weights to different tiers) in order to derive their own proposed lump-sum values.

3.20 AM&A and H3G suggested that taking a conservative approach could mean applying a discount to estimates of market value.[100] In addition, EE, H3G and AM&A argued that our estimated lump-sum value of 1800 MHz was high relative to that of 900 MHz.[101]

Alternative estimates of lump-sum values put forward in responses to the August 2014 consultation

3.21 Respondents to the August 2014 consultation suggested different lump-sum values for 900 MHz and 1800 MHz spectrum from those we had proposed. This was for two reasons:

a) They disagreed with our proposed UK market values for 800 MHz and 2.6 GHz (as already discussed in Section 2).

b) They disagreed with our view (based on benchmark evidence) of the value of ALF spectrum relative to these UK market values for 800 MHz and 2.6 GHz (as reflected in the 900:800 MHz ratio in the case of 900 MHz and the distance method in the case of 1800 MHz).

3.22 A summary of proposals put forward by stakeholders is shown in Table 3.1, and compared to our estimates in August 2014. In order to identify their position on the second of these factors, we have also presented the 900:800 ratios and distance method Y/X ratios[102] which are implied by their lump-sum value estimates (except in the case of Vodafone, who presented explicit ratios). Differences between these relativities, and relativities implied by our proposed lump-sum values in the August 2014 consultation, result from different interpretations of the benchmarking evidence and/or methods of deriving lump-sum values from this evidence (which is the focus of step 2 in this section).

3.23 The figures in bold in Table 3.1 were cited by stakeholders. We have derived the other figures in the first four rows of the tables. Differences between the MNOs proposals (and between these and our estimates) are driven mainly by the different allocation of individual country benchmarks to different tiers summarised above. In addition, AM&A used a much lower value for the Sweden 1800 MHz benchmark than Ofcom, Frontier and NERA.

[99] Frontier, report for Vodafone, page 17.
[100] AM&A, page 34, and H3G, page 29.
[101] Responses to our August 2014 consultation: EE pages 5-6, H3G page 2, AM&A, page 39
[102] This ratio is derived as the difference in value between 1800 MHz and 2.6 GHz ("Y"), divided by the difference in value between 800 MHz and 2.6 GHz ("X"), expressed as a percentage.

Table 3.1: Summary of MNO and Ofcom estimates for 900 MHz and 1800 MHz (based on values of 4G auction bands preferred by stakeholder)

	900 MHz value per MHz	900 MHz to 800 MHz ratio	1800 MHz value per MHz	Equivalent Y/X ratio for 1800 MHz
EE (based on AM&A)[103]	**£21m**	70%	**£8m**	12%
H3G (based on AM&A)[104]	**£23.2m**	93%	**£7.7m**	19%
Telefónica[105]	**£15.5m**	62%	**£10m**	25%
Vodafone (based on Frontier)[106]	not given	**57%-65%**	not given	**28%**
Our August 2014 consultation[107]	£23m	65%	£14m	28%

Source: Ofcom from stakeholder responses

3.24 In the case of 900 MHz, Telefónica argued that we had overstated the 900:800 MHz relativity (its estimate of the 900 MHz lump-sum value implying a 900:800 MHz ratio of 62%, as against the August 2014 consultation measure of 65%). The ratio implied by our estimates in August 2014 was consistent with the top of the range presented by Vodafone, but Vodafone said that the appropriate value is likely to be close to the bottom of this range (i.e. 57%). In contrast EE and H3G argued that we had understated the 900:800 MHz ratio, by a significant amount in H3G's view.

3.25 Conversely, EE and H3G argued that we had overstated the relativity for 1800 MHz significantly. They proposed values of 1800 MHz which implied Y/X ratios of 12% and 19% respectively, well below the 28% implied in the August 2014 consultation.

3.26 In contrast, Telefónica suggested a more modest adjustment to our Ofcom's August 2014 consultation position. Vodafone said that our Y/X ratio was consistent with the appropriate relative value of 1800 MHz.

3.27 In summary, and focusing on relative values:

[103] EE response to the August 2014 consultation, page 42. We derived the ratios using EE's proposed values of £29.89m per MHz for 800 MHz and £4.99m per MHz for 2.6 GHz, reported on page 28 of AM&A's response.
[104] H3G response to the August 2014 consultation, page 4. We derived the ratios using H3G's proposed values of £25.04m per MHz for 800 MHz and £3.57m per MHz for 2.6 GHz on page 12 of its response. We note that AM&A (p. 29) presents H3G's 800 MHz estimate, gross of DTT coexistence costs, as £28.04m, but this value does not appear in H3G's submission and H3G said that technical / commercial evidence implies an 800 MHz value of £25m per MHz (which is used in deriving its £23.2m per MHz figure).
[105] Telefónica response to the August 2014 consultation, page 74. We derived the ratios using Telefónica's proposed values of £25m per MHz for 800 MHz and £4.95m per MHz for 2.6 GHz.
[106] Vodafone response to the August 2014 consultation, Annex 2, pages 2-3 and Annexe 4. Frontier (on behalf of Vodafone) said that 31% (net of coexistence costs) is an appropriate relative value, which corresponds to 28% on a gross basis.
[107] Based on UK values of £35.63m per MHz for 800 MHz and £5.5m per MHz for 2.6 GHz.

a) For 900 MHz, Vodafone and Telefónica's estimates were lower than our estimate, while EE and H3G's estimates were broadly consistent with ours.

b) For 1800 MHz, Vodafone and Telefónica's estimates were broadly consistent with ours, while EE and H3G's were lower.

c) EE and H3G also argued that the ratio (of 61%) between the 1800 MHz and 900 MHz lump-sum values implied by the August 2014 consultation (£14m per MHz to £23m per MHz) was unjustifiably high.

3.28 Respondents argued that there was a need for sensitivity analysis and commented on the extent to which they considered we had met this need, as described in Annex 7, paragraphs A7.152-A7.154.

Addressing stakeholder responses

3.29 We have reviewed our analysis in light of stakeholder responses. Our approach in this document remains the same as in the August 2014 consultation. Stakeholders agreed that our primary focus should be on relative benchmarks rather than absolute benchmarks and that, for 1800 MHz, our focus should be on benchmarks derived from the distance method. As regards aspects of our approach with which stakeholders disagreed, we remain of the view that:

a) The variation in quality of evidence between countries justifies the continued use of three tiers (as opposed to two).

b) We should exercise judgement in deciding the tier of each benchmark from the available evidence (based on three criteria which we now specify).

c) In deriving lump-sum value estimates, we should consider the benchmarks in the round, rather than relying on summary statistics such as weighted averages.

d) We should consider a range of cross-checks, similar to those in our August 2014 consultation.

3.30 Annexes 7 and 8 consider the specific points raised by stakeholders that were summarised above.

3.31 Arguments relating to technical and commercial evidence are considered further in Annex 9. In summary:

a) While we remain of the view that the possibility of greater certainty of spectrum availability is a reason to be conservative in interpreting the evidence, we do not agree that the change in certainty of future spectrum availability since the time of the 4G auction is much stronger than we considered it to be in our August 2014 consultation.

b) In assessing benchmark evidence, we take account of arguments as to the technical characteristics and commercial possibilities of the 900 MHz band relative to the 800 MHz band.

c) We remain of the view that there is a risk that 1800 MHz awards which took place before 2012 may be understating the more recent market value of 1800 MHz relative to 800 MHz and 2.6 GHz bands

d) We remain of the view that any network cost modelling will be subject to significant uncertainty about the specification of the model and appropriate parameter assumptions.

e) We consider that it is not appropriate to use assumptions incorporated in Analysys Mason's 700 MHz model as a basis for informing our view of the relative value of 900 MHz and 800 MHz spectrum.

3.32 We consider Telefónica's points about the conversion of European auction data into UK equivalent values in Annex 7, paragraphs A7.26 to A7.55. We remain of the view that use of a proxy value for 2.6 GHz, when applying the distance method to Sweden, is the most appropriate approach (see Annex 7, paragraphs A7.93 to A7.118).

3.33 We consider comments from AM&A, H3G and EE about our framework for tiering in Annex 7, paragraphs A7.161 to A7.191.

3.34 We consider the arguments put to us about the choice of tier for specific country benchmarks in Annex 8. On the basis of this assessment we remain of the view that the Austria benchmarks should be treated as Tier 1 for both 900 MHz and 1800 MHz bands, that Ireland should be treated as Tier 1 for both bands, and that Tier 2 is appropriate for Spain (900 MHz) and Germany (1800 MHz).

3.35 We further consider stakeholders' alternative estimates of spectrum values in Annex 7, paragraphs A7.192 to A7.201. As part of this discussion in Annex 7, we consider arguments that our 900 MHz and 1800 MHz estimates are inconsistent (paragraphs A7.193 and A7.201).

3.36 As described above (paragraph 3.20), AM&A and H3G appear to have interpreted our August 2014 consultation as suggesting that taking a conservative approach could mean applying a discount to estimates of market value. To be clear, we do not consider that such an approach would be appropriate. We have addressed, in Section 1 above (paragraphs 1.42 to 1.45), the comments that we received in response to the August 2014 consultation on our conservative approach to interpreting the evidence.

Changes since our August 2014 consultation

3.37 The main changes to the analysis set out in our August 2014 consultation are as follows:

a) We have revised some of our benchmark data, as set out in paragraph 3.41 below;

b) We have moved the Sweden 1800 MHz benchmark from Tier 2 to Tier 1, as set out in paragraph 3.65;

c) We have revised our view of the risk of understatement or overstatement attached to some benchmarks, as set out in paragraphs 3.54 and 3.65; and

3.38 We outline below (paragraph 3.48) the criteria we now use for deciding in which tier a benchmark should be placed. These are similar to the criteria we used in the August 2014 consultation, although we now include a specific criterion related to strategic bidding. We provide a more detailed explanation of the criteria in Annex 7. Our

assessment when applying these criteria to each country benchmark is set out in Annex 8.

Our approach following consideration of stakeholders' responses

3.39 Our approach to estimating the lump-sum value of 900 MHz and 1800 MHz spectrum in the UK remains as described at paragraph 3.5 above. We now summarise our updated position on each main component of this approach.

Absolute value benchmarks

3.40 The data points used to develop the benchmarks are taken from auctions of 800 MHz, 900 MHz, 1800 MHz and 2.6 GHz licences in Europe since the start of 2010. The auction prices we consider are set out in Table 3.2 in terms of their UK-equivalent absolute values. They include adjustments to reflect differences from the UK 4G auction licences such as annual spectrum fees, licence duration, delayed availability of spectrum, currency and population.

Table 3.2: Results of European auctions 2010-2014 (absolute values in UK-equivalent £m per MHz)[108]

	800 MHz	900 MHz	1800 MHz	2.6 GHz
Austria (2013; 2010)[109]	68.3	78.2	44.2	1.9
Czech Republic (2013)	44.9		5.9	3.0
Denmark (2012; 2010)[110]	16.4	2.9	1.3	10.3
Germany (2010)	53.0		1.9	1.6
Greece (2014; 2011)[111]	38.8	32.9	14.5	3.5
Ireland (2012)[112]	59.7	36.1	23.4	
Italy (2011)	52.1		16.7	3.8
Portugal (2011)	41.5	29.3	8.0	7.4
Romania (2012)	44.3	47.7	19.2	10.7
Slovak Republic (2013)	39.3		7.2	4.7
Spain (2011)[113]	59.1	39.8		4.6
Sweden (2011)	21.2		9.4	

Source: Ofcom

[108] We do not consider that reliable band-specific auction prices can be derived from available information about auctions in the Netherlands, Norway, Slovenia or Switzerland.
[109] 800/900/1800 MHz awarded in October 2013; 2.6 GHz in October 2010.
[110] 800 MHz awarded in June 2012; 900/1800 MHz in September 2010; 2.6 GHz in May 2010.
[111] 800 MHz and 2.6 GHz awarded in October 2014; 900 MHz and 1800 MHz in November 2011.
[112] Results based on information from Comreg.
[113] A multiband auction took place in in July 2011. One lot of unsold 900 MHz spectrum was re-auctioned in November 2011. The 900 MHz value shown is from November 2011.

3.41 There are a number of changes to the data in Table 3.2 from our August 2014 consultation as follows:[114]

a) Licences awarded in Portugal and Spain are subject to annual licence fees, in addition to the price paid at auction. The absolute values used in our August 2014 consultation excluded these fees. We have recalculated these values so that they now include (the present value of) these fees.

b) In some cases[115] lot prices differed within bands in the same award. In our August 2014 consultation, we presented prices which were a simple average of lot prices. We have recalculated these prices as weighted averages, using lot size and population covered as weights, as proposed by respondents.

c) We use discount rates when we adjust for differences in licence duration or delayed availability of spectrum or to include the present value of annual fees. We now use country-specific discount rates rather than UK discount rates (for Tier 1 and Tier 2 countries), as described in Annex 7, paragraphs A7.26 to A7.55.

d) We now use revenue-constrained LRPs (rather than LRPs without revenue constraint) to derive the prices of different frequency bands in the Austrian auction of October 2013 (as explained in Annex 7, paragraphs A7.178 and A7.180).

e) We have added auction values for 800 MHz and 2.6 GHz from the auction in Greece which took place in October 2014 (i.e. after our August 2014 consultation).

Relative value benchmarks

3.42 For each country in Table 3.2 above, we calculate benchmarks based on the ratio between values in different spectrum bands. For 900 MHz benchmarks, we calculate the ratio between 900 MHz and 800 MHz values in the country concerned and apply this to the corresponding value of 800 MHz in the UK. For 1800 MHz benchmarks, we apply the distance method, which consists of: (a) calculating the Y/X ratio (described in footnote 102 above) based on the relative values of 1800 MHz, 800 MHz and 2.6 GHz in the country concerned; and (b) relating this to the corresponding 800 MHz and 2.6 GHz values in the UK.[116] We set out details of these calculations in Annex 7 (paragraphs A7.56-A7.121), including our treatment of differences in expected DTT co-existence costs and coverage obligations between the UK and benchmark countries.

3.43 The resulting relative value benchmarks for the lump-sum values of 900 MHz and 1800 MHz in the UK that are derived from the European auctions are shown in Tables 3.3 and 3.4 below. Table 3.3 also shows the 900 MHz benchmarks when expressed in terms of the ratio of 900 MHz to 800 MHz value (i.e. the relative value benchmark in the table expressed as a ratio to the UK 800 MHz value of £33m per MHz which is gross of expected DTT co-existence costs and without coverage

[114] See Annex 7, paragraphs A7.26-A7.55 for further details.
[115] Czech Republic (800 MHz), Portugal and Sweden (1800 MHz), Austria and Spain (2.6 GHz).
[116] For example, in Italy the Y/X ratio = 27%. We can identify a benchmark value for 1800 MHz in the UK, in this case £12.8m per MHz, which would lead to the same 27% ratio in the UK (taking 800 MHz and 2.6 GHz values from the 4G auction), so £12.8m is our Italy distance method benchmark for the value of 1800 MHz in the UK.

obligation).[117] Similarly, Table 3.4 also shows the 1800 MHz benchmarks when expressed in terms of the Y/X ratio.

Table 3.3: Relative value benchmarks for 900 MHz in UK, and associated ratio of 900 MHz to 800 MHz

	Relative value benchmark £m per MHz	900 MHz / 800 MHz ratio
Austria	37.8	115%
Denmark	5.7	17%
Greece	28.8	87%
Ireland	18.2	55%
Portugal	21.2	64%
Romania	30.6	93%
Spain	22.2	67%

Source: Ofcom

Table 3.4: Relative value benchmarks for 1800 MHz in UK, and associated Y/X ratio[118]

	Relative value benchmark £m per MHz	Y/X ratio
Austria	23.0	64%
Czech Republic	7.2	6%
Germany	5.6	0%
Greece	13.3	29%
Ireland	13.3*	28%
Italy	12.8	27%
Portugal	5.9	2%
Romania	11.3	21%
Slovak Republic	7.3	6%
Sweden	16.0*	38%

Source: Ofcom

* Relative value benchmark derived using our preferred 2.6 GHz proxy

[117] As discussed in Annex 7, for some countries we derive the relative value using a country benchmark for 800 MHz that is net of expected DTT co-existence costs and/or with coverage obligation. For these countries we derive the UK-equivalent benchmark using a UK value of 800 MHz that is correspondingly also net of expected DTT co-existence costs and/or with coverage obligation. But, so that the ratios in Tables 3.3 and 3.4 are directly comparable between countries, all the ratios in the tables are expressed relative to the UK value of 800 MHz that is gross of expected DTT co-existence costs and without coverage obligation (£33m per MHz). This means that, for the countries for which we use a different UK 800 MHz value, the ratio shown in Table 3.3 or 3.4 is different from the ratio used to generate the relative value benchmark.

[118] For Ireland and Sweden we use proxy estimates of the value of 2.6 GHz in deriving distance method benchmarks for 1800 MHz, as discussed in Annex 7, paragraphs A7.93-A7.118.

3.44 The above sets of benchmarks differ from those in our August 2014 consultation as a result of the changes to the absolute values in Table 3.2 referred to above. The 900 MHz / 800 MHz ratio is higher for Austria, Portugal and Spain compared to the August 2014 consultation (changing from 110% to 115%, 61% to 64% and 65% to 67% respectively). The ratio is lower for Ireland (changing from 57% to 55%). The Y/X ratio for 1800 MHz is lower for Austria, Ireland and Sweden (changing from 66% to 64%, 29% to 28% and 40% to 38% respectively).[119]

3.45 The relative value benchmarks are also affected by the fact that we have revised down the forward-looking market value for 800 MHz spectrum from £35.63m per MHz to £33m per MHz (gross of expected DTT co-existence costs and without coverage obligation) as discussed in Section 2. As a result, some of the above benchmarks have shifted down from the August 2014 consultation, typically[120] by around 8% for 900 MHz benchmarks and by around 5% for 1800 MHz benchmarks where other adjustments have not been made.

Framework for using benchmarks to assess UK market value

3.46 We develop our estimates for UK market value based on this set of relative value benchmarks. To do so:

a) First, we group the benchmarks into tiers, according to our assessment of the quality of evidence as a basis for ALF. We place more weight on benchmarks in a higher tier as we regard them as providing better quality evidence.

b) Second, we assess the risk that individual benchmarks may be understated or overstated estimates of market value in the UK and characterise the nature of that risk in terms of likelihood, scale and direction of any potential understatement or overstatement.

c) Third, we reach a view as to the lump-sum value of 900 MHz and 1800 MHz in the UK, in light of these benchmarks, taking account of the quality and nature of each benchmark evidence point (reflecting, respectively, the tier of the evidence point and its risk of understatement or overstatement referred to above).

d) Fourth, we apply cross-checks to our estimates of the lump-sum values for 900 MHz and 1800 MHz in the UK.

Quality of benchmarks (tiers)

3.47 We categorise the available benchmarks into three tiers which reflect their relative quality to serve as a basis for ALF.

3.48 In particular we use criteria reflecting the following considerations:

a) Whether auction prices appear likely to have been primarily determined by a market-driven process of bidding in the auctions (e.g. not set by reserve prices);

[119] With minor changes of 1% point in some of the Tier 3 countries as well.
[120] There is some variation in the effect, depending on, for example, whether the appropriate UK 800 MHz figure is gross or net of expected DTT co-existence costs, and with or without coverage obligation. Also, a given change in the 800 MHz value, other things equal, does not lead to an identical proportionate change across 1800 MHz benchmarks.

b) Whether the evidence available to us suggests that the relative prices in the auction reflected bidders' intrinsic valuations of spectrum or whether they reflected strategic bidding; and

c) Whether we have a clear, evidence-based reason for considering that the outcome is less informative of forward-looking relative spectrum values in the UK (having regard to country-specific circumstances and auction dates).

3.49 A more detailed discussion of the criteria is in Annex 7 and the choice of tier for each country benchmark is explained in Annex 8.

3.50 When using benchmarks to inform our judgement on the lump-sum value of 900 MHz and 1800 MHz in the UK, we consider that we should place most weight on benchmarks which are in Tier 1, some weight on benchmarks in Tier 2, and that benchmarks that are in Tier 3 should be considered as having relatively little informative value for these purposes.

Assessment of risks of understatement or overstatement

3.51 In interpreting the benchmarks we consider whether there is a risk that benchmarks might understate or overstate the value of the corresponding band in the UK. Our approach to assessing the likelihood and scale of this risk is set out in Annex 7.[121] We apply this approach to each country benchmark, as assessed in detail in Annex 8. We take these risks into account in interpreting the evidence.

Lump-sum value of 900 MHz spectrum in UK

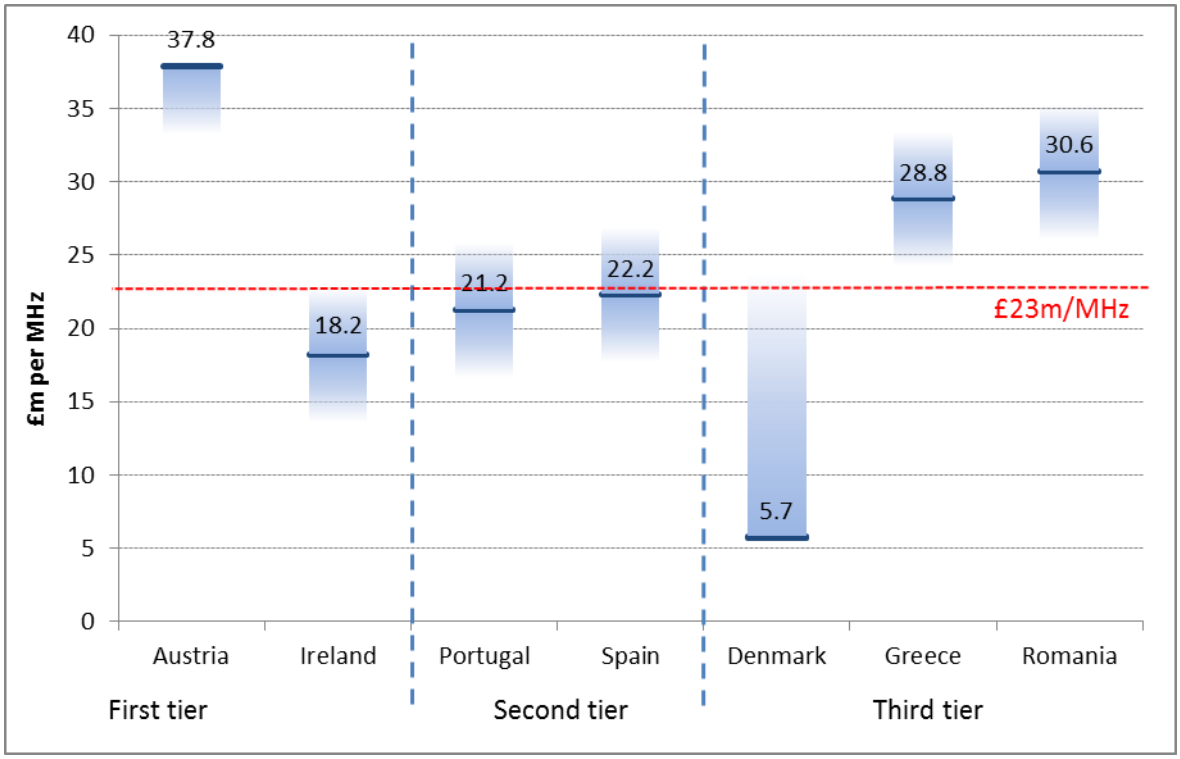
Relative value benchmarks

3.52 We have relative value benchmarks (based on 900 MHz to 800 MHz paired ratios) from seven countries where spectrum has been auctioned in both bands since 2010 as shown in Table 3.3 above – Austria, Denmark, Greece, Ireland, Portugal, Romania and Spain. Our assessment of the tier in which we categorise each benchmark, along with our assessment of the risk that the benchmark might either understate or overstate the market value of 900 MHz in the UK, is set out in Annexes 7 and 8. Table A8.1 in Annex 8 summarises this assessment of tier and risks for each benchmark country.

3.53 These relative value benchmarks are shown in Figure 3.1, grouped by tier. The shaded areas in Figure 3.1 illustrate our assessment of the likelihood or scale of possible understatement or overstatement associated with each benchmark. The length of these shaded areas reflects a combination of the likelihood and scale of potential understatement or overstatement (with a larger risk of a larger understatement or overstatement being represented by a longer shaded area, although the resulting length of the shaded areas is not drawn to a specific scale and so is only illustrative).[122]

[121] Some specific types of auction circumstances and/or country-specific factors can be relevant to this assessment of risks as well as to the grouping of benchmarks into tiers, such as the date of the auction. We discuss this further in Annex 7, including an explanation of when the choice of tier is affected or when we instead only take account of this factor through the assessment of risks.
[122] The Denmark relative value benchmark depends on the 800 MHz auction price that is gross of expected DTT co-existence costs but with a coverage obligation (£16.4m per MHz). Another way to

Figure 3.1: 900 MHz paired ratio benchmarks in £m per MHz



Source: Ofcom

Developments in our analysis since August 2014 consultation

3.54 Stakeholders argued that some of the benchmarks should be in different tiers from those which we set out in August 2014 (higher in some cases, lower in others). We have considered these arguments in detail; having done so, and as noted above, we have not changed the tiers for any of the country benchmarks for the reasons set out in Annex 8. We have categorised Greece, which was not in our August 2014 consultation, as a Tier 3 benchmark. Our assessment of the risk of understatement or overstatement has changed in the following cases:

a) In the case of Austria, our previous view was that, in light of suggestions from stakeholders of strategic bidding, the direction of any understatement or overstatement in the benchmark was unclear.[123] We now analyse in further detail for Austria the implications of possible strategic bidding for each of the choice of tier and the assessment of risks. We consider that, given the available evidence, intrinsic value bidding is at least as likely as strategic behaviour. This is one of our reasons for maintaining Austria in Tier 1. We also take strategic behaviour into account when judging the likelihood of under- or over-statement. We assess the direction of this risk by asking, *if* strategic bidding took place, whether this is more likely to have led to an understatement or an overstatement of the benchmark. Our view now is that there is an additional source of risk of strategic bidding relevant to the 900 MHz band compared to the 800 MHz band. On balance, we consider there is a risk that this benchmark overstates UK market

derive the benchmark would be to use the lower Denmark 800 MHz auction price that is net of expected DTT co-existence costs and without a coverage obligation (£7.1m per MHz). This would yield a relative value benchmark of £12.6m per MHz, which is much higher than £5.7m per MHz and still subject to similar risks of being understated.

[123] August 2014 consultation, paragraph 3.51.

value, but we cannot be sure of the scale of this possible overstatement or the likelihood (other than that intrinsic value bidding is at least as likely).

b) In the case of Ireland, our view in the August 2014 consultation was that there was a risk of overstatement, due to suggestions from stakeholders of price-driving in the 900 MHz band. However, we have now identified two reasons for considering this benchmark may also be at risk of understatement. First, the possibility of greater commercial opportunities for LTE in the 900 MHz band since this auction occurred in 2012. Second, H3G's argument that as a "challenger" operator it had more scope to acquire 900 MHz spectrum without bidding aggressively against larger rivals, as compared with its scope to acquire 800 MHz. Therefore, we now consider that there is a risk of either understatement or overstatement in the Irish benchmark.

c) In the case of Spain, our previous view was that there was a risk of overstatement as the spectrum was won at reserve price. However, now we also take account of a risk of understatement from the possibility of greater commercial opportunities for the 900 MHz band since this auction occurred in 2011. Therefore, we now consider that there is a risk of either understatement or overstatement in the Spanish benchmark.[124]

Estimate of market value of 900 MHz spectrum in UK

3.55 We have two benchmarks (Austria and Ireland) in Tier 1, of which the higher is almost double that of the lower. There is a risk that the Austria benchmark overstates UK market value, but we cannot be sure of the likelihood or scale of this possible overstatement. The average of these benchmarks is £28.0m per MHz.

3.56 In light of (a) the risk that one of the two benchmarks (Austria) overstates UK market value, and (b) our view that we should take a conservative approach to interpreting the evidence, we consider that in looking at the benchmarks in Tier 1 alone an appropriate estimate of UK market value would be below the average – and would be between the average and the lower of these two benchmarks, i.e. between around £18m and £28m per MHz. A figure of £23m, which is halfway between these two points (or a quarter of the way from the lower benchmark to the upper benchmark), could be appropriate, looking solely at first-tier benchmarks.

3.57 We next consider second-tier benchmarks. The average or mid-point between the two second-tier benchmarks is £21.7m. This is just over 5% lower than the figure of £23m we derive from the first-tier benchmarks. However, taking into account that we place less weight on second-tier than first-tier benchmarks, we do not consider there is a strong basis to modify the figure of £23m per MHz.

3.58 Considering the third tier of evidence, the low Denmark benchmark is well below the Ireland benchmark (and is at a larger risk of larger understatement), while Romania

[124] We also consider that the Portugal benchmark may be at risk of understatement because of the possibility of greater commercial opportunities for 900 MHz since this auction occurred. This is an additional factor which we did not consider in our August 2014 consultation. However, unlike Ireland and Spain, we had already identified a risk of understatement for Portugal, as well as of overstatement, and we remain of the view that there is a risk of either understatement or overstatement in this benchmark; hence, our assessment of risks for the Portugal benchmark is similar to before.

and Greece are closer to the Austria benchmark than to the Ireland benchmark.[125] We place considerably less weight on these third tier benchmarks, as noted above.

3.59 On balance, subject to the cross-checks discussed later in this section, we consider that **£23m per MHz** is an appropriate estimate of the market value of 900 MHz spectrum in UK for the purpose of setting ALF, adopting a conservative approach to interpreting the benchmark evidence.

3.60 Another way of describing this market value is by expressing it as the ratio to the value of 800MHz spectrum. It implies a value of 900 MHz which is 70% of our estimated UK market value for 800 MHz (of £33m per MHz, gross of expected DTT co-existence costs and without coverage obligation).

3.61 £23m per MHz is the same lump-sum value for 900 MHz as our estimate in the August 2014 consultation. While we have made several revisions to our assessment of benchmarks in that consultation, these revisions have gone in different directions, and have tended to balance one another out. We have revised downwards our estimate of the value of 800 MHz in the UK, and made other adjustments (as described in paragraphs 3.44 and 3.45 above), which affected benchmark values. The net effect of these changes on 900 MHz Tier 1 and 2 benchmarks is a reduction in the Austria and Ireland benchmarks, and a reduction in the Portugal and Spain benchmarks. We have also revised our view of the direction of risk in the Austria, Ireland and Spain benchmarks as set out in paragraph 3.54 above. While we now consider the Austria benchmark to be at risk of overstatement, we consider that the risk for Ireland and Spain is in both directions, whereas previously we considered the risk was of overstatement.

Lump-sum value of 1800 MHz spectrum in UK

Distance method benchmarks

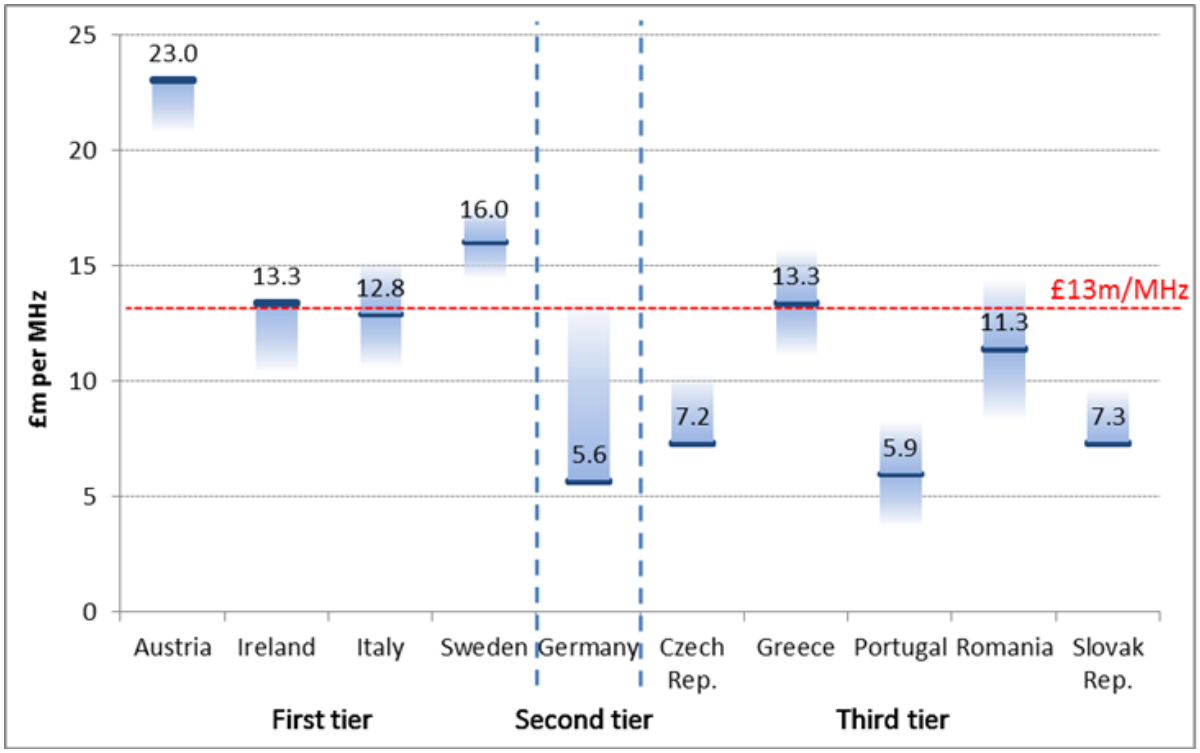
3.62 We derive ten distance method benchmarks from countries where spectrum has been auctioned in relevant bands as shown in Table 3.4 above – Austria, Czech Republic, Germany, Greece, Ireland, Italy, Portugal, Romania, Slovak Republic, and Sweden.

3.63 Interpreting these benchmarks requires an assessment of the interplay of different auction and country factors for the three bands involved in the distance method calculation: 800 MHz, 1800 MHz and 2.6 GHz. Our position on tiering and interpretation of these benchmarks is set out in Annex 8.

3.64 The benchmarks are shown in Figure 3.2. As with Figure 3.1, the shaded areas illustrate our assessment of the likelihood, scale and direction of potential understatement or overstatement associated with each benchmark.

[125] The average of Tier 3 benchmarks alone is £21.7m per MHz. The average of Tiers 1, 2 and 3 benchmarks is £23.5m per MHz. Any weighted average of Tiers 1, 2 and 3 with less weight on Tier 2 than Tier 3 (and at least as much weight on Tier 1 as Tier 2) would be higher. None of these averages takes account of the risk of understatement or overstatement in the benchmarks.

Figure 3.2: 1800 MHz distance method benchmarks in £m per MHz



Source: Ofcom

Developments in our analysis of 1800 MHz benchmarks since August 2014 consultation

3.65 The choice of tier and interpretation of risk for the above set of benchmarks differs from that in our August 2014 consultation in the following respects:

a) In the August 2014 consultation we recognised there was a case for treating the Sweden benchmark as belonging in Tier 1, but on balance we included it in Tier 2. Our revised view is that there is a stronger case for including Sweden in Tier 1, as we do not have clear evidence for considering that the joint venture between two potential bidders (Tele2 and Telenor) had an effect in significantly reducing competition in the 1800 MHz auction (compared to the 800 MHz auction), such that the resulting relative value is less informative of forward-looking relative spectrum values in the UK.

b) In the case of Austria, our view now is that there is an additional source of risk of strategic bidding relevant to the 1800 MHz band compared to the 800 MHz band. On balance we consider there is a risk that this benchmark overstates UK market value, but we cannot be sure of the scale of this possible overstatement or the likelihood (other than that intrinsic value bidding is at least as likely).

c) We have added a benchmark for the Greek auction, following the auction of 800 MHz and 2.6 GHz which took place in October 2014.

3.66 Stakeholders argued that some of benchmarks should be in different tiers to those which we set out in August 2014 (higher in some cases, lower in others). We have considered these arguments in detail in Annex 7, paragraphs A7.161-A7.191. Having considered these arguments, our view of benchmarks is the same as our view in the August 2014 consultation, with the exception of Sweden as noted above.

Estimates of market value of 1800 MHz spectrum

3.67 We have four benchmarks in Tier 1: Austria, Ireland, Italy and Sweden. The highest, Austria, is around 80% higher than the lowest, Italy, while Ireland and Sweden are somewhat closer to Italy than Austria. There is a risk that the Irish benchmark overstates the UK market value due to the unavailability of 2.6 GHz spectrum in Ireland, and we categorise this as a larger risk, although we cannot be sure of the scale of potential overstatement. As noted above, there is also a risk that the Austria benchmark overstates UK market value. The average of the four benchmarks is £16.3m per MHz.

3.68 In light of (a) the risk that two of the four benchmarks (Austria and Ireland) overstate UK market value, and (b) our view that we should take a conservative approach to interpreting the evidence, we consider that in looking at the benchmarks in Tier 1 alone an appropriate estimate of UK market value would be below the average – and would be between the average and the lowest of these four benchmarks, i.e. between £12.8m and £16.3m per MHz.

3.69 As in the case of 900 MHz, we can consider an estimate halfway between these two points, which would be £14.6m. However, we consider that an estimate lower than £14.6m would be more appropriate, on the basis that:

a) Ireland is at larger risk of overstatement, albeit that we cannot be sure of the scale of any overstatement;

b) Ireland is only 4% higher than the Italy benchmark, which is the lowest benchmark in Tier 1, so if Ireland is more than 4% overstated the true lowest benchmark in Tier 1 may be lower than we have taken it to be.

3.70 We next consider the single benchmark in Tier 2, which is Germany. The average of Tier 2 benchmarks alone would be £5.6m (i.e. the value of the German benchmark). However, the German benchmark is at larger risk of being a larger understatement. The extent to which this second-tier benchmark is consistent with the implications we draw from the first-tier benchmarks depends on the scale of understatement, which is unknown. Given this, and the lesser weight we place on second-tier than first-tier benchmarks, we do not consider there is a strong basis to modify the view we derive from the first-tier benchmarks.

3.71 Of the benchmarks in Tier 3, Greece is close to £13m, Romania is materially lower, and the others are lower still. However, we place considerably less weight on these benchmarks.[126]

3.72 On balance, subject to the cross-checks discussed later in this section, we consider that **£13m per MHz** is an appropriate estimate of the market value of 1800 MHz spectrum in UK for the purpose of setting ALF, adopting a conservative approach to interpreting the benchmark evidence.

3.73 Another way of describing this market value is by expressing it as the distance method Y/X ratio. It implies a Y/X ratio of 27%.

[126] The average of Tier 3 benchmarks alone is £9m per MHz. The average of Tiers 1, 2 and 3 benchmarks is £11.6m per MHz. Any weighted average of Tiers 1, 2 and 3 with less weight on Tier 2 than Tier 3 (and at least as much weight on Tier 1 as Tier 2) would be higher. None of these averages takes account of the risks of understatement in the benchmarks for Czech Republic and Slovak Republic.

3.74 £13m per MHz is a lower lump-sum value for 1800 MHz than our estimate in the August 2014 consultation of £14m per MHz. We have made several revisions to our assessment of benchmarks since that consultation. We have revised downwards our estimate of the value of 800 MHz in the UK, and made other adjustments (as described in paragraphs 3.44 and 3.45 above), which affected benchmark values. The net effect of these changes on 1800 MHz Tier 1 and 2 benchmarks is a reduction in the Austria, Ireland, Italy and Sweden benchmarks. We have revised our view of the direction of risk in the Austria benchmark to be a risk of overstatement, and we have moved Sweden from Tier 2 to Tier 1.

3.75 While we have a downward revision of our estimate for 1800 MHz, our 900 MHz estimate has not changed compared to our August 2014 consultation. In both cases the Tier 1 and 2 benchmarks are generally lower than before. However, in the case of 900 MHz we no longer consider the Ireland and Spain benchmarks to be at greater risk of overstatement than of understatement.

Cross-checks

3.76 We consider the following cross-checks of the estimates set out above:

a) First, we compare our estimates of the value of 900 MHz and 1800 MHz in the UK to the value of these bands in benchmark countries, in terms of the absolute UK-equivalent value, rather than the relative value measures which we used to derive our estimates above. We begin by considering each band individually, and then we compare results between the two bands.

b) Second, we compare the ratio of our estimates of 900 MHz and 1800 MHz lump-sum values in the UK to the corresponding ratio within benchmark countries where both bands were awarded.

c) Third, we compare our estimates to the average of Tier 1 countries, and the average of Tier 1 and Tier 2 countries, within each band.[127]

3.77 For each cross-check, we consider whether it would be appropriate in light of our analysis of the cross-check to revise either of our estimates.

Absolute values

3.78 We consider in turn absolute benchmarks for 900 MHz and 1800 MHz, and then consistency between our values for the two bands. We consider the absolute values of 900 MHz and 1800 MHz in the countries concerned as a cross-check on our estimates of £23m and £13m per MHz respectively. These absolute values are an input into the relative value benchmarks we have used above, and so they should not be seen as an independent source of evidence. However, we see it as a useful sense check to ask whether our estimated values seem reasonable when compared with absolute values of that band in other countries.

3.79 To be clear, we consider that our assessment of the evidence above using relative value benchmarks provides a better approach, because relative values are likely to be more reliable than absolute values which are more sensitive to a range of country-specific factors, as discussed in the August 2014 consultation.

[127] In our August 2014 we used weighted averages as a cross check. We consider these in Annex 7.

3.80 For example, there is much greater potential for absolute benchmarks to be affected by factors such as urbanisation, which vary widely between countries and may affect the value of spectrum (in particular, sub-1 GHz spectrum may be higher-value, other things equal, in less urbanised countries, as discussed in Annex 7). Austria, Ireland, Greece, Romania and Portugal are, to varying degrees, less urbanised than the UK. This may have increased the absolute value of 900 MHz in those countries, although not necessarily the relative value of 900 MHz to 800 MHz.

3.81 We would only modify the lump-sum value estimates derived from the (more reliable) relative values based on the evidence of the (less reliable) absolute values in exceptional circumstances (e.g. if the absolute values were tightly grouped and substantially different to our lump-sum value estimate for that band). For the reasons set out below, we do not consider that such circumstances are present either for the 900 MHz or the 1800 MHz band.

Absolute values of 900 MHz

3.82 The absolute values of this spectrum in our benchmark countries are included in Table 3.2 above. We repeat them in Table 3.5 in ascending order and they are also shown in Figure 3.3.

Table 3.5: Absolute values for 900 MHz spectrum (UK-equivalent £m per MHz)

Country	Absolute value	Tier	Risk of under / overstatement?
Denmark	£2.9m	3	Larger risk of larger under-statement
Portugal	£29.3m	2	Risk of under- or over-statement
Greece	£32.9m	3	Risk of under- or over-statement
Ireland	£36.1m	1	Risk of under- or over-statement
Spain	£39.8m	2	Risk of under- or over-statement
Romania	£47.7m	3	Risk of over-statement
Austria	£78.2m	1	Risk of over-statement

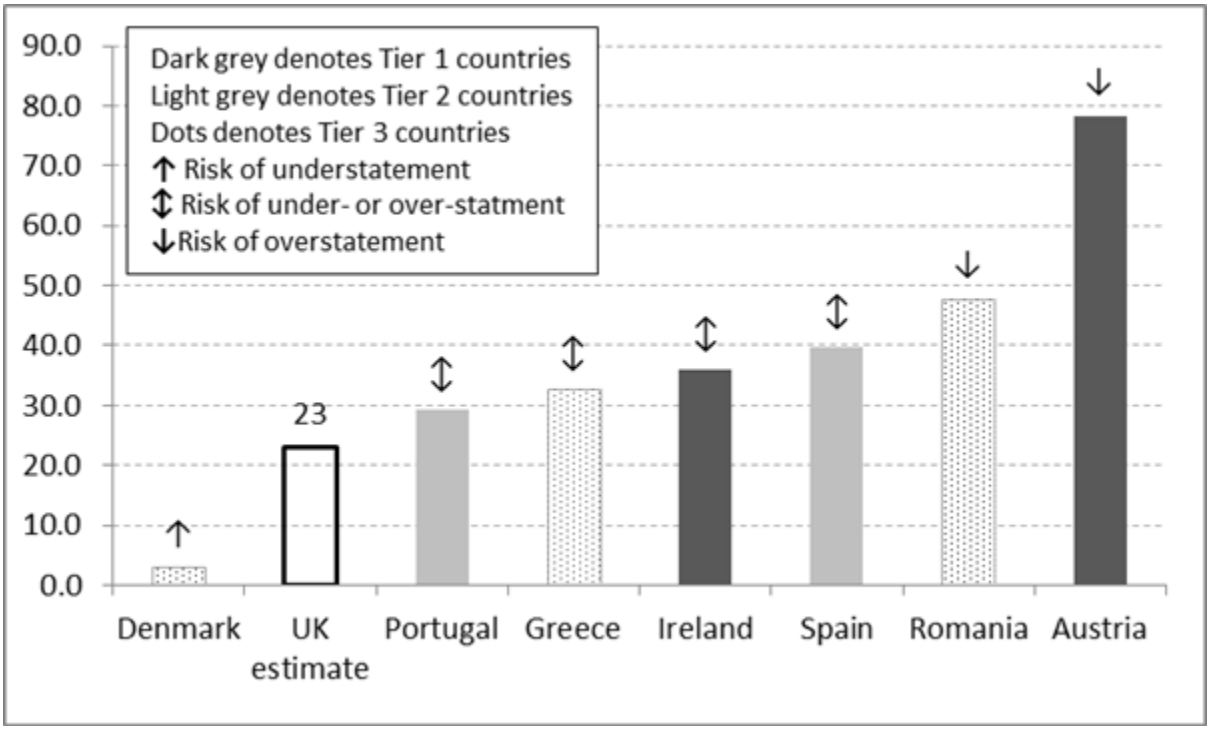
Source: Ofcom

3.83 Seven countries in our sample auctioned 900 MHz lots since 2010. The average of Tier 1 benchmark countries is £57m per MHz, and it is £46m per MHz across Tier 1 and Tier 2 countries. The average absolute value in all countries is £38m per MHz. Each of these averages is substantially higher than our estimate of £23m per MHz for the UK (around 150%, 100% and 65% higher respectively).

3.84 The absolute values of 900 MHz are more widely dispersed than the relative values, with a range of more than £75m between the highest and lowest absolute value in Table 3.5, or around £55m excluding Denmark, compared to a range of £30m for the relative values, or £17m excluding Denmark.

3.85 Our estimate of £23m per MHz in the UK is lower than all but one of the absolute values in these countries (Denmark, in which the value is at larger risk of larger understatement). Our estimate is considerably lower than the value of 900 MHz in the two countries from which we derived Tier 1 benchmarks: it is less than one third of the value in Austria (albeit that this figure has a risk of overstatement). Our estimate is also below values in the two Tier 2 countries..

Figure 3.3: Absolute values for 900 MHz spectrum (UK-equivalent £m per MHz)



Source: Ofcom

3.86 This analysis indicates that our estimate is below the range of values indicated by absolute values from other countries in our benchmark set. We note that this would be true of any estimate below £29m (i.e. the next-lowest absolute value) – i.e. only a very large upward revision of our estimate would change its ranking.

Absolute values of 1800 MHz

3.87 Eleven countries in our sample auctioned 1800 MHz lots since 2010, as shown in Table 3.6 and Figure 3.4. The average absolute value in Tier 1 benchmark countries is around £23.5m; it is £19m per MHz for Tier 1 and 2 benchmark countries; and £14m per MHz across all countries. These averages are respectively around 80%, 45% and 5% above our estimate of £13m per MHz for the UK.

3.88 Again, the absolute values for 1800 MHz are more widely dispersed than the corresponding set of relative values. All the distance method benchmarks we consider are above the UK value of 2.6 GHz of £5.5m[128] and they range up to £23m. In contrast, absolute values range from around £1m to £44m. Two of these absolute values (Denmark and Germany) are substantially lower than the UK value of 2.6 GHz.

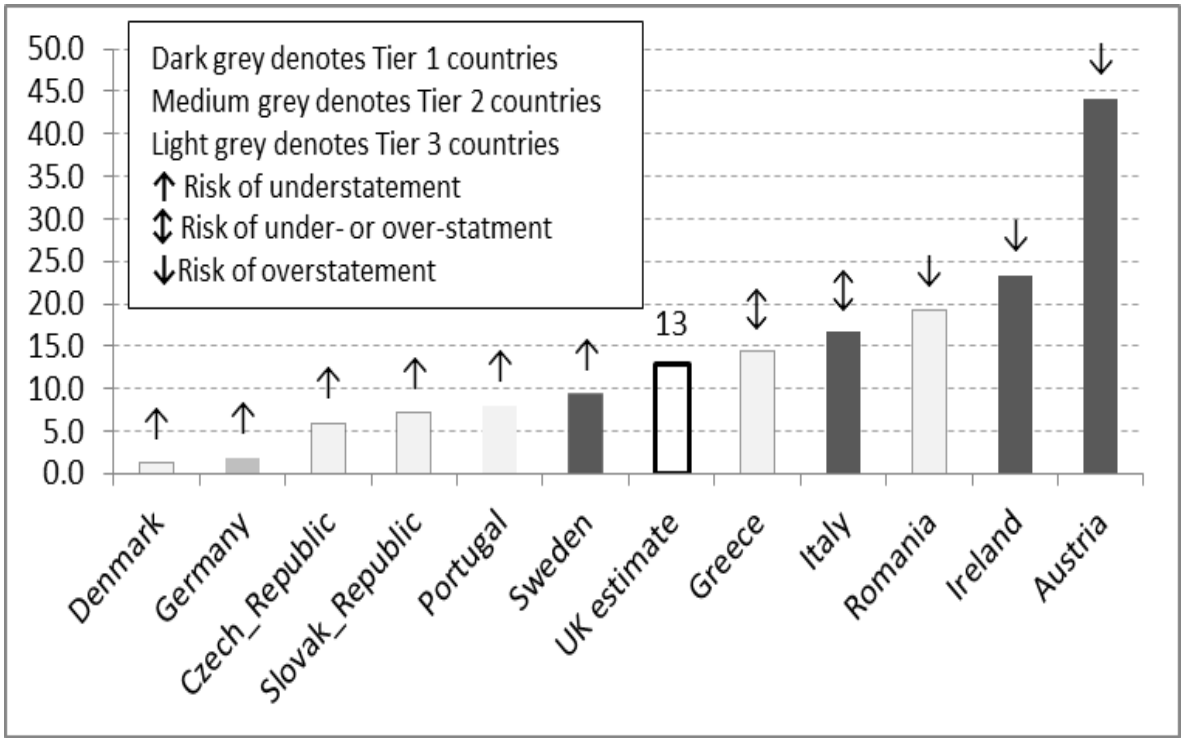
[128] This is a result of how the distance method benchmark is calculated, as set out in Annex 7, paragraphs A7.58-A7.64.

Table 3.6: Absolute values for 1800 MHz spectrum (UK-equivalent £m per MHz)

Country	Absolute value	Tier	Known risk of under / overstatement?
Denmark	£1.3m	3	Larger risk of larger under-statement
Germany	£1.9m	2	Larger risk of larger under-statement
Czech Republic	£5.9m	3	Larger risk of under-statement
Slovak Republic	£7.2m	3	Larger risk of larger under-statement
Portugal	£8.0m	3	Larger risk of under-statement
Sweden	£9.4m	1	Risk of under-statement
Greece	£14.5m	3	Risk of under-or over-statement
Italy	£16.7m	1	Risk of under-or over-statement
Romania	£19.2m	3	Larger risk of over-statement
Ireland	£23.4m	1	Larger risk of over-statement
Austria	£44.2m	1	Risk of over-statement

Source: Ofcom

Figure 3.4: Absolute values for 1800 MHz spectrum (UK-equivalent £m per MHz)



Source: Ofcom

3.89 Our estimate of £13m per MHz in the UK is below the absolute value of 1800 MHz in three of the four Tier 1 benchmark countries. Of these, two of the higher values are at risk of overstatement, while the lower one is at risk of understatement. It falls in the middle of the ranking of all absolute values for this band, with six of these benchmarks lower than £13m and five of them higher than £13m. Overall, four of the six values which are below our estimate are from countries with benchmarks in Tier 3, while one is in Tier 2 and one in Tier 1. All of the absolute values below £13m are at larger risk of understatement (apart from Sweden which is also at risk of understatement but we cannot be sure of the likelihood).

3.90 This analysis indicates that our estimate is between the highest and lowest absolute values from other countries in our benchmark set. It has a lower ranking when considered against values in Tier 1 benchmark countries, but a middle ranking within the full set of absolute values.

Our view on cross-checks against absolute values

3.91 Taken together, one interpretation of these results might be either that our 900 MHz estimate should be higher or that our 1800 MHz estimate should be lower. This is because our lump-sum value estimate for the UK for 1800 MHz lies in about the middle of the rankings of absolute values, whereas for 900 MHz it is near the bottom of the rankings. However, that suggestion would fail to take into account the tiers and the risks of understatement and overstatement in these absolute values. For example, all of the 1800 MHz absolute value country benchmarks that are lower than our lump-sum value estimate of £13m per MHz are at risk of understatement and most are in Tier 3.

3.92 In addition, we reiterate that these values are sensitive to country-specific factors, and this is reflected in the wide dispersion of the results.

3.93 We do not consider that a revision to either of our estimates is appropriate in light of this analysis.

Within-country ratios of the value of 1800 MHz to 900 MHz

3.94 We now compare the ratio of 1800 MHz to 900 MHz implied by our lump-sum value estimates against the ratios in our benchmark sample where both 900 MHz and 1800 MHz have been auctioned (as shown in Table 3.7).

3.95 AM&A said that this this cross-check is of limited value as the manner in which we conduct it provides no new information at all. We recognise that it does not involve independent evidence from that used to develop our lump-sum value estimates. However, we still consider this cross-check is useful, as it indicates that our estimates imply a relative value of 1800 MHz to 900 MHz in the UK which is consistent with the relative values of these bands within benchmark countries.[129]

[129] As described above, our 900 MHz estimate is based on its value relative to 800 MHz within benchmark countries, while our 1800 MHz estimate is based on its value relative to 800 MHz and 2.6 GHz within countries. In this sense, the value of 1800 MHz in a country did not inform our 900 MHz benchmark from that country, and the value of 900 MHz in a country did not inform our 1800 MHz benchmark from that country.

Table 3.7: Ratio of value of 1800 MHz to value of 900 MHz

Country	900 MHz / 800 MHz ratio	Tier (900 MHz)	Tier (1800 MHz)
Austria	56%	1	1
Ireland	65%	1	1
Portugal	27%	2	3
Greece	44%	3	3
Romania	40%	3	3
Denmark	43%	3	Excluded

Source: Ofcom

3.96 Our analysis suggests a value for 1800 MHz that is around 57% of the value of 900 MHz spectrum (£13m per MHz compared to £23m per MHz). This is towards the higher end of the within-country relative values of 900 MHz and 1800 MHz shown above. However the two countries (Austria and Ireland) which are in the Tier 1 for both 900 MHz and 1800 MHz both have a similar or higher ratio compared to our lump-sum value estimates.[130] In the other four countries, either one or both of the 900 MHz and 1800 MHz benchmarks are in Tier 3 which means that we place considerably less weight on them. These ratios typically represent the ratio of the reserve prices set by regulators.

3.97 We do not consider that a revision to either of our estimates is appropriate in light of this cross-check.

Comparison of estimates to average benchmark values

3.98 We considered the average of Tier 1 relative value benchmarks above when deriving our estimates. For both bands we consider that we should choose a value falling below this average. We now compare our lump-sum value estimates to the average of Tier 1 relative value benchmarks for each of 900 MHz and 1800 MHz, as shown in Table 3.8.[131]

[130] In the case of Ireland, we identify a risk of overstatement in 1800 MHz to 900 MHz ratio. The ratio in Ireland (65%) lies above the ratio of our lump-sum value estimates (57%).

[131] We could also compare our lump-sum value estimates to the average of Tier 1 and Tier 2 benchmarks combined for each band. The ratio of £23m for 900 MHz is 93% of the average of £24.9m while that of £13m for 1800 MHz is 92% of the average of £14.2m per MHz. Including the Tier 2 benchmarks in the average has a proportionately greater effect for 1800 MHz than for 900 MHz. However, this is due to the effect of a single benchmark which we consider to be at larger risk of larger understatement (Germany). Overall, we consider the comparison to the average of Tier 1 and Tier 2 benchmarks combined is less meaningful for this reason, and because it does not take account of the greater weight on first-tier than second-tier benchmarks.

Table 3.8: Average benchmark values, £m per MHz

	900 MHz	1800 MHz
UK lump-sum value estimate	£23m	£13m
Average of Tier 1 benchmarks	£28.0m	£16.3m
UK value as % of average	82%	80%
Average of Tier 1 and Tier 2 benchmarks	£24.9m	£14.2m
UK value as % of average	93%	92%

Source: Ofcom

3.99 Our estimates of UK market value for 900 MHz and 1800 MHz are, respectively, 82% and 80% of the average of Tier 1 benchmarks. We consider that these ratios are broadly consistent between the two spectrum bands, noting that, in the case of 1800 MHz, our assessment takes account of the Ireland benchmark being at larger risk of overstatement.

3.100 We do not consider that a revision to either of our estimates is appropriate in light of this cross-check.

Summary of our provisional decisions on lump-sum values of 900 MHz and 1800 MHz spectrum

3.101 Our lump-sum value estimates are summarised in Table 3.9.

Table 3.9: Lump-sum values for 900 MHz and 1800 MHz

900 MHz	1800 MHz
£23m per MHz	£13m per MHz

Section 4

Annualisation

Introduction

4.1 This section sets out our approach to converting our estimate of the lump-sum value of the spectrum into annual fees and corresponds to step 3 in the analytical framework we set out in Section 1. Supporting material for this section is set out in Annex 10.

4.2 The rest of this section discusses in turn the following issues:

a) Spreading the lump-sum value;

b) Inflation index;

c) Discount rate for annualisation;

d) Tax adjustment; and

e) Discount rate used in derivation of benchmarks (in Annex 7).

4.3 For each of these issues, we summarise our position in the August 2014 consultation and stakeholder responses before setting out our analysis.

4.4 We address the issue of terminal value in Annex 10, including our response to stakeholder comments.

4.5 At the end of the section we provide a summary of the conclusions we are minded to reach on deriving annual licence fees from lump-sum values.

4.6 In summary, in the light of the responses to the August 2014 consultation we have made some modifications to our analysis. As discussed below and in Annex 10, we now:

a) Use observed market debt rates on 10-year bonds in deriving our estimate for the cost of debt;

b) Adjust the cost of debt for an inflation risk premium; and

c) Incorporate an adjustment for the degree of risk sharing.

Spreading the lump-sum value

4.7 No responses to the August 2014 consultation commented on our proposals to spread the lump-sum value over 20 years using a constant real profile (with the exception of a point raised on terminal value, which we discuss in Annex 10). This remains our view of the appropriate approach.

Inflation index

Our position in the August 2014 consultation

4.8 In our August 2014 consultation, we proposed to use CPI as the measure of inflation in calculating ALFs, both for the purposes of (i) the discount rate that we adopt at various stages of our ALF methodology (in estimating the lump-sum value of spectrum and also in annualising such lump sums into ALF), and (ii) the way we derive the change in ALF each year in line with this measure of inflation.

4.9 For the purposes of calculating the discount rate, we proposed to use a CPI assumption of 2% per annum and a RPI assumption of 3.3% per annum.

Stakeholder responses

4.10 No respondents commented on our proposal to use CPI.

4.11 Vodafone[132] suggested that our approach to calculating the cost of debt in the August 2014 consultation using a real RPI-adjusted rate and then converting that to a CPI adjustment is unnecessarily cumbersome and compounds the risk of forecast error. Oxera on behalf of Vodafone also alluded to arguments made in relation to CPI in its previous reports[133]. We understand this to be a reference to its previous argument that licensees are exposed to inflation risk from assuming 2% inflation in deriving the real discount rate, but linking ALFs to actual outturn inflation[134].

4.12 Telefónica[135] also suggested that the discount rate should be adjusted to reflect the lack of inflation risk premium needed in ALF (this argument is discussed further in Annex 10).

Our analysis

4.13 Our revised approach to estimating the discount rate using observed market debt rates (discussed in Annex 10) does not require a separate RPI estimate.

4.14 We have considered the issue of inflation risk, and the related issue of the appropriate inflation forecast in light of stakeholders' responses, in Annex 10. Based on the analysis set out in that annex and in the August 2014 consultation, we maintain our view that we should apply a long-term CPI inflation assumption of 2% per annum.

Discount rate for annualisation

4.15 In spreading a lump sum over a 20-year period, we use a discount rate at which the present value of the resulting payment stream equals the lump-sum value paid today. What discount rate is appropriate depends, among other things, on the uncertainty associated with this future ALF payment stream. An important factor in this uncertainty relates to changes in the market value of the spectrum over time. The

[132] Vodafone's response to the August 2014 consultation, p.42.

[133] See, for example, Vodafone's response to the August 2014 consultation, Annex 4, p.12.

[134] Oxera report for Vodafone May 2014, p.10; Vodafone response to the May 2014 consultation, p.10-11.

[135] Telefónica's response to the August 2014 consultation, p.79 and Annex II, p.16-18.

discount rate which will leave MNOs indifferent between paying ALF and paying a lump-sum amount depends on the extent to which they (rather than the Government) are exposed to the effect of such changes. Accordingly, the degree to which exposure to such changes is borne by the licensee or by the Government is an important consideration in determining an appropriate discount rate. For ease of exposition, we refer (throughout this section and in Annex 10) to the "degree of exposure to changes in market value of spectrum over time" as the "degree of risk" or just as "risk".[136]

Our position in the August 2014 consultation

4.16 In the August 2014 consultation, we set out that the discount rate used to annualise the lump-sum value should reflect the risk of the cash flows coming from licensees to the Government through the ALF. Exactly what the nature of this risk is depends on the nature of the ALF obligation. We considered two (hypothetical) polar cases to illustrate this. In the first polar case, the licensees face none of the risk of the cash flows and the Government faces all of the risk, whereas in the second polar case, the licensees face all of the risk and the Government none of the risk:

a) If, hypothetically, the ALF payments were set up in such a way that they varied in line with the future after-tax cash flows of the licensee (e.g. through some form of (hypothetical) net revenue sharing arrangement between the licensees and the Government), the correct discount rate to use would be the rate that the licensee would use to convert the expected cash flows from using the spectrum into a lump-sum. This may be approximated by the MNOs' WACC as calculated for the MCT market review 2015-18.[137] This higher discount rate would lead to higher ALFs, reflecting the position in this first polar case that the Government would bear the risk of variation in the cash flows through variation in the ALFs.

b) If the ALF payments were set up so that they were completely fixed regardless of circumstances, and licensees had no option but to pay this level of fee, the ALF would effectively be akin to a form of secured debt (or finance lease) and the correct discount rate would be the corresponding interest rate for such a debt instrument. This lower discount rate would lead to lower ALFs, reflecting the position in this second polar case that the licensees would bear the risk of variation in the cash flows (and the Government would not) because the level of ALF payments would be fixed.

4.17 We recognised that there is no solution that perfectly fits the case we are addressing here. We therefore sought to identify what we considered to be the best available proxy rate to use for the purposes of setting ALFs, taking a conservative approach to interpreting the available evidence.

[136] The key consideration in this context is the extent to which the licensee is exposed to changes in the market value of spectrum over time (which we refer to as the extent of the licensee's risk exposure). However, it is sometimes more convenient for drafting purposes to phrase this in terms of the extent to which the exposure to changes in the market value of spectrum over time is, in effect, being transferred away from the licensee to Government (which, for convenience, we refer as the extent of Government's risk exposure). However, where we do refer to the extent of Government's risk exposure this is intended as a reference to the extent to which the licensee's exposure to changes in the market value of spectrum over time is reduced (e.g. by the effect of reviews of ALF).

[137] Mobile call termination market review 2015-18, Draft Statement, 6 February 2015, http://stakeholders.ofcom.org.uk/consultations/mobile-call-termination-14/draft-statement/

4.18 We noted a number of features of ALF which made it closer to the 'debt rate' case than the 'WACC' case. However, we also recognised that ALF is not exactly aligned with the debt rate case, as (i) licensees could avoid paying the ALF by handing back the spectrum with no effect on the rest of its financial operations (in contrast to most debt where 'default' can have significant negative implications), and (ii) ALFs could be revised either up or down (although we noted that these two factors were likely to be closely linked).

4.19 We suggested that the ability for ALF to be revised up or down alters the balance of risk between the Government and licensees compared to a situation where ALFs are set 'once and forever'. At the extreme, if ALFs were revised so frequently that changes in market value were reflected in the fee levels in real time, the ALF would essentially reflect the underlying expected cash flows from the spectrum. This would transfer all of the risk of these cash flows to the Government. Any reduction (increase) in expected cash flows would be reflected in a decrease (increase) in market value of the spectrum, which would immediately feed through to lower (higher) ALFs. As such, the ALF obligation would be much closer to the 'WACC' case described above.

4.20 We said that in practice, our approach to fee reviews is somewhere between these two extremes. This suggests that the Government could in practice be left sharing the underlying risks of the business for which the spectrum is employed. This further suggests that using the debt rate could understate the discount rate it would be appropriate to use if the review regime were significantly to transfer risk from the licensees to the Government. However, we noted that there is considerable difficulty in estimating the extent of such a transfer of risk. In line with our conservative approach when interpreting the evidence to derive ALFs, we therefore proposed to use the cost of debt rate for the purposes of deriving ALFs.

Stakeholder responses

4.21 Stakeholders put forward the following arguments:

a) H3G[138] argued that the WACC is not a relevant upper bound as, in its view, the risk of the ALF will never reflect the underlying business risk.

b) EE[139] and Vodafone[140] said that the cost of debt is not the lower bound but the correct rate. In their view, using the cost of debt is therefore not conservative in itself, and instead we should be conservative in our approach to estimating it.

c) According to H3G,[141] the correct rate could be somewhat below the traditional cost of debt. It argued that ALF payments are for all relevant purposes risk free and the risk-free rate should therefore be the relevant discount rate. It suggested that at most we should include only a very small debt premium on top of the risk-free rate to reflect the low likelihood of default and the limited fallow period if default were to occur. Telefónica, Vodafone and EE also suggested a number of adjustments to the cost of debt observed from market data to better reflect the specific features of ALF.

[138] H3G's response to the August 2014 consultation, p.39.

[139] EE's response to the August 2014 consultation, p.45 and 49.

[140] Vodafone's response to the August 2014 consultation, p.40.

[141] H3G's response to the August 2014 consultation, p.40-42 and Annex C.

d) Vodafone[142], EE[143] and Telefónica[144] all argued that we should calculate the cost of debt based on current yields to maturity, rather than using our traditional approach.

e) By contrast, BT[145] suggested that the WACC is a relevant polar case, and there are arguments to use it as the discount rate. It suggested that, while it may be difficult to determine exactly where between the two poles the ALF case sits:

> "Many regulatory settings require judgements about the future to be made and Ofcom cannot simply avoid doing this in this context by stating it is hard to do; that would be an abrogation of their duties. Ofcom should be able to exercise its regulatory judgement on the appropriate range in which such risk sharing could reasonably fall rather than deliberately set it at the bottom extreme of the range which is guaranteed to be below the right value with complete certainty."[146]

Our analysis

4.22 In this sub-section we present our revised analysis, in light of stakeholders' comments, of:

a) The relevant upper polar case;

b) The relevant lower polar case;

c) Why we consider there is a significant degree of risk sharing such that we should depart from the lower polar case; and

d) The derivation of the discount rate with risk sharing.

4.23 In Annex 10 we set out in detail our approach to calculating the lower polar case, in particular our view on:

a) Using observed market debt rates instead of our traditional approach to estimating the cost of debt; and

b) The further adjustments we consider are warranted to account for:

i) Use of an average efficient operator rather than most efficient operator;

ii) Duration;

iii) Security;

iv) Inflation risk; and

v) Liquidity risk.

[142] Vodafone's response to the August 2014 consultation, p.40-41 and Annex 4.

[143] EE's response to the August 2014 consultation, p.49-53.

[144] Telefónica's response to the August 2014 consultation, p.76-77 and Annex II, p.4-10.

[145] BT's response to the August 2014 consultation, p.3-5.

[146] BT's response to the August 2014 consultation, p.5.

Upper polar case – why WACC is the right rate

Stakeholder responses

4.24 H3G[147] suggested that MNOs' WACC reflects many additional business risks unrelated to and on top of the value of spectrum, including risks relating to consumer demand and the intensity of competition. By contrast, it suggested the business risks associated with spectrum are much narrower, as the market value of spectrum (especially higher frequency spectrum) at the margin is determined by the costs of technological substitutes for increasing network capacity.[148]

4.25 H3G[149] also argued that, even if ALFs were revised annually to reflect full market value, they would still not reflect the same risk as the relevant spectrum cash flows. This is because market value reflects the present value of expected long-term forward-looking cash flows, i.e. a weighted-average of expected future cash flows, hence, should always be less variable than year-on-year annual cash flows.

4.26 By contrast, BT[150] argued that the annuity should be derived on an equivalent basis to how the purchaser established its own lump-sum value of the spectrum (e.g. in deciding its maximum bid in an auction) with annual charges set on an equivalent basis in terms of applicable discount rate. This relates to the risk faced by the licensee in raising the relevant funds up front (i.e. its WACC) rather than the risk associated either with the flow of payments to the Government or the risks around the licensees' revenues from using the spectrum.

Our analysis

4.27 H3G's argument is essentially that the exposure to systematic risk is different for a firm holding spectrum alone compared to the entirety of a mobile business. In relation to this, we note that in the context of disaggregating BT's WACC, we have set out that certain conditions strengthen the case for assessing risk on a project-specific basis:

a) there are strong a priori reasons for thinking that the systematic risk faced by the project is significantly different from that faced by the overall company (e.g. different income elasticities of demand and/or stability of cash flows);

b) there is evidence which can be used to assess variations in risk, e.g.:

i) it is possible to identify benchmark firms that are close to "pure play" comparators in terms of having similar risk characteristics to individual projects within the firm;

[147] H3G's response to the August 2014 consultation, p.39.

[148] With regard to the cost of debt, EE also argued that the risks associated with ALF payments to Government are not affected by the firm-specific factors that are reflected in the yield to maturity (YTM) on MNO parent company bonds. It suggested that basing the discount rate on a YTM that reflects the average risk of a MNO is therefore likely to lead to ALFs being set too high (EE's response to the August 2014 consultation, p.53). In Annex 10 we consider various specific adjustments which have been suggested to reflect the differences between ALF and corporate debt, including the more secure nature of the ALF obligation relative to unsecured debt.

[149] H3G's response to the August 2014 consultation, p.39.

[150] BT's response to the August 2014 consultation, p.4.

ii) it is possible to use other quantitative analysis (such as quantified risk assessments);

iii) data on the firm are available at a disaggregated level (e.g. via separated accounts); and

c) correctly identifying variations in risk, and reflecting this in an adjusted rate of return, is likely to bring about significant gains for consumers.[151]

4.28 We consider that these conditions are not met within the context of ALF for the following reasons:

a) We do not agree with H3G that there is a strong a priori reason to consider that the systematic risk faced by holding spectrum is significantly different from that of mobile operators as a whole. For example, we do not consider that the network cost savings associated with having additional marginal spectrum are unaffected by the factors H3G suggested as "additional business risks".[152] We remain of the view, as we set out in the October 2013 consultation, that we consider the WACC applicable to an average UK mobile-only operator (as derived in the MCT market review 2015-18 for the MCT charge control) is likely to capture the systematic risks which would apply to the ALF licences.

b) Further, there is a lack of evidence that can be used to assess the suggested variations in risk. For example, there is clearly no 'pure play' spectrum holder or disaggregated MNO accounts which could be used as a basis for such an assessment, and no other quantified analysis has been conducted in this area.[153]

4.29 We therefore consider that the MCT WACC is the appropriate upper bound for the discount rate in the hypothetical upper polar case where ALF changes frequently enough to reflect real-time changes in value, or is directly linked to MNOs' net revenues.

4.30 However, we do not consider that the WACC is the correct discount rate for annualising the lump-sum value in all circumstances.

4.31 BT's view described at paragraph 4.26 is similar to our proposed approach in the October 2013 consultation. However, we set out in the August 2014 consultation that

[151] See paragraph 5.24 in Ofcom's approach to risk in the assessment of the cost of capital: Final statement, 18 August 2005, http://stakeholders.ofcom.org.uk/binaries/consultations/cost_capital2/statement/final.pdf.

[152] In particular, network cost savings do vary with the level of consumer demand, as set out, for example, in our cost benefit analysis for changing the use of 700 MHz spectrum (see Decision to make the 700 MHz band available for mobile data: Statement, 19 November 2014, http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/statement/700-mhz-statement.pdf and Analysys Mason, *Assessment of the benefits of a change of use of the 700 MHz band to mobile*, 27 October 2014, http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/benefits_700MHz.pdf.

[153] We note that the recent MCT market review 2015-18 includes some illustrative analysis of disaggregating betas for mobile from the wider parent companies, but even this presents significant challenges as noted in that document (see paragraphs A10.142-A10.147 in Mobile call termination market review: Draft statement, 6 February 2015, http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-call-termination-14/statement/Annexes_7-13.pdf). Disaggregating part of the mobile business from the rest of the mobile business would likely be equally, if not more, challenging.

the nature of our annualisation exercise is not to reproduce the original cash flows on which the lump-sum value is based. Rather, we are seeking to spread the lump-sum value over a notional 20-year period to calculate a constant real annual payment from the licensees to the Government. In principle, an average efficient MNO (on which our estimation of the discount rate is based)[154] and the Government should be indifferent between payment for the spectrum in the form of a lump-sum payment or ALF. This means that the discount rate used to annualise the lump-sum value should reflect the risk of the cash flows coming from licensees to the Government through the ALF, rather than the risk to the licensee of the cash flows associated with using the spectrum. Therefore, we consider that the WACC is not relevant in all circumstances, but only as the upper polar rate.

Upper polar case – the most appropriate WACC estimate

4.32 We set out in the October 2013 and August 2014 consultations (and re-confirmed above) that we consider the WACC calculated for the MCT charge control would be a reasonable proxy for the WACC applicable to the ALF licences.

4.33 We published our estimate for the mobile WACC in the context of the MCT market review 2015-18 draft Statement in February 2015. This gives a pre-tax nominal WACC of 9.1%. This suggests a post-tax[155] nominal WACC of 7.3% is appropriate, giving a post-tax real WACC of 5.2% when incorporating our CPI estimate of 2%.

Lower polar case – why the cost of debt is the right rate

4.34 H3G argued that the cost of debt is too high for the lower bound (see paragraph 4.21c) above).

4.35 We set out in the August 2014 consultation that even where the ALF payments are completely fixed, there is still a risk that the Government does not receive the payments due to the risk that the licence holder may default on its payments, reducing the expected value of ALF. H3G acknowledged this risk, albeit that it considered it to be very small.

4.36 We remain of the view that the appropriate discount rate for the lower polar case would be some form of cost of debt (which incorporates a debt premium to reflect such a risk) rather than the risk-free rate. In Annex 10 we consider the arguments as to the size of this premium (and potential adjustments suggested to account for any difference between ALF and other forms of debt).

Lower polar case –the most appropriate cost of debt estimate

4.37 We have set out in Annex 10 the factors we consider in determining the appropriate cost of debt for ALF. On the basis of the analysis set out in Annex 10, we consider the appropriate lower polar rate is 3.0% (post-tax, nominal). This reflects the observed yield to maturity (YTM) on 10-year MNO debt, which represents a change in our view, taking account of stakeholder responses to the August 2014

[154] We have considered the relevance of the average efficient operator in Annex 10.

[155] From 1 April 2015, the corporate tax rate will be 20% (see HMRC, *Rates and allowances: Corporation tax,* https://www.gov.uk/government/publications/rates-and-allowances-corporation-tax). We are minded to use a corporate tax rate of 20% (as we did in the August 2014 consultation) since this represents the best estimate of what the tax rate will be on a long-run, forward-looking basis. Our post-tax calculations therefore include an adjustment for a corporate tax rate of 20%.

consultation. It also reflects an adjustment for inflation risk premium in ALF, as discussed in Annex 10.

4.38 Converting this to a post-tax real figure using our 2% inflation assumption gives a cost of debt of 0.9%.

Degree of risk sharing

Stakeholder responses

4.39 The MNOs argued that the Government does not share the risk of the underlying spectrum cash flows:

a) EE,[156] H3G[157] and Vodafone[158] argued there is little risk of licensees returning spectrum (unless market value falls below the ALF) due to its importance to their business and the ability to trade spectrum rights to a competitor;

b) H3G[159] and Vodafone[160] also noted that we retain significant discretion over the circumstances under which we would open a review and argued it is more likely to be revised up than down. Vodafone suggested there will always be a lag between changes in value and evidence of these changes becoming available, during which time licensees will bear any change in value. H3G noted that "Ofcom has now committed to there not being a review of the ALF for a period of at least five years" (emphasis in the original) and suggested that our suggested approach of reviewing ALF only if there is reason to believe there is a material misalignment between ALF and spectrum value means that "Government's risk is effectively 'capped' and could perhaps be characterised more in terms of low probability / high impact events that could cause spectrum value to diverge materially from that currently estimated by Ofcom".[161] They therefore suggested it is not clear Government is really sharing risk to any significant extent. EE[162] argued that, even with a review process, the ALF payments will be much less volatile than the profitability of a business. Further, it suggested that the Government would not be exposed to individual business risks but only to significant changes in overall market value;

c) EE[163] and H3G[164] said that, if there was a default, there would likely be a high degree of recoupment (even compared to other secured debt) due to (i) the Government's priority claim in the event of insolvency and (ii) the highly saleable nature of the spectrum. Telefónica made a similar point in response to the October 2013 consultation[165]; and

[156] EE's response to the August 2014 consultation, p.46 and 48.

[157] H3G's response to the August 2014 consultation, p.41 and Annex C, p.10-11.

[158] Vodafone's response to the August 2014 consultation, p.39-40.

[159] H3G's response to the August 2014 consultation, Annex C, p.6-7.

[160] Vodafone's response to the August 2014 consultation, p.39-40.

[161] H3G's response to the August 2014 consultation, Annex C, p.6.

[162] EE's response to the August 2014 consultation, p.49.

[163] EE's response to the August 2014 consultation, p.46-48.

[164] H3G's response to the August 2014 consultation, p.41 and Annex C.

[165] Telefónica's response to the October 2013 consultation, paragraph 314.

d) EE[166] argued we mischaracterised debt, such that ALF is actually closer to other forms of debt than we had set out.

4.40 As noted above (see paragraph 4.21e)), in contrast, BT argued that risk is shared with the Government and so it was wrong to set the discount rate at the cost of debt, which effectively assumed zero risk sharing. Instead, BT said that we should exercise regulatory judgement on the appropriate range of risk sharing.

Our analysis – why there is risk sharing

4.41 As set out above, we do not consider that our approach to fee reviews is at either of the hypothetical polar cases. As proposed in our previous consultations, our approach is to set the ALF as a fixed annual fee in real terms and it will remain at this level unless and until it is changed following a future ALF review. As a consequence ALF will not vary each year with the revenues earned from the spectrum (or be linked to drivers of spectrum value in real terms in any other way). As the upper polar case represents a situation in which the Government bears all of the systematic risk associated with changes in spectrum market value from year to year, it is not an appropriate representation of our approach to fee reviews.

4.42 On the other hand, we do not consider that the lower polar case is appropriate either. Our methodology for deriving the annual fee rates is to convert the lump-sum values (for 900 MHz and for 1800 MHz in Section 3) into their equivalent 20-year annuities. This is because the lump-sum values themselves are derived using information on the value of auctioned licences which happen to have an initial period of 20-years during which ALF is not charged. However, this does not mean that ALF will necessarily be fixed for 20 years (or, indeed, that it will definitely be reviewed at 20 years).

4.43 We set out at paragraph 6.28 in the August 2014 consultation that we currently are not minded to review ALF within the next five years, and thereafter we would be likely to review ALF only if there were grounds to believe that a material misalignment had arisen between the level of these fees and the value of the spectrum, in keeping with our general policy on fee reviews. However, given the scope for spectrum value to change over time, we consider that it is reasonable to assume that these fee rates are likely to be reviewed at some stage during a 20-year period, although we cannot predict with any certainty at what point any such review (or reviews) might occur.

4.44 We do not agree with the suggestion that in future reviews we would be more likely to revise ALF upwards than downwards. It is reasonable to expect we would initiate a review where a material misalignment had arisen between the level of these fees and the value of the spectrum in either direction (i.e. the value of the spectrum had changed such that it was either materially above or materially below the level of ALF). We also note that there are external influences which could induce us to open a review. For example, there could be particular points at which evidence of changes in underlying market value becomes available. In addition, licensees have the ability to hand the spectrum back (and doing so may not have the same negative implications for their other debt as 'normal' default on debt, as set out in paragraphs 4.47-4.50 below). This is most likely to occur when the licensee is unable to trade the spectrum rights under the licence with the current level of ALF liabilities, i.e. the ALF is higher than the value of the licence to the marginal excluded user. In addition, licensees are, in the first instance, more likely to request a fee review if they consider

[166]EE's response to the August 2014 consultation, p.47-49.

the ALF is too high. Therefore, the hand back provision may not be truly distinct from the fee review provision in terms of its effect on the Government's share of risk.

4.45 However, the potential for the licensee to hand back the licence could provide a 'hard stop' on the licensee's exposure to the risk of ALF not being changed in the face of large falls in market value (in that the licensees can always decide to hand spectrum back and so are not dependent on our discretion as to whether or not to open a review of ALF in these circumstances). While the importance of spectrum to the MNOs' business would probably make this a 'last resort', it remains an option open to them were they to consider that the value of the spectrum was materially lower than the cost involved in continuing to use it. The fact licensees are able to hand back the spectrum when its value falls could influence the variability in outcomes in terms of future ALF payments and as such is an important factor in why the Government could be exposed to changes in the underlying value.

4.46 As to the point that the Government is likely to achieve a high degree of recoupment in the case of default, we have considered this in relation to the 'security' of ALF payments compared to other forms of debt in Annex 10.

4.47 Turning to EE's view that we mischaracterised debt, we consider that this arises from an overly narrow reading of our arguments. For example, in the August 2014 consultation, we noted that the ability to hand back spectrum provides the option of 'defaulting' on this debt with limited effect on the rest of a licensee's financial operations. This is in contrast to most debt, where default can have significant negative implications (e.g. cross default clauses).

4.48 Failing to repay a debt can have significant repercussions for a firm beyond the contractual provisions for such an eventuality set out in relation to that debt. The effect on the market's perception of the firm's creditworthiness and financial security, and the knock-on effect this can have on its ability to raise new financing, are significant implications from failing to meet a debt obligation. These are less likely to arise from a firm handing back a spectrum licence. Cross-default clauses are therefore only one example of the way in which default on debt can have negative consequences for a firm. EE's argument was that "a significant proportion of corporate debt instruments do not contain this clause, and this is only one characteristic which affects yields on bonds, [and so] Ofcom simply cannot justify any discount rate in excess of the cost of debt on this basis".[167] However, this does not address the wider point.

4.49 EE[168] also highlighted that corporate debt payments are not always fixed or non-performance related, noting that the Deutsche Telekom bond used as one of the comparators in determining the cost of debt contains a clause which allows for an adjustment to coupon payments following a change in the credit rating of the bond issuer. However, such an adjustment does not seem likely to be as fundamental as an ALF review. Were a future review of ALF to use a similar methodology to that used in this document, it could affect not just the discount rate at which a lump-sum value is converted into an annual payment equivalent, but also the size of the lump-sum value itself. In contrast, to extend the analogy of the bond, a clause such as that noted by EE may affect the coupon payment, but it would not change the principal which is due for repayment at maturity.

[167] EE's response to the August 2014 consultation, p.47.

[168] EE's response to the August 2014 consultation, p.49.

4.50 Having considered the arguments raised by EE, our view remains that ALF has certain features which make it more risky (from the Government's point of view as 'lender') than 'normal' secured debt.

4.51 For these reasons, we agree with BT that it is not appropriate to assume that the Government bears zero risk and the licensees all of the risk. We therefore consider that we should exercise our regulatory judgement about the extent of risk sharing to be reflected in the discount rate (in contrast to our proposal in the August 2014 consultation).

Our analysis – the degree of risk sharing

4.52 As set out in paragraphs 4.41-4.51, we consider that neither polar position (WACC or cost of debt) will be correct. However, the judgement on the appropriate balance to strike between these polar cases will be influenced by the way the review regime operates.

4.53 In the August 2014 consultation we recognised that it was possible that the appropriate discount rate lies above the cost of debt. However, we also recognised the difficulty in estimating the transfer of risk from licensees to Government, and we said that because of our view that we should take a conservative approach when interpreting the evidence, we did not make an allowance for such risk sharing. We have reconsidered this point in light of BT's representation that taking a conservative approach is not the same as deliberately setting ALFs below our view of the appropriate level.

4.54 We agree with BT's comment, and therefore our revised view is that, despite the difficulties of estimating the extent of such a transfer of risk, we should exercise our regulatory judgement on the risk-sharing allowance. Accordingly, we have undertaken an exercise to explore the nature of risk sharing (i.e. exposure to changes in the market value of spectrum over time).

4.55 A future review is likely to be conducted only if there is evidence that a material misalignment between ALF and the market value of spectrum has developed. However, in our view, it is reasonable to assume that these fee rates are likely to be reviewed at some stage during a 20-year period, although we cannot predict with any certainty at what point any such review (or reviews) might occur (see paragraph 7.41). We do not think it sensible to try to assign meaningful specific probabilities to when a review (or reviews) might take place. Accordingly, we cannot calculate the exact degree of risk sharing associated with the potential for review. However, we can gain meaningful insights into this question by considering the potential scale of risk transfer under various circumstances.

4.56 A highly stylised and simplified scenario would be one where there was a single review around halfway through the period, i.e. after around ten years, at which point the ALF would be reset on the basis of the information available at that time. The simple calculation of risk transfer under this scenario is set out in Annex 10. Under this assumption, the Government would bear slightly more than 40% of the risk in the stylised example. This represents a significant proportion of the risk which would, correspondingly, imply a discount rate significantly above the cost of debt. We consider this scenario provides a relevant insight that there could be a significant transfer of risk (noting that the stylised scenario needs to be interpreted carefully taking into account its limitations). The potential quantum of the effect reinforces our view that it is not appropriate to ignore risk sharing in estimating an appropriate discount rate.

4.57 However, as noted above, this calculation is on the basis of a stylised scenario and in practice the position is likely to be much more complicated than this. Some of the differences between the simplifying assumptions in our stylised scenario described above and the approach to reviews in practice would imply the Government takes on a greater share of risk. However, other differences would imply the Government's share of risk is reduced relative to the stylised scenario. We consider this further in Annex 10.

4.58 For example, one possible difference from the stylised scenario considered above is that it assumes a single review during a 20-year period. If there were more than one review during the 20 years, this would tend to increase the degree of risk transfer above 40% (as illustrated by the scenarios discussed in Annex 10).

4.59 Although it is possible to create many scenarios of how the review regime might operate, these are essentially hypothetical since there is no certainty as to whether and when any reviews will be undertaken. This means that there is no clear way of quantifying the effect of the possibility of review taking place on the Government's share of risk and the consequent effect on an appropriate discount rate. Therefore, while we consider that the illustrative examples discussed in Annex 10 provide a point of reference which could suggest that the Government may bear a significant share of the risk, the assessment of the share of risk that should be incorporated in the discount rate is inevitably a matter of judgement rather than of fact.

4.60 However, we consider that one key difference between the stylised scenario considered above and the position in practice is that a review of ALF would not be undertaken at a fixed point in time. Neither would a review necessarily be undertaken as soon as there appeared to be some difference between the ALF and the true value. While a review could be undertaken where there was evidence of material misalignment between ALF and market value, there would be no requirement for reviews to be undertaken automatically.

4.61 The consequence of this is that any review would be subject to a "threshold for review" effect, in that there would need to be evidence of a material misalignment between underlying market value and ALF before a review was instigated. While it is not possible to be definitive about the scale of this effect given the nature of the review regime, it is clear that it reduces the extent of risk transfer relative to the stylised scenario (i.e. single review at a fixed point in time) set out above. This would suggest that taking a figure for risk transfer of less than 40% (in the case of a review about half-way through the 20-year period) could be reasonable for a single review.

4.62 Taking a higher level view is also helpful in our analysis here. We know that the level of risk borne by Government is between the two extremes of 0% and 100%, but will not be at either of these extremes. The nature of the review regime means there is likely to be some variance in underlying market value which does not trigger a review, which suggests the top end of this range is less likely. Since we are taking a conservative approach in interpreting the evidence, we consider it appropriate to discount the entire top half of the range and only consider a share of risk for the Government from the bottom half of the range between 0% and 100%. We have not identified clear reasons to prefer any particular figure within this narrower range of 0% to 50%, given the complexity and uncertainty relevant to the analysis. The mid-point within this narrower range is 25%.

4.63 Taking our illustrative example to be informative as a starting point, the above considerations suggest an adjustment somewhat lower than 40% may be justified, as a conservative interpretation of the evidence. Incorporation of the effect of the

threshold for review in the illustrative example, not taking account of the potential for there to be more than a single review, and a high level sense check lead us to the view that a risk transfer adjustment of 25% would be a sensible and conservative reflection of the risk that the Government is likely to bear. Accordingly, we apply a 25% risk sharing adjustment in estimating an appropriate discount rate as set out in paragraphs 4.64-4.67.

Derivation of discount rate

4.64 In line with our analysis above and in Annex 10, we consider that the appropriate starting point for the discount rate is the cost of debt based on observed YTM data on comparator bonds, which gives a rate of 0.9% (real, post-tax).

4.65 As set out in paragraphs 4.52-4.63, we uplift this by 25% of the difference between the cost of debt and the WACC to reflect the additional risk the Government bears over and above that of a 'normal' creditor. We set out in Annex 10 that we calculate this uplift as:

$$ALF\ discount\ rate = ALF\ debt\ rate + Government\ share\ of\ operating\ risk * (MCT\ WACC - ALF\ debt\ rate)$$

4.66 This gives an uplift of 25 %*(5.2%-0.9%) or 1.1%.

4.67 For the purposes of annualising the lump-sum value, we therefore consider we should apply a discount rate of 2.0%.

4.68 As explained above, we have made revisions to our approach to deriving the appropriate discount rate for ALF in light of responses that we received commenting on the approach that we proposed in the August 2014 consultation. Given that we are consulting on the impact of the geographic coverage commitment, if parties also wish to comment on our revised approach to deriving the discount rate we will consider any such comments carefully.

Tax adjustment

Our position in the August 2014 consultation

4.69 In the August 2014 consultation, we proposed to make a tax adjustment to ensure we levy an appropriate pre-tax ALF, taking into account any difference in the tax treatment of a lump-sum payment and an ALF payment. We noted that the tax treatment of annual fees would be more favourable than that of a lump-sum payment due to the ALF incorporating an allowance for the time value of money and adjusting for inflation. We said that as the ALF is close to being a form of debt instrument (although it may not exactly reflect the same risk as debt, as discussed above), this implies that the ALF payments displace 100% debt capacity. We noted that the tax deduction on interest payments for an equivalent lump-sum payment would therefore also assume that the lump-sum payment displaced 100% debt capacity. However, we considered that the tax deduction for interest payments is embedded in the after-tax debt rate, so it is not necessary to make an additional adjustment to the tax adjustment factor (TAF) to allow for this as stakeholders had suggested.

Stakeholder responses

4.70 Telefónica suggested that "the conceptually correct approach is to take into account interest deductibility of debt financing of the lump sum, and to use a pre-tax cost of debt to calculate the annuity. The riskiness of the ALF cash-flows is akin to debt and therefore the tax benefit of the ALF and lump sum are identical (as debt financing costs are fully tax deductible). Consequently, there is no need for a TAF adjustment term when the correct discount rate (i.e. pre-tax cost of debt) is used".[169]

4.71 In addition, H3G[170] argued that interest payments on debt are normally tax deductible (unlike profits to equity holders), in which case the "pre-tax" and "post-tax" cost of debt should be identical. Accordingly, it argued that the relevant discount rate should simply be the "pre-tax" cost of debt and no further tax adjustment should be necessary. It suggested this would be a much simpler and more transparent approach than Ofcom's current method.

4.72 H3G[171] further suggested that a tax adjustment approach is based on an erroneous assumption that licensees would not revalue their licences to reflect market value, even on a periodic basis. It claimed financial reporting rules nevertheless require companies to conduct revaluation reviews of all assets on a periodic basis and to restate them accordingly.

Our analysis

4.73 We set out in the October 2013 consultation that the implications for the level of ALF are broadly similar whether using a post-tax approach (with its adjustment for the differential tax treatment) or using a real pre-tax approach. We set out that, as using a pre-tax calculation ultimately depended on a calculation using the real post-tax rate, we considered that it would be more transparent to do the calculation on a post-tax basis, and to make explicit our assumptions on the more favourable tax treatment of annual licence fees compared to a lump-sum payment. This is why we continue to adopt a post-tax approach with an explicit adjustment for tax effects.

4.74 H3G suggested we are using a "non-standard concept of an 'after-tax' debt rate",[172] and by implication a non-standard approach to such calculations. However, this is not the case. A standard textbook on corporate finance sets out "…two ways to value a lease: … 2. Easy way: Discount the lease cash flows at the after-tax interest rate…" (original emphasis).[173] The lease cash flows being described in this quotation are after-tax flows that include the effects of capital allowances. We therefore consider, in contrast to H3G and Telefónica, that our approach is conceptually correct.

4.75 With regard to H3G's suggestion that that all assets will be marked to market, it is not clear to us that this would affect the tax benefit gained from that asset. First, while a revaluation may occur in future, the expected value of that revaluation (assuming the current value is the best unbiased estimate of the asset's true value) would be zero i.e. it could go up or down with equal probability. Second, even if an asset were revalued upwards for accounting purposes, this would not feed through into the tax

[169] Telefónica response to the August 2014 consultation, Annex II, p.20.

[170] H3G's response to the August 2014 consultation, p.42.

[171] H3G's response to the August 2014 consultation, p.43.

[172] H3G's response to the August 2014 consultation, p.42.

[173] Brealey, Myers and Allen (2014), *Principles of Corporate Finance*, p.650.

deduction achievable, as the total tax benefit a company can achieve on an asset cannot exceed the amount it paid for it. Any such revaluation would therefore not affect the amortisation tax benefit on the spectrum asset purchased via a lump-sum payment as H3G seeks to suggest.

4.76 We therefore continue to apply a tax adjustment factor in our derivation of ALF. As in the August 2014 consultation, we use a flat 20% corporate tax rate. We assume a CPI inflation rate of 2% (as discussed above) and (as before) amortise the lump-sum payment over 20 years. The tax adjustment is calculated from the difference in tax benefits from ALF payments compared to the amortisation tax deductions available through a lump-sum payment, converted to present values using the after-tax discount rate of 2.0% (as discussed above). The TAF is thus calculated as:

$$TAF = 1 + \left[\frac{(PV\ of\ tax\ benefits\ of\ ALF - PV\ of\ tax\ benefits\ of\ the\ amortisation\ of\ LSV)}{LSV}\right]$$

4.77 Equivalently, the TAF can be calculated as:

$$TAF = \frac{LSV - (t * PV\ of\ amortised\ LSV)}{LSV * (1 - t)}$$

4.78 This latter version is computationally simpler (in that it is no longer necessary to derive the tax benefit of ALF through iteration), but produces the same result. The implication of increasing the discount rate above the debt rate is that we consider that ALF displaces less than 100% of debt. The equivalent lump sum would therefore also displace less than 100% of debt. We calculate that the impact of the tax adjustment is equivalent to an increase of 7.4% in the lump-sum value (slightly lower in the August 2014 consultation). The full derivation of our ALF figures incorporates a TAF of this amount.

Discount rates for derivation of benchmarks

Our position in the August 2014 consultation

4.79 In the August 2014 consultation, we proposed to use different discount rates for the different benchmarking adjustments:

a) In estimating an adjustment to an auction price for licence duration or delayed access to spectrum, we are adjusting for the difference in value an operator would place on having access to spectrum for a shorter (or longer) period. This will reflect the difference in cash flows they expect to earn over (for example) 15 years compared to 20 years. The risk of these expected cash flows should be reflected in this adjustment, and so we considered it appropriate to use the WACC in adjusting for licence duration. The appropriate WACC to use will reflect expectations at the time of the auction. We noted that more of the auctions affected by this adjustment were closer in time to 2011 than 2014, and we therefore intended to use the 2011 MCT WACC (adjusted to reflect CPI inflation) in adjusting the international benchmarks for licence duration.

b) Incorporating the value of annual fees into the upfront bids for licences is essentially the reverse adjustment we make in annualising the lump sums into annual fees. We noted that the correct discount rate would therefore be the same as that used for annualisation, although it should reflect the view of the discount rate as at the time of the relevant auction. We considered we should be consistent between the dates of the calculation for the discount rates for the two

benchmark adjustments. Therefore, as above, we proposed to use the 2011 MCT cost of debt (again adjusted for CPI) to adjust benchmark auction results for the presence of annual fees.

Stakeholder responses

4.80 Telefónica[174] argued that we should use country-specific rates rather than UK discount rates.

Our analysis

4.81 We recognise that it is a simplification to use UK discount rates when deriving benchmarks that relate to another country. We have now investigated the components of WACC in different benchmark countries which allows us to apply country-specific discount rates. However, in some cases this information is insufficient to exactly reflect what we consider to be the most appropriate rate (particularly for incorporating annual fees into the upfront bids); we have therefore had to use a proxy approach. In addition, for our analysis of country-specific discount rates we have focused on the Tier 1 and Tier 2 benchmarks which are affected by adjustments involving the discount rate: Austria, Ireland, Portugal, Spain and Sweden.[175] These are the most relevant benchmark countries for the purpose of country-specific discount rates. For the remaining countries, we continue to use the 2011 UK WACC and cost of debt figures in order to avoid a level of analysis which is disproportionate to the relevance of these benchmarks to our results.[176]

4.82 In order to adjust for differences in licence duration and delayed availability of spectrum, we still consider that a post-tax WACC from the time of the relevant auction is the appropriate rate. We now apply different discount rates for different auctions, reflecting the post-tax real WACC in force at the time of the auction in each of the five countries listed above or the date of the review of mobile termination rates closest to that auction.

4.83 Turning to the adjustment to incorporate the present value of annual fees into a lump sum for licences, we still consider that this is essentially the reverse adjustment we make in annualising the lump sums into annual fees. The starting point is therefore that we should calculate the discount rate on the same basis as that used in annualisation. As set out above, we use a cost of debt derived from observed YTM data adjusted to reflect an estimate of the degree of risk borne by Government over and above that borne by 'ordinary' debt holders. This cost of debt is expressed in real, post-tax terms. However, in practice for these five countries, we consider it is appropriate to calculate the discount rate as follows:

a) Cost of debt without a risk sharing adjustment: For at least some of these countries, we understand that the annual fees may not be reviewed, or not reviewed on the basis of changes in market value. Where there is limited prospect for a future review based on changes in market value, the Government's

[174] Telefónica's response to the August 2014 consultation, p.52.

[175] For the 1800 MHz band, Italy is a Tier 1 and Germany is a Tier 2 benchmark, but they are unaffected by the choice of discount rate (see Annex 7).

[176] In the August 2014 consultation, we used the 2014 tax rate in these figures, instead of the tax rate as at the time of the 2011 MCT decision. We have changed this so that we now apply the original tax rate of 24% (see paragraph A8.156 in Wholesale mobile voice call termination: Statement, 15 March 2011, http://stakeholders.ofcom.org.uk/consultations/mtr/?a=0).

additional share of risk may be minimal. We also note that the spectrum licensees have already paid a lump sum at auction, so the annual fees only reflect a proportion of the value of the spectrum. This will reduce the probability of a hand-back of spectrum (which is relevant to the extent of risk sharing by governments, as discussed above).

b) Cost of debt in the WACC calculation: In some of these countries, e.g. Ireland and Sweden, we are aware that the NRA used a long term view of the cost of debt or risk-free rate, which is less affected by the macro-economic cycle at any given time. However, we use the cost of debt in the WACC calculation, given that we do not have reliable information about YTM for MNOs' long term bonds in all five countries. We consider this approach is practical and proportionate.

c) Nominal discount rate: Generally annual fees in these countries do not appear to be up-rated annually by inflation in the same way we are adopting for ALFs in the UK. We should therefore discount future fee payments using a nominal discount rate.[177]

d) Pre-tax discount rate: We set out in the previous sub-section that the conceptually correct approach is to discount the lump sum using the post-tax discount rate, but adjusting explicitly for any difference in tax position between a lump sum and annual payments. We still consider this to be correct. However, we do not have a reliable basis to calculate a separate TAF for each of the five countries in question. We note below that we have previously set out that the implications for the level of ALF is broadly similar whether using a post-tax approach (with its adjustment for the differential tax treatment) or using a real pre-tax approach. We therefore consider it an adequate proxy to apply the pre-tax discount rate.

Summary of provisional decision on deriving annual licence fees from lump-sum values

4.84 In summary, in deriving an annual fee from the lump-sum value we are minded to:

- spread the lump-sum value of spectrum over 20 years, using an ALF profile that is flat in real terms, that is a 20-year annuity;
- apply a post-tax discount rate of 2.0%;
- take into account the differential tax benefits of the lump-sum value and the ALF; and
- use the CPI index to adjust base year ALF level each year when the licence fee comes due for payment.

4.85 We use the following formula for calculating the base level of ALF from the lump-sum value of spectrum and updating it for inflation. This formula assumes an annuity payment with the payments made at the beginning of the year (as in our previous consultations).

[177] An exception is Ireland, where spectrum usage fees are index-linked to CPI. We therefore use a real discount rate in relation to Ireland.

$$ALF_t = LSV * TAF * \left[\frac{r}{1-(1+r)^{-t*}}\right] * \left[\frac{1}{(1+r)}\right] * \left[\frac{CPI_t}{CPI_{t0}}\right]$$

4.86 Where:

- ALF_t is the value of ALF in year t;
- LSV is the lump-sum value of spectrum;
- TAF is an adjustment factor that reflects the tax advantages of ALF over lump-sum payments (equal to 1.074 in this case);
- r is the real post-tax discount rate, i.e. 2.0%;
- t* is the length of period over which we spread the LSV for the purposes of calculating ALF, which is equal to the initial term of the licences obtained in the 4G auction, i.e. 20 years;
- CPI_{t0} is the level of the CPI (all items) index in March 2013 and CPI_t is the latest available figure for the same index published in the Consumer Price Inflation Reference Tables by the ONS.

Section 5

Our provisional decision on the base level of ALFs, before considering the impact of the geographic coverage obligation

Introduction

5.1 In the previous three sections we set out the assessment that we had reached of the first three steps of our analytical approach. In this section we explain step 4, setting out the provisional decision that we had reached towards the end of 2014 (subject to final internal confirmation and approvals) on the base levels of ALF (i.e. levels of ALF in March 2013 prices). We go on to consult in Section 6 on the impact of the geographic coverage obligation on ALF. We discuss in Section 7 how the ALFs should be implemented (including indexation for inflation since March 2013).

5.2 The rest of this section:

a) Sets out our provisional decision for base level of ALFs.

b) Provides a comparison to the proposals set out in the August 2014 consultation.

Our provisional decision on the base level of ALFs, before considering the impact of the geographic coverage obligation

5.3 Section 3 explained that our provisional decision on the lump-sum values for 900 MHz and 1800 MHz is £23m per MHz and £13m per MHz respectively. Section 4 explained that our provisional decision on an appropriate discount rate and tax adjustment factor (TAF) for converting these lump-sum values into an annual equivalent fee is 2.0% and 1.074 respectively. Using these values in the formula set out in paragraph 4.85 means that our provisional decision is that the base levels of ALF (expressed in March 2013 prices), before considering the impact of the geographic coverage obligation, are as follows:

a) 900 MHz: **£1.48m** per MHz; and

b) 1800 MHz: **£0.84m** per MHz.

Comparison to proposals in the August 2014 consultation

5.4 Table 5.1 provides a comparison of our position in the August 2014 consultation and our provisional decision in this document for each of steps 1-4, before considering the impact of the geographic coverage obligation. The percentage change in the ALFs at step 4 reflects the combined effect of changes at step 2 and step 3:

a) For 900 MHz, the reduction in ALF of 5% reflects the impact of the reduction in discount rate at step 3 (since the lump-sum value for 900 MHz at step 2 is unchanged).

b) For 1800 MHz, the overall reduction in ALF of 13% reflects the combination of the reduction in lump-sum value for 1800 MHz at step 2 (which contributes 7% of this 13%) and the reduction in the discount rate at step 3 (which contributes 6%).

Table 5.1: Comparison of estimates between August 2014 consultation and our provisional decision

	Step 1 (£m per MHz)		Step 2 (£m per MHz)		Step 3 (%)	Step 4 (£m per MHz pa)	
	800 MHz[178]	2.6 GHz	900 MHz	1800 MHz		900 MHz	1800 MHz
August 2014 consultation	**£35.63m**	**£5.5m**	**£23m**	**£14m**	**2.6%**	**£1.57m**	**£0.96m**
Provisional decision	**£33.0m**	**£5.5m**	**£23m**	**£13m**	**2.0%**	**£1.48m**	**£0.84m**
Effect on ALFs compared to August 2014 consultation	*input to step 2*		0%	-7%	-6%	-6%	-13%

Source: Ofcom

5.5 The derivation of lump-sum values for 900 MHz and 1800 MHz at step 2 uses the UK market values for 800 MHz and 2.6 GHz derived at step 1 as an input. Accordingly, it is possible to decompose the change in lump-sum values for 900 MHz and 1800 MHz at step 2 into separate components that reflect:

a) The change in UK market values for 800 MHz and 2.6 GHz (as explained in Section 2): and

b) The change in values of the 900 MHz and 1800 MHz bands relative to these UK market values (of 800 MHz and 2.6 GHz) that is implied by our analysis of the international benchmark evidence (in Section 3).

5.6 The separate impact of these changes is shown in Table 5.2, with the breakdown being as follows:

a) In the case of 900 MHz, our provisional decision on the lump-sum value is the same as in the August 2014 consultation (£23m per MHz). This is because our assessment of the value of 800 MHz in the UK is 7% lower (changing from £35.63m per MHz in the August 2014 consultation to £33m per MHz); but this is offset by an increase in the ratio of 900:800 MHz that is implied by our analysis of the international benchmarking evidence (changing from 65% in the August 2014 consultation to 70%).

b) In the case of 1800 MHz, our provisional decision on the lump-sum value is 7% below the value in the August 2014 consultation (£13m per MHz instead of £14m per MHz). This reflects the combination of the lower value of 800 MHz in the UK and a slightly lower Y/X ratio that is implied by our analysis of the international

[178] The figures in this table for 800 MHz are expressed gross of expected DTT co-existence costs (of £3m per MHz). The corresponding values of 800 MHz net of the expected costs of DTT co-existence (i.e. as reflected in the observed bids for 800 MHz lots in the auction) are £32.63m per MHz in the August 2014 consultation and £30m per MHz in Section 2 of this document.

benchmarking evidence (changing from 28% in the August 2014 consultation to 27% in Section 3 of this document).

Table 5.2: Break down of the change in lump-sum values

	Lump-sum values from August 2014 consultation	Effect of changes in:			Revised lump-sum values
		UK values of 800 MHz and 2.6 GHz	International benchmark analysis	Both factors together	
900 MHz	**£23m per MHz**	-7% (x 0.93)	+8% (x 1.08)	0% (x 1.0)	**£23m per MHz**
1800 MHz	**£14m per MHz**	-5% (x 0.95)	-2% (x 0.98)	- 7% (x 0.93)	**£13m per MHz**

Source: Ofcom

5.7 In Table 5.3 we show the effects of our provisional decision, before considering the impact of the geographic coverage obligation, on the level of payments by licensee.[179] We also include, for comparison, the current level of payments.

Table 5.3: Base level of ALF payments for 900 MHz and 1800 MHz by licensee (in £m per annum, March 2013 prices)

	Vodafone	Telefónica	EE	H3G	Total
Current fee levels	£15.6m	£15.6m	£24.9m	£8.3m	£64.4m
Based on proposals in August 2014 consultation	£65.8m	£65.8m	£86.4m	£28.8m	£246.7m
Based on provisional decision in this document	**£61.2m**	**£61.2m**	**£75.6m**	**£25.2m**	**£223.3m**
Ratio to Current	3.9	3.9	3.0	3.0	3.5
% change vs August 2014 consultation proposals	-7%	-7%	-13%	-13%	-10%

Source: Ofcom

[179] The numbers in this table are based on H3G paying ALF for 2x15 MHz of 1800 MHz spectrum and EE paying ALF for 2x45 MHz, corresponding to the position after the transfer of 2x5 MHz from EE to H3G on 1 October 2015.

Section 6

Impact of the geographic coverage obligation on market value of ALF bands

Introduction

6.1 The Government and the MNOs agreed a series of commitments on 17 December 2014. These included a commitment by each MNO to implement 90% geographic voice coverage throughout the UK by no later than 31 December 2017 (at specified signal strength thresholds). This commitment has been given effect through a variation of the MNOs' spectrum licences. In this document we refer to this commitment as the "geographic coverage obligation".[180]

6.2 The MNOs can meet the obligation using any frequencies or technologies available to them, including LTE at 800 MHz, GSM at 900 MHz, GSM at 1800 MHz, and UMTS at 2100 MHz. Voice services are provided over GSM and UMTS at present. Although the LTE networks in the UK do not currently provide voice services, we consider it is reasonable to assume that voice over LTE (VoLTE) will become a viable option for providing voice services before the end of 2017 (i.e. within the timeframe relevant to meet the geographic coverage obligation).[181]

6.3 The question which we consider in this section is whether, and if so how, this geographic coverage obligation affects the market value of spectrum in the ALF spectrum bands at 900 MHz and 1800 MHz, taking account of the incremental costs incurred by the MNOs to meet the obligation. We have set this out as step 2b in the analytical framework we describe in Section 1.

6.4 We begin this section with an explanation of the approach which, in our view, is appropriate for assessing the impact of the geographic coverage obligation on the market value of the ALF bands. Then we set out our initial view of the implications of applying this approach to each of the 900 MHz and 1800 MHz spectrum. For the reasons explained below, our initial view is that the geographic coverage obligation is unlikely to have a material effect on the market value of either 900 MHz or 1800 MHz spectrum for the purpose of ALF.

[180] There is also a different coverage obligation in the 800 MHz spectrum licence acquired in the 4G auction by Telefónica, which we refer to as the "800 MHz coverage obligation". This obligation is specified in terms of data coverage rather than voice coverage.

[181] The reasonableness of this assumption is reflected by the fact that LTE at 800 MHz is one of the technologies that was included in the Statement of Commitments that the MNOs agreed with the Government (and which is now reflected in the varied licence). It is also consistent with the approach to VoLTE we have taken in the MCT market review 2015-18 (see paragraphs A7.55-A7.58 and A7.139-A7.140, http://stakeholders.ofcom.org.uk/consultations/mobile-call-termination-14/draft-statement/). Furthermore, we note in the MCT market review 2015-18 that VoLTE has now been deployed operationally in other countries such as Hong Kong, Japan, South Korea, Romania, Singapore and the USA, and that trials have already been undertaken in the UK by Vodafone.

Approach to assessing the impact of the geographic coverage obligation on market value

6.5 The Government Direction requires us to revise ALF to reflect full market value. In Section 2 we define market value for the purpose of ALF as the market-clearing price in a well-functioning market, or the forward-looking marginal opportunity cost of the spectrum. As noted in Section 2, this means that, taking Vodafone's holdings of 900 MHz as an example, we are not therefore seeking to establish Vodafone's value of its 900 MHz licence. Instead it is the value that is denied to other operators by Vodafone continuing to hold this spectrum that is relevant to the marginal opportunity cost and market value. In particular, it is the value to the other operator that would gain the highest value if it were to acquire Vodafone's 900 MHz frequencies (or part of them). Below we refer to this highest-value alternative holder of the spectrum as the marginal operator or marginal bidder.

6.6 The market value of spectrum for the purpose of ALF therefore depends on the value to the marginal operator, the highest-value operator that does not hold that specific spectrum, since this determines the opportunity cost. For example, in analysing the market value of the 800 MHz band, we have identified EE as the marginal bidder for 800 MHz spectrum. This is because EE was the highest losing bidder in the 4G auction for additional 800 MHz spectrum (i.e. for more spectrum than it won in the auction).

6.7 We recognise that the MNOs may incur incremental costs to meet the geographic coverage obligation which could, therefore, reduce the overall value that they attach to their current spectrum holdings. However, for the impact on the market value of 900 MHz and 1800 MHz, in our view this is not the relevant consideration. We consider that the impact on market value depends on the value to the marginal operator of acquiring additional ALF spectrum.

6.8 As in Section 2, we use the term "additional spectrum" to refer to more spectrum in that band than the operator currently holds. For example, considering the four MNOs:

a) EE and H3G currently have no spectrum in the 900 MHz band. Therefore for these operators, "additional spectrum" would mean them acquiring some spectrum in the 900 MHz band.

b) All four operators currently have holdings in the 1800 MHz band: EE has the largest holdings of 2x45 MHz, H3G has 2x15 MHz (in both cases after completion of the spectrum trade between EE and H3G), whilst Telefónica and Vodafone have smaller holdings of 2x5.8 MHz each. Therefore, additional 1800 MHz spectrum would mean these operators acquiring more 1800 MHz spectrum than they currently hold.

6.9 In general, the value of spectrum to an operator is the difference in its profit with and without the specific spectrum in question.

6.10 Putting together these two points (i.e. looking at this question from the perspective of the marginal operator and the difference in profit with and without the specific spectrum in question), we show in Table 6.1 our approach to considering the impact of the geographic coverage obligation on the market value of the ALF bands.

6.11 The marginal operator's profit without the additional ALF spectrum and without the geographic coverage obligation is shown in Table 6.1 as the value labelled "A". In Sections 2 to 5 in this document, in effect, we assess estimates of the market value

of ALF spectrum shown in Table 6.1 as the marginal operator's difference in profit with and without additional ALF spectrum, i.e. C (= B-A). We do so using the available market information (in particular, bids in the 4G auction and international benchmarks). For example, the highest losing bidders' incremental bid values in the 4G auction for additional 800 MHz and 2.6 GHz spectrum provide market information which we consider when deriving the market value of those bands.

Table 6.1: Impact of geographic coverage obligation on market value of ALF spectrum through its effect on marginal operator's profit

	Profit without geographic coverage obligation	Profit with geographic coverage obligation	Incremental cost of geographic coverage obligation
Without additional ALF spectrum	A	D	G = A-D
With additional ALF spectrum	B	E	H = B-E
Market value of ALF spectrum	C = B-A	F = E-D	
Impact of geographic coverage obligation on market value of ALF spectrum[182]			F-C or G-H

Source: Ofcom

6.12 The geographic coverage obligation could affect the marginal operator's profit both with and without additional ALF spectrum. The market value becomes the difference in profit with and without additional ALF spectrum in the presence of the geographic coverage obligation, i.e. F (= E-D).

6.13 As far as we are aware there is no market information currently available that we can use to assess the market value in the presence of the geographic coverage obligation (F).[183] This is in contrast to the market value without that obligation (C), as explained above.

[182] The two expressions of F-C and H-G are equivalent:

F-C = (E-D)-(B-A)

G-H = (A-D)-(B-E), which can be rearranged as (E-D)-(B-A)

[183] In contrast, for the 800 MHz coverage obligation in the spectrum licence acquired in the 4G auction by Telefónica there is market information available that the impact was a reduction in market value of the 800 MHz spectrum with the obligation of £1.55m per MHz (or £31m for the 2x10 MHz block). This was the difference in bid value in the 4G auction of the marginal bidder for the spectrum with the 800 MHz coverage obligation (Vodafone) compared to the same amount of 800 MHz spectrum without the obligation - see paragraph 2.53a) in Section 2.

The 800 MHz coverage obligation does not fit neatly into the approach set out in Table 7.1. This is because the obligation was attached to a specific lot of 2x10 MHz of 800 MHz spectrum in the 4G auction, so that there was not a meaningful distinction between acquiring this additional spectrum and having the 800 MHz coverage obligation – they came as a package (whereas the geographic coverage obligation applies to each MNO regardless of whether or not it acquires additional ALF spectrum). Therefore, in terms of Table 7.1, we interpret £31m as the difference between the first two columns (without distinguishing the rows), i.e. as the impact of the 800 MHz coverage obligation on the market value of the 800 MHz spectrum to which that obligation applies. For the avoidance of doubt, for the purpose of ALF we focus in Section 2 on the market value of the 800 MHz band without the 800 MHz coverage obligation.

6.14 We now consider two aspects to the possible impact of the geographic coverage obligation on the market value of ALF spectrum:

a) First, the impact of additional ALF spectrum on the incremental cost to the marginal operator of meeting its own geographic voice coverage obligation; and

b) Second, the impact on the marginal operator's value of additional ALF spectrum of the existence of the geographic coverage obligation on other MNOs, against which it is competing.

Impact of additional ALF spectrum on the incremental cost to the marginal operator of meeting its own geographic voice coverage obligation

6.15 We can describe the impact of the geographic coverage obligation on the market value of the ALF bands by considering the incremental cost of the obligation to the marginal operator with and without additional ALF spectrum:

a) Incremental cost of the geographic coverage obligation to the marginal operator, which is the difference in its profit with and without the geographic coverage obligation with its existing spectrum holdings, i.e. G (= A-D).

b) Incremental cost of the geographic coverage obligation to the marginal operator with additional ALF spectrum, i.e. H (= B-E).

c) The impact on the market value of the ALF bands of the geographic coverage obligation is the difference between the two incremental costs set out above, i.e. G-H.

6.16 Therefore, we recognise that the marginal operator may incur incremental costs to meet the geographic coverage obligation. However, in our view it is not the incremental cost of the geographic coverage obligation on its own which leads to an impact on market value. Instead it is the difference in the incremental costs of the marginal operator with and without additional ALF spectrum. The reason is that each MNO – and hence the marginal operator – has the geographic coverage obligation regardless of whether or not it acquires additional ALF spectrum.[184]

6.17 One possibility is that the geographic coverage obligation has no impact on the marginal operator's value of additional ALF spectrum. This might be, for example, because the marginal operator's current spectrum holdings are the lowest cost way for it to meet the geographic coverage obligation, and acquiring additional ALF spectrum would not change this. In this case, the difference in profit with and without the geographic coverage obligation would be the same both with and without additional ALF spectrum, i.e. H would be the same as G (which also means that F would be the same as C). In other words, the geographic coverage obligation would not change the market value of the ALF spectrum.

6.18 Another possibility is that the impact of the geographic coverage obligation could be to decrease the market value of the ALF spectrum. However, for the incremental costs of meeting the geographic coverage obligation to have a direct impact in reducing ALF, a significantly different approach would need to be relevant, such as:

[184] If an operator other than an MNO were the marginal operator for additional ALF spectrum, the impact on market value is likely to be zero as that operator does not have to meet the geographic coverage obligation.

a) If market value for the purpose of assessing the impact of the geographic coverage obligation on ALF were to depend on the private value of the ALF spectrum to the licensee, instead of the opportunity cost (and if the operators' holdings of non-ALF spectrum did not provide similar voice coverage capabilities to their ALF spectrum). Therefore, such a different approach would require us to define "market value" as the private value instead of the opportunity cost, which we do not consider appropriate; and

b) If the geographic coverage obligation were causally related only to the operators' holdings of ALF spectrum.

6.19 For the sake of completeness, we have also considered the possibility that the marginal operator's cost of meeting the geographic coverage obligation would be reduced if it acquired additional ALF spectrum. If this were the case, the impact of the geographic coverage obligation could be to increase the market value of that ALF spectrum. It might seem counter-intuitive that there could be an increase in the market value of ALF spectrum as a consequence of the geographic coverage obligation, especially as the MNOs might incur an incremental cost in order to meet this obligation. The rationale for this implication is as follows:

a) The marginal operator for the ALF spectrum has the geographic coverage obligation regardless of whether or not it acquires any additional ALF spectrum. Therefore, it is not the cost of meeting the obligation in itself which is relevant to market value (see paragraphs 6.7 and 6.16 above).

b) So the value of the ALF spectrum to the marginal operator is greater with the geographic coverage obligation, if it could use additional ALF spectrum to reduce its cost of meeting the obligation. This is because:

i) the marginal operator can derive the same value from the additional ALF spectrum as it could without the geographic coverage obligation;

ii) plus there is another source of value, given the geographic coverage obligation, namely reducing the marginal operator's cost of meeting that obligation.

Impact on the marginal operator's value of additional ALF spectrum of the existence of the geographic coverage obligation on other MNOs

6.20 There is a second type of effect which could have an impact on market value. In the discussion above we suggested that the marginal operator can derive the same value from the additional ALF spectrum with the geographic coverage obligation as it could without the obligation (see paragraph 6.19b)i) above). However, it is possible this is not the case, due to the effect of the geographic coverage obligation on other MNOs against which the marginal operator is competing.

6.21 The geographic coverage obligation must be met by each of the MNOs. This means that, from the perspective of the marginal operator, the other MNOs – against which it is competing – may have more extensive network coverage with the geographic coverage obligation than in the absence of that obligation. Depending on the exact nature of the sources of value that the marginal operator would derive from additional ALF spectrum, this increase in coverage by its competitors could affect the marginal operator's commercial value from additional ALF spectrum. For example, one possibility is that the geographic coverage obligation could reduce the marginal operator's commercial value, perhaps because:

a) Without the obligation, achieving superior coverage to its competitors could be part of the marginal operator's value of additional ALF spectrum.

b) However, if these competitors have more extensive coverage with the geographic coverage obligation, the likelihood that the marginal operator would achieve such superior coverage to its competitors through using additional ALF spectrum could be reduced.

6.22 Using the approach in Table 6.1, it would be possible to distinguish in separate columns between:

a) Profit with geographic coverage obligation on other operators (but not the marginal operator); and

b) Profit with geographic coverage obligation on the marginal operator as well as other operators.

6.23 The former would reflect the second effect discussed in this sub-section, arising from the impact on the marginal operator's value of additional ALF spectrum of the existence of the geographic coverage obligation on other MNOs, against which it is competing. The latter would, in addition, take account of the first effect of additional ALF spectrum in reducing the marginal operator's cost of meeting its own obligation (discussed in the preceding sub-section).

6.24 We now consider each of the ALF bands in turn.

Impact on market value of the 900 MHz band

6.25 The available evidence from bids for sub-1 GHz spectrum (at 800 MHz) in the 4G auction suggests that the marginal operator for additional 900 MHz spectrum may be EE. However, similar points as discussed below would also be relevant if the marginal operator were H3G.

6.26 First, we consider the difference in the marginal operator's incremental cost of meeting its own geographic coverage obligation. EE's holdings include 2x5 MHz of 800 MHz spectrum plus large holdings in the 1800 MHz and other higher-frequency bands. The relevant question is whether EE's cost of meeting the coverage obligation would be lower with additional sub-1 GHz spectrum at 900 MHz, compared to with its existing spectrum holdings.

6.27 We do not consider it likely that EE's (or H3G's) cost of meeting the geographic coverage obligation would be materially lower with acquisition of 900 MHz spectrum. The obligation relates to voice coverage, which does not have the same bandwidth requirements as data services. EE and H3G each hold only 2x5 MHz of 800 MHz spectrum. But this limited bandwidth of sub-1 GHz spectrum may still be sufficient to deliver sufficiently wide coverage to assist in meeting the obligation for voice services, without the need for additional sub-1 GHz spectrum (and, as noted at paragraph 6.2 above, we consider it reasonable to assume that voice over LTE will become a viable option for providing voice services by the end of 2017).

6.28 Second, there is the potential for an effect on the market value of 900 MHz arising from the existence of the geographic coverage obligation on other MNOs, e.g. if there is a change in voice coverage competition arising from the geographic coverage obligation (see paragraph 6.21 above). Whether or not this is the case, and the scale of any effect, depends on the sources of value of additional 900 MHz spectrum to the

marginal operator. For example, part of the value of additional 900 MHz spectrum to EE in the absence of the geographic coverage obligation could have been an extension of its voice coverage to gain a competitive advantage in voice coverage over its competitors.[185] If so, then this value could be reduced if the existence of the geographic coverage obligation required other operators to extend their own voice coverage beyond the levels that they would otherwise have reached.

6.29 However, it seems unlikely to us that the marginal operator's competitive position in voice coverage would be a significant factor in its value for additional 900 MHz spectrum for the same reasons as given above (i.e. it is unlikely that 900 MHz would confer a material capability that it could not obtain using its existing 800 MHz spectrum holding).

6.30 We therefore invite comments on our initial view that the geographic coverage obligation is unlikely to affect the market value of the 900 MHz band for the purpose of ALF.

Impact on market value of the 1800 MHz band

6.31 As for the 900 MHz band, we consider the two types of effect described in our approach.

6.32 First, we consider that acquiring additional 1800 MHz spectrum is unlikely to affect the marginal operator's incremental cost of meeting its own geographic coverage obligation. As discussed below, the underlying reasons are:

a) operators without large holdings of sub-1 GHz spectrum already have material holdings in the 1800 MHz band; and

b) operators with sub-1 GHz spectrum are more likely to use that low-frequency spectrum for their lowest-cost way to meet the coverage obligation.

6.33 It is not clear which of the MNOs is the marginal operator for additional 1800 MHz spectrum, so we consider each in turn:

a) EE already holds 2x45 MHz of 1800 MHz spectrum as well as 2x5 MHz in the 800 MHz band, 2x20 MHz in the 2.1 GHz band and 2x35 MHz of 2.6 GHz spectrum. It could use one or more these bands to meet the coverage obligation. It seems likely that its cost of meeting the coverage obligation would not be materially affected by acquiring additional 1800 MHz spectrum on top of its large holdings in that band.

b) H3G already holds 2x15 MHz of 1800 MHz spectrum as well as 2x5 MHz in the 800 MHz band and 2x15 MHz in the 2.1 GHz band. It seems likely that its cost of meeting the coverage obligation would not be materially affected by acquiring additional 1800 MHz spectrum on top of its already significant holdings in that band.

[185] We do not directly observe EE's value of additional 900 MHz spectrum. Instead in Section 2 we assess the lump-sum market value of the 900 MHz band taking into account EE's bids for additional 800 MHz spectrum in the 4G auction and international benchmarking evidence on the relative value of 900 MHz and 800 MHz spectrum.

c) Telefónica only holds 2x5.8 MHz of 1800 MHz spectrum, but it also has 2x10 MHz in the 800 MHz band, 2x17.4 MHz in the 900 MHz band and 2x10 MHz in the 2.1 GHz band. It could use one or more these bands to meet the coverage obligation, such as its sub-1 GHz spectrum. It seems likely that its cost of meeting the coverage obligation would not be materially affected by acquiring additional 1800 MHz spectrum on top of its significant sub-1 GHz holdings.

d) Vodafone similarly only holds 2x5.8 MHz of 1800 MHz spectrum, but it also has 2x10 MHz in the 800 MHz band, 2x17.4 MHz in the 900 MHz band, 2x15 MHz in the 2.1 GHz band, 2x20 MHz of paired spectrum and 25 MHz of unpaired spectrum respectively in the 2.6 GHz band. It seems likely that its cost of meeting the coverage obligation would not be materially affected by acquiring additional 1800 MHz spectrum on top of its significant sub-1 GHz holdings.

6.34 The second effect is the possible impact that the existence of the geographic coverage obligation on other MNOs could have on the marginal operator's value of additional 1800 MHz spectrum. It is not clear that any change in voice coverage competition would materially affect the market value of 1800 MHz spectrum. This is because extension of voice coverage is unlikely to be a source of value of additional 1800 MHz spectrum, given each MNO's existing spectrum holdings as discussed above.

6.35 We therefore invite comments on our initial view that the geographic coverage obligation is unlikely to affect the market value of the 1800 MHz band for the purpose of ALF.

Question 1: Do you agree with the approach we put forward to assess the impact of the geographic coverage obligation on revising ALF to reflect full market value?

Question 2: Do you agree with our assessment under the approach that we have put forward of the impact of the geographic coverage obligation on the market value of 900 MHz and/or 1800 MHz spectrum for the purpose of revising ALF to reflect full market value (where possible, supported by evidence)?

Question 3: If you think that we should use a different approach to assess the impact of the geographic coverage obligation, what is your alternative approach and why do you consider it more appropriate than the approach we put forward?

Question 4: If you have set out an alternative approach to assess the impact of the geographic coverage obligation, what is your assessment under that approach of the impact of the geographic coverage obligation on the market value of 900 MHz and/or 1800 MHz spectrum for the purpose of revising ALF (where possible, supported by evidence)?

Question 5: Do you have any other comments on whether, and if so how, the geographic coverage obligation, taking account of the associated incremental costs incurred by the MNOs, should impact ALF?

Section 7

Implementation

Introduction

7.1 This section sets out how we are minded to implement the revised fees, including:

a) having a common date for introduction of revised ALF;

b) the choice of common effective date and phasing-in revised ALF;

c) calculating the first year's payment of revised ALF following the common effective date; and

d) implementation of inflation indexation.

7.2 We also set out our current position on future reviews of the level of ALF.

Having a common date for introduction of revised ALF

October 2013 and August 2014 consultations

7.3 The licences currently have different fee payment dates, reflecting the difference in the dates on which the licences were initially granted (28 February for EE, 31 July for Vodafone and Telefónica and 31 October for H3G).

7.4 In both the October 2013 and the August 2014 consultations, we proposed for reasons of fairness as between the licensees that the revised ALF should be introduced on a date that was common to all of the licensees, rather than an introduction that produced a 'staggered' effect because of the different fee payment dates.

7.5 As to the way to achieve a common implementation across the licensees, in the August 2014 consultation we considered that it would be better to move licensees to a **common actual payment date**. We noted that a common actual payment date would simplify the regulations and their implementation by comparison with the alternative of having to specify and implement different inflation adjustments across the year (to reflect different licensee payment dates). However, recognising that changing the fee payment date may cause some disruption to licensees, we proposed to do this after the first payment of the revised ALF.

7.6 For the first payment of the revised ALF, we proposed to achieve a common implementation across the licensees by using a **common effective date** and by adjusting the payment in the first year following the common effective date so that each licensee's first payment following such date would be made up of two sums:

a) the revised ALF applied to the licensee's spectrum holdings; plus

b) a sum equal to the difference between the revised ALF and current ALF, pro-rated in relation to the number of months between the common effective date for the introduction of the revised ALF and the licensee's payment date.

7.7 Overall, we therefore proposed to achieve a common implementation across the licensees by:

a) for the first year of implementation - setting a common effective date for the introduction of revised ALF with each licensee's payment date remaining as it currently stands for payment of the first ALF following this common effective date; and

b) from the second year onwards – setting a common actual payment date for any subsequent ALF payment after the first one (i.e. by changing each licensee's payment date so that they are all on the same date). We proposed that the common actual payment date would be the first anniversary of the common effective date.

Stakeholder responses

7.8 In response to our August 2014 consultation, H3G said that it agreed with setting the same common effective date for all licensees and Vodafone said that it agreed with adopting a common actual payment date. EE and Telefónica did not comment specifically on these issues.

Our view

7.9 In light of stakeholders' responses, we remain of the view that it is fair to introduce the revised ALF so that all the licensees will pay a rate that reflects the market value of the corresponding spectrum from the same point in time. In line with our revised proposals as set out in the August 2014 consultation, we consider that a simple and pragmatic approach to achieve fairness through a common implementation across the licensees is by:

a) setting a common effective date that we use to determine the fees payable by each individual licensee on its first payment date following the common effective date (as if each licensee had to start paying the relevant fees at the revised rate from the common effective date);

b) adjusting the first payment of revised ALF which will be due on each licensee's respective current payment date, as explained above; and

c) setting a common actual payment date falling on the anniversary of the common effective date, so that from this point onwards the licensees will have the same payment date.

The choice of Common Effective Date ("CED") and phasing-in the revised ALF

October 2013 and August 2014 consultations

7.10 We said in the October 2013 consultation that we proposed to set the common effective date to be the first day of the month following the new fees regulations coming into force, and that we did not propose to phase-in the revised ALFs. A number of respondents (including the MNOs and Prospect) argued in their responses to that consultation that there was a case to phase in the new fee rates over time and that we should consider the impact of different lengths of phase-in on

investment, notably the deployment of 4G networks. Some of the responses drew attention to other cases where increased fees have been phased in over time.

7.11 We considered these arguments carefully, and in the August 2014 consultation we set out revised proposals, including a proposal for phasing-in the revised ALFs. We proposed to set a common effective date as soon as practicable after the new fees regulations come into force, with a two-stage phase-in of revised ALF consisting of the following[186]:

a) one half of the increase (from the current ALF rate to the proposed new ALF rate) coming into effect on the CED; and

b) the second half of the increase becoming effective one year later (which as set out above would be the common actual payment date). We specified that from this date ALF rates would be at the proposed revised level.

Stakeholder responses

7.12 BT and the current licensees, except for Telefónica, provided comments on our proposal to adopt a two-stage phase-in.

7.13 BT argued that we should introduce revised ALF in full, without phasing it in. BT contended that phasing-in the revised fees was not compatible with the Government Direction because the Government Direction requires the 900/1800 MHz spectrum to be charged at full market value and "not at some fraction of full market value". BT also said that the delay in charging for the 900/1800 MHz spectrum at full market value puts BT at an unfair disadvantage to its mobile competitors (because BT paid full market value for its spectrum at the time of the 4G auction), potentially distorting competition. BT also argued that under the Government Direction we should seek to "recoup" some of the "missed charges" in future payments[187].

7.14 On the other hand, EE, H3G and Vodafone agreed that the revised ALFs should be phased-in. H3G did not comment specifically on the length of the phasing-in period. EE and Vodafone argued for a longer phase-in period (EE suggested three or more years, and Vodafone suggested five years). They argued that we had not properly considered the impact of the increase in fees on operators, in particular the effect on operators' investment plans, operating costs and consumer prices, and that we should carry out a cost benefit analysis of different options for phasing-in.

7.15 Both EE and Vodafone said that our proposals in the August 2014 consultation for a phasing-in period were not conservative and were not consistent with the approach we had previously taken in other sectors. In particular, they both pointed to the 5-year phasing-in proposed for consultation in the context of the broadcasting sector. In addition, EE referred to the 3-year phasing-in we applied to the introduction of revised licence fees for the maritime sector and Vodafone referred to our adoption of "glidepaths" when imposing wholesale charge controls following our analysis of specific markets for communications services. We understand Vodafone's argument to be that instances where, it said, we have adopted glidepaths for introducing price changes within the context of market reviews are analogous to the

[186] For simplicity, we have set out separately how we will take account of inflation (see paragraphs 7.31-7.36).
[187] BT's response to the August 2014 consultation, p. 5.

current decision on whether to phase-in ALFs. We note that the arguments put forward by the MNOs who responded on this point are broadly the same arguments made in response to the October 2013 consultation[188].

Our view

7.16 We have considered carefully BT's arguments that we should not phase-in the revised ALFs. On BT's argument that phasing-in revised fees that reflect full market value would not be compatible with the Government Direction, we consider that BT has incorrectly taken a narrow interpretation of the Government Direction. We do not agree with BT that implementing the revised fees through phasing-in would not be compatible with the Government Direction. We also do not agree that the Government Direction requires Ofcom to "recoup" what BT describes as "missing charges" in future payments.

7.17 We also do not agree with BT's argument that adopting phasing-in would put BT at an unfair disadvantage to its mobile competitors. The spectrum holding awarded to BT at the 4G auction concerned a different frequency band (i.e. 2.6 GHz) and all the other winning bidders in the 4G auction paid on the same basis as BT for their spectrum holdings in the same band. Furthermore, the two-stage phase-in of revised ALF that we are minded to adopt would result in the MNOs paying fees reflecting our estimate of market value in full from the common actual payment date (i.e. on the anniversary of the common effective date) and any effect of ALF levels on BT's competitive position ahead of this date is unlikely to be material (noting also that BT has not yet launched its own mobile services using 2.6 GHz spectrum).

7.18 We consider it appropriate to introduce revised ALFs as soon as practically possible, in the interests of good administration and recognising that we are revising ALFs having been directed to do so by Government. Specifically, we consider it appropriate to adopt the proposal we set out in the August 2014 consultation (and in the October 2013 consultation) of having a common effective date as soon as practicable after the new fees regulations come into force.

7.19 On the subject of phasing-in, we have considered EE's and Vodafone's comments on consistency with the approach that we have taken in other sectors. We remain of the view that we should take an approach that considers in the round what an appropriate phase-in period would be for the revised ALFs, rather than focusing on previous decisions that we have taken in other sectors on phasing-in. Nonetheless, we do not consider that the two-stage phase-in that we proposed in the August 2014 consultation would be inconsistent with the examples of our previous decisions that EE and Vodafone have cited as relevant precedents, which concern the fees set for the maritime, aeronautical and satellite sectors[189]. In particular[190]:

[188] EE's comments on phasing-in are set out in EE's response to the August 2014 consultation, p. 67-74 (section 7). EE made similar comments on phasing-in in its response to the October 2013 consultation, p. 37-40 (section 7.2). Vodafone's comments on phasing-in are set out in Vodafone's response to the August 2014 consultation, p. 36-38 (section 3.6) and Annex 3.1, p. 34-39 (section 6). Vodafone made similar comments in response to the October 2013 consultation. See, in particular, p. 50 (section 6.3.1) of that response and Annex 1, p. 54-59.

[189] Vodafone and EE both referred also to the consultation on broadcasting AIP which put forward a working hypothesis that AIP would be phased-in over a 5 year period. However, in our subsequent statement we said that we would consider, and consult on, the issue nearer the time (i.e. we have made no decision in this regard).

a) the increases in the AIP-based fees for the maritime sector were introduced through a mix of a two-step phase-in and a three-step phase-in for larger increases of up to 300%;

b) the increases in the AIP-based fees for the aeronautical sector were introduced over a 5-step phase-in but these fees are increasing by a factor of up to 100 (i.e. 10,000%) from a low starting level[191];

c) the increase in the AIP-based fees for satellite earth stations (of up to approximately 200%) were introduced over a two-step phase-in[192].

7.20 We also do not agree that the use of glide paths when setting price controls is analogous to consideration of phase-in in the context of revising ALFs, as Vodafone argued. In the context of price controls, a glide path is used to reinforce the incentive for the regulated company to make cost savings which can then be passed on to consumers in time. If the regulated company cannot retain at least some of the benefits of cost reduction for a period then it will have a reduced incentive to make them. This cost-reduction incentive does not arise in a similar way with ALFs.

7.21 In relation to EE and Vodafone's arguments for a longer phase-in period in response to the August 2014 consultation, we continue to believe that the two-step phase-in that we proposed in the August 2014 consultation is a fair and reasonable approach. In taking this view, we are balancing on one hand the fact that a significant period of time has passed since the Government Direction was made in December 2010, and since the conclusion of the 4G auction in March 2013, and that licensees have, accordingly, had a significant period of notice that their fees would be significantly increased after the 4G auction. The conclusion of the 4G auction in March 2013 will have provided further information to licensees on the possible level of the increase, although we agree with the point made by licensees that they did not know the precise level of the revised ALFs at this point. However, on the other hand, recognising that the revised ALFs are significantly higher than the current level of fees, we think that a phase-in is appropriate.

7.22 We note that a two-step phase-in would mean that the licensees would all have more than one year's notice of the specific amount payable from the second year of implementation of revised ALFs, which is when their fees would start reflecting our estimate of market value in full.

7.23 We also note that an effect of this present consultation will be to postpone the date on which the revised fees will be introduced by a further period of time.

7.24 Accordingly, we are minded to implement the revised ALF by:

a) setting a common effective date as soon as practicable after the new fees regulations come into force, now likely to be late summer 2015 rather than the beginning of 2015 as a result of this consultation;

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[190] Aside from the relative magnitude of the fee increase, we note that these cases differ also in other respects. For example, the increases in the AIP-based fees for the maritime and aeronautical sectors affected a wide range of different types of licensees (including private individuals).

[191] EE referred to the increases in the AIP-based fees for the aeronautical sector in its response to the October 2013 consultation (p.39, section 7.2).

[192] EE referred to the increase in the AIP-based fees for satellite earth stations in its response to the October 2013 consultation (p.39, section 7.2).

b) introducing one half of the increase (from the current ALF rate to the proposed new ALF rate) with effect from the CED; and

c) introducing the second half of the increase with effect from the common actual payment date, which will be one year later.

7.25 If parties wish to provide any further evidence on the length of phase-in period, we will of course consider it carefully.

Calculating the first year's payment of ALF following the CED

August 2014 consultation

7.26 In the August 2014 consultation, we set out how we proposed to calculate the first year's payment of ALF following the CED, using for illustration 31 January 2015 as the CED and 31 January 2016 as the common actual payment date. (In line with the August 2014 consultation, we do not deal in this sub-section with adjusting for inflation; this is covered in the next sub-section.)

7.27 We proposed that each licensee's first year's payment of ALF following the CED would be made up of the following components:

a) a sum equal to 50% of the increase in ALF (i.e. half of the difference between the revised ALF and the current ALF) applied to the licensee's spectrum holdings; plus

b) a sum equal to the current ALF, pro-rated in relation to the number of months between the licensee's payment date and the common actual payment date.

7.28 This is the approach that we adopted in the draft fees regulations in the Notice published alongside the August 2014 consultation.

Stakeholder responses

7.29 Stakeholders did not comment on this specific point in response to the August 2014 consultation or to the Notice with the draft regulations.

Our view

7.30 We remain of the view that it is appropriate for us to calculate the first year's payment of ALF following the CED as described above.

Implementation of inflation indexation

August 2014 consultation

7.31 In the August 2014 consultation, we set out how we were minded to take account of inflation in setting ALF and how we were minded to implement the inflation indexation.

7.32 As we explained in the August 2014 consultation, the formula for calculating each year's ALF (ALF_t) incorporates an annual increase in ALF in line with inflation, as measured by the CPI index. In particular, the nominal value of ALF is inflated by the ratio:

$$\left[\frac{CPI_t}{CPI_{t0}}\right]$$

where:

a) CPI_{t0} is the level of the CPI (all items) index in March 2013 (which is when the UK 4G auction was completed); and

b) CPI_t is the latest available figure for the same index published in the Consumers Price Inflation Reference Tables by the Office for National Statistics ("ONS").

7.33 We specified that, in practice, the latest available CPI index figure at any time is likely to be two months old because inflation data related to each month is usually published by the ONS between the 15th and the 20th of the following month.

7.34 The draft fees regulations in the Notice published alongside the August 2014 consultation set out the formula that would be used to derive inflation-adjusted ALF rates for the fees due on the CED and subsequently for the fees due on the common actual payment date.

Stakeholder responses

7.35 Stakeholders did not comment on the above indexation mechanism in response to the August 2014 consultation and our Notice with the draft regulations.

Our view

7.36 We remain of the view that it is appropriate for us take account of inflation in setting ALF and to implement the inflation indexation as described above.

Future Review of ALF

October 2013 and August 2014 consultations

7.37 In the October 2013 consultation, we proposed that the revised fees should be introduced for an indefinite period and should not be time limited. In the August 2014 consultation, in light of stakeholders' comments, we said that we were currently not minded to review ALF within the next five years, and thereafter we would be likely to review ALF only if there were grounds to believe that a material misalignment had arisen between the level of these fees and the value of the spectrum, in keeping with our general policy on fee reviews as set out in the Strategic Review of Spectrum Pricing[193].

Stakeholder responses

7.38 We received no further comments from stakeholders on this issue in response to our August 2014 consultation.

[193] August 2014 consultation, paragraph 6.28.

Our view

7.39 The licence fees payable by the holders of the 900MHz and 1800 MHz licences are prescribed by Ofcom through regulations. Accordingly, once we have implemented the revised ALFs by making new regulations, these fees will remain applicable until we amend or revoke such regulations. This means that, in effect, ALFs are set for an indefinite period and are not time limited.

7.40 Our view on future reviews of ALF has not changed from the position set out in the August 2014 consultation. While we note that we cannot bind ourselves in advance as to the decisions we may take in the future on the exercise of our powers to revise spectrum fees, we consider that there would be a benefit in some period of certainty for licensees. We currently are not minded to review ALF within the next five years, and thereafter we would be likely to review ALF only if there were grounds to believe that a material misalignment had arisen between the level of these fees and the value of the spectrum, in keeping with our general policy on fee reviews as set out in the Strategic Review of Spectrum Pricing.

7.41 Since the August 2014 consultation, we have considered what assumptions it would be reasonable to make about the possibility of a review (or reviews) being carried out within the next 20 years. This affects the exposure that the licensees have to changes in the market value of spectrum over time and so is relevant to the choice of discount rate (as set out in Section 4 and Annex 10). In our view, it is reasonable to assume that these fee rates are likely to be reviewed at some stage during a 20-year period, although we cannot predict with any certainty at what point any such review (or reviews) might occur. For example, we recognise that it is possible there could be grounds for a review following an award of the 700 MHz spectrum and/or the review that we will need to undertake of the fees for the 2.1 GHz licences, though this would still depend on there being evidence of a material misalignment between ALF and market value around these times.

The new Regulations

7.42 On 1 August 2014, we published a notice explaining how we would give effect to Ofcom's revised proposals to implement the Government's direction[194]. The Notice was given in accordance with section 122(4) and (5) of the Wireless Telegraphy Act 2006 and contained a draft of the statutory instrument that we proposed to make in order to revise the fees which are currently payable under the Wireless Telegraphy (Licence Charges) Regulations 2011.

7.43 The draft statutory instrument set out how we proposed to give effect to our final decisions on the level of the ALFs and implementation, including in particular the adoption of a common effective date, phasing-in, the annual adjustment to inflation and the introduction of a common actual payment date. The figures in the draft statutory instrument reflected the proposals in the August 2014 consultation on the level of ALF (adjusted for inflation up to the date of that consultation) and used, for illustration, a CED of 31 January 2015.

7.44 We did not receive any comment on the specific provisions of the draft statutory instrument attached to our Notice[195].

[194] See http://stakeholders.ofcom.org.uk/consultations/notice-proposal-fees/

[195] EE said that, where applicable, their comments on the August 2014 consultation also apply to the parallel consultation on Ofcom's Notice.