Annual licence fees for 900 MHz and 1800 MHz spectrum

Statement

Annexes 9-13

Contents

Annex 9

Technical and commercial evidence

Introduction

A9.1 This annex contains further material on technical and commercial evidence which supports our assessment in Sections 1 and 2 on future spectrum availability and in Section 3 on estimating lump-sum values. It covers:

a) Possibility of greater certainty around spectrum availability;

b) Technical and commercial evidence relating to the relative values of 800 MHz and 900 MHz spectrum;

c) Technical and commercial evidence relating to the value of 1800 MHz spectrum;

d) Network cost modelling; and

e) Qualcomm's trade of licences for 1.4 GHz spectrum.

A9.2 We outlined our provisional views on the first and fourth of these issues in Annex 9 of our August 2014 consultation, and on the third issue in Annex 7 of the August 2014 consultation.[1] Stakeholders provided a numbers of comments on these views. Additionally, H3G and Vodafone made arguments relating to the second issue of the technical and commercial value of 900 MHz spectrum relative to 800 MHz. We considered these comments as part of our assessment of technical and commercial evidence in Annex 9 of our February 2015 consultation.

A9.3 In their responses to the February 2015 consultation, stakeholders have put forward new arguments in relation to the first, second and fourth issues listed above.

A9.4 In this annex, for each of the issues listed above, we have set out our analysis as presented in the February 2015 consultation. We then summarise stakeholders' new arguments. Finally, we set out our view for each issue, taking into account the responses received.

Possibility of greater certainty around spectrum availability

Position in the August 2014 consultation

A9.5 In the August 2014 consultation we recognised the possibility that the market value of ALF spectrum may have changed since the 4G auction.[2] In particular, we considered that there might be greater certainty over the availability of potential substitute bands for mobile spectrum use (700 MHz, 2.3 GHz, 3.4 GHz and 1452-1492 MHz), and that this might serve to reduce the forward-looking market value of current mobile bands such as 900 MHz and 1800 MHz. This was one of the

[1] We considered stakeholder arguments about the relative value of 900 MHz and 800 MHz spectrum in Annex 6 of our October 2013 consultation, paragraphs A6.29 to A6.34.
[2] Paragraphs 1.39-1.41, http://stakeholders.ofcom.org.uk/binaries/consultations/annual-licence-fees-900-MHz-1800-MHz/summary/condoc.pdf

reasons why we considered we should adopt a conservative approach when interpreting the available evidence on market values.

Stakeholder responses to the August 2014 consultation

A9.6 In response to our August 2014 consultation, Vodafone[3] argued that "the extent of the certainty of future spectrum availability has increased significantly, and is much stronger an effect than merely the possibility expressed by Ofcom". It said that such certainty takes two forms:

a) "A certainty that 2.3 GHz, 3.4 GHz, 1452-1492 MHz and 700 MHz spectrum will be released for mobile broadband use within a reasonable timeframe".[4] Vodafone noted that these bands have been suggested for mobile use for some time, but said that it would not have been appropriate for bidders in the 4G auction to have discounted their immediate need for usable LTE spectrum on the grounds that some other possibly usable spectrum might become available at some relatively ill-defined future date;[5] and

b) "A certainty that it is Ofcom's intention to release substantial additional spectrum for mobile use, as and when it is needed to satisfy mobile data demand, in order to maximise the consumer benefit from mobile data services".[6] Vodafone cited our May 2014 Mobile Data Strategy (MDS) statement as a "clear exposition of Ofcom's policy that if needed, additional spectrum will…be made available".[7] It agreed that many potential bands can only be released some time into the future, but said that we are estimating a 20-year spectrum valuation for which the basis lies in total avoided costs over the whole period.[8] It also said that, due to carrier aggregation and the steady increase in additional harmonised bands, it is of less criticality than in the past which particular spectrum band will be used to provide any additional capacity, meaning that any increase in the certainty of supply of future additional spectrum will inevitably have a downward impact on the value of the non-core LTE spectrum.[9]

A9.7 Vodafone said that taking account of the downward pressure on ALFs arising from these factors indicates that an appropriate spectrum value is lower than the lump-sum values for 900 MHz and 1800 MHz that were proposed in the August 2014 consultation[10] (although it provided no quantification of the effect).

Our assessment in the February 2015 consultation

Spectrum release in the short to medium term

A9.8 In the February 2015 consultation we noted that in our August 2014 consultation (paragraph 1.40) we said that the 2.3 GHz, 3.4 GHz, 700 MHz and 1452-1492 MHz bands were all recognised at the time of the 4G auction as likely to become available for mobile use. However, we also said that there had been further developments in relation to each band since then which might have served to

[3] Vodafone response, Annex 3.3, page 1
[4] Vodafone response, Annex 3.3, page 1
[5] Vodafone response, Annex 3.3, pages 6-7
[6] Vodafone response, Annex 3.3, page 1
[7] Vodafone response, Annex 3.3, page 7
[8] Vodafone responses, Annex 3.3, p. 20
[9] Vodafone response, Annex 3.3, page 7
[10] Vodafone response, Annex 3.3, page 4

reduce the value of current mobile spectrum. In February 2015 we also noted that some further developments had occurred since the publication of our August 2014 consultation. Specifically, we made the following comments:

a) The 700 MHz band: Of the prospective bands for future release, 700 MHz is likely to be the closest substitute for ALF spectrum, as it is paired low-frequency spectrum. In the November 2012 UHF strategy statement (published before the 4G auction) we said that we would seek to enable a harmonised release of the 700 MHz band for mobile broadband use, and noted that this could potentially occur as early as 2018.[11] In November 2014, we published a statement confirming our decision to make the 700 MHz band available for mobile use.[12] We also set out our intention to do so by the start of 2022, and sooner if possible, while noting (paragraph 1.19) that there is too much uncertainty about some aspects of the process for us to commit to a specific implementation timetable;

b) The 2.3 GHz / 3.4 GHz bands: In November 2014, we published a consultation outlining our proposals for auctioning spectrum in these bands in late 2015 or early 2016.[13] This re-stated our earlier intention to complete the award in the financial year 2015/16, although when the spectrum release was first proposed in December 2012 the Ministry of Defence announced that preparations were expected to start at the end of 2013, with the auction completed by the summer of 2014[14]; and

c) The 1452 – 1492 MHz band: In September 2014 we published a consultation proposing to vary the technical conditions in this licence to better enable its use for Supplemental Downlink (SDL).[15] This could be a substitute for additional ALF spectrum (in terms of downlink spectrum). However, as mentioned in the August 2014 consultation (footnote 12), it is also possible that this band may be a complement to ALF bands rather than a substitute, because to be used as SDL it may be bonded to the paired spectrum deployments in the ALF bands. If so, increased certainty of availability of this band could increase, not reduce, the market value of the ALF bands.

A9.9 We said that, for each of the above bands, developments since the 4G auction, including those between August 2014 and February 2015, could have further increased the degree of confidence in their future availability. We continued to 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.

A9.10 However, we said that, as mentioned in the August 2014 consultation (paragraph A9.6), the suggestion that these bands could be used for mobile broadband pre-dates bidding in the 4G auction. As a result, we said the impact of developments since the 4G auction on expectations should not be overstated. In addition, in terms of timing of release, we noted that in the case of 700 MHz the November 2014 statement did not specify an implementation timetable. We therefore did not agree

[11] Paragraph 1.8, and paragraph 1.27 http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/statement/UHF_statement.pdf
[12] http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/statement/700-mhz-statement.pdf
[13] http://stakeholders.ofcom.org.uk/binaries/consultations/2.3-3.4-ghz-auction-design/summary/2_3_and_3_4_GHz_award.pdf
[14] https://www.gov.uk/government/news/mod-to-auction-off-radio-spectrum
[15] http://stakeholders.ofcom.org.uk/binaries/consultations/licence-variation-1.4ghz/summary/1.4ghz-consultation.pdf

with Vodafone's view that the 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.

Additional spectrum release for mobile use

A9.11 Next we considered Vodafone's argument that our MDS statement is a "clear exposition of Ofcom's policy" that, if needed, additional spectrum will be made available for mobile use over a longer time period.

A9.12 In the MDS statement[16] we said that addressing demand for mobile data is a priority for us in the coming years. We noted that there was a range of potential solutions to meeting the likely growth in demand, but making additional spectrum available was likely to be part of the solution. We said it was possible that there would be limited benefit in making more spectrum available for mobile data services (in addition to the 2.3 GHz, 3.4 GHz and 700 MHz bands) if demand could be met at lower cost through technology and network improvements. However, we noted that "if further major changes to spectrum use *do* turn out to be beneficial, they can require several years of preparation", so it was important for us to start preparatory work in order to maintain options for the future.

A9.13 We identified a number of potential bands and ranked them from high priority (for which we aim to take specific action to create the option for a change in use) to low priority (for which we do not plan any pro-active action). However, we also highlighted (in paragraph 2.11) the substantial challenges associated with releasing more and more spectrum for mobile.[17]

A9.14 In view of this, in the February 2015 consultation we said that:

a) We did not consider that the MDS statement represents a commitment to release spectrum "as and when it is required for mobile services".[18] As part of our duties we must consider incumbent (and other competing) users of any spectrum bands which have been identified for possible mobile use. Although our MDS statement notes that use of additional spectrum is likely to be part of the solution to addressing mobile data growth, it recognises that the scope for further spectrum releases may be constrained by the challenges associated with international harmonisation and / or coexistence.[19]

b) We also noted that no sub-1 GHz bands were identified as high priority spectrum in the MDS statement. In relation to the 470-694 MHz band specifically, we said that we would only expect any switch-off of DTT to occur post 2030[20] and that we

[16] See paragraphs 1.2 to 1.5 of Ofcom, Mobile Data Strategy, May 2014, http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/statement.pdf
[17] We also said in the MDS statement (paragraph 4.11) that we would undertake further work on bands above 6 GHz. A Call for Inputs in relation to spectrum above 6 GHz was published in January 2015. This highlighted a number of challenges associated with identifying spectrum above 6 GHz for mobile. It did not set out a policy position with regard to the use of this spectrum. Also, the extent to which this high-frequency spectrum would be a substitute for either of the ALF bands is unclear.
[18] Vodafone response, Annex 3.3, p. 5
[19] For example, we noted in the case of the 1350-1375 MHz and 1375-1400 MHz bands (paragraph 4.30) that there was less international support for harmonisation and that existing users in these bands may make release of the spectrum challenging, as well as costly.
[20] Paragraph 4.11, Ofcom, Mobile Data Strategy, May 2014, http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/statement.pdf

would anticipate opposing a co-primary mobile allocation (along with broadcasting) in this band.[21] Vodafone pointed out that we are estimating a 20-year spectrum valuation for which the basis lies in total avoided costs over the whole period. However, the timing of release is still an important consideration because the present value of ALF spectrum will be more sensitive to substitute bands which are made available earlier in time.

A9.15 On this basis, we did not consider that our MDS statement supports Vodafone's view that 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.

Stakeholder responses to the February 2015 consultation and July 2015 update note

Expectations of spectrum release in the short to medium term and impact on future spectrum valuations

A9.16 EE noted that the planned spectrum release in the 700 MHz, 1.4 GHz, 2.3 GHz and 3.4 GHz bands will increase the (downlink) spectrum available in 2022 by 2.3 times the spectrum available in 2013/14.[22] EE argued that:

a) The 2.3 GHz device ecosystem has been developing rapidly, with over 60 new devices becoming available in the past six months (now 427 in total), while there are now 9 commercially launched 3.4 GHz networks and a growing number of user devices on 3.4 GHz;

b) It is "quite clear that the release of the 1452-1492 MHz band will reduce the value of 1800 and 900 MHz spectrum".

   i. Firstly, the 3GPP specifications currently only cover the pairing of this band with 800 MHz and 2.1 GHz, rather than ALF spectrum;

   ii. Secondly, downlink capacity is a highly spectrally efficient substitute for additional ALF spectrum as operators have a very high ratio of downlink to uplink traffic (i.e. downlink is the constraint on overall traffic);

   iii. Thirdly, as each of the operators already holds some ALF spectrum, no operator would obtain any incremental benefit from bonding with 1.4 GHz as a result of acquiring additional ALF spectrum, which it could not already achieve through its existing holdings.

A9.17 Telefónica said that the release of 700 MHz has moved from the realms of discussion to concrete planning in an exceptionally short time-scale, with Germany and France scheduling auctions in mid-2015.[23] In its response to the July 2015 update note, it said that the June 2015 German auction results indicate that availability of 700 MHz has reduced the forward-looking intrinsic value of LTE capacity spectrum, particularly in the 900 MHz band.[24] It argued that "this evidence

[21] Paragraph 1.5, Ofcom, Update on the UK preparations for the World Radiocommunication Conference 2015 (WRC-15), January 2015, http://stakeholders.ofcom.org.uk/binaries/consultations/wrc15/Update_on_WRC-15.pdf
[22] EE response to the February 2015 consultation, pp. 23-24
[23] Telefónica response to the February 2015 consultation, p. 15
[24] Telefónica response to the July 2015 update note, pp. 19-20

is directly relevant to the UK, given that Ofcom will in due course award 700 MHz for mobile broadband" and "reinforces the point that Ofcom first made in the August 2014 Consultation that it should adopt a conservative approach when interpreting the evidence".

A9.18 Telefónica broadly supported Vodafone's view that certainty over future spectrum availability since the time of the 4G auction was much stronger than Ofcom considered it to be.[25]

A9.19 Vodafone did not respond directly to the points set out above, but in the context of the prospect of future ALF reviews (discussed in Section 8) it noted[26] that "the knowledge of future availability of mobile spectrum is something that at the very least will provide some degree of dampening down on any potential tendency for any future upwards valuation of spectrum, tending towards stabilisation of spectrum values". It also said that we "had expressed a clear intention to avoid any "capacity crunch" in future growth in mobile data demand by preparing for the timely release of additional spectrum as needed", arguing that "this provides a cap on any tendency for the value of mobile spectrum to rise if demand exceeds supply."

How we take account of greater certainty of future spectrum availability

A9.20 EE said that we made "no attempt to quantitatively estimate the impact of the now greater certainty over forthcoming spectrum releases compared with the position in February 2013" (i.e. at the time of the 4G auction).[27] EE said that without considering the potential quantitative impact of our own announcements we could not know how conservative we would need to be to properly reflect this impact.[28]

A9.21 EE cited a 2009 report by Aegis and Plum consulting report ("*Estimating the commercial trading value of spectrum*").[29] In this report, Aegis and Plum estimated that the value (to a modelled operator) of an additional increment of spectrum falls from £85m / 2x1 MHz to £1m-£12m / 2x1 MHz if the operator already holds 2x15 MHz of spectrum, rather than 2x5 MHz. EE said that the report "shows that the forthcoming spectrum releases have the potential to substantially lower the value of 1800 MHz spectrum".

A9.22 EE also said that our approach did not take account of other new developments relevant to spectrum valuation but that "many of these factors are already captured in Ofcom's MCT cost model".[30]

Our assessment

A9.23 In our February 2015 consultation (paragraph 1.41) we recognised the "[p]ossibility 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". As noted in paragraph A9.8 above, this related in particular to the 700 MHz, 1.4 GHz, 2.3 GHz and 3.4 GHz bands.

[25] Telefónica response to the February 2015 consultation, p. 14
[26] Vodafone response to the February 2015 consultation, p.55.
[27] EE response to the February 2015 consultation, p. 22
[28] EE response to the February 2015 consultation, p. 25
[29] EE response to the February 2015 consultation, p. 22
[30] EE response to the February 2015 consultation, p. 25

A9.24 In the following, we set out our view of:

a) Expectations of spectrum release in the short to medium term;

b) How these expectations have changed since the time of the 4G auction; and

c) How any such change in expectations may have affected the market value of ALF spectrum.

A9.25 We then set out our view on how we should take account of this in our estimates of 900 MHz and 1800 MHz market values.

Expectations of spectrum release in the short to medium term and impact on future spectrum values

A9.26 Since our February 2015 consultation, there have been further developments in relation to each of the 700 MHz, 1.4 GHz, 2.3 GHz and 3.4 GHz bands discussed above:

a) In May 2015 we published a consultation on the 2.3 and 3.4 GHz spectrum, in which we anticipated that we would be able to award the spectrum in the 2015/16 financial year. However we noted the proposed acquisition of EE by BT, and of O2 by H3G, the second of which would, if it proceeded, reduce the number of UK mobile national wholesalers from four to three. In light of these changing market conditions, we consulted on the option of withholding some of the available spectrum from the 2.3 and 3.4 GHz award. Our initial thinking was that it might be appropriate to withhold around 60 MHz of the 190 MHz of spectrum available.[31]

b) In May 2015 we varied Qualcomm's 1452-1492 MHz Spectrum Access licence to enable this spectrum to be used for SDL.[32] Qualcomm has since agreed to trade this spectrum to Vodafone and H3G.

c) In its March 2015 budget, the Government confirmed that up to £600m would be made available in financial assistance towards the cost of clearing the 700 MHz band for future mobile use.[33] However, we note that our November 2014 statement on 700 MHz release did not specify an implementation timetable due to uncertainty about some aspects of the process. The fact that 700 MHz was recently awarded in the June 2015 auction in Germany and is scheduled to be auctioned in France in 2015, has not changed the expected timetable for release in the UK.

How these expectations have changed since the time of the 4G auction

A9.27 As explained in paragraph A9.10 above, the 2.3 GHz, 3.4 GHz, 700 MHz and 1452-1492 MHz bands were all recognised at the time of the 4G auction as likely to

[31] Ofcom, Public Sector Spectrum Release: Award of the 2.3 and 3.4 GHz spectrum bands, Statement and consultation, 26 May 2015, http://stakeholders.ofcom.org.uk/binaries/consultations/2.3-3.4-ghz-auction-design/statement/statement.pdf

[32] Ofcom, Variation of the Spectrum Access licence for 1452-1492 MHz and changed to fixed links use in the paired bands 1350-1375 MHz and 1492-1517 MHz, May 2015, Statement, http://stakeholders.ofcom.org.uk/consultations/licence-variation-1.4ghz/statement/

[33] https://www.gov.uk/government/publications/the-digital-communications-infrastructure-strategy/the-digital-communications-infrastructure-strategy

become available for mobile use.[34] Overall, though, we agree with stakeholders that work on the release of these bands has continued to progress, and that these developments will tend to reduce uncertainty about their future availability.

A9.28 We note Vodafone's comments in paragraph A9.19 above, which suggest that future availability of mobile spectrum will prevent the future value of mobile spectrum from rising. However, as we explained in the February 2015 consultation, there are substantial challenges associated with releasing large amounts of additional spectrum for mobile and we have not commited to releasing spectrum as and when it is required for mobile services. We also consider that there is potential for strong growth in demand for mobile capacity, and we do not know how operators' expectations of growth may have changed since the 4G auction. As a result, while we agree that greater certainty of future availability of mobile spectrum may lead to lower future spectrum values (and we reflect this in our approach to interpreting the evidence), we disagree that it provides a "cap" on such values.

A9.29 For a given level of demand, the release of new mobile spectrum bands on the value of existing bands will depend on their effectiveness and value as substitutes or complements to the existing bands. To date, evidence on this point has been limited. One possible evidence point is the 2015 German auction, which included 700 MHz and 1.4 GHz[35] spectrum, as well as the 900 MHz and 1800 MHz bands. If the observed prices of ALF spectrum in auctions from 2013 or earlier reflect significant uncertainty about the future availability of 700 MHz and 1.4 GHz spectrum, one might expect that the inclusion of these bands in the German auction and subsequent auctions would lead to lower prices for ALF spectrum than would otherwise have prevailed. In principle, we could identify such an effect by comparing ALF spectrum prices in such auctions with prices from earlier auctions in the same country, or in other relevant countries. But in practice we do not consider that a reliable inference can be drawn from the available evidence for the following reasons:

a) Comparison of 2015 prices with earlier auction in Germany:

   i) The 2010 auction did not include 900 MHz spectrum so we have no earlier auction price (within the timeframe we consider for auction prices, since 2010) against which to compare the 2015 auction price of 900 MHz.

   ii) The 2010 auction in Germany included part (2x25 MHz) of the 1800 MHz band with the remaining 2x50 MHz sold in the 2015 German auction. The absolute UK-equivalent value in 2010 was only £1.9m per MHz compared to £20.7m per MHz in the 2015 auction, i.e. a higher price despite the inclusion in the auction of the 700 MHz and 1.4 GHz bands. However, we do not consider that we should draw a strong inference from this comparison, in particular because the 2010 price carries a larger risk of larger understatement for auction-specific reasons discussed in Annex 8 .

b) Comparison of 2015 prices with other countries:

   iii) As set out in Table 5.3 and Figure 5.3 in Section 5, the 900 MHz absolute value in the 2015 German auction was lower than the 900 MHz absolute

[34] We also note that the 4G auction occurred a year after the February 2012 World Radio Conference.
[35] This is known as the 1.5 GHz band in Germany (but covers the equivalent 1452-1492 MHz frequency range).

values from earlier auctions in all other relevant countries apart from Denmark (i.e. Portugal, Greece, Ireland, Spain, Romania and Austria). But this was not true of the 1800 MHz price. Table 5.4 and Figure 5.4 show that the absolute value from the 2015 German auction for 1800 MHz was lower than Ireland and Austria, but higher than the other eight countries in our dataset (Denmark, Czech Republic, Slovak Republic, Portugal, Sweden, Greece, Italy and Romania).

A9.30 In summary, in our view, the German 2015 auction, in itself, does not provide clear evidence of the effect of 700 MHz and 1.4 GHz availability on the value of ALF spectrum. In any case, we do not consider that we could rely on a single auction to identify such an effect, particularly given the other auction-specific and country-specific factors that can influence prices.

A9.31 We have derived Tier 1 relative value benchmarks for both 900 MHz and 1800 MHz from the 2015 German auction, by combining the 900 MHz and 1800 MHz auction prices with the prices from the earlier 2010 German auction. This means that any effect that the availability of new spectrum had on 900 MHz or 1800 MHz prices in the 2015 auction (compared to the 800 MHz and 2.6 GHz prices in 2010) is reflected in our analysis.

A9.32 As regards the question of whether the 1.4 GHz band might be a complement to ALF spectrum, we note that bonding with ALF spectrum will be technically feasible. However, to be clear, we have not relied on the possibility that 1.4 GHz band might be a complement to ALF spectrum at any point in our analysis and our conclusions treat it as a substitute to ALF spectrum.

How we take account of greater certainty of future spectrum availability

A9.33 Given our use of evidence of bids from the 4G auction, the impact on spectrum value of future spectrum release depends on the change in expectations since the 4G auction about these future releases (as distinct from the change in the actual amount of mobile spectrum made available since the 4G auction). In order to produce reliable quantitative estimates of the impact (on spectrum values) of such a change in expectations, we would need to make judgements about the magnitude of the change in expectations, as well as to quantify the effect on the market value of ALF spectrum. We have not identified a robust approach to quantifying the impact of improved prospects of future spectrum release, and stakeholders have not presented any such approach.

A9.34 As in the February 2015 consultation, we continue to take account of the impact of greater certainty of future availability of mobile spectrum on forward-looking market values. The way in which we do this is by adopting a conservative approach when interpreting the evidence (the other key reason for adopting a conservative apporach being an asymmetry of risk between setting ALFs above or below market value).

A9.35 Regarding EE's other comments on this issue:

a) EE commented that "The Aegis/Plum report shows that the availability of other spectrum can have a dramatic impact on the market value of an additional increment of spectrum." We agree with the general proposition that additional substitute spectrum is likely to reduce the value of existing bands (all else being equal, e.g. as regards demand on the network). We do not consider that Aegis and Plum's specific valuations are informative in the present case (and EE have

not claimed that they are), particularly given the report's intention to develop a generic framework to provide insights into the drivers of spectrum value.[36] Moreover, as noted above, all of the spectrum bands in question were already recognised at the time of the 4G auction as likely to become available for mobile use.

b) Our view of EE's comments on the MCT cost model is set out in paragraphs A9.85 to A9.128 below.

Technical and commercial evidence relating to the relative values of 800 MHz and 900 MHz spectrum

A9.36 In order to provide context for this issue, we first summarise our position in the October 2013, August 2014 and February 2015 consultations, and stakeholder responses to these documents.

Position in the October 2013 and August 2014 consultations

A9.37 In our October 2013 consultation (paragraph 4.42) we noted that among our international benchmarks 800 MHz spectrum had tended to command a higher price than 900 MHz spectrum. We also noted that the technical evidence was not sufficiently clear-cut or robust to derive a reliable inference about the relative value of 900 MHz and 800 MHz. On this basis we considered on balance that 900 MHz was unlikely to have a higher value than 800 MHz spectrum in the UK.

A9.38 In our August 2014 consultation (paragraphs A7.79 to A7.82), we further considered technical and commercial evidence on this point, and particularly whether the development of an LTE ecosystem for the 900 MHz band over recent years might have increased its value, such that older auction results might understate the current value of these bands in the UK. We noted that:

a) The 900 MHz band was not currently a core LTE band, and was still commonly used for GSM and UMTS services; we were aware of only a limited number of examples of deployments of LTE900 networks from operators in Sweden and the Czech Republic towards the end of 2013. However we noted this might have been due, in part, to operators finding it difficult to free enough 900 MHz spectrum from legacy services for use with new technologies, although we said this consideration was less relevant from the perspective of the valuation of the spectrum by a marginal excluded bidder.

b) The number of LTE devices on this band had been increasing since 2012, and we noted this in a February 2013 consultation[37] which was published during the UK 4G auction and so was likely to be reflective of expectations at that time.

c) While the increasingly developed ecosystem might make LTE use for 900 MHz networks more common in the future, the timing of this was currently uncertain due to the issues in re-farming spectrum. We considered that there was limited evidence of a change in LTE900 expectations over the period of auctions we

[36] Aegis and Plum's results imply that the value of additional 1800 MHz to an operator with 2x5 MHz of 1800 MHz is £42.5m / MHz.
[37] Table 1, Ofcom, *Variation of 900 MHz, 1800 MHz and 2.1 MHz mobile licences*, February 2013, http://stakeholders.ofcom.org.uk/binaries/consultations/variation-900-1800-2100/summary/condoc.pdf

were considering, and we did not take this factor into account in our interpretation of benchmarks in the August 2014 consultation.

Stakeholder responses to the October 2013 and August 2014 consultations

A9.39 In its response to our October 2013 consultation, Vodafone argued that the value of 900 MHz spectrum should be at most 60% of the value of 800 MHz spectrum.[38] It argued that the 900 MHz band has no practical usability for LTE for some years to come, whereas 800 MHz is immediately free and capable of being used for LTE. Vodafone said that "There were two elements to Ofcom's reasoning in the 2012 auction statement on 900 MHz: 900 MHz is not suitable for 4G as yet from an ecosystem viewpoint, and 900 MHz is also occupied by legacy technologies…".[39]

A9.40 In response to our August 2014 consultation, EE said that an implied UK ratio of 900 MHz to 800 MHz of 65% is conservative, given the similar propagation and other technical characteristics of the two bands.[40]

A9.41 H3G argued that "a comparison of technical characteristics and commercial opportunities of 800 MHz and 900 MHz shows that they are of almost identical value".[41] It noted that the 900 MHz band has similar propagation characteristics to 800 MHz and enjoys a higher transmission power limit, leading to incrementally better coverage and capacity. In terms of commercial value, it noted that the 900 MHz band is currently used to serve 3G customers (the largest part of the customer base) and remaining 2G customers, and is also liberalised for 4G, allowing MNOs to refarm the band when appropriate.

A9.42 H3G also considered that the higher observed prices for 800 MHz over 900 MHz in some European auctions can be explained by specific auction characteristics, such as spectrum caps or the amount of spectrum being auctioned, rather than differences in the long-term value of these bands.[42]

A9.43 In its response to our August 2014 consultation, and in the context of considering the Austrian auction, Vodafone[43] commented that:

> "No matter what Ofcom makes of the evidence above, the simple fact remains that the 900 MHz LRP in Austria was, in Ofcom's analysis, above the value for 800 MHz. But Ofcom has previously stated that in its view, 900 MHz is unlikely to be more valuable in the UK than 800 MHz [First Consultation at 4.42] and therefore its value sets an upper limit for 900 MHz. Thus, Ofcom cannot treat the relative value of 900/800 spectrum from the Austrian auction as more important (first tier) evidence for deriving a UK market value while being internally consistent."

Our assessment in the February 2015 consultation

A9.44 Although 900 MHz licences have been liberalised for LTE since July 2013, none of the UK operators are currently using this band for LTE. As we noted in the August 2014 consultation, LTE900 network deployments have to date been limited:

[38] Annex 8 of Vodafone's response to the October 2013 consultation, page 2.
[39] Annex 8 of Vodafone's response to the October 2013 consultation, page 6.
[40] EE's response to the August 2014 consultation, p. 31.
[41] H3G's response to the August 2014 consultation, p. 33.
[42] H3G response, pp. 35-36.
[43] Vodafone's response to the August 2014 consultation, page 26.

a) Tele2 and Telenor have been operating an LTE network in Sweden since 2010 under the Net4Mobility joint venture, and using shared 900 MHz spectrum they have achieved 97% coverage population by March 2013.[44]

b) In November 2013 Vodafone announced plans to roll out LTE using 900 MHz spectrum to 50% of the Czech Republic by March 2014, with full national coverage by the end of 2014.[45]

c) In September 2014 (i.e. a development since our August 2014 consultation) T-Mobile announced that it will use its 900 MHz spectrum to boost 4G coverage in the Netherlands, and set a target of the end of 2015 to reach full national coverage.[46]

A9.45 We considered, as Vodafone noted above, that the limited deployment of LTE900 to date is likely to be due to a combination of two factors – a relatively limited ecosystem of compatible devices in use, and 900 MHz licence holders' use of this band to provide legacy services.

A9.46 As regards device availability, our February 2013 consultation (on Variation of 900 MHz, 1800 MHz and 2.1 MHz mobile licences) noted that LTE900 equipment was currently available on the market. This was a change from the assessment in our earlier August 2012 1800 MHz licence variation decision.[47] GSA data showed that there were 58 LTE900 devices available by March 2013, rising to 205 in January 2014 and 425 in October 2014 (19% of total devices). The proportion of devices which were LTE800 and LTE900 respectively is shown in Figure A9.1 below. The Samsung Galaxy S4 (released in April 2013), iPhone 5s (released in September 2013) and iPhone 6 (released in September 2014) all support LTE900, as do leading handsets from other major vendors.

A9.47 As to the second factor noted by Vodafone, i.e. the need to provide legacy services, we did not consider this is necessarily relevant in determining the forward-looking marginal opportunity cost of 900 MHz spectrum compared to 800 MHz spectrum, which depends on the value to the marginal operator who is not already using the spectrum. However, we said the need to provide legacy services may be a reason for the limited deployment of LTE900 in Europe to date.

A9.48 In this context, we considered whether operators who have acquired new or additional 900 MHz spectrum in 4G auctions (and who might be less likely than incumbent holders of 900 MHz licences to use this band for legacy services) are currently planning to deploy LTE900. We noted that:

a) There have been no recent instances of an MNO acquiring 2x10 MHz of new 900 MHz spectrum. Operators in Romania (RCS & RDS), Ireland (H3G), the Netherlands (T-Mobile), Austria (Hi3G) and Norway (Telco Data) have acquired

[44] https://www.telegeography.com/products/commsupdate/articles/2013/03/19/tele2-sweden-reaches-99-4g-coverage/
[45] https://www.telegeography.com/products/commsupdate/articles/2013/11/06/vodafone-cr-sets-out-stall-to-blanket-over-50-of-country-with-3glte-by-1q14/
[46] https://www.telegeography.com/products/commsupdate/articles/2014/09/10/t-mobile-netherlands-will-use-900mhz-spectrum-to-improve-4g-coverage/
[47] Table 2, Ofcom, *Decision to vary Everything Everywhere's 1800 MHz spectrum licences to allow use of LTE and WiMax technologies*, August 2012, http://stakeholders.ofcom.org.uk/binaries/consultations/variation-900-1800mhz-lte-wimax/statement/statement.pdf

new 2x5 MHz blocks of 900 MHz spectrum in 4G auctions (in the case of Austria, Hi3G did so having sold a similar-sized block prior to the auction of 900 MHz).

b) Of these five countries where operators acquired 2x5 MHz of 900 MHz spectrum:

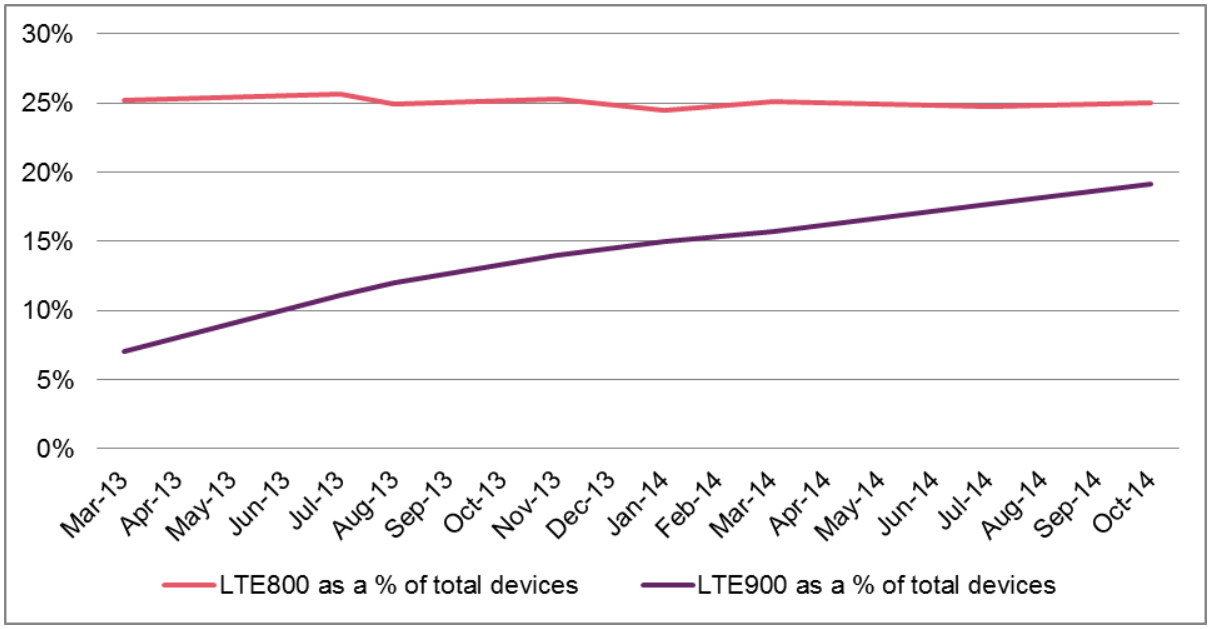
   i) There are currently no indications of imminent LTE900 network rollout in Ireland or Austria.

   ii) However, in Romania and Norway, GSA reports that the acquiring operators of new 900 MHz spectrum (RCS & RDS / Telco Data) have plans to use it for LTE services.

   iii) In the Netherlands, T-Mobile has already announced LTE900 network rollout for 2015 (as discussed in paragraph A9.22 above).

c) In Slovenia, GSA reports LTE900 network rollout plans by Telekom Slovenije. This MNO had increased 900 MHz holdings from 2x12.5 MHz to 2x15 MHz in the April 2014 auction.

Figure A9.1 Proportion of mobile devices with LTE800, LTE900 up to October 2014



Source: GSA

A9.49 We said that the above analysis suggests that wider use of the 900 MHz band for LTE services is becoming a realistic possibility (although larger bandwidth deployments are still likely to be constrained by existing 2G and 3G use for some time).

A9.50 We also considered whether the auction evidence suggests a trend over time in the relative value of the 900 MHz and 800 MHz bands. This information is set out in Table A9.1, ordered by the date of the 900 MHz award.[48]

A9.51 We noted that:[49]

[48] Consistent with Table 3.2, the ratios 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).

a) For three of the four first-tier and second-tier evidence points, 900 MHz sold at a significant discount to 800 MHz.

b) The values of 900 MHz, relative to 800 MHz, in auctions in 2011 lie between the highest and lowest relative values from more recent auctions in 2012 and 2013.

c) The results do not follow a clear trend. For example, evidence from the November 2012 Irish auction (the second most recent 900 MHz award) indicates that 900 MHz was only 55% of the value of 800 MHz.

d) The result that 900 MHz sold for more than 800 MHz in the most recent auction (Austria) is consistent with H3G's argument above. However, this is a single evidence point.

Table A9.1: Relative values of 900MHz to 800 MHz in European auctions

	900 MHz awarded in:	900 MHz / 800 MHz value	At or near ratio of reserve prices	Tier of benchmark evidence
Denmark	Sept 2010	17%	No	3
Greece	Nov 2011	87%	Yes	3
Portugal	Nov 2011	64%	Yes	2
Spain	Nov 2011	67%	No	2
Romania	Sept 2012	93%	Yes	3
Ireland	Nov 2012	55%	No	1
Austria	Oct 2013	115%	No	1
Germany[50]	June 2015	29%	No	1

Source: Ofcom

A9.52 We also noted that operators may have anticipated the development of the 900 MHz LTE ecosystem, and factored this into their auction bidding strategies accordingly.

A9.53 On balance, based on the available evidence, we said that it is not clear whether the value of 900 MHz, relative to the value of 800 MHz, has risen over the period since late 2010. In view of this, we did not consider it appropriate to take the date of award into account in our choice of tier for 900 MHz benchmarks. However, we did take account of the evidence of a recent increase in commercial opportunities for LTE deployment in the 900 MHz band in our assessment of the risk of understatement of the relevant 900 MHz benchmarks. The way in which we did this is explained in paragraph A7.165 in Annex 7.

[49] For ease of comparison, we have included the 2015 German auction in Table A9.1. The observations in paragraph A9.51 were based on auction evidence up to February 2015, before the German auction had begun.

[50] Table A9.1 has been updated to include the 900 MHz / 800 MHz ratio based on the 900 MHz price from the June 2015 German auction, which was not available when we published our February 2015 consultation. We have included it here for ease of comparison with other countries.

A9.54 In relation to Vodafone's argument in response to our August 2014 consultation (paragraph A9.43 above), we said that our view in the October 2013 consultation that 900 MHz was unlikely to be more valuable than 800 MHz in the UK was based on the benchmark evidence at that time, and this was made clear in the relevant paragraphs in the October 2013 consultation.[51] We did not, therefore, consider it relevant to our choice of tier for the Austria 900 MHz relative value benchmark.

Stakeholder responses to the February 2015 consultation and July 2015 update note

Current LTE900 prospects

A9.55 Some stakeholders argued that we have overstated the extent to which LTE900 prospects have developed over the last few years:

A9.56 In relation to **network deployment**:

a) Vodafone said that the number of active LTE900 operators is currently very small.[52] Frontier argued that there are specific reasons for operators' LTE900 deployment in Romania and the Netherlands (namely a lack of 800 MHz spectrum), and that there appears to be no evidence in the public domain of imminent LTE900 deployment plans in Slovenia or Norway.[53] Vodafone commented that Romania is "already considered by Ofcom to be less relevant evidence generally".

b) Regarding the UK, Frontier argued that there have been no changes in expectations relating to LTE900 deployment.[54] It also said that Vodafone and O2 are unlikely to roll out LTE900 soon, due to re-farming difficulties and the fact that holdings are fragmented.

A9.57 In relation to **device ecosystems**:

a) Frontier said that comparing global LTE device ecosystems for 900 MHz and 800 MHz would tend to overstate the relative number of compatible devices available in Europe because LTE900 deployment in non-European markets was more extensive.[55]

b) Telefónica agreed that the intrinsic technical characteristics of the 800 MHz and 900 MHz bands are quite similar, and said that it is differences in the current and future device ecosystems which primarily drive any difference in value.[56] However, in relation to LTE900 device availability, it said that:

i) The LTE900 ecosystem was improving but still lagged behind the LTE800 ecosystem;

ii) Because the 900 MHz band was the primary legacy band for both 2G and 3G services, manufacturers would continue to make 900 MHz the last priority amongst major LTE bands for many years to come;

[51] See paragraphs 4.42-4.43 and A6.33-6.34.
[52] Vodafone response to the February 2015 consultation, p. 47
[53] Vodafone response to the February 2015 consultation, Annex 2, p. 17
[54] Vodafone response to the February 2015 consultation, Annex 2, p. 16
[55] Vodafone response to the February 2015 consultation, Annex 2, p. 18
[56] Telefónica response to the February 2015 consultation, pp. 15-16

iii) While carrier aggregation was becoming more important, 800 MHz and 1800 MHz were the priority aggregation bands, while 900 MHz was not a priority for manufacturers. Telefónica said it was not aware of any plans to standardise pairing with 900 MHz.

iv) Telefónica said that "for the foreseeable future, any operator that acquires additional blocks at 800 MHz (or 1800 MHz) is buying an option to acquire the latest 4G technology as soon as it comes available. The same operator acquiring 900 MHz faces a potential delay of uncertain duration...avoiding such delays is highly valuable".[57]

A9.58 In its response to the July 2015 update note, Telefónica argued that the 2015 German auction results support the view that 900 MHz is worth less than 800 MHz.[58] In commenting on Deutsche Telekom's letter to Ofcom, Telefónica said that "900 MHz will continue to support legacy technologies for the foreseeable future, meaning there is little supply or demand for spectrum for LTE at 900 MHz." Vodafone[59] reiterated its view that the 900 MHz band is not "4G-ready" because it is currently encumbered with legacy traffic, and lacks a fully developed 4G ecosystem. Vodafone said it is unlikely to be ready for the next five years. Vodafone also argued that the low prices for 700 MHz and 1.5 GHz (as well as 900 MHz) in the German auction are consistent with the fact that the device ecosystems for these bands are underdeveloped, which reinforces the importance for spectrum values of a band being "4G-ready".[60]

Expectations about LTE900 in 2012

A9.59 Stakeholders also argued that we have underestimated the extent to which LTE900 development was anticipated by auction participants in 2012. Vodafone in particular said that the fact that 900 MHz will be used for LTE in the UK and Europe is not new information that has emerged recently, and would have been taken into account in bidders' valuations. Vodafone acknowledged that "simply due to the passage of time…it may be that LTE900 as a general concept is now, in February 2015, less of a distant prospect than it was in July 2012".[61]

A9.60 In relation to **network deployment**:

a) Vodafone said that even if more countries were now considering rolling out LTE900 networks, Ofcom has not established that operators' current LTE900 plans have been brought forward from those in mind at the time of auctions. Vodafone (p. 47) and Frontier (p. 14) argued that the value of 900 MHz as derived from historical auctions could even overestimate the current market value of 900 MHz due to a decrease in the premium for the possibility of LTE900 deployment (i.e. operators were overly optimistic in their predictions);[62]

b) Frontier said that there are no indications of imminent LTE900 deployment in Ireland, and that it is reasonable to expect that Irish operators' bids would have

[57] Telefónica response to the February 2015 consultation, p. 16
[58] Telefónica response to the July 2015 update note, p. 18
[59] Vodafone response to the July 2015 update, page 9.
[60] Vodafone response to the July 2015 update note, Annex 2, p.10
[61] Vodafone response to the February 2015 consultation, pp.46-47
[62] Vodafone response to the February 2015 consultation, p. 47, and Annex 2, p. 14

reflected expectations about the commercial opportunities of 900 MHz spectrum when bidding in the 2012 auction.[63]

A9.61 In relation to **device ecosystems**:

a) Vodafone said that device availability is not more than was suggested in Ofcom's July 2012 4G Statement.[64] It also referred to a Real Wireless report accompanying our July 2012 Statement which predicted a critical mass of LTE900 devices emerging 12-18 months after 800 MHz, and said that it is hard to see that this was achieved. Vodafone concluded that "if anything, on the device side, LTE900 capability has not advanced as rapidly as was expected by Ofcom in 2012".[65]

b) Frontier said that the trend line in Figure A9.1 appears to have slowed in the more recent period, and said this suggests that, if anything, operators were expecting a more rapid increase in LTE900 devices at the time of the UK's 4G auction.[66]

New evidence since August 2014

A9.62 Frontier argued that the available evidence since the August 2014 consultation cannot be considered sufficiently strong to justify a substantial change in the assessment of 900 MHz benchmarking evidence.[67]

Our assessment

A9.63 Our view in the February 2015 consultation was that a recent increase in the commercial opportunities for LTE900 created a risk of understatement in the relevant 900 MHz benchmarks (i.e. those that took place in 2012 or earlier, such as in Ireland, Portugal and Spain). We did not explicitly consider the degree to which this increase in commercial opportunities may have been anticipated by bidders (and factored into bids for 800 MHz and 900 MHz spectrum) at the time of these auctions. We agree that this is an important consideration.

A9.64 In the following section, we:

a) update our consideration of whether the auction evidence suggests a trend over time in the relative value of the 900 MHz and 800 MHz bands (by including the new data point from the June 2015 German auction);

b) consider the current strength of LTE900 prospects for a marginally excluded UK operator; and

c) assess the degree to which these prospects may have been anticipated in 2012.

A9.65 In doing so, we consider both the evidence on device ecosystem and the evidence on LTE900 network deployment. We consider that the device ecosystem is a more important determinant of the value of 900 MHz to a prospective operator acquiring

[63] Vodafone response to the February 2015 consultation, Annex 2, p. 16
[64] Vodafone response to the February 2015 consultation, p. 47
[65] Vodafone response to the February 2015 consultation, p. 48
[66] Vodafone response to the February 2015 consultation, Annex 2, p. 18
[67] Vodafone response to the February 2015 consultation, Annex 2, p. 14

900 MHz spectrum for LTE use in Europe (noting Telefónica's view that differences in device ecosystems primarily drive spectrum value differences).

Relative values of 900 MHz and 800 MHz from auctions

A9.66 The June 2015 German auction is the most recent award in our dataset. It produced a relative value of 900 MHz to 800 MHz of 29%, the second lowest in our dataset (as shown in Table A9.1 above). This new data point does not support the view that the value of 900 MHz has risen relative to 800 MHz spectrum since 2010. However, given the other auction-specific and country-specific factors that can influence prices, we should not give undue weight to a single data point.

A9.67 In the February 2015 consultation (paragraphs A9.50 to A9.53), we considered whether the auction evidence suggests a trend over time in the relative value of the 900 MHz and 800 MHz bands. Based on the available evidence, we said it was not clear whether the value of 900 MHz, relative to the value of 800 MHz, had risen over the period since late 2010. Accordingly, our position, that there was a risk of understatement in 900 MHz benchmarks from awards in 2012 or earlier, did not rely on empirical evidence of a trend over time in relative auction prices. Our position remains the same now.[68]

Current LTE900 prospects

A9.68 In relation to **network deployment**, we have set out in previous consultations our view that the prospect of LTE deployment by incumbents (i.e. Vodafone and Telefónica) is not necessarily relevant to establishing the forward-looking value of 900 MHz spectrum to a marginal operator in the UK.

A9.69 There is evidence that deployment of LTE networks in 900 MHz spectrum is now a practical reality in Europe. We noted in our February 2015 consultation that there have been cases where incumbents are already using 900 MHz spectrum to roll out an LTE network (Telenor in Sweden, Vodafone in Czech Republic and T-Mobile in the Netherlands). We also noted several cases in which a non-incumbent operator had acquired 900 MHz spectrum, and that in most of these cases there was evidence that the operator was planning to introduce LTE900 services.[69] In each case they are doing so in competition with rivals offering LTE in other bands. In our

[68] We also note that Frontier argued that there was no new evidence between August 2014 and February 2015 to justify the change in our position as regards the possibility of a recent increase in commercial opportunities for LTE deployment in the 900 MHz band. The change in our view on the technical and commercial value of 900 MHz was not based specifically on changes that occurred since the August 2014 consultation. Instead, it reflected our review of the evidence regarding LTE900 development since the date of our benchmark auctions (not just since August 2014) in light of arguments from both EE and H3G (in their responses to the August 2014 consultation) that the value of 900 MHz was understated by auction evidence.

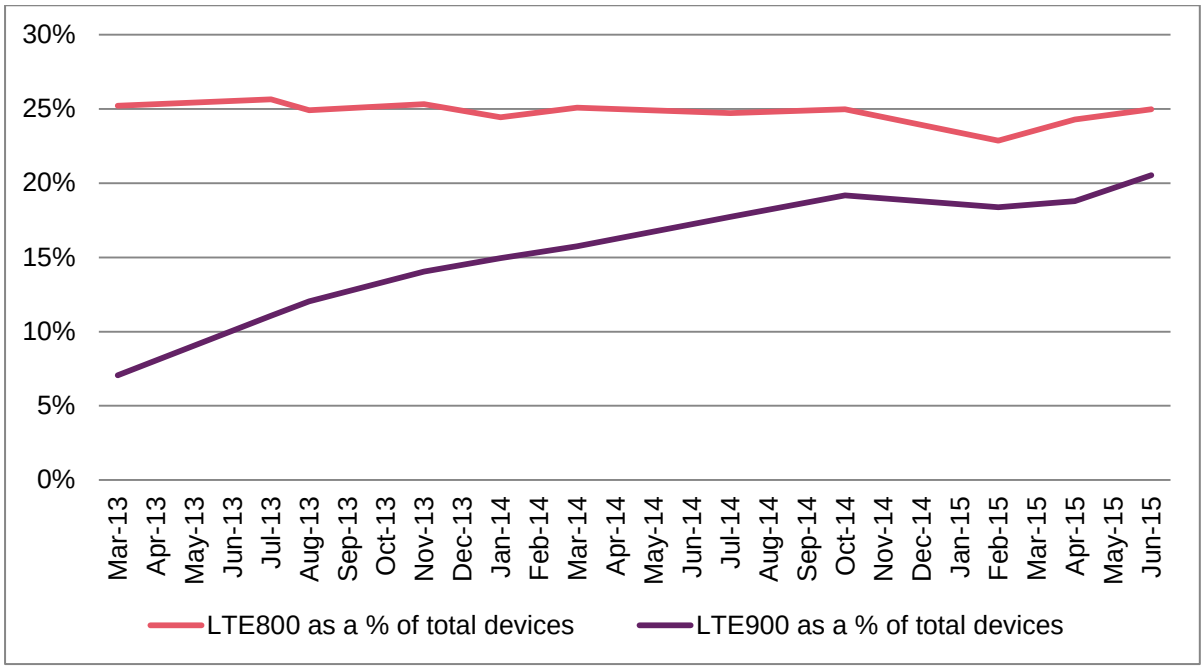
[69] Telekom Slovenije in Slovenia have now rolled out LTE in 900 MHz and their LTE900 base stations are listed here: http://www.svetidej.com/aplikacije/zemljevidi/brskalnik/maps-c4141c-293-41-lte-frekvenca.html. Telco Data in Norway is owned by the parent company which owns mobile broadband operator Ice.net. In November 2014, Ice.net announced a new 4G LTE network and said that services will later be expanded to the 800MHz, 900MHz and 1800MHz bands. https://www.telegeography.com/products/commsupdate/articles/2014/11/14/alcatel-lucent-rolling-out-lte-450-for-net-1-ice-net-in-sweden-norway-denmark/

view, this evidence supports the view that it is now feasible for an operator acquiring 900 MHz spectrum to use it to deliver LTE services in Europe.[70]

A9.70 In relation to **device ecosystems,** Telefónica's observations on the comparative development of the LTE800 and LTE900 device ecosystems are consistent with the fact that our estimate of the lump-sum value of 900 MHz in the February 2015 consultation was at a substantial discount to that for 800 MHz, as is our conclusion on the value of 900 MHz set out in Section 5.

A9.71 Updated GSA data on the proportion of total devices which are LTE800 and LTE900 respectively is shown in Figure A9.2 below. It indicates that there was some further convergence between LTE device availability on the two bands between October 2014 and June 2015. By June 2015, 21% of devices supported LTE900 while 25% supported LTE800 (compared to 19% and 25% in October 2014). GSA noted that the number of smartphones supporting LTE900 increased by 131% (from 161 to 372) between August 2014 and July 2015.[71]

Figure A9.2 Proportion of mobile devices with LTE800, LTE900 up to June 2015

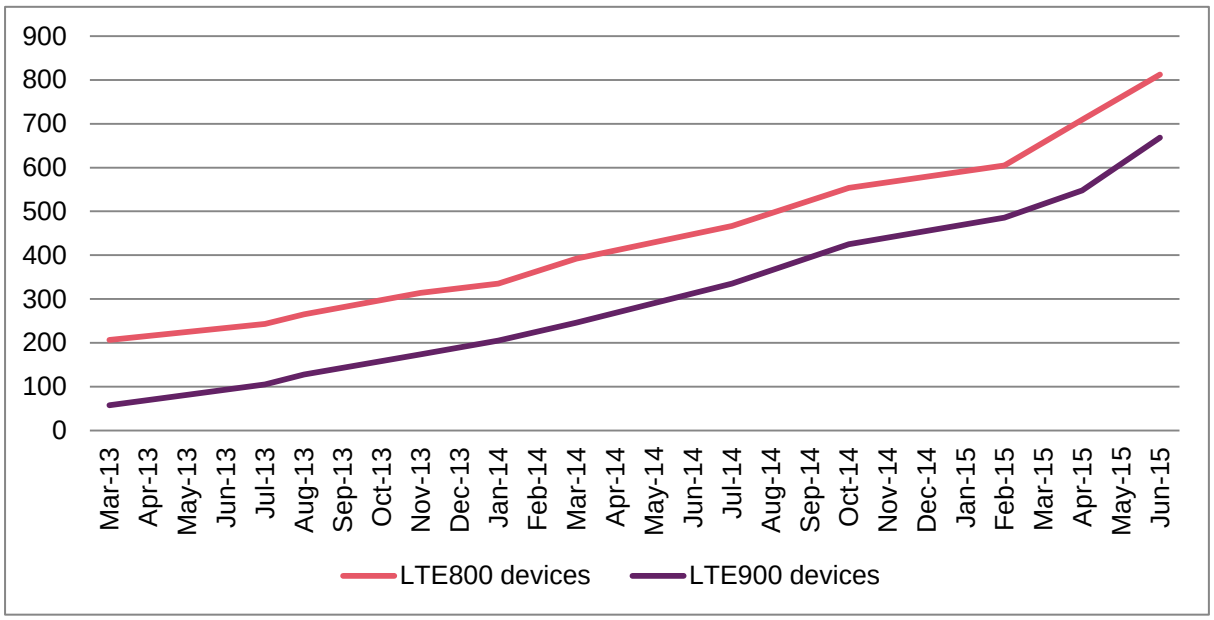


Source: GSA

[70] We note Frontier's point that the LTE900 rollout by RCS&RDS (in Romania) and T-Mobile (the Netherlands) reflects the lack of other sub-1 GHz spectrum. However, the reason why an operator chooses to deploy LTE in 900 MHz is not relevant in this context. The point is that existing LTE 900 deployments provide hard evidence that it is entirely possible for an operator acquiring 900 MHz spectrum to use it for LTE if it wishes to.

[71] Page 4, GSA report, *LTE in 900 MHz spectrum (3GPP band 8) – market status*, July 31 2015

Figure A9.3 Absolute number of mobile devices with LTE800, LTE900 to June 2015



Source: GSA

A9.72 The GSA data presented in the figures above relate to the global LTE900 ecosystem, and this could potentially overstate the number of compatible devices available in Europe. However, we consider that, for a marginal operator contemplating the use of 900 MHz to provide LTE services, the compatibility of market-leading devices would be a more important consideration than the total number of compatible devices. We note that the UK's ten leading 4G handset devices[72], including the iPhone 6 and Samsung Galaxy S6, all support the 900 MHz band (as well as the 800 MHz band).

A9.73 As regards carrier aggregation, the evidence presented above suggests that, even if 900 MHz is a low priority band, it has not prevented growth in the LTE900 device ecosystem. An inability to pair 900 MHz with other LTE bands might make 900 MHz less valuable for a given device ecosystem size, but, to the extent that this was understood by operators at the time of our auctions, it would be reflected in our relative values for 900 MHz and 800 MHz. Overall, we consider that the device ecosystem for LTE900 is sufficiently well established at this point to make 900 MHz a realistic band for LTE deployment.

Expectations about LTE900 in 2012

A9.74 In order to assess whether the development of LTE900 has outstripped expectations in 2012, we have reviewed our July 2012 4G Auction Statement and the accompanying Real Wireless report (to which Vodafone referred).[73] Table A9.2 below summarises comments and evidence relating to commercial opportunities for LTE900 (both network deployment and device ecosystems) from these documents and compares them to the evidence available now.

[72] Based on USwitch's mobile tracker, August 2015, http://www.uswitch.com/mobiles/mobile_tracker/.
[73] Annex 2, Ofcom, Assessment of future mobile competition and award of 800 MHz and 2.6 GHz, Statement, July 2012, and Real Wireless report: "LTE and HSPA device availability in the UK-relevant frequency bands, http://stakeholders.ofcom.org.uk/consultations/award-800mhz-2.6ghz/statement/

Table A9.2: Summary of comments and evidence about LTE900 in our July 2012 statement and Real Wireless report compared to evidence available now

Comment and evidence in 2012	Consistent with the evidence available now?	Implications
Network deployment		
We presented a chart showing indicative timescales for LTE deployment in the UK, suggesting deployment in 900 MHz beginning from around 2015 to 2019 (with the wide range reflecting the uncertainty),[74] but we also said it is possible that use of LTE in 900 MHz may be earlier than indicated in the chart.[75]	There have been some LTE deployments in the 900 MHz band in Europe, but none in the UK. However, the wide timeframe reflected in the chart means that it is too early to say whether or not developments have fallen short of predictions as reflected in the chart.	Too early to conclude.
Real Wireless referred to a 2012 survey of over 40 European mobile operators. The survey indicated that 59% of operators said that they were considering using 900 MHz for 4G in the future,[76] while 20% of operators expected to refarm 900 MHz for LTE before 2014.[77] Real Wireless also said that "there is considerable carrier interest, even among those confident of securing 800 MHz licences, in re-farming 900 MHz in 2014 or later as a way to move directly to LTE-A".[78]	As noted in paragraph A9.69, some European operators have already deployed 900 MHz for LTE. However, far fewer than 20% have refarmed 900 MHz spectrum for this purpose.	Current LTE 900 developments lag behind the 2012 assessment.

[74] Paragraph 3.204 and Figure 3.15, Annex 6, Ofcom, Assessment of future mobile competition and award of 800 MHz and 2.6 GHz, Second consultation, January 2012, http://stakeholders.ofcom.org.uk/consultations/award-800mhz-2.6ghz/
[75] Paragraph A2.70 and Figure A2.7, Ofcom, Assessment of future mobile competition and award of 800 MHz and 2.6 GHz, Statement
[76] Page 26, Real Wireless report
[77] Page 28, Real Wireless report
[78] Executive Summary, Real Wireless report

Real Wireless said that the 900 MHz band would initially fall into the second tier of LTE bands, but will start to feature as a Tier 1 LTE band "around 2015/16".[79] 59% of operators responding to a 2012 survey said that 900 MHz would be a Tier 1 band.[80] Real Wireless described a Tier 1 band as one which is: Supported by one of the top 10 global procurers by volume (such as Telefónica or Vodafone); Adopted in areas of early and high value LTE adoption; and Supported on a broad geographical basis around the world.[81]	In terms of global procurers, Vodafone has deployed LTE900 in the Czech Republic while T-Mobile has done the same in the Netherlands, but neither MNO has done so elsewhere in Europe. It has not yet been adopted in areas of early and high value LTE, such as the US or UK. There is also limited evidence of network rollout in different regions of the world – GSA data shows 14 operators worldwide have done so, with non-European rollout confined to Indonesia, Singapore, South Korea and Taiwan.[82] As a result, it does not appear that Tier 1 status has been achieved.	Current LTE 900 developments lag behind the 2012 assessment.
Device ecosystems		
We said that "it is difficult to infer much based on current device availability, as the availability of the 900 MHz band for LTE is a recent development". However, we also said that there is potentially a global market for manufacturers of handsets for those compatible with 900 MHz LTE, and that while the use of 900 MHz spectrum for LTE is likely to be somewhat later than 800 MHz, 1800 MHz and 2.6 GHz, if national wholesalers with 900 MHz spectrum wanted to use it for LTE there would be a reasonable selection of user devices available.[83]	A reasonable selection of LTE900 devices emerged a little later than for other 4G spectrum bands, as anticipated in July 2012, but it is available for national wholesalers now.	Current LTE900 developments are broadly in line with the 2012 assessment.
Real Wireless said that 900 MHz LTE iPhone support is unlikely to follow until 2014, meaning that although, if certain assumptions prove correct, an LTE900 operator will have plenty of device choice by the end of 2013, the iPhone would not be one (unless a major player is willing to offer Apple major incentives).[84]	The iPhone 5s and iPhone 5c, released in September 2013, supported the LTE900 band. This is a little earlier than Real Wireless predicted.	Current LTE900 developments may exceed the 2012 assessment.

[79] Executive Summary, Real Wireless report
[80] Page 26, Real Wireless report
[81] Page 25, Real Wireless report
[82] Page 4, GSA report, *LTE in 900 MHz spectrum (3GPP band 8) – market status*, July 31 2015
[83] Paragraphs A2.63 and A2.67, Ofcom, Assessment of future mobile competition and award of 800 MHz and 2.6 GHz, Statement
[84] Page 32, Real Wireless report

Figure 3-7 of Real Wireless's report indicated that 21% of European device variants available to EU operators will support the 900 MHz band by 2016.[85]	As shown in Figure A9.2, 21% of devices supported the 900 MHz band in June 2015 – earlier than Real Wireless predicted. However, GSA statistics set out above are global and so not fully comparable (we note the potential for global data to overstate the European ecosystem).	Current LTE 900 developments are broadly in line with the 2012 assessment.
Real Wireless said that "achieving a critical mass of devices [for LTE900] will take 12-18 months longer than for 800 MHz".[86]	Vodafone said that "it is hard to see that a critical mass of LTE900 devices….was achieved as soon as 12-18 months after LTE800", which Figure A9.2 suggests was likely to have been achieved no later than mid-2013.[87] Figure A9.2 shows that the LTE900 ecosystem is still smaller than the LTE800 ecosystem. However, for the purposes of achieving a critical mass of devices, we consider that it is *absolute device numbers* – not relative ecosystem sizes – that is more relevant. Figure A9.3, based on global GSA data, suggests that the number of devices supporting LTE900 has tended to equal the number of devices supporting LTE800 with a delay of less than 12 months.	Current LTE 900 developments are broadly in line with the 2012 assessment.[88]
Figure 3-8 of Real Wireless's report indicated that the number of mobile devices supporting LTE900 would be 54% of the number of LTE800 devices by 2016.[89]	Global GSA data for June 2015 shows that the LTE900 ecosystem is already 82% of the size of the LTE800 ecosystem (in terms of number of device variants).	Current LTE900 developments may exceed the 2012 assessment.

[85] Page 37, Real Wireless report
[86] Page 28, Real Wireless report
[87] Page 48, Vodafone response to the February 2015 consultation
[88] Although the time lag in the number of LTE900 devices is less than 12 months, we recognise that this is global data which may tend to overstate the size of the LTE900 ecosystem relative to LTE800.
[89] Page 11, Real Wireless report

A9.75 The above statements relating to expectations for LTE900 reflect the fact that there was a high degree of uncertainty about the timeline for moving to LTE900 in 2012, with Real Wireless noting that "most carriers remain open-minded on how to use this band, with no short term plans".[90] The statements should also be treated with caution, as the extent to which they reflect the views of operators in the relevant countries of interest (such as Ireland) at the time of their auctions is unclear.

A9.76 However, the comparison in the above table suggests that there is some evidence that LTE900 deployment may have occurred more slowly than was expected in 2012. On the other hand, we consider that ecosystem development has at least been in line with, and may have exceeded, expectations in 2012. We consider that the development of the LTE900 device ecosystem is the more relevant determinant of the potential value of the 900 MHz band to a marginal operator. For this reason, we remain of the view that the value of 900 MHz, relative to 800 MHz, in auctions from 2012 or earlier risks understating the forward-looking market value of 900 MHz relative to 800 MHz in the UK.

A9.77 We note Vodafone's view that "simply due to the passage of time…it may be that LTE900 as a general concept is now, in February 2015, less of a distant prospect than it was in July 2012".[91] We consider that, even if LTE900 prospects had developed in line with market expectations at the time of these auctions, the increased certainty over the development of the LTE ecosystem creates a possibility that forward-looking values today could be higher than at the time of the auctions in Ireland and Spain. This is a further reason for considering there is a risk that these auctions might understate the value of 900 MHz.

A9.78 Our view in the February 2015 consultation was that there is a *risk* (of unknown likelihood) that 900 MHz benchmarks from auctions in 2012 or earlier understate forward-looking market value. We did not have a definitive view that there is an understatement, or that an understatement is more likely than not. Having considered stakeholder responses and evidence comparing LTE900 developments with expectations in 2012, we remain of the view that there is a risk of understatement of relevant 900 MHz benchmarks from an increase in the attractiveness of the LTE900 ecosystem.

Technical and commercial evidence relating to the value of 1800 MHz spectrum

Position in the August 2014 consultation

A9.79 In the August 2014 consultation we considered the following evidence relating to the development of LTE1800:

a) Network deployments:

i) An LTE1800 network was first deployed in Europe by CenterNet and Mobyland (Poland) in September 2010.

[90] Page 28, Real Wireless report
[91] Page 47, Vodafone response to the February 2015 consultation

ii) In March 2011, T-Mobile announced its intention to deploy an LTE1800 network in Germany[92]; this was launched four months later in July 2011.

iii) In November 2011, we received an application from EE to use its 1800 MHz licences for LTE services. We consulted on this issue, saying we were minded to vary EE's licence to allow LTE use, in March 2012, [93] before approving the request in an August 2012 statement.

iv) By September 2012, 33% of LTE networks had been launched on the 1800 MHz band.[94]

b) Device compatibility:

v) There were a number of LTE1800-enabled devices available at the beginning of 2011.

vi) The LTE1800 ecosystem developed rapidly during the first half of 2012, and in the March 2012 consultation mentioned above we stated that LTE1800 equipment was commercially available.

vii) By April 2012 there were more LTE devices compatible with 1800 MHz than with 800 MHz[95], and this trend was reinforced in September 2012 by the launch of the iPhone 5 supporting LTE1800 but not LTE800.

A9.80 Based on this evidence, we considered that increased interest in Europe in 1800 MHz for LTE can reasonably be dated between late 2011 and early 2012. As noted above, in March 2012 we published a notice setting out our intention to vary EE's 1800 MHz licences to enable it to provide services using LTE technology in those frequencies, as it requested in November 2011. Leading consumer devices with LTE1800 also appeared in 2012. On this basis we considered there to be 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.

Stakeholder responses to August 2014 consultation

A9.81 In its response to the August 2014 consultation, AM&A[96] disagreed with our view that the timing of 1800 MHz awards makes the relative values less reflective of market value today. It said that:

a) It is not clear that the value of having GSM capacity prior to 2011 was lower than the value of having LTE today. The ecosystem in different spectrum bands is constantly evolving, and beyond the short term it is the frequency and propagation characteristics of the spectrum (for harmonised bands) which is most important;

[92] http://www.gsma.com/spectrum/wp-content/uploads/2012/03/gsaalanhadden1800mhzworkshop250311.pdf
[93] Table 2, Ofcom, *Notice of proposed variation of Everything Everywhere's 1800 MHz spectrum licences to allow use of LTE and WiMax technologies,* March 2012, http://stakeholders.ofcom.org.uk/binaries/consultations/variation-900-1800mhz-lte-wimax/summary/condoc.pdf
[94] GSA report, http://www.gsacom.com/news/gsa_360.php
[95] This is based on data from GSMA.
[96] AM&A response to the August 2014 consultation, page 13

b) Ofcom assumes that operators were unable to anticipate this change in use for the band – but this may not have been the case; and

c) There are many factors that influence the relative value of spectrum between bands over time – of which the technology used in each band is just one.

Our assessment in the February 2015 consultation

A9.82 In relation to AM&A's arguments, we considered that:

a) Given that the GSM customer base is not increasing, we would expect operators bidding in auctions to have limited need for additional GSM capacity. We consider it likely that the market value of 1800 MHz spectrum would be higher if operators were bidding with a view to deploying an LTE network.

b) In paragraph A7.84 of the August 2014 consultation, we considered whether or not operators would have anticipated the development of the 1800 MHz LTE ecosystem. We said that, while this may have been the case for auctions in 2011, there was much less certainty about this development for auctions before 2011. AM&A has not presented any evidence to the contrary. Our view remained that this is the case. We also noted that two or more bidders would need to anticipate the change in use of the band in order for pre-2011 auction prices to have reflected the value of 1800 MHz spectrum for LTE.

c) Finally, we agreed that there are other factors that influence relative spectrum value. Where there was sufficient evidence to establish the likely impact of a particular factor on relative values, we considered it as part of our benchmarking exercise. We did not consider other factors when we believed that there is not a clear hypothesis or empirical evidence supporting a possible relationship between that factor and auction prices.

A9.83 In light of this, we continued to take account of the date of award in our interpretation of the relevant 1800 MHz benchmarks. The way in which we did this was explained in paragraphs A7.143-A7.145 of the February 2015 consultation.

Stakeholder responses to the February 2015 consultation and our assessment

A9.84 In response to the February 2015 consultation, stakeholders did not sumbit any further comment on the way in which we take account of the date of award in our interpretation of 1800 MHz benchmarks. As a result, we have maintained our view as outlined in paragraphs A9.82 to A9.83 above.

Network cost modelling

Position in the August 2014 consultation

A9.85 In Annex 9 of the August 2014 consultation we set out our views on using network cost modelling to estimate the value of ALF spectrum. We said that any such cost model would be subject to significant uncertainty about appropriate parameter assumptions, leading to valuation estimates that vary over a wide range.[97] To illustrate this position we attempted to assess the value of 900 MHz spectrum by adapting the Analysys Mason model which we used in a separate project as part of

[97] Paragraph A9.26, August 2014 consultation

our cost-benefit analysis on changing the use of the 700 MHz band. We considered that the resulting outputs were not informative for the purposes of deriving our proposals on ALF.

A9.86 We also retained our view from the October 2013 consultation that an attempt to derive point estimates of value based on technical modelling would be of limited additional benefit for deriving proposals on ALF (over and above the evidence that is available to us on the market value of 900 MHz and 1800 MHz spectrum from UK and international benchmarks).[98]

Stakeholder responses and our assessment in the February 2015 consultation

A9.87 Vodafone provided a detailed response to our treatment of network cost modelling[99], arguing that:

a) A purpose-built cost model for 900 MHz would produce a narrower range of outputs than those from the 700 MHz model, and that some of the assumptions in our cost modelling exercise were incorrect;

b) The relative intensity of use of 800 MHz and 900 MHz spectrum in our model confirms that the latter has a lower value;

c) Ofcom's policy rules out modelling scenarios with high data demand and limited release of spectrum;

d) Declining consumer willingness to pay places downward pressure on spectrum valuation from cost modelling.

A9.88 We considered each of these points in turn, setting out Vodafone's argument and our assessment for each point.

Likely outputs from a purpose-built model

A9.89 Vodafone argued that some of the assumptions that we used in our 700 MHz cost modelling exercise inflated our indicative estimates of the value of 900 MHz spectrum. It considered that a purpose-built cost model would produce a narrower (and lower) range of outputs.[100]

Our assessment in the February 2015 consultation

A9.90 We remained of the view that a purpose-built 900 MHz model would be subject to significant uncertainty about the specification of the model and appropriate parameter assumptions, and would be unlikely to be helpful in deriving a point estimate lump-sum value for the ALF bands. Therefore, we did not place significant weight on modelling results in informing our estimates.

A9.91 Notwithstanding this point, we addressed Vodafone's specific arguments about our cost modelling exercise as set out below:

[98] Paragraphs A6.26, *Annual licence fees for 900 MHz and 1800 MHz spectrum*, First consultation, October 2013
[99] Vodafone response, Annex 3.3, Section 2
[100] Vodafone response, Annex 3.3, pages 23-25

a) Vodafone disagreed with the assumption that 900 MHz can be used for LTE in 2015. In the model we assumed that 900 MHz would be available on all devices immediately from 2015. We said that, as discussed in paragraph A9.24 of our February 2015 consultation, there is evidence of recent development in the LTE900 ecosystem, with leading consumer devices supporting LTE900 and some deployment of LTE900 networks. Although 900 MHz is not supported as an LTE band on all devices, we said this suggests that operators would be able to serve a significant proportion of traffic with 900 MHz spectrum from 2015.

b) Vodafone argued that it was unrealistic to assume that 18-22% of traffic must be carried on sub-1 GHz spectrum. In the August 2014 consultation we noted that both EE and H3G offer mobile broadband services today using little or no sub-1 GHz spectrum, suggesting that operators can adapt their commercial strategies to mitigate this problem. This might imply that the estimated benefits of 900 MHz were overstated. However, we also noted that the model might be failing to capture additional benefits if it allowed these operators to improve their competitive position by extending coverage and, in doing so, serving more traffic. As a result, we explained there was a significant risk that the structure of the model, which was designed for a different purpose, was not well-suited to modelling the value of 900 MHz to specific individual operators.

c) Vodafone disagreed with the assumption that EE would be allowed to extend its spectrum holdings before additional spectrum is released. However, we said this is consistent with our analysis in Section 2 to treat the overall cap in the 4G auction as non-binding on a forward-looking basis.[101]

d) Vodafone argued that the use of a 2x5 MHz increment is inconsistent with our marginal bidder analysis. As discussed in Section 2 of the February 2015 consulation, we considered a 2x5 MHz increment as well as a 2x10 MHz increment in the derivation of our UK market value for 800 MHz.

e) Vodafone argued that it was not clear whether the latest mobile termination rate (MTR) modelling assumptions have been used. We said that the 700 MHz model was developed to inform our May 2014 Consultation on future use of the 700 MHz band, and the latest MCT[102] assumptions were not available at the time this work was undertaken. As a result, some assumptions were taken from the 2011 MCT model. However, as an illustration we assessed the impact on the modelling exercise of updating three major 2011 MCT model assumptions:

   i) Geotypes: The assumed traffic split by geotype is unchanged in the 2015 MCT model compared with 2011.

   ii) Demand: The data volume forecasts used in the 2015 MCT model are different from the forecasts used in the 700 MHz model. However, as explained in paragraphs A7.198 to A7.201 of the 2015 MCT Draft Statement,

[101] In addition, we noted that in our modelling exercise we estimated the network cost savings from 2x5 MHz of additional 900 MHz spectrum for H3G as well as EE, and the benefits (assuming a 25% traffic share) were actually greater when H3G was modelled as the acquiring operator. It could be argued that this is inconsistent with the evidence considered in Section 2 that additional sub-1 GHz spectrum is of greater value to EE than to H3G. However, we considered that this further points to the limitations in network cost modelling of this type in deriving robust results, especially for individual operators.

[102] The model to which Vodafone refers for setting MTRs is known as the MCT cost model, hence we use the term “MCT model” hereafter.

we considered that there are good reasons why we would not expect the data volume forecasts to be the same.[103]

iii) Site costs: The overall cost of a site is similar in the latest MCT model, although additional carrier costs are higher in the 2015 MCT model than the corresponding costs used in the 700 MHz model. We said an increase in the cost of adding a new carrier to a site would have an ambiguous effect in the model on the network cost savings associated with 900 MHz spectrum. This is because these higher cost estimates would apply to the 900 MHz band, reducing the net benefit associated with 900 MHz spectrum, but also to other bands which would be deployed in its absence (increasing the benefit associated with 900 MHz). The overall effect depends on the specific carrier deployment profile assumed for 900 MHz.

A9.92 We did not fully repeat the adapted 700 MHz cost modelling exercise based on all the MCT assumptions made for the purposes of the 2015 MCT Draft Statement. But based on the analysis reported above, we said that we did not have evidence to suggest that it would significantly affect the conclusions that we drew from the exercise.

Relative use of 800 MHz and 900 MHz

A9.93 Vodafone argued that the relative intensity of use of 800 MHz and 900 MHz spectrum in our cost modelling exercise confirms that 900 MHz spectrum has a lower relative value than 800 MHz.[104] Specifically, it said that 800 MHz spectrum is being deployed and loaded with traffic much earlier and more extensively than 900 MHz spectrum, which is used later in time, less intensively, and only at a sub-national level. Vodafone acknowledged that "quantification of any relative value from the cost model has not been attempted and would be difficult to carry out" but said that, given the very obvious lower use made in the model of 900 MHz relative to 800 MHz, it would be expected that a relative value of 62% is on the high side of what a suitably developed cost model might provide.

Our assessment in the February 2015 consultation

A9.94 In the February 2015 consultation we said that, as explained in paragraphs A9.23-A9.24 of our August 2014 consultation, our adapted 700 MHz model does not distinguish between 800 MHz and 900 MHz spectrum in terms of the technical and commercial characteristics of these bands. As Vodafone noted, it does assume that 900 MHz spectrum is used less intensively than 800 MHz. However, this is an artefact of the model's original purpose, which was designed for estimating the benefits of 700 MHz spectrum release. We did not consider that this assumption regarding intensity of use is relevant in the context of estimating the market value of 900 MHz spectrum, as it would not necessarily apply to an operator without an existing LTE network, or an operator who might use both 800 MHz and 900 MHz spectrum as incremental spectrum to provide additional coverage for its established LTE network.

[103] Paragraphs A7.198-A7.201, Ofcom, Mobile call termination market review 2015-18, Draft Statement, February 2015, http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-call-termination-14/statement/Annexes_7-13.pdf
[104] Vodafone response, Annex 3.3, page 26

A9.95 A purpose-built 900 MHz cost model, which incorporated additional assumptions to attempt to capture differences in device ecosystems and other factors, might be able to generate a relative value estimate. However, as highlighted in paragraph A9.90 above, we said there is significant uncertainty about the relevant assumptions to make and the results would be highly sensitive to these assumptions. For example, as the discussion earlier in this annex indicates, any modelling assumption about the relative strength of the 900 MHz and 800 MHz ecosystems would be subject to significant uncertainty.

A9.96 As a result, it would only be able to produce a wide range of possible relative values, rather than a specific point estimate. We did not believe that this would be particularly useful in adjusting or refining our estimate of the 900 MHz / 800 MHz paired ratio that we have derived through international benchmarking.

Spectrum volume and data demand scenarios

A9.97 Vodafone argued that the effect of "Ofcom's stated policy of positioning itself to release additional spectrum" for mobile broadband is to rule out cost modelling scenarios which combine high data demand forecasts with low or medium spectrum release forecasts.[105] As these scenarios generally produce higher spectrum valuation estimates, Vodafone said that this policy effectively places an upper bound on the spectrum values that can be obtained through cost modelling.

A9.98 Vodafone also argued that high volume data forecasts (or more strictly data forecasts in general) cannot be adopted in any cost modelling scenario without consideration of consumer willingness to pay for mobile services.[106] It said that a low willingness to pay for additional data caps the level of profitable investment in capacity that can be made by operators, which in turn restricts the level of demand for data traffic that is actually possible.[107]

Our assessment in the February 2015 consultation

A9.99 In the February 2015 consultation, we described our position on future spectrum availability, which is now set out in paragraphs A9.8-A9.15 above. We did not agree that our position constitutes a 'cap' on spectrum values that can be obtained through cost modelling as it does not eliminate the possibility that high future growth in mobile data demand could be accompanied by limited spectrum release.

A9.100 In light of this, we considered that the "central high" scenario in our adapted 700 MHz cost model (which combined a high traffic forecast and a medium spectrum release forecast including the 1.4 GHz and 3.6 to 3.8 GHz bands) is based on reasonable and consistent assumptions. This produced values (up to £121m per MHz) well in excess of our proposed lump-sum value.[108] We noted that the 700 MHz model produces very similar results to this under the alternative assumption of a high supra-1 GHz spectrum release.[109]

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[105] Vodafone response, Annex 3.3, page 22
[106] Vodafone response, Annex 3.3, page 2
[107] Vodafone response, Annex 3.3, page 32
[108] Table A9.2, August 2014 consultation
[109] Scenario 3, Figure 3.13, Analysys Mason, Assessment of the benefits of a change in use of the 700 MHz band to mobile, October 2014, http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/benefits_700MHz.pdf. Network cost savings are significantly lower under the highest spectrum release scenario which

A9.101 We agreed with Vodafone that consumer willingness to pay is relevant in principle in the context of data demand forecasts. However, in our November 2014 statement on future use of the 700 MHz band we said that, while in principle a more detailed model could explicitly estimate consumers' willingness to pay, we considered that such an elaboration of the demand model would increase its complexity without necessarily increasing confidence in the resulting forecasts.[110]

Stakeholder responses to the February 2015 consultation

A9.102 EE said that we have failed to properly consider cost modelling to determine the value of 1800 MHz spectrum.[111] It argued that:

a) We have previously recognised the benefits of modelling spectrum value. EE said that licence fees for ALF spectrum has been set to date on the basis of cost modelling, and it has also been used to set Administrative Incentive Pricing for other bands;

b) Our arguments for not using cost modelling to value 1800 MHz spectrum are not valid:

i) EE disagreed that the fact that uncertainty about parameter assumptions leads to a wide range of estimates is a reason to ignore cost modelling evidence. EE said that our current approach to assessing lump-sum values does not lead to the identification of current market value of spectrum free from such uncertainty about appropriate parameter assumptions, as it is inherent to the process of seeking to establish the market value of mobile spectrum. EE said that there is now less uncertainty about modelling an LTE network. It also noted that the size of the range of 900 MHz values produced by the adapted 700 MHz cost model was due in large part to the assumptions that a particular percentage of traffic must be served with sub-1 GHz spectrum, which made estimates highly sensitive to overall traffic forecasts (an issue which does not apply in the case of 1800 MHz spectrum).

ii) EE noted our finding that cost modelling in relation to 900 MHz produced higher results than international benchmarking, which we said was principally a result of the assumption that a certain proportion of traffic must be served by sub-1 GHz spectrum.[112] EE said that for 1800 MHz the use of cost modelling shows that benchmarking overstates market value (discussed further in paragraphs A9.103-A9.105 below).

iii) EE disagreed that, in the context of acquiring 1800 MHz spectrum, there are significant additional performance benefits not captured by network cost modelling. EE said that these benefits (i.e. benefits related to extended coverage and the introduction of new services and technologies) are not relevant to the commercial valuation of an additional increment of 1800 MHz spectrum to the UK mobile operators.

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includes 470 – 694 MHz spectrum, but as explained in paragraph A9.12 (b) we do not envisage this band being released for mobile before 2030.

[110] Paragraph 4.11, http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/statement/700-mhz-statement.pdf

[111] EE response to the February 2015 consultation, pp. 28-33

[112] Paragraph A9.17, Further consultation on Annual Licence Fees, August 2014, http://stakeholders.ofcom.org.uk/binaries/consultations/annual-licence-fees-900-MHz-1800-MHz/annexes/Annex_9-11.pdf

A9.103 EE acknowledged that during most of the ALF consultation process there has not been a cost model that would have enabled the value of additional ALF spectrum to the 1800 MHz operators to be readily modelled. However, EE argued that the 2015 MCT cost model (published alongside the MCT final statement on 17 March 2015) can be used to estimate the value of ALF spectrum.[113] Specifically, EE said that the MCT model can be used to calculate the savings in network equipment costs caused by an incremental increase in the amount of 1800 MHz spectrum available to an MNO, and argued that this saving constitutes an estimate of the value of that spectrum to an MNO.

A9.104 EE commissioned CEG to adapt the MCT model in a number of ways for the purpose of estimating the value of 1800 MHz spectrum:

a) CEG modified the base-case spectrum holding, which in the MCT model is chosen to be representative of an average efficient MNO, to reflect the 4 MNOs' actual spectrum holdings. CEG also assumed that each MNO acquires some spectrum in the upcoming awards of 1.4 GHz and 2.3/3.4 GHz;

b) CEG used demand forecasts for the period 2015-2034 from Analysys Mason's forecasts in the 700 MHz model (used in our assessment of the benefits of releasing the 700 MHz band for mobile);

c) CEG reflected technology improvements by incorporating Analysys Mason's (increasing) spectral efficiency profile in the 700 MHz model.

A9.105 CEG modelled three scenarios (along with a sensitivity analysis on the third scenario), which differ in terms of assumed spectrum release and spectral efficiency gains. Based on these results, EE concluded that "our modelling results suggest….a reasonable range for ALFs based on a lump sum value for 1800 MHz of between £1.21m and £5.48m per MHz."[114]

Our assessment

General approach to cost modelling

A9.106 Network cost modelling entails building a stylised model of a firm's commercial options, incorporating informed assumptions about the value of a range of parameters. While this is an important tool which Ofcom uses to inform a range of policy decisions, it is fundamentally based on a set of parameter assumptions. When estimating the market value of ALF spectrum, we have had primary regard to market-based evidence from auctions in the UK and Europe, as this directly reflects valuations for spectrum expressed by market participants.[115] We have considered whether network cost modelling can provide additional benefit, over and above this market-based evidence, in determining a point estimate of the lump-sum value of ALF spectrum. In this context, we still consider that estimates of spectrum value based on network cost modelling would only be of limited additional benefit.

[113] EE response to the February 2015 consultation, pp. 33-37
[114] EE response to the February 2015 consultation, p. 37
[115] Our MCT model used our market-based estimates of the lump-sum value of 1800 MHz as an input to the calculation of overall network costs based on LRIC+, rather than deriving this input from network cost modelling (though, for clarification, spectrum licence costs do not affect final MTRs as they were set on the basis of LRIC, which does not include licence costs).

A9.107 We recognise that our approach to assessing lump-sum values does not eliminate uncertainty in specrum valuation. However, we consider that taking a range of market-based evidence in the round, and using our regulatory judgement to decide how much weight to place on the various pieces of market-based evidence, is an appropriate way to address such uncertainty.

A9.108 We agree that the size of the range of 900 MHz values produced by our adapted 700 MHz cost modelling exercise was driven in large part by traffic assumptions which are not relevant to 1800 MHz spectrum. However, other assumptions also affected the results. For example, network cost savings varied considerably for each operator according to traffic distribution across sites. Any cost model which is built or adapted to value 1800 MHz spectrum would still be subject to significant sensitivities regarding its results.

A9.109 Finally, we recognise that an additional increment of 1800 MHz spectrum (particularly if it was only 2x5 MHz) is unlikely to allow operators to launch entirely new services. However, we consider that it might provide additional benefits which would not be captured by a network cost modelling approach. This could be by way of:

a) Improving performance by delivering higher user throughput for certain consumers. The performance benefits of deploying additional 1800 MHz spectrum will not be as significant as for sub-1 GHz spectrum, but any additional spectrum is likely to deliver performance improvements not captured purely by modelling capacity; and

b) Depending on the identity of the marginal bidder, an additional increment of 1800 MHz could carry a contiguity premium associated with creating larger blocks of spectrum, allowing the benefits of LTE to be achieved more fully in terms of peak data rates and capacity.

A9.110 We consider that these benefits could cause a marginal operator's value of additional 1800 MHz spectrum to exceed the avoided network costs captured by cost modelling.

Using the MCT model to estimate the value of 1800 MHz spectrum

A9.111 The MCT model was designed for a specific purpose – to calculate the costs of mobile call termination for a hypothetical efficient operator, in order to inform us in setting the charge control for MTRs. It was not built to calculate the value of spectrum licences for different spectrum bands to operators. Adapting a complex model to meet a different purpose is not straightforward, and there is a significant risk that the results generated by an adapted model will not be reliable.

A9.112 We consider that there are a number of features of the design of the MCT model which make it unsuited to being adapted for the purposes of spectrum valuation. We discuss these below.

Identical valuation of different frequency bands

A9.113 EE presented the range of cost savings noted above, derived by CEG from adapting the MCT model, as representing evidence of the market value of 1800 MHz spectrum. However, we find that CEG's adapted model values an increment of 800 MHz, 1800 MHz and 2.6 GHz spectrum identically.

A9.114 The reason for this result is that the MCT model does not distinguish between different frequency bands when modelling capacity. The only property in the model that varies between frequency bands is the cell radius, which feeds into the calculation of coverage assets but not capacity assets. As a result, adding a 2x5 MHz or 2x10 MHz increment of spectrum (i.e. more capacity) will produce the same network cost saving regardless of frequency.

A9.115 However, lower frequency bands deliver significant benefits in a purely capacity driven network (i.e. separate from coverage). This is because lower frequencies deliver higher user throughputs at the cell edge and in hard to reach locations, such as deep indoors.[116] As a result, we consider that it is important to take account of frequency when modelling the cost savings from making additional spectrum available (indeed, this consideration underpinned our assumption in the 700 MHz model that a certain proportion of traffic must be delivered using low frequency spectrum).

A9.116 Because the MCT model is not concerned with individual frequency bands, the fact that the number of capacity assets is independent of the frequency mix deployed does not affect the validity of the MCT outputs (as long as it is appropriately calibrated). However, it does mean that the model is in our view unsuited to estimating the value of increments of specific frequency bands.

Traffic distribution

A9.117 A further consideration relates to the way that the MCT model distributes traffic on its network. In most mobile networks, a relatively small proportion of sites will serve a high proportion of total traffic and additional spectrum available will primarily be employed on the busiest sites, where capacity is most constrained. This is reflected in the 700 MHz model by assuming a highly uneven distribution of traffic (by geotype) across sites, before determining whether a new site is needed based on the traffic of the busiest site.

A9.118 However, the MCT model estimates the number of new sites required (or avoided) based on peak busy hour throughput per site averaged across all sites in a geotype. This means that the benefit of additional spectrum is effectively spread across all sites in a geotype, rather than focused on the busiest sites.

A9.119 While this simplified approach is suitable for the MCT model which aims to estimate the incremental network equipment needed to deliver a certain increment of traffic, it will potentially underestimate the value of additional increments of spectrum.

Availability of other spectrum bands

A9.120 We next consider the way in which future spectrum releases are incorporated within the MCT model.

A9.121 In Annex 11 of the MCT statement, we explained that we did not consider it appropriate to include additional spectrum (i.e. future spectrum releases) in the

[116] We have recognised this point in numerous publications, for example in paragraph 6.12, Mobile Data Strategy consultation, November 2013, http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/summary/MDS_Condoc.pdf

2015 MCT model.[117] CEG has adjusted the model to reflect future availability of 2.3 GHz and 3.4 GHz spectrum by increasing paired 2.6 GHz spectrum holdings, while it reflects future spectrum availability in the 1.4 GHz band by increasing spectrum in the 1800 MHz band.

A9.122 However, in practice we consider that, as established LTE bands with well-developed device ecosystems, 1800 MHz and 2.6 GHz are likely to be more valuable than 1.4 GHz and 2.3 / 3.4 GHz spectrum respectively.[118] This means that CEG's adjustments are likely to overstate new spectrum bands' substitutability with 1800 MHz spectrum (indeed, 1.4 GHz spectrum is considered to be perfectly substitutable, which is in our view clearly not the case).

A9.123 This means that the downward impact of future spectrum availability on the value of 1800 MHz spectrum will tend to be overstated, at least in the immediate term. In other words, we consider that the way in which CEG has adjusted the model will tend to understate the value of 1800 MHz spectrum.

Range of 1800 MHz values

A9.124 Finally, we have assessed the reasonableness of the range of 1800 MHz values produced by the adapted MCT model (£1.21m to £5.48m per MHz), taking into account our existing views about the relative values of different spectrum bands.

A9.125 We said in the October 2013 consultation that we do not consider it credible that 1800 MHz spectrum has a lower value than 2.6 GHz spectrum in the UK.[119] We remain of the view that the UK market value of 1800 MHz exceeds the value of 2.6 GHz, for reasons including:

a) Technical evidence: Propagation characteristics for 1800 MHz spectrum are substantially better than 2.6 GHz spectrum.[120]

b) Benchmarking evidence: Evidence from our benchmarking sample strongly indicates that the value of 1800 MHz is significantly higher than the value of 2.6 GHz. Of the nine benchmark countries where both bands were auctioned, 1800 MHz sold for more than 2.6 GHz in eight countries, and for at least 50% more in seven countries. Denmark was the only country where 2.6 GHz achieved a higher price than 1800 MHz, but here we have specific reasons to believe that the 1800 MHz benchmark carried a larger risk of larger understatement of market value.[121]

[117] Ofcom, *Mobile call termination review 2015-18*, March 2015, http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-call-termination-14/statement/Annexes_7-13_final.pdf. In paragraph A11.38, we said that "we aim to model the least cost means of delivering the regulated services using known technology, but recognising where an efficient national network would start from in terms of legacy network deployments. This principle extends to the spectrum assumptions."

[118] For example, in the 2015 German auction, the average price paid for 1.4 GHz spectrum was €8.2m per MHz, compared to €24.7m per MHz for 1800 MHz spectrum in the same auction (see Table 3 in the July 2015 update note).

[119] Paragraph 4.45 in our October 2013 consultation.

[120] Paragraph 4.43 in our October 2013 consultation.

[121] Although we consider relative value benchmarks more reliable than absolute values, we also note that the absolute values of 1800 MHz spectrum in our Tier 1 benchmark countries are also all substantially higher than the range proposed by EE.

A9.126 Most of CEG's results (and the entirety of the range proposed by EE, which is based on two of CEG's results for EE and H3G) are lower than our conservative UK market value for 2.6 GHz of £5.5m per MHz, as proposed in the August 2014 and February 2015 consultations. We therefore consider CEG's results to be implausible in light of the available benchmark evidence from benchmarks and the UK 4G auction.

Summary

A9.127 Overall, taking into account the points discussed above:

a) Our view is that the sensitivity of network cost modelling estimates to underlying parameter assumptions means that such estimates provide limited additional benefit, over and above the market-based evidence we use, in estimating the lump-sum value of ALF spectrum;

b) As regards the 2015 MCT model, we consider that the features of the model make it unsuited to being used to estimate the market value of an increment of 1800 MHz spectrum.

A9.128 As a result, we have not placed weight on modelling estimates in our assessment of the lump-sum value of 900 MHz or 1800 MHz spectrum.

Qualcomm's trade of licences for 1.4 GHz spectrum

A9.129 We note that Qualcomm has recently agreed to trade its 40 MHz of spectrum in the 1.4 GHz band to Vodafone and H3G (20 MHz each). This follows a variation in its licence to allow this spectrum to be used for Supplemental Downlink (SDL), which can provide additional mobile download capacity.

A9.130 For the following reasons we consider that the prices of these spectrum trades would provide limited additional benefit, over and above the market-based evidence we already use, in estimating the lump-sum value of ALF spectrum:

a) Unlike the UK market value information we use for the 800 MHz and 2.6 GHz bands, we do not have as good reasons to expect an established relationship between the market value of 1.4 GHz and ALF spectrum, given its somewhat different characteristics and the early stage of development of SDL in 1.4 GHz in terms of either device ecosystem or network deployment.

b) Even disregarding the point above, interpreting the price information would involve consideration of the nature of the Qualcomm private trade process, such as the extent to which bidders might have had incentives to shade their bids.

A9.131 We also note that, to inform the lump-sum value of ALF spectrum we would still need to obtain relative value information to combine with the UK market value of the 1.4 GHz band, and the availability of such information is limited. The Germany 2015 auction could provide information on relative prices of 1.4 GHz to each of 900 MHz and 1800 MHz, as all three bands were included in that auction.[122] Italy also

[122] The average per MHz price of spectrum in the 1.4 GHz band (€8.2m) was 33% of the price of the 1800 MHz band (€24.7m) and 43% of the price of the 900 MHz band (€19.2m).

auctioned the band in September 2015. However, we do not have 900 MHz prices for Italy and in any case the 1.4 GHz spectrum was sold at the reserve price.[123]

[123] http://www.telecompaper.com/news/italy-raises-eur-460-mln-with-l-band-auction--1101734

Annex 10

Annualisation: supporting material

A10.1 This annex provides details of the underlying evidence and reasoning which supports the analysis set out in Section 6. Specifically, this annex sets out the assessment underlying our views on:

a) The relevant discount rate in the lower polar case, i.e. where the risk of the ALF (meaning the degree of exposure to changes in market value of spectrum over time) were completely unrelated to the risk of the underlying cash flows.

b) The analysis underlying our estimate of an appropriate degree of risk sharing to incorporate within our discount rate.

c) Terminal value.

What would be the relevant discount rate if the risk of the ALF was unrelated to the risk of the underlying cash flows?

A10.2 We set out in Section 6 (paragraph 6.21) that we consider the relevant lower polar rate, where the level of the ALF was unrelated to the risk of the underlying cash flows, would be the cost of debt. In this section, we consider:

a) Whether this cost of debt should be estimated based on our traditional approach to estimating the cost of debt rather than observed market debt rates, i.e. Option A vs Option B (in the terminology of the August 2014 consultation);

b) Whether this cost of debt should be based on an estimate of the rate for an average efficient operator rather than most efficient operator; and

c) Whether we should make any further adjustment to the cost of debt to allow for:

i) Duration

ii) Security

iii) Inflation risk

iv) Liquidity risk

A10.3 We then set out the data we have used in coming to our point estimate of an appropriate cost of debt.

Option A vs. Option B

<u>Our position in the August 2014 consultation</u>

A10.4 In the August 2014 consultation, we set out two possible ways to derive the debt rate:

a) consider the spread of the debt over nominal UK government gilts, then add this to our estimate of the risk-free rate; and

b) take the current yield to maturity (YTM) of the debt, which reflects the expected rate of return on the debt if it was bought today and held to maturity.

A10.5 We noted that the latter approach (Option B) reflected data on the actual returns investors currently expect at this point in time, which was the return a generic MNO would have to offer if seeking financing. By contrast, the former approach (Option A) involved taking a longer term view as to likely equilibrium market rates. We suggested that as we were setting these fees, including the discount rate, for an extended period of time, this made potential short-term distortions more serious, since there were fewer prospects for these being removed in further reviews than in the case of setting WACC for periodic market reviews. We suggested we might therefore be more interested in the long-term equilibrium market rate as reflected in Option A, which was likely to be less affected by short-term distortions.

A10.6 We also noted that Option A was the approach we generally take in calculating the cost of debt for the WACC for a similar reason of consistency through time, and so there was also a potential benefit from regulatory consistency to consider. Moreover, we suggested this would ensure consistency between different stakeholders and different market interventions.

Stakeholder responses to our August 2014 consultation

A10.7 H3G and BT did not comment on the approach used to calculate the cost of debt (although H3G did disagree with the numbers used). Vodafone[124], EE[125] and Telefónica[126] all argued that we should calculate the cost of debt based on current yields to maturity. Their arguments can be summarised as follows:

a) Only a yield to maturity approach will ensure equivalence between a lump-sum payment and ALFs.

b) Setting a 'one-off' decision like ALF is fundamentally different to a charge control. Charge controls allow for financing of new and existing debt raised over time, meaning that a long-term average may be appropriate. In addition, regular resetting of the cost of debt through repeated reviews (as in a charge control) allows for investors to receive a fair bet from the use of long-term averages, as they will get a lower return when rates are rising and a higher return when rates are falling. Neither of these elements holds for ALF, which is akin to arranging a one-off 20-year lease between the Government and the mobile operators today.

c) Recent regulatory precedent for the cost of debt, from the Competition Commission (now the Competition and Markets Authority, CMA) and other regulators, tends to give weight to observations of debt yields.

Our analysis in the February 2015 consultation

A10.8 In the February 2015 consultation we noted that, as we set out in the August 2014 consultation, in principle, an average efficient MNO (on which our estimation of the discount rate is based)[127] and the Government should be indifferent between payment for the spectrum in the form of a lump-sum payment or ALF. Given that the

[124] Vodafone's response to the August 2014 consultation, p.40-41 and Annex 4.
[125] EE's response to the August 2014 consultation, p.50-53.
[126] Telefónica's response to the August 2014 consultation, p.76-77 and Annex II, p.4-10.
[127] We discuss this further in paragraphs A10.16-A10.21.

ALF will take effect from the Common Effective Date, we said thatthe relevant initial comparison is between a lump sum paid on that date and ALF payments which commence from that date. However, as this date is some way in the future, we considered that the best information we have as to the opportunity cost of taking on debt at that time is arguably the cost of debt recently observed in YTM data.[128]

A10.9 Further, in contrast to our position in the August 2014 consultation, in our February 2015 consultation we recognised that, as the MNOs highlighted, there is a valid distinction between ALF and the charge controls for which we usually use WACC figures derived from long-run average data.

A10.10 We noted that the analogy of a financing lease is that the borrowing for ALF is hypothecated (i.e. associated with a particular asset, in this case spectrum). By contrast, the WACC calculated for a charge control is not concerned with the financing of a particular asset, but the financing of all assets used by the regulated firm(s) in price controlled markets. The majority of this financing comes from equity rather than being secured through debt issuance. It is therefore important to consider the estimation of both sources of funding, including their common components, in coming to an estimate of the WACC for a charge control.

A10.11 Further, we set out that, while the ALF annualisation exercise starts from a notional one-off transaction, Communications Providers (CPs) need to finance regular on-going capex programmes (which the WACC within a charge control has to support). CPs smooth financing decisions through time to support capex investment. The costs of financing in the long run are therefore relevant in ensuring appropriate investment signals are sent through the charge control.

A10.12 However, we said that it is important to note that ALF is designed to provide a price signal over time. Therefore, the indifference between paying ALF and paying a one-off lump sum should, in theory, hold for all ALF payments over time. For example, if spectrum was traded, the new licensee should also be indifferent between paying a lump sum at the point at which they take on the licence and paying ALF. More broadly, in each year when an ALF payment falls due, the forward-looking opportunity cost of making this payment for the following 20 years should be equivalent to paying a 20-year lump-sum amount at that time. This would suggest that indifference requires a different rate over time, reflecting market rates at each point in time.

A10.13 We recognised that there is, however, no single rate which can achieve this indifference over time for all current and potential future licensees. Therefore, we considered the best alternative is to use a discount rate which reflects returns actually observed in the market, as this will at least get close to indifference in the first period for which ALF is set, while using a long-term average rate would only provide indifference if and when rates return to their long-term average. We noted that there is considerable uncertainty as to when this would occur, or over what period.

[128] Note that we are not assuming MNOs would actually finance the licence payment with debt. ALF is a debt-like obligation, and so to ensure equivalence we assume the lump-sum payment would require a similar return to debt for investors to find it worth investing in.

A10.14 Therefore, in our February 2015 consultation we set out that the starting point for the lower polar rate is a cost of debt based on observed yields to maturity for comparator bonds.[129]

Stakeholder responses to our February 2015 consultation and our conclusions

A10.15 In their responses to our February 2015 consultation, the MNOs supported the position that we set out in that consultation. We therefore conclude that the starting point for the lower polar rate is a cost of debt based on observed yields to maturity for comparator bonds, for the reasons set out in the February 2015 consultation.

Average efficient operator vs. most efficient operator

Stakeholder responses

A10.16 In response to our August 2014 consultation, EE[130] argued we should not use an average efficient operator standard in estimating the cost of debt, but should instead use the debt rate of the most efficient operator. It argued that using an estimate related to the average efficient operator does not appropriately incentivise efficiency, as MNOs that are able to raise debt more efficiently will effectively pay a higher ALF than implied by their financing costs, reflecting the average (higher) cost of debt due to the fact that other MNOs raise debt less efficiently (i.e. at higher cost).

A10.17 We received no responses to our February 2015 consultation on this issue.

Our analysis

A10.18 It is important to consider what is meant by 'efficient' in this context. A lower cost of debt does not necessarily imply greater efficiency in delivering investment, or in providing services. For example, a firm with an efficient level of gearing may have a higher cost of debt than one with a very low level of gearing, but with a commensurately lower cost of equity, such that its overall financing costs are lower than the minimally leveraged firm. However, we also note that a lower cost of debt could signal that the firm is well managed (in that the market views it as financially sustainable and able to service its debts), and is thus more likely to provide services efficiently over time.

A10.19 More importantly, we are not convinced that efficiency is better encouraged by using the lowest observable cost of debt in the market. EE stated that it "sees no reason why operators that are able to raise debt more efficiently should be penalised by the financing costs of other operators".[131] However, there is equally no reason why operators who are able to raise debt 'less efficiently' (on EE's definition) should receive a windfall gain as a result of the financing costs of other ('more efficient') firms.

[129] We note that, at the extreme, this could mean relying on spot rates. However, as Figure A10.4 below shows, rates vary over time and to avoid relying on an unduly short period that risks being unrepresentative, we are minded to use an average over twelve months in coming to our estimate of the cost of debt. We therefore refer to averages over twelve months in our analysis in paragraphs A10.56-A10.62.
[130] EE's response to the August 2014 consultation, p.53.
[131] EE's response to the August 2014 consultation, p.53.

A10.20 EE's argument therefore logically supports the use of operator-specific discount rates. However, for the purposes of ALF we are setting fees to apply to any holder of a licence authorising the use of the relevant band of spectrum, rather than for each individual operator. We therefore conclude that it is appropriate to use the position of an average efficient operator, not the position of individual operators, in coming to a discount rate.

A10.21 We recognise that using lower observations of the cost of debt may have some validity if we were to base the discount rate on expected yields, rather than promised yields. In some cases, the debt rate may be very high because the firm is offering a very high promised yield, but where the probability of this yield being realised is very low, such that the expected yield is in fact much lower than the observed debt rate. Lower observed debt rates are more likely to reflect a situation where the promised and expected yields are close. We have therefore taken into account whether the debt rates of the comparator bonds appear unusually high in our assessment of the data.

Duration

Stakeholder responses to our August 2014 consultation

In response to our August 2014 consultation, Vodafone[132] and EE[133] argued we should not use 20 year bonds as the comparator debt instrument, as such bonds have a longer duration than ALF due to the presence of a bullet payment at maturity. This means the bonds we have used as benchmarks have their payments weighted in greater proportion towards the maturity of the instrument and therefore experience greater term risk than the ALFs.

Our analysis in the February 2015 consultation

A10.22 In the February 2015 consultation, we explained that the duration (or Macaulay duration) of a bond measures the weighted average term to maturity of the cash flows from a bond. The more the cash flows received from the bond are weighted towards its maturity date, the longer its duration. Thus a constant stream of payments (an annuity stream) has a lower duration than the same maturity bond with a bullet payment at the end. We noted that the issue to be considered is whether our analysis of interest rates needs adjusting for this reason.

A10.23 The actual maturities of the bonds used in our analysis in the August 2014 consultation were 15, 16, 18, 20, and 36 years. Our judgement of the rate was therefore not just based on bonds with durations of 20 years or more.

A10.24 EE modelled a series of 20 zero coupon bonds, with terms ranging from 1 year to 20 years, with the principal payment on each of the bonds matching the annual ALF payment, using Bloomberg data to compare the yields on this series of bonds to those of 'normal' bonds with bullet payments. As EE noted, there are several large gaps in the data used, as Bloomberg does not report fair value yields for maturities of 6 years, 11-14 years and 16-19 years. For the purpose of calculating zero coupon yields, EE interpolated yields for these maturities using simple linear

[132] Vodafone's response to the August 2014 consultation, Annex 4, p.12-18.
[133] EE's response to the August 2014 consultation, p.53-56. EE also subsequently provided an updated version of this analysis, taking into account the indexing of ALF for inflation.

interpolation between fair yield observations for maturities immediately above and below these 'gaps'.

A10.25 Oxera, on behalf of Vodafone, calculated the implied average yield based on the annual discount rate that would be applied to each year's payment under the ALF. This is derived from the term structure of Vodafone's debt, which provides an individual discount rate for each year's ALF payment. Oxera suggested that the most appropriate average cost of debt for an ALF would be based on a 10–15-year bond, with detailed analysis of the term structure indicating a rate close to 12-year yields. The 12-year spread in Figure 3.3 of its analysis is about 110 base points (bps), with the 10-15 year bonds ranging from c.100-130bps.

A10.26 In our February 2015 consultation we accepted the findings of Oxera's and EE's analysis which suggested the duration of a 20-year bond with no principal repayment would be between about 9 and 12 years.[134] Therefore, in deriving our debt rate we have had regard to the yields on bonds with a maturity of around 10 years. We considered that this is a simple and transparent way to allow for the difference in duration from setting ALFs as a constant stream with no bullet payment.

Stakeholder responses to our February 2015 consultation and our conclusions

A10.27 We received no further comments on this issue in response to our February 2015 consultation. Therefore, we have had regard to the yields on bonds with a maturity of around 10 years in deriving our debt rate, in line with the approach that we proposed in the February 2015 consultation.

Security

Stakeholder responses

A10.28 In response to our August 2014 consultation, we received the following comments:

a) H3G[135] argued that at most Ofcom should allow a small premium on top of the risk-free rate to allow for any small perceived risk of a fallow period and associated loss of ALF income during this period. It quantified this should add a premium of at most 0.2% to the risk-free rate, based on a maximum expected probability of default per year of 2.5% (weighted across all the 900MHz and 1800MHz licences); an average expected fallow period of 18 months; and an expected recovery rate of the value of the spectrum licences of 93%.

b) Telefónica[136] also argued that we should make some adjustment to the cost of debt to allow for the greater security of ALF compared to unsecured corporate debt. NERA (on behalf of Telefónica) acknowledged there is considerable uncertainty around the exact magnitude of the discount but argued that it seems very unlikely, based on the evidence presented by Ofcom, that there should be

[134] EE suggested the Macaulay duration of the bond without the principal payment (similar to ALFs) is 8.75 years (EE's response to the August 2014 consultation, p.54); Oxera on behalf of Vodafone suggested that the average cost of debt for the ALF payments would be very close to the yield of a 12-year bond (Vodafone's response to the August 2014 consultation, Annex 4, p.15).
[135] H3G's response to the August 2014 consultation, p.40-42 and Annex C.
[136] Telefónica's response to the August 2014 consultation, Annex II, p.14-16.

no discount at all. It suggested a discount of 10 to 12 basis points is a reasonable estimate of the securitisation benefit in the ALF setting.

A10.29 In response to our February 2015 consultation, EE made reference to a previous submission by Economic Insight (on behalf of H3G) which quantified the impact of a hand back of spectrum and a 'fallow' period to be equivalent to 20bps, which it considered should be added to the risk free rate. EE considered that this approach gives the lower end of the appropriate range as -0.7%.[137]

Our analysis

A10.30 We disagree with the argument put forward by H3G[138] and EE that the appropriate lower polar case should be an adjusted risk-free rate (where the risk free rate is based on index-linked gilt yields and the adjustment reflecting a fallow period following 'handing back' of the licence) for the following reasons:

a) First, we consider that we should be cautious in interpreting index-linked gilts yields when estimating the risk-free rate. This is due to a number of factors including pension regulation and quantitative easing;[139]

b) Second, index-linked gilts provide protection for RPI inflation, while we are indexing ALF for CPI inflation. Our estimate of the RPI/CPI inflation wedge in our 2015 MCT WACC is 1.3%. This means a real risk-free rate based on CPI would be about 1.3% higher than one based on RPI and therefore EE's estimate of the discount rate should be 1.3% bps higher too.

c) Third, this approach ignores the default premium and the default risk premium that are in addition to the risk-free rate and present in the cost of debt.[140] We consider that in the hypothetical lower polar case, where the MNOs would not be able to avoid paying ALF by handing back spectrum the risk of the cash flows should incorporate the risk of default (for example, amongst other things, bankruptcy of the borrower). We consider that the MNO's ability to hand back spectrum creates a risk and requires a premium in addition to the default premium and the default risk premium (i.e. on top of the cost of debt). We consider it appropriate to take account of the MNOs' ability to avoid paying ALF by handing back spectrum in our analysis of risk sharing, rather than the hypothetical lower polar case, because:

   i) the risk of hand back of the licence is in addition to default on the ALF (which is akin to the risk of default on corporate debt); and

   ii) 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.

A10.31 H3G argued that the debt premium in this case should be considerably smaller than that observed in corporate bonds. It argued that there is no sharing of risk associated with changes in spectrum value (or any such risk sharing cannot be

[137] A risk free rate of -0.90% plus the 0.2% uplift.
[138] H3G's response to the August 2014 consultation, p.40-42 and Annex C.
[139] For a fuller discussion of these issues see Mobile call termination market review 2015-18, Final Statement, 17 March 2015, http://stakeholders.ofcom.org.uk/consultations/mobile-call-termination-14/statement/, Annex 10 p A10.26
[140] The default premium is the allowance required to cover the expected loss. The default risk premium is the risk allowance which rewards the investor for bearing the risk that the actual loss might differ to the expected loss.

postulated without a clear and transparent framework for future ALF reviews, under which the rules and procedures are clearly set out). So it claimed that the only risk is associated with non-payment by MNOs, i.e. the risk of MNOs defaulting on their payments (or, potentially, handing back the spectrum) and relatedly the risk of a subsequent 'fallow' period thereafter. H3G's advisor, Economic Insight, argued that the risk of default is "likely to be extremely minimal"[141] and the Government is likely to recover almost 100% of the value in any case.

A10.32 We discuss the sharing of risk related to changes in market value separately in Section 6 and below at paragraphs A10.62 – A10.86. Here we focus on the arguments related to the discount rate in the absence of this aspect, i.e. where we assume the ALF is completely fixed regardless of circumstances. H3G's argument essentially comes down to the view that MNOs are less likely to default on ALF payments than on other forms of debt, and Government is more likely to recoup a large proportion of the value in any case, as the ALF is secured against a valuable asset, i.e. the spectrum.

A10.33 We do not consider appropriate to adopt a 'bottom up' assessment such as that proposed by Economic Insight (on behalf of H3G) because it would require a number of assumptions for which there is little available evidence. For example, Economic Insight asserted that "18 months would appear to be the maximum period one might reasonable [sic] assume – and therefore this provides an upper bound with regards to the length of any fallow period….".[142] It is not clear on what basis Economic Insight considers 18 months would be the maximum possible fallow period, given the complexity which would likely be involved in ensuring any award was undertaken according to best practice and would not distort competition, and the generally contentious nature of any auction rules.

A10.34 As to the point made by Economic Insight that Government is likely to achieve a high degree of recoupment in the case of default, this may be the case where default arises due to the failure of an individual business, such that the current licensee left the market and returned the spectrum (although we note that it is not correct that unpaid ALFs would rank higher than other debts in the event of insolvency, contrary to the arguments of a number of MNOs[143]). However, if the reason for default is that the earning power of the asset has declined, then the prospects for recoupment may be rather more limited. In this case where licensees return the spectrum because its market value has fallen, the Government would only be likely to re-allocate the spectrum at a lower ALF (or equivalently lower lump sum if it were allocated through auction). An assumption that the Government regains 100% of the value once the fallow period ends is therefore also open to question. This was one of the factors we highlighted in our August 2014 and February 2015 consultations in proposing that we should not make an adjustment for security. Having considered this argument, we conclude that we should not disregard observed market data on debt premia paid by MNOs in favour of such a bottom up calculation.[144]

[141] H3G's response to the August 2014 consultation, Annex C, p.9.
[142] H3G's response to the August 2014 consultation, Annex C, p.13-14.
[143] See paragraph 4.39c of the February 2015 consultation.
[144] We note that Economic Insight's evaluation of top-down evidence on spreads between secured and unsecured debt concludes that, while the spread on secured debt tends to be lower than that for senior unsecured debt, "differences are small and can be hard to measure – meaning that it is hard to identify a 'security' adjustment factor, consistent with Ofcom's findings" (H3G's response to the August 2014 consultation, Annex C, p.23).

A10.35 As regards Telefónica's comment that we should make some adjustment to the cost of debt to allow for the greater security of ALF compared to unsecured corporate debt, we noted in the August 2014 and February 2015 consultations that ALF is more akin to a secured debt, and that it is likely that a secured debt would attract a lower rate than an unsecured debt. However, we suggested it was not appropriate to make an adjustment for this.

A10.36 NERA's proposed adjustment of 10-12 basis points is based on the benefit from securitisation corresponding to a one-notch rating uplift. This comes from the observation that Moody's *Rating Methodology for Regulated Electric and Gas Networks* sets out that structural enhancements (including securitisation, which NERA suggested generally involves special purpose assets rather than general assets) "can deliver up to three notches of uplift from a fundamental rating if they are very comprehensive and effective".[145] Allowing for the negative relationship between spectrum value and the probability of the MNOs handing back spectrum, NERA suggested that a one-notch uplift is appropriate.

A10.37 In Moody's most recent *Rating Methodology for Regulated Electric and Gas Networks* (p.22),[146] it sets out the following:

> "Structural enhancements that we view as very comprehensive and effective can deliver an uplift of up to three notches within the grid. However, across the rated universe, the current typical uplift is in the range of zero to two notches. Due to the broad spectrum of possible financing structures (which can contain a variety of elements in an array of potential combinations), these enhancements are scored in increments of half-a-notch. While debt structural features could in theory be stronger than those we have encountered, more restrictive terms and conditions would constrain management abilities to pursue strategies and policies and may not be suited to certain types of businesses, so they have typically fallen within a moderately narrow range."

A10.38 This suggests that, while such enhancements can theoretically deliver up to three notches, more typically they deliver only an uplift of up to two notches. Elsewhere in the same document, Moody's sets out a number of factors which can contribute to these structural enhancements, and notes that it considers the whole package of structural considerations and creditor protections to gauge its overall effectiveness. While securitisation is not specifically mentioned, it is likely that this would be considered such an enhancement; however, it would be only one such factor. Many of the other factors (e.g. restrictions on business activities or raising additional debt, factors giving creditors the right to influence the firm in taking corrective action when its credit position deteriorates) are not relevant to ALF. Therefore, it is not clear that securing ALF against the spectrum asset would be considered comprehensive and effective as a form of enhancement.

A10.39 This is particularly the case given the fact, as acknowledged by NERA, that the value of the spectrum licences used for securitisation is negatively correlated with the probability of the MNO defaulting on its ALF contract, such that the value of securitisation is reduced.

[145] Quoted in Telefónica's response to the August 2014 consultation, Annex II, p.15.
[146] NERA referred to the 2009 version of this document. A new version was produced in November 2014 which supersedes this.

A10.40 We have therefore decided not to change our position from that set out in the August 2014 and February 2015 consultations in light of Telefónica and NERA's reasoning, as:

a) a three notch uplift is outside the typical range of adjustments, making a two notch uplift the relevant upper bound;

b) it is not clear what uplift (if any) would be afforded for security against a specific asset in isolation (although it seems likely to be less than the full notch suggested by NERA); and

c) as Telefónica acknowledged, the value of any security is likely to be weaker due to the correlation between default and spectrum value.

A10.41 We have therefore decided not to adjust the cost of debt for security.

Inflation risk

Stakeholder responses

A10.42 In response to our August 2014 consultation, Telefónica[147] suggested we should reduce the cost of debt to remove any inflation risk premium, as the Government would not bear any inflation risk due to the indexation of ALF. We received no further comments on this issue in response to our February 2015 consultation.

Our analysis

A10.43 NERA on behalf of Telefónica[148] noted that the ALF structure provides the Government with a safeguard against unexpected changes in inflation (as it is indexed to outturn inflation), while the reference bonds used by Ofcom do not contain such protection but instead pay higher yields. For such a protection, a market participant would need to pay a fee, in the form of an inflation risk premium. NERA suggested the debt rate should be reduced by up to 20bps (in addition to the forecast CPI inflation) from the nominal yield in order to account for the protection against inflation risk provided by the MNO.

A10.44 This argument assumes that part of the nominal rate may be compensation for inflation risk. This risk-premium is very hard to estimate and varies over time. NERA presented some evidence comparing our 3.3% RPI assumption[149] with breakeven inflation from index-linked gilts to suggest that an adjustment of 10-20 bps would be reasonable. However, it was unable to provide similar evidence based on CPI as there are no gilts indexed to CPI inflation. NERA acknowledged that recent forecasts of CPI inflation are broadly in line with our 2% estimate, although it noted Consensus Economics' previous aggregate inflation forecasts were above this.[150]

[147] Telefónica's response to the August 2014 consultation, p.79 and Annex II, p.16-18.
[148] Telefónica's response to the August 2014 consultation, Annex II, p.16.
[149] We note that, as we are using YTM data adjusted for CPI in deriving our cost of debt, we do not require an estimate for RPI inflation in the context of setting ALF. We do however use an estimate of RPI inflation of 3.3% in deriving the WACC in the MCT market review 2015-18 (Mobile call termination market review 2015-18, Final Statement, 17 March 2015, http://stakeholders.ofcom.org.uk/consultations/mobile-call-termination-14/statement/.
[150] Telefónica's response to the August 2014 consultation, Annex II, p.17-18)

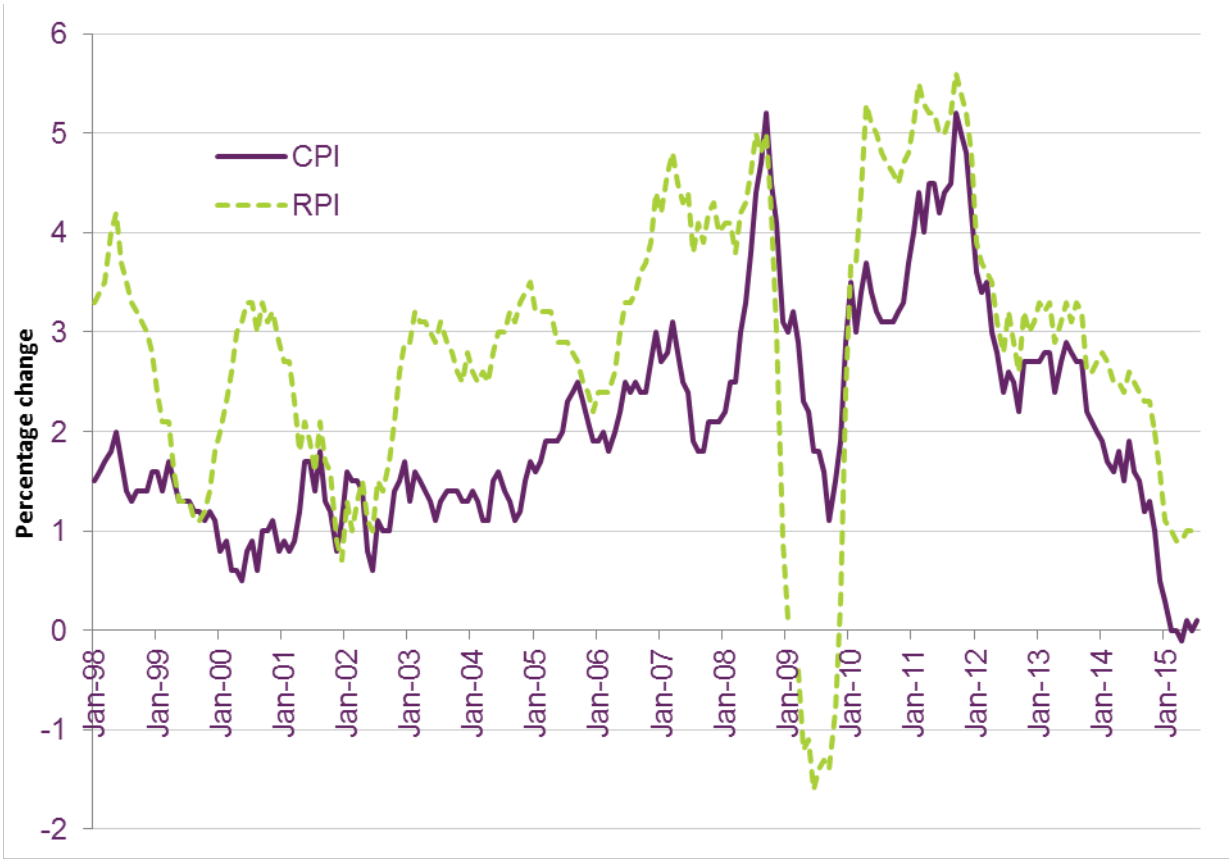
A10.45 We consider there are two potential issues with the evidence presented by NERA in estimating the inflation risk premium it suggested should be deducted:

a) It focuses on the wrong measure of inflation; and

b) It considers a relatively short period of time (from mid-2013 to the end of August 2014).[151]

A10.46 With regard to a), this arises because the lack of CPI-indexed gilts means it is not possible to directly infer the level of CPI inflation being built into returns. NERA's quantification is therefore based on considering the difference between RPI breakeven inflation in index-linked gilts and our RPI assumption. This would not necessarily be an issue if it were reasonable to believe that the risk faced by investors from unforeseen changes in RPI were the same as the risk from unforeseen changes in CPI. However, RPI is generally more volatile than CPI, showing a greater variance over the last 15 years. This is illustrated by Figure A10.1, which shows the trend in average percentage changes in RPI and CPI since 1998. The standard deviation in CPI over this period was 1.09 percentage points; the corresponding standard deviation in RPI was 1.41 percentage points. Therefore, an investor could expect to be exposed to greater inflation risk if inflation is measured via RPI compared to CPI. While information on inflation breakevens from RPI-linked gilts is still the best information available, this should be borne in mind in interpreting this evidence.

Figure A10.1: CPI and RPI - percentage change over 12 months

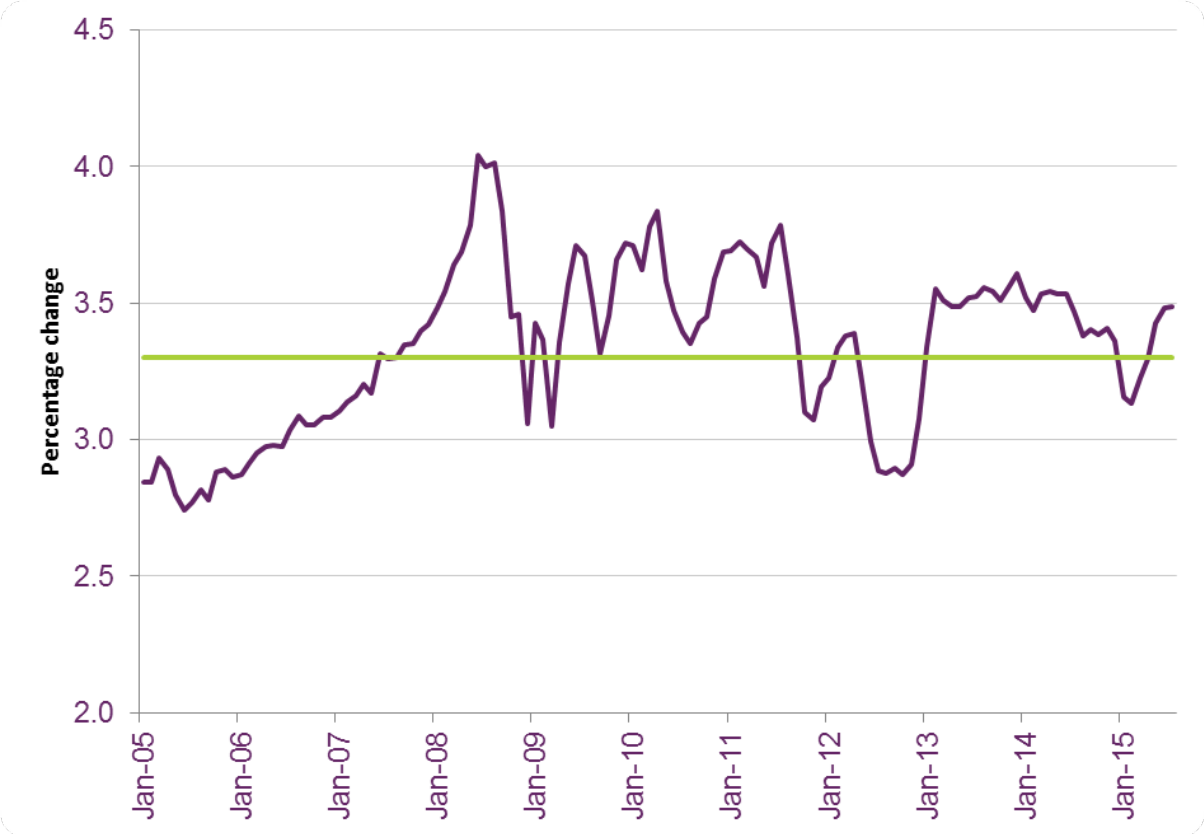


Source: ONS data

[151] NERA only considered price data since mid-2013 to avoid potential distortions related to the ONS' review process of potential modifications to the RPI.

A10.47 NERA's analysis focused on a relatively limited period of one year. Even over this period, the breakeven inflation figures vary widely (from 2 to 34 bps above the 3.3% figure); over a longer period, the volatility is even wider. Figure A10.2 shows the monthly average 20 year breakeven inflation from British government securities between January 2005 and August 2015. This shows the breakeven inflation implied from gilts to be as much as 56 bps below the 3.3% RPI figure and up to 74 bps above this figure over this period. However, the average difference is only 4 bps over this period.[152] Clearly, our RPI assumption of 3.3% is a forward-looking figure and so is not designed to reflect the level of inflation historically expected in gilt rates in the past (although it does seem to be reasonably close); however, this does demonstrate that while the inflation expectations implicit in gilt rates can vary considerably, this variability goes in both directions and over time they may even out to some degree.

Figure A10.2: Monthly average breakeven inflation from 20-year zero coupon Government securities



Source: Bank of England (BoE) data

A10.48 Based on the above analysis, we consider that:

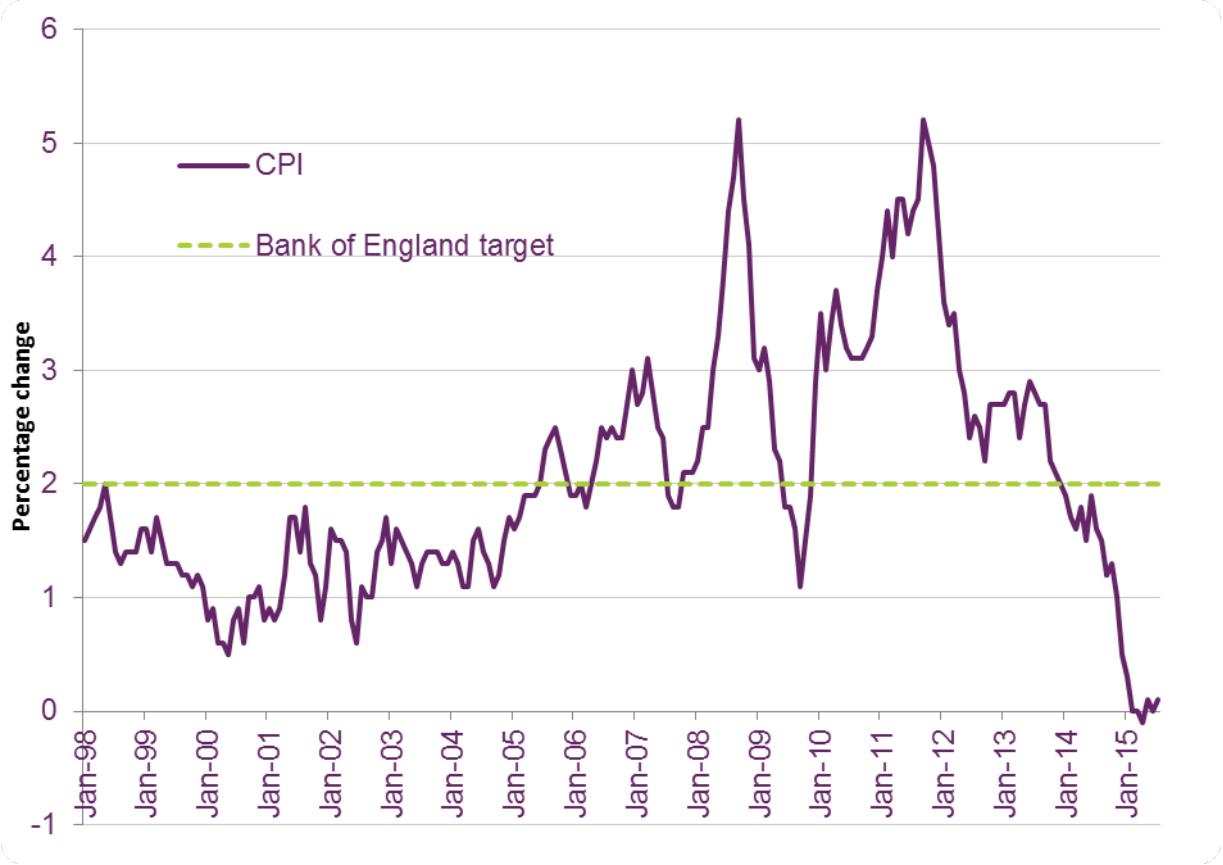
a) Any adjustment should be at the lower end of any range derived from figures based on RPI inflation, given the lower variance in CPI inflation.

b) The argument in favour of an inflation risk adjustment would be stronger where the evidence suggests that the inflation assumption included in the discount rate

[152] Breakeven inflation will also include an inflation risk premium, which we have assumed to be 10 bps (see paragraph A10.49)

is likely to differ significantly from average outturn inflation. It is not clear that this is the case, given that our CPI inflation assumption is based on the BoE target rate of inflation which the BoE has a strong incentive to keep to in the long-term (as we discussed in the August 2014 and February 2015 consultations). Further, past CPI inflation has been very close to this rate on average (around 2.1%), with periods where it has both over- and undershot this target (see Figure A10.3).

Figure A10.3: CPI – percentage change over 12 months



Source: ONS data

A10.49 We have decided to use a 2% estimate for CPI inflation in deriving ALF, which is the same estimate as proposed in the August 2014 and February 2015 consultations. We recognise that in principle there could be some merit in adjusting for inflation risk, although in practice this adjustment is likely to be relatively small and is difficult to estimate with certainty. We therefore maintain the view as set out in the February 2015 consultation that it is appropriate to reduce the cost of debt by 10 bps, the lower figure proposed by Telefónica. We have included such an adjustment of 10 bps in deriving the cost of debt below.

Liquidity risk

Stakeholder responses

A10.50 In response to our August 2014 consultation, Telefónica[153] suggested we should reduce the cost of debt to remove any liquidity premium, as this is not relevant for

[153] Telefónica's response to the August 2014 consultation, p.78 and Annex II, p.11-14.

ALF. We received no further comments on this issue in response to our February 2015 consultation.

Our analysis

A10.51 Liquidity risk refers to the difficulties that a creditor may encounter when trying to sell an asset on the secondary market at market value. This can restrict the creditor's ability to manage risk exposure, and so creditors require a premium for bearing liquidity risk.

A10.52 NERA on behalf of Telefónica argued that liquidity risk is not relevant to the Government when setting ALFs as there is no (realistic) option for the Government to sell the ALF "contract" with the MNO to a third party. Instead the Government will hold the "contract" to maturity unless the MNO 'defaults'. It stated that "concerns of an illiquid market are not relevant where the sale of the ALF revenue stream by the government is not a realistic option."[154]

A10.53 If the Government has no realistic option to sell on the ALF "contract" (to use NERA's terminology), it would appear to be completely unable to mitigate its risk exposure. It would therefore appear that liquidity risk is of even greater relevance to ALF than other forms of debt (given it is not just a risk that it cannot sell on the "contract", but a certainty). We therefore do not agree with Telefónica that we should adjust the cost of debt to remove any liquidity premium. This would, if anything, reinforce the argument for making a risk sharing adjustment, since the Government's exposure to changes in market value cannot be alleviated by reselling the ALF "contract" to a third party.

Data analysis

A10.54 In February 2015 we considered a sample of the sterling denominated debt of each MNO parent company[155] with a maturity date around 10 years in the future, in line with our conclusions as to duration. In this decision document we update that information.

A10.55 Table A10.1 summarises the debt we consider alongside the average YTM over the 12 months to August 2015 (Table 10.2 summarises the same data but for the 12 months to 14 January 2015, as set out in our February 2015 consultation). Figure A10.4 illustrates the YTM since January 2013.

[154] Telefónica's response to the August 2014 consultation, Annex II, p.11.

[155] Hutchison Whampoa, the owner of H3G, is a diversified conglomerate operating across a number of sectors including retail, ports and telecoms. We consider that estimates for Hutchison Whampoa are therefore unlikely to convey useful information about a UK MNO.

Table A10.1: YTM on long-dated debt, August 2015

	Debt maturity	Years to maturity	Credit rating	12 month average	12 month minimum	12 month maximum	Latest month[156] Aug 2015
Vodafone	2025	10	BBB+	3.4%	2.6%	4.0%	3.7%
Telefonica	2026	11	BBB	3.7%	2.8%	4.3%	3.8%
Orange	2025	10	BBB+	3.2%	2.6%	3.9%	3.3%
	2028	13	BBB+	3.6%	2.9%	4.3%	3.7%
Deutsche Telekom	2028	13	BBB+	3.5%	2.8%	4.0%	3.6%

Source: Bloomberg, Ofcom analysis as at 27 August.2015

Table A10.2: YTM on long-dated debt, January 2015 (as set out in our February 2015 consultation)

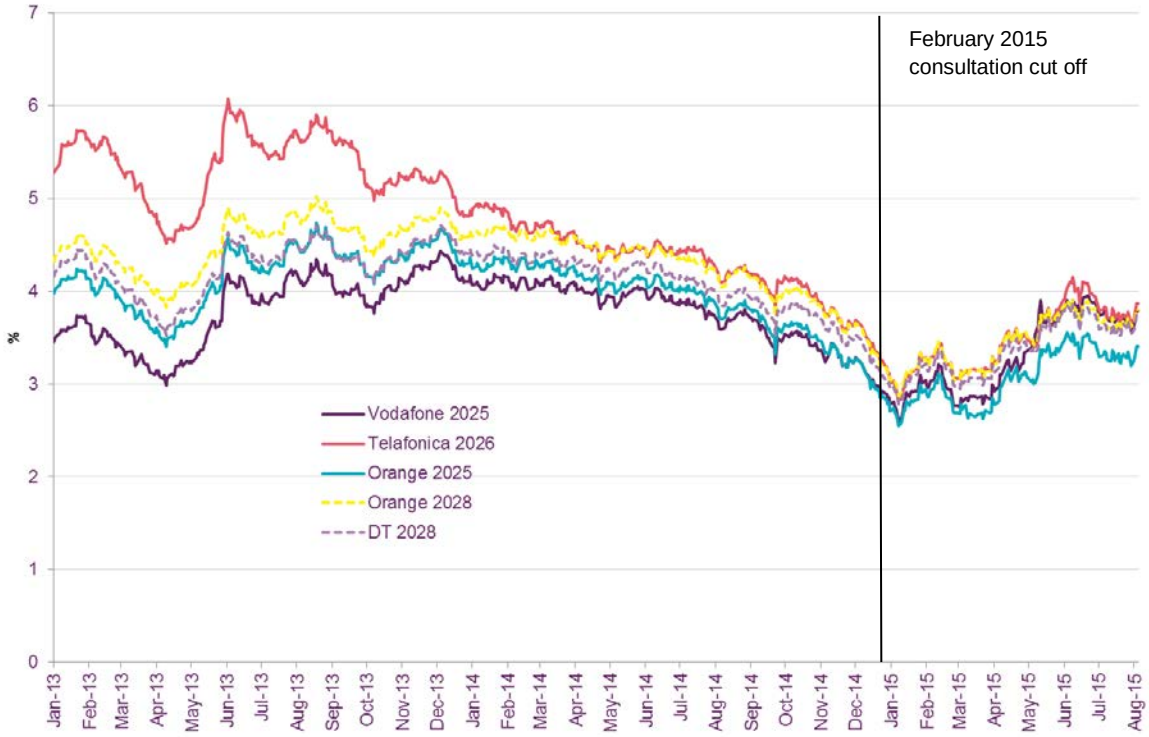
	Debt maturity	Years to maturity	Credit rating	12 month average	12 month minimum	12 month maximum	Latest month Jan 2015
Vodafone	2025	10	BBB+	3.8%	2.9%	4.2%	3.0%
Telefonica	2026	11	BBB	4.3%	3.2%	4.9%	3.4%
Orange	2025	10	BBB+	3.9%	2.9%	4.4%	3.0%
	2028	13	BBB+	4.3%	3.2%	4.7%	3.3%
Deutsche Telekom	2028	13	BBB+	4.1%	3.1%	4.5%	3.2%

Source: Bloomberg, Ofcom analysis as at 14 January 2015

A10.56 Since the February 2015 consultation, we note that 12 month average yield to maturity on our sample of bonds have fallen by between 40 and 70bps and the 12 month minima and maxima have fallen by between 20 and 70bps. However, in contrast the average rates for August 2015 are between 30 and 70bps higher than those in January 2015.

[156] In our February 2015 consultation we used nine working days of data up to 14 January 2015 to calculate the latest month (January 2015). Because we have cut the data for this decision later in the month (27 August 2015) to ensure consistency with our February 2015 consultation the latest month (August 2015) data is calculated as the nine working days to 27 August 2015.

Figure A10.4: YTM on UK sterling denominated debt



Source: Bloomberg, Ofcom analysis as at 27 August 2015

A10.57 The chart shows that the yields have fallen to some extent over the two years up to approximately our data cut off point for our February 2015 consultation with the decline particularly marked over the second six months of 2014. Since then yields have increased up to June 2015 from when they have dropped back slightly. Average yields for the 12 months to August 2015 for Vodafone, Orange and Deutsche Telekom have been 3.2-3.6% (3.8-4.3% for the year to January 2015 as reported in our February 2015 consultation). Telefónica's yield has fallen substantially over the last two years, although it remains the highest of the MNOs shown in August 2015 and on average over the last 12 months.

A10.58 Based on this data, we consider that a reasonable range for the nominal YTM for an average efficient MNO is 2.6-4.3% (slightly lower than the range of 2.9-4.7% we set out in February 2015 based on the data up to January 2015). This range captures the average YTM over the last 12 months for Vodafone, Deutsche Telekom and Orange (all maturities) and is bounded by the minimum and maximum YTM for these companies over the last year. This range also encompasses the level of Telefónica's average debt premium which has converged with the other MNO's premium from its historically high level. The average nominal yield of these bonds over the last year for the four UK MNO parent companies is 3.5% (lower than the 4.1% we set out in February 2015 based on the data up to January 2015).

A10.59 In discussing the use of the average efficient operator, we noted that there may be an argument for placing more weight on lower yields where this could reflect a smaller difference between the promised and expected yield (see

paragraph A10.21). This would suggest we should not use a number at the top end of this range.[157]

A10.60 Further, we note that in paragraph A10.26 we set out that we have had regard to the yields on bonds with a maturity of around 10 years. The average across all four UK MNO parent companies and maturities shown includes bonds with a slightly longer maturity. In addition, we note that Telefonica has a slightly higher yield than would be expected for its maturity (for example, compared to Vodafone and Orange's 2025 bonds). We may therefore place more weight on Vodafone and Orange's 10 year bonds. This would suggest a nominal yield of 3.2-3.4% (slightly lower than the 3.8-3.9% we set out in February 2015 based on the data up to January 2015). This is also in line with BBB rated bonds with a 10 year maturity more generally, which have had an average nominal yield of 3.3% over the 12 months to August 2015 (slightly lower than the 3.8% we set out in February 2015 based on the data up to January 2015).[158]

A10.61 In light of the above, we consider that a nominal YTM of 3.3% is appropriate (February 2015: 3.8%). This is slightly below the mid-point of the 2.6-4.3% range (February 2015 consultation: 2.9-4.7%) and the average of the UK MNOs 10 year bonds, but the same as 10-year BBB bond returns more generally. Allowing for a reduction of 10 bps to remove any inflation risk premium gives a nominal rate of 3.2% (February 2015: 3.7%). We have therefore used a nominal YTM of 3.2% (pre-tax). This gives a post-tax nominal rate of 2.6% (February 2015: 3.0%) with a range of 2.0-3.4% (February 2015: 2.2-3.7%).[159,160] The equivalent post-tax real rate is 0.6% (February 2015: 0.9%) (using our CPI inflation assumption of 2%).

Risk sharing scenarios

A10.62 We refer in Section 6 (paragraph 6.96) to stylised scenarios of risk sharing we have modelled. This section sets out these scenarios. Our interpretation and the inferences we draw are set out in Section 6.

Stylised example: Single review after 10 years

A10.63 One way of approaching this issue is to consider a simplified scenario where there is one review in a 20 year period, set in advance to take place in year 10.

A10.64 In constructing this scenario, we assume risk is shared only by the periodic resetting of ALF. The ALF period is 20 years and the ALF is reset once after 10 years. We assume the resetting will be symmetric, with the probability of an increase equal to the probability of an equivalent decrease in the ALF. [161] Where the

[157] In our August 2014 consultation, in line with the approach taken in the MCT consultation, we proposed to place particular weight on Vodafone, as it has a predominantly mobile oriented business. However, we no longer take this approach in MCT, as set out in Mobile call termination market review 2015-18, Draft Statement, 6 February 2015, http://stakeholders.ofcom.org.uk/consultations/mobile-call-termination-14/draft-statement/.
[158] Source: Bloomberg's BVCSGU10 Index 28 August 2014 to 27 August 2015 and 13 January 2014 to 12 January 2015.
[159] The tax rate used in our February 2015 consultation was 20%. The tax rate used in this decision is 18.3%. See Section 6 for a discussion of the appropriate tax rate.
[160] This is the range set out in paragraph A10.59, adjusted for inflation risk premium and after tax.
[161] In other words, we are considering the effect of *variability* in the market value of spectrum and not an *expected value* effect (in which the probability of increases in spectrum value over time is different from the probability of decreases in spectrum value over time)

ALF is fixed, it reflects the same risk as other debt and so should be discounted at the cost of debt. The value which determines the reset should be discounted at the same rate as the risky operating cash flow that occurs in year 10. We ignore the effect of taxes.

A10.65 Under this scenario, for the first ten years, the ALF payments will not be reset and so should be discounted at the debt rate. After 10 years the ALF will be reset to reflect the value of the asset at that date. Once it is reset, given the assumption of a single review, it will again have no risk from that point onwards (other than the risk normally associated with debt). Therefore, for years 11-20 the payments should also be discounted at the debt rate, when viewed from the end of year 10.

A10.66 However, viewed from time zero, the actual ALF during the second decade (as represented by the forward-looking value assessed in year 10) is risky as there is the potential for it to be different to the licensee's initial expectations. The licensee should discount this forward looking value (as assessed in year 10) at the rate which it uses to discount other cashflows which are subject to uncertainty. We assume that an appropriate discount rate for this is the WACC (as used in discounted cashflow business models). This is in line with our analysis in Section 6 (see paragraphs 6.21 - 6.26).[162]

A10.67 Therefore, the ALF for the first 10 years should be discounted at the debt rate. The expected ALF from the last 10 years should be discounted back to year 10 at the debt rate, and then back to year zero at the WACC.

A10.68 Using a notional ALF payment of £1 per year, a debt rate of 0.6% and a WACC of 5.2%, the present value (PV) of the first ten years' payments at year zero is around £9.70.[163] The PV of the second ten years' payments viewed from the end of year 10 is the same.[164] However, discounting this latter amount back to year zero at the WACC gives a present value of around £5.85.[165] The PV across the whole 20 years is thus around £15.50.

A10.69 A PV of £15.50 across 20 years is equivalent to an annual payment of £1 discounted at roughly 2.56%. A discount rate of 2.56% is roughly 43%[166] between the notional debt rate and WACC figures set out above, which we interpret as the amount of risk transferred from the licensee to the Government, relative to a scenario with no review.

A10.70 Under this stylised example, the above assumptions and figures imply that the licensee bears roughly 60% of the risk (and the Government roughly 40%) where there is one review after 10 years.

Varying the timing and number of reviews

A10.71 In practice, ALF reviews are not set events which take place at pre-arranged points in time regardless of circumstances. Instead, as set out in Section 6 paragraph

[162] We note that the results below are not very sensitive to the WACC used in the calculations.

[163] $\sum_{t=1}^{10} \frac{1_t}{(1+0.006)^t} = 9.68$

[164] Because there is an equal probability of an increase as a decrease, the expected value of the payments after the second review is the same as the payments in the initial period. The expected value of payments for years 11-20 is therefore still £1 per annum.

[165] $\frac{9.68}{1.052^{10}} = 5.83$

[166] In our February 2015 consultation we estimated this percentage to also be 43% (based on the a cost of debt of 0.9% and WACC of 5.2%.)

6.84, our policy is that we would be likely to review ALFs 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 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.

A10.72 The actual review regime is therefore more flexible than the stylised example set out above. In practice, reviews may occur earlier or later than the 10-year point modelled above. In addition, reviews may occur more or less often than once in 20 years.

A10.73 These points have differing implications:

a) A single review during the 20-year period which is fixed for some year other than year 10 would reduce the extent to which risk is transferred from the licensee to Government (in effect, reducing the Government's risk share), all else equal. This is because having a review earlier or later leaves a longer period during which the ALF is fixed (due to the assumption that there is only one review).

b) A regime with a greater number of equally spaced reviews (e.g. two reviews every 6.67 years; three reviews every five years etc.) can significantly increase the transfer of risk from the licensee to Government (in effect, increasing Government's share of risk) compared to a regime with one review, as the period for which the ALF is 'fixed' and the licensee is exposed to risk (of changes in market value) is commensurately shorter.

A10.74 We note that these two factors could both be present in that, if a review occurs early (e.g. after five years), the assumption that there is only one review looks less likely (as it would imply there would then be a 15-year period during which there was no review). A scenario with an earlier or later review may therefore be more likely to be associated with a scenario where there is more than one review within a 20 year period.

A10.75 To consider a specific example, if we assume two equally spaced reviews (at years 6.67 and 13.33) and use the same discount rate and ALF as above, the PV at year 0 of ALF payments in the first period before review 1 would be roughly £6.50.[167] For the second period (between years 6.67 and 13.33), the payments should be discounted to year 6.67 at the cost of debt,[168] then to year 0 at the WACC.[169] For the third period (after the second review in year 13.33 to year 20), the payments

[167] $\sum_{t=1}^{6.67} \frac{1_t}{(1+0.006)^t} = 6.52$

[168] As above, because there is an equal probability of an increase as a decrease, the expected value of the payments after the reviews is the same as the payments in the initial period. The expected value of payments for the two periods following reviews is therefore still £1. Because reviews are equally spaced, the PV of payments for the period for which they are fixed after the review are the same. I.e. the PV of payments in years 6.67-13.33 is $\sum_{t=1}^{13.33-6.67=6.67} \frac{1_t}{(1+0.006)^t} = 6.52$

[169] $\frac{6.52}{1.052^{6.67}} = 4.65$

should be discounted to year 13.33 at the cost of debt then back to year 0 at the WACC.[170] The PV across the whole 20 years is then around £14.50.[171]

A10.76 A PV of this amount is equivalent to an annual payment of £1 discounted at roughly 3.3%. A discount rate of 3.3% is roughly 59%[172] between the debt rate and WACC figures set out above, which we interpret as the amount of risk transferred to Government, relative to a scenario with no review.

A10.77 Under this stylised example, the above assumptions and figures imply the licensee bears roughly 40% of the risk (and the Government bears roughly 60%) where there are two equally spaced reviews in a 20-year period.

Threshold review effect

A10.78 A further feature of the review regime in practice is that we would be likely to review ALFs 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. By definition, the probability of a review taking place at a particular point in time (such as 10 years) will be less than 100%. This is because the review may be initiated only if spectrum value appears to differ from ALF by some minimum amount, i.e. a material misalignment. As a result, the licensee's share of risk would be higher than in the equivalent scenario with a certain review. How much higher depends on the probability of the threshold for a review being passed, which in turn depends on:

a) The underlying variability in market value (how much spectrum value actually changes) – the more spectrum values are liable to change, the greater the probability of this change exceeding the threshold for a material misalignment; and

b) The threshold at which the change in value relative to ALF constitutes a material misalignment – the greater this threshold, the less likely it is a review would be opened, all else equal.

A10.79 The general effect of having such a threshold before opening a review at a fixed time is to reduce the amount of risk transferred from the licensee to Government (as the likelihood of opening a review is lower). The scale of the effect of the threshold depends upon the level of the threshold and the exact way in which the resetting of ALF is performed under a threshold based review. However, we consider that the overall effect of a threshold based regime would be to reduce the transfer of risk to Government relative to the simple scenario, even if the scale of that reduction is unclear.

Derivation of discount rate

A10.80 In line with our analysis above, we consider that an 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 0.6% (real, post-tax).

[170] $\frac{6.52}{1.052^{13.33}} = 3.31$

[171] £6.52+£4.65+£3.31 = £14.48

[172] In our February 2015 consultation we estimated this percentage to also be 59% (based on the a cost of debt of 0.9% and WACC of 5.2%.)

A10.81 As set out in paragraphs A10.62-A10.79 and Section 6 paragraph 6.119, we uplift this to reflect the additional risk the Government bears over and above that of a 'normal' creditor. This uplift can be calculated in one of two ways:

(1)

$$ALF\ discount\ rate = ALF\ debt\ rate + Government\ share\ of\ operating\ risk * (MCT\ WACC - MCT\ debt\ rate)$$

(2)

$$ALF\ discount\ rate = ALF\ debt\ rate + Government\ share\ of\ operating\ risk * (MCT\ WACC - ALF\ debt\ rate)$$

A10.82 One way to illustrate the difference between these two equations is to consider the upper-bound ALF discount rate that would result at a risk sharing factor of 100%. With the second equation this upper bound would be the WACC, which we explained above is the upper polar rate. However, with the first equation it would be a lower discount rate, below the upper polar rate of the WACC. This is illustrated in Figure A10.5.

Figure A10.5: Difference between Equations 1 and 2

Source: Ofcom analysis

A10.83 The difference between these figures is essentially the difference between:

a) our long-term estimate of the risk-free rate, which is part our calculation of the WACC (and reflects long term decisions across multiple investments); and

b) market gilt rates, which are reflected in the ALF cost of debt (based on YTM).

A10.84 This difference is separate to the difference in systematic risk between the cost of debt and the WACC (essentially the cost of equity), which is what has been analysed in the risk sharing discussion above. If we use the cost of debt derived for ALF in the risk sharing adjustment (i.e. the second equation), we capture more than

the increased exposure to systematic risk in the adjustment. If we use the MCT cost of debt in the risk sharing adjustment (i.e. the first equation), then we would not incorporate this difference between risk-free rates into the analysis, despite this being part of the difference between the polar cases.

A10.85 The appropriate approach depends on how the risk-free element of the return changes as the risk borne by Government changes, i.e. at what point, as Government's share of risk increases, the investment in ALF becomes less of a form of hypothecated debt and more of a traditional investment influenced by the firm's general operations. We have no information on this point, and so consider that a reasonable approach is to pro-rate the difference in risk-free rates along with the difference in systematic risk. This means that, at a higher risk exposure of the Government, a larger proportion of the difference in risk-free rate is incorporated in the ALF discount rate.

A10.86 We have therefore decided to use the ALF debt rate in both parts of the discount rate derivation i.e. Equation (2) above, as proposed in the February 2015 consultation.

Terminal value

Our position in previous consultations

A10.87 Prior to our October 2013 consultation, a licence holder said that (at least some of) the bids in the 4G auction were based on valuations which reflected a significant terminal value component, i.e. a value of holding the licence beyond the initial 20 year term. It suggested that, in recognition of this, we should either reduce our estimates of the lump-sum values of ALF licences by the amount of this terminal value, or else convert the lump-sum values into a perpetuity, rather than a twenty-year annuity.

A10.88 In the October 2013 consultation (paragraph 5.11) we set out our provisional view that the adjustments for terminal value which the licence holder proposed were not appropriate when calculating ALFs. Our reasons for this view are discussed below.

A10.89 In our August 2014 consultation (paragraph 4.4) and February 2015 consultation (A10.104), we said that we remained of the view that we should not make an adjustment for terminal value, for the reasons set out in the previous consultations.

Stakeholder responses

A10.90 In its response to our October 2013 consultation, EE (page 30) argued that:

> "A new licence has 'terminal value' associated with it, i.e. a value that relates to the period following the initial 20 year period for which the auction determines the upfront payment. This is because at the end of the initial licence period, the licensee will have a set of assets associated with the licence such as a network based on those frequencies (and possibly other bands), a customer base and brand value. A licensee who sells the licence at the end of the initial 20 year licence period cannot expect to recover its terminal value associated with network equipment, brand and customers without selling those too. The Direction tasks Ofcom with finding the market value of the renewal licence, not the private value of the incumbent licensees."

A10.91 In response to our August 2014 consultation, EE further argued that:

a) The Government Direction requires us to set ALF reflecting the value of holding spectrum in the year in question, and not the value of holding it at some point in the future.

b) Our approach would force licence holders to pay multiple times for the option of holding their licences in future:

   i) EE argued that "Assuming (for the sake of argument) that Ofcom continues to set ALFs based on 20 year licence periods, under Ofcom's current proposals in years 1-20 the licence holder will pay ALFs based on the marginal operator's expected value of using the spectrum in that period, plus its expected (terminal/option) value of using the spectrum from year 21 onwards."

   ii) EE argued that "In years 21 - 40, the licence holder would pay ALFs based on the marginal operator's expected value at year 20 of using the spectrum in that period, plus its expected (terminal/option) value of using the spectrum from years 41 and beyond. The licence holder will, however, already have paid for a portion of the value for using the spectrum in years 21-40 in the initial 20 year period, meaning it must pay for that portion two times over, over 40 years."

   iii) This effect continues in years 41-60, 61-80, 81-100, and so on, for as long as the licence remains in force.

A10.92 We received no further comments on this issue in response to our February 2015 consultation.

Our analysis

A10.93 We recognise that bids for auctioned spectrum (such as in the UK 4G auction) may include some terminal value (using EE's terminology) that the bidder would expect to realise by holding spectrum beyond the initial 20-year period for the types of reason to which EE referred. In other words, the holder of the spectrum at the end of 20 years could have a private value of continuing to hold the spectrum, even if it were to pay ALF after year 20 at a rate which reflected market value.

A10.94 However, we do not consider that such a terminal value means that it would be appropriate to adjust our approach to deriving ALFs, either in our derivation of a lump-sum value or in annualising it into annual fees. In particular, as explained in greater detail below, this is because we consider that this terminal value is part of the opportunity cost of the spectrum in the initial 20-year period.

A10.95 To be specific and to simplify the discussion below, we consider the issue in terms of 20-year periods (as in EE's response). Consistent with our approach elsewhere in this document, we denote the highest-value non-holder of the spectrum licence in question as the marginal operator. We use the term "marginal operator (year 1)" to refer to the highest-value non-holder of the licence at the start of the first 20-year

period; and "marginal operator (year 21)" to refer to the highest-value non-holder at the start of the second 20-year period.[173]

A10.96 Our October 2013 consultation (paragraph 5.11) set out two reasons for considering that it was not appropriate to reduce our estimates of the lump-sum values of ALF licences by the amount of a terminal value. The first reason was that it was appropriate to maintain consistency between licences awarded in the 4G auction and ALF licences. The second reason was based on characterising market value over a defined period of time as the difference in value between the start and end of that period in a competitive market. The following paragraphs provide a further explanation, focusing on the points raised by EE in its response to the August 2014 consultation.

A10.97 In assessing the value of holding a 900 MHz or 1800 MHz licence over the first 20 years, we are considering the overall value that this licence would have for the marginal operator (year 1) were it to hold the licence from the start of the first 20-year period. This overall value can be split into two elements:

a) The first element relates to the value the marginal operator (year 1) would have in holding the licence for only those 20 years, e.g. if there were a notional automatic revocation at the end of year 20.

b) The second element (which EE referred to as the terminal value) is the difference in value to the marginal operator (year 1), between:

   i) holding the licence from years 21 onward on the assumption that it *held the licence in years 1-20*; and

   ii) acquiring the licence for the first time at the start of year 21 and holding it thereafter.

A10.98 The current licensee, by holding the licence from years 1 to 20, deprives the marginal operator (year 1) of both of these elements of value. As a result, it is appropriate to reflect in ALFs both of these elements of lost value to the marginal operator (year 1), i.e. the opportunity cost.

A10.99 EE argued that this approach forces licence holders to pay multiple times for the option of holding their licences in future. However, this is incorrect. The licence holder's payments in years 1-20 relate to years 21-40 only to the extent that they reflect additional value which a marginal operator (year 1) could have achieved if it had held the licence in years 1-20. This is not part of the value of the marginal operator (year 21) which sets opportunity cost and market value at the start of the second 20-year period.

A10.100 By the end of year 20, the opportunity for the marginal operator to achieve any complementarity value[174] between the first period (years 1-20) and the second period (years 21-40) has been lost. The licence holder's payments in years 21-40 will reflect the value to the marginal operator of acquiring the licence at the start of

[173] The marginal operator (year 21) could be a different company to the marginal operator (year 1), or it could be the same company (although it may have a different value reflecting the different point in time and circumstances).

[174] Holding a spectrum licence in one period is complementary to holding it in another period if the value of the two together is higher than the sum of the value of holding the licence in the first period only, and the value of holding it in the second period only.

year 21 (extending the logic above, this is the value to the marginal operator (year 21) of holding the licence for years 21-40 with a notional automatic revocation at the end of year 40, plus the complementarity value to the marginal operator (year 21) between years 21-40 and years 41 onward).

A10.101 The same logic can be applied at the start of year 41 – and then at the start of year 61 and so on. Accordingly, if there is a complementary value from holding a licence from one period to the next, we can think of the total complementary value of holding a licence from now for as long as the licence continues in force. Any licence holder who holds the licence for the next 20 years deprives all rivals of the value they would obtain from holding the licence in those 20 years only, and the complementarity value between that 20-year period and all future periods.

A10.102 Another way of understanding this result is by reference to maintaining consistency between licences awarded in the 4G auction and the ALF licences (i.e. the first reason in the October 2013 consultation, and set out at paragraph A10.97 above). In short, whether access rights to a particular block of spectrum are awarded through auctioning a licence (with an initial period of 20 years) or whether they are assigned through a licence which incurs ALF from the outset, both types of licence are the same *after* year 20. In particular, they are both liable to pay ALF after year 20 (and the same ALF if they were for spectrum in the same band). The difference *before* year 20 is that, in the first case, the licensee makes an upfront auction payment (but no ALF payments) and, in the second case, the licensee pays ALF (but makes no upfront payment).

A10.103 Since the position is identical after year 20, the licences can be economically equivalent only if the present value of the ALF payment stream in years 1-20 (in the case of the ALF licence) equals the upfront auction payment (in the case of the auctioned licence). In striking this equivalence, the upfront auction payment will reflect the value of the spectrum to the marginal operator (year 1), *including* any terminal value component (noting, for completeness, that it is this marginal operator (year 1) that, through this equivalence, sets the market value of the spectrum on which the ALF is based in the first 20-year period).

A10.104 The second reason in the October 2013 consultation (and set out at paragraph A10.97 above) considers the change in value over the first 20-year period in a competitive market. One way to characterise market value over a defined period of time is the difference in present value (PV) between the start and end of that period in a competitive market. Considering (for simplicity) the case of only two 20-year periods, it is the difference between the PV:

a) to the marginal operator (year 1) in a competitive market for both 20-year periods (i.e. years 1-40), assessed at the start of the first 20-year period for the licence (i.e. year 1); and

b) to the marginal operator (year 21) in a competitive market for the second 20-year period (i.e. years 21-40), assessed at the start of the second 20-year period (i.e. year 21).

A10.105 The former is analogous to the market value we assess in Section 2 based on bids in the 4G auction.

A10.106 The latter is the value to the marginal operator (year 21) which sets the opportunity cost in a competitive market at that point in time, i.e. at the start of the second 20-year period.[175]

A10.107 Consistent with our analysis in the October 2013 consultation, in our view it is reasonable to consider that the PV of the marginal operator (year 21) at the start of the second 20-year period might be zero. The reason is that annual fees might be expected to apply after 20 years and the level of annual fees might be set at the PV for the marginal operator (year 21) in a competitive market at that time, since this would represent full market value. On this basis the PV, net of ALF, would be zero for the marginal operator (year 21). This description applies to the simplified case of only two 20-year periods, but the same principle applies if we consider further 20-year periods.

A10.108 In light of the above analysis, we remain of the view that in setting ALFs to reflect market value it is not appropriate to adjust our lump sum estimates for terminal value.

[175] We note that (assessed at year 1) the value expected by the marginal operator (year 1) in the second 20-year period could be different from the value to the marginal operator (year 21). For example, as discussed above, it might be higher, reflecting the anticipation of a complementarity value between the first and second 20-year periods, which EE refers to as a terminal value. However, this is not relevant to determine market value for the second 20-year period because, as noted at paragraph A10.94 above, this complementarity value of the marginal operator (year 1) for the second 20-year period is hypothetical as, by definition, it is the non-holder of the licence in the first 20-year period).

Annex 11

Marginal bidder analysis of paired 2.6 GHz spectrum in the absence of Niche

Hypothetical UK auction outcome in the absence of Niche

11.1 In the absence of Niche's bids (and assuming no change in bids by other bidders) the UK auction outcome would have been as set out in Table A11.1 below.

Table A11.1: UK auction outcome in the absence of Niche[176]

Bidder	A1	A2	C	E	Bid value (£m)	Opportunity cost in 4G auction (£m)	Base price (£m)
EE	1	0	7	0	1,049.5	251.729	330
H3G	1	0	0	0	565.5	364.2	364.2
HKT	0	0	0	0	0	0	0
MLL	0	0	0	0	0	0	0
Telefónica	0	1	2	0	1,347.003	606.662	606.662
Vodafone	2	0	5	9	2,133.52	695.215	724.656

Source: Ofcom, Winner Determination and Pricing (WDP) software

11.2 In Table A11.1 above, we assumed that if there were unallocated lots they would be valued at zero. Also, base prices may be higher than the respective individual opportunity cost. This is the case when the collective opportunity cost imposed by a sub-set of multiple winners (core price) is higher than the sum of the individual opportunity costs (Vickrey prices) for each of those winners – see paragraph A6.53 in Annex 6 of this statement.

11.3 Compared to the actual spectrum allocation in the UK auction:

a) EE and H3G would hold the same respective spectrum packages;

b) Telefónica would hold additional 2xC; and

c) Vodafone would hold additional 1xC + 4xE.

Marginal bidder analysis for paired 2.6 GHz spectrum in the absence of Niche

11.4 Given the hypothetical UK auction outcome above, in Table A11.2 below we set out, for each bidder, the incremental bid values (IBVs) for fewer lots of C than the bidder's allocation in Table A11.1 ("decremental C") and for additional lots of C ("incremental C").

[176] The base price for H3G at £364.2m does not take into account spectrum reservation. Applying the specific auction pricing rule for reserved spectrum, the base price for H3G would be at £225m (while the remaining figures in this table would be the same).

Table A11.2: Incremental bid values for a decremental or incremental C lot

Bidder	IBV for decremental C (£m per MHz)	IBV for incremental C (£m per MHz)
Vodafone	5.37	5.37
H3G	N.A.	5[177]
EE	15.05	N.A. (spectrum cap)
Telefónica	6.4	Negative IBV

Source: Ofcom

11.5 To illustrate how the IBVs were computed, take the case of Vodafone (i.e. the £5.37m per MHz values). According to the hypothetical UK auction outcome in the absence of Niche, Vodafone would hold 2xA1 + 5xC + 9xE at a bid value of £2,133.52m. Vodafone also submitted a bid for 2xA1 + 4xC + 9xE at £2,079.82m, and another bid for 2xA1 + 6xC + 9xE at £2,187.220m. Therefore:

11.5.1 Vodafone's IBV for an incremental C lot would be £53.7m (=£2,187.220m - £2,133.52m), i.e. £5.37m per MHz[178]; and

11.5.2 Vodafone's IBV for a decremental C lot would be £53.7m (=£2,133.52m - £2,079.82m), i.e. £5.37m per MHz.

11.6 In this hypothetical case, the marginal bidder for 2.6 GHz spectrum would have been Vodafone (i.e. the bidder with the highest IBV for incremental C). Thus, the highest IBV for incremental C would have been £5.37m per MHz, rather than Telefónica at £6.4m per MHz as in the actual analysis (see paragraph 2.225 in Section 2 of this statement). The lowest IBV for decremental C would also have been £5.37m per MHz, rather than Niche at £5.5m per MHz as in the actual analysis which we use as our preferred estimate from the marginal bidder analysis for the actual auction (see paragraphs 2.227-2.228 in Section 2 of this statement).

[177] This IBV refers to an increment of 2xC, given that H3G did not express value for 1xA1 + 1xC.
[178] Vodafone also submitted a bid for 2xA1 + 7xC + 9xE at £2,240.920m implying that Vodafone's IBV for an incremental of 2xC would have been £107.4m (= £2,240.920m - £2,133.52m), i.e. £5.37m per MHz as well.

Annex 12

Statutory instrument

A12.1 A copy of this statutory instrument is annexed to this Statement for indicative purposes. The statutory instrument will be formally published on the government's legislation.gov.uk website in due course.

STATUTORY INSTRUMENTS

2015 No. 0000

ELECTRONIC COMMUNICATIONS

The Wireless Telegraphy (Licence Charges for the 900 MHz frequency band and the 1800 MHz frequency band) (Amendment and Further Provisions) Regulations 2015

Made - - - -	*23rd September 2015*
Coming into force - -	*15th October 2015*

The Office of Communications ("OFCOM") make the following Regulations in exercise of the powers conferred by sections 12, 13(2) and 122(7) of the Wireless Telegraphy Act 2006([a]) (the "Act") and as required by article 6(1) and (2) of the Wireless Telegraphy Act (Directions to OFCOM) Order 2010([b]).

Before making these Regulations, OFCOM have given notice of their proposal to do so in accordance with section 122(4)(a) of the Act, published notice of their proposal in accordance with section 122(4)(b) of the Act, and have considered the representations made to them before the time specified in the notice in accordance with section 122(4)(c) of the Act.

Citation and commencement

1.—(1) These Regulations may be cited as the Wireless Telegraphy (Licence Charges for the 900 MHz frequency band and the 1800 MHz frequency band) (Amendment and Further Provisions) Regulations 2015 and shall come into force on 15th October 2015.

(2) These Regulations shall not extend to the Channel Islands and the Isle of Man.

Interpretation

2. In these Regulations—

"kHz" means kilohertz;

([a]) 2006 c. 36.
([b]) S.I. 2010/3024.

"licence" means a wireless telegraphy licence of the Public Wireless Networks licence class;

"MHz" means megahertz;

"OFCOM" means the Office of Communications;

"paired 200 kHz channel" means two associated blocks of frequencies of 200 kHz each;

"900 MHz frequency band" means the frequencies from 880.0 to 960.0 MHz; and

"1800 MHz frequency band" means the frequencies from 1710.0 to 1880.0 MHz.

Amendment to the Wireless Telegraphy (Licence Charges) Regulations 2011

3.—(1) The Wireless Telegraphy (Licence Charges) Regulations 2011([a]) shall be amended in accordance with paragraph (2).

(2) In Schedule 2 (licence charges and payment intervals), under the heading "Public Wireless Networks", omit the following entries—

"Public Wireless Networks		(a) £142,560 for each 2 x 200 kHz national channel in the band 880.0–960.0 MHz.	12 months
		(b) £110,880 for each 2 x 200 kHz national channel in the band 1710.0–1880.0 MHz.	12 months"

Licence charges payable for the 900 MHz frequency band on 31st July 2016

4.—(1) On 31st July 2016 each holder of a licence authorising the use of frequencies in the 900 MHz frequency band shall pay to OFCOM a total sum which comprises £194,989 for each authorisation under its licence of use of a paired 200 kHz channel in that band.

(2) If OFCOM receive notice from a licensee of the licensee's intention to make payment of the total sum due under paragraph (1) in ten equal instalments, regulation 8 shall apply.

Licence charges payable for the 1800 MHz frequency band on 31st October 2015, 28th February 2016 and 31st July 2016

5.—(1) Each holder of a licence authorising the use of frequencies in the frequency ranges 1721.7 to 1736.7 MHz and 1816.7 to 1831.7 MHz shall pay to OFCOM on 31st October 2015 a total sum which comprises £222,073 for each authorisation under its licence of use of a paired 200 kHz channel in those ranges.

(2) Each holder of a licence authorising the use of frequencies in the frequency ranges 1736.7 to 1781.7 MHz and 1831.7 to 1876.7 MHz shall pay to OFCOM on 28th February 2016 a total sum which comprises £185,113 for each authorisation under its licence of use of a paired 200 kHz channel in those ranges.

(3) Each holder of a licence authorising the use of frequencies in the frequency ranges 1710.1 to 1721.7 MHz and 1805.1 to 1816.7 MHz shall pay to OFCOM on 31st July 2016 a total sum which comprises £138,913 for each authorisation under its licence of use of a paired 200 kHz channel in those ranges.

(4) If OFCOM receive notice from a licensee of the licensee's intention to make payment of the total sum due under paragraph (1), (2) or (3) in ten equal instalments, regulation 8 shall apply.

Licence charges payable for the 900 MHz frequency band for each subsequent payment

6.—(1) On 31st October 2016 and on each anniversary of that date, each holder of a licence authorising the use of frequencies in the 900 MHz frequency band shall pay to OFCOM a total sum which comprises the amount in pounds sterling calculated in accordance with paragraph (2) and rounded, if paragraph (3)

([a]) S.I. 2011/1128, amended by S.I. 2012/1075, 2013/917, 2014/1295, 2015/1334.

applies, in accordance with that paragraph, for each authorisation under its licence of use of a paired 200 kHz channel in that band.

(2) The formula to calculate the total sum mentioned in paragraph (1) is—

$$S = 451{,}200 \times \left(P \div 125.6\right)$$

where—

(a) "S" means the total sum;

(b) "P" means the most recent CPI that is available on 30th September of the year in which the charges are due; and

(c) "CPI" means the monthly all items consumer prices index published by the UK Statistics Authority.

(3) If the total sum calculated in accordance with paragraph (2) is a fraction of a whole number, it shall be rounded down to the nearest whole number.

(4) If OFCOM receive notice from a licensee of the licensee's intention to make payment of the total sum due under paragraph (1) in ten equal instalments, regulation 8 shall apply.

Licence charges payable for the 1800 MHz frequency band for each subsequent payment

7.—(1) On 31st October 2016 and on each anniversary of that date, each holder of a licence authorising the use of frequencies in the 1800 MHz frequency band shall pay to OFCOM a total sum which comprises the amount in pounds sterling calculated in accordance with paragraph (2) and rounded, if paragraph (3) applies, in accordance with that paragraph, for each authorisation under its licence of use of a paired 200 kHz channel in that band.

(2) The formula to calculate the total sum mentioned in paragraph (1) is—

$$S = 326{,}000 \times \left(P \div 125.6\right)$$

where—

(a) "S" means the total sum;

(b) "P" means the most recent CPI that is available on 30th September of the year in which the charges are due; and

(c) "CPI" means the monthly all items consumer prices index published by the UK Statistics Authority.

(3) If the total sum calculated in accordance with paragraph (2) is a fraction of a whole number, it shall be rounded down to the nearest whole number.

(4) If OFCOM receive notice from a licensee of the licensee's intention to make payment of the total sum due under paragraph (1) in ten equal instalments, regulation 8 shall apply.

Payment by instalments

8.—(1) If OFCOM receive notice from a licensee of the licensee's intention to make payment in ten equal instalments of the total sum prescribed in regulation 4, 5, 6 or 7, the licensee—

(a) shall not be required to make payment at the prescribed time other than in accordance with this paragraph; and

(b) shall make payment of the sum in ten equal instalment payments with the first instalment to be paid to OFCOM on the day which shall be the same day as the total sum was due to be paid to OFCOM and each subsequent instalment to be paid on the same day in each of the nine consecutive months thereafter (or in a month in which there is no such day, on the last day of the month).

(2) Where at any time the licensee fails to make payment in accordance with paragraph (1)(b), the total of the outstanding instalment payments shall become immediately due for payment.

Philip Marnick
Group Director, Spectrum Group
23rd September 2015 For and by the authority of the Office of Communications

EXPLANATORY NOTE

(This note is not part of the Regulations)

These Regulations increase the level of fees payable to OFCOM in respect of the licences of the Public Wireless Networks licence class granted under section 8 of the Wireless Telegraphy Act 2006 (c. 36) for the use of the frequencies in the bands 880.0–960.0 MHz and 1710.0–1880.0 MHz.

Regulation 3 removes the level of such fees from Schedule 2 of the Wireless Telegraphy (Licence Charges) Regulations 2011 (S.I. 2011/1128, amended by S.I. 2012/1075, S.I. 2013/917, S.I. 2014/1295, S.I. 2015/1334) and Regulations 4 to 7 prescribe the new fee levels.

Regulations 4 and 5 prescribe the fees payable on the first payment date following the entry into force of these regulations. Regulations 6 and 7 prescribe the fees payable on 31 October 2016 and on each anniversary of that date.

Regulation 8 allows the holders of these licences to pay fees by ten equal monthly instalments.

A full impact assessment has not been produced for this instrument. A full impact assessment has been produced by the Department for Business, Innovation and Skills in relation to the Wireless Telegraphy Act (Directions to OFCOM) Order 2010 (S.I. 2010/3024), which this instrument implements. A copy of that impact assessment is available from Information Economy, Department for Business, Innovation and Skills, 1 Victoria Street, London, SW1H 0ET or at http://www.legislation.gov.uk/uksi/2010/3024/impacts.

Annex 13

Glossary of terms

2G	Second generation of mobile standards and technology, including the GSM technology standard.
3G	Third generation of mobile standards and technology, including the UMTS technology standard.
4G	Fourth generation of mobile standards and technology. The term 4G is generally used to refer to mobile broadband services delivered using the next generation of mobile broadband technologies, including Long Term Evolution (LTE) and WiMAX.
4G auction	The UK 4G auction for 800 MHz and 2.6 GHz (paired and unpaired) spectrum which concluded in March 2013.
ALF	Annual Licence Fees to be paid by the holders of the licences for 900 MHz and 1800 MHz spectrum (which are currently EE, H3G, Telefónica, and Vodafone).
AM&A	Analysys Mason and Aetha.
AMPU	Average margin per user.
ASM	The Additional Spectrum Methodology is a method we use to assess the opportunity costs of spectrum in the 4G auction.
BT	British Telecommunications plc.
CBA	Cost-Benefit Analysis.
CCA	A Combinatorial Clock Auction is a package or combinatorial auction format in which bids are made for packages of spectrum (not individual lots, as in an SMRA). If there are multiple bands available in the auction (as, for example, in the UK 4G auction and in auctions in Austria and Ireland), such packages may include spectrum in more than one band.
CEPT	European Conference of Postal and Telecommunications Administrations
Communications Act	The Communications Act 2003.
CPI	The Consumer Price Index (CPI) is a measure of prices. It measures the price level of consumer goods and services purchased by households. The most significant item excluded in the CPI, but included in the RPI, is mortgage interest rate payments. Changes in the index measure price inflation.
DMSL	Digital Mobile Spectrum Ltd. A company established by four MNOs (EE,

	H3G, Telefónica and Vodafone) with responsibility for ensuring that consumers continue to receive clear Freeview TV signals following the rollout of 4G mobile services in the 800 MHz spectrum band.
DTT	Digital Terrestrial Television - Broadcasting delivered by digital means. In the UK and Europe, DTT transmissions use the DVB-T and DVB-T2 technical standards.
EC	The European Commission.
FDD	Frequency Division Duplex – a technology used in paired spectrum that deals with traffic asymmetry between uplink and downlink where separate frequency bands are used for sending and receiving operations.
GHz	Gigahertz. 1,000,000,000 (or 10^9) oscillations per second.
Government Direction	The Wireless Telegraphy Act 2006 (Directions to Ofcom) Order 2010 (S.I. 2010/3024).
GSA	The Global mobile Suppliers Association is an association of worldwide mobile suppliers.
GSM	Global System for Mobile Communications. A 2G standard for mobile communications which supports services including international roaming, SMS texting, web browsing and picture messaging.
GSMA	The GSM Association is an association of mobile operators, handset and device makers and other related companies.
IMT	International Mobile Telecommunications. The ITU term that encompasses 3G, 4G and 5G wireless broadband systems.
IBV	Incremental Bid Value – the difference in bid value between two different packages bid for by a bidder in a CCA, which relates to a specified increment of spectrum (the difference in spectrum between the two packages).
ITU	International Telecommunications Union - Part of the United Nations with a membership of 193 countries and over 700 private-sector entities and academic institutions. The ITU is headquartered in Geneva, Switzerland.
LRP	Linear Reference Price. In a CCA, auction prices are derived for packages of spectrum, not for individual lots or bands. LRPs are the output of a mathematical algorithm which takes account of both winning and losing bids in a CCA to generate linear prices (i.e. a single price per MHz for each band that is the same for each bidder) that best support the auction outcome.
LTE	Long-Term Evolution is a standard for communication of high-speed data for mobile phones and data terminals.

MDS	Ofcom's Mobile Data Strategy.[b]
MCT	Mobile Call Termination. MCT is a wholesale service provided by a mobile communications provider to connect a call to a recipient on its network.
MHz	Megahertz. 1,000,000 oscillations per second.
MNO	Mobile Network Operator.
NPV	Net Present Value.
NRA	National Regulatory Authority. The relevant communications regulatory body for each country in the EU. Ofcom is the NRA for the United Kingdom.
ONS	Office for National Statistics.
PPC	Price Point Calculator software provided by DotEcon to calculate LRPs.
PPP	Purchasing Power Parity. Exchange rates between countries that allow for the exchange to be equivalent to each currency's relative purchasing power.
RFR	Risk-free rate. The return an investor would expect from an absolutely risk-free investment over a specified period of time.
RPI	The Retail Price Index (RPI) is an price index which is calculated by measuring the cost of a basket of retail goods and services. Changes in the index measure price inflation.
RSC	Radio Spectrum Committee of the European Commission
SDL	Supplemental Downlink.
SMRA	Simultaneous multiple-round ascending auction. In this type of auction participants bid for individual spectrum lots (not packages, as in a CCA).
TAF	Tax Adjustment Factor. An adjustment applied in deriving ALFs from LSVs to reflect the advantageous tax treatment of ALFs compared with a lump-sum payment.
TDD	Time Division Duplex – a technology used in unpaired spectrum that deals with traffic asymmetry where the uplink is separated from the downlink by the allocation of different time slots in the same frequency band.
UMTS	Universal Mobile Telecommunications Service. A 3G standard for mobile communications which provides mobile users with interactive multimedia capabilities at higher data rates than for 2G.

[b] See http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/statement.pdf

UHF	Ultra High Frequency. The part of the spectrum between 300 MHz and 1 GHz.
WACC	Weighted average cost of capital.
WRC	World Radiocommunication Conference. The WRC reviews and revises the Radio Regulations. They are held every three to four years.
YTM	Yield to maturity. The rate of return anticipated on a bond if it was bought today and held until its maturity date.