Annual Licence Fees for 900 MHz and 1800 MHz frequency bands

ANNEXES

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Annex

A1. Updates to benchmarks

Introduction

A1.1 In this annex we provide an overview of the structure of the international benchmarking analysis and the changes made to it from the 2018 Consultation and 2015 Statement. To this end it provides an overview of the methodology employed in:

a) the derivation of UK-equivalent absolute values and relative value benchmarks for European auctions;

b) and the approach to tiering these benchmarks based on the quality of the evidence.

A1.2 The methodology employed in these processes remains consistent with that previously used. This annex then goes on to highlight changes in our approach, in particular:

a) the update in accounting for purchasing power parity (PPP) changes between auction dates of auctions used to construct relative benchmarks;

b) the inclusion of the Czech Republic in the 2.6GHz proxy[1]; and

c) further updates to pricing, population, and inflation (CPI) data.

A1.3 Our assessment of the informational value of individual European auctions is provided separately in Annex 2.

Overview

A1.4 Our overarching methodology remains as it was in the June 2018 Consultation[2] and the 2015 Statement.[3] We begin by identifying European auctions that took place for the 800MHz, 900MHz, 1800MHz and 2.6GHz bands since 2010. We consider European awards to be the most appropriate in informing us about the value of 900MHz and 1800MHz spectrum in the UK. This is because we consider that European countries are more likely to share regulatory and other characteristics that affect the value of the 900MHz and 1800MHz bands in the UK. We consider that this approach gives us a sufficient and appropriate set of comparators. Annex 2 lists all the auctions we have included in our sample to date. Where possible, we have used prices from these awards to derive UK-equivalent absolute value benchmarks and relative value benchmarks. As in the June 2018 consultation we express all UK-equivalent values in April 2018 prices.

A1.5 Paragraphs A1.7 to A1.19 lay out these steps in greater detail.

A1.6 Paragraphs A1.20A1.20 to A1.51 explain where the detailed calculations differ from our June 2018 consultation (and 2015 statement).

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[1] This proxy is explained below

[2] Ofcom, June 2018 Consultation, Section 4. https://www.ofcom.org.uk/__data/assets/pdf_file/0022/114736/consultation-alf.pdf

[3] Ofcom, 2015 Statement, Annex 7 https://www.ofcom.org.uk/__data/assets/pdf_file/0028/79534/annexes_1-7.pdf

Absolute Benchmarks

A1.7 We construct absolute value benchmarks for European auctions which have been held since 2010 in the 800MHz, 900MHz, 1800MHz and 2.6GHz spectrum bands. In constructing the benchmarks we make a series of adjustments to account for a number of country- and lot-specific factors which have the potential to affect auction values in comparator countries relative to the UK.

a) All payments associated with an auction are summed to get a final award value. Any payments not paid at the date of award such as ALFs or deferred payment options are discounted from the date of initial payment to derive the present value of the award (see paragraph A1.43 below).

b) The present value of any award is scaled by differences in licence duration between that award and the 20-year duration of the 2013 UK awards using the weighted average cost of capital (WACC, see paragraph A1.36 to A1.40 below).

c) All awards are converted from the domestic currency in which they were awarded to £ sterling using PPP exchange rate conversions in the year of the award.

d) A single absolute benchmark value per spectrum band in a benchmark country is derived by averaging the values of all relevant lots sold, weighted by population covered and size of a given lot.

A1.8 Despite making these adjustments a number of country-specific factors have the potential to affect auction prices in comparator countries relative to the UK. Licence holders have previously argued that, for this reason, absolute auction prices may not provide reliable indicators of the value of spectrum in the UK. Some country-specific factors, such as general price levels, will be reflected in the PPP estimates which we have used to derive absolute value benchmarks. However, other differences in auction values are more difficult to address in a robust way – for example the greater propagation characteristics of lower-frequency bands may be more or less important depending on the level of urbanisation and population density in a country.

A1.9 In general, we expect that relative values are less likely to be affected by country-specific factors than absolute values.[4]

Relative Benchmarks for 900 MHz and 1800 MHz

A1.10 To calculate the relative values of 900MHz we identify European countries in which both 800MHz and 900MHz spectrum has been auctioned since 2010. Similarly, we construct relative 1800MHz values for all such countries where a set of auctions in the 800MHz and 1800MHz (and preferably also 2.6GHz) spectrum bands have been carried out. In doing so we account for differences in coverage obligations and digital terrestrial television (DTT) coexistence costs.

[4] See August 2014 consultation, paragraph A7.37 to A7.41.

A1.11 For the 900 MHz band, we focus on the relative value of 900 MHz to 800 MHz licences in countries where both bands have been auctioned. We consider this is likely to be the most informative benchmark evidence for the value of 900 MHz in the UK, particularly in light of the similar underlying technical characteristics of these two bands.[5] A UK-equivalent value is derived using the following formula, where the integer refers to the type of spectrum band and the subscript BC identifies any given benchmark country for which both an 800MHz and 900MHz auction took place:

$$900_{\mathrm{UK}} = \frac{900_{\mathrm{BC}}}{800_{\mathrm{BC}}} \cdot 800_{\mathrm{UK}}$$

A1.12 For the 1800 MHz band, we adopt the distance method proposed by Analysys Mason and Aetha (in a report for EE and H3G in 2014)[6] as our preferred method for deriving benchmark values of 1800 MHz spectrum. Benchmark values of 1800 MHz generated by the distance method reflect the UK auction values of both 800 MHz and 2.6 GHz spectrum in the UK auction. We consider that, in principle, this is an advantage over the paired ratios of 1800 MHz to 800 MHz or 1800 MHz to 2.6 GHz spectrum.

A1.13 The distance method is applied by:

a) calculating the "Y/X" ratio which is calculated as the difference in value between 1800 MHz and 2.6 GHz ("Y"), divided by the difference in value between 800 MHz and 2.6 GHz ("X"), which is referred to as the "Y/X ratio" and expressed as a percentage; and

b) relating this to the corresponding 800 MHz and 2.6 GHz values in the UK.

A1.14 Expressed formulaically, the distance method takes the following expression, where the integers represent an 800 MHz, 1800 MHz or 2.6 GHz spectrum value for a given benchmark country or the UK denoted by subscripts BC and UK respectively.

$$1800_{\mathrm{UK}} = \frac{1800_{\mathrm{BC}} - 2.6_{\mathrm{BC}}}{800_{\mathrm{BC}} - 2.6_{\mathrm{BC}}} \cdot (800_{\mathrm{UK}} - 2.6_{\mathrm{UK}}) + 2.6_{\mathrm{UK}}$$

A1.15 In obtaining both the 900 MHz and 1800 MHz relative values we rely on the 800 MHz and 2.6 GHz UK spectrum market values calculated in the 2015 Statement.[7] Adjusting these values to April 2018 prices using UK CPI, the market values for these spectrum bands for the purpose of calculating ALFs are:

a) £32.2m per MHz for the 800 MHz band net of expected DTT co-existence costs,

b) £35.5m per MHz for the 800 MHz band gross of expected DTT co-existence costs, and

c) £5.9m per MHz for the 2.6 GHz band.

[5] See August 2014 consultation, paragraph 3.23.
[6] AM&A, Review of Ofcom's determination of UK lump-sum values for 1800MHz and 900MHz spectrum to set annual licence fees, Final Report for EE and Three, page 2.
[7] See Section 2 of our 2015 Statement (https://www.ofcom.org.uk/__data/assets/pdf_file/0033/79764/statement.pdf).

A1.16 We focus on relative value benchmarks as evidence for the market value for 900 MHz and 1800 MHz spectrum (see Section 4), and use absolute value benchmarks as a cross-check on our findings (see Annex 4 for details).

Quality of evidence: tiers

A1.17 We categorise the available relative value benchmarks into three tiers, which reflect how informative of UK market values we consider them to be. Our criteria for placing a relative benchmark in Tier 1 (highest quality) are that:

a) The auction prices appear likely to have been primarily determined by a market-driven process of bidding in the auctions (generally this means the prices were not set by reserve prices);

b) Based on the evidence available to us, the relative prices in the auction are at least as likely to be based on bidders' intrinsic valuations of spectrum as on strategic bidding; and

c) The outcome appears likely to be informative of forward-looking relative spectrum values in the UK, having regard to country-specific circumstances and auction dates.

A1.18 Our criteria for placing a benchmark in Tier 2 are that one or more of the criteria for Tier 1 are not met; but (a) there is some evidence that the relative auction prices reflect bidders' relative intrinsic valuations of different bands, and (b) while there is a clear, evidence-based reason for considering that the outcome is less informative of forward-looking relative spectrum values in the UK, the outcome is not obviously uninformative of forward-looking relative spectrum values in the UK. Our criterion for placing a benchmark in Tier 3 is that it does not meet the criteria for Tier 1 or Tier 2.

A1.19 In addition to our assessment of which tier a benchmark is in, we have assessed whether there is a risk that each benchmark is an understated or overstated estimate of the UK value of the relevant band.

Updates to the model compared to the 2018 Consultation

Accounting for PPP changes between auction dates

A1.20 To derive UK-equivalent absolute values, we need to convert from local currency prices to £ sterling. In constructing relative values, we must further consider inflation between the first and second auction when these were held in different years.

A1.21 We account for currency conversions using the ratio of the PPP indices for a given benchmark country and the UK in the year of an auction award. This is done using annual PPP data from the 2018 World Bank World Development Indicator (WDI) series. The WDI values give the number of units of a country's currency required to buy the same amounts of goods and services in the domestic country as US dollars would buy in the United States.

A1.22 In previous models, we used UK CPI as a proxy for inflation in benchmark countries where the absolute values used in the construction of the benchmark were separated by more than a year. This was done by removing the PPP adjustment from the absolute values used.

This meant that differences in award timing were only accounted for using UK CPI. In its response to the 2018 Consultation Telefonica suggested this methodology produced an incorrect account of inflation.[8]

A1.23 We agree with Telefonica that it is more appropriate to convert auction prices to £ sterling at the time of award and then apply UK CPI to adjust for inflation. This approach accounts for differences in national inflation rates and as such we consider produces a more accurate ratio of spectrum values in the given benchmark country.

A1.24 This issue only arises for countries where the auctions used to construct relative spectrum values are separated by significant lengths of time. For the 900/800MHz ratios constructed this was the case for the pairs of auctions in Germany, Denmark and Greece (see Table A1.1). These benchmarks are highlighted with bold text in the table. Benchmarks are classified by country and the year of the 900 or 1800 MHz auctions used to construct the benchmark respectively.

Table A1.1: Timing of 900MHz and 800MHz auctions used to construct relative ratios

Tier	Country	800 MHz	900 MHz	Gap between auctions
1	Austria (2013)	10/13	10/13	None
	Germany (2015)	**5/10**	**6/15**	**61 months**
	Ireland (2012)	11/12	11/12	None
2	Portugal (2011)	11/11	11/11	None
	Spain (2011)	7/11	11/11	4 months
3	**Denmark (2010)**	**6/12**	**9/10**	**21 months**
	Greece (2011)	**10/14**	**11/11**	**35 months**
	Romania (2012)	9/12	9/12	None

Source: Ofcom

A1.25 For the distance method used to derive the value of 1800 MHz spectrum, the auctions in Austria, Czech Republic, Denmark, Germany, Greece and Sweden are affected by a separation of at least one year between the dates of at least two of the three auctions used to construct the benchmark for any given country (see Table A1.2). These benchmarks are highlighted with bold text in the table.

[8] Telefonica Response to Ofcom's Consultation on ALF for 900 and 1800, Section 54.b.

Table A1.2: Timing of 1800MHz, 800MHz and 2.6GHz auctions used to construct the distance method[9]

Tier	Country	800 MHz	1800 MHz	2.6 GHz	Max gap between auctions
1	**Austria (2013)**	**10/13**	**10/13**	**10/10**	**36 months**
	Czech Republic (2016)	**11/13**	**6/16**	**6/16**	**31 months**
	Denmark (2016)	**6/12**	**9/16**	**5/10**	**76 months**
	Germany (2015)	**5/10**	**6/15**	**5/10**	**61 months**
	Ireland (2012)	11/12	11/12	Proxy[10]	No gap
	Italy (2011)	9/11	9/11	9/11	No gap
	Sweden (2011)	3/11	10/11	Proxy	7 months
2	Germany (2010)	5/10	5/10	5/10	No gap
3	Czech Rep (2013)	11/13	11/13	11/13	No gap
	Greece (2011)	**10/14**	**11/11**	**10/14**	**35 months**
	Greece (2017)	**10/14**	**11/17**	**10/14**	**37 months**
	Portugal (2011)	11/11	11/11	11/11	No gap
	Romania (2012)	9/12	9/12	9/12	No gap
	Slovak Republic (2013)	12/13	12/13	12/13	No gap
	Sweden (2016)	**3/11**	**10/16**	**Proxy**	**67 months**

Source: Ofcom

A1.26 If the ratio of PPP values in the UK and a benchmark country is stable between auctions, inflation is entirely reflected by UK CPI. When the inflation rate has differed between the UK and a benchmark country between auctions, this will be captured by the ratio of PPP values.

A1.27 The impact of this adjustment is greatest for Denmark – where it results in an increase of around 8% – and Greece – where it leads to an 11% decrease in estimated value compared

[9] Bold text is used to indicate benchmarks where the auctions used to construct it are separated by more than 12 months.
[10] See below for an explanation of the 2.6GHz proxy.

with the value we would obtain using the previous inflation and exchange rate conversion. This is primarily due to the significant time lag between the Danish 1800 MHz and 2.6 GHz awards (around six years), a period during which UK inflation outpaced Danish inflation. This meant that our previous approach overstated the value of 2.6 GHz relative to the other bands, which resulted in an understated distance method benchmark. This impact was amplified by the fact that the price of 2.6 GHz spectrum is relatively high in Denmark, such that changes in value of this band have a proportionately larger impact on the Y/X ratio in Denmark.

A1.28 For Austria (a change of 0.1%) and Germany (a change of 1.8%) the impact of adjusting the approach to currency conversion is smaller than for Denmark and Greece.

Inclusion of the Czech Republic within the 2.6 GHz Proxy

A1.29 If 800 MHz and 1800 MHz auction values are available for a given country, but a 2.6 GHz spectrum value is not, a 2.6 GHz proxy is used to derive the relative UK-equivalent 1800 MHz value.

A1.30 We have previously calculated this proxy by calculating the ratio of 2.6 GHz to 800 MHz prices in all countries that provide more useful evidence on this ratio (Austria, Germany, Italy, Spain and the United Kingdom), and then taking the midpoint of the range implied by the highest and lowest 2.6 GHz ratios from each of these countries. The highest ratio is given by the United Kingdom (18% based on the net 800 MHz value, and 17% based on the gross 800 MHz value) while the lowest ratio is given by Austria (3% based on the net and gross 800 MHz value).[11]

A1.31 We have now expanded that list to include the ratio for the Czech Republic, as we have a new 2.6 GHz price from the Czech Republic's 2016 auction, and we consider that the 2.6 GHz to 800 MHz ratio calculated using this price provides good evidence on the ratio (as set out in Annex 2, paragraphs A2.72 to A2.75). The new ratio for the Czech Republic is 11% (based on the net 800 MHz value) or 10% (based on the gross 800 MHz value).

A1.32 As such, the upper and lower bounds continue to be defined by the ratios of the UK and Austrian auctions respectively. Therefore, the inclusion of the Czech Republic has no impact on the value of the 2.6GHz proxy. The ratio of 2.6 GHz to 800 MHz used is therefore 10.7% net and 9.7% gross of DTT co-existence costs.

Discount Rates

A1.33 There are three situations where we use a discount rate in deriving our international benchmark estimates:

a) some of the auctions involve spectrum licences with different licence durations. In order to derive a value on a comparable basis to the UK auction licences, we need to adjust the auction prices to estimate the value for a licence duration of twenty years;

[11] See Table A7.7 of the 2015 Statement.

b) in some countries there were significant delays between the conclusion of spectrum auctions and the spectrum becoming available for use by the successful bidder. In order to derive a value on a comparable basis to the UK auction licences, we need to allow for the fact that observed auction prices are likely to reflect the value of the licence at the date the spectrum becomes available for use, discounted back to the date of the auction; and

c) some of the auctions involved licences on which ALFs were payable. In order to derive a value on a comparable basis to the UK auction licences, we need to incorporate the value of these fees into the present values of the auction revenues.

A1.34 As in our 2015 Statement, we use country specific discount rates (from mobile call termination (MCT) decisions) for Tier 1 and Tier 2 countries whose benchmarks are affected by adjustments requiring a discount rate. For other countries we use the corresponding UK discount rate as a proxy.

A1.35 The discount rates we use in each of these scenarios are summarised in Table A1.3 and discussed in more detail below.

Table A1.3: Overview of adjustments made to the discount rates

	Tier 1 and 2 countries whose benchmarks are affected by adjustments involving the discount rates	Other countries
(i) Where benchmark country licences are different lengths	Country-specific post-tax real WACC from contemporaneous MCT decision	UK post-tax real WACC from 2011 or 2015 MCT decision
(ii) Delayed availability of spectrum	Country-specific post-tax real WACC from contemporaneous MCT decision	UK post-tax real WACC from 2011 or 2015 MCT decision
(iii) ALFs charged during initial licence period/auction price paid in instalments	Country-specific pre-tax nominal cost of debt from contemporaneous MCT decision	UK pre-tax nominal cost of debt from 2011 or 2015 MCT decision

Source: Ofcom

Licence duration, fees/payments by instalments, and delayed availability of spectrum

A1.36 In order to calculate UK-equivalent values for a notional 20-year spectrum licence, we make adjustments to international benchmarks to reflect differences in licence duration, or where there was delayed availability of spectrum in a given country. These adjustments are intended to reflect the difference in value an operator would place on having access to spectrum for a shorter (or longer) period, which itself depends on the difference in future cash flows they expect to earn. As the risk of these expected cash flows should be reflected in this adjustment, in the 2015 statement we considered it appropriate to make this

adjustment using the WACC.[12] The appropriate WACC to use will reflect expectations at the time of the auction.

A1.37 We previously used a country-specific discount rate for all countries where a Tier 1 or 2 auction was held whose benchmarks are affected by adjustments requiring a discount rate. The choice of discount rate generally affects relative benchmarks where licences for different bands within each country have different start and end dates.

A1.38 As this is the case for our new Tier 1 benchmarks (Czech Republic and Denmark), we have used country-specific discount rates for these countries. The discount rate is derived from the country-specific pre-tax nominal WACC, the corporate tax rate and inflation. These values were taken from the national regulator's mobile call termination (MCT) statement published most closely to the auction date.

A1.39 For Denmark the post-tax real WACC is 4.44% and 4.02% for 2010 and 2016 respectively and the pre-tax nominal cost of debt 5.41%. For the Czech Republic the post-tax real WACC is 4.86 % and 4.56 %, and the pre-tax nominal cost of debt is 4.51 % and 3.71% for 2013 and 2016 respectively.[13]

A1.40 For new Tier 3 benchmarks for countries where the majority of auctions were held prior to 2015, we continue to use the UK post-tax real WACC and pre-tax nominal cost of debt from the 2011 MCT statement. For countries where the majority of the benchmark auctions were held in 2015 or later, we use the UK post-tax real WACC and pre-tax nominal cost of debt from the 2015 MCT statement. This approach of using UK values is taken in order to avoid a level of analysis which is disproportionate to the weight placed on these benchmarks in our assessment of lump-sum values.

A1.41 In our 2015 Statement we accounted for the delayed availability of spectrum in Germany and Austria. We have since become aware that the 800MHz and 2.6GHz spectrum auctioned in Italy in 2011 also became available after a delay. We have updated our calculation of the Italian benchmark to reflect this information.

A1.42 The Greek 1800MHz spectrum bands auctioned in 2017 also became available after a delay. We account for this delay but as Greece is a Tier 3 benchmark we do not use a country-specific discount rate to do so.

A1.43 For ALFs charged during the initial licence period or for auction prices which can be paid in instalments we considered that the adjustment to incorporate the present value of annual fees into a lump sum for licences is essentially the reverse adjustment we make in annualising the lump sums into annual fees if there were no likelihood of review.

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[12] See A7.38, Annex 7 2015.

[13] For 2010, we use the 2012 Czech Republic values sourced from these two documents: https://www.ctu.cz/sites/default/files/obsah/ctu-online/74041/soubory/oop04-122011-19.pdf and https://www.ctu.cz/cs/download/art/oop/rozhodnuti/oop_art-07-12_2013-09.pdf. The 2016 Czech Republic values are sourced from these two documents: https://www.ctu.cz/sites/default/files/obsah/stranky/69256/soubory/oopart-2-04-2016-6.pdf and https://www.ctu.cz/sites/default/files/obsah/ckeditor/oop_04-12_2015-07.pdf.
For Denmark we received the values directly from correspondence with the Danish Business Authority.

A1.44 As in the 2015 statement, we consider that it is appropriate to calculate the discount rate by using a pre-tax nominal[14] cost of debt (without a risk sharing adjustment) for the following reasons[15]:

a) Cost of debt without a risk sharing adjustment: For at least some of these countries, we understood that the annual fees may not be reviewed, or not reviewed on the basis of changes in market value. We said that where there is limited prospect for a future review based on changes in market value, the government's additional share of risk may be minimal. We also noted that the spectrum licensees have already paid a lump sum at auction, so the annual fees only reflect a proportion of the value of the spectrum. This will reduce the probability of a hand-back of spectrum.

b) Cost of debt in the WACC calculation: In some of these countries, e.g. Ireland and Sweden, we were aware that the NRA used a long-term view of the cost of debt or risk-free rate, which is less affected by the macro-economic cycle at any given time. Nevertheless, we adopted the cost of debt value from the regulator's WACC calculations, given that we do not have reliable information about the yield to maturity for MNOs' long-term bonds in the relevant countries. We considered this approach was practical and proportionate.

c) Nominal discount rate: Generally, annual fees in these countries did not appear to be adjusted annually for inflation in the same way we are adopting for ALFs in the UK. We said we should therefore discount future fee payments using a nominal discount rate. Ireland is the exception. Since its fees are index-linked to inflation, we used a real rather than nominal rate for the cost of debt.

d) Pre-tax discount rate: In the context of annualisation, we considered that the conceptually correct approach was to discount the lump sum using the post-tax discount rate, but adjusting explicitly for any difference in tax position between a lump sum and annual payments through a tax adjustment factor (TAF). We previously set out that the implications for the level of ALF is broadly similar whether using a post-tax approach (with a separate adjustment for the differential tax treatment) or using a pre-tax approach. We therefore considered it a reasonable proxy to apply the pre-tax discount rate.

A1.45 Further to the approach we used in 2015, we now make a 40 basis points reduction to the nominal pre-tax cost of debt to adjust for a liquidity risk premium. This value is the UK liquidity risk premium found to be appropriate in the annualisation calculation outlined in Annex 5. Using the UK value as a proxy for the extent of liquidity effect in any domestic debt premium is a reasonable simplification given the low sensitivity of the model to variation in this rate

A1.46 Table A1.4 below summarises the discount rates used.

[14] With the exception of Ireland, for which we use a pre-tax real cost of debt (as explained in sub-paragraph c))
[15] See Section A7.45 in Annex 7 2015.

Table A1.4: Information for country-specific discount rates for Austria, Germany, Ireland, Portugal, Spain and Sweden, Czech Republic, Denmark

	Austria	Germany (2010)	Germany (2015)	Ireland	Portugal	Spain	Sweden	Denmark	Denmark (2016)	Czech Republic	Czech Republic (2016)
Year of the auction	2013	2010	2015	2012	2011	2011	2011	2010	2016	2013	2016
Year rates refer to	2013	2010	2014	2012	2012	2011	2011	2010	2016	2013	2016
Real post-tax WACC	**6.7%**	**4.5%**	**3.4%**	**6.6%**	**6.1%**	**6.2%**	**4.9%**	**4.4%**	**4.0%**	**4.9%**	**4.6%**
Tax rate	25%	29.41%	29.65%	12.5%	29%	30.1%	26.3%	22%	22%	19%	19%
Relevant inflation rate	1.75%	1.02%	1.15%	2.21%	1.7%	1.7%	2%	1.5%	1.5%	1.75%	1.75%
Pre-tax cost of debt (COD)	**7.28% (nominal)**	**4.95% (nominal)**	**4.06% (nominal)**	**4.59% (real)**	**6.1% (nominal)**	**5.5% (nominal)**	**3.84% (nominal)**	**5.41% (nominal)**	**5.41% (nominal)**	**4.51% (nominal)**	**3.71% (nominal)**
COD minus liquidity premium[16]	6.88%	4.55%	3.66%	4.20%	5.70%	5.10%	3.44%	5.01%	5.01%	4.11%	3.31%
Are annual fees index-linked?	No	N/A	N/A	Yes	No	No	N/A	No	No	No	No

[16] We made an adjustment to the cost of debt to account for a liquidity risk premium in line with the annualisation methodology outlined in Annex 5. As a simplifying assumption we applied the same 40 basis points reduction for all benchmark countries where a discount rate based on the cost of debt was required.

Potential for review of annual fees	Yes*	N/A	N/A	No	Yes**	Yes	N/A	No	No	Yes***	Yes***
Source	RTR	BNetzA	BNetzA	Comreg	Anacom	CME	PTS	DBA	DBA	CTU	CTU

Source: For a discussion of Denmark and the Czech Republic see below, for all other countries see 2015 Annex 7, Table A7.2

* Changes to the annual licence fee require an amendment of the relevant legal regulations in the TKGV, the ordinance that regulates the fee. However, this ordinance has not been changed since it was first issued in 1998.

** The Portuguese Government changed the level of annual licence fees in December 2013, http://www.anacom.pt/render.jsp?contentId=1187122&languageId=1

*** To change the level of annual licence fees the government would need to issue a new decree.

Pricing information

A1.47 Our primary data source on European spectrum auctions continues to be DotEcon's database. This dataset has been updated since 2015. We use the current version resulting in some minor changes in input information compared to that used in the 2015 Statement and 2018 consultation.

A1.48 The updated database continues to include all the award-level and lot specific variables used in our 2015 and 2018 publications. The information used relates to price information (such as reserve prices, upfront fees and the future payments, by year, of fees levied on the licence) as well as other non-price information (such as lot size and licence duration).

A1.49 For combinatorial clock auctions (CCAs) we continued to rely on the lot specific price information derived for the 2015 Statement. In CCAs, the published prices are for winning packages which often include spectrum in more than one band. Unlike simultaneous multiple-round auctions (SMRAs), prices are not determined on a lot- or band-specific basis in these awards but as prices for the winning packages of spectrum.[17]

Population data

A1.50 Annual population data is drawn from the World Bank World Development Indicators population series. Generally, calculations consider the annual population of a given country in the year of an auction award. An exception to this rule is made for a series of regional Spanish auctions for which we do not have annual population data and where we continue to rely on the population figures used in the 2015 Statement.

CPI data

A1.51 UK inflation is accounted for using the Statistics Board (Office for National Statistics) (ONS) consumer price index (CPI). This most recent version of the CPI index was used which uses 2015 as the base year.[18]

[17] For a more detailed explanation of how the CCA prices are derived, see Section A7.14 to A7.23 in Annex 7 to the 2015 Statement. https://www.ofcom.org.uk/__data/assets/pdf_file/0028/79534/annexes_1-7.pdf

[18] See https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/d7bt/mm23.

A2. Recent European spectrum awards

Introduction

A2.1 This annex is an update to the 2015 Statement Annex 8. Here we list all recent European spectrum auctions since the 2015 Statement and discuss the results of the relevant awards in these countries. The awards and countries not included here remain as set out in Annex 8 to the 2015 Statement. We have, however, updated the data and methodology for all benchmarks (including those set out in Annex 8 to the 2015 Statement) as set out in Annex 1.

A2.2 In response to our 2018 consultation, we received comments on the additional European auctions discussed in Annex 4 of our June 2018 consultation. One stakeholder commented on the Turkish 1800 MHz award in 2015 (that we assessed in the 2015 Statement). The awards from our June 2018 consultation were:

a) the Danish 1800 MHz auction in September 2016;

b) the Norwegian 1800 MHz auction in January 2016; and

c) the Norwegian 900 MHz auction in May 2017.

A2.3 In addition, stakeholders drew our attention to three additional European auctions of 1800 MHz spectrum since 2015 that we had not considered in our June 2018 consultation. These were:

a) the Czech Republic 1800 MHz award in June 2016;

b) the Greece 1800 MHz award in November 2017; and

c) the Sweden 1800 MHz award in October 2016.

A2.4 As a part of our wider research since the June 2018 consultation, we have identified some further awards that have taken place since the 2015 Statement.

a) the Croatian 1800 MHz award in November 2015

b) the Lithuanian 900 MHz and 1800 MHz awards in January 2016.

c) the Slovenian 1800 MHz award in September 2016.

A2.5 Due to the auction format and unavailability of band specific prices for the Lithuanian and Slovenian awards, we were not able to calculate benchmark spectrum values.[19] However, we do not think these would qualify as Tier 1 benchmarks (our approach to tiering overseas awards is explained below).

A2.6 Several other European countries have assigned spectrum licences in the 900 MHz and 1800 MHz frequency bands since our 2015 Statement. However, we did not consider that

[19] This spectrum was awarded using the combinatorial clock auction (CCA) format and to calculate benchmarks from a CCA we would require detailed band specific price data from the NRA.

these awards were relevant in informing us about market value in the UK as they did not involve an auction process. These were:

a) The Maltese 1800 MHz award in September 2018; and

b) the French 900 MHz and 1800 MHz award in October 2018.

A2.7 Tables A2.1 and A2.2 set out the complete list of countries that we use for the 900 MHz and 1800 MHz relative benchmarks respectively and the dates of the auctions used in deriving those benchmarks.

Table A2.1: Auctions used in deriving the 900 MHz relative value benchmarks

	Tier	800 MHz auction	900 MHz auction
Austria (2013)	1	October 2013	October 2013
Germany (2015)	1	May 2010	May 2015
Ireland (2012)	1	November 2012	November 2012
Portugal (2011)	2	November 2011	November 2011
Spain (2011)	2	July 2011	July 2011
Denmark (2010)	3	June 2012	October 2010
Greece (2011)	3	October 2014	November 2011
Romania (2012)	3	September 2012	September 2012

Table A2.2: Auctions used in deriving the 1800 MHz relative value benchmarks[20]

	Tier	800 MHz auction	1800 MHz auction	2.6 GHz auction
Austria (2013)	1	October 2013	October 2013	September 2010
Czech Republic (2016)	1	November 2013	June 2016	June 2016
Denmark (2016)	1	June 2012	September 2016	May 2010

[20] The notation 'n/a' in this table is used for countries in which no 2.6 GHz spectrum has been auctioned or in the case of Sweden the 2.6 GHz spectrum was auctioned in 2008 and is for that reason outside our observation period. To derive a distance method benchmark for these countries we have used the 2.6 GHz proxy. For further details see Annex 1.

	Tier	800 MHz auction	1800 MHz auction	2.6 GHz auction
Germany (2015)	1	May 2010	June 2015	May 2010
Ireland (2012)	1	November 2012	November 2012	n/a
Italy (2011)	1	September 2011	September 2011	September 2011
Sweden (2011)	1	March 2011	October 2011	n/a
Germany (2010)	2	May 2010	May 2010	May 2010
Croatia (2015)	3	November 2013	November 2015	n/a
Czech Republic (2013)	3	November 2013	November 2013	November 2013
Greece (2011)	3	October 2014	November 2011	October 2014
Greece (2017)	3	October 2014	November 2017	October 2014
Portugal (2011)	3	November 2011	November 2011	November 2011
Romania (2012)	3	September 2012	September 2012	September 2012
Slovak Republic (2013)	3	December 2013	December 2013	December 2013
Sweden (2016)	3	March 2011	October 2016	n/a

Annex structure

A2.8 In this annex, we cover:

a) European awards that we have derived benchmarks for since the 2015 Statement. This includes the auctions in our June 2018 consultation and awards highlighted by stakeholders in response to our consultation;

b) Awards that we have identified or considered since our 2015 Statement but where we have not derived benchmarks; and

c) Specific comments raised by stakeholders on auctions that we considered in our 2015 Statement and our responses to these comments.

European awards since the 2015 Statement

A2.9 As with the 2015 Statement, our assessment of the recent European spectrum awards in the 900 and 1800 MHz bands contains separate sections for each of the new benchmarks considered. For each country, we include:

a) The circumstances and outcome of the auction or auctions. This includes a table summarising the amount of spectrum won by each winning bidder, and the prices paid. It also includes a table detailing the major rules and features of the auction design.

b) Our position in the 2015 Statement on previous benchmarks from that country, if applicable.

c) Where relevant, a summary of responses to the June 2018 consultation relating to the benchmarks included in this Annex.

d) Our final assessment of whether the absolute and relative values derived from each auction are likely to reflect market value in the country concerned, and whether market value in the country concerned is likely to reflect UK market value.

e) A summary of the benchmarks and our assessment. This includes a table capturing absolute and relative benchmarks from the award, along with the tier of evidence to which the values belong. It also includes our interpretation of each benchmark in terms of the likelihood, scale and direction of any overstatement or understatement of UK market value.

A2.10 We have not identified 900 MHz relative value benchmarks since the 2015 statement. Therefore, Table A2.3 sets out the principal relative value benchmarks from the recent European spectrum auctions since the 2015 Statement for the countries where these have been derived for 1800 MHz only. The awards that we consider but do not derive benchmarks for are included at the end of this section.

Table A2.3: Summary of 1800 MHz distance method benchmarks from auctions since the 2015 Statement

Country	1800 MHz relative value benchmark in £m per MHz (Y/X ratio)	Assessment of the distance method benchmark	Tiering assessment			
			Tier	Were prices determined by a market-driven process?	Intrinsic value bidding or strategic bidding? Or, if 'No' in previous column, evidence of prices reflecting relative intrinsic values?	Relevant country-specific factors?
Croatia (2015)	£20.9m (57%)	Risk of overstatement	Tier 3	No	Intrinsic value bidding less likely than strategic bidding	No
Czech Republic (2016)	£14.9m (34%)	Risk of understatement	Tier 1	Yes	Intrinsic value bidding at least as likely as strategic bidding	No
Denmark (2016)	£27.4m (77%)	Risk of overstatement	Tier 1	Yes	Intrinsic value bidding at least as likely as strategic bidding	No
Greece (2017)	£14.7m (34%)	Risk of understatement	Tier 3	No	No evidence that prices reflect relative intrinsic values	No
Sweden (2016)	£14.1m (28%)	Larger risk of understatement	Tier 3	No	Intrinsic value bidding less likely than strategic bidding	No

Croatia 2015 award

A2.11 We identified the Croatian award as a part of our wider research following the 2018 consultation. This award took place after publication of our 2015 Statement, and stakeholders did not refer to this award in their responses to our 2018 consultation.

A2.12 We consider three relevant awards in Croatia in this Annex:

a) 800 MHz: October 2012;

b) 800 MHz: November 2013;

c) 1800 MHz: November 2015.

A2.13 In Croatia, there are three MNOs: Hrvatski Telekom, VIPnet and Tele2.[21]

October 2012 800 MHz award

A2.14 In October 2012, 800 MHz spectrum was awarded in Croatia. The NRA intended to auction this spectrum with a reserve price of HRK 150 million per 2x10 MHz lot and a spectrum cap of 2x10 MHz implying that each MNO was limited to bid for one lot.

A2.15 The award information is set out in Table A2.4 below.

Table A2.4: October 2012 800 MHz results

	800 MHz	Price Paid (HRK[22])
Total Available	**2x30**	**-**
VIPnet	2x10	150,000,000
Hrvatski Telekom	2x10	150,000,000
Unsold	2x10	-

A2.16 Only two of the three existing MNOs expressed interest for this spectrum. For this reason, the NRA assigned one lot of 800 MHz spectrum to VIPnet and Hrvatski Telekom each against a set fee of HRK 150 million and the third lot was not sold[23].

[21] Europe's Digital Progress Report – 2017 (Croatia) available at http://ec.europa.eu/newsroom/document.cfm?doc_id=44461
[22] Croatian kuna.
[23] The licence is valid up to October 2024.

A2.17 The licence holders were able to choose between paying the full spectrum price upfront or splitting the payments over the duration of the licence. We understand that these licences were also subject to annual licence fees[24].

November 2013 800 MHz auction award

A2.18 In November 2013, the NRA auctioned the unsold 2x10 MHz 800 MHz spectrum from 2012. Two lots of 2x5 MHz (A and B lot) were offered using a first-price sealed-bid auction (FPSB) for an eleven-year period starting immediately.

A2.19 We understand that there was no spectrum cap, but a coverage obligation required that the MNO cover at least 50% of territory in five years from the moment when the NRA declares this spectrum available with acceptable levels of interference.[25] The reserve price for one lot of 2x5 MHz (either A or B lot) was HRK 105 million.

A2.20 The results of this auction are set out in Table A2.5 below.

Table A2.5: November 2013 800 MHz results

	800 MHz	Block A MHz	Block B MHz	Price Paid (HRK)
Total Available	**2x10**			**-**
Vipnet	2x5	2x5		110,149,999
Hrvatski Telekom	2x5		2x5	105,652,000

A2.21 The NRA received two offers for the A lot and one for the B lot.[26] VIPnet secured the A lot for HRK 110,144,999 and Hrvatski Telekom bought the B lot for HRK 105,652,000.

A2.22 The successful MNOs were able to split the payments of auction price into equal instalments for the duration of the license. VIPnet chose to pay the auction price and annual licence fee up-front, whilst Hrvatski Telekom paid the auction price up-front and the ALF in installments for the duration of the licence.[27]

[24] An 800 MHz spectrum licence includes a usage fees of 800,000 kuna per MHz per year, spectrum management fees of 180,000 kuna per MHz per year and a separate fee of 0.5% of the revenues they generate from providing 800 MHz services. Available at https://www.telecomengine.com/croatia-4g-spectrum-sale-raises-52-million/

[25] At the time of this award non-EU neighbouring countries did not have the time obligation for the use of WBB.

[26] The following bids were submitted for block A: VIPnet bid HRK 110,144,999 and Hrvatski Telekom HRK 105,110,000.

[27] Available at https://www.telegeography.com/products/commsupdate/articles/2013/11/07/vipnet-t-ht-granted-800mhz-leftovers/

November 2015 1800 MHz auction award

A2.23 In November 2015, the NRA auctioned 2x7.8 MHz of 1800 MHz spectrum (A and B lots[28]) using a FPSB auction format.

A2.24 The results of this auction are in Table A2.6 below and the auction features summarised in Table A2.7 below.

Table A2.6: November 2015 1800 MHz results

	1800 MHz	Price Paid (HRK)
Total Available	**2x7.8**	**-**
VIPnet	2x7.8	141,400,000

Table A2.7 November 2015 1800 MHz auction features

	Description	Comment
Number of bidders; number of lots; lot sizes	There was only one bidder for the auctioned 2x7.8 MHz spectrum.	In 2017, a total of 150 MHz of 1800 MHz spectrum had been assigned in Croatia[29].
Spectrum caps/restrictions	Spectrum cap of 2x30 MHz applied (including previously assigned spectrum)[30].	Spectrum cap was binding for Hrvatski Telekom due to its previous holdings, and Tele2 would have been able to bid for the smaller lot (2x3 MHz). Only VIPnet was able to bid for both auctioned lots.
Reserve prices	Reserve price for lot A (2x3 MHz): 54,000,000 Reserve price for lot B (2x4.8 MHz): 86,000,000	The auctioned 2x3 MHz lot sold 2% above reserve price. The auctioned 2x4.8 MHz lot sold at reserve price.

[28] A lot was 2x3 MHz and B lot was 2x4.8 MHz.
[29] The three MNO holdings of 1800 MHz spectrum in 2017: Tele2 2x27 MHz; VIPnet 2x17.8 MHz; HT 2x30 MHz.
[30] Hrvatski Telekom's market review would suggest that the spectrum cap was binding for all but VIPnet. See Hrvatski Telekom's review available at: https://www.t.ht.hr/ResourceManager/FileDownload.aspx?rId=10192&rType=2

	Description	Comment
Obligations	To cover 95% of population and 75% of territory in five years for new entrants from the date of the licence assignment, and for the existing operators the same percentage as in existing licenses for that frequency band.	Before the 2015 1800 MHz auction, VIPnet already held an 1800 MHz licence (2x10 MHz) from a previous spectrum assignment.
Other factors	The NRA expected the successful MNO to pay the auction price upfront.	

A2.25 We have considered whether absolute and relative values derived from this auction are likely to reflect market value in Croatia, and whether the value of 1800 MHz spectrum in Croatia is likely to reflect UK market value.

Whether award outcomes are likely to reflect market value in Croatia

800 MHz spectrum award in October 2012

A2.26 Only two of the existing MNOs expressed interest for the offered spectrum. For this reason, the licensed spectrum was assigned through an administrative process for a set fee, and one of the 2x10 MHz lots was not sold. As the award is not likely to reflect market value in Croatia we do not consider it relevant for our assessment.

800 MHz spectrum award in November 2013[31]

A2.27 In the 2013 800 MHz auction, there was no spectrum cap and two lots of 2x5 MHz 800 MHz spectrum was offered for sale in a FPSB auction. Two of the existing MNOs bid: the NRA received two bids for lot A and one bid for lot B. Lot A sold for 4.9% above the reserve price, and lot B 0.6% above the reserve.

A2.28 Generally, the auction prices suggest that the interest in additional 800 MHz spectrum at the time of the auction was low and/or that the reserve prices were set high relative to the market value[32].

A2.29 Considering this, it is unlikely that the auction was market-driven, and that the primary determinant of the auction results was the level of the reserve prices. On this basis, we

[31] In total, 60 MHz of 800 MHz spectrum has been licensed in Croatia.
[32] At the time of 800 MHz award the NRA decided not to auction the spectrum in the 2.6 MHz and 3.6 GHz frequency bands due to lack of demand from operators.

conclude that the award risks understating market value in Croatia, but that the extent and scale of this understatement is unknown.

1800 MHz award in 2015

A2.30 In November 2015, the NRA auctioned 1800 MHz spectrum in two non-standard lots (A lot 2x3 MHz and B lot 2x4.8 MHZ) using a FPSB auction format.[33]

A2.31 We understand that the NRA received one bid for each lot. A spectrum cap of 2x30 MHz applied and the cap was binding for Hrvatski Telekom. Tele2 would have been able to bid for the 2x3 MHz lot, but only VIPnet expressed interest. The smaller lot sold 2% above the reserve price, whilst the 2x4.8 MHz lot sold at reserve. In the absence of the spectrum cap, Hrvatski Telekom could have bid for more spectrum and this would have driven up the price of the 1800MHz spectrum. We therefore consider that this creates a risk that the 1800 MHz prices understate the market value of 1800 MHz in Croatia.

A2.32 As we noted in our 2015 Statement, awards of less than 2x5 MHz of 1800 MHz spectrum may have lower value than 2x5 MHz LTE lots.[34] We consider that this creates a risk that the 1800 MHz auction prices understate the market value in Croatia.

A2.33 The auction used a FPSB format which introduces a risk that participants engage in bid shading rather than bidding their valuation of the lot.[35,]

A2.34 In a single-round sealed-bid first price auction, bidders are highly likely to consider how others might bid.[36] When determining what to bid, bidders will typically trade off the amount paid in the event of winning (which they would want to minimise) with the chance of having a higher bid than those of their rivals. In having these considerations, bidders will decide what share of their valuation they will bid. Making bids below valuation is referred to as "bid shading".

A2.35 In the Croatian case, the auction format may have played a role in the outcome of the auction and there is a risk that the outcome understates market value due to bid shading.

A2.36 Due to lack of competition for the 1800 MHz spectrum driven by binding spectrum caps, non-standard lot sizes and the auction format, we consider that there is a larger risk the 1800 MHz auction price understates the market value in Croatia although we cannot be sure of the scale of this understatement.

2.6 GHz proxy

[33] In total, 150 MHz of 1800 MHz spectrum has been assigned to date (this includes the 2015 spectrum auction). We understand that additional to the 2015 spectrum auction that 2x47 MHz of spectrum was assigned separately.
[34] See 2015 Statement Annex 8, paragraph A8.231.
[35] For a fuller discussion of FPSB auctions see paragraphs Sweden 2016 award see paragraphs A2.215 A2.216.
[36] See paragraphs 7.13 to 7.18. of 'Award of available spectrum: 872-876 MHz paired with 917-921 MHz'. These outline some considerations around using first-price sealed-bid format to auction spectrum, available at https://www.ofcom.org.uk/__data/assets/pdf_file/0021/38424/872-876.pdf.

A2.37 As noted earlier, the Croatian NRA has not awarded spectrum in the 2.6 GHz frequency band.[37] To derive a distance method benchmark, we use the 2.6 GHz proxy. As noted in the 2015 Statement, using the 2.6 GHz proxy value carries a risk of under/overstatement to the distance method benchmark as there is a risk that the average ratio of 2.6 GHz to 800 MHz may not reflect closely the relative value of these bands in Croatia.[38] The scale of this under/overstatement is however unknown.

Likelihood of spectrum awards reflecting market value in the UK

A2.38 Given that Croatia has a lower level of urbanisation than in the UK, the market value of 800 MHz in Croatia may be overstated relative to the UK.[39] The scale of this potential overstatement risk is however unknown.

A2.39 We are not aware of any country-specific factors in Croatia that would cause the 1800 MHz spectrum auction in Croatia to understate or overstate the value in the UK.[40]

Assessment of the Croatian 1800 MHz benchmarks

A2.40 Below we outline our assessment of the Croatian distance method benchmark.

A2.41 We also summarise our tiering assessment of that benchmark.

Risk of understatement or overstatement of the Croatian distance method benchmark

A2.42 Here we list the risks associated with the Croatian distance method benchmark relative to the UK market value:

a) The prices for the Croatian 800 MHz award in 2013 were, in our view, primarily determined by the reserve set by the NRA. Consequently, there is a risk that the 800 MHz price understates the market value. We are unable to determine the scale of this understatement.

b) Due to binding 1800 MHz spectrum caps, the small lot sizes and the format of the auction, we consider that the 1800 MHz award has a larger risk of understating the UK market value although the scale of this understatement is unclear.

c) We consider that using the 2.6 GHz proxy to calculate the distance method benchmark risks under/overstating market value in the UK, but the scale of this risk is unknown.

[37] At the time of the assignment of the 800 MHz band for mobile communications services, the NRA decided not to auction the spectrum in the 2.6 GHz and 3.6 GHz frequency bands due to lack of interest from the MNOs. This decision was to ensure mobile communications operators could further invest in network development and coverage. One reason for this was also the lack of use of previously assigned spectrum. 'Europe's Digital Progress Report (2017) available at: http://ec.europa.eu/newsroom/document.cfm?doc_id=44461

[38] See 2015 Statement Annex 8 paragraph A8. 910 in relation to the Swedish distance method benchmark.

[39] According to the World Development Indicators, around 57% of Croatian population is urban compared to 83% in the UK. Available at: http://databank.worldbank.org/data/reports.aspx?source=2&series=SP.URB.TOTL.IN.ZS&country=

[40] Furthermore, consultation feedback from stakeholders has not identified any such factors in relation to the Croatian awards.

d) We are combining auction prices from different auctions in different years, 2013 (800 MHz) and 2015 (1800 MHz). There is a risk that this gap in time affects the risk of under/overstatement, although we have not identified a clear direction or magnitude of the possible effects.

A2.43 Overall, our view is that the 1800 MHz Croatian distance method benchmark carries a risk of overstatement of an unknown scale.

Tiering of the Croatian distance method benchmark

A2.44 Considering the criteria for inclusion in Tier 1:

a) The 800 MHz spectrum sold very close to the reserve price, and only the smaller lot of 1800 MHz spectrum sold slightly above reserve price. We consider that the auction price did not reflect a market-driven process.

b) Given the FPSB format of the 1800 MHz auction, there is a risk that the auction result reflected strategic bidding rather than bidders' intrinsic valuations.

c) The outcome appears likely to be informative of forward-looking relative spectrum values in the UK, having regard to country-specific circumstances and auction dates.

A2.45 Overall, we consider that the benchmark does not meet the Tier 1 criteria. We therefore consider the criteria for inclusion in Tier 2:

a) As awards feeding into the distance method benchmark sold at or close to reserve prices, we consider that the relative band prices would tend to reflect relative reserve prices rather than bidders' relative valuation of different bands;

b) The outcome is not obviously uninformative of forward-looking relative spectrum values in the UK having regard to country-specific circumstances and auction dates.

A2.46 Based on this assessment, we consider that the benchmark should be in Tier 3.

Table A2.8: Summary of evidence points from Croatia (in April 2018 prices)

	Absolute values (£m/MHz)		Relative value benchmarks[41] (£m/MHz)
	800 MHz	1800 MHz	Distance method
Final values	80.6	49.7	20.9 (57%) (Tier 3)
Assessment of risk	Risk of understatement	Larger risk of understatement	Risk of overstatement

[41] Based on the UK 800 MHz value with coverage obligation and net of expected DTT co-existence costs.

Czech Republic 2016 award

Awards considered in our 2015 Statement

A2.47 We considered three relevant awards in the Czech Republic in our 2015 Statement[42]:

a) 800 MHz: November 2013;

b) 1800 MHz: November 2013;

c) 2.6 GHz paired/un-paired: November 2013.

A2.48 The Czech Republic has three MNOs: T-Mobile, Telefónica and Vodafone.

Assessment in our 2015 Statement

A2.49 In 2015, our view was that[43]:

a) The price of 1800 MHz carries a larger risk of understating market value in the Czech Republic due to the lot structure in the auction and the tight spectrum caps and reservations, though we could not be sure of the scale of this possible understatement.

b) The 2.6 GHz price also carries a larger risk of understating market value in the Czech Republic due to tight spectrum caps, though we could not be sure of the scale of this possible understatement.

c) For similar proportional understatements of the 1800 MHz and 2.6 GHz band, the net effect on the distance method is one of understatement. Hence, on balance, we considered that the distance method benchmark carries a larger risk of understatement of UK market value, though we could not be sure of the scale of this possible understatement.

A2.50 We also considered that the 2.6 GHz / 800 MHz ratio carries a larger risk of understatement of relative market value in the Czech Republic (though we cannot be sure of the scale of understatement), as the 800 MHz price likely reflects market value while the 2.6 GHz price risks understating market value.[44]

A2.51 Considering the benchmark against each of the criteria for inclusion in Tier 1, we said:

a) The auction prices for 1800 MHz and 800 MHz were above reserve, and we considered they appeared likely to have been primarily determined by a market-driven process of bidding.

b) Based on the evidence available to us, the relative prices in the auction were at least as likely to be based on bidders' intrinsic valuations of spectrum as on strategic bidding; and

[42] See 2015 Statement Annex 8 from paragraph A8.224 onwards.
[43] See 2015 Statement Annex 8 Table A8.2.3.
[44] See 2015 Statement Annex 8 paragraph A8.251.

c) Due to the lot structure for 1800 MHz spectrum in the auction, the tight spectrum caps and reservations, and the fact that significant amounts of spectrum was unsold, we considered that the 1800 MHz benchmark is less likely to be informative of forward-looking relative spectrum values in the UK.

A2.52 We considered that the 1800 MHz benchmark did not meet our third Tier 1 criteria. We therefore considered the criteria for inclusion in Tier 2.

a) Given the fact that 800 MHz and 1800 MHz spectrum sold above reserve price, we considered there is some evidence that the relative auction prices reflect bidders' relative intrinsic valuations of these bands;

b) However, the 1800 MHz benchmark was obviously uninformative of forward-looking relative spectrum values in the UK.

A2.53 We therefore considered that the benchmark should be in Tier 3.

Responses to our June 2018 consultation

A2.54 We had no further feedback from stakeholders on our assessment of the 2013 800 MHz, 1800 MHz and 2.6 GHz awards in the Czech Republic. However, BT noted that Ofcom had not considered the 2016 Czech 1800 MHz and 2.6 GHz auction awards in its 2018 consultation. BT suggested that the latest 1800 MHz auction data would provide an additional benchmark when used with the 800 MHz and 2600 MHz data points from the Czech spectrum auction in 2013.

A2.55 BT proposed that using the B lot prices of auctioned 1800 MHz spectrum awarded to Vodafone would produce a benchmark with an absolute value of £18.1 million per MHz. It also noted that the distance method benchmark could be calculated by using the 2013 auction data for 800 MHz and 2.6 GHz and would yield a value of £14.6 million per MHz. BT suggested that there was a strong case for this benchmark to be Tier 1 and noted that the Tier 3 designation of the 2013 1800 MHz benchmark was due to perceived deficiencies with the previous 1800 MHz auction.

A2.56 Telefónica also noted that Ofcom had omitted the 2016 Czech Republic auction for 1800 MHz and 2.6 GHz from its consultation analysis. It suggested that including this auction would likely raise the distance method benchmark for the Czech Republic but suggested that we would be likely to deem it in Tier 3 and did not consider it a material omission.

Our assessment

A2.57 We received no further feedback from stakeholders on our assessment of the 2013 awards for 800MHz, 1800MHz and 2.6 GHz in the Czech Republic. Our view of those auctions remains as set out in our 2015 statement. As we set out in Annex 1 we have updated the data and methodology used to derive benchmark values.

A2.58 In response to BT's and Telefónica's consultation feedback, we have assessed the 2016 Czech Republic 1800 MHz and 2.6 GHz awards. Our analysis, tiering and risk assessment are included in the following sections.

June 2016 1800 MHz and 2.6 GHz auction

A2.59 In June 2016, 1800 MHz and 2.6 GHz paired/un-paired spectrum awards took place in the Czech Republic. The spectrum was auctioned using a Simultaneous Multiple Round Ascending (SMRA) format. The results of this auction are set out in Table A2.9, with the auction features summarised in Table A2.10.

Table A2.9: June 2016 1800 MHz and 2.6 GHz results[45]

	1800 MHz	2.6 GHz paired	2.6 GHz unpaired	Price paid (CZK)
Total Available	**2x15.8**	**2x10**	**50**	**2.6 bn**
Telefónica	2x10.8	-	25	1.5 bn
T-Mobile	-	2x10	25	0.7 bn
Vodafone	2x5	-	-	0.4 bn
Unsold	-	-	-	

Table A2.10: June 2016 1800 MHz and 2.6 GHz auction features

	Description	Comment
Number of bidders; number of lots; lot sizes	1800 MHz: In 2016, there were three bidders. Spectrum was awarded in two 2x5 MHz and two 2x2.9 MHz lots. 2.6 GHz: in total 70 MHz of 2.6 GHz spectrum was awarded; paired spectrum awarded in one 2x10 MHz lot, and un-paired in two 25 MHz lots.	This 1800 MHz spectrum was initially auctioned in the 2013 multiband spectrum auction when it was reserved for new entrants and auctioned in one lot of 2x15.8 MHz lots, but went unsold. Most of the paired 2.6 GHz was assigned in 2013 (2x10 MHz was unsold), whilst all un-paired spectrum went unsold.
Spectrum caps/restric-tions	1800 MHz: a spectrum cap of 2x30 MHz including existing holdings. 2.6 GHz: no cap applied.	In the 2016 auction, the 1800 MHz spectrum cap was not binding for any of the winners.

[45] The full breakdown of the auction outcome is available in Czech only at https://www.ctu.cz/sites/default/files/obsah/ctu-online/45604/soubory/oznameniovysledcichaukcedle7.pdf.

	Description	Comment
Reserve prices	1800 MHz[46]: CZK 75.0 million per 2x2.9 MHz lot, and CZK 130.0 million per 2x5 MHz lot. 2.6 GHz: CZK 138.0 million per 2x10 MHz lot.[47]	The reserve prices are based on the 2013 auction reserve prices adjusted for a shorter licence length (the licence end date was aligned with the spectrum auctioned in 2013).
Obligations[48]	1800 MHz: Obligation to provide coverage to 20% of the population within seven years, with a minimum download speed of 2Mbps, increasing to 5Mbps after this period. 2.6 GHz paired: Obligation to provide coverage to 10% of the population within seven years, with a minimum download speed of 2Mbps, increasing to 5Mbps after this period.	The coverage obligations for 1800 MHz is less onerous than in the 2013 auction.[49] The requirements on 2.6 GHz spectrum are identical to the earlier requirements.[50]
Other factors	Licence length: the Czech 1800 MHz licence is for 13 years.[51] Annual licence fees apply.[52]	n/a

A2.60 We have considered whether absolute and relative values derived from this auction are likely to reflect market value in the Czech Republic, and whether the value of 1800 MHz spectrum in the Czech Republic is likely to reflect UK market value.

Whether award outcomes are likely to reflect market value in the Czech Republic

A2.61 In the June 2016 auction, there were no restrictions on participation, the spectrum cap (2x30 MHz) was not binding on any of the bidders and all 1800 MHz spectrum (2x15.8

[46] See Call for Offers (2016) available at https://www.ctu.eu/sites/default/files/obsah/ctu-online/45604/soubory/20160208-vyhlasenivyberovehorizenienfinal.pdf.
[47] The 2.6 GHz un-paired spectrum CZK 93.0 million.
[48] See Call for Offers (2016) available at https://www.ctu.eu/sites/default/files/obsah/ctu-online/45604/soubory/20160208-vyhlasenivyberovehorizenienfinal.pdf section 7.3.1.
[49] In the 2013 Invitation to tender the NRA outlines coverage obligations of 50% coverage within eight years for 1800 MHz.
[50] In 2015, we did not consider that these coverage obligations are likely to require deployments significantly above commercial levels. All the MNOs that secured spectrum from the 2016 auction had previous 1800 MHz holdings which were subject to the more stringent coverage obligations.
[51] For the purposes of calculating our absolute value benchmarks, we have accounted for the differences in licence lengths between the UK and Czech Republic using a discount factor. The UK licence length is 20 years, whilst the Czech Republic 1800 MHz spectrum licence was awarded for 13 years. More detail on the methodology is included in Annex 1.
[52] Further details on annual licence fees available at https://aplikace.mvcr.cz/sbirka-zakonu/.

MHz) sold above the reserve price. Based on this, we consider that the 1800 MHz award is reflective of the market value in the Czech Republic.

Coverage obligations on 800 MHz, 1800 MHz and 2.6 GHz

A2.62 Our view is that the 800 MHz coverage obligations carry no risk of over/understatement to these spectrum values.

A2.63 The coverage obligations for 1800 MHz were less onerous in 2016 than in 2013, and unchanged for 2.6 GHz. Successful MNOs in the 2016 auction were already subject to the 2013 coverage obligations.

A2.64 In 2015[53] we did not consider that the 1800 MHz or 2.6 GHz coverage obligations were overly onerous on operators. We consider it unlikely that the more lenient 2016 requirements influenced the auction prices for the 800 MHz, 1800 MHz or 2.6 GHz spectrum.

Lot structure, competition and auction revenue from 1800 MHz/2.6 GHz spectrum

A2.65 Two of the auctioned lots were 2x2.9 MHz, and all auctioned lots were located between existing spectrum assignments. We have previously noted that lots of 1800 MHz which are smaller than 2x5 MHz may have a lower value.[54] In 2015, we also said that lots located between existing spectrum holdings may have different values to operators depending on their existing holdings and that this may have reduced the intensity of competition for such 1800 MHz lots.[55]

A2.66 We understand that two out of three operators were awarded 1800 MHz spectrum in the 2016 auction: Vodafone acquired a 2x5 MHz lot of 1800 MHz spectrum for CZK 442 million, and Telefónica 2x10.5 MHz for CZK 947.5 million.[56] Auction prices for all lots were significantly above the reserve prices (see Table A2.10 for all reserve prices).[57]

A2.67 In addition, T-Mobile acquired 2x10 MHz of 2.6 GHz paired spectrum for CZK 227.7 million and 25 MHz of un-paired 2.6 GHz for CZK 502.2 million, and Telefónica 25 MHz of un-paired 2.6 GHz for CZK 497.55 million.

A2.68 All individual lots sold significantly above the reserve price, and price per MHz was slightly higher for the 2x2.9 MHz lots of 1800 MHz than 2x5 MHz lots. One possibility is that, jointly

[53] See 2015 Statement Annex 7 paragraph A7.95 and footnote 104.
[54] In most European auctions 1800 MHz has been auctioned in 2x5 MHz lots suitable for LTE. The implication of smaller chunks of 1800 MHz spectrum being sold is that they may have much lower value than standard 2x5 MHz LTE lots (eg. see 2015 Statement Annex 8 paragraph A8.225 or A8.786).
[55] In the 2013 multiband award, 1800 MHz spectrum was auctioned in 2x1 MHz lots that sold at reserve. In reference to this, Telefónica observed that these lots were located in between existing spectrum assignments and were therefore worth significantly more to particular operators, depending on their pre-auction holdings of 1800 MHz. In response to this, we said this might have served to reduce competition among incumbent operators, and also new entrants, for individual 2x1 MHz lots. If so, it meant that the average price for the 2x1 MHz lots of 1800 MHz was significantly lower than the market value in the Czech Republic of a 2x5 MHz block suitable for LTE (see 2015 Statement Annex 8 paragraph A8.231).
[56] Telefónica acquired the A1 lot for CZK 270.0 million (2x2.9 MHz), A2 lot for CZK 262.5 million (2x2.9 MHz) and the B2 lot for CZK 442.0 million (2x5 MHz).
[57] All lots sold above the reserve: A1 260%, A2 250%, B1 240% and B2 240% above the reserve price.

with their existing holdings, these smaller lots may have a higher value to an operator than if an MNO held no 1800 MHz at all, explaining the final auction price for these lots.

A2.69 Considering this, it is not clear whether or by how much the pre-2016 auction 1800 MHz holdings, the non-standard size of 1800 MHz lots, or the fact that these auctioned lots were located in between existing spectrum assignments reduced competition for any of the 1800 MHz lots. It is possible that had the spectrum been structured differently the final auction prices could have been higher. We consider that there is a risk that the 1800 MHz price understates market value in the Czech Republic, but the scale of this understatement is unknown.

A2.70 The 2.6 GHz paired spectrum sold over 1.5 times above the minimum price set by the NRA. This would suggest that the auction is likely to have been competitive and reflective of market values in the Czech Republic. Based on the information available to us, we have not identified a risk associated with this award.

Likelihood of spectrum awards reflecting market value in the UK

A2.71 We are not aware of any country-specific factors that would mean the Czech 2016 1800 MHz value is not reflective of the UK market value in the 1800 MHz frequency spectrum.

Assessment of the 2016 Czech Republic benchmarks

Risk of understatement or overstatement of the Czech distance method benchmark

A2.72 Considering the risks associated with the distance method benchmark relative to the UK market value:

a) We note that there were no bidding restrictions on the participants, and the 1800 MHz spectrum cap was not binding for any of the participants.[58] We consider the 1800 MHz auction price to reflect a market-driven process.

b) However, the lot structure and location carry a risk of understating the Czech distance method benchmark.

c) We are combining auction prices from different auctions in different years, 2013 (800 MHz) and 2016 (1800 MHz and 2.6 GHz). There is a risk that this gap in time affects the risk of understatement or overstatement, although we have not identified a clear direction or magnitude of the possible effects.

A2.73 Based on this assessment, we think there is a risk of understatement to the distance method benchmark.

Tiering of the Czech Republic distance method benchmark

A2.74 Considering the criteria for inclusion in Tier 1:

[58] Based on information published by the NRA available at: http://data.ctu.cz/dataset/prehled-pridelu-radiovych-kmitoctu

a) The auction prices of 800 MHz, 1800 MHz and 2.6 GHz were all above reserve (see paragraphs A2.51 and paragraphs A2.68 to A2.7). This would suggest that the auction prices were primarily determined by a market-driven process of bidding.

b) Based on the evidence available to us, we consider that the relative prices in the auction are at least as likely to be based on bidders' intrinsic valuations of spectrum as on strategic bidding; and

c) The Czech auction outcome appears likely to be informative of forward-looking relative spectrum values in the UK, having considered country-specific circumstances and the timing of these awards.

A2.75 Considering the factors above, we conclude that the Tier 1 criteria are satisfied for the 1800 MHz distance method benchmark from the Czech Republic.

Table A2.11: Summary of evidence points from the Czech Republic (in April 2018 prices)[59]

	Absolute values (£m/MHz)			Relative value benchmarks[60] (£m/MHz)
	800 MHz	1800 MHz	2.6 GHz	Distance method
Final values	52.0	21.3	5.5	14.9 (34%) (Tier 1)
Assessment of risk	No risk identified	Risk of understatement	No risk identified	Risk of understatement

[59] The absolute value for 800 MHz is based on the 2013 auction data, whilst 1800 MHz and 2.6 GHz values and the distance method benchmark are derived from the 2016 auction.
[60] Based on the UK 800 MHz value with coverage obligation and net of expected DTT co-existence costs.

Denmark

Awards considered in our 2015 Statement

A2.76 We considered three auctions in Denmark in Annex 8 of our 2015 Statement:

a) 2.6 GHz: May 2010;

b) 900 MHz and 1800 MHz: September 2010;

c) 800 MHz: June 2012.

A2.77 Denmark has four MNOs: TDC, Telenor, Telia and Hi3G.

A2.78 Our view was that:

a) the joint venture between Telenor and Telia and restrictions on incumbents to participate created an unknown understatement for the absolute 800 MHz price in Denmark of unknown scale.[61]

b) the exclusion of incumbent operators from the September 2010 auction created a larger risk that the 900 MHz and 1800 MHz prices were a larger understatement of market value in Denmark.[62]

c) the price for 2.6 GHz, based on the winning bids by TDC, Telia and Telenor, was reflective of market value in Denmark.[63]

A2.79 We did not include a distance method benchmark for Denmark because the formula generated a negative number, which we did not consider to be in any way sensible as an indication of the UK market value of 1800 MHz. We considered that, in any case, any benchmark for 1800 MHz based on the award of this band in Denmark would at best be Tier 3 evidence.[64]

A2.80 We considered that the 900 MHz / 800 MHz paired ratio of 18% (which implied a UK equivalent market value in March 2013 prices of £5.7m per MHz for 900 MHz spectrum) carried a larger risk of larger understatement of UK market value and that it should be in Tier 3.[65]

Danish 1800 MHz award considered in our June 2018 consultation

September 2016 1800 MHz award

A2.81 In September 2016, an award of 1800 MHz spectrum took place in Denmark. The award used a combinatorial multi-round ascending (CMRA) format.[66]

[61] See 2015 Statement, Annex 8, paragraphs A8.269 and A8.281.
[62] See 2015 Statement, Annex 8, paragraph A8.294.
[63] See 2015 Statement, Annex 8, paragraphs A8.270 and A8.282.
[64] See 2015 Statement, Annex 8, paragraph A8.285.
[65] See 2015 Statement, Annex 8, paragraphs A8.286, A8.290 and A8.295.
[66] See https://www.dotecon.com/news/danish-1800-mhz-auction-third-auction-stage-begins/

A2.82 The results of this auction are set out in Table A2.12 below, with the auction features summarised in Table A2.13 below.

Table A2.12: September 2016 1800 MHz results

	1800 MHz	Price Paid[67]	Package mark-up on reserve price
Total Available	2x65	-	
TDC	2x20	DKK 300.2m	200%
Hi3G	2x20	DKK 300.2m	200%
TT-Netvaerket	2x25	DKK 425.2m	240%
Unsold	-	-	

Note: TT-Netvaerket is a joint venture between Telenor and Telia.

Table A2.13: September 2016 1800 MHz auction [68]

	Description	Implications
Number of bidders; number of lots; lot sizes	3 bidders.[69] 2 categories of lots: A lots: 3 lots of 2x10 MHz subject to a coverage obligation in one of three coverage area groups. B lots: 7 lots of 2x5 MHz.[70]	As in the June 2012 800 MHz auction, Telenor and Telia participated in the auction in the form of the joint venture between them (TT-Netvaerket). All bidders acquired spectrum in the auction.
Spectrum caps / Restrictions	A 2x30 MHz cap applied to all bidders (not including existing holdings). Each bidder could acquire at most one A lot.	The overall cap was not binding on any bidder. Each bidder acquired one A lot at the reserve price.[71]
Reserve prices	DKK 50m for A lots and DKK 25m for B lots (i.e. DKK 25m per 2x5 MHz)	

[67] See https://ens.dk/en/our-responsibilities/spectrum/auctions
[68] See: https://ens.dk/sites/ens.dk/files/Tele/information_memorandum_june_2016.pdf
[69] See: https://www.telegeography.com/products/commsupdate/articles/2016/09/30/danish-cellcos-awarded-1800mhz-spectrum-for-mobile-broadband-services/
[70] If A lots had not all been assigned (as they were), the unassigned lots would have been offered as additional B lots. In this case, B lots would have been subject to the coverage obligation in all coverage area groups in which the coverage obligation was not assigned along with A lots.
[71] See: Danish Energy Authority. https://ens.dk/ansvarsomraader/frekvenser/auktioner-og-udbud-frekvenser

	Description	Implications
Obligations	The auction rules identified three coverage area groups (two consisting of 82 coverage areas of 1 km^2 and one consisting of 81 coverage areas of 1 km^2), where there was no access to a download speed of 30 Mbit/s. Each bidder who acquired an A lot in the auction was assigned one of these groups with the obligation to ensure provision of a mobile voice service and a mobile broadband service offering users, for most of the time, a connection with a download speed of 30Mbit/s and an upload speed of 3Mbit/s across the coverage areas in their group.	

A2.83 The auction had four stages[72]:

a) 1st stage - assignment of A lots;

b) 2nd stage – assignment of coverage area groups;

c) 3rd stage – multiround ascending auction for B lots; and.

d) 4th stage – assignment of spectrum.

Assessment in the June 2018 consultation

A2.84 We considered whether absolute and relative values derived from this auction were likely to reflect market value in Denmark, and also whether market value in Denmark was likely to reflect UK market value.

Whether award outcomes are likely to reflect market value

A2.85 We noted that package prices for 1800 MHz spectrum in the 2016 Danish auction sold for well above the combined reserve prices of the lots won, all incumbents were able to participate, and the spectrum cap was not binding on any of the bidders.

A2.86 We also considered whether the auction award outcome was likely to reflect market value in light of:

a) coverage obligations;

b) auction design, in particular the capping of one A lot per bidder;

c) the effect of the joint venture between Telenor and Telia; and

d) the possibility that the auction was subject to strategic bidding.

A2.87 Before considering the specifics of the obligations in the Danish auction we recap our general approach to coverage outlined in the 2015 statement.

[72] See: June 2018 consultation, Annex 4, paragraph A4.20, and https://ens.dk/sites/ens.dk/files/Tele/information_memorandum_june_2016.pdf, pages 48-80.

General approach to coverage obligations

A2.88 In our 2015 Statement, we took into account the coverage obligations that applied to auction lots.

A2.89 For 800 MHz we adopted the following approach:[73]

a) when coverage obligations applied which were likely to be over and above commercial levels, and price differentials between 800 MHz lots in the benchmark country could be ascribed to differences in these coverage obligations, we included only blocks without, or with less onerous, coverage obligations in the calculation of an average price of 800 MHz for the benchmark country. We then used the corresponding UK value of 800 MHz (i.e. without a coverage obligation) when deriving the relative value benchmark.

b) when there were no differences in coverage obligations across 800 MHz lots in the benchmark country, we calculated the value of 800 MHz as the average of all available lots. We then considered whether or not any coverage obligation (i.e. on all 800 MHz lots) was likely to be onerous. Where there was a basis for believing coverage obligations to be onerous, we used the UK value of 800 MHz with a coverage obligation in the derivation of the relative value benchmark; otherwise we used the UK value of 800 MHz without coverage obligation for this purpose.

c) Denmark was the only exception to this. In that case we used the larger 800 MHz (2x20 MHz) lot which was subject to a coverage obligation. This was because the other 800 MHz lot, which did not include a coverage obligation, was affected by DTT co-existence costs.

A2.90 In calculating the European auction prices of 900 MHz, 1800 MHz and 2.6 GHz we included all available lots in our dataset, irrespective of their coverage obligations, and we considered the implications of the coverage obligations qualitatively if and when necessary. In principle, if such obligations were likely to require deployments significantly in excess of commercial levels then we considered that the auction price could risk understating the value of that band (without a coverage obligation) in the UK in our assessment. [74]

A2.91 The Danish 2016 1800 MHz auction was conducted by the Danish Energy Agency, and its stated purpose was to "improve mobile coverage – especially in sparsely populated areas – and to promote effective competition in the telecommunications market to ensure the provision of innovative and advanced services in the Danish market."[75]

A2.92 The coverage obligations set in the 1800 MHz licences were described by the Danish Energy Agency as "ambitious"[76], and were aimed at improving the availability of voice and broadband services in areas where the current availability was lowest.[77]

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[73] See 2015 Statement, Annex 7, paragraph A7.96 and Tables A7.3 and A7.4.
[74] See 2015 Statement, Annex 7, paragraph A7.95.
[75] See Danish Energy Agency, *1800 MHz Auction, Information Memorandum*, page 1. https://ens.dk/sites/ens.dk/files/Tele/information_memorandum_june_2016.pdf
[76] Ibid.
[77] Ibid.

A2.93 While in our 2015 Statement we concluded that none of the non-800 MHz coverage obligations were likely to require deployments significantly in excess of the commercial level, in our June 2018 consultation we were not able to reach this view in the case of the Danish 2016 1800 MHz auction, particularly given the regulator's view that the obligations are ambitious.

Restrictions on A lots

A2.94 We said that the constraint on bidders only being able to acquire one of the three A lots of 2x10 MHz spectrum with a coverage obligation meant that, with only three bidders in the auction, these lots were sold at the reserve price of DKK 50m. As a result, we considered that there was a risk that the overall award outcome may understate market value in Denmark.

A2.95 We calculated an alternative estimate of market value which attempts to account for this risk by removing the A lots and the DKK 50m paid for them from the auction outcomes. That is, the estimate is based on the total prices paid by operators minus reserve prices for A lots, divided by the amount of spectrum in B lots. For example, in considering TT-Netvaerket's winning bids, if we consider all of its lots (including its A lot) then it acquired 2x25 MHz of spectrum for DKK 425.2m, that is DKK 8.5m per MHz. If we remove its A lot and the DKK 50m paid for it then TT-Netvaerket acquired 2x15 MHz of spectrum for DKK 375.2m, that is DKK 12.5m per MHz. On this basis, the estimate of the prices paid by TDC and Hi3G for B lots is also DKK 12.5m per MHz.

A2.96 We noted that one limitation of this approach was that the total price paid also includes any payments for assignment of the coverage obligations, determined in the second stage of the auction. We did not know what prices, if any, were paid for particular coverage obligations in the second phase. This created a risk that this alternative approach could overstate market value as any sum paid in the second phase of the auction would be included in our estimate of the market value of B lots. In other words, in deriving our B lots only estimate, while we have removed the sums paid for the A lots we may not have removed any sums paid for the assignment of A lot coverage obligations.

A2.97 We said we did not know what payments were made for assignment of the coverage obligations. It is possible that an operator could have had a high valuation for having one obligation rather than another, for example if the coverage area groups for one particular obligation could be more easily reached by extension of its existing network than would be the case with the other coverage obligations in the auction. However, we noted that these payments (and hence the risk of overstatement) may have been limited for a number of reasons. For a detailed discussion see our June 2018 consultation paragraph A4.36.

A2.98 We considered there was a case for identifying an unknown risk of smaller overstatement from an 1800 MHz price based on excluding A lots and their reserve prices as described in paragraph A2.95 above. However, on balance we have taken a conservative approach of identifying this as an unknown risk of unknown overstatement.

Effect of the joint venture

A2.99 In the 2015 Statement, we noted that there was a risk that the joint venture between Telenor and Telia may have reduced the intensity of competition in the Danish 2012 auction for 800 MHz. We considered that this created an unknown risk of understatement in the 800 MHz value. The same joint venture bid for the 1800 MHz in the 2016 auction. We considered that there was also an unknown risk of understatement in the 2016 1800 MHz auction value in light of this joint venture.

Strategic bidding

A2.100 In our 2015 Statement we considered the risk that firms might bid differently from their intrinsic value of the spectrum, such as by bidding higher to exclude a rival or raise its costs, bidding lower to reduce the amount they pay in the auction, or placing bids as a signal to rivals, as part of a coordinated strategy of demand reduction. [78]

A2.101 In considering the Danish 2016 1800 MHz auction, we did not have access to bid data which could potentially be informative as to whether strategic bidding occurred.

A2.102 We considered whether Hi3G (as the operator with the smallest spectrum holding prior to the auction) could have been a target for strategic investment or price driving.[79] Prior to the auction it held no 800 MHz spectrum but held spectrum in the other bands (2x5 MHz of 900 MHz spectrum, 2x10 MHz of 1800 MHz spectrum and 2x10 MHz of 2.6 GHz spectrum). We said it was not clear that Hi3G needed to win spectrum in this auction in order to remain a credible competitor in the downstream market. In any case, it acquired 2x20 MHz of 1800 MHz spectrum in the auction, at a price that was around 12% lower than TT but the same as TDC. We said, in our view, these results did not provide clear support of strategic investment or price driving.

A2.103 We also considered the possibility that with 2x65 MHz spectrum available, an outcome of each bidder getting at least 2x20 MHz (including one of the A lots with the coverage obligations) and the joint venture getting the remaining 2x5 MHz could have been a focal point for strategic demand reduction. We said while we could not rule out the possibility of strategic demand reduction, we did not have clear evidence that it took place.

A2.104 Overall, we considered that we were not in a position to take a view as to whether strategic bidding affected prices in Denmark.[80]

Risk of understatement or overstatement

A2.105 On the basis of the above assessment, we considered that there was a risk that the auction prices of the Danish 1800 MHz spectrum based on B lots only were an overstatement of

[78] For more details see 2015 Statement, Annex 7, paragraphs A7.182-A7.186.
[79] We characterise this strategic behaviour where a bidder overstates its true demand to raise the auction prices paid by other bidders. One potential motivation is to force another bidder to spend more for one lot category, so that it has a smaller budget to compete for another category in which the price-driving bidder is interested. Another is to weaken downstream competition (by making it harder for the bidder who is the intended target of a price driving strategy to finance other investments which could otherwise make it more competitive). Price driving could lead to auction prices that overstate market value in some bands, and possibly to prices that understate market value in other bands (if the bidder who is the intended target of a price driving strategy is budget-constrained in the latter).
[80] This is consistent with our approach in our 2015 Statement that in the absence of clear evidence we are not in apposition to take the view that alleged cases of strategic bidding did or did not occur. See Annex 7, paragraph A7.186.

market value, as they may include payments for the assignment of A lot coverage obligations. The risk of overstatement may be small, but on a conservative approach we considered this to be an unknown risk of unknown overstatement.

A2.106 We considered there was a risk that the auction prices of the Danish 1800 MHz spectrum based on all lots were an understatement of market value. This was due to the coverage obligations and the restrictions on A lots, which meant that each operator acquired an A lot at reserve price. Our view was that there was a larger risk of a larger understatement to this estimate. As an illustration, in the example in paragraph A2.95, if the price based on B lots were correct (DKK 12.5m per MHz), the price based on all lots (DKK 8.5m per MHz) would understate it by over 30%.

Likelihood of reflecting UK market value

A2.107 We were not aware of any country-specific factors that would cause the 2016 1800 MHz spectrum auction in Denmark to be an understatement or overstatement of the value in the UK.

Relative benchmarks

Distance method benchmark

A2.108 As set out in paragraph A2.79, we did not include a distance method benchmark for Denmark in our 2015 Statement because the formula generated a negative number, which we did not consider to be a sensible indication of the UK market value of 1800 MHz.

A2.109 In our June 2018 consultation, we calculated a distance method benchmark for Denmark using the results of the 2016 1800 MHz auction, the 2010 2.6 GHz auction and the 2012 800 MHz auction. We generated estimates using both approaches to calculating the market value from the 2016 auction, as set out in paragraphs A2.110 to A2.112.

Considering all lots in 2016 1800 MHz auction

A2.110 Using an 1800 MHz price based on both A and B lots in the auction led to a negative Y/X value. This was because the UK equivalent market value of the Danish 1800 MHz derived from the 2016 auction was slightly less than the UK equivalent market value of the Danish 2.6 GHz auction.[81] As noted above, we did not consider that to be credible in a UK context.

A2.111 We noted that the advantage of the distance method was that it generated a benchmark for each country using the information on spectrum values in each of the 800 MHz, 1800 MHz and 2.6 GHz bands. We considered this to be more relevant than the ratios of 1800 MHz to either 800 MHz or to 2.6 GHz on their own.[82] However, when the implied values of 1800 MHz and 2.6 GHz are close together the output of the distance method becomes highly insensitive to the relative values of 1800 MHz and 800 MHz. For example, if we ruled out the possibility of a negative value and assumed the value of 1800 MHz and 2.6 GHz in Denmark to be equal, this would mean the Y/X ratio in the distance method (i.e. the

[81] This meant that the "Y" in the Y/X which is the difference in value between 1800 MHz and 2.6 GHz was negative.
[82] See 2015 Statement Annex 7 paragraph A7.78.

"distance" element) would be zero, and the benchmark would simply be the value of 2.6 GHz spectrum in the UK (£5.9m per MHz). However, with this approach the value of 800 MHz in Denmark has no effect on the value of the benchmark, and it delivers the same result as a benchmark based on the 1800 MHz to 2.6 GHz ratio.

Considering only B lots in 2016 1800 MHz auction

A2.112 We also considered only B lots, and noted this led to a Y/X value of 68%, which would imply an 1800 MHz distance method benchmark of £24.8m per MHz.[83]

A2.113 Considering each of the tiering criteria our provisional view was that:

a) As A lots were sold at reserve price, final package prices indicate that B lots were acquired at prices significantly above reserve, and as such appear likely to have been primarily determined by a market-driven process of bidding. 800 MHz and 2.6 GHz prices also appear to have been reached through a market-driven process.

b) Based on our assessment of strategic bidding, we considered that the relative prices in the 1800 MHz auction were at least as likely to reflect intrinsic valuation of spectrum in Denmark as to reflect strategic bidding. We had no evidence of strategic bidding in the 800 MHz and 2.6 GHz awards.

c) We did not have clear, evidence-based reasons to consider the auction outcome is less informative of forward-looking relative values in the UK (having regard to country-specific circumstances and auction dates).

A2.114 Next, we considered whether this benchmark carries a risk of understatement or overstatement. We noted there were several effects on the benchmark which may have caused understatement or overstatement:

a) Effect of the TT Joint Venture. This may have affected both the 1800 MHz and 800 MHz value. If it affected both bands to a similar extent, the combined effect might be the distance method benchmark having a risk of understatement. For example, (based on our revised estimates set out in Table A2.14 below) if both bands would have been 50% higher absent the JV, then the benchmark would have been 6% higher. [84]

b) Coverage obligation assignment payments: as mentioned above, we said these could lead to a risk of overstatement of the 1800 MHz price, and hence of the distance method benchmark.

[83] See paragraph A2.137 below for our revised estimates of these numbers.
[84] This is based on the increase of the value of the distance benchmark using only the B lots when comparing the case where the 800 MHz and 1800 MHz absolute values are increased by 50% with the standard case where they are not.

c) Combining auction prices from three different auctions in three different years, 2010 (2.6 GHz), 2012 (800 MHz) and 2016 (1800 MHz). We said there was a risk that these gaps in time affect the risk of understatement or overstatement, although we had not identified a clear direction or magnitude of the possible effects.[85]

d) Sensitivity of the distance method benchmark, given that the 800 MHz and 2.6 GHz auction prices in Denmark are relatively close together (e.g. much closer together than in the UK).[86] Again, we had not identified a clear direction or magnitude of the possible understatement or overstatement.

A2.115 Taking the first two effects together we said there was a risk of either understatement or overstatement in the distance method benchmark.

Stakeholder responses to the June 2018 consultation

Whether award outcomes are likely to reflect market value

A2.116 Both BT and Three argued that we had failed to properly account for the coverage obligation in the 800 MHz auction and that our approach implicitly assumed that the Danish 800 MHz coverage obligation had a similar cost to the UK 800 MHz coverage obligation.

A2.117 Three said that while the geographic scope of the UK obligation was broader, the Danish obligation required licensees to deliver higher minimum download speeds (10 Mbps compared to 2 Mbps). It also considered that the format of the auction was likely to have had a material impact on the final prices. BT and Three both highlighted a 2012 DotEcon report[87] which described the Danish 800 MHz coverage obligation as '*fairly onerous*' and considered that the low price was a feature of the auction design which was designed to ensure that both the spectrum and the coverage obligation was efficiently assigned. [88]

Relative benchmarks

A2.118 BT and Three raised concerns with Denmark's inclusion as a Tier 1 benchmark.

A2.119 Three considered that the Danish benchmark failed to meet the first and third criteria for a Tier 1 benchmark (that is, whether (i) the auction prices appear likely to have been primarily determined by a market-driven process of bidding in the auctions; and (iii) the outcome appears likely to be informative of forward-looking relative spectrum values in

[85] In our assessment of relative value benchmarks for Germany, we initially considered that a time difference of five years could create a risk of understatement or overstatement (2015 Statement, Annex 8, paragraphs A8.378 and A8.379), and concluded that changing expectations about 700 MHz availability over this period created a risk of understatement in both 900 MHz and 1800 MHz benchmarks (paragraphs A8.487 and A8.489). Our dataset for deriving international benchmarks also includes separate awards in Austria (2.6 GHz in 2010 and other bands in 2013), Greece (900 MHz and 1800 MHz in 2011, 800 MHz and 2.6 GHz in 2014), and Spain (separate awards of 800 MHz and 900 MHz in 2011).
[86] For example, in Denmark the ratio of prices of 2.6 GHz to 800 MHz is 62%, whereas in the UK it is 17%.
[87] https://www.dotecon.com/publications/digital-dividend-the-danish-way/
[88] BT response to June 2018 consultation, pages 16-17. Three response to June 2018 consultation, pages 29-30.

the UK, having regard to country-specific circumstances and auction dates) and therefore should be moved to a lower tier.[89]

A2.120 BT considered that we should either:

a) Relegate the Danish benchmark to a lower tier on the basis that the 800 MHz price was not reflective of market value and there can be no presumption that the cost of the coverage obligation on the Danish 800 MHz spectrum was equivalent to that on the UK 800 MHz spectrum; or

b) Use the Danish 1800 MHz 'all lots' result in the distance method benchmark along with the UK 800 MHz value excluding the coverage obligation. It argued that the impact on value of the 1800 MHz Danish coverage obligation was a better proxy than the UK 800 MHz coverage obligation for the impact on value of the Danish 800 MHz coverage obligation. It considered that this was likely to reduce the asymmetric risk of large overstatement in the resulting benchmark, meaning it could potentially remain in Tier 1.[90]

A2.121 BT and Three also said that we were incorrect to consider that the Danish distance method benchmark using 'B lots only' was at risk of over or under-statement. They argued that if the 800 MHz price carried a risk of understatement and the 1800 MHz price a risk of overstatement with no risk identified for 2.6 GHz, then the distance method benchmark would be overstated. BT argued that it should carry a larger risk of larger overstatement.[91]

A2.122 Telefónica highlighted what it considered to be two errors in our calculation of the Danish benchmark[92]:

a) That we had updated the purchasing power parity (PPP) exchange rates for all auctions in Denmark even if they were held before 2015. It noted that this was inconsistent with our approach to the other international benchmarks which were still based on the 2015 PPP exchange rate data. It considered that for consistency we should have kept the PPP rates from 2015 for all awards before 2015 and only used new rates for awards from 2016 onwards.

b) That in estimating the distance method benchmark we were effectively using absolute values in DKK which we adjusted for inflation using UK CPI. It argued that to properly adjust for inflation we had two options:

   i) Keep all benchmarks in local currency and then adjust using an appropriate inflation rate for that country; or

   ii) Convert benchmarks to GBP at the time of the auction and then apply UK CPI to adjust for inflation.

[89] Three response to June 2018 consultation, pages 29-31.
[90] BT response to June 2018 consultation, page 17.
[91] BT response to June 2018 consultation, pages 16-17.
[92] Telefonica response to June 2018 consultation, pages 21-22.

A2.123 Telefónica noted that making these adjustments to the calculation of the distance method benchmark would lead to a positive Y/X ratio for the 'all lots' benchmark, and therefore it should not be discarded. It did not consider that we had provided sufficient evidence to justify excluding this benchmark even if there may be a valid reason to be concerned about it understating market value.

A2.124 It argued that we should have considered both the 'all lots' and 'B lots only' benchmarks in interpreting the Danish evidence and that putting 100% weight on the upper bound of the value estimate (that is, the 'B lots only' benchmark) was not a conservative approach. It proposed treating the 'B lots only' and 'all lots' benchmarks as upper and lower bounds and that using the midpoint between the average and the lower bound of these would be an appropriate estimate for the Danish auction. It considered that this would imply a distance method benchmark of £12.9m per MHz.[93]

Our assessment

Whether award outcomes are likely to reflect market value

800 MHz

A2.125 The approach we adopted to taking into account coverage obligations in 800 MHz auctions in our 2015 Statement and June 2018 consultation is summarised in paragraph A2.88 above.

A2.126 We agree with BT and Three that, for countries where we are unable to identify an 800 MHz value without a coverage obligation, our approach implicitly assumes the coverage obligation costs are the same proportion of underlying 800 MHz value in both the UK and the benchmark country. We consider this to be a reasonable assumption to make in the absence of auction evidence on the cost of the coverage obligation from the benchmark country, whilst recognising it carries the risk of us potentially overstating the market value of 800 MHz spectrum in some countries and understating it in other countries.

A2.127 We have considered BT's alternative approach in the case of the Danish 800 MHz band (set out in paragraph A2.120 b) above). We recognise that conceptually using the impact of a coverage obligation on the value of another spectrum band in the benchmark country could be an informative proxy for the impact of the coverage obligation on the value of 800 MHz spectrum, particularly if the nature of the coverage obligations is similar. However, in this case, the Danish 1800 MHz auction is not informative as to the impact of the coverage obligation on the value of 1800 MHz spectrum. This is because, while the 1800 MHz 'B lots' (those without a coverage obligation) were sold via a competitive auction process, the 'A lots' (those with a coverage obligation) were restricted to one per bidder and were sold at reserve price. This means that we do not know what the market value of 1800 MHz spectrum in Denmark with a coverage obligation is, other than that all three bidders in the auction were prepared to pay at least the reserve price for it. Therefore, we do not know what bidders considered the cost of the coverage obligation to be. As a result, we do not

[93] Telefonica response to June 2018 consultation, pages 22-24.

consider that this alternative approach would lead to a more accurate estimate of the impact on the value of Danish 800 MHz spectrum.

A2.128 Having considered further the Danish 800 MHz coverage obligations in light of stakeholders' comments, we agree that it is likely that the Danish coverage obligation was more onerous than the UK 800 MHz coverage obligation, and therefore there is a risk that, even using the UK 800 MHz with coverage obligation price in the calculation of the distance method benchmark, we have not fully taken account of the Danish 800 MHz coverage obligation.

A2.129 We therefore have re-considered our assessment of the Danish relative benchmarks to reflect the risk that we have not fully taken account of the Danish 800 MHz coverage obligation (see paragraph A2.145 below).

1800 MHz

A2.130 We remain of the view, set out in our June 2018 consultation[94] (and as explained above) that there is a risk that the auction prices of the 2016 Danish 1800 MHz spectrum based on B lots only is an overstatement of market value, as they may include payments for the assignment of coverage obligations. The risk of overstatement may be small, but on a conservative approach we consider this to be an unknown risk of unknown overstatement.

A2.131 We consider there is a risk that the auction prices of the 2016 Danish 1800 MHz spectrum based on all lots is an understatement of market value. This is due to the coverage obligations and the restrictions on A lots, which meant that each operator acquired an A lot at reserve price. Our view is that there is a larger risk of a larger understatement to this estimate.

900 MHz and 2.6 GHz

A2.132 In response to the June 2018 consultation stakeholders did not comment on our assessment of the Danish 900 MHz and 2.6 GHz awards. We remain of the view that:

a) the Danish 900 MHz auction price is unlikely to be reflective of market value in Denmark, with the exclusion of incumbent operators from the auction creating a larger risk that the auction price had a larger risk understatement of market value.

b) the price for 2.6 GHz spectrum, based on the winning bids by TDC, Telia and Telenor, was reflective of market value in Denmark, with no risk of overstatement or understatement identified.

Likelihood of reflecting UK market value

A2.133 In response to our June 2018 consultation stakeholders did not highlight any country-specific factors that would cause the 2016 1800 MHz spectrum auction in Denmark to be an understatement or overstatement of the value in the UK. We remain of the view that this auction is likely to reflect forward-looking UK market value of 1800 MHz.

[94] June 2018 consultation, Annex 4, paragraph A4.37.

Relative benchmarks

Distance method benchmark

Methodological issues

A2.134 We agree with Telefónica that it was inconsistent to use updated PPP exchange rate data for the Danish and Norwegian auctions in the June 2018 consultation, whilst continuing to use the 2015 PPP data for the other international benchmarks. However, we disagree with their proposed solution that we should have kept the PPP rates from 2015 for all awards before 2015 and only used new rates for awards from 2016 onwards. We consider that the correct approach is to use the most up-to-date PPP data for all awards. This is the approach we took to Denmark in the June 2018 consultation. As set out in Annex 1 we have now applied this approach to all other international benchmarks as well.

A2.135 We have also revised our approach to adjusting for inflation in relative benchmarks following Telefónica's comments. When deriving relative benchmarks where auctions occurred at different times, we now convert the benchmarks to GBP at the time of the award and then apply UK CPI to adjust for inflation. As set out in Annex 1 we have now applied this approach to all international benchmarks.

A2.136 As set out in Annex 1, we have also updated the WACC and cost of debt used for Danish country-specific estimates consistent with our approach of using country-specific estimates for Tier 1 benchmarks.

Results

A2.137 In light of these changes, we have updated our estimates of the Danish distance method benchmark:

a) Considering all lots in the 2016 1800 MHz auction leads to a Y/X value of -31%, which would imply a distance method benchmark of £-2.7m per MHz; and

b) Considering only B lots in the 2016 1800 MHz auction leads to a Y/X value of 77%, which would imply a distance method benchmark of £27.4m per MHz.[95]

Tiering

A2.138 As set out in paragraphs A2.116 and A2.117, BT and Three argued that the 800 MHz price was not reflective of market value. We disagree. The 800 MHz spectrum sold above reserve price in a competitive auction which is indicative of the prices reflecting market value. As set out in paragraphs A2.128 and A2.99 above, we recognise that the presence and nature of the coverage obligation, as well as the presence of the joint-venture, creates a risk of understatement. However, an auction price carrying a risk of understatement (or overstatement) is different to a situation where the price is not reflective of market value, for example, an auction where all lots sold at reserve price.

[95] This is higher than our estimate of £24.8m per MHz in our June 2018 consultation. This is due to the methodological changes discussed in paragraphs A2.134-A2.136 above, and updated input data as discussed in Annex 1.

A2.139 We take account of this through using the UK 800 MHz price with coverage obligation in the distance method benchmark and by including a risk that the 800 MHz market value understates market value in our assessment of the risk of the benchmark understating/overstating UK market value. We take account of this through using the UK 800 MHz price with coverage obligation in the distance method benchmark and by including a risk that the 800 MHz market value understates market value in our assessment of the risk of the benchmark understating/overstating UK market value.

A2.140 Three also argued that the Danish benchmark failed to satisfy the third criterion for Tier 1, namely that the outcome appears likely to be informative of forward-looking relative spectrum values in the UK, having regard to country-specific circumstances and auction dates.

A2.141 We consider that the benchmark does satisfy the third criterion for Tier 1, on the basis that we have fully taken account of the coverage obligation in our assessment of the value and risk of understatement of the 800 MHz Danish market value. In light of this we do not consider that there is any country specific circumstance that would mean that this value which reflects market value in Denmark is not informative of forward-looking relative spectrum value in the UK.

A2.142 We therefore conclude that the Danish distance method benchmark based on 'B lots only' from the 1800 MHz auction satisfies the criteria for a Tier 1 benchmark.

A2.143 We consider that the distance method benchmark based on all lots is less informative of market value. As the A lots (which accounted for 46% of the total spectrum in the auction) were sold at reserve price we do not consider that the overall auction prices were primarily determined by a market-driven process of bidding in the auctions.

Assessment of risk

A2.144 For the distance method benchmark **using 1800 MHz B lots only,** in our June 2018 consultation we were of the view that it carried a risk of either understatement or overstatement (see paragraphs A2.128 and A2.114 above).

A2.145 As set out in paragraphs A2.125 to A2.129, we consider that there is a risk that our June 2018 consultation assessment did not fully take account of the Danish 800 MHz coverage obligation which could lead to a risk of the distance method benchmark being overstated (if using the B lots).

A2.146 Considering these factors in the round, and in light of BT and Three's responses, we have revised our assessment and conclude that the Danish distance method benchmark using 'B lots only' carries a risk of overstatement.

A2.147 For the distance method benchmark **using all 1800 MHz lots**, we consider that there are the following effects which may cause understatement or overstatement:

a) Effect of the TT Joint Venture. This affects both the 1800 MHz and 800 MHz. If it affected both bands to a similar extent, the combined effect might be the distance method benchmark having a risk of understatement.

b) Restrictions on 1800 MHz A lots. The A lots with the coverage obligations were sold at reserve price as bidders were only able to acquire one A lot. This creates a larger risk that the benchmark could understate market value.

c) 800 MHz coverage obligation. For the reasons set out above this could lead to the distance method benchmark having a risk of overstatement.

d) Combining auction prices from three different auctions in three different years, 2010 (2.6 GHz), 2012 (800 MHz) and 2016 (1800 MHz). There is a risk that these gaps in time affect the risk of understatement or overstatement, although we have not identified a clear direction or magnitude of the possible effects.

e) Sensitivity of the distance method benchmark, given that the 800 MHz and 2.6 GHz auction prices in Denmark are relatively close together (e.g. much closer together than in the UK). Again, we have not identified a clear direction or magnitude of the possible understatement or overstatement.

A2.148 Considering these effects in the round we conclude there is a risk of understatement in the distance method benchmark using all lots.

Interpretation of Danish benchmarks

A2.149 We consider that, as a Tier 1 benchmark, the distance method benchmark based on the Danish 1800 MHz 'B lots only' provides the best evidence from Denmark of the UK market value of 1800 MHz. We consider that the distance method benchmark based on the Danish 1800 MHz 'all lots' provides less good evidence.

A2.150 We disagree with Telefónica's proposed approach of treating the two benchmarks as upper and lower bounds and using the midpoint between the average and the lower bound as an appropriate estimate. This approach ignores the quality of the evidence and implicitly puts more weight on the 'all lots' benchmark. Where we have grounds to consider that one set of evidence is more informative than another, we will use it in preference to the less informative set of evidence.

A2.151 Therefore, we use the Danish distance method benchmark using 'B lots only' in our assessment of the international benchmarks.

900 MHz / 800 MHz paired ratio

A2.152 We have also considered whether the 800 MHz coverage obligation would lead us to change our view of the risk of overstatement/understatement of the Danish 900 MHz / 800 MHz paired ratio.

A2.153 Our view as set out in our 2015 Statement was that this ratio carried a larger risk of larger understatement of UK market value.[96] This was because:

a) the price of 900 MHz carried a larger risk of larger understatement of Danish market value with the single lot of 2x5 MHz spectrum being acquired at reserve price;

[96] 2015 Statement, Annex 8, paragraph A8.286.

b) there was a risk that the 900 MHz market value understated forward-looking UK market value due to the timing of the award; and

c) the presence of the joint venture meant that there was a risk that the 800 MHz spectrum price understated market value.

A2.154 Even accounting for the 800 MHz coverage obligation, we consider the ratio carries a larger risk of understatement of UK market value as the likelihood and scale of the risk of understatement remains stronger for 900 MHz than 800 MHz. Taking into account the 800 MHz coverage obligation we consider that the 900 MHz / 800 MHz paired ratio benchmark risk moves from being a larger risk of larger understatement to a larger risk of understatement of UK market value.

Absolute benchmarks

A2.155 The data from the 2016 1800 MHz award enables us to derive absolute value benchmarks for the 1800 MHz band in Denmark which are (in April 2018 prices):

a) £10.0 million per MHz based on considering all lots. We consider that this carries a larger risk of larger understatement.

b) £15.4 million per MHz based on considering only B lots. We consider that this carries a risk of overstatement.

A2.156 These numbers have changed slightly from the figures in the June 2018 consultation since we have made changes to the WACC and cost of debt used for Denmark. (see Annex 1 for details).

Table A2.14: Summary of evidence points from Denmark (in April 2018 prices)[97]

	Absolute values (£m/MHz)				Relative value benchmarks[98] (£m/MHz)		Ratios (%) for cross-checks
	800 MHz	900 MHz	1800 MHz	2.6 GHz	900 MHz / 800 MHz	Distance method	1800 MHz/ 900 MHz
Final values	16.3	2.7	15.2	11.4	5.6 (17%) Tier 3	27.4 (77%) Tier 1	557%
Assessment of risk	Risk of under-statement	Larger risk of larger under-statement	Risk of over-statement	No risk identified	Larger risk of under-statement	Risk of over-statement	Larger risk of over-statement

[97] 1800 MHz values and the distance method benchmark are based on B lots only.
[98] Based on the UK 800 MHz value with coverage obligation and gross of expected DTT co-existence costs.

Greece 2017 award

Awards considered in our 2015 Statement

A2.157 We considered four awards from two auctions in Greece in Annex 8 of our 2015 Statement:

a) 900 MHz: November 2011;

b) 1800 MHz: November 2011;

c) 800 MHz: October 2014;

d) 2.6 GHz paired: October 2014.

A2.158 Greece has three MNOs: Cosmote, Vodafone and Wind Hellas.

Assessment in our 2015 statement

A2.159 In our 2015 Statement assessment of the 800 MHz, 900 MHz, 1800 MHz and 2.6 GHz spectrum awards, we considered the Greek relative value benchmarks and said the following[99]:

a) 900 MHz: The price of 900 MHz could understate or overstate market value in Greece at the time of the auction. However, we had three reasons why this market value might be overstated relative to forward-looking UK market value: lower levels of urbanisation in Greece, and the lack of availability of both 700 MHz and 800 MHz at the time of the award. There was also a risk (of unknown likelihood and scale) that market value is understated, due to LTE900 developments. However, on balance our view was that the 900 MHz price carries a larger risk of overstating forward-looking UK market value of larger scale. Our overall view was that the 900 MHz / 800 MHz carries a larger risk of larger overstatement.

b) 1800 MHz: The price of 1800 MHz could understate or overstate market value in Greece at the time of the auction. There was a risk (of smaller scale) that this market value understates forward-looking market value, due to LTE1800 developments, but also a larger risk that it overstates market value due to 700 MHz availability developments. On balance, our view was that the 1800 MHz price carries a larger risk of overstatement, but we cannot be sure of the scale of this overstatement.

c) 800 MHz and 2.6 GHz: our assessments of the 800 MHz and 2.6 GHz bands remained as set out in our February 2015 consultation.[100]

[99] See 2015 Statement Annex 8 paragraph A8.533.

[100] In the February 2015 consultation on 800 MHz and 2.6 GHz we said that, on balance, we considered there was a risk of 800 MHz and 2.6 GHz prices understating or overstating market value in Greece, but we could not be sure of the likelihood and scale of possible overstatement.

A2.160 We said that the distance method benchmark carries a larger risk of overstatement (of unknown scale), as the 1800 MHz price carries a larger risk of overstatement, while the 800 MHz and 2.6 GHz prices are at risk of understatement or overstatement.

A2.161 Our assessment in the February 2015 consultation was outlined in the 2015 Statement. Considering the 900 MHz and 1800 MHz relative benchmarks against the Tier 1 criteria, we said:

a) All spectrum sold at or close to reserve prices, so the benchmarks largely reflected the relative value of reserve prices set by the regulator, rather than a market-driven process of bidding.

b) Based on the evidence available to us, the relative prices in the auction were at least as likely to be based on bidders' intrinsic valuations of spectrum as on strategic bidding; and

c) The outcome appeared likely to be informative of forward-looking relative spectrum values in the UK, having regard to country-specific circumstances and auction dates.

A2.162 We considered that neither benchmark met the first of our criteria for Tier 1. We therefore considered the criteria for inclusion in Tier 2.

a) The award did not provide evidence that operators had a stronger demand for some bands than for others at these relative prices, so we did not consider there was evidence that the relative auction prices reflect bidders' relative intrinsic valuations of the bands;

b) The outcome was not obviously uninformative of forward-looking relative spectrum values in the UK having regard to country-specific circumstances and auction dates.

A2.163 We considered that neither benchmark met our first criterion for Tier 2. We therefore considered that both benchmarks should be in Tier 3.[101]

Responses to our June 2018 consultation

Additional 1800 MHz benchmark since the 2015 Statement

A2.164 BT noted that Ofcom had overlooked the Greek auction on 1800 MHz in November 2017. It proposed that Ofcom calculate a new benchmark using the 2017 1800 MHz auction prices and existing data for 800 MHz and 2.6 GHz from 2014.

A2.165 BT also calculated the following absolute and relative benchmark values for Greece (in 2018 prices):

a) Absolute UK value of £12.3 million per MHz, and;

b) Distance method UK value of £13.5 million.

A2.166 BT suggested that these estimates would provide better 1800 MHz benchmark evidence for Greece as the auctioned 1800 MHz spectrum sold above the reserve price in 2017. BT

[101] See 2015 Statement Annex 8 paragraphs A8.527 to A8.529.

said it considered this to be a good market-driven auction and Ofcom should consider the benchmark as a Tier 1 or 2. However, as the 800 MHz and 2600 MHz awards sold at reserve price, BT considered there to be a risk of under/over-statement of unknown scale and direction to the relative benchmark. BT also noted that the Greek benchmark tiering should be consistent with the Tier choice for Denmark as it also has limitations.

A2.167 Stakeholders did not make any further comment on our assessment of historic awards or benchmarks for Greece outlined in the August 2015 Statement.

Our assessment

A2.168 As we received no further stakeholder comments on the Greek awards of 2011 and 2014, our conclusions with regard to those awards, and the benchmarks based upon the results, remain the same as in our 2015 statement.

A2.169 In response to BT's consultation feedback we have assessed the Greek 1800 MHz auction award from November 2017. Our analysis, tiering and risk assessment are included in the following sections.

November 2017 1800 MHz auction

A2.170 The November 2017 award of 1800 MHz spectrum in Greece used an SMRA format.

A2.171 The results of this auction are set out in Table A2.15, with the auction features summarised in Table A2.16.

Table A2.15: November 2017 1800 MHz[102,103]

	1800 MHz	A-lot MHz	B-lot MHz	Price Paid (€)
Total Available	**2x55**	**2x30**	**2x25**	**201,450,000**
Cosmote	2x25	-	50	83,150,000
Vodafone	2x15	30	-	59,200,000
Wind Hellas	2x15	30	-	59,100,000
Unsold	-	-	-	-

[102] A-lots were licensed for 18 years and B-lots for 15 years.
[103] See https://www.eett.gr/opencms/opencms/admin_EN/News/news_0470.html.

Table A2.16: November 2017 1800 MHz

	Description	Comment
Number of bidders; number of lots; lot sizes	1800 MHz: There were three bidders for the auctioned 2x55 MHz spectrum. The auction awarded six 2x5 MHz A lots, and five 2x5 B lots. The A lots were for a period of 18 years, and B lots for 15 years.	The previous licence period was going to end in 2018. The NRA sought to align all licence end dates in this auction.
Spectrum caps/restric-tions	1800 MHz: a spectrum cap of 2x35 MHz applied.	The spectrum cap considered previous 1800 MHz holdings. The spectrum cap was binding for Cosmote. Due to its existing spectrum holdings (2x25 MHz from 1995 and 2x10 MHz from 2011) it could not bid for the 18-year licence.
Reserve prices	1800 MHz: A lot (15 years) €16,500,000 per 2x5 MHz B lot (18 years) €19,700,000 per 2x5 MHz.	Two out of the three bidders paid marginally above the reserve price for the awarded spectrum. One bidder secured spectrum at reserve price.
Obligations	1800 MHz: geographical coverage obligations and download speed requirements apply.	The licensee can use any frequency band to fulfill these obligations with less stringent time limits applying to new entrants.
Other factors	No annual licence fees apply to licensed spectrum.	Operators were able to split the auction price payment across different years.[104]

A2.172 We have considered whether absolute and relative values derived from the November 2017 auction are likely to reflect market value in Greece, and whether the value of 1800 MHz spectrum in Greece is likely to reflect UK market value.

[104] However, in the absence of this information, in our calculations we have assumed that this was paid up-front.

Whether award outcomes are likely to reflect market value in Greece

A2.173 We understand that three operators were awarded 1800 MHz spectrum in the 2017 auction: Cosmote secured 2x25 MHz (five B lots) for €83.2 million, Vodafone was awarded 2x15 MHz (three A lots) for €59.2 million and Wind Hellas secured 2x15 MHz (three A lots) for €59.1 million. Overall, the 1800 MHz auctioned (2x55 MHz) spectrum revenue was 0.4 per cent higher than the reserve price set by the NRA for this spectrum.[105]

A2.174 Due to its existing holdings of 1800 MHz spectrum from the 1995 and 2011 awards and the spectrum cap (2x35 MHz), Cosmote was only able to bid for the shorter 'B' lots. It is possible that, knowing this, Vodafone and Wind Hellas bid below their true valuation. In the absence of this cap, it is possible that Cosmote would have competed for additional spectrum pushing prices above reserve.

A2.175 The licensees for all 1800 MHz spectrum auctioned in 2017 in Greece were required to comply with geographical coverage obligations and provide broadband services within their network. Licensees can use any of the spectrum frequencies that have been granted to them. In the event that a new entrant was awarded a licence, they were given a longer time period to fulfil these obligations (typically in three to five years' time depending on the requirement attached to the licence).

A2.176 We do not consider that these coverage obligations linked to the 2017 Greek spectrum awards are likely to require network deployments significantly in excess of commercial levels.[106] For this reason, we do not consider that these coverage obligations create a risk of over/understatement to the market value.

Risk of understatement or overstatement of the Greek 2017 spectrum awards

A2.177 On balance, in light of the factors set out above, we consider that the 2017 auction prices of 1800 MHz spectrum in Greece run a risk of an understatement of market value, but we cannot be sure of the likelihood or scale.

Likelihood of spectrum awards reflecting market value in the UK

A2.178 We are not aware of any country-specific factors that would suggest that the 2017 1800 MHz spectrum auction in Greece under/overstates the 1800 MHz value in the UK. However, as outlined above, we consider that the 1800 MHz GHz spectrum auction does not reflect a market-driven process and is of limited use in assessing the forward-looking spectrum values in the UK.[107]

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[105] Two out of the three bidders paid marginally above the reserve price for the awarded spectrum (Cosmote paid 0.8 per cent, and Vodafone 0.2 per cent above the reserve). Wind Hellas secured spectrum at the reserve price.
[106] At the time of the auction, MNOs already met the geographical coverage obligation. Furthermore, the NRA considered the requirement to cover 95% of the population in areas at the border with neighbouring countries and 85% of main national main roads as realistic and the specified broadband service requirements as achievable.
[107] See paragraph A2.182 on tiering.

Assessment of the Greek 2017 1800 MHz benchmarks

A2.179 Next, we outline our assessment of the likelihood of the distance method benchmark reflecting the UK market value and the risk of over/understatement. We also summarise our tiering assessment on the Greek distance method benchmark.

Risk of understatement or overstatement of the Greek distance method benchmark

A2.180 We calculated a distance benchmark for Greece using the 800 MHz award from 2014, the 1800 MHz award from 2017 and the 2.6 GHz award from 2014. Risks to the distance method benchmark and whether it under/overstates the UK market value include:

a) The 2014 800 MHz spectrum award was reviewed in our 2015 Statement. We remain of the view that there is a risk that the 800 MHz price from Greece risks over/understating the forward-looking 800 MHz market value, but we cannot be sure of the scale of overstatement.

b) Taking account of the competition, spectrum caps and auction revenue for the 2017 1800 MHz award, we consider that there is a risk of understatement to the UK 1800 MHz of an unknown scale.

c) The 2014 2.6 GHz award was reviewed in our 2015 Statement. Our view remains that there is a risk of 2.6 GHz Greek prices under/overstating market value in the UK, although we cannot be sure of the likelihood or scale.

d) Combining auction prices from different auctions in different years, 2014 (800 MHz and 2.6 GHz) and 2017 (1800 MHz). There is a risk that this gap in time affects the risk of under/overstatement, although we have not identified a clear direction or magnitude of the possible effects.[108]

A2.181 These factors considered, we think there is a risk of an understatement of an unknown scale in the distance method benchmark.

Tiering of the Greek 2017 distance method benchmark

A2.182 Considering the criteria for inclusion in Tier 1:

a) Both 1800 MHz and 800 MHz spectrum sold at or very near reserve prices, and some of the lots in the 2.6 GHz award sold marginally above reserve. Based on this, we think the spectrum prices largely reflect the relative value of reserve prices set by the regulator rather than a market-driven process of bidding.

[108] In our assessment of relative value benchmarks for Germany, we initially considered that a time difference of five years could create a risk of understatement or overstatement (2015 Statement, Annex 8, paragraphs A8.378 and A8.379), and concluded that changing expectations about 700 MHz availability over this period created a risk of understatement in both 900 MHz and 1800 MHz benchmarks (paragraphs A8.487 and A8.489). Our dataset for deriving international benchmarks also includes separate awards in Austria (2.6 GHz in 2010 and other bands in 2013), Czech Republic (800 MHz in 2013, 1800 MHz and 2.6 GHz in 2016), Spain (separate awards of 800 MHz and 900 MHz in 2011), Sweden (800 MHz in 2011 and 1800 MHz in 2011/2016) and Croatia (800 MHz in 2013 and 1800 MHz in 2015).

b) Based on the available evidence, we do not consider that the relative prices in the Greek auctions are more likely to be driven by strategic bidding than intrinsic valuation; and

c) We are not aware of any country-specific factors that would indicate that the 1800 MHz benchmark in Greece is less likely to be informative of forward-looking relative spectrum values in the UK.

A2.183 The benchmark does not meet the first criterion for Tier 1. We therefore consider the criteria for inclusion in Tier 2:

a) We do not consider that there is evidence that operators had a stronger demand for some bands than for others at these relative prices (all frequency bands feeding into the distance method benchmark sold at or close to reserve). We do not consider that there is sufficient evidence to show that relative auction prices reflect bidders' relative intrinsic valuations of different bands;

b) The outcome is not obviously uninformative of forward-looking relative spectrum values in the UK having regard to country-specific circumstances and auction dates.

A2.184 The Greek benchmark does not meet our first criterion for Tier 2 benchmark. We therefore consider that the benchmark should be in Tier 3.

A2.185 BT suggested that the Greek 2017 1800 MHz award should be included in Tier 1. However, we disagree with this based on the assessment outlined above.

Table A2.17: Summary of evidence points from Greece (in April 2018 price)[109]

	Absolute values (£m/MHz)			Relative value benchmarks (£m/MHz)[110]	Ratios (%) for cross-checks
	800 MHz	1800 MHz	2.6 GHz	Distance method	1800 MHz/ 900 MHz
Final values	41.8	16.6	3.8	14.7 (34%) (Tier 3)	46%
Assessment of risk	Risk of under or over-statement	Risk of under - statement	Risk of under or over-statement	Risk of understatement	Larger risk of larger understatement

[109] The absolute value for 1800 MHz is based on the 2017 auction data, whilst 800 MHz and 2.6 GHz values are derived from the 2014 auction.
[110] Based on the UK 800 MHz value with coverage obligation and net of expected DTT co-existence costs.

Sweden 2016 award

Awards considered in our 2015 Statement

A2.186 We considered two auctions in Sweden in Annex 8 of our 2015 Statement:

a) 800 MHz: March 2011;

b) 1800 MHz: October 2011.

A2.187 Sweden has four MNOs: Teliasonera, Tele2, Telenor and Hi3G.

1800 MHz distance method benchmark

A2.188 Overall, in 2015 our view was that[111]:

a) There is a risk that the 800 MHz and 1800 MHz prices both understate market value in Sweden at the time of the award;

b) There is a larger risk that the market value of 800 MHz in Sweden at the time of the auction is a larger overstatement of the forward-looking market value of 800 MHz. Combined with (a), we considered that the 800 MHz price from Sweden carries a larger risk of overstatement of forward-looking 800 MHz market value, but we could not be sure of the scale of overstatement; and

c) There is a risk that the market value of 1800 MHz in Sweden at the time of the auction is a small understatement of forward-looking market value due to LTE1800 developments, but there is a larger risk that the market value at the time of the award is an overstatement of forward-looking market value (of unknown scale) due to 700 MHz availability developments. Combined with (a), we considered that the 1800 MHz price from Sweden carries a risk of overstatement of forward-looking 1800 MHz market value, but we could not be sure of the likelihood or scale of overstatement.

A2.189 As regards our distance method benchmark, given our view that there is a larger risk that 800 MHz overstates forward-looking market value than there is for 1800 MHz, we considered that the distance method benchmark risks understating forward-looking UK market value, though we cannot be sure of the likelihood or scale.

A2.190 In 2015 we considered the criteria for including the 1800 MHz distance method benchmark for Sweden in Tier 1 as[112]:

a) We said the auction prices in the Swedish auctions for 1800 MHz and 800 MHz were significantly above reserve, and as such appeared likely to have been primarily determined by a market-driven process of bidding.

[111] See 2015 Statement Annex 8 paragraphs A8.917 and A8.918.
[112] See 2015 Statement Annex 8 A8.912. Further analysis on the 2015 Statement conclusions is outlined in paragraphs A8.919 onwards.

b) We considered that, based on the evidence available to us, the relative prices in the Swedish auction were at least as likely to reflect intrinsic valuation of spectrum in Sweden as to reflect strategic bidding.

c) We used a proxy measure for 2.6 GHz in Sweden, and we assessed the reliability of this approach in paragraphs A7.114 to A7.140 of Annex 7.[113] Overall, we did not have clear, evidence-based reasons to consider the auction outcome is less informative of forward-looking relative values in the UK (having regard to country-specific circumstances and auction dates).[114]

A2.191 Therefore, we were satisfied that the 1800 MHz distance method benchmark from Sweden met our Tier 1 criteria.

Responses to our June 2018 consultation

Our assessment of the Swedish evidence in our 2015 Statement

A2.192 In its 2018 consultation response, BT disagreed with our tiering assessment of the 2011 1800 MHz Swedish benchmark in our 2015 Statement and proposed moving it from Tier 1 to Tier 2.

A2.193 BT referred to the arguments previously outlined by EE. In the past, EE has argued that the 2.6 GHz proxy value (average based on benchmarks in other markets) is less appropriate than actual data. It further noted that if a proxy value is needed, then the Swedish benchmark should not be considered Tier 1 evidence.

A2.194 BT also suggested that Ofcom rejected the relevance of the Swedish 2.6 GHz auction value as it contradicted Ofcom's view that 1800 MHz is more valuable than 2.6 GHz. BT highlighted that evidence from recent UK auctions and the 2015 Turkish auction indicate that the spectrum value does not necessarily fall with rising frequency. On this basis, BT argued it not appropriate to include the 2011 1800 MHz Swedish auction in Tier 1 and proposed moving it to Tier 2.

A2.195 Telefónica suggested that the use of 2.6 GHz proxy introduces uncertainty and risk of error and considered it inappropriate to put substantial weight on this benchmark suggesting it should be Tier 2, not Tier 1.

[113] See 2015 Statement Annex 7 paragraphs A7.114 to A7.140.

[114] We used a proxy measure for 2.6 GHz in Sweden, and our assessment of the reliability of this approach is outlined in our 2015 Statement (See 2015 Statement Annex 7 paragraphs A7.114 to A7.140). While we noted that there is no uniquely correct method to derive a 2.6 GHz proxy value in Sweden, in 2015 we set out our methodological and empirical reasons for favouring our preferred approach over alternative methods. In Annex 7 we discuss alternative methods which would imply distance method benchmarks of £14.6m per MHz and £17.6m per MHz (see Table A7.9), which are respectively 9% below and 10% above the benchmark we use. As noted above, we have specific reasons to favour our preferred approach to these alternatives. In any case, we do not consider that the range between these figures is sufficiently large to warrant exclusion of this benchmark from the Tier 1 evidence group.

A2.196 Stakeholders did not make any further comment on our assessment of historic awards or benchmarks for Sweden outlined in the August 2015 Statement.

Swedish 1800 MHz award in 2016

A2.197 BT noted that Ofcom had overlooked an 1800 MHz auction in 2016 in Sweden. BT presented estimates of Swedish absolute (£8.4 million per MHz), and relative (£15.2 million per MHz) benchmarks. BT did not provide any tiering view for the new 1800 MHz distance method benchmark.

A2.198 BT also highlighted that only one operator bid for new 1800 MHz (2x10 MHz) spectrum at a modest reserve price suggesting that the market value for additional 1800 MHz spectrum in Sweden is low.[115] In the light of this, BT suggested that the 2011 1800 MHz price is more likely than previously thought to be an overstatement of market value in Sweden (of potentially larger scale).

Our assessment

Our assessment of the Swedish evidence in our 2015 Statement

A2.199 We received no further comments from stakeholders on our assessments of the 2008 2.6 GHz, 2011 800 MHz and 1800 MHz awards in Sweden. Our assessment of those awards and the benchmarks based upon their results remains as we set out in our 2015 Statement. As we set out in Annex 1 we have updated the data and methodology we have used to derive benchmark values.

A2.200 In 2015[116], we considered that the 2008 Swedish auction price for the 2.6 GHz band was unlikely to be representative of the value of 2.6 GHz spectrum relative to the value of the 800 MHz and 1800 MHz bands given that these latter bands provided the main LTE network layers in Europe. At the time we said that our observation period for awards in Europe only included awards after 2010. The rationale for this cut-off date was that generally we considered more recent evidence to be more informative.

A2.201 As before, we consider that a market-based price, where available, will typically be more informative than a proxy value in informing us of the UK spectrum values. However, as the 2.6 GHz Swedish award predates the European harmonization decision of 800 MHz and the wider use of 800 MHz as a LTE[117] we do not consider it a suitable measure for calculating the distance method benchmark.

A2.202 We have assessed the reliability of using the 2.6 GHz proxy in the past[118] and concluded that our preferred proxy provided better predictions, on average, than either the zero-

[115] The Swedish 1800 MHz award was for a 2x5 MHz licence not for 2x10 MHz. Details of this award are available at https://pts.se/en/english-b/radio/auctions/assignment-in-the-1800-mhz-band/
[116] See 2015 Statement Annex 8 paragraph A8.903.
[117] See 2015 Statement Annex 8 paragraphs A8.897 to A8.901.
[118] See 2015 Statement Annex 7 paragraphs A7.114 to A7.140.

proxy method or 1800 MHz/800 MHz paired ratio. In addition, we did not have clear evidence that it was likely systematically to overstate or understate values.[119]

A2.203 We do not consider that there is new evidence to suggest that we should change our position on this.

Additional 1800 MHz benchmark since the 2015 Statement

A2.204 In response to BT's consultation feedback, we have assessed the Swedish 2016 1800 MHz award. We consider that this auction provides some additional information on the Swedish spectrum values and aligns with our conclusions on the 2011 1800 MHz distance method benchmark from Sweden. Our assessment of the 2011 award has not changed from the 2015 Statement.

A2.205 Our analysis, tiering and risk assessment are included in the following sections.

October 2016 1800 MHz auction

A2.206 In October 2016, an award of 1800 MHz spectrum took place in Sweden. The auction awarded a 2x5 MHz licence (block 14), previously held by Net4Mobility, using a first-price sealed-bid auction (FPSB) format. The location of the awarded spectrum was dependent on the winner's existing spectrum holdings.[120]

A2.207 The results of this auction are set out in Table A2.18, with the auction features summarised in Table A2.19.

Table A2.18: October 2016 1800 MHz[121,122]

	1800 MHz	Price Paid (SEK)
Total Available	**2x5**	**-**
Hi3G	2x5	100,050,000
Unsold	-	-

[119] See 2015 Statement Annex 7 paragraph A7.138 (c).
[120] A winner with an existing licence for block 13 in the 1800 MHz band was going to be assigned location A, and a winner without an existing licence for block 13, location B.
[121] https://pts.se/en/english-b/radio/auctions/assignment-in-the-1800-mhz-band/
[122] In a press release on Hi3G's website, Johan Johansson, the CEO of 3 Sweden, said that the company plans to use its 1800MHz frequency to expand its 4G LTE network, which TeleGeography notes is currently operating in the 800MHz and 2600MHz bands, available at https://www.telegeography.com/products/commsupdate/articles/2016/10/25/3-sweden-wins-1800mhz-spectrum-auction/

Table A2.19: October 2016 1800 MHz auction

	Description	Comment
Number of bidders; number of lots; lot sizes	There was only one bidder (Hi3G) for one 2x5 MHz lot.	At the time of the 2016 1800 MHz auction, Hi3G was the only MNO that did not hold any spectrum in the 1800 MHz frequency band.
Spectrum caps/restrictions	No spectrum cap.	n/a
Reserve prices	SEK 40 million for the 2x5 MHz lot.	The auctioned 1800 MHz 2x5 MHz lot sold above reserve price. The auction revenue was over two and half times the reserve price.
Obligations	No coverage obligations.	n/a
Other factors	Licence length: the Swedish 1800 MHz licence is for 10.5 years.[123] Annual licence fees apply.[124]	n/a

A2.208 We have considered whether absolute and relative values derived from this auction are likely to reflect market value in Sweden, and whether the value of 1800 MHz spectrum in Sweden is likely to reflect UK market value.

Background to the 1800 MHz spectrum awards

A2.209 At the time of the 2016 award, there were four MNOs in Sweden and all MNOs except Hi3G had previously secured 1800 MHz spectrum.[125] This meant that before the start of the 2016 auction both TeliaSonera and Net4Mobility held a considerable amount of 1800 MHz spectrum. In contrast, Hi3G was the marginal bidder in the 2011 1800 MHz spectrum auction and failed to secure any spectrum.

[123] For the purposes of calculating our absolute value benchmarks, we have accounted for the differences in licence lengths between the UK and Sweden using a discount factor. The UK licence length is 20 years, whilst the Swedish 1800 MHz spectrum licence was awarded for 10.5 years. More detail on the methodology is included in Annex 1.
[124] Annual licence fees apply, legislation on fees available at https://pts.se/globalassets/startpage/dokument/legala-dokument/foreskrifter/avgifter/ptsfs-2017-5.pdf page 8-9.
[125] At the time of the 2016 1800 MHz spectrum auction TeliaSonera held a 2x25 MHz licence (expiring in 2037) and a 2x10 MHz licence (expiring in 2027); Net4Mobility (a joint venture by Tele2 and Telenor) held a 2x10 MHz licence (expiring in 2037) and two 2x10 MHz licences (expiring in 2027). Licences assigned in the 2011 auction expire in 2037, and the licences that were renewed in 2011 expire in 2027.

A2.210 The 2016 1800 MHz auction offered only one 2x5 MHz lot for sale, and Hi3G was the only bidder as the previous licence holder Net4Mobility did not bid.[126] There were no spectrum caps or restrictions on participation. Despite lack of competition in the auction this spectrum sold significantly above the reserve price.

A2.211 Below, we consider whether the 1800 MHz award is likely to reflect market value and consider competition in the 800 MHz award, 2016 auction design, auction revenue from the 1800 MHz spectrum and the value of the 2.6 GHz proxy.

Whether award outcomes are likely to reflect market value in Sweden

Competition in the 800 MHz auction

A2.212 In 2015 we concluded that the 800 MHz price in 2011 had a larger risk of overstating the market value in 2011. We considered the likelihood and scale of this risk to be unknown.[127]

A2.213 We have no reason to change our view of this award.

Auction design, competition in the auction and revenue from the 1800 MHz award in 2016

A2.214 The Swedish 1800 MHz was a FPSB format. In general, for FPSB auctions, perceptions of the strength of other bidders can affect the outcome. When a single licence is offered, bidders that underbid their best estimate of the value of the lot, in an attempt to minimise the amount that they will have to pay, may inefficiently lose the auction to a bidder having a lower valuation (but who bids a higher proportion of their value). Differences in perceptions of bidder strength could arise either because there are genuine differences or because one bidder errs in its assessment of the strength of its rivals. In this Swedish auction, it is likely that Hi3G erred in anticipating at least one competing bid for the auctioned award since it could have bid at the reserve price if it expected no competition.

A2.215 Based on the discussion above, we consider that the use of a FPSB auction format runs a risk of bid shading as bidders seek to minimise the amount they will pay. On the other hand, cautious bidders may end up bidding closer to their valuation to ensure they win the auctioned spectrum.[128]

A2.216 The Swedish 1800 MHz FPSB auction was held to reassign an expiring licence for 2x5 MHz previously held by Net4Mobility. Hi3G, which did not have an existing 1800 MHz spectrum licence, was the only bidder and its bid of SEK 100.05 million was significantly above the reserve price (SEK 40 million).

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[126] This 2x5MHz lot accounts for only around 7% of all licensed 1800 MHz spectrum, compared to the 2011 auction where 2x35 MHz was auctioned (half of the 1800 MHz frequency band). In comparison to all international benchmarks that we have considered previously (including the 2015 Statement, 2018 consultation and this document) the 2016 Swedish award auctioned very little spectrum.

[127] See 2015 Statement Annex 8 paragraph A8.917.

[128] Considering that a market-driven 1800 MHz value (the 2011 1800 MHz award) was available at the time of the 2016 auction, our view is that the common-value uncertainty over the value of the auctioned spectrum in 2016 was low, and therefore the risk of winner's curse and Hi3G overbidding its valuation of 1800 MHz in the 2016 auction unlikely.

A2.217 Against this background, we have considered two alternative interpretations of the 2016 auction outcome with differing implications for the market value of 1800 MHz spectrum in Sweden more generally.

A2.218 One possible explanation for the auction outcome where only Hi3G bid, is that (as suggested by BT) the market value for additional 1800 MHz spectrum in Sweden is low. On this interpretation, the marginal or losing bid for the 2x5 MHz of 1800 MHz spectrum in the 2016 award is representative of the marginal opportunity cost of the 1800 MHz band in Sweden, i.e. also including the other 2x65 MHz.[129] In the 2016 auction there was no competing bid to Hi3G's winning bid, suggesting that the other existing MNOs placed a relatively lower valuation on acquiring this additional 1800 MHz spectrum than the reserve price.

A2.219 This first interpretation suggests that the 1800 MHz benchmark may overstate the market value in Sweden.

A2.220 A second, alternative, interpretation of the auction circumstances is that the marginal bid for the 2x5 MHz in the 2016 award is not representative of the marginal opportunity cost of the 1800 MHz band as a whole.[130] On this interpretation, the marginal bidder for 1800 MHz spectrum in Sweden is likely to be Hi3G. This interpretation is consistent with the fact that Hi3G was the marginal bidder in the 2011 auction.[131]

A2.221 This second interpretation suggests that the forward-looking marginal opportunity cost for 1800 MHz spectrum in Sweden is provided by Hi3G's value for additional 1800 MHz spectrum, beyond the 2x5 MHz that it acquired in the 2016 award. We have identified two considerations affecting what we could infer about this marginal opportunity cost from Hi3G's bid in the 2016 auction:

a) For the 2x5 MHz in the auction, since we expect the FPSB format of the 2016 auction to imply bid shading, it is likely that Hi3G's value is higher than its bid. This consideration suggests that the 2016 auction price may understate market value.

b) Hi3G's value for additional 1800 MHz spectrum could be either lower than its value for the 2x5 MHz in the 2016 award (if it has declining marginal value for 1800 MHz spectrum) or higher (if there is a synergy in a larger block than 2x5 MHz). This consideration implies that the 2016 auction price may either overstate or understate market value.

A2.222 Overall, we consider it important to recognise the limited amount of spectrum in the 2016 auction – only 2x5 MHz – and the pattern of holdings of 1800 MHz spectrum in Sweden, with TeliaSonera and Net4Mobility already holding substantial amounts before the auction (at least 2x30 MHz each). These facts, along with the evidence of Hi3G being the marginal bidder in the 2011 auction, tend to suggest that the second interpretation described above is more likely than the first interpretation. Based on this assessment, and considering the

[129] 2x35 MHz held by TeliaSonera and 2x30 MHz by Net4Mobility – see the footnote to paragraph A2.210 above.
[130] The auctioned spectrum accounted for only around 7% of the band.
[131] The spectrum in the 2011 auction accounted for 50% of the frequency band.

auction circumstances, on balance, we conclude that the 1800 MHz award risks under/overstating the market value.

A2.223 For completeness, we note that in the 2015 Statement we also assessed the Norwegian 2013 award where a FPSB auction was used, although in that case it was a combinatorial auction for multiple spectrum bands. We concluded, along with several stakeholders, that the Norwegian 2013 award was unlikely to be informative of market value, due to the significant risk of bid shading.[132, 133] We decided not to derive benchmarks from the Norwegian award for three reasons:

a) the auction was a FPSB auction

b) there was evidence of bid shading (Tele2's failure to win any spectrum, an unsold lot of spectrum, and subsequent interest in the unsold lot by Tele2), and

c) the regulatory authority was unable to provide detailed bidding information that would have allowed us to derive band-specific estimates due to data confidentiality.

A2.224 We have no reason to change our position on this Norwegian award (see paragraph A2.244).

A2.225 The information for the Swedish 1800 MHz auction in 2016 allows us to construct a benchmark. However, in the absence of competition and given the likelihood of bid shading considering the auction format, we do not consider that the prices were determined by a market-driven process and it is likely that the bidders' valuation is not based on intrinsic valuation of spectrum but rather strategic bidding to secure it at the lowest possible cost.

A2.226 Our assessment of the 2016 Swedish 1800 MHz auction does not undermine the relevance of the 2011 Swedish 1800 MHz auction and we have included benchmarks from both auctions in our evidence base. However, given the circumstances of this 2016 award, on balance, we consider that there is a risk the 1800 MHz award may under/overstate the market value of 1800 MHz spectrum in Sweden.

2.6 GHz proxy

A2.227 As the latest 2.6 GHz spectrum award in Sweden is from 2008, we have used the 2.6 GHz proxy to derive the benchmark. Based on our 2015 assessment, we consider that the use of a proxy carries a risk that the distance method benchmark may under/overstate market value in Sweden although the scale of this is unknown.

Risk of understatement or overstatement of the Swedish 2016 spectrum award

A2.228 Based on the assessment above, on balance, we consider that the 2016 auction prices of 1800 MHz spectrum in Sweden run a risk of an under/overstatement of market value.

[132] See 2015 Statement Annex 7 paragraphs A7.19 and footnote 51.
[133] See 2015 Statement Annex 8 paragraphs A8.659 to A8.669.

Likelihood of spectrum awards reflecting market value in the UK

A2.229 We are not aware of any country-specific factors that would cause the 2016 1800 MHz spectrum auction in Sweden to be an understatement or overstatement of the value in the UK. However, overall, we consider that the 1800 MHz award in 2016 does not reflect a market-driven process, for the reasons set out above, and is of limited use in assessing forward-looking spectrum values in the UK.

Assessment of the Swedish 2016 1800 MHz benchmark

A2.230 Below we outline our assessment of the likelihood and scale of any over/understatement for the distance method benchmark using the 2016 1800MHz award. We also summarise our tiering assessment on the Swedish 2016 distance method benchmark.

Risk of understatement or overstatement of the Swedish 2016 distance method benchmark

A2.231 Here we list the risks associated with the Swedish distance method relative to the UK market value:

a) Considering competition for the 2011 800 MHz spectrum, and the impact of WRC12 and LTE we considered in the 2015 Statement that there was a risk that the 800 MHz price from Sweden carried a larger risk of overstatement of forward-looking 800 MHz market value, but we could not be sure of the scale of overstatement.

b) We consider that due to the auction design and the circumstances surrounding the 2016 1800 MHz auction, the benchmark runs a risk of understatement/overstatement to the UK 1800 MHz market value of an unknown scale for this effect.

c) Using the 2.6 GHz proxy in the distance method benchmark risks under/overstating market value in the UK. The scale of this risk is unknown.

d) We are combining auction prices from different auctions in different years, 2011 (800 MHz) and 2016 (1800 MHz). There is a risk that this gap in time affects the risk of understatement or overstatement, although we have not identified a clear direction or magnitude of the possible effects.

A2.232 All these factors considered, we think there is a larger risk of an understatement of an unknown scale in the distance method benchmark.

Tiering of the Swedish 2016 distance method benchmark

A2.233 Considering the criteria for inclusion in Tier 1:

a) The auction price for the 2016 1800 MHz spectrum was above reserve. However, the FPSB auction format raises the risk of bid shading. Additionally, the absence of competing bids for the 1800 MHz award means that there was no excluded marginal bidder. Overall, we do not consider the 1800 MHz Swedish auction price reflects a market-driven process.

b) With the FPSB auction, bidders have an incentive to shade their bids to minimise their costs of acquiring the spectrum. For this reason, it is not clear whether Hi3G's bid for the 1800 MHz spectrum was based on intrinsic valuation of this spectrum rather than a bidding strategy to secure an award at the lowest possible cost.

c) We are not aware of any country-specific factors that would indicate that the 1800 MHz benchmark in Sweden is less likely to be informative of forward-looking relative spectrum values in the UK.

A2.234 Based on this assessment, we do not consider the benchmark meets our criteria for Tier 1. We therefore consider the criteria for inclusion in Tier 2:

a) We consider that the circumstances of the 1800 MHz auction are such that we think there is a risk that the relative prices of the different awards do not reflect bidders' relative valuations of different frequency bands in Sweden.

b) There are no other factors suggesting the distance method benchmark is uninformative of forward-looking relative spectrum values in the UK.

A2.235 Based on this assessment we therefore consider that the benchmark should be in Tier 3.

Table A2.20: Summary of evidence points from Sweden (in April 2018 prices)[134]

	Absolute values (£m/MHz)		Relative value benchmarks[135] (£m/MHz)
	800 MHz	1800 MHz	Distance method
Final values	23.3	8.1	14.1 (28%) (Tier 3)
Assessment of risk	Larger risk of overstatement	Risk of under/overstatement	Larger risk of understatement

[134] The absolute value for 1800 MHz is based on the 2016 auction data, whilst 800 MHz value is derived from the 2011 auction. The distance method is calculated using the 2.6GHz proxy.
[135] Based on the UK 800 MHz value with no coverage obligations and gross of expected DTT co-existence costs.

Lithuania 2016 award

A2.236 We identified the Lithuanian 1800 MHz award as a part of our wider research following the June 2018 consultation. Stakeholders did not refer to this award in their responses to our 2018 consultation and no stakeholder has argued for the inclusion of a benchmark from Lithuania as part of our assessment of lump-sum values of the 900 and 1800 MHz spectrum in the UK.

A2.237 In addition, we note that 800 MHz spectrum was auctioned in Lithuania in 2013. In this auction one 2x10 MHz and four 2x5 MHz lots were awarded, and a spectrum cap of 2x10 MHz applied. All MNOs secured spectrum up to the cap:

a) Omnitel two lots of 2x5 MHz for €1,477,062 (€738,531 each),

b) Tele2 two lots of 2x5 MHz for €579,240 (€289,620 each) and

c) Bite Lietuva one lot of 2x10 MHz for €292,516.

A2.238 Two out of three bidders secured their 800 MHz spectrum at or very close to the reserve price (1% above). This may suggest the 800 MHz value is understated, although one MNO paid more than reserve price (mark-up 155%).

A2.239 In 2016, the Lithuanian NRA awarded 900 MHz/1800 MHz in a combinatorial clock auction (CCA). Three packages were auctioned. These consisted of one 2x11.6 MHz of 900 MHz and one 2x25 MHz lot of 1800 MHz for a period of 15 years. Due to a spectrum cap (2x11.6 MHz in 900 MHz band and 2x25 MHz in 1800 MHz band), each provider could only bid for one package.

A2.240 All three MNOs participated and secured spectrum up to the cap. We do not have band specific reserve prices available for the Lithuanian award, and therefore have been unable to derive relative [and absolute] value benchmarks. However, we understand that the MNOs secured the spectrum for the following prices:

a) Omnitel €14,300,000

b) Tele2 €13,700,000

c) Bite Lietuva €10,100,000

A2.241 This compares with the reserve price of €10,000,000 for the package of 900/1800 MHz. Considering this, it is likely that the bids above reserve price reflect the first pick reward rather than competitive pressure for this spectrum.[136]

A2.242 As a result of the spectrum cap, we do not consider this award to be a market-driven process and we think that it would therefore be of only limited use in assessing forward-looking spectrum values in the UK. This means that we consider it likely that the Lithuanian auction prices understate the value of 900/1800 MHz spectrum in Lithuania. Based on this assessment of the Lithuanian award, we consider that any relative benchmarks derived

[136] We consider it likely that MNOs bidding above the reserve sought to win the right to pick which specific spectrum bands given that only three bidders were going to participate, and that all bidders were restricted to one 900/1800 MHz licence.

from this award (if we had band-specific prices) would not be Tier 1. However, to undertake a full assessment on the relative benchmarks for Lithuania we would require band specific prices, which we do not have available to us. Considering that the benchmarks are unlikely to be Tier 1 and completing this assessment would require extensive time and analysis, we do not consider it necessary or proportionate to further investigate the circumstances of this award.[137] As we do not have band specific reserve prices available to us, we cannot derive benchmarks for the Lithuanian 2016 awards.

[137] In CCAs, unlike SMRAs, prices are not determined on a lot- or band-specific basis but prices are for the winning packages of spectrum. To determine a band specific price requires extensive analysis which we have previously done for the Austrian 2013 award (we obtained Linear Reference Prices from the NRA, as detailed in the May 2014 Update on European auctions). The CCAs that we considered in 2015 are listed in the 2015 Statement (see 2015 Statement Annex 7 paragraphs A7.14 to A7.23). We also note the situations where we were unable to infer prices with sufficient accuracy from publicly available information, and to obtain additional information from the relevant NRA to inform our benchmarking analysis (eg. Ireland multiband auction in 2012).

Norway

Awards considered in our 2015 Statement

A2.243 In Annex 8 of our 2015 Statement we considered the Norwegian December 2013 combinatorial multiband award which was a sealed-bid, first-price combinatorial auction awarding licences for the use of 800 MHz, 900 MHz and 1800 MHz spectrum.

A2.244 Due to the auction format and unavailability of band-specific prices we were unable to derive benchmarks from this auction. For further details of our assessment, see 2015 Statement, Annex 8, pages 179-181.

Awards considered in our June 2018 consultation

A2.245 In our June 2018 consultation we considered two additional auctions that had taken place in Norway since our 2015 Statement:

a) 1800 MHz in January 2016

b) 900 MHz in May 2017

January 2016 1800 MHz award

A2.246 This award was a multi-round ascending clock auction for the 2x15 MHz of 1800 MHz spectrum that was unsold in the 2013 multiband auction.[138] The results of this auction are set out in Table A2.21 below, with the auction features summarised in Table A2.22 below.

Table A2.21: January 2016 1800 MHz auction results[139]

	1800 MHz	Price Paid	Package mark-up on reserve price
Total Available	2x15	-	
TeliaSonera	2x5	NOK 292.7m	5754%
TeleNor	2x10	NOK 585.3m	5753%
Ice Communication[140]	-	-	-
Unsold	-	-	-

[138] See: https://eng.nkom.no/technical/frequency-auctions/auctions/planned-completed-auctions/_attachment/20880?_download=true&_ts=150f040a7c3

[139] See: https://eng.nkom.no/technical/frequency-auctions/auctions/planned-completed-auctions/auction-23-1800-mhz

[140] Telco Data who won spectrum in the December 2013 multiband auction was re-named Ice Communication in 2014. See: https://icegroup.com/blog/telco-data-becomes-integrated-in-fully-financed-ice/

Table A2.22: January 2016 1800 MHz auction features

	Description	Comment
Number of bidders; number of lots; lot sizes	There were 3 bidders and 3 lots of 2x5 MHz each. Only 2 bidders (the main incumbents) secured spectrum.	The three lots were the unsold spectrum from the December 2013 multiband auction.
Spectrum caps / Restrictions	No spectrum cap.	
Reserve prices	NOK 5m for each paired lot.	
Obligations	No coverage obligations.	

May 2017 900 MHz award

A2.247 This was an SMRA auction of 2x20 MHz 900 MHz spectrum. The results of this auction are set out in Table A2.23 below, with the auction features summarised in Table A2.24 below.

Table A2.23: May 2017 900 MHz auction results[141]

	900 MHz	Price Paid	Package mark-up
Total available	2x20		
TeliaSonera	2x10	NOK 394.0m	41%
TeleNor	2x10	NOK 396.2m	42%
Third bidder[142]	-	-	-
Unsold	-	-	-

[141] See: https://www.dotecon.com/news/nkom-announces-900-mhz-auction-results/

[142] See https://www.dotecon.com/news/nkom-announces-900-mhz-auction-results/. This notes that there were three bidders but their identity is not given.

Table A2.24: May 2017 900 MHz auction features[143]

	Description	Implications
Number of bidders; number of lots; lot sizes	There were 3 bidders and 4 lots of 2x5 MHz each. Only 2 bidders (the main incumbents) secured spectrum.	
Spectrum caps / Restrictions	Spectrum cap of 2x15.1 MHz including existing holdings in the band.	Following the auction both TeliaSonera and TeleNor held 2x15 MHz of spectrum.
Reserve prices	NOK 140m for each paired block	
Obligations	No coverage obligations.	

Assessment in the June 2018 consultation

Whether award outcomes are likely to reflect market value

A2.248 The January 2016 1800 MHz spectrum sold well above reserve price. We considered that the price for 1800 MHz, based on the winning bids in the January 2016 auction, may be reflective of market value in Norway.

A2.249 The May 2017 900 MHz spectrum sold above reserve price. We noted that for both TeliaSonera and TeleNor the spectrum cap was binding which could create a risk that the auction price understates market value in Norway. We said this may be mitigated in part by the presence of the third bidder who did not secure any spectrum. On balance, we considered that there was a risk that the price for 900 MHz, based on the winning bids in the May 2017 auction might understate market value in Norway.

Likelihood of reflecting UK market value

A2.250 We were not aware of any country-specific factors that would cause the 2016 1800 MHz auction and the 2017 900 MHz auction in Norway to be an understatement or overstatement of the value in the UK.

Relative benchmarks

A2.251 We said that while the more recent 1800 MHz and 900 MHz auctions provided us with prices for those spectrum bands, without data on the price of the 800 MHz or 2.6 GHz

[143] See https://www.nkom.no/teknisk/frekvensauksjoner/auksjoner/planlagte-avsluttede/_attachment/27995?_ts=15adcabcd30

bands, we were unable to derive relative value benchmarks for the 900 and 1800 MHz bands in Norway.[144] We considered whether we could apply the prices for 1800 MHz and 900 MHz spectrum from the 2016 and 2017 auctions to the 2013 auction to infer a price for 800 MHz spectrum. However, this implied a negative price for 800 MHz[145] which we did not consider to be in any way sensible as an indication of the market value of 800 MHz.

A2.252 For these reasons, we did not propose to derive relative value benchmarks for Norway.

Stakeholder responses to the June 2018 consultation

A2.253 Telefónica supported our analysis of Norway and our focus on ratios rather than absolute benchmarks.[146] No other stakeholder made a substantive comment on our analysis of 900 MHz or 1800 MHz in Norway.

Our assessment

A2.254 We maintain our view of the Norwegian 900 MHz and 1800 MHz auctions as set out in our June 2018 consultation and summarised above.

A2.255 Using the data from the 2016 1800 MHz and 2017 900 MHz awards, we derive the following absolute value benchmarks for the ALF bands in Norway (in April 2018 prices):

a) 900 MHz: £28.8m per MHz

b) 1800 MHz: £36.8m per MHz

A2.256 These numbers have changed slightly from the figures in the June 2018 consultation, almost entirely due to changes we have made changes around the cost of debt used in the discount rate (see Annex 1 for details).

A2.257 We note that these estimates for 900 and 1800 MHz give an 1800 MHz/900 MHz ratio of 128%.

A2.258 For the reasons set out in our 2018 consultation and summarised above, we consider that the 900 MHz value has a risk of under-statement while for the 1800 MHz value we have not identified a risk of under- or over-statement.

[144] In our 2015 Statement, we noted that the NRA was unable to provide us with LRP or other band-specific price information for the 2013 multiband auction. Since total receipts from the auction were well above reserve prices, we considered that it was not possible to use reserve prices as an approximation of the market value of spectrum by band. For this reason, we did not derive benchmarks from the Norwegian auction in 2015 (See 2015 Statement, Annex 8, paragraphs A8.664-A8.667).

[145] In other words, the price paid for 1800 MHz and/or 900 MHz spectrum in the recent auctions was higher than the implied prices for 1800 MHz and 900 MHz in the 2013 multiband auction.

[146] Telefonica response to June 2018 consultation, page 26.

Table A2.25: Summary of evidence points from Norway (in April 2018 prices)

	Absolute values (£m/MHz)		Ratios (%) for cross-checks
	900 MHz	1800 MHz	1800 MHz/ 900 MHz
Final values	28.8	36.8	128%
Assessment of risk	Risk of under-statement	No risk identified	Risk of overstatement

Slovenia 2016 award

A2.259 We identified a Slovenian 1800 MHz award carried out in 2016 as a part of our wider research following the June 2018 consultation. Stakeholders did not refer to this award in their responses to our 2018 consultation and no stakeholder has argued for the inclusion of a benchmark from Slovenia as part of our assessment of lump-sum values of the 900 and 1800 MHz spectrum in the UK.

A2.260 We noted in the 2015 Consultation that 800 MHz, 900 MHz, 1800 MHz and 2.6 GHz spectrum were auctioned in Slovenia in 2014 in a multiband CCA.[147] We attempted to obtain estimates of band-specific prices for Slovenia, but we were not able to do so. For this reason, we did not propose to derive a distance method benchmark for the Slovenian auction in 2015. We are therefore only able to derive an 1800MHz absolute value on the basis of the 2016 award which is reported as part of our crosschecks analysis in Annex 4.

A2.261 In September 2016 the Slovenian regulator auctioned 10 MHz of 1800 MHz paired spectrum which had remained unsold in the 2014 auctions. A 10 MHz unpaired block of 2.1 GHz spectrum was auctioned simultaneously to the 1800 MHz award. The auction format was a sealed-bid first price auction.

A2.262 The successful bidder was obliged to provide coverage to 25% of the population of Slovenia after three years rising to 40% of the population after five years. We do not consider these coverage obligations particularly onerous and consider it unlikely that they materially impacted on the value of 1800 MHz award.

A2.263 Two mobile network operators participated in the auction, Telemach and Telekom Slovenije. Only one MNO, Telemach, bid for the 1800 MHz spectrum and secured it at the reserve price of €5,200,000 (€2,600,000 for each 10MHz block). The licences were awarded until January 2031.[148]

A2.264 For the 2.1 GHz spectrum, in the first round, Telemach bid slightly above the reserve price while Telekom Slovenije bid at the reserve price. In the second round Telekom Slovenije did not increase its bid. This may suggest that the reserve price for 2.1 GHz was high relative to the market value.

A2.265 Perceptions of the strength of other bidders can affect the outcome. It is unclear whether Telemach could have anticipated that the 1800 MHz spectrum would remain uncontested based on the 2014 awards. The fact that Telemach bid at reserve price may be indicative that it expected limited competition in the auction.

A2.266 Alternatively, the 1800 MHz spectrum selling at reserve price may indicate that the reserve price was set too high, overstating the market value. However, as there was no unsold

[147] See footnote 108 of the February 2015 Consultation: https://www.ofcom.org.uk/__data/assets/pdf_file/0022/83146/annual-licence-fees-900MHz-1800-further-consultation.pdf

[148] Available at https://www.akos-rs.si/agency-for-communication-networks-and-services-of-the-republic-of-slovenia-successfully-concluded-first-spectrum-auction-for-public-mobile-services

spectrum we consider it more likely that the auction outcome was driven by limited competition, and there is a risk of understatement to the 1800 MHz market value.

A2.267 In addition, due to the first price sealed-bid auction format[149], we consider that there is a risk of bid shading and for this reason the 1800 MHz value may be an understatement of the market value in Slovenia.

A2.268 On balance we conclude that there is a risk of understatement.

Table A2.26: Summary of evidence points from Slovenia (in April 2018 prices)

	Absolute values (£m/MHz) 1800 MHz
Final values	12.2
Assessment of risk	Risk of understatement

[149] For a more detailed discussion see the 2016 Swedish award in paragraphs A2.206 onwards.

Turkey

Our position in 2015

A2.269 The three incumbent operators, Avea, Turkcell and Vodafone, participated in the 2015 multiband auction awarding 800/900/1800 MHz/2.1 GHz and 2.6 GHz spectrum. We understand that the bands were awarded sequentially, beginning with 800 MHz and ending with 2.6 GHz.

A2.270 Spectrum caps prevented MNOs from winning more than one lot in each band, restricting competition with the result that the smallest lot in each band sold at the reserve price.

A2.271 In the 2015 statement, we did not consider that average lot prices from this auction reflected market value.[150] We noted that the incremental price difference between the smallest and largest lot could provide a more meaningful indicator of bidders' valuation of spectrum. However, the average incremental price for larger amounts of 2.6 GHz spectrum was substantially above that of 1800 MHz.

A2.272 We had previously said that we do not consider it credible that 1800 MHz spectrum has a lower value than 2.6 GHz spectrum in the UK.[151] In 2015 we considered this to mean that the higher average incremental price of 2.6 GHz compared to 1800 MHz in Turkey may be due to auction-specific or country-specific circumstances which are not relevant to the UK.

A2.273 In the auction, 800 MHz sold marginally above reserve, and the 1800 MHz and 2.6 GHz average prices are unlikely to be meaningful indicators of market value. We also noted that there was lack of competition for 900 MHz spectrum, and the 900 MHz licences were unsuitable for LTE.

A2.274 Subsequently, we said that if we were to include[152]:

a) A 900 MHz benchmark based on the ratio of reserve prices, this would be at best a Tier 3 benchmark.

b) For 1800 MHz, a distance method benchmark based on average prices would be at best Tier 3.

A2.275 We concluded that we should not include relative benchmarks or absolute values from this auction in our dataset for 900 MHz or 1800 MHz. At the time we noted that no stakeholder had argued that we should do so. If we were to include benchmarks from the Turkey auction, we did not consider that it would materially affect our conclusions on lump-sum values of the 900 and 1800 MHz spectrum, given the discussion of tiering above.

[150] See 2015 Statement Annex 8 paragraph A8.945.
[151] See 2013 consultation paragraph 4.45.
[152] See 2015 Statement Annex 8 paragraphs A8.941 to A8.948.

Responses to the 2018 Consultation

A2.276 BT said that the results of the 2015 award in Turkey should be fully considered and incorporated into our benchmark analysis. BT said that Ofcom should not exclude Turkey entirely on the grounds that it is inconsistent with a presumption that 1800 MHz spectrum must be more valuable than 2.6 GHz.

Assessment

A2.277 As noted in Annex 1, our benchmarking analysis focuses on European auctions since 2010 because we consider that European countries are more likely to operate within a similar regulatory framework to the UK, and are more likely to be more informative about the spectrum value in the 900 MHz and 1800 MHz frequency bands in the UK. This approach is consistent with our methodology as set out in our previous consultation and statement documents.[153]

A2.278 We continue to believe that 1800 MHz has some favourable characteristics that generally make it more valuable than 2.6 GHz and that it is not credible that 1800 MHz spectrum has a lower value than 2.6 GHz spectrum in the UK.

A2.279 Apart from BT no other telecoms provider has suggested that we include Turkey. Our existing set of benchmarks for 1800 MHz already includes seven Tier 1 benchmarks, one Tier 2 benchmark and eight Tier 3 benchmarks. For 900 MHz we have three Tier1 benchmarks, two Tier 2 benchmarks and three Tier 3 benchmarks. As noted above the outcome of the Turkish auction did not reflect a market driven process and the features of the auction indicate that it would provide Tier 3 benchmarks at best. Consequently, we do not consider that it is necessary to expand the scope of our benchmark exercise to include Turkey.

[153] See 2014 further consultation https://www.ofcom.org.uk/__data/assets/pdf_file/0025/74680/condoc.pdf, for example.

UK

PSSR award

A2.280 We completed the public sector spectrum release (PSSR) auction of the 2.3 and 3.4 GHz bands on 13 April 2018.[154] The lump-sum auction prices of these bands were £5.1474m per MHz for 2.3 GHz and £7.5648m per MHz for 3.4 GHz.[155] In our view, these auction prices do not provide evidence that would lead us to change our assessment of the forward-looking market values for the 900 and 1800 MHz spectrum:

a) These auction prices are for different bands than the 900 and 1800 MHz spectrum.

b) In our July 2017 statement on the PSSR auction, we noted that the 2.3 and 3.4 GHz spectrum is likely to be used by mobile network operators to deliver additional *capacity* for mobile broadband.[156] This emphasises that these PSSR auction bands are unlikely to be a close substitute for 900 MHz spectrum (which is low-frequency spectrum with advantages in providing *coverage*).

c) To the extent that 2.3 GHz could be a substitute for 1800 MHz spectrum, we note that the auction price of the 2.3 GHz band was broadly similar to the market value for 2.6 GHz spectrum (£5.9m per MHz in April 2018 prices (paired spectrum)), and is TDD[157] (unpaired) spectrum which might have a different value to FDD[158] (paired) spectrum.

d) Whilst the auction price of the 3.4 GHz band was significantly larger than for 2.3 GHz (even though it is at a higher frequency), we also note that it is part of the wider 3.4-3.8 GHz band that has been identified as the primary band for the introduction of 5G in Europe.[159]

[154] https://www.ofcom.org.uk/spectrum/spectrum-management/spectrum-awards/awards-in-progress/2-3-and-3-4-ghz-auction

[155] These are the base prices from the principal stage of the auction (i.e. excluding additional prices for specific frequency locations in the assignment stage). The figure for 3.4 GHz is the lower of the two auction prices paid by winning bidders for 3.4 GHz spectrum (Telefónica paid an auction price that was 5% higher).

[156] July 2017 PSSR auction statement, paragraph 1.2.

[157] Time Division Duplex – a technology that deals with traffic asymmetry where the uplink is separated from the downlink by the allocation of different time slots in the same frequency band in unpaired spectrum.

[158] Frequency Division Duplex – a technology that deals with traffic asymmetry between uplink and downlink where separate frequency bands are used to send and receive signals.

[159] July 2017 PSSR auction statement, paragraph 2.15 b).

Specific comments raised by stakeholders on auctions that we considered in our 2015 Statement

Introduction

A2.281 In response to our June 2018 consultation, stakeholders made comments on the international benchmarks from three of the countries that we considered in our 2015 Statement, namely Austria, Sweden and Germany.

A2.282 In this section we summarise stakeholders' comments and set out our responses to them on the points raised in relation to Austria and Germany. We discussed the comments raised in relation to Sweden as part of our wider analysis of Swedish auctions earlier in this annex (see paragraphs A2.193 to A2.204).

Austria

Stakeholder responses

A2.283 BT and Telefónica noted that the MNOs had discussed the Austrian auction at length in multiple responses prior to the 2015 Statement. Both BT and Telefónica continued to be of the view that the Austrian auction should not be considered a reliable benchmark and was distorting the lump-sum value of UK 1800 MHz auction: [160]

a) Telefónica continued to believe that this auction should be treated as a Tier 3 benchmark, not Tier 1, and noted that "*it was widely understood that prices in this auction were grossly distorted by strategic bidding behaviour."* It considered that it would be conservative to remove this benchmark from Tier 1 and was of the view that this would reduce the lump sum value of 1800 MHz in the UK to £13m per MHz (rounded down).

b) BT argued that we should re-consider moving the benchmark to Tier 2. It noted that:

   i) it was a combinatorial auction where a breakdown of the prices by band was not available;

   ii) Telekom Austria Group, which won 50% of the spectrum in the auction of 800 MHz, 900 MHz and 1800 MHz in 2013 commented at the time that the prices were high due to "*internationally unique intransparency (sic) paired with high reserve prices and increments"*; and

   iii) strategic behaviour leading to high prices was also an issue, quoting a 2013 press release from the Austrian regulator.[161]

[160] Telefonica response to June 2018 consultation, pages 24-25. BT response to June 2018 consultation, pages 19-20.
[161] https://www.rtr.at/en/pr/PI28102013TK.

Our assessment

A2.284 The points raised by BT and Telefónica in the June 2018 consultation were raised previously by stakeholders ahead of the 2015 Statement. We considered these submissions carefully in reaching our view on the Austrian auctions in our 2015 Statement.

A2.285 We continue to consider our assessment of the Austrian auctions as set out in our 2015 Statement, Annex 8, paragraphs A8.159-A8.223 is appropriate. We do not consider that BT and Telefónica have provided new reasoning or evidence that would lead us to revise our view.

A2.286 We therefore remain of the view that the relative benchmarks from Austria (for both 900 MHz and 1800 MHz) satisfy the criteria for Tier 1 benchmarks with the 900 MHz / 800 MHz relative benchmark carrying a larger risk of larger overstatement and the 1800 MHz distance method benchmark carrying a larger risk of overstatement.

Germany

Stakeholder responses

A2.287 Telefónica argued that the value of 1800 MHz from the German 2015 auction should be revised from a risk of understating to a risk of overstating. It noted that the marginal price for 1800 MHz was set by the competition between Telefónica and Vodafone for a fifth block which was won by Vodafone, who Telefónica argued had no obvious immediate use for it. It considered that this implied Vodafone was bidding beyond its intrinsic value and that a large proportion of the value it attached to 1800 MHz was associated with a broader strategic goal of maintaining a target spectrum share relative to Telefónica and T-Mobile.[162]

Our assessment

A2.288 Telefónica raised this point in response to our July 2015 update note on the German 2015 auction.[163]

A2.289 We considered its argument in our 2015 Statement (Annex 8), where we concluded:

> *"it is not obvious that the intrinsic value to Vodafone of the fifth 1800 MHz lot it acquired would have been less than its value to Telefónica, or that Vodafone could have expected to gain a significant strategic advantage from preventing Telefónica from acquiring this lot. For example, we note that, by acquiring a fifth 1800 MHz lot, Vodafone expanded its share of total paired spectrum holdings in the 1800 MHz, 2.1 GHz and 2.6 GHz bands to 29% (from 27%).[164] Again, we consider that, to have an incentive to bid in excess of its intrinsic value, Vodafone*

[162] Telefonica response to June 2018 consultation, page 25.
[163] Ofcom, *Update on Annual licence fees for 900 MHz and 1800 MHz spectrum: German 2015 auction*, July 2015 https://www.ofcom.org.uk/__data/assets/pdf_file/0020/81317/2015-07_alf_update_germany.pdf
[164] The equivalent expansion in share of total holdings (in MHz terms) would be to 30%, rather than 28%, if unpaired 2.1 GHz and 2.6 GHz spectrum is included in the total.

would have needed to derive sufficient "broader strategic value" from this additional share of capacity spectrum. It is not clear to us that such strategic value would arise from this relatively small difference in spectrum holdings."[165]

A2.290 We remain of this view. We do not consider that Telefónica has provided any substantive new evidence to change our view.

[165] 2015 Statement, Annex 8, paragraph A8.457 b).

A3. Technical and commercial evidence

Introduction

A3.1 This annex sets out our assessment of the impact of technical and commercial developments on spectrum values. It covers developments in: alternative mobile spectrum availability; technological developments; mobile data demand; mobile revenues; and mobile network costs. It also presents our assessment of stakeholders' views on relative 1800 MHz / 900 MHz spectrum values.

June 2018 consultation position

A3.2 In the June 2018 consultation, we considered whether technological and commercial developments since our 2015 Statement could have an impact on forward-looking market values of 900 MHz and 1800 MHz spectrum. We said that increasing demand for mobile capacity could increase the forward-looking value of ALF spectrum. On the other hand, we said there is also additional capacity for mobile use compared to expectations in 2015 – noting we are now intending to auction 3.6-3.8 GHz spectrum in 2019 alongside the 700 MHz band, as well as developments such as enhanced MIMO which may offer routes to increased capacity without additional spectrum. We considered that, on balance, recent technological or commercial developments did not provide clear evidence as to whether market values were higher or lower than in our 2015 assessment.[166]

Stakeholder responses to the June 2018 consultation

A3.3 Respondents said the real value of 900 MHz and 1800 MHz spectrum has declined since 2015 due to technological and commercial developments. They made the following arguments:

a) **The supply of mobile spectrum has increased more than was expected in 2013**, which should reduce the value of current spectrum. MNOs highlighted the sale of 1.4 GHz spectrum and the recent 2.3 GHz and 3.4 GHz spectrum award, as well as planned releases of 700 MHz, 3.6-3.8 GHz and possible future releases at 26 GHz. Telefónica said this constitutes a 77% increase in mobile "coverage" spectrum (which it defined as sub-1.5 GHz) and a 92% increase in capacity spectrum (defined as 1.5 to 4 GHz).[167]

b) **Technological developments allow a given level of demand to be met with less spectrum,** which has reduced spectrum values. Respondents highlighted the use of massive MIMO and beamforming in higher frequency bands, which they said make them better substitutes for lower frequencies.

[166] Paragraphs 4.36-4.41, June 2018 consultation.
[167] Telefonica response to June 2018 consultation, page 17.

c) Vodafone and Three said that **mobile data traffic growth in the UK has largely borne out expectations of traffic growth in 2013**, so this does not imply that spectrum values have increased. BT said that slowing growth rates since 2013 imply falling real values.

d) Telefónica and Three said that **spectrum is less valuable to operators now because mobile revenues have declined**. Vodafone said there was an expectation when 4G was released that operators would be able to increase ARPUs by charging a premium for 4G services, whereas spend on mobile services had slightly declined since 2013.[168]

e) BT said **spectrum values depend partly on the value of avoided network equipment costs, which have declined over time.** Vodafone said that UK Government reforms in 2016 and 2017 have lowered site infrastructure costs, which reduces the cost of densifying mobile networks as an alternative to acquiring additional spectrum.[169]

A3.4 Telefónica also said that **there has been a convergence in the value of all spectrum bands below 4 GHz over time**, and that there is no longer any meaningful premium for the marginal value of 900 MHz over 1800 MHz spectrum.[170] It said the evidence on relative values from recent international spectrum awards is consistent with this view. In contrast, BT said that the available evidence suggests our ratio of 1800 MHz to 900 MHz is too high.[171]

Our assessment

A3.5 We discuss each of the points raised by respondents in more detail below. In summary, we recognise that there is now greater certainty over the availability of potential substitute mobile spectrum, specifically in the 3.6-3.8 GHz band, compared with 2015. There have also been technological developments (massive MIMO and beamforming) which may have increased the effectiveness of spectrum above 3 GHz. Given this, we consider that this might serve to reduce the forward-looking market value of 1800 MHz spectrum relative to our 2015 assessment if taken in isolation (i.e. before considering the changes in market value benchmarks since the 2015 statement). We explain in Section 4 how we have taken account of this in coming to a view on the most appropriate 1800 MHz estimate.

A3.6 We consider that the potential impact on 900 MHz spectrum is unlikely to be significant, as 3.6-3.8 GHz spectrum is less likely to be a close substitute for this spectrum than for other mid-frequency bands.[172]

A3.7 We do not consider that other technological or commercial developments provide a firm basis on which to adjust our estimates of the market value of 900 MHz and 1800 MHz spectrum as presented in Section 4.

[168] Vodafone response to June 2018 consultation, pages 22-23.
[169] Vodafone response to June 2018 consultation, page 23.
[170] Telefonica response to June 2018 consultation, pages 18-21 and pages 28-30.
[171] BT response to June 2018 consultation, pages 26-29
[172] We define mid-frequency bands as those in the 1800 MHz to 6 GHz frequency range.

Alternative mobile spectrum availability

A3.8 We have previously recognised the possibility that the market value of 900 MHz and 1800 MHz spectrum might have changed since the 2013 4G auction, due to greater certainty over the availability of potential substitute bands for mobile use – particularly the 700 MHz, 2.3 GHz, 3.4 GHz and 1.4 GHz bands. This was one of the reasons why we considered we should adopt a conservative approach when interpreting the available evidence on market values in our 2015 Statement. This means that our estimates of market value already take account of developments in the availability of these bands between 2013 and our 2015 Statement. It would not be appropriate to make a further adjustment to the lump-sum values derived in the 2015 statement, to reflect such developments in the availability of these spectrum bands.

A3.9 The potential impact on market values of further developments in spectrum availability, since 2015, depends on the following:

a) the extent of any changes in expectations around spectrum availability since those factored into our assessment in the 2015 statement; and

b) the degree of substitutability with 900 MHz or 1800 MHz spectrum.

A3.10 We agree that, on a forward-looking basis, there is likely to be some degree of substitutability between 900 MHz / 1800 MHz spectrum and the bands highlighted by respondents in their responses, with the exception of the 26 GHz band which we do not consider to be currently useable for mobile (and which also has very different technical characteristics from 900 MHz and 1800 MHz spectrum).[173] In particular, we consider that:

a) As the 700 MHz band has particularly good coverage properties, it is a potential substitute for 900 MHz.

b) Mid-frequency bands in the 2.3 GHz and 3.4-3.8 GHz frequency range are potential substitutes for 1800 MHz spectrum in terms of delivering additional capacity for mobile broadband.

A3.11 Accordingly, the availability of these bands could in principle affect the value that MNOs place on additional 900 MHz and 1800 MHz spectrum, if expectations around their availability have materially changed since we last assessed ALFs in our 2015 Statement.[174] For each of these bands, we have therefore considered the extent to which there is now greater certainty over their availability compared with 2015. This assessment is summarised in Figure A3.1 below.

[173] See paragraphs A3.124 to A3.126, Ofcom, Award of the 2.3 and 3.4 GHz spectrum bands, Competition issues and Auction Regulations, Statement, July 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0013/104305/Statement-annexes-Award-of-the-2.3-and-3.4-GHz-spectrum-bands.pdf

[174] We discuss whether the degree of substitutability between these bands and ALF spectrum has also increased over time, due to technological developments, in more detail in the next sub-section.

Figure A3.1: Assessment of potentially substitutable mobile spectrum bands

Band	Whether there have been material developments since the 2015 Statement	Amount of spectrum (% of existing and planned mobile spectrum)[175]
700 MHz	In our November 2014 Statement on 700 MHz release, we said we would make the band available for mobile "by the start of 2022 and sooner if possible".[176] Since our 2015 Statement, we have outlined our intention to release the spectrum by Q2 2020.[177] We have also decided to release the centre-gap (of 20 MHz) for mobile use.[178]	80 MHz **7%**
1.4 GHz	This spectrum was acquired by Vodafone and Three by the time of our 2015 Statement.[179]	40 MHz **4%**
2.3 GHz **3.4 – 3.6 GHz**	This spectrum was auctioned in April 2018, later than planned at the time of our 2015 Statement.	190 MHz **17%**
3.6 - 3.8 GHz	Our 2014 Mobile Data Strategy highlighted this band as a high priority band for mobile release.[180] Since our 2015 Statement, we have published a Consultation and Decision on releasing this band for mobile use.[181] We expect to auction this spectrum by early 2020. With regards to availability, it will be useable in some parts of the UK before mid-2020 and possibly earlier, subject to coordination requirements to account for existing users. Most of the users will have left the band by mid-2020, thereby making the band useable nationwide by this date with only some minor deployment restrictions as a consequence of the coordination requirements. These deployment restrictions would be lifted if an agreement is reached with existing users early.	120 MHz **11%**

[175] Percentages based on the share of all mobile spectrum between 700 MHz and 3.8GHz, including UK Broadband spectrum holdings at 3.4-3.6 and 3.6-3.8GHz.
[176] See paragraph 1.19, https://www.ofcom.org.uk/__data/assets/pdf_file/0024/46923/700-mhz-statement.pdf.
[177] Our July 2018 update on 700 MHz clearance said this programme is scheduled to finish by Q2 2020. See https://www.ofcom.org.uk/__data/assets/pdf_file/0011/116111/700-MHz-Clearance-Programme-update-17-July.pdf
[178] See paragraph 1.16, https://www.ofcom.org.uk/__data/assets/pdf_file/0031/92659/Maximising-the-benefits-of-700-MHz-clearance-Statement.pdf
[179] We recognise that the Central Management Unit (CMU) within DCMS has commissioned a feasibility study into sharing 1427-1452 MHz frequencies with mobile, but we understand that this has yet to report any findings.
[180] Ofcom Mobile Data Strategy, Statement, May 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0027/58347/Mobile-Data-Strategy-statement.pdf
[181] Improving consumer access to mobile services at 3.6GHz to 3.8GHz, October 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0019/107371/Consumer-access-3.6-3.8-GHz.pdf

A3.12 Based on this assessment, we consider that:

a) There is now slightly greater certainty over the timing and amount of 700 MHz spectrum to be made available for mobile. However, the significance of this should not be overstated given that we decided to release this band in 2014 and at that time set out our objective to do so by the start of 2022 (while indicating a desire to do so sooner if possible). This release decision included the centre-gap frequencies, even though we did not confirm its use for Supplemental Downlink (SDL) for mobile until 2016.[182] On balance, we consider it unlikely that these limited developments are sufficient to have materially affected operators' forward-looking values for additional 900 MHz spectrum, compared with our assessment in 2015.

b) The decision to make the 3.6-3.8 GHz band available for mobile, by clearing existing satellite earth stations and fixed links in this band, means that there is now greater certainty over the timing of release of this spectrum, compared with expectations in 2015. We expect that this spectrum is most useful for providing additional mobile capacity. As such, this could affect the forward-looking market value of 1800 MHz spectrum, relative to our 2015 assessment.

A3.13 We do not consider that there have been material developments in the 1.4, 2.3 or 3.4 GHz bands since 2015 to warrant further revisions to our estimates of market value. This spectrum was recognised at the time of our 2015 Statement for its potential mobile use and since the 2015 statement the 2.3-3.4 GHz spectrum has since been auctioned. However, this release was already confirmed in our May 2015 PSSR Statement and Consultation which preceded the September 2015 ALF statement.[183]

A3.14 We recognise that other spectrum bands have also been identified as potentially viable for mobile use. However, as there are currently no concrete release plans for other bands, it is unlikely that MNO valuations for existing mobile spectrum would be materially affected by such developments. Three noted that in 2016 the Government increased its target for public sector spectrum release by a further 250 MHz of sub-10 GHz (by 2022).[184] However, as Three recognised, this spectrum may be made available for other uses e.g. fixed links, backhaul or satellite.

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[182] We also note that the centre-gap might be a complement rather than a substitute for existing spectrum because to be used as SDL it may be bonded to paired spectrum deployments.

[183] The anticipated release date was by the end of the 2015/16 financial year. See paragraph 2.11, Public Sector Spectrum Release: Award of the 2.3 and 3.4 GHz spectrum bands, May 2015, https://www.ofcom.org.uk/__data/assets/pdf_file/0027/68337/Public_Sector_Spectrum_Release_statement.pdf. While the auction was delayed and ultimately held in 2018, this spectrum is now available for mobile use and so this delay does not affect our estimates of forward-looking 900 MHz and 1800 MHz values. Indeed, Vodafone (Table 1 of its June 2018 consultation response) said 2.3-3.4 GHz availability has no material impact on forward-looking 900/1800 MHz values.

[184] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/518303/enabling_uk_growth_pssr_programme_annual_report.pdf.

Technological developments

A3.15 All MNOs argued that technological improvements, particularly those which improve spectral efficiency, have affected absolute and relative spectrum values.

Absolute spectrum values

A3.16 Vodafone said the development and standardisation of a new 5G air interface will offer an improvement in spectral efficiency for all mobile bands. It said that while the development of a set of 5G technologies was foreseen, the precise nature of these technologies (including whether a new air interface would be included) was unclear in 2013. As such, Vodafone said this should reduce the value of all spectrum for a given level of demand. [185]

A3.17 Three said that massive MIMO – which is much more certain now than in 2013 – can be used to deliver 3-5 times more capacity (compared with MIMO which delivers a 70% capacity boost),[186] though it did not say to which bands this applied. Three said this reduces the amount of spectrum MNOs need to meet forecast demand, which reduces MNOs' intrinsic valuations of future spectrum, as well as their valuations of 1800 MHz spectrum.[187]

A3.18 To begin with, we note that spectral efficiency and mobile data demand are both generally increasing over time.[188] Other things equal, this would tend to have offsetting implications on the value that MNOs place on a marginal increment of spectrum. The relevance of changes in spectral efficiency for our market value estimates therefore depends on the degree to which changes since 2013 have departed from expectations about these trends.

A3.19 In this context, while there may be many headline rates reflecting favourable scenarios, we understand that the 5G New Radio (NR) air interface specification is expected to bring modest gains of efficiency of around 25%, compared with mean throughput rates for user equipment achievable with later evolutions of 4G.[189] While the precise mix of technologies and timing of 5G was not known in 2013, these general gains over time are more predictable as they are a key target of the design of new technologies. For instance, a 2011 report by Real Wireless projected spectral efficiency growth to 2020 based upon efficiency gains due to several innovations, including the generational change from 3G to 4G.[190] In terms of expectations, the 25% gain from 4G to 5G is commensurate with the 20% gain Real Wireless expected from the move from high-end 3G to early 4G networks and is also consistent with average gains expected over the various release forecasts towards 2020.

[185] Vodafone response to June 2018 consultation, page 25
[186] Vodafone suggested that massive MIMO delivers a 4-fold increase in spectral efficiency.
[187] Three response to June 2018 consultation, page 24
[188] We discuss mobile data demand in more detail in the next section.
[189] See http://ctw2018.ieee-ctw.org/files/2018/05/5G-NR-CTW-final.pdf, slide 28. This efficiency gain is the baseline that should be achievable in most deployments and does not include massive MIMO which may only be practicable in the higher frequency bands (and is also possible with 4G).
[190] https://www.ofcom.org.uk/__data/assets/pdf_file/0025/72790/4gcapacitygainsfinalreport.pdf, page 12.

A3.20 As such, we do not consider that the development of a 5G air interface constitutes a step change in spectral efficiency improvements compared with expectations at the time of the 4G auction. We therefore do not consider that it provides a reason to adjust market values.

A3.21 Regarding Three's point, we consider that massive MIMO is likely to differentially affect spectral bands. We consider in the next section whether the *relative* impacts of technological developments on different spectrum bands (including massive MIMO) should give us cause to amend our market values for 900 and 1800 MHz spectrum.

Relative spectrum values

A3.22 Vodafone said that relative 900 MHz and 1800 MHz spectrum values would be affected by the following factors: Uptake of TDD;[191] the development and standardisation of "massive" MIMO and beamforming; and the rollout of GSM-R.[192]

Uptake of TDD spectrum

A3.23 Vodafone said the potential for using unpaired TDD spectrum has increased in recent years, particularly following 3GPP release 12 which supported carrier aggregation between TDD (i.e. unpaired) and FDD (i.e. paired[193]) carriers. It said this is reflected in the higher price paid by Telefónica for 2.3 GHz TDD spectrum in the 2018 auction, compared to unpaired 2.6 GHz spectrum in the 2013 auction. Vodafone said the ability to use TDD spectrum to effectively deliver incremental capacity could serve to reduce the value of both 900 MHz and 1800 MHz (FDD) spectrum.

A3.24 We agree with Vodafone that TDD spectrum can be used to effectively deliver incremental capacity where demands are asymmetric, as it allows for more capacity to be allocated for downlink than the uplink. The availability of TDD bands such as 2.3 GHz (including the impact of 3GPP Release 12, which was completed in March 2015) was public knowledge before our 2015 Statement. As such, we consider that our existing market value estimates will already reflect the uptake of, and potential for, TDD spectrum.

A3.25 We note that the higher price paid by Telefónica for 2.3 GHz spectrum in 2018 could also be related to Telefónica's need for additional capacity, rather than a relative increase in TDD spectrum values per se.

Massive MIMO and beamforming

A3.26 Vodafone and Three said that massive MIMO technology offers a significant increase in spectral efficiency compared to earlier MIMO technologies. Moreover, Vodafone said that massive MIMO will only be practical at higher frequencies (i.e. more than 3 GHz). BT said that massive MIMO schemes with much greater spectral efficiency are not suited to 1800

[191] Time Division Duplex – a technology that deals with traffic asymmetry where the uplink is separated from the downlink by the allocation of different time slots in the same frequency band in unpaired spectrum.
[192] Vodafone response to June 2018 consultation, pages 25-26
[193] Frequency Division Duplex – a technology that deals with traffic asymmetry between uplink and downlink where separate frequency bands are used to send and receive signals.

MHz but are becoming available for the 3.4-3.8 GHz band.[194] BT argued that together with beamforming (which improves coverage properties for high frequency spectrum), this means that higher frequency spectrum will be a better substitute for other spectrum because it can deliver additional capacity more efficiently.[195]

A3.27 We recognise that recent developments in massive MIMO and beamforming technologies have the potential to increase spectral efficiency, in a way that was not fully anticipated when we set ALFs in 2015. This means that the additional mobile capacity that can be delivered using a given amount of spectrum, as well as the potential coverage area, is likely to be greater now than previously expected.

A3.28 As BT and Vodafone highlighted, these technologies are better suited for mid frequency bands (notably mid-frequency bands between 1800 MHz and 6 GHz) as opposed to lower frequency bands. Moreover, we agree that not all mid-frequency bands will be able to benefit from massive MIMO in the same way. For example, the size of massive MIMO antennas is inversely proportional to frequency, with higher frequencies using smaller antennas. Therefore, deploying massive MIMO using frequencies such as 1800 MHz would require much larger and heavier antennas than 3.4-3.8 GHz. Furthermore, massive MIMO is likely to be more effective when applied to TDD spectrum rather than FDD spectrum, because the reciprocal nature of TDD means that estimates of the channel are better, leading to more efficient utilization of spectrum. This suggests that operators are unlikely to achieve the same capacity gains by applying MIMO technology at 1800 MHz than at bands above 3 GHz.

A3.29 Similarly, the use of beamforming may allow operators to achieve closer coverage levels with 3 GHz frequencies to the coverage of 1800 MHz spectrum (although we still consider the 1800 MHz band possesses more favourable propagation characteristics compared to higher frequency spectrum – e.g. for offering services to customers in rural or indoor locations). Beamforming therefore provides a further reason why mobile spectrum at higher frequencies might now be a closer – albeit still imperfect – substitute for additional 1800 MHz spectrum.

A3.30 In terms of the impact on the forward-looking spectrum value for 1800 MHz and 900 MHz, we consider that:

a) These technology improvements might serve to reduce the market value of an additional increment of 1800 MHz spectrum, compared to our estimates in the 2015 Statement. This is primarily because they can potentially offer relative improvements in and MNO's alternatives to adding capacity at 1800 MHz. They may also narrow the coverage differences observed with different mid-frequency spectrum bands, although we still consider 1800 MHz will have better coverage characteristics than higher frequency spectrum.

[194] BT response to June 2018 consultation, pages 30-31

[195] BT also said this holds even if 5G technology were deployed in all bands, which overlooks the fact that in practice 1800 MHz is encumbered by 4G use and is not currently harmonised as a 5G band, other than for potential future Supplementary Uplink use. See BT response to June 2018 consultation, page 30.

b) Massive MIMO and beamforming adopted at higher frequencies is less likely to impact 900 MHz values. This is on the basis that the value of low-frequency spectrum is much more closely linked to its coverage advantages rather than its ability to deliver capacity. While we recognise that beamforming could improve the coverage properties of mid-frequency spectrum, we do not expect the coverage gains to be sufficient to change the relative value of mid-frequency spectrum relative to 900 MHz spectrum, compared to our 2015 statement.

Rollout of GSM-R

A3.31 Vodafone said one issue that has affected the value of 900 MHz spectrum has been the rollout of GSM-R across the Network Rail network, which has reduced power limits for 900 MHz spectrum. As this is a UK-specific issue (and doesn't affect 800 MHz spectrum), Vodafone's reasoning is that this implies that 900 / 800 MHz relative values from other countries will be overstated relative to the UK.

A3.32 We recognise that use of 900 MHz spectrum close to rail infrastructure may be affected by power limitations imposed to protect GSM-R, which Network Rail reports has been required at about four hundred sites. This issue has been recognised for some time, and, as such, we are working with Network Rail, the Department for Transport and MNOs to mitigate and reduce the impact of radio interference on the GSM-R service. In particular, Network Rail is currently trialing an upgraded GSM-R radio and if this trial is successful, the upgrade will be rolled out across the entire GB rail fleet. We also published a coordination procedure in 2013 and understand that working practices between network rail and the MNOs have been established since 2015.[196]

A3.33 As such, we consider the usage of GSM-R is unlikely to have a material impact on the forward-looking value of 900 MHz spectrum.

Convergence in spectrum values

A3.34 Telefónica identified several trends which it said are driving a convergence between values of sub-1 GHz bands and higher frequency bands, as well as between *all* mobile frequency bands below 4 GHz.[197]

A3.35 Our estimated lump-sum values for 900 MHz and 1800 MHz imply 900 MHz is worth around 36% more than 1800 MHz, per MHz, on a forward-looking basis.[198] This implied premium has fallen from 67% when we first consulted on revising ALFs in 2013.[199] It reflects (among other things) new international benchmark evidence, which we would expect to reflect technical and commercial developments over time.

[196] See: https://www.ofcom.org.uk/__data/assets/pdf_file/0029/76079/gsmr_operators.pdf.
[197] Telefonica response to June 2018 consultation, pages 18-20.
[198] See Section 4. Our 900 MHz lump-sum value is £19 million per MHz and our 1800 MHz lump sum value is £14 million per MHz, in April 2018 prices.
[199] We proposed lump-sum values of £25 million per MHz for 900 MHz, and £15 million per MHz for 1800 MHz (in March 2013 prices). See: https://www.ofcom.org.uk/consultations-and-statements/category-1/900-1800-mhz-fees

A3.36 Against this context, we have considered the relevance of the technological trends identified by Telefónica, and whether they provide reasons to make further adjustments to our 900 MHz or 1800 MHz market values, over and above the evidence from our analysis of relevant benchmarks in section 4.

A3.37 Regarding convergence in the value of sub-1 GHz and higher frequencies, Telefónica said:

a) The "coverage premium" for 900 MHz has been eroded by the release of 900 MHz [*sic*[200]] and will be further eroded by the release of 700 MHz and 1400 MHz.

b) Less spectrum is needed at rural sites due to lower traffic levels, which means the incremental benefits of deploying lower frequency over higher frequency spectrum diminish after the first 2x5 MHz block.

c) Sub-1 GHz spectrum may save some costs in meeting coverage requirements, but it offers no revenue benefits.

d) Network densification and small cell solutions mean that operators may value the superior in-building penetration characteristics of low frequency spectrum less.

e) Higher frequency bands are increasingly preferred for increasing urban capacity, as low frequency signals travel too far and are harder to manage with dense base station or small cell deployments.[201]

A3.38 On the other hand, BT said it would seem more likely that the value of 900 MHz spectrum is closer to 800 MHz than to 1800 MHz, given their similar technical characteristics and the fact that LTE900 technology is now widely available. It said coverage deep in to buildings is much more limited with 1800 MHz and maximum cell sizes are much smaller, which impacts roll-out costs where used to deliver coverage.[202]

A3.39 Our view on these points is as follows:

a) **We would expect a premium to persist for all low frequency bands.** It remains the case that low frequency spectrum has desirable properties as an efficient means of providing good quality voice and data service across a wide area, including to cover roads and rail and as a means of providing services indoors. Furthermore, as discussed in our 2015 Statement and in paragraph A3.8 above, we have already taken account of greater certainty over the release of the 700 MHz and 1400 MHz bands by taking a conservative approach to interpreting the evidence on market value (in particular for sub-1 GHz spectrum). There have also been further releases of higher frequency spectrum (e.g. 3.6-3.8 GHz), which could serve to reduce market values for a given increment of higher frequency spectrum such as 1800 MHz. It is therefore not clear that new spectrum releases have materially affected the relative values of sub-1 GHz and higher frequency spectrum compared to the relativity in our 2015 statement.

[200] We take this to mean 800 MHz spectrum.
[201] Telefónica also said new technologies such as MIMO rely on the use of small antennas which only work with higher frequencies. We explain in paragraph A3.30 why we consider that this is less likely to affect sub-1 GHz spectrum values.
[202] BT response to June 2018 consultation, page 28.

b) **Lower traffic levels at rural sites is not a new development since 2015**. As such, to the extent it is true, our estimates of market value (which are based on marginal values of losing bidders in the UK and other auctions) will already reflect this.

c) **We disagree that sub-1 GHz spectrum offers no benefits.** First, coverage is a relevant aspect of providing mobile services which operators can use as a competitive differentiator to attract subscribers and gain market share. Second, even if coverage can also be achieved through other means (and thus the revenue potential of sub-1GHz spectrum were limited), sub-1GHz spectrum can provide a cost advantage in delivering coverage. Regardless of this, these are not new developments since 2015 and, as such, do not constitute a reason to revise our market value estimates for sub-1 GHz spectrum.

d) **We consider that low frequency spectrum still confers important advantages in terms of in-building penetration.** We recognise that additional low frequency spectrum is not the only way to provide good in-building coverage. For instance, technologies such as cellular repeaters, small cells and femtocells can improve coverage in certain circumstances when deployed alongside higher frequency bands. However, good quality indoor coverage can be achieved using low frequency spectrum with fewer cell sites. While Wi-Fi calling can also be used to deliver indoor coverage, it relies on fixed infrastructure being in place (the quality of which may be beyond the control of the MNO) and may also rely on third party access rights.

e) **We do not consider the use of higher frequency spectrum for increasing capacity is a new development.** While we recognise that higher frequency bands may be preferred for increasing capacity in areas of high demand, particularly with dense base stations or small cell deployments, we consider this has been recognised for some time. As a result, we do not consider that it is necessary to adjust our market value estimates to account for this.

A3.40 Overall, we disagree with Telefónica that there is no longer a premium for 900 MHz over 1800 MHz spectrum. With regard to BT's sub-1GHz coverage arguments and the availability of LTE900, we do not consider that this gives us a reason to adjust our market value estimates. Our market value estimates are based on international benchmark evidence and would therefore reflect the technical and commercial capabilities of the bands (particularly as we have taken account of developments in LTE900 prospects in our interpretation of the benchmark evidence - see Annex 9 of the 2015 Statement). As explained in this annex (and consistent with our final estimates of the value of 900 MHz and 1800 MHz) we still consider 900 MHz to be more valuable (on a per MHz basis) than 1800 MHz spectrum.

A3.41 In respect of convergence in the value of all bands below 4 GHz, Telefónica said:

a) New handsets support a wide range of 4G bands, including 700, 800, 900, 1400, 2100, 2300, 2600 and 3400 MHz frequencies.

b) Network densification and beamforming erode the propagation advantages offered by 1800 MHz over higher bands, while higher frequency bands may offer capacity advantages over 1800 MHz.

c) The 900 MHz and 1800 MHz bands are not pioneer 5G bands.

A3.42 Our views on these points are as follows:

a) **There are still significant differences in the size of the device ecosystems supporting these bands**, with 900 MHz and particularly 1800 MHz being two of the most established bands, which may affect operators' relative valuations for different spectrum.[203] Notwithstanding this point, we recognise that equipment manufacturers will support new mobile bands in their devices as these bands become available, such that they can be used to deliver mobile services to end users. This is one reason why we have taken account of greater certainty over the release of other mobile spectrum bands in our interpretation of market values. As such, we consider this trend is already reflected in our market value estimates and does not warrant a further adjustment.

b) **We agree that other mid-frequency bands may be closer, if imperfect, substitutes for 1800 MHz spectrum than we considered at the time of our 2015 Statement, due to the impact of massive MIMO and beamforming.** However, as set out in paragraph A3.29 above we still consider the 1800 MHz band possesses favourable propagation characteristics compared to higher frequency spectrum. We also note that replicating propagation characteristics via network densification comes at a cost that would be reduced with access to 1800 MHz spectrum.

c) **We recognise that the 900 MHz and 1800 MHz bands are not 5G pioneer bands, though we note that 5G Release 15 includes specifications for almost all UK mobile spectrum bands**. In any case, to the extent that other bands are better-placed to deploy 5G, it does not necessarily reduce the value of either 900 MHz or 1800 MHz spectrum (or their relativity), particularly if existing technologies (such as 4G) used on the 900 and 1800 MHz bands are likely to remain in place for many years to come.

Overall view on impact of technological developments

A3.43 Our overall view on the impact of technological developments on spectrum values is as follows:

a) We do not consider there is a clear basis on which to conclude that mobile spectrum values (and in particular for the 900 MHz and 1800 MHz bands) have fallen in general since our assessment in the 2015 Statement due to technological developments.

[203] According to the August 2018 GSA Evolution to LTE report, there were: 8,313 LTE devices compatible with the 1800 MHz band and 3,850 LTE devices compatible with the 900 MHz band, compared with (for instance) 1,324 LTE devices compatible with the APT700 MHz band; 3,793 devices compatible with the 2.3 GHz band; and 221 devices compatible with the 3.4 GHz band (i.e. band 42, referenced in the report as 3500 MHz). With regards to the 1400 GHz band, we said in our July 2017 Statement on the Award of the 2.3 and 3.4 GHz spectrum bands that a handful of devices supported this band, though we understand that additional devices supporting this band have become available since then.

b) We consider that developments in massive MIMO and beamforming technologies may have increased the effectiveness of spectrum above 3 GHz. We consider this might serve to reduce the forward-looking market value of 1800 MHz spectrum relative to our 2015 assessment, if taken in isolation (i.e. before considering the changes in market value benchmarks since the 2015 statement). We consider that the potential impact on 900 MHz spectrum is unlikely to be significant.

c) We do not consider that any of the other technological developments discussed above provide a firm basis on which to make further adjustments to our estimates of the market value of 900 MHz and 1800 MHz spectrum

Mobile data demand

A3.44 In our June 2018 consultation, we said that increasing demand for mobile capacity could increase the forward-looking value of 900 MHz and 1800 MHz spectrum.

A3.45 Three and Vodafone argued that high data growth *per se* does not necessarily imply increasing spectrum values, as MNOs would be expected to take account of future growth when bidding for spectrum. Rather, increasing spectrum values relies on the occurrence of faster-than-expected traffic growth. In this respect, they said that data growth has evolved in line with expectations in 2013. BT said that the slowing mobile data growth rate observed since 2013 indicates this factor may tend to reduce forward looking real values.[204]

A3.46 We agree that the relevant consideration is how data traffic growth has evolved since the 2013 4G auction, relative to expectations at the time of the auction. We have therefore reassessed the traffic forecasts used in our consultation on the release of the 700 MHz band, which were formulated by Analysys Mason around the time of this auction.[205] Analysys Mason's forecasts predicted data carried on mobile networks could increase 25 times between 2014 and 2030, which implied an annual compound annual growth rate (CAGR) of 22% for the period as a whole.[206] However, the forecasts also predicted a slowdown in growth rates over time. Their implied forecast CAGR for the truncated period between 2014 and 2020 was 44%.[207] This is still somewhat below the actual CAGR between 2014 and 2017 (52%, based on Ofcom Connected Nations data).[208]

A3.47 Three referenced a 2013 report by the GSMA which forecast that data usage would grow by an annual rate of 54% across Europe from 2012 to 2017.[209] This pan-European forecast is

[204] BT response to June 2018 consultation, pages 14-15.
[205] The consultation was published in May 2014.
[206] Ofcom, *Mobile Data Strategy - Update on our strategy for mobile spectrum,* June 2016, paragraph 3.7, https://www.ofcom.org.uk/__data/assets/pdf_file/0033/79584/update-strategy-mobile-spectrum.pdf
[207] Based on Table 2, Ofcom, Consultation on future use of the 700 MHz band, May 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0025/28492/consultation-future-use-700MHz-band.pdf. Alternative forecasts from 2012 by Real Wireless, which were also considered in our consultation, indicate a 46% CAGR for this period.
[208] Based on Figure 29, 2017 Connected Nations, Ofcom, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/108513/connected-nations-mobile-2017.pdf. Total data use increased from 44.3 million GB in June 2014 to 155.9 GB in June 2017.
[209] Three response to June 2018 consultation, page 24.

very close to the actual UK growth rate (i.e. 52%) for the slightly shorter period from 2014 to 2017 noted above.[210]

A3.48 Turning to global mobile data traffic trends, Vodafone said that Cisco forecasts appear to have been largely borne out by actual growth figures since 2012. We note that Cisco's annual forecasts also suggest data traffic growth expectations have remained relatively stable, as there have been limited year-on-year revisions to their forecasts.[211]

A3.49 Overall, we consider that the evidence on data traffic growth suggests that actual growth has been broadly in line with earlier forecasts. As such, we do not consider that there is a basis to conclude that mobile data demand has fallen below expectations (which would imply a decline in real spectrum values, other things equal), or that it has increased materially above expectations so as to imply an increase in forward-looking spectrum values since 2015.

Mobile revenues

A3.50 Telefónica and Three said the value they place on spectrum is related to the expected incremental revenue they can earn, and that mobile service revenues (both ARPUs and total revenue) have fallen over time, implying lower valuations for additional spectrum.

A3.51 Firstly, although expected revenue is likely to be an important driver of spectrum value, we consider that profits are likely to be a better indicator of value – specifically, the difference in an operator's profit with and without the specific spectrum in question. How this changes over time depends on trends in costs as well as revenues. While it is difficult to identify the incremental profits that would be generated by an increment of 900 MHz or 1800 MHz spectrum, we note that mobile network equipment costs have generally been declining over time (as discussed in more detail in the next sub-section). A decline in equipment costs would have a positive impact on operator profits, unless passed through in full to downstream retail prices. In this context we note that EBITDA for the four MNOs was at least as high in real terms in 2017 as in 2012 and 2013 (see Figure 5.1 in Section 5 for a comparison of EBITDA between 2009 and 2017).[212]

A3.52 Notwithstanding the likely greater relevance of profits to spectrum value, we have considered the revenue-related arguments made by respondents:

[210] It is also very close to the actual UK growth rate for the comparable period 2012-2017 (51%). See Figure 29 of the 2017 Connected Nations report – total data use was 19.7 million GB in June 2012.
[211] Based on a comparison of Cisco's Global Mobile Data Traffic Forecast Updates, February 2013 to February 2017.
[212] Earnings Before Interest, Taxation, Depreciation and Amortisation.

a) Telefónica presented Telegeography data showing that UK wireless service revenues declined by almost 15% and ARPUs dropped by 24% between 2009 and 2016.[213] However, the relevant period for our assessment is 2013 onwards, after which the data shows a much smaller decline in both revenues and ARPU. Furthermore, as this data was presented in US dollars, it would reflect exchange rate movements over this period. As sterling depreciated considerably against the US dollar between 2013 and 2016, this could explain a significant part of the observed decline in ARPUs and revenues when expressed in US dollar terms.[214]

b) This would also be consistent with our CMR data on average household spend on mobile services and average revenue per subscription (to which Vodafone and Three refer), which show much more moderate declines of less than 3% and around 5% respectively between 2013 and 2017.[215] [216] In both cases, household spend and average revenues increased in real terms in at least one year.

c) Moreover, by focusing on average revenues, these metrics do not capture subscriber growth trends which we consider are relevant to the question of spectrum value. The combined impact of subscriber growth and average revenues – which we consider to be more informative for this question than ARPU trends in isolation – can be assessed by looking at (real) aggregate mobile revenues. To this end, Three noted that mobile industry revenues were lower in each year from 2014 to 2017 than in 2013 (in real terms).[217] While this is true, revenues have barely changed since 2014 (i.e. an approximately £0.1 billion variation across 2014 to 2017 as shown below in Figure A3.3).[218] This is likely to reflect continued growth in mobile subscriptions, as shown below.

[213] Telefonica response to June 2018 consultation, pages 13-14.
[214] See https://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/timeseries/auss/mret. The sterling / dollar exchange rate was 1.56 for 2013 and 1.35 for 2016.
[215] Vodafone response to June 2018 consultation, pages 22-23. The decline in average household spend is based on Figure A3.2 below, taken from Figure 1.2, Ofcom, 2018 Communications Market Report, https://www.ofcom.org.uk/__data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf.
[216] Three response to June 2018 consultation, page 26. The decline in average revenue per subscription between 2013 and 2016 was 4.4% - see Figure 4.18 of the 2017 CMR. Also, on page 52 of the 2018 CMR, we said average mobile revenue per subscription decreased in real terms in 2017 by 1%.
[217] Three response to June 2018 consultation, page 26.
[218] Taken from Figure 4.1, Ofcom, 2018 Communications Market Report, https://www.ofcom.org.uk/__data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf.

Figure A3.2: Average household spend on communications services

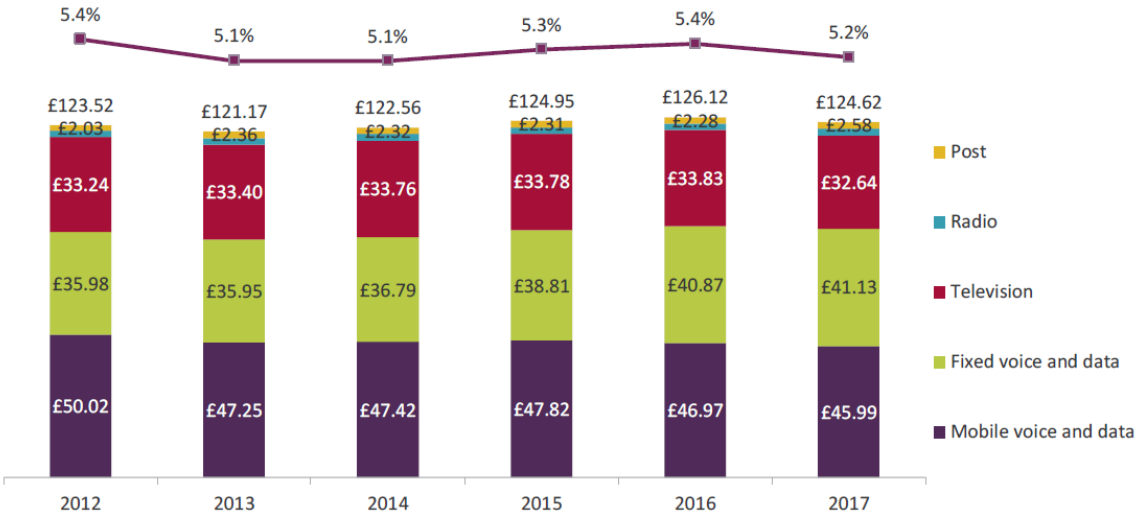


Figure A3.3: Retail mobile voice and data revenues (£ billion) and active subscribers

	2012	2013	2014	2015	2016	2017
Retail mobile voice & data revenues (£ billion)	17.0	16.3	15.7	15.7	15.8	15.6
Active mobile subscribers (millions)	88.1	88.4	89.9	92.0	91.5	92.0

Source: Ofcom 2018 CMR. Both figures are CPI-adjusted (2017 prices)

A3.53 Vodafone said that there was an expectation when 4G was released that operators would be able to increase ARPUs by charging a premium for 4G services. This would imply that spectrum values have fallen over time even with a flat industry revenue profile. However, the evidence Vodafone presented of this was not compelling.[219]

A3.54 Furthermore, we consider that there is always the potential for new revenue opportunities in the near-term, which may not have been fully recognised at the time of the 4G auction. For example:

a) 4G spectrum holdings could be used to support home broadband delivered as a fixed-wireless service. In February 2018, EE launched a EE4G router product delivering home broadband via fixed-wireless access (FWA) which uses 1800 MHz spectrum,[220] while Three offers a HomeFi FWA broadband product over its mobile network.[221] These opportunities could allow for greater monetisation of additional spectrum.

[219] Vodafone (page 22) cited a press release by EE from February 2013 noting higher 4G price plans and ARPUs for customers migrating to 4G early, but it did not present a view on longer-term expectations around revenue growth.
[220] See: https://newsroom.ee.co.uk/ee-launches-4g-home-broadband-antenna-to-connect-more-than-580000-homes-across-the-uk/.
[221] See: http://www.three.co.uk/Discover/Devices/Huawei/HomeFi?id=1299&ds_rl=1238715&gclid=EAIaIQobChMIg8S0_Ljl3gIVj-R3Ch0EQgm_EAAYASAAEgJy2vD_BwE&gclsrc=aw.ds&aidset=1&memory=0&colour=Black

b) There is also now greater certainty over commercial prospects for 5G. Earlier this year, for instance, we outlined a range of new opportunities that 5G will create for MNOs and other wireless operators.[222] Values for additional spectrum may increase in general if spectrum can be used to realise new revenue opportunities both within and also outside of traditional mobile telephony.[223] We recognise that the 900 and 1800 MHz bands are not pioneer 5G bands, but (as explained in paragraph A3.42(c) above) standards support a route to 5G in all mobile bands.

A3.55 It is not clear that these prospects were fully recognised at the time of the 4G auction in 2013, or that they are reflected in some of our earlier international benchmarks. As such, our forward-looking market value estimates could understate true values for the spectrum in question, in particular for 1800 MHz spectrum.

A3.56 Overall, we do not therefore consider that revenue trends since 2013 provide a robust basis for adjusting our market value estimates for 900 MHz or 1800 MHz.

Mobile network costs

Equipment / operational costs

A3.57 BT said the value of additional spectrum partly depends on the level of avoided network equipment costs that would have been required to achieve the same level of coverage and network quality, in the absence of that spectrum. BT said its experience shows, consistent with Ofcom's Mobile Call Termination (MCT) cost model, that equipment and operational costs have decreased over time. Consequently, the value of avoided network equipment costs may have decreased since 2015, in real terms.[224]

A3.58 We recognise that mobile network equipment costs are on a general downward trend. In our 2018 MCT model, for instance, we forecast that capex for backhaul and core nodes would fall by 3% per year in real terms (1-2% for opex) for the next review period, before flattening over time.[225] These trends were rolled forward from the 2015 MCT model as we considered they remained broadly in line with previous trends based on operator data. The 2015 trends were themselves a continuation of an assumption of declining equipment cost trends from the earlier 2011 MCT model.

[222] See Section 3, Ofcom, Enabling 5G in the UK, March 2018, https://www.ofcom.org.uk/__data/assets/pdf_file/0022/111883/enabling-5g-uk.pdf. For instance, we said that MNOs may extend the use of 5G beyond mobile broadband and leverage innovations such as network slicing (which allows for parts of a network to be available for different purposes and/or users) to offer specialised services to markets such as manufacturing, healthcare and logistics.

[223] One such opportunity could be better home broadband connectivity (as discussed above although there we were referring to 4G-based FWA services). For instance, Three UK's chief executive has said that 5G could offer a good enough home broadband experience for people to effectively ditch their fixed connection. See https://www.bbc.co.uk/news/technology-46127712.

[224] BT response to June 2018 consultation, page 15.

[225] Table A9.1, Mobile Call Termination Market Review 2018-2021, Final Statement, https://www.ofcom.org.uk/__data/assets/pdf_file/0022/112459/MCT-review-statement-annexes-115.pdf

A3.59 BT made no specific comment on this modelling approach, and in general agreed with our light-touch approach to updating the MCT modelling for our 2018 MCT decision.[226] BT has presented no new evidence that cost trends have materially departed from expectations.

A3.60 As such, we would expect this downward trend in network equipment costs to be reflected in operators' forward-looking value for spectrum. We also note that Vodafone agreed that falling telecoms equipment costs do not necessarily lead to a reduction in the value of spectrum over time on its own.[227]

A3.61 In our view, it is not therefore necessary to make further adjustments to our market value estimates, to take any further account of network cost trends.

Infrastructure costs

A3.62 Vodafone said that mobile network infrastructure costs have reduced since 2015. It highlighted Government changes to planning regulations to reduce the cost of site rollout in rural areas, as well as changes to the Electronic Communications Code (ECC) which came into effect in December 2017 to reduce the cost of building and operating infrastructure. Vodafone said this is effectively new information which, all else being equal, will serve to reduce spectrum values as it will reduce the cost of densifying the network as an alternative to acquiring additional spectrum. Vodafone said it could particularly impact the value of low frequency spectrum such as 900 MHz as it reduces the cost of building more rural base stations.

A3.63 Firstly, we note that avoided network costs are only one aspect of spectrum value. A marginal operator's value for additional spectrum may also be affected by improved performance e.g. by delivering higher throughput for certain consumers, which can be monetised. This was one of the reasons we didn't use cost modelling to estimate 900 MHz or 1800 MHz market values in 2015.[228]

A3.64 Secondly, we note that Vodafone did not raise the impact of these reforms in the context of our 2018 or 2015 MCT reviews. This is despite the fact that work on ECC reform commenced in 2011, and recommendations were proposed by the Law Commission (for DCMS) in February 2013 i.e. at the time of the 4G auction.[229] The DCMS subsequently announced in December 2014 that it would reform the ECC, at the same time as agreeing the geographic voice coverage obligation with the MNOs.

A3.65 We recognise that these were only proposals at the time, and they have been modified since then. There is now also greater certainty over their implementation. Nevertheless, the government's general desire to facilitate network infrastructure rollout has been clear for some time, and stakeholders would have been aware of this at the time of the 4G

[226] See page 2 of BT/EE's September 2017 response to our 2017 MCT consultation, https://www.ofcom.org.uk/__data/assets/pdf_file/0025/106882/BT-EE.PDF.
[227] Vodafone response to June 2018 consultation, page 23.
[228] Paragraphs A9.109-A9.110, September 2015 Statement
[229] For details, see https://www.lawcom.gov.uk/project/electronic-communications-code/.

auction and throughout the ALF-setting process up to 2015. We therefore disagree with Vodafone that this constitutes "effectively new information".

A3.66 Thirdly, in terms of the impact on network infrastructure rollout:

a) The revised ECC addresses some, but by no means all, of the issues faced by network operators seeking to increase the density of their networks. For instance, issues such as wayleaves remain.

b) Three told us that the ECC reforms are not working as intended, as landowners are benefiting from unclear drafting or exemptions to avoid reductions in site rentals.[230] Such limitations would tend to further reduces any impact on network rollout costs.

c) Vodafone does not present any quantitative evidence of the impact that these changes have had on its site rentals or rollout costs.

A3.67 Overall, while we recognise that the ECC reforms, in conjunction with other planning reforms,[231] may serve to somewhat lower the cost of deploying new sites, we consider that the impact of these reforms is likely to be limited – particularly when considering other sources of spectrum value, and also what was known or anticipated about these reforms at the time of our 2015 statement.

A3.68 In light of the above, we do not consider that these reforms provide a basis on which to adjust our market value estimates for 900 MHz or 1800 MHz spectrum.

Evidence on relative 1800 MHz / 900 MHz spectrum values

Convergence between 900 MHz and 1800 MHz spectrum values

A3.69 Telefónica said that the available evidence from international spectrum auctions supports the view that the value of 900 MHz and 1800 MHz spectrum is converging. It presented a chart showing that the 900 MHz premium over 1800 MHz has declined over time (and is negative for post-2014 auctions), and said this is more likely to be due to declining 900 MHz values than increasing 1800 MHz values, as there is also a downward trend in our 900 MHz benchmarks over time.[232] Telefónica also noted that 600 MHz spectrum sold at a big discount to 1800 MHz and 2100 MHz in the USA, which it said is consistent with there no longer being any premium for 900 MHz over 1800 MHz.[233]

A3.70 In relation to the 1800/900 MHz ratio, we first note that there are only 3 out of 10 countries (Denmark (2010 and 2016), Norway, Germany) with higher ratios than our implied ratio (which is 74%). These ratios are shown in Table A4.3. In considering the implications of these ratios:

[230] Meeting between Three and Ofcom, 11 September 2018.
[231] For details, see https://www.parliament.uk/business/publications/written-questions-answers-statements/written-statement/Commons/2016-03-17/HCWS631/
[232] Telefonica response to June 2018 consultation, pages 26-28.
[233] Telefonica response to June 2018 consultation, page 17.

a) We have previously explained our view that Denmark's ratio is less important evidence as 900 MHz lots all sold in 2010 to a single bidder at the reserve price, so this band carries a larger risk of larger understatement for 900 MHz.[234] Furthermore, as noted in Table A2.14, the 2016 1800 MHz absolute value carries a risk of overstatement which means that the 1800 / 900 MHz ratio from Denmark carries a larger risk of overstatement.

b) We said in our June 2018 consultation that evidence from the two remaining countries (Norway and Germany) is not definitive.[235] Furthermore, we have also identified a risk of overstatement for the 1800 / 900 MHz ratios for both these countries.[236]

A3.71 To the extent that there has been convergence in the value of these bands over time, we disagree that the evidence suggests this has been driven by falling 900 MHz values.

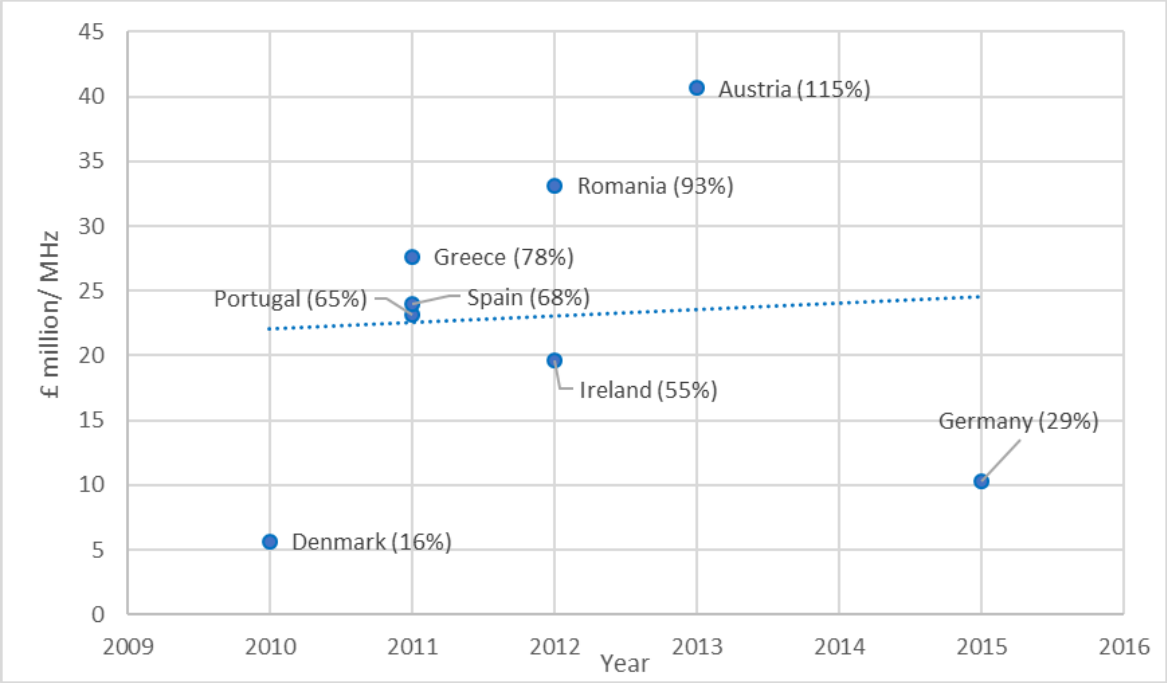
a) First, the data is already quite limited and Telefónica's assessment of 900 MHz paired benchmarks over time excluded Austria (a Tier 1 benchmark in our analysis) and Denmark (a Tier 3 benchmark), on the basis that Telefónica considered them to be unreliable data points.[237] The six benchmark observations that Telefónica uses is a very small sample from which to robustly establish a time series.

b) Second, Telefónica's approach places equal weight on all the evidence points (other than Austria and Denmark) whereas we consider that the quality of evidence provided by some benchmarks is greater than others. Specifically, Ireland, Germany, and Austria (which we continue to classify as a Tier 1 benchmark for the reasons set out in Annex 8 of our 2015 Statement), should in our view be accorded more weight when drawing conclusions from the benchmark evidence.

c) Third, if all 900 MHz to 800 MHz paired ratio benchmarks are included and given equal weight, Figure A3.4 below shows there is no clear evidence to support a conclusion that the trend in the value of 900 MHz (derived from the paired ratios of 900 MHz and 800 MHz) is downward. When Austria and Denmark are included in the analysis, the linear line of best fit is slightly positive (though, as explained above, we do not consider that robust inferences about trends over time can be drawn from this).

[234] For this reason, the 900 MHz to 800 MHz ratio benchmark for Denmark is in Tier 3.
[235] June 2018 consultation, paragraph 4.57.
[236] See paragraph 5.90 of the September 2015 Statement (Germany) and Table A2.25 of this document (Norway).
[237] See paragraph 71 of Telefonica's response.

Figure A3.4: 900 MHz paired ratio benchmarks (£ million / MHz) over time



A3.72 For these reasons, we disagree that the available data provides evidence of a clear downward trend in 900 MHz values.

A3.73 Finally, as noted in Annex 1, we do not place great weight on auction results in the USA as we consider that evidence from European auctions are more likely to be informative of spectrum values in the UK, and we have focused on these auctions for the purposes of our international benchmarking.

Value of 1800 MHz spectrum is too high relative to 900 MHz

A3.74 Contrary to Telefónica's reasoning, BT argued that the value of 1800 MHz was too high relative to 900 MHz. BT said the lump-sum values that we proposed in the June 2018 consultation imply that Vodafone or Telefónica would be willing to swap 2x10 MHz of 900 MHz for 2x13 MHz of 1800 MHz and queried whether this was credible.[238]

A3.75 As BT noted, there is no available evidence of market value from trades in the UK for 900 MHz or 1800 MHz spectrum. The most relevant evidence available to us on the relative value of 1800 MHz to 900 MHz is therefore the ratios from countries which have auctioned both these bands. We considered these ratios in our 2015 Statement, and placed particular weight on the three countries (Austria, Germany and Ireland) that provided a Tier 1 benchmark for both bands.[239] We have since derived an 1800/900 MHz ratio from recent

[238] BT response to June 2018 consultation, page 26-27.
[239] Paragraph 5.90, September 2015 Statement.

auctions in Norway, which we consider should be given similar weight in our cross checks on the ratio of 1800 MHz to 900 MHz from Tier 1 countries.[240]

A3.76 Our revised ratio of 1800 MHz to 900 MHz (74%) is higher than two of these four country ratios (i.e. Austria, for which we have identified a risk of understatement, and Ireland, for which we have identified a risk of overstatement) and lower than the other two ratios (i.e. Germany and Norway, for which we have both identified risks of overstatement).[241] It also lies slightly below the average ratio (94%) for these four countries – though, as explained, three of these ratios carry a risk of overstatement while the other carries a risk of understatement.

A3.77 The other ratios presented in Table A4.3 are lower than 74% (other than Denmark based on the 2016 1800 MHz value, for which the ratio is extremely high at over 500%). Using all ratios but excluding the Danish outlier would lower the mean to 64%.[242] However, these come from countries where either or both of our 900 MHz or 1800 MHz benchmarks are Tier 3 and generally reflect reserve prices set by regulators, which means that we place considerably less weight on them.

A3.78 BT also said that applying the distance method using our proposed lump-sum value for 900 MHz (£19 million), rather than 800 MHz, would suggest the UK value of 1800 MHz is around £8 million.[243] We recognise that the distance method approach can be applied using 900 MHz rather than 800 MHz. However, in coming to its estimate of the 1800 MHz value, BT's methodology also assigns equal weight to all benchmarks calculated under this revised distance method, which we do not consider to be appropriate given that some benchmarks are more informative than others about relative values. If we adopt BT's alternative distance method approach whereby 900 MHz is used rather than 800 MHz, but continue to place more weight on the benchmarks which we have identified as Tier 1 (consistent with our methodology), the average of the midpoint and lowest value of Tier 1 benchmarks (Austria, Ireland, and Germany) under this method is £14.9 million / MHz[244] i.e. slightly *higher* than our lump sum value for 1800 MHz derived in section 4.

A3.79 Finally, we also note that, to the extent that the 1800 MHz / 900 MHz ratio implied by our lump sum values is too high, this could be because the 900 MHz value is too low rather than the 1800 MHz value is too high.

A3.80 Overall, we do not consider that analysis of the ratios of 1800 MHz to 900 MHz provides a reason to amend our estimate of the lump sum values.

A3.81 Finally, BT also noted that our proposed 1800 MHz price is 171% higher than the price paid for UK 2.3 GHz spectrum in our April 2018 PSSR auction, and 47% higher than the price paid by Vodafone and Three for lower frequency 1.4 GHz spectrum (assuming the trade

[240] See footnote in Table A4.1.
[241] See Tables A8.1.10 (Austria), A8.7.3 (Ireland), A8.5.4 (Germany) of the 2015 Statement, and Table A2.2.25 (Norway) of this document.
[242] Including the Denmark (2010 and 2016) outlier, the ratio is 114%.
[243] BT response to June 2018 consultation, page 27.
[244] The lowest of these benchmarks is Austria (£13.2 million / MHz) and the average is £16.6 million / MHz.

price reported in the press at the time is correct). It said these premia appear excessive, particularly as there is an argument that TDD spectrum is more valuable than FDD spectrum, since spectrum value is largely based on the additional downlink capacity that it provides rather than the uplink.[245]

A3.82 Regarding these UK-based spectrum prices:

a) We considered the implications of the PSSR award in our June 2018 consultation.[246] Our view was that these auction prices do not provide evidence that would lead us to change our assessment of the forward-looking market values for 900 and 1800 MHz spectrum. In particular, we noted that the auction price of the 2.3 GHz band (£5.1 million / MHz) was broadly similar to the market value for 2.6 GHz spectrum in our 2015 Statement (£5.5 million per MHz, or £5.9 million in April 2018 prices), which we have explicitly used to derive our lump-sum estimates. Furthermore, as BT noted, this band is TDD (unpaired) spectrum. While we agree that TDD spectrum can be used to effectively deliver incremental capacity particularly for downlink (as discussed in paragraphs A3.23 to A3.25 above), we do not consider that it is necessarily worth more than FDD spectrum as TDD spectrum has some disadvantages over FDD spectrum, such as the possible need to use the same time slot scheme and synchronise with neighbouring operators to avoid interference.

b) We considered the implications of the Qualcomm trade of 1.4 GHz spectrum in our 2015 Statement.[247] We considered that the prices of this trade would provide limited additional benefit in estimating the lump-sum value of 900 and 1800 MHz spectrum, noting that the development of SDL in 1.4 GHz in terms of either device ecosystem or network deployment was in its early stages (relative to 1800 MHz which is an established 4G band). Furthermore, even disregarding this point, 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 bids. As such, we do not consider the reported price paid for 1.4 GHz spectrum in 2015 gives us a firm basis on which to conclude that our 1800 MHz lump-sum value is too high.

Overall view

A3.83 For the reasons set out above, we do not consider that the available evidence on relative 1800 MHz and 900 MHz values gives us grounds to revise the estimates of market value for these bands discussed in Section 4.

Overall conclusion on impact on market values

A3.84 Our assessment of the impact of technical and commercial developments is as follows:

[245] BT response to June 2018 consultation, pages 28-30.
[246] See paragraph A4.75 of the June 2018 consultation.
[247] See paragraphs A9.129 to A9.131 of the September 2015 Statement.

a) Greater certainty over the availability of mobile spectrum in several bands (i.e. 700 MHz, 1.4 GHz, 2.3 GHz and 3.4 GHz) was recognised in our 2015 Statement. As such, we have not further adjusted our market value estimates from the benchmarking discussed in section 4 for this. However, there is now greater certainty over the availability of potential substitute mobile spectrum, specifically in the 3.6-3.8 GHz band, compared with 2015. There have also been technological developments (massive MIMO and beamforming) which may have increased the effectiveness of spectrum above 3 GHz. Given this, we consider that this might serve to reduce the forward-looking market value of 1800 MHz spectrum relative to our 2015 assessment if taken in isolation (i.e. before considering the changes in market value benchmarks since the 2015 statement).

b) Developments in the availability and effectiveness of 3.6-3.8 GHz spectrum are unlikely to have a significant impact on the value of 900 MHz spectrum, as 3.6-3.8 GHz spectrum is less likely to be a close substitute for this spectrum than for other mid-frequency bands.

c) We do not consider that other technological developments since 2015, nor trends in data traffic growth, revenues, profits or network costs give us cause to make further adjustments to our estimates of market value for either 900 MHz or 1800 MHz.

d) Finally, we also we do not consider that the available evidence on relative 1800 MHz and 900 MHz values gives us grounds to revise market value estimates for these bands.

A3.85 We have considered how best to reflect the impact of point (a) above, in our assessment of the lump sum value for 1800 MHz spectrum in section 4.

A4. Cross-checks on lump sum values

Introduction

A4.1 In this annex we detail the cross-checks on the lump sum estimates obtained from our assessment in Section 4 of the relative value benchmarks and commercial and technical developments.

A4.2 Consistent with our 2015 statement[248] and June 2018 consultation, we consider three sets of cross checks:

a) Absolute UK-equivalent values of spectrum bands in relevant European auctions. Our view is that we would only modify the lump-sum value estimates derived from the (more reliable) relative values based on the evidence from the (less reliable) absolute values in exceptional circumstances (e.g. if the absolute values were tightly grouped and substantially different to our lump-sum value estimate for that band, having regard to the risk of understatement or overstatement of estimates).

b) The ratio of our estimates of 1800 MHz to 900 MHz lump-sum values in the UK to the corresponding ratio for benchmark countries where both bands were awarded.

c) The average of Tier 1 countries, and the average of Tier 1 and Tier 2 countries, within each band.

Absolute value cross-checks

A4.3 We have considered the following evidence on absolute values from recent auctions as cross-checks to our estimates based on relative values.

900 MHz

A4.4 The absolute values of 900 MHz spectrum in our benchmark countries are summarised in Table A4.1 below and they are also shown in Figure A4.1 below. The tiers shown in Table A4.1 and Figure A4.1 relate to the tiers for the associated relative value benchmark in that country (i.e. paired ratio of 900 / 800 MHz) even though we present in this table/figure the absolute value estimates. We have done this to avoid the potential confusion from two tierings for a given award – i.e. one for the paired ratio, one for the absolute value.

A4.5 The risk of under/overstatement for each award in Table A4.1 and Figure A4.1 relates to that absolute value, that is the risk of under or overstatement for that 900 MHz award as described in Annex 8 of the 2015 statement (see relevant country table) or, in the case of updates, the relevant country update Annex 2 of this statement.

A4.6 The absolute values from seven of the nine benchmark countries (including Norway) are materially higher than our estimate from the relative benchmarks of £19m per MHz (in

[248] 2015 Statement, paragraph 5.69 and 5.74.

April 2018 prices). £19m per MHz is higher than only one Tier 1 benchmark (Germany (2015)), which is at risk of under-statement and only one Tier 3 benchmark (Denmark) which is also at risk of understatement. As such, the evidence does not point to a reduction from our estimate derived from the relative benchmarking analysis and, if anything, considering the absolute value benchmarks alone a case could be made for selecting a higher estimate of market value. However, as explained above, we would only modify the lump-sum value estimates derived from our (relative value) benchmarks based on the cross-check against absolute values in exceptional circumstances. Given the greater weight we place on the relative value benchmarks and our conservative approach to interpreting the evidence, we do not consider that a revision to our estimate from the relative value benchmarks for 900 MHz (i.e. £19m per MHz) is appropriate in light of the absolute value cross checks.

Table A4.1: Absolute values for 900 MHz spectrum (UK-equivalent 2018 £m per MHz)[249]

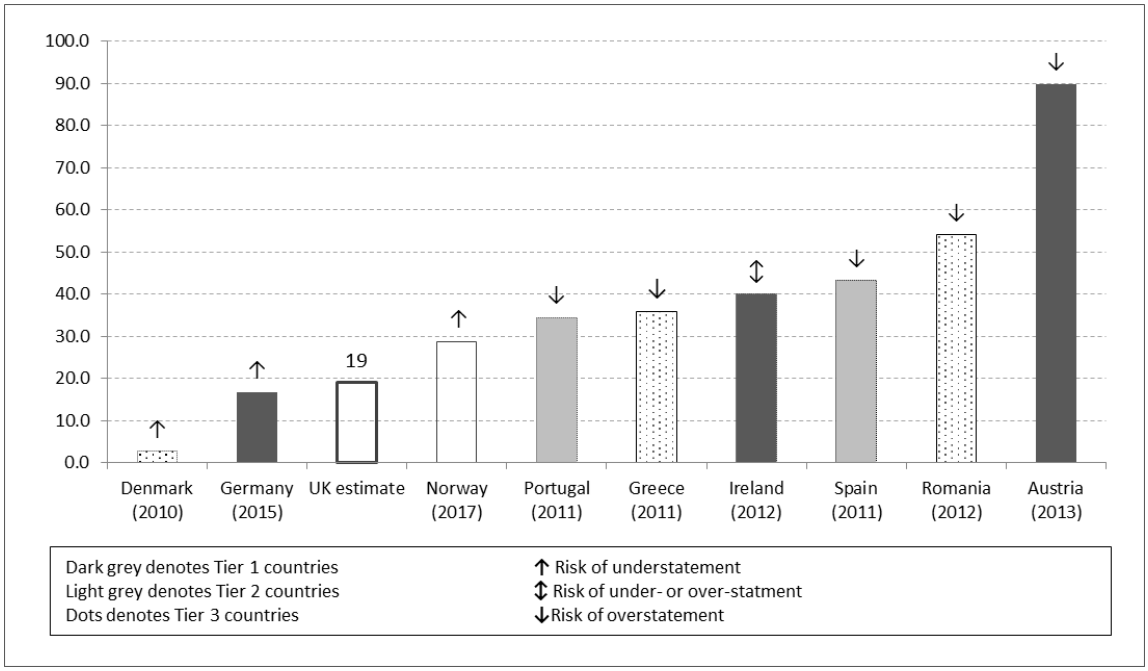
	Absolute Value	Tier (for relative benchmark)	Known risk of under / overstatement of absolute benchmark
Denmark (2010)	£2.7m[250]	3	Larger risk of larger under-statement
Germany (2015)	£16.8m	1	Larger risk of under-statement
Norway (2017)	£28.8m	N/A[251]	Risk of under-statement
Portugal (2011)	£34.5m	2	Larger risk of larger over-statement
Greece (2011)	£35.9m	3	Larger risk of larger over-statement
Ireland (2012)	£40.1m	1	Risk of under- or over-statement
Spain (2011)	£43.3m	2	Larger risk of larger over-statement
Romania (2012)	£54.1m	3	Risk of over-statement
Austria (2013)	£89.9m	1	Larger risk of larger over-statement

[249] Some of the absolute values have moved differently than simply uprating for UK CPI relative to the values reported in the 2015 Statement. The precise cause of each change is country-specific but all are the product of a combination of updates to the population data, PPP data, and inflation data used relative to the 2015 Statement.
[250] This value has fallen compared to the 2015 Statement and 2018 Consultation. This change is driven mainly by changes in the WACC and cost of debt values. An overview of methodological updates to our methodology is given in Annex 1.
[251] As set out in our June 2018 consultation, we have not identified a tier for Norway for 900 MHz or 1800 MHz, as we do not have relative value benchmarks from Norway for either band. However, as explained in Annex 2, we consider that the 900 MHz and 1800 MHz prices appear likely to have been primarily determined by a market-driven process of bidding in the auctions based on intrinsic valuations, and to be informative of forward-looking relative spectrum values in the UK – i.e. these evidence points are consistent with our criteria for Tier 1 benchmarks. We therefore consider it appropriate to give them similar weight in our cross checks as evidence points on absolute values from Tier 1 countries.

	Absolute Value	Tier (for relative benchmark)	Known risk of under / overstatement of absolute benchmark
Tier 1 Average	£48.9m		
All values average	£38.5m		

Source: Ofcom

Figure A4.1: Absolute values for 900 MHz spectrum (UK-equivalent 2018 £m per MHz)



Source: Ofcom

1800MHz

A4.7 For 1800 MHz, we have considered our revised estimate of market value against the evidence in our June 2018 consultation as well as the new evidence from Croatia, the Czech Republic, Greece, Slovenia and Sweden.

A4.8 The absolute values of 1800 MHz spectrum in our benchmark countries are set out in Table A4.2 and Figure A4.2 below. As with the 900 MHz absolute value table and figure above, the tiers in Table A4.2 and Figure A4.2 below relate to the tiers for the associated relative value benchmark in that country while the assessment of over/understatement relates to the 1800 MHz absolute value itself.

A4.9 The absolute value for the new Tier 1 country, the Czech Republic (2016), of £21.3m per MHz is comfortably above our £14m estimate of the value of 1800 MHz derived from consideration of the relative value benchmarks and commercial/technical developments. This is also the case, but to a lesser extent, for the other new Tier 1 country identified in

our consultation, Denmark (2016) at £15.4m per MHz. From Table A4.2 below, it can be seen that eleven (out of nineteen) countries across all tiers are above £14m per MHz, of which six are Tier 1 benchmarks. The remaining eight (out of nineteen) countries have absolute values below our £14m estimate, although only one of these is a Tier 1 benchmark.

A4.10 The average absolute value of the Tier 1 benchmark countries is £23.4m per MHz while the average absolute value across all the countries in Table A4.2 is £18.7m per MHz. Considering the absolute values in the round, we do not consider that a revision to the lump sum estimate of £14m per MHz is appropriate in light of this cross-check.

Table A4.2: Absolute values for 1800 MHz spectrum (UK-equivalent 2018 £m per MHz)[252]

	Absolute Value	Tier (for relative benchmark)	Known risk of under / overstatement of absolute benchmark
Denmark (2010)	£1.2m	N/A[253]	Larger risk of larger under-statement
Germany (2010)	£2.0m	2	Larger risk of under-statement
Slovak Republic (2013)	£7.8m	3	Larger risk of larger under-statement
Sweden (2016)	£8.1m	3	Risk of under- or over-statement
Czech Republic (2013)	£9.4m	3	Larger risk of under-statement
Sweden (2011)	£10.3m	1	Risk of over-statement
Portugal (2011)	£10.9m	3	Risk of under- or over-statement
Slovenia (2016)	£12.2m	N/A[254]	Risk of under-statement
Denmark (2016)	£15.2m	1	Risk of over-statement
Greece (2011)	£15.8m	3	Larger risk of over-statement

[252] As explained for the preceding table some absolute values have moved differently than simply uprating for UK CPI relative to the values reported in the 2015 Statement. For Portugal we have used updated auction price information. Further the Czech Republic input data has been updated to reflect annual licence fees of which we have become aware since the publication of the 2015 Statement.

[253] We did not assign a tier to the Danish (2010) 1800 MHz relative value benchmark because the Y/X ratio produced a negative value which we did not consider to be sensible as an indication of the UK market value of 1800 MHz. See 2015 Statement, Annex 8, paragraph A8.285.

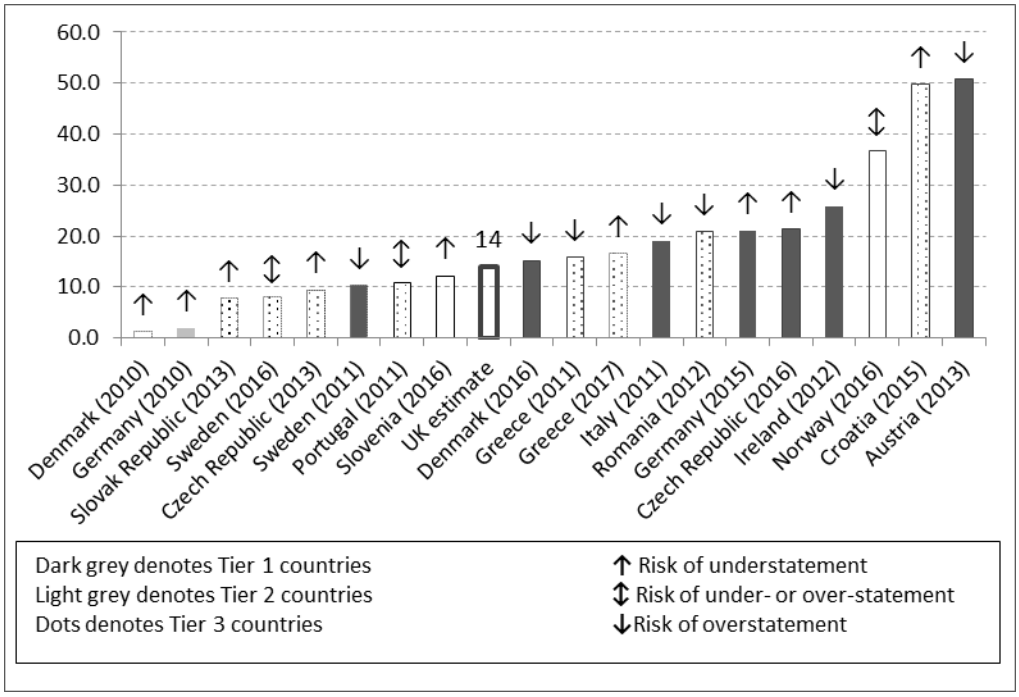
[254] We have not been able to derive a 1800 MHz relative value benchmark for Slovenia as we do not have band specific prices for 800 MHz or 2.6 GHz. See Annex 2.

	Absolute Value	Tier (for relative benchmark)	Known risk of under / overstatement of absolute benchmark
Greece (2017)	£16.6m	3	Risk of under-statement
Italy (2011)	£19.1m	1	Larger risk of over-statement
Romania (2012)	£20.9m	3	Larger risk of over-statement
Germany (2015)	£21.0m	1	Larger risk of under-statement
Czech Republic (2016)	£21.3m	1	Risk of under-statement
Ireland (2012)	£25.9m	1	Larger risk of over-statement
Norway (2016)	£36.8m	N/A[255]	No risk identified
Croatia (2015)	£49.7m	3	Larger risk of under-statement
Austria (2013)	£50.8m	1	Larger risk of over-statement
Tier 1 Average	£23.4m		
All values average	£18.7m		

Source: Ofcom

[255] See footnote in Table A4.1 above.

Figure A4.2: Absolute values for 1800 MHz spectrum (UK-equivalent £m per MHz)



Source: Ofcom

Within country ratios of 1800 MHz to 900 MHz

A4.11 In the assessment of the ratios of 1800 MHz to 900 MHz conducted in our 2015 Statement, we presented the results for all countries for which we were able to derive a ratio, but focused on the three countries – Austria (2013), Germany (2010 and 2015) and Ireland (2012) – from which we were able to derive Tier 1 benchmarks in both bands.

A4.12 In our June 2018 consultation we also noted that we had new 1800 MHz to 900 MHz ratios for Denmark (2010 and 2016) and Norway (2016 and 2017), although we considered that the Danish 900 MHz auction (in 2010) provided less important evidence for the value of 900 MHz spectrum in the UK, and the 900 MHz price was at a larger risk of larger understatement.

A4.13 Table A4.3 below sets out the ratios of 1800 MHz to 900 MHz for all countries where we have both 1800 MHz and 900 MHz absolute values. We are unable to derive a ratio of 1800 MHz to 900 MHz for the Czech Republic (our new Tier 1 benchmark for 1800 MHz) as we do not have a 900 MHz award price.

Table A4.3: Ratio of value of 1800 MHz to value of 900 MHz[256]

	1800 MHz / 900 MHz ratio	Tier (900 MHz to 800MHz paired ratio)	Tier (1800 MHz distance method benchmark)	Risk of over/understatement of the 1800 /900 MHz ratio
Austria (2013)	57%	1	1	Risk of understatement[257]
Ireland (2012)	65%	1	1	Risk of over-statement[258]
Germany (2015)	125%	1	1	Risk of over-statement[259]
Norway (2016)[260]	128%	N/A	N/A	Risk of over-statement[261]
Denmark (2010 and 2016)	557%	3	1	Larger risk of over-statement[262]
Portugal (2011)	32%	2	3	Larger risk of larger under-statement[263]
Romania (2012)	39%	3	3	Risk of under or over-statement[264]
Greece (2011)	44%	3	3	Risk of under-statement[265]
Greece (2011 and 2017)	46%	3	3	Larger risk of larger under-statement[266]
Denmark (2010)	42%	3	N/A	Risk of under- or overstatement[267]

[256] As a result of the refresh of the input data (described above in the footnote to Table A4.3) some of these ratios have changed slightly from the 2015 Statement and June 2018 consultation.
[257] See 2015 Statement Annex 8, Table A8.1.10.
[258] See 2015 Statement Annex 8, Table A8.7.3.
[259] See 2015 Statement Annex 8, Table A8.5.4.
[260] As explained in the footnote to Table A4.1, we consider that it is appropriate to give the absolute values from the Norwegian auctions similar weight in our cross checks as evidence points on absolute values from Tier 1 countries.
[261] See Annex 2, Table A2.25.
[262] See Annex 2, Table A2.14.
[263] See 2015 Statement Annex 8, Table A8.11.3.
[264] See 2015 Statement Annex 8, Table A8.12.3.
[265] See 2015 Statement Annex 8, Table A8.6.5.
[266] See Annex 2, Table A2.17.
[267] See 2015 Statement Annex 8, Table A8.3.7.

	1800 MHz / 900 MHz ratio	Tier (900 MHz to 800MHz paired ratio)	Tier (1800 MHz distance method benchmark)	Risk of over/understatement of the 1800 /900 MHz ratio
Tier 1 average including Norway	94%			
Average for all	114%			
Average for all excluding Denmark (2010 and 2016)	64%			

Source: Ofcom

A4.14 The UK ratio of 1800 MHz to 900 MHz lump sum values derived in Section 4 is 74%. From the table above, it can be seen that three countries are above that level and seven are below, with two of the Tier 1 benchmarks (Austria and Ireland) being below the derived UK ratio.

A4.15 In our June 2018 consultation, we considered that the fact that prices for 1800 MHz had been higher than for 900 MHz in the recent awards in Germany (2015) and Norway (2016 and 2017) might indicate that the values of the two bands were moving closer together. We did not consider the evidence from these two countries to be definitive. As we did not have clear evidence that the value of 900 MHz had decreased, on balance we considered it more likely that the value of 1800 MHz had increased.

A4.16 As discussed in Annex 3 in response to our June 2018 consultation, Telefónica said that there is no longer any meaningful premium for the marginal value of 900 MHz over 1800 MHz spectrum, and that the empirical evidence on relative values from recent awards is consistent with this view. It also said this is more likely to be due to declining 900 MHz values than increasing 1800 MHz values, as it estimated that there was a downward trend in the 900 MHz benchmarks over time. In contrast, BT said that the available evidence suggests our ratio of 1800 MHz to 900 MHz is too high (and by implication that the ratio of 900 MHz to 1800 MHz is too low, contrary to Telefonica's view).

A4.17 We have considered these arguments in paragraphs A3.69 et seq. in Annex 3. In summary, we do not consider that the available evidence on the relative value of 1800 MHz to 900 MHz spectrum gives us grounds to revise the estimates of market value for these bands. We have not therefore revised either of our estimates in light of this cross-check.

Averages across tiers

A4.18 For 900 MHz, our estimate of £19m per MHz is 81% of the average (£23.5m per MHz) across the Tier 1 relative benchmarks, and 81% of the average across Tiers 1 and 2 (which is also £23.5m per MHz). For 1800 MHz, our estimate of £14m per MHz is 77% of the average of Tier 1 countries (£18.3m per MHz) and 84% of the average across Tier 1 and Tier 2 relative benchmarks (£16.7m per MHz). However, we do not consider the latter proportion to be informative, as there is only one Tier 2 benchmark for 1800 MHz (Germany 2010), which we consider to be at larger risk of larger understatement.

A4.19 Overall, this cross-check indicates that we have been conservative in interpreting the evidence on lump sum values for both bands. We have not revised either of our estimates in light of this cross-check.

A5. Annualisation: supporting material

Introduction

A5.1 Our approach to annualisation is summarised in Section 4. This annex sets out in more detail our approach, the reasons for it and how we have taken account of stakeholders' comments to our June 2018 consultation.

Approach to annualisation

June 2018 consultation position

A5.2 In our June 2018 consultation we proposed, consistent with our 2015 Statement, to:

a) convert the lump-sum values into an equivalent annual licence fee (ALF) by spreading the lump-sum value of spectrum over 20 years, using a payment profile that is flat in real terms, that is a 20-year real annuity;

b) apply a post-tax discount rate and a tax adjustment factor (to reflect the more favourable tax treatment of annual fees compared to a lump-sum payment) to derive the annuity; and

c) use the CPI index to adjust the base year ALF level each year for inflation when the licence fee comes due for payment.

A5.3 Accordingly, we proposed to use the following formula to calculate the ALF. This formula assumes the ALF is an annuity payment with payments made at the beginning of the year.

$$ALF_t = LSV * TAF * \underbrace{\left[\frac{r}{1-(1+r)^{-t*}}\right] * \left[\frac{1}{(1+r)}\right]}_{\text{Annualisation rate}} * \left[\frac{CPI_t}{CPI_{t0}}\right]$$

A5.4 Where:

- ALF_t is the value of ALF in year t;
- LSV is the lump-sum value of spectrum;
- TAF is an adjustment factor that reflects the tax advantages of ALF over lump-sum payments;
- r is the real post-tax discount rate;
- t* is the length of period over which we spread the LSV for the purposes of calculating ALF, i.e. 20 years;

- CPI_{t0} is the level of the CPI (all items) index in April 2018 and CPI_t is the latest available figure for the same index published in the Consumer Price Inflation Reference Tables by the UK Statistics Authority.[268]
- We refer to the expression on the right-hand side of the formula which is multiplied by the LSV to derive the base level of ALF (i.e. before updating for inflation) as the "annualisation rate".

Stakeholder responses and our assessment

A5.5 Stakeholders did not make substantive comments on our overall approach to converting lump-sum valuations into an annuity but focused on our approach to estimating the individual components of the formula shown above. We discuss these comments in the following sections.

A5.6 In light of this, we have decided to use the formula set out above to calculate the base level of ALF, in line with the consultation proposal.

Approach to estimating the discount rate

Introduction

A5.7 As set out in our June 2018 consultation[269], in spreading a lump sum over a 20-year period, we use a discount rate at which the present value of the resulting payment stream equals our estimate of the lump-sum value today. An appropriate discount rate depends on, among other things, the uncertainty associated with this future ALF payment stream. One significant uncertainty relates to how changes in the market value of the spectrum over time are reflected in the ALFs. The discount rate which will leave MNOs indifferent between paying ALF and paying a lump sum depends on the extent to which they (rather than the government) are exposed to the effect of such changes in market value on ALFs, and, therefore, it is an important consideration in determining an appropriate discount rate.

A5.8 In both our June 2018 consultation and our 2015 Statement, we considered that the appropriate discount rate would sit somewhere between a suitably defined cost of debt (the lower polar case) and the weighted average cost of capital (WACC, the upper polar case), where the two cases are as follows.

a) *Lower polar case*: if, hypothetically, the ALF payments were fixed for the 20-year period, regardless of circumstances, then the ALF would be akin to the repayment of a loan from the government to the MNO. The appropriate discount rate would then reflect the corresponding interest rate on such a loan (which would reflect the default risk borne by the government in "lending" to the licensee).

[268] In our 2015 Statement we calculated values in March 2013 prices and therefore CPI_{t0} was the level of CPI (all items) index in March 2013.
[269] June 2018 consultation, paragraph 4.68.

b) *Upper polar case*: if, hypothetically, the ALF payments were set up in such a way that they varied in response to changes in market value of the spectrum, reflecting changes in the underlying cash flows derived from the use of the spectrum, then the licensee's risk associated with paying ALFs would be reduced (since ALF payments would be positively correlated with its cash flows derived from the use of spectrum). Instead, the risk is transferred to the government which would be receiving a stream of annual payments varying in line with the variation of the cash flows of the licensee.

A5.9 Neither of these hypothetical cases fits the likely situation over the life of the ALF payments. A licensee could avoid paying the ALFs by handing back the spectrum and in principle ALFs could be revised either up or down during the 20-year period. However, it is difficult to assess the probability of such events and their exact impact on the level of ALFs.

A5.10 Given these uncertainties, the risk-sharing adjustment is ultimately a matter of judgement. We proposed a 25% risk-sharing adjustment to the discount rate in the June 2018 consultation (consistent with the adjustment in the 2015 Statement).

A5.11 Stakeholders mostly commented on the specific elements of our discount rate calculations, raising issues with the way we have estimated the discount rate in the lower polar case, the upper polar case and the size of the risk-sharing adjustment. We provide our updated analysis and responses to the issues raised in the following sub-sections.

A5.12 BT disagreed with our overall proposal to use a discount rate above the lower polar case. BT stated that we were speculating on the likelihood of resetting the ALFs, but instead we "could exercise a conservative approach by assuming the ALFs will be fixed for the 20-year duration. Under this conservative assessment, the Government would not bear any of the risk and the discount rate should be based solely on the cost of debt."[270]

A5.13 There is, in our view, clearly some degree of sharing of the risk of changes in the market value of spectrum between the licensee and the government. Both parties are in a position to take actions that could amend the value of the ALFs. On the one hand, the licence holders could hand back spectrum and/or request Ofcom to revisit fees if there was evidence of a material misalignment from market value. On the other hand, Ofcom could initiate such a review in the event of material misalignment. Each of these situations could trigger a revision to the ALFs, such that there was variability in the cash flows received by the government – in contrast to a series of permanently fixed obligations.

A5.14 Hence, we do not agree with BT and do not consider that it would be appropriate to ignore this risk sharing in our analysis. We recognise that the extent of such risk sharing is difficult to estimate, but this does not mean we should ignore it or that we cannot use our regulatory judgement to estimate the extent of risk sharing. Indeed, in earlier submissions BT urged us to exercise such judgment, arguing that setting the discount rate at the

[270] BT's response to June 2018 consultation, page 32.

bottom of the range (i.e. lower polar case) was "…guaranteed to be below the right value with complete certainty".[271]

A5.15 Therefore, we maintain our overall approach of estimating a discount rate separately for the lower and the upper polar cases, and then choosing a value in between to reflect the presence of risk-sharing.

Lower polar case

June 2018 consultation position

A5.16 We considered that yields on bonds with a maturity of around 10 years would give an estimate of the cost of debt appropriate for the lower polar case.[272] We therefore considered a sample of the sterling denominated bonds of each MNO parent company with a maturity date of around 10 years in the future, and a BBB rated 10-year bond index[273] (since each MNO parent company had a BBB rating). We placed most weight on the yields from the index of 10-year BBB-rated bonds.

A5.17 Based on data for the 12 months to May 2018, we considered that the evidence broadly supported a yield to maturity (YTM) range of 2.5% to 3.0%. We proposed to use a pre-tax nominal cost of debt of 2.7% which was around the midpoint for the range and below the UK MNO average yield of 2.8% over the 12 months to May 2018.

A5.18 We then proposed to reduce this by 10bps for an inflation risk premium, consistent with the 2015 Statement, to account for the fact that the government would not bear inflation risk. This is due to the inflation indexation of ALFs, whereas corporate bonds without inflation indexation (i.e. fixed interest securities) are likely to trade at yields which include an expected compensation for inflation risk.

Stakeholder responses

A5.19 Vodafone considered that our choice of using bonds with a maturity of around 10 years and our choice of sterling issued debt of the parent groups of the UK MNOs and an index of 10-year BBB-rated sterling denominated bonds was reasonable. It also said that our choice of looking at information on yields over the last 12 months appeared broadly reasonable.[274]

A5.20 Other respondents considered that we had overstated the cost of debt for a number of reasons:

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[271] BT's response to the August 2014 consultation, page 5.
https://www.ofcom.org.uk/__data/assets/pdf_file/0024/76326/bt_response.pdf
[272] A constant stream of payments (i.e. an annuity like ALF) has a lower duration than the same maturity bond with a bullet payment at the end. Bonds with a maturity of around 10 years have a similar duration to a 20-year ALF. See paragraphs A10.22-A10.26 of 2015 Statement.
[273] Specifically Bloomberg's BVCSGU10 Index which includes unsecured sterling bonds rated BBB-, BBB and BBB+.
[274] Vodafone's response to the June 2018 consultation, page 31.

a) BT believed that we had overstated the cost of debt by assuming a BBB rating for a pure-play UK mobile spectrum operator and by using yields on debt issued by the parent companies, which have business operations in more risky countries than the UK. It said that if we instead assumed a credit rating one notch higher than the parent companies, to account for the lower risk of the UK operations, the cost of debt would fall by around 14 bps.[275]

b) NERA (on behalf of Telefonica) considered that including BT in the sample to determine the cost of debt may overstate the credit risk faced by MNOs because BT Group faces higher risk than MNOs owing to its pension deficit and unregulated activities. It noted that in the 2018 WLA Market Review we disaggregated BT Group's asset beta into three parts: Openreach copper access, Other UK Telecoms, and Rest of BT, with the Other UK Telecoms category (which includes BT's activities as an MNO) facing lower risk than BT Group as a whole. NERA considered that by not applying any such disaggregation we were overstating the credit risk borne by the government.[276]

c) BT and Telefonica both considered that we had overstated the cost of debt by basing our estimate on unsecured corporate bonds and not accounting for the effect of securitisation.[277] NERA (on behalf of Telefonica) suggested that a reduction of 10 to 12 bps was appropriate to adjust for security.[278]

d) NERA (on behalf of Telefonica) also argued that we had failed to correct the observed cost of debt for liquidity risk which they argued was necessary to fulfil our objective of making the government indifferent between a lump sum payment and ALFs. NERA proposed that the cost of debt should be adjusted down by 30 to 41 bps.[279]

Our assessment

Choice of bonds

A5.21 We do not agree with BT that we have overstated the cost of debt by considering yields on bonds issued by parent companies of the UK MNOs. There is not a mechanistic link between the geographic revenue mix of parent groups and their credit ratings. In the 2018 MCT Statement, we noted that the majority of UK and European mobile providers had a BBB credit rating, and used BBB evidence from bond indices and individual bond issues to derive a cost of debt for a UK MNO.[280] In the lower polar case, the discount rate should reflect the credit risk of the licensee, i.e. a UK MNO.[281] In the absence of a pure-play UK MNO which issues debt on a stand-alone basis, we continue to believe that BBB bond

[275] BT's response to June 2018 consultation, page 33.
[276] NERA's paper submitted by Telefonica in response to June 2018 consultation (NERA August 2018 Report), page 8.
[277] BT's response to June 2018 consultation, page 32-33.
[278] NERA August 2018 Report, page 10.
[279] Ibid, page 9.
[280] 2018 MCT Statement, pages 112-113.
[281] We also note that BT refers to the risk of a UK mobile spectrum operator, rather than a UK MNO. We discuss later why we do not consider that there is a meaningful distinction between the two.

yields are a good starting point for the evaluation of the required compensation for that risk.

A5.22 We also do not agree with NERA that we should have excluded BT bonds in our analysis. Within our disaggregation of the BT Group WACC in charge controls, for example in the 2018 WLA Market Review, we assessed the systematic risk (measured by the asset beta) of the Other UK Telecoms part of BT (which includes its mobile activities) to be slightly lower than that for BT Group as a whole.[282] However, when disaggregating the cost of debt, we used the same debt premium for BT Group as for Other UK Telecoms. While theoretically there is a link between systematic risk and credit risk, in practice, it is quite difficult to estimate differences in debt premiums for relatively small differences in the asset beta.

A5.23 Further, in our June 2018 consultation we placed most weight on the evidence from the BBB bond index rather than individual bond issues. Even if we had excluded BT from the analysis of parent company bonds, it is not clear that we would have reached a different position on the proposed cost of debt of 2.7%. Without BT bonds in the sample, the 12-month average yield ranged from 2.3% to 3.3% with the closest maturity to 10 years being the Telefonica 11-year rate at 2.9%. [283]

A5.24 We present updated evidence on bond yields below. We then address the other issues raised by stakeholders – specifically the adjustments for security and liquidity.

A5.25 As in the June 2018 consultation, we focus on a BBB bond index of 10-year maturity and on bonds issued by the parent companies of UK MNOs with a remaining maturity of around 10 years.[284] Table A5.1 summarises the YTM on debt we have considered updated to 31 October 2018 and Figure A5.1 illustrates the YTM over the past three years.

Table A5.1: Yield to maturity on sterling debt with maturities of around 10 years

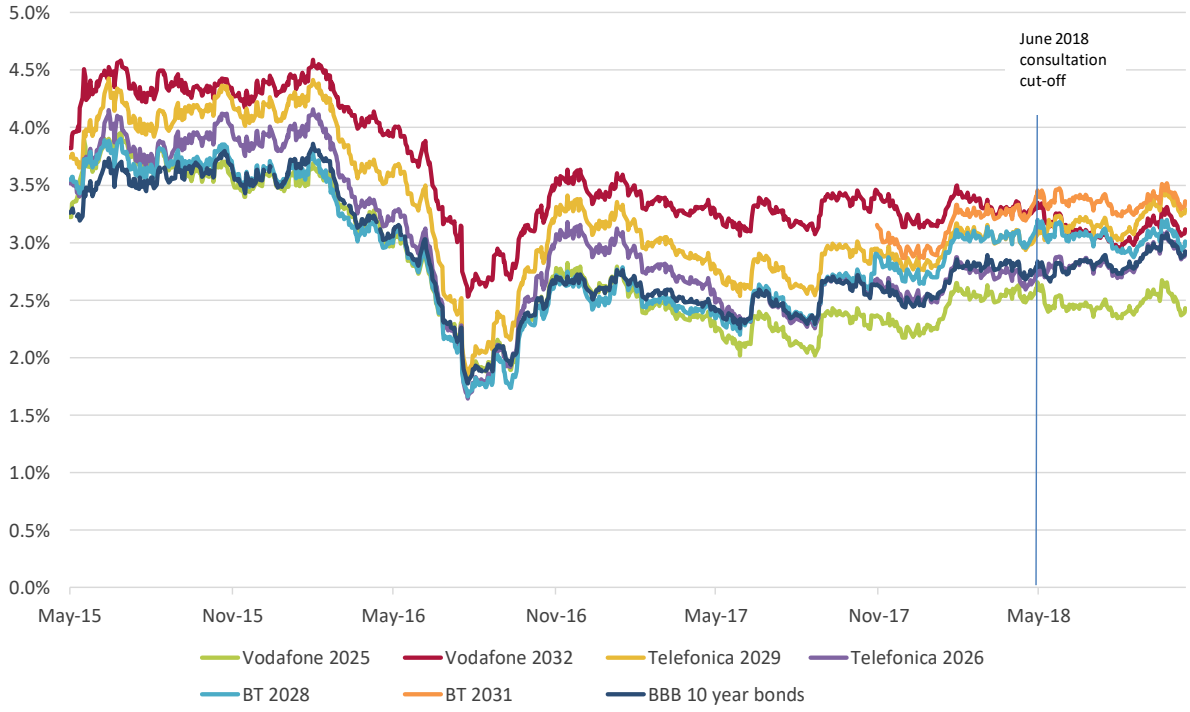
	Credit rating	Debt maturity	Years to maturity [285]	12-month average yield	12-month minimum yield	12-month maximum yield	Average October 2018[286]
Vodafone	BBB+	2025	6	2.4%	2.2%	2.7%	2.5%
		2032	14	3.2%	2.9%	3.5%	3.2%
Telefonica	BBB	2026	7	2.7%	2.5%	3.1%	3.0%
		2029	11	3.1%	2.8%	3.5%	3.3%

[282] In the 2018 WLA Market Review, we assumed an asset beta of 0.73 for Other UK Telecoms versus 0.78 for BT Group.
[283] Table 4.4, June 2018 consultation.
[284] None of the parent companies have issued new bonds since the June 2018 consultation with a maturity of around 10 years, hence, the sample of bonds used remains the same.
[285] Years to maturity rounded to the nearest whole year counting from 31 October 2018 to date of maturity.
[286] The average for October 2018 is based on 23 working days' worth of data from 1 October 2018 to 31 October 2018 (inclusive).

	Credit rating	Debt maturity	Years to maturity [285]	12-month average yield	12-month minimum yield	12-month maximum yield	Average October 2018[286]
BT	BBB	2028	10	3.0%	2.6%	3.2%	3.1%
		2031	13	3.2%[287]	2.9%	3.5%	3.4%
10-year BBB rated bonds[288]		2028	10	2.8%	2.4%	3.1%	3.0%

Source: Bloomberg, Ofcom analysis as at 31 October 2018. Credit ratings are Bloomberg Composite ratings.

Figure A5.1: Yield to maturity on sterling debt with maturities of around 10 years



Source: Bloomberg, Ofcom analysis as at 31 October 2018.

A5.26 For the 12 months to October 2018, yields on the BBB 10-year index have ranged from 2.4% to 3.1% and averaged 2.8% with more recent observations at the top end of this range (the average yield on the index for the month of October is 3.0%). Average yields on individual MNO bonds with maturity closest to 10 years (Telefonica 2029 and BT 2028 bonds) sit at or close to the top of the BBB index range.

A5.27 The average 12-month yield on the Vodafone 2025 bond of 2.4% is at the low end of the BBB index range (however, it only has about 6 years left to maturity). BT 2031 and

[287] The average from 16 November 2017 (when bond was issued) until 31 October 2018.
[288] Source: Bloomberg's BVCSGU10 Index 1 November 2017 to 31 October 2018.

Vodafone 2032 bonds have the highest average yields for the same period of 3.2% (and have a longer remaining time to maturity of 13 and 14 years respectively).

A5.28 Given the above observations, the June 2018 consultation range of 2.5% to 3.0% still looks reasonable although more recent observations sit closer to the top end of this range. Given the slight increase in debt yields, we propose to increase the cost of debt from 2.7% used in the consultation to 2.8% which reflects the most recent 12-month average yield on the BBB index. This point estimate is slightly below the 12-month average yield on most of the UK MNO bonds shown above (the average of which is 2.9%).

Inflation risk premium

A5.29 We did not receive any responses to our June 2018 consultation on the issue of the inflation risk premium.

A5.30 We have decided to maintain our consultation position and reduce the pre-tax nominal cost of debt by 10 bps for the inflation risk premium.

Adjustment for security

A5.31 BT and Telefonica both considered that we had overstated the cost of debt by basing our estimate on unsecured corporate bonds which do not account for what they considered the greater security of ALF compared to unsecured debt.

A5.32 NERA (on behalf of Telefonica) notes that "the ALF can be viewed as a debt obligation secured against the value of the spectrum licence"[289], and estimated a reduction of 10 to 12 basis points to the cost of debt to reflect this effect. NERA's estimates are based on the assumption that the value of securing ALF against the spectrum value could result in a one notch uplift to the credit rating.

A5.33 BT also makes the point that since "ALF payments are secured assets where the Government is able to recover the market value of the spectrum in the event that an MNO 'defaults', the ALF payments offer a level of security that corporate bonds do not."[290]

A5.34 In the 2015 Statement, we decided not to make an adjustment for security. The available evidence on the potential benefits of security considered the potential ratings uplifts applied by a credit rating agency (specifically Moody's) for structural enhancements to debt which aim to increase creditor protection (of which securitisation can be a feature).

A5.35 Specifically, we noted that:[291]

a) In practice, structural enhancements appear to deliver a two-notch uplift at most;

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, given that there are many other factors typically included in structural enhancements);

[289] NERA August 2018 Report, page 10.
[290] BT's response to June 2018 consultation, page 32.
[291] 2015 Statement, paragraph A10.40.

c) The value of any security is likely to be weaker due to the correlation between default and spectrum value. In other words, there is likely to be a greater probability of the licensee defaulting if the value of spectrum has declined.

A5.36 NERA considers that it has addressed the last point by only assuming a one-notch uplift. However, according to Moody's methodology, the degree of ratings uplift due to structural features depends on: "factors that reduce the likelihood that an issuer will default on its debt", and "factors that give creditors either the right, or ability to influence the taking of corrective action – to stop or reverse credit deterioration."[292] The ALF payments would clearly not fit these descriptions.

A5.37 Unlike more traditional forms of secured debt, there is no liquid market where the government could immediately realise the value of the spectrum. For example, if an airline defaults and it has a secured lease on a fleet of planes, the party providing the lease could realise the remaining value of the fleet by re-selling on the secondary market for planes. Unless the airline's default is a result of a major downturn in the airline industry which significantly reduces the value of all planes in the market, the creditor can realise the value of the asset against which the lease is secured.

A5.38 In the event that the licensee defaults on the ALFs, the government cannot easily realise the remaining value of the spectrum. The spectrum would need to be reclaimed from the defaulting licensee, an appropriate release mechanism designed and consulted on (e.g. an auction) and the necessary transaction(s) conducted (i.e. acquisition by a new buyer or buyers); all of which would take time with an uncertain impact on the value paid for any spectrum so released. If the default of the licensee is linked to a decline in the value of the spectrum, then the value the government may be able to recoup will be reduced.

A5.39 Finally, NERA considers that its estimate of how much a one-notch uplift is worth is significantly understated, because our overall discount rate of 1.5% "implicitly assigns a BB+ rating to the credit risk associated with the ALF payments."[293] A one-notch uplift to a BB+ rating would be worth significantly more according to NERA's analysis.

A5.40 We think this line of argument conflates different issues. In the lower polar case, we are concerned with identifying the best estimate of the discount rate which would leave the MNOs (and government) indifferent between the MNOs paying a lump-sum today and making 20 annual payments (with no possibility of these payments being revised). This assessment is independent of any risk-sharing adjustment which arises from the possibility of a review of ALFs (and which led to the discount rate of 1.5% in the June 2018 consultation to which NERA refers). Therefore, the question of whether ALF payments offer any additional security to the government relative to an unsecured creditor should be confined to the lower polar case.

A5.41 On balance, we consider that it remains appropriate not to make any adjustment for security in our lower polar case.

[292] Moody's (2017), Regulated Electric and Gas Networks, Rating Methodology, p.20.
[293] NERA August 2018 Report, page 10.

Liquidity risk premium

A5.42 NERA (on behalf of Telefonica) proposed that the cost of debt should be adjusted down by 30 to 41 bps (27.0% to 37.3% of the debt premium calculated by NERA) to account for the fact the government does not require compensation for liquidity risk.

A5.43 Liquidity risk refers to the difficulties that a creditor may encounter when trying to sell an asset on the secondary market. This can restrict the creditor's ability to manage risk exposure, and so creditors may require a premium for bearing liquidity risk.

A5.44 The evidence on the extent to which the observed investment grade corporate bond yields include compensation for liquidity risk is mixed. NERA's proposed adjustment is based on the evidence used by the Competition Commission (CC) in its enquiry into the Heathrow and Gatwick price control determination where the CC attempted to decompose the debt premium for BBB-rated corporate debt into its constituent components.[294]

A5.45 One component of observed bond yields is the default premium, which reflects the expected loss to the creditor in the event of default (reflecting the possibility that a bond may not be repaid in full in the case of default). Another component is the default risk premium, which rewards the investor for bearing the risk that the actual loss might differ to the expected loss. There is a body of empirical literature which attempts to estimate these default components and assess how well they explain observed bond yields.[295]

A5.46 Research cited by the CC and NERA generally finds that observed bond yields appear to include compensation for factors other than default risk, with liquidity risk being the main such factor. [296] NERA used the CC's range of 27.0% to 37.3% as an approximation of the proportion of the debt premium attributable to liquidity risk.[297]

A5.47 NERA argues that the risk of the ALF cash flows is driven by the "default risk" associated with the payments. Liquidity risk is not associated with the cash flows coming from the MNOs to the government, and so should not be included in the discount rate.

A5.48 While the lack of ability to re-sell seems clear[298], we agree with NERA that the government may not need to be compensated for the liquidity risk that might be implicitly captured in bond yields used to derive the discount rate in the lower polar case. The main risk the government needs compensation for in the lower polar case is default risk.

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[294] Competition Commission (2007): A report on the economic regulation of the London airports companies (Heathrow Airport Ltd and Gatwick Airport Ltd), presented to the Civil Aviation Authority 28 September 2007; for the relevant discussion, see Appendix F, page F25.
[295] For example, all of the studies cited by the Competition Commission explore this issue.
[296] The CC notes that this decomposition method has become well established and has been used by leading academic researchers.
[297] Note that some of the estimates are based on all non-default components of the debt premium and potentially overstate the liquidity premium.
[298] Consistent with our position in the 2015 Statement, paragraph A10.53.

A5.49 We have reviewed the evidence considered by the CC.[299] The CC's estimate of the liquidity premium is based on US studies, all conducted around 2005 and 2006, which provide direct or indirect evidence on the proportion of the debt premium for BBB-rated corporate debt that is attributable to factors other than default risk. Three of the studies considered by the CC estimate that 27% to 29.8% of the debt premium is attributable to factors other than default risk, with one study providing a higher estimate of 37.3%.

A5.50 Some of the more recent research also suggests that factors such as liquidity risk could account for around a quarter of the debt premium on investment grade debt. Haitao et al (2017) estimate a figure of 25% for liquidity risk for investment-grade bonds.[300] This is similar to Chen et al (2017) who find that liquidity risk accounts for 27% of the credit spread for 10-year BBB bonds.[301] These studies are consistent with the lower end of the CC's range of 27.0% to 37.3%. While we do not have the underlying data, recent research by the Bank of England would also appear to support similar estimates of around 25-30% for UK investment grade corporate bonds.[302]

A5.51 On the other hand, there is also research which suggests liquidity risk could be quite small for investment grade debt, with default risk being the main driver of observed bond yields.[303]

A5.52 The above discussion highlights that decomposing bond spreads is an area of ongoing empirical research, and that any estimates of the liquidity premium need to be treated with caution.

A5.53 Overall, given that there are a number of studies suggesting that the liquidity risk premium is non-negligible, we have decided to make a 30% downward adjustment to the debt premium to reflect this effect. We think this is a reasonable interpretation of the available evidence.

A5.54 The nominal pre-tax cost of debt for the lower polar case of 2.8% is based on the 12-month average yield on the 10-year BBB index up to 31 October 2018. Over the same period, we estimate the average debt premium for the BBB index of 135bps. Applying a 30% adjustment for liquidity translates into a reduction of 40 basis points to the cost of debt (rounded to the nearest 10bp).

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[299] Competition Commission (2007): A report on the economic regulation of the London airports companies (Heathrow Airport Ltd and Gatwick Airport Ltd), presented to the Civil Aviation Authority 28 September 2007; for the relevant discussion, see Appendix F, page F25.

[300] Haitao Li, Chunchi Wu, Jian Shi, (2017) "Estimating liquidity premium of corporate bonds using the spread information in on- and off-the-run Treasury securities", China Finance Review International, Vol. 7 Issue: 2, pp.134-162, https://doi.org/10.1108/CFRI-11-2016-0125

[301] Hui Chen Rui Cui Zhiguo He Konstantin Milbradt (2017) "Quantifying Liquidity and Default Risks of Corporate Bonds over the Business Cycle", The Review of Financial Studies, Vol. 31 Issue: 3, pp 852–897, https://doi.org/10.1093/rfs/hhx107

[302] Bank of England (2017), Quarterly Bulletin, 2017 Q3, Corporate Bond Purchase Scheme: design, operation and impact. Chart 9. https://www.bankofengland.co.uk/quarterly-bulletin/2017/q3/corporate-bond-purchase-scheme-design-operation-and-impact

[303] Feldhütter, P., & Schaefer, S. M. (2018). *"The Myth of the Credit Spread Puzzle".* Review of Financial Studies, 31(8), 2897-2942. DOI: 10.1093/rfs/hhy032

Lower polar case for annualisation

A5.55 We have decided to use a pre-tax nominal cost of debt of 2.8%. Allowing for a reduction of 10 bps for an inflation risk premium and a reduction of 40 bps to adjust for the liquidity risk premium gives a pre-tax nominal rate of 2.3%.

A5.56 We derive a post-tax nominal discount rate by allowing for the average corporate tax rate which will prevail over the 20-year period (17.1%).[304] This gives a post-tax nominal rate of 1.9%. The equivalent post-tax real rate is -0.1% (using our CPI inflation forecast of 2%) and is the discount rate for the lower polar case.

Upper polar case

June 2018 consultation position

A5.57 In our 2015 Statement[305] we concluded that the WACC used in the 2015 MCT Statement was a reasonable proxy for the upper polar case. In our June 2018 consultation we proposed a similar approach and used the WACC determined in the 2018 MCT Statement. The pre-tax nominal WACC in the 2018 MCT Statement was 9.1%.[306] The corresponding post-tax real WACC we used in the June 2018 consultation was 5.5% (converted from the pre-tax nominal WACC using the tax rate of 17.1% and CPI inflation of 2%).[307]

Stakeholder responses

A5.58 Stakeholders criticised our approach of using the WACC from the 2018 MCT Statement.

A5.59 Vodafone said that we had not attempted to show that the MCT WACC was appropriate for the purposes of setting ALFs and that there was little reason to presume that the same point estimate of the cost of capital was appropriate for both purposes.[308]

A5.60 Three noted that as the 2018 MCT Statement did not include a full re-analysis of the WACC and instead relied on the WACC estimate from the 2015 MCT Statement. It said it was incumbent upon us to undertake a proper review of the MNOs' forward-looking cost of capital.[309]

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[304] See paragraph A5.139 below.
[305] Paragraph 6.45.
[306] Ofcom, Mobile Call Termination final statement, March 2018, paragraph 5.40, page 83, https://www.ofcom.org.uk/__data/assets/pdf_file/0021/112458/Final-Statement-Mobile-Call-Termination-Market-Review-2018-2021.pdf
[307] Nominal post-tax WACC = nominal pre-tax WACC * (1 – tax rate). Real post-tax WACC = (1 + nominal post-tax WACC) / (1+CPI inflation) – 1. The tax rate of 17.1% was our estimates of the average tax rate over the 20-year period from the TAF calculation.
[308] Vodafone's response to June 2018 consultation, page 33.
[309] Three's response to June 2018 consultation, page 32.

A5.61 Three[310] and Vodafone[311] said that the approach used in MCT placed greater weight on historical data than the approach we used to calculate the cost of debt for the lower polar case in the June 2018 consultation. They argued that our estimate of the risk-free rate (RFR) was not sufficiently forward-looking.

A5.62 Three considered that our estimate of the RFR was based on outdated evidence. It noted that our estimate was based on an analysis of gilt yields up to 29 December 2017, and that we had not attempted to make use of additional data available since then. It considered that the evidence supported a negative (real, RPI-deflated) RFR.[312]

A5.63 As set out in paragraphs A5.12-14 above, BT disagreed that the WACC was an appropriate upper bound for calculating the discount rate, in contrast to its position in 2014. BT also considered that there were reasons to believe that the systematic risk associated with holding spectrum was lower than the risk facing MNOs as a whole, and that in the absence of pure-play spectrum comparators, BT did not believe we should be making a speculative assessment of the appropriate WACC. In addition, BT argued that if we were using the MCT WACC for the upper polar case, in selecting the point estimate for the WACC we should select the low end of the MCT WACC range to make a conservative judgement on the ALFs.

A5.64 Stakeholders also made the following criticisms of our proposed approach:

a) Telefonica argued that we had erred in continuing to use what it and NERA described as a long-run estimate of the WACC as this was inconsistent with our use of current estimates of the cost of debt. It (and NERA on its behalf) argued that the relevant upper bound should be the current "short-run" WACC because "buying spectrum" is a one-off transaction with no ongoing capex even if the payment conditions allow for some risk-sharing.[313]

b) Three argued that our approach of using market-aligned evidence to inform our estimate of the debt premium but long-term historic averages for the risk-free rate results in an inconsistency in the parameters of the cost of debt. It noted that the MNO cost of debt in real RPI terms based on the current YTM on 10-year bonds would be lower than the risk-free rate, and therefore inconsistent with the existence of a debt premium.[314]

[310] Three's response to June 2018 consultation, page 35.
[311] Vodafone's response to June 2018 consultation, page 34.
[312] Three's response to June 2018 consultation, page 33.
[313] NERA August 2018 Report, page 6.
[314] Three's response to June 2018 consultation, page 39.

c) Three[315] and Vodafone[316] also considered that there was an inconsistency between the cost of debt implicit in the cost of capital estimate and the cost of debt used as a component in the discount rate. They noted that the cost of debt used in the 2018 MCT WACC was in a range between 4.3% and 4.8% while the cost of debt we derived from the YTM on 10-year bonds was between 2.5% and 3.0%.

d) Similarly, BT noted that our estimate of the post-tax real WACC had increased from 5.2% to 5.5% between the 2015 Statement and June 2018 consultation. It did not consider this was consistent with the reduction in the cost of debt given the observed decline in interest rates.[317]

Our assessment

A5.65 We consider that the approach for the upper polar case based on the forward-looking WACC (which reflects the riskiness of a UK MNO) remains appropriate. This is consistent with how we define the upper polar case, which is that, hypothetically, if the ALF payments were set up in such a way that they varied in line with the future after-tax cash flows of the licensee (e.g. through some form of net revenue sharing arrangement between the licensees and the government) the government would be fully exposed to the underlying systematic risk.

A5.66 However, in light of stakeholder responses and new evidence, we have revised our estimate of the WACC for the upper polar case:

- We have updated the market parameters underpinning the WACC to ensure they are appropriately forward-looking. In particular, we have based our RFR assumption on recent evidence, consistent with the cost of debt in the lower polar case; and we have also revised our estimate of the required total equity market return (the TMR), to reflect our most recent assessment of the appropriate TMR.
- We have reflected our latest view of the systematic risk of an MNO (as measured by the asset beta) in the WACC.
- We have updated the cost of debt underpinning the WACC such that it is consistent with the cost of debt in the lower polar case.

A5.67 The overall impact of the changes above is to reduce the post-tax real WACC from 5.5% used in the June 2018 consultation to 4.2%.

Market parameters

A5.68 Some cost of capital parameters, namely the RFR and the equity risk premium (the ERP), are market-wide parameters which affect all firms.

[315] Three's response to June 2018 consultation, page 39.
[316] Vodafone's response to June 2018 consultation, page 34.
[317] BT's response to June 2018 consultation, page 34.

Risk-free rate

A5.69 The upper polar case should reflect the cost of capital commensurate with the systematic risk of the cash flows derived from using the spectrum in question. On the one hand, this could suggest that our RFR assumption should reflect our best view of the expected RFR over the period for which ALFs are set (i.e. 20 years), to be consistent with the notion that the risk borne by the government in the upper polar case would reflect the operating risk of MNO cash flows over this period. This might suggest placing more weight on forward rates or longer-run averages (assuming interest rates start to recover from current lows), rather than purely on spot rates.

A5.70 On the other hand, we consider that there is merit in stakeholders' arguments that there should be consistency between the cost of debt used to derive the lower polar case and the WACC components used to derive the upper polar case. Since our lower polar case is based on current debt rates (to be precise the last 12 months), this would point towards a RFR closer to spot rates.

A5.71 In the 2015 Statement, we decided to use current debt rates for the lower polar case. In reaching this decision, we noted that there was no single rate which could achieve indifference between paying ALFs and a lump-sum over time for all current and potential future licensees. However, we considered that using current market rates would at least get close to achieving indifference between paying ALFs and a lump-sum in the first period for which the ALFs are set.[318]

A5.72 These considerations are in principle also relevant to the upper polar case. Therefore, we have decided to adopt a consistent approach to the estimation of the RFR and the cost of debt, and to use current market rates both in the upper and lower polar cases. We noted earlier that the average debt premium underpinning the nominal pre-tax cost of debt of 2.8% (from which the lower polar case is derived) is 135bp. This implies a nominal risk-free rate of 1.5% (rounded to the nearest 10bp).

A5.73 Therefore, we have used 1.5% as the nominal RFR.

Equity risk premium and total market return

A5.74 The TMR represents the sum of the RFR and the ERP. While the expected TMR and expected ERP are not directly observable, in recent cost of capital determinations we have placed more weight on empirical estimates of the TMR than the ERP because historically it has been less volatile than the ERP.[319] We then derived the ERP by subtracting the RFR estimate from the TMR estimate.

[318] February 2015 consultation, paragraph A10.13.

[319] For example, Table 71 in the 2018 Credit Suisse Yearbook shows that the ratio of standard deviation to arithmetic mean for the nominal TMR is 1.9, which is lower than the equivalent ratio for the nominal ERP calculated for equities against bonds (3.4) and equities against bills (3.1).

A5.75 No stakeholder raised specific concerns with our TMR estimate in response to the June 2018 consultation.[320] However, we have since reviewed different evidence on the TMR in our cost of capital work for the recent 2018 BCMR Consultation.[321] We see no reason to depart from our 2018 BCMR proposal to adopt a real (CPI-deflated) TMR of 6.7%, equivalent to a nominal TMR of 8.8% (using CPI of 2%), since this represents our latest view of the forward-looking TMR. Combined with our estimate of the RFR, this implies a nominal ERP of 7.3%.

Asset beta

A5.76 A company's equity beta measures the sensitivity of returns to shareholders relative to returns on the equity market as a whole (i.e. it measures systematic risk). A company's asset beta measures systematic risk, stripping out the effect of financial leverage.

A5.77 Consistent with our position in the 2015 Statement, we do not agree with BT that the systematic risk associated with holding spectrum is lower than the risk facing the MNOs as a whole.[322] In the upper polar case, our assumption is that ALFs are adjusted to reflect changes in the cash flows derived from the use of spectrum. We do not consider there are any obvious reasons why the risk of these cash flows would be significantly different to the risk of cash flows of an average UK mobile operator.[323]

A5.78 In the 2018 MCT Statement, we concluded that an appropriate asset beta for a UK MNO was in the range of 0.55 to 0.75.[324] This was based on asset beta evidence for UK and European parent companies of MNOs. Further, the analysis performed for us at the time by NERA found no statistically significant difference in the asset betas between mobile and fixed telecoms providers.[325] In light of this finding, we also considered our assessment of the Other UK Telecoms asset beta that we used in disaggregating BT Group's beta when setting charge controls on BT. The Other UK Telecoms part of BT captures its fixed telecoms activities (other than local copper access services and access to physical infrastructure[326]) and its mobile activities. We would therefore expect the asset beta identified for Other UK Telecoms to also provide a benchmark for the asset beta of a UK MNO.

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[320] NERA presents two WACC scenarios using revised RFR assumptions: one scenario where the TMR is kept constant at the level used in the 2018 MCT WACC and one scenario where the ERP is kept constant. NERA makes it clear that they have used these values for illustration and have not independently assessed the appropriate level of the TMR.
[321] Ofcom, Business Connectivity Market Review consultation, November 2018, Annex 21. https://www.ofcom.org.uk/__data/assets/pdf_file/0017/124730/bcmr-annexes-1-22.pdf
[322] 2015 Statement, paragraph 6.35.
[323] In MCT we estimate the WACC for an average efficient mobile provider in the UK. We think this concept is compatible to the business risk we are trying to capture in the upper polar case.
[324] See Ofcom, Mobile Call Termination final statement, March 2018, Annexes 1-15, paragraph A10.22, page 110, https://www.ofcom.org.uk/__data/assets/pdf_file/0022/112459/MCT-review-statement-annexes-115.pdf
[325] NERA (2017), "*The Evidence for Differences in Risk for Fixed vs Mobile Telecoms",* page 17. *https://www.ofcom.org.uk/__data/assets/pdf_file/0020/112457/Annex-16-NERA-Report-The-Evidence-for-Differences-in-Risk-for-Fixed-vs-Mobile-Teleco.pdf*
[326] Access to BT's ducts and poles.

A5.79 In the 2018 BCMR Consultation, we provided an updated assessment of the Other UK Telecoms asset beta range. In light of more recent empirical beta estimates for BT and a range of comparators we proposed that the range of 0.55 to 0.75 remained appropriate.

A5.80 As explained in the 2018 MCT Statement, given our objective to estimate the asset beta for a UK MNO, we prefer to place most weight on betas calculated against the 'home index'. The only telecoms companies with mobile operations in the UK and which are also listed in the UK are BT and Vodafone. Their latest asset beta estimates are presented in the table below, alongside the asset beta for Telefonica (the only other publicly listed comparator (albeit overseas) with mobile operations in the UK) and the range of asset betas for a selection of European comparators.

Table A5.2 Daily asset beta estimates

	"Home" index			World index		
	1Y	2Y	5Y	1Y	2Y	5Y
BT (27%*)	0.56	0.51	0.71	0.37	0.38	0.68
Vodafone (67%*)	0.70	0.65	0.68	0.48	0.46	0.59
Telefonica (71%*)	0.46	0.50	0.57	0.40	0.50	0.69
European telecoms (range**)	0.39-0.83	0.40-0.74	0.39-0.65	0.27-0.63	0.38-0.63	0.43-0.74

*Source: NERA October 2018 report for Ofcom[327], Table 3.5, Table 3.9, Table D.4, Table D.6. By "home" index we mean FTSE All Share for BT and Vodafone, and FTSE All Europe for all other companies, consistent with NERA's analysis for Ofcom. [328] World index = FTSE All World. *Numbers in brackets show the proportion of revenue derived from mobile activities (average for the last two financial years). **Range excludes BT and Vodafone.*

A5.81 Table A5.2 above presents one-year, two-year and five-year daily asset betas. In previous cost of capital reviews, we have typically placed most weight on the two-year betas, to strike a reasonable balance between using recent data and having statistically robust estimates. However, in the 2018 BCMR Consultation we proposed using five-year betas, given the significant impact the European referendum has had on two-year betas of UK-focused companies.[329] We did not consider it would be appropriate to ignore the referendum effect, but rather to give it due weight in our analysis. Evidence on one-year betas can also be useful as it might provide an indication of future changes to the two-year and five-year betas.

A5.82 To choose a point estimate for the asset beta of a UK MNO, we consider the following arguments and evidence.

[327] NERA (2018), "Cost of Capital: Beta and Gearing for the 2019 BCMR", (NERA October 2018 Report) https://www.ofcom.org.uk/__data/assets/pdf_file/0018/124740/nera-wacc-report.pdf

[328] When considering European telecoms, we recognise that in some cases the "home" index could also be the domestic index, rather than the FTSE All Europe.

[329] See Ofcom, Business Connectivity Market Review Consultation, November 2018, Annexes 1-22, paragraph A21.98 to A21.101, page 225 to 226, https://www.ofcom.org.uk/__data/assets/pdf_file/0017/124730/bcmr-annexes-1-22.pdf

a) The asset betas of the two UK-listed companies with UK mobile businesses look reasonable against the range of asset betas of other European telecoms comparators, both against a 'home index' and against a 'world index'. BT's and Vodafone's betas against the 'home index' lie in the range of 0.51-0.71 and 0.65-0.70 respectively, within the range for other comparators. BT's and Vodafone's betas measured against the 'world index' (which might provide a more consistent basis for cross-country comparisons) are also within the range of betas for other European comparators.

b) Previous analysis by NERA suggested that there was no statistically significant difference in the asset betas between mobile and fixed telecoms providers.[330] Our view of the Other UK Telecoms range in the 2018 BCMR Consultation is 0.55 to 0.75 (which is the same range as used in the 2018 MCT Statement for an average efficient UK MNO). In the 2018 BCMR Consultation, we proposed a point estimate of 0.65.

c) The average asset betas for the two UK MNO parent groups (BT and Vodafone) against the 'home index' (FTSE All Share) are: 0.63 (1-year betas), 0.58 (2-year) and 0.70 (5-year): which is within the 0.55 to 0.75 range proposed for Other UK Telecoms.

A5.83 Considering the evidence in the round, we do not see compelling evidence to choose a different point estimate for the asset beta of a UK MNO to the estimate of the asset beta for Other UK Telecoms proposed in the 2018 BCMR Consultation. This is our latest forward-looking estimate of the appropriate asset betas for fixed[331] and mobile services, informed by evidence from a range of telecoms comparators.

A5.84 The discount rate in the upper polar case should reflect our best view of the risk facing a UK MNO. Therefore, we use 0.65 as the asset beta for the WACC in our upper polar case.

Debt beta, gearing and cost of debt

A5.85 We use a debt beta of 0.10, consistent with the 2018 MCT Statement and the 2018 BCMR Consultation.

A5.86 In the 2018 MCT Statement, we considered that a range of 25% to 50% for the forward-looking gearing was appropriate. We do not see any reason why this range would no longer be appropriate. Over the last few years, the average gearing of most UK and European telecoms operators has fallen within this range.[332] For example, BT's one-year gearing is 37% and Vodafone's is 40%, with an average of 35% for one-year gearing across the European comparators and 36% averaged over two-years or five-years.[333] We use 40% in our WACC for the upper polar case which is closer to the recent gearing of BT and Vodafone and the mid-point of the 25-50% range (when rounded to the nearest 5%).

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[330] NERA (2017), "*The Evidence for Differences in Risk for Fixed vs Mobile Telecoms", page 17.* https://www.ofcom.org.uk/__data/assets/pdf_file/0020/112457/Annex-16-NERA-Report-The-Evidence-for-Differences-in-Risk-for-Fixed-vs-Mobile-Teleco.pdf

[331] Other than local copper access and physical infrastructure access.

[332] NERA October 2018 Report, Table 3.5 (page 19) and Table 3.9 (page 32).

[333] We note that Telefonica's gearing has been over 50% whether measured on a one-year, two-year or five-year basis (NERA October 2018 Report, Table 3.9, page 32) and as such is above the gearing range considered in the 2018 MCT statement.

A5.87 We use a pre-tax nominal cost of debt of 2.8%, consistent with the cost of debt from which we derive the lower polar case, for reasons set out in the above discussion of the RFR.

Overall WACC

A5.88 Table A5.3 summarises the parameter values and the resulting estimate of the post-tax real WACC of 4.2%. Therefore, we use 4.2% as the discount rate in the upper polar case.

Table A5.3: WACC for UK MNO, upper polar case

WACC component	Estimate	Source or derivation
Nominal RFR	1.5%	Ofcom estimate
Nominal TMR	8.8%	Ofcom estimate
Nominal ERP	7.3%	= Nominal TMR – Nominal RFR
Debt beta (βd)	0.10	Ofcom estimate
Asset beta (βa)	0.65	Ofcom estimate
Gearing (g)	40%	Ofcom estimate
Equity Beta (βe)	1.02	= (βa - βd*g) / (1-g)
Pre-tax nominal cost of equity (Ke)	10.8%	= (RFR + ERP *βe) / (1-t)
Pre-tax nominal cost of debt (Kd)	2.8%	Ofcom estimate
Corporate tax rate (t)	17.1%	Ofcom estimate
Pre-tax nominal WACC	7.6%	= Ke*(1-g) + Kd*g
CPI inflation forecast	2.0%	Ofcom estimate
Post-tax nominal WACC	6.3%	= pre-tax nominal WACC * (1-t)
Post-tax real WACC	4.2%	= (1+ post-tax nominal WACC) / (1+CPI inflation) -1

Source: Ofcom. All real values are with respect to CPI.

Risk-sharing adjustment

June 2018 consultation position

A5.89 We considered that the appropriate discount rate would sit somewhere between the lower polar case (proxied by an appropriately adjusted cost of debt) and the upper polar case (i.e. the WACC), to reflect the fact that the licensee and the government share the risk of changes in the market value of spectrum. We applied a 25% risk-sharing adjustment in the June 2018 consultation as we had done in the 2015 Statement.

Stakeholder responses

A5.90 Telefonica submitted a report from NERA which assessed the degree of risk-sharing using an option pricing model. Based on this model NERA considered that the risk-sharing

adjustment should be no higher than 20%.[334] This model was an extension of the model NERA (on behalf of Telefonica) submitted in response to the February 2015 consultation.

A5.91 BT disagreed that our assessment of a 25% risk-sharing was conservative and considered that a conservative approach would be to assume the ALFs would be fixed for the 20-year duration; that is the discount rate should be based solely on the cost of debt.[335]

Our assessment

Previous reasoning to support a 25% risk-sharing adjustment

A5.92 As in our 2015 Statement, the June 2018 consultation maintained that we would expect the degree of risk-sharing to sit somewhere between the two polar cases. This is primarily because: (i) the ALFs could be revised up or down, transferring some of the risk of changes in market value of the spectrum away from the licensee to the government; (ii) the licensee could in principle hand back the spectrum and avoid paying ALFs, which could also be seen as a transfer of risk from the licensee to the government. The judgement on an appropriate balance to strike between the two polar cases depends on the way the review regime operates.

A5.93 A future review is likely to be conducted only if there is evidence that a material misalignment between ALFs and the market value of spectrum has developed. In our previous judgement, we did not think it sensible to try to assign specific probabilities to when a review (or reviews) might take place. However, we noted that we could gain insights into this question by considering the potential scale of risk transfer under various circumstances.

A5.94 We previously started by considering a stylised example where there was one review in a 20-year period, set in advance to take place in year 10, with the probability of an increase in ALF equal to the probability of an equivalent decrease in ALF. In this stylised scenario, we inferred that the government would bear over 40% of the risk.

A5.95 In this simple example, the ALF payments in the first ten years will not be reset and so should be discounted at the cost of debt. After the reset of ALF payments at year 10, the remaining payments in years 11-20 will again be fixed. Therefore, when viewed from the end of year 10, they should also be discounted back to year 10 at the rate commensurate with the lower polar case (effectively the cost of debt). However, when viewed from time zero, the actual ALF payments during the last ten years are risky. Therefore, the expected value of the remaining payments (as assessed at year 10) should be discounted back to year zero at the rate which reflects this cash flow uncertainty, that is, the upper polar case (i.e. the WACC).

[334] NERA August 2018 Report, page 27.
[335] BT's response to June 2018 consultation, page 32.

A5.96 Using a notional annual payment of £1 per year, a debt rate of -0.1% and a WACC of 4.2%, the present value (PV) of the first ten years of payments at year 0 is around £10.[336] The PV of the remaining ten years of payments at the end of year 10 is the same. However, when discounted back to year 0 at the WACC, the PV of the last ten years of payments is around £7. The PV across the full 20-year period is thus around £17.

A5.97 A PV of £17 across 20 years is equivalent to an annual payment of £1 discounted back at roughly 1.8%. A discount rate of 1.8% lies about 44% between the discount rates in the lower and upper polar cases.[337]

A5.98 While this is a stylised example, it provides some insight into the potential quantum of the risk-sharing and suggests to us that it would not be appropriate to ignore the risk-sharing in our analysis.

A5.99 There are likely to be several differences between this stylised example and the approach to reviews in practice:

a) First, the timing of any review is not known in advance. For example, a single review which is fixed for some year other than year 10 would reduce the extent to which the risk is transferred to the government as there would be a longer period either before or after the review occurred for which the ALFs are fixed.[338]

b) Second, having more than one review, on the other hand, could significantly increase the transfer of risk to the government, since the periods for which the ALFs are 'fixed' would typically be shorter than in a one review scenario. For example, if we consider two equally spaced reviews during the 20-year period, using the same logic as in the one-review scenario considered above, the government would bear roughly 60% of the risk.[339]

c) Third, in practice a review of ALF would likely be undertaken only when there was a material misalignment between ALF and the underlying market value. This would tend to reduce the extent of risk transfer from the licensee to the government, all else equal.

A5.100 While it is possible to create many different scenarios of how and when any review might occur, there is no certainty as to whether and when any review would be undertaken. We know that the level of risk borne by the government lies between 0% and 100%. In the 2015 Statement we considered that since we were taking a conservative approach to interpreting the evidence it was appropriate to drop the top end of the range, leaving us

[336] All PV calculations assume that payments occur at the beginning of the year, consistent with how we calculate the annuity payments.
[337] Updating our discount rate assumptions in the lower and upper polar cases does not have a material effect on the degree of risk-sharing in this stylised example. In 2015, our stylised example showed a risk-sharing of 43%. 2015 Statement, paragraph A10.69.
[338] For example, with one review at year 5, the total PV across the 20-year period would be around £18 (the sum of the PV of the first five payments of around £5 and the PV of the remaining 15 years of around £13). This is equivalent to a discount rate of 1.2%, which sits around 30% between the lower and upper polar cases.
[339] With two reviews at years 6.67 and 13.33, the total PV across the 20-year period would be around £16, equivalent to a discount rate of 2.5%, which sits 60% between the lower and upper polar cases.

with a range of 0% and 50%. We did not identify clear reasons to prefer any particular figure within this narrower range of 0% to 50%, given the complexity and uncertainty associated with the analysis. Choosing the mid-point of a range reflected an equal probability of the value being above or below that mid-point. The mid-point within this narrower range was 25%.

Using option pricing theory to assess the degree of risk-sharing

Our view on the option pricing approach in the 2015 Statement

A5.101 On our specific proposal of using an adjustment factor of 25%, Telefonica submitted a report by NERA which uses option pricing techniques to estimate the level of risk-sharing. This report builds on the NERA submission in response to our 2015 February consultation.

A5.102 The approach adopted by NERA is to consider the licensee's ability to hand back spectrum as a hard stop on the licensee's exposure in the face of a significant fall in the market value of the spectrum. NERA characterised this as the government granting the MNOs a "put option", which can be valued using option pricing theory.

A5.103 A put option is a contract which gives the holder of the option the right (but not the obligation) to sell a financial instrument (e.g. a stock) at a pre-determined price (referred to as the "strike price"). This can be thought off as an insurance contract where the option holder can protect themselves from the downside risk of the price of the underlying financial instrument falling below a pre-determined level. Using the concept of a put option to describe this type of insurance can in principle be extended to real assets or other obligations (such as ALF payments).

A5.104 In the 2015 Statement we disagreed that NERA's analysis was a better way of guiding our regulatory judgement on the appropriate amount of risk-sharing. We noted that option pricing is complex and is sensitive to a number of underlying assumptions. [340]

A5.105 We also disagreed with NERA that the value of the government's "right" to revise ALFs if the market value of spectrum goes up (characterised by NERA as the government holding a call option) might offset the value of the put option held by the licensee.[341] In our view, while representing the ALF review regime in terms of a call and a put option might characterise the allocation of risk, it cannot make this underlying risk "go away" (i.e. does not change the fact that the government is exposed to uncertainty about future market value).

NERA's 2018 estimates of the risk-sharing adjustment

A5.106 In the August 2018 report, NERA again argued for considering risk sharing within an option pricing framework. NERA modified its earlier analysis and presented what it saw as the maximum allowance for risk sharing in an option pricing framework. Using data on the share price volatility of BT, Vodafone, and Telefonica (the three parent groups of UK

[340] 2015 Statement, paragraph 6.110-6.116
[341] A call option gives the holder of the option the right (but not the obligation) to buy an asset at a pre-determined price.

MNOs) to estimate the volatility of the underlying asset, i.e. spectrum, NERA calculated that the associated risk-adjustment would be between 13% and 25%, with the upper end of this range based on the asset volatility of BT.[342]

A5.107 As we previously explained, any option pricing framework is sensitive to the parameter values of the model and analysis of volatility alone is helpful in illustrating this point. For example, in Table A5.4 we extend NERA's analysis and show the asset volatility of BT, Vodafone and Telefonica over recent two-year and five-year periods, rather than just the one-year period considered by NERA, in order to be more consistent with the sample of data used to estimate mobile company betas above. On this basis, the range for the risk-sharing adjustment becomes wider, with 25% close to the middle of the range of implied risk-sharing adjustments, rather than at the top end (which was the case for the one-year volatility analysis).[343]

Table A5.4: Risk sharing adjustments based on extending the NERA option pricing model

	Asset volatilities			Risk-sharing adjustment		
	1Y	2Y	5Y	1Y	2Y	5Y
Telefonica	7.3%	8.6%	10.8%	13%	15%	20%
Vodafone	11.6%	10.0%	12.5%	21%	18%	23%
BT Group	13.8%	18.8%	17.7%	25%	33%	32%

Source: NERA August 2018 Report, Table 5.2. Ofcom analysis of Bloomberg data as 20 June 2018. We have derived asset volatilities in the same way as NERA, by multiplying share price volatility by (1 – gearing). The risk-sharing adjustments have been generated using the Excel model provided by NERA.

A5.108 NERA argues that a 25% risk-sharing adjustment could only be justified if the volatility of BT Group is used. NERA then goes to say that we had previously assessed that BT was not an unbiased comparator for the risk/ volatility of a UK MNO, and that BT's mobile activities face lower risk than BT as a whole.[344] Effectively NERA suggests that a risk-sharing adjustment based on BT's volatility is likely to overstate the appropriate adjustment.

A5.109 We have earlier concluded that the appropriate asset beta for a UK MNO would be in the range of 0.55 to 0.75, with 0.65 being our best assessment of the appropriate point estimate. In determining the range and the point estimate we considered various evidence, with BT Group providing an important comparator. Based on the most recent evidence on five-year betas, an MNO asset beta of 0.65 would be slightly lower than the asset beta for BT Group; however, it would be higher relative to both the one-year and two-year asset betas for BT Group. Furthermore, neither Vodafone nor Telefonica necessarily provide better pure-play comparators for UK MNOs than BT Group, yet NERA is comfortable with

[342] NERA August 2018 Report, Table 5.2 (page 26)
[343] For one-year volatility the mid-point for risk-sharing is 20%, for 2-year volatility it is 22% and for 5-year volatility is 25%.
[344] NERA August 2018 Report, page 26.

relying on their asset volatilities. For example, Vodafone might be more mobile focused than BT, yet it derives the vast majority of its revenue from overseas.[345]

A5.110 Another consideration is that the estimated asset volatilities shown above provide a measure of total risk, whereas the asset beta measures systematic risk. It is not clear that the ratio of systematic to total risk would necessarily be the same across the three companies shown above. Indeed, a comparison of the asset betas provided earlier with the asset volatilities suggests that it is not the case. To give an example, BT has the highest one-year asset volatility out of three companies, yet it's one-year asset beta is the lowest.

A5.111 We remain unconvinced that NERA's methodology is superior to the simpler examples that we have considered or that it allows us to obtain a more reliable point estimate for the sharing of systematic risk.

Whether NERA's approach to the assessment is conservative

A5.112 NERA further claims that its overall approach is conservative, i.e. the modelling provides an upper bound on the likely risk-sharing adjustment. This is based on the following reasoning:[346]

a) The model does not consider the government's option to trigger an increase in the ALF in response to increases in market value (NERA describe this as the government holding a call option);

b) The licensee's put option is valued "at the money" (i.e. it ignores the fact that the MNOs are only likely to hand back spectrum when there is a material misalignment between market value and ALFs);

c) The model uses Ofcom's estimates of the discount rate for the lower and the upper polar cases from the June 2018 consultation despite disagreeing with those estimates.

Value of the call option and implications for risk-sharing

A5.113 On NERA's analysis, since the call option would have a positive value to its holder (in NERA's framework, it is the government who has a call option), the net value to the government is the difference between the value of the call option and the value of the put option. Assuming the call option has positive value, this would imply, in NERA's framework, that the government needs less compensation for risk (all else equal), compared to a scenario where the value of the call option is ignored.

A5.114 We note that the government (or Ofcom on its behalf) would not only act if the value of the spectrum went up. Ofcom has a duty to secure the optimal use of spectrum and, in this case, is under a Direction to set ALFs at full market value. This means ALFs could be revised both up or down in the case of material misalignment with market value. Therefore, the government's position is not akin to that of a regular market participant who would value

[345] For the financial year ended 31 March 2018, only 15% (14% in 2017) of Vodafone's revenue was generated within the UK. UK mobile revenue accounted for 11% (10% in 2017) of total group revenue. See 02 Regional Results tab https://www.vodafone.com/content/dam/vodafone/investors/financial_results_feeds/year-ended-31-march-2018/FY_2018_Web_Spreadsheet_FINAL.xlsx

[346] NERA August 2018 Report, page 27.

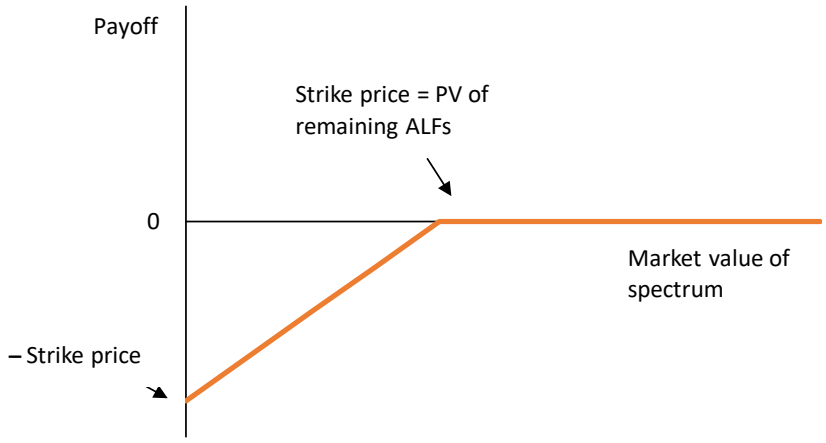
the right to exercise a call option and would want to only benefit from potential increases in the value of the underlying asset.

A5.115 Nevertheless, if we maintain the NERA perspective that the government's position could be characterised as buying a call option and selling a put option, the payoff profile to the government from revising ALFs in line with changes in market value of the spectrum, would look similar to the payoff profile from buying a call option and selling a put option.

A5.116 If the put and the call options have exactly the same values, then in NERA's framework the appropriate risk-sharing adjustment would be zero. However, the underlying risk of changes in spectrum value (and hence ALFs) has not gone away in this scenario. Even if the two options have the same expected values today, it does not imply that the party holding such a portfolio of options faces no risk.

A5.117 First, let us consider the payoff to the government from "selling" a put option to the MNOs. This is the option NERA values in its framework. The diagram below illustrates the payoffs at the exercise date.[347] We assume that the ALF payments at year 0 have been set to reflect the market value of the spectrum. The figure shows that, if, at the exercise date, the market value of spectrum is below the level used to set the initial value of ALFs, the government "loses" money since the licensee could hand back the spectrum (i.e. exercise their put option). If the government can then find a new licensee (or the existing licence secures lower ALFs rather than returning the licence), the new level of ALFs would reflect the lower value of the spectrum. The maximum "loss" is the present value of remaining ALFs at the exercise date (the option strike price).

Figure A5.2: Payoff from selling a put option



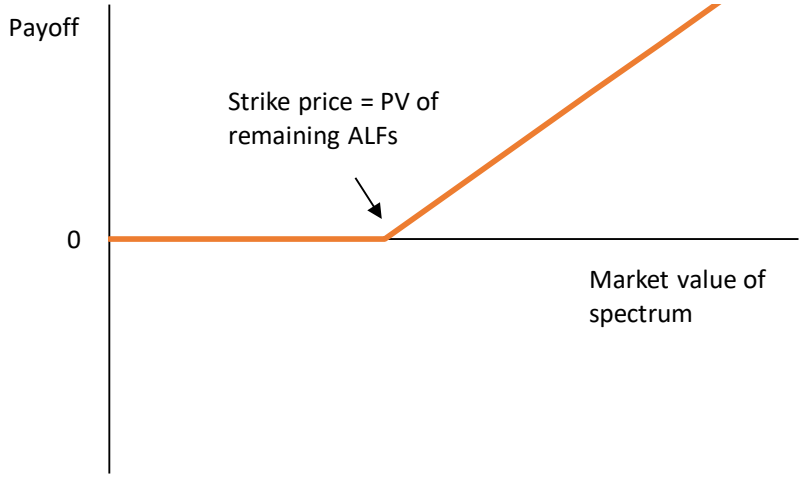
Source: Ofcom

A5.118 Now we consider the payoff to the government at the exercise date from buying a call option. Figure A5.3 shows that, through holding the call option, the government "gains" if

[347] The payoff diagram focuses on the payoffs when the options are exercised and ignores the proceeds from selling the put option.

the market value of the spectrum goes up (from the current level of ALFs), since the government can exercise its right to revise the ALFs upwards in line with this increase.

Figure A5.3: Payoff from buying a call option



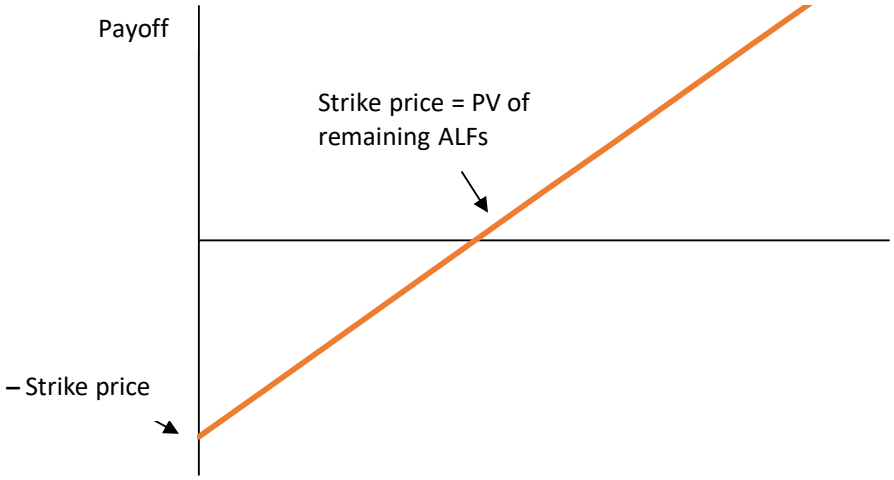
Source: Ofcom.

A5.119 As the figure above illustrates, adding a call option introduces another source of risk to the government in the sense that the government is now also exposed (beyond the payoffs from the put granted to the licensee) to the risk of ALFs being revised if the market value of the spectrum increases.

A5.120 If either the call or the put option can be exercised at any point in time during the 20-year period, with the ALFs reset to reflect changes in the market value of the spectrum at the exercise date, the payoffs to the government look the same as if the government was continuously exposed to the risk of changes in market value of the spectrum, as shown in the figure below.[348] In terms of risk-sharing, this scenario would be analogous to the upper polar case, where the government fully shares in the operating risks faced by the licensee.

[348] This assumes the number of resets is not limited and after each reset, the government effectively has a new call option and the licensee a new put option.

Figure A5.4: Payoff from selling a put option and buying a call option



Source: Ofcom.

A5.121 In practice, as we explain earlier, ALFs would not be continuously revised in line with changes to the market value of spectrum. There would probably be a limited number of reviews during the 20-year period, with any review only occurring if there is a material misalignment between spectrum value and ALFs. The challenge is to identify what level of risk the government is exposed to, but if there is some possibility of a review of ALFs we do not consider that the risk sharing could fall to zero.

Valuing the option "at the money"

A5.122 Valuing the option "at the money" effectively means assuming that the put option would be exercised by the licensee as soon as the market value of the spectrum falls below the current level of ALFs. In practice, the licensee would only be likely to hand back spectrum when there has been a material and sustained decline in the market value of the spectrum.[349]

A5.123 We recognise that introducing a materiality threshold would reduce the value of the put option in NERA's framework, but it would also reduce the value of the call option. Therefore, it is not clear that even in NERA's framework introducing a materiality threshold would necessarily reduce the risk-sharing adjustment.

A5.124 In coming to our earlier judgement to use a 25% risk-sharing adjustment (at paragraphs A5.99-100 above), we took into account the fact that a review is only likely if there is a material misalignment between market value and ALFs. Without such a threshold, the risk sharing by the government would be greater, as explained above.

[349] The effect of a licence hand-back is similar to the effect of a downward revaluation of the ALFs, with both only likely to occur in the event of a material misalignment between ALFs and market value. One difference is that, in practice, licence hand-back is likely to be a last resort – i.e. if the government (or regulator on its behalf) judged that ALFs did not require reduction or the reduction was insufficient based on the licensee's expected value of the licence.

Using Ofcom's discount rates

A5.125 The upper and polar cases we now use are very close to those proposed by NERA, so this point is no longer material.[350] Further, it seems that the risk-sharing implied by the NERA model is not particularly sensitive to the combinations of the cost of debt and WACC under consideration here.

Conclusion on option pricing

A5.126 Characterising ALFs with the prospect of reviews as a series of real options might be conceptually appealing at first glance. However, option pricing tends to be used to estimate expected values (e.g. for pricing purposes), rather than to estimate the underlying risk of options.[351] Attempting to use such techniques to approximate the average riskiness of holding different options over the full licence period remains particularly complex and reliant on assumptions with a wide margin of error.

A5.127 Therefore, we remain of the view that ultimately the risk-sharing adjustment is a matter of regulatory judgement. An option pricing model does not substitute for that judgement and risks concealing the underlying risk arising from the review regime for ALFs.

Conclusion

A5.128 Because of the possibility of a review of ALFs which exposes the government to the systematic risk of the cash flows from the operation of the licences, we consider that a risk-sharing adjustment remains appropriate.

A5.129 We consider that a 25% risk-sharing adjustment remains appropriate.

Discount rate for annualisation: summary

A5.130 Combining our revised discount rates in the lower and the upper polar cases together with the 25% risk-sharing adjustment produces an overall discount rate of 1.0%.

The annualisation rate

Length of period and inflation adjustment

June 2018 consultation position

A5.131 We considered that a reasonable approach to converting lump-sum values into annual licence fees is to the spread the lump-sum value over 20 years using a constant real profile. This is consistent with our approach in the 2015 Statement. We chose a 20-year period

[350] NERA proposed a lower polar case of -0.2% or -0.3%, and an upper polar case of either 3.9% or 5.0%. NERA August 2018 Report, Table 3.3.

[351] Brealey, Myers and Allen, Principles of Corporate Finance, 11th International Edition, Chapter 21, Page 536. "Finding the opportunity cost of capital [for a stock option] is impossible, because the risk of an option changes every time the stock price moves."

because this was consistent with the initial term of the spectrum licences awarded in the UK 4G auction.

A5.132 We proposed the ALF in each year after the base year would increase by out-turn inflation, with CPI being used as the measure of inflation in calculating ALFs.

Stakeholder responses and our assessment

A5.133 No response to the June 2018 consultation suggested that we should adopt a different time period and we have therefore decided to continue using a 20-year period. Similarly, no responses suggested explicitly that we move away from inflation indexation of the ALF payments themselves from the base values.

A5.134 A separate argument was made by the MNOs that spectrum has not held its real value since 2015. We address this point in Section 4 and Annex 3. Vodafone also argued that operators face an ever-increasing burden of spectrum costs, both through one-off auction payments and ALFs.[352] The implication for efficiency, investment, competition and consumers of MNOs paying for spectrum, specifically paying ALFs, at market value is addressed in Section 5.

A5.135 Having identified the appropriate lump-sum value and the annualisation rate, the ALF in each year after the base year will increase by out-turn inflation. We continue to use CPI as the measure of inflation in calculating ALFs beyond the base year.

Tax adjustment

June 2018 consultation position

A5.136 Using the same methodology as in our 2015 Statement, we calculated a tax adjustment from the difference in tax benefits from ALF payments compared to the tax deductions available from amortisation of a lump-sum payment, converted to present values using the post-tax real discount rate. We proposed to calculate the tax adjustment factor (TAF) as follows:

$$TAF = 1 + \left[\frac{(PV\ of\ tax\ benefits\ of\ ALF - PV\ of\ tax\ benefits\ of\ the\ amortisation\ of\ LSV)}{LSV}\right]$$

Stakeholder responses

A5.137 No stakeholder disagreed with our use of the TAF, although Vodafone noted that there is a circularity in the calculation as the TAF is both an input to the annualisation rate as well as a function of the annualisation rate. It suggested we could equivalently use a pre-tax discount rate in the annualisation calculation to remove this circularity.

[352] Vodafone's response to June 2018 consultation, page 14.

Our assessment

A5.138 We consider that our approach is more appropriate than simply using a pre-tax discount rate in the annualisation rate as it explicitly considers the more favourable tax treatment of ALFs compared to a lump-sum payment. That said, the difference is small, although using a pre-tax discount rate would produce a slightly higher annualisation rate (and hence higher ALFs) than our current approach.

A5.139 Based on the discount rate from the preceding analysis and the effective corporate tax rate over the period for which we are setting ALFs (17.1%), the TAF is 1.049.

Annualisation rate

A5.140 The annualisation rate is calculated as follows:

$$TAF * \left[\frac{r}{1-(1+r)^{-t*}}\right] * \left[\frac{1}{(1+r)}\right]$$

A5.141 Where:

- TAF is an adjustment factor that reflects the tax advantages of an ALF over lump-sum payments;
- r is the real post-tax discount rate; and
- t* is the length of period over which we spread the LSV for the purposes of calculating ALF, i.e. 20 years.

A5.142 With a TAF of 1.049, a real post-tax discount rate of 1.0% and a 20-year period, the annualisation rate is 5.75%.

A6. Statutory instrument

[Please see next page]

STATUTORY INSTRUMENTS

2018 No. 1368

ELECTRONIC COMMUNICATIONS

The Wireless Telegraphy (Licence Charges for the 900 MHz Frequency Band and the 1800 MHz Frequency Band) Regulations 2018

Made - - - -	*14th December 2018*
Coming into force	
for the purpose of regulation 3	*30th October 2019*
for the purpose of the remainder	*31st January 2019*

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) Regulations 2018.

(2) Regulation 3 shall come into force on 30th October 2019 and all other regulations shall come into force on 31st January 2019.

Interpretation

2. In these Regulations—

"concurrent licence" means a licence held by two or more persons;

"kHz" means kilohertz;

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

"licensee" means a person who is the holder of a licence authorising use of national channels within the 900 MHz frequency band or national channels within the 1800 MHz frequency band;

"MHz" means megahertz;

"OFCOM" means the Office of Communications;

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

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

"payment date" means 31st October in any year;

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

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

"2011 Regulations" means the Wireless Telegraphy (Licence Charges) Regulations 2011[a].

Amendment to the 2011 Regulations

3.—(1) The 2011 Regulations 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

4.—(1) On 31st October 2019 and on each payment date thereafter, the 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 paragraphs (2) and (3), 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—

$$S = £437,200 \times \left(CPI_t \div CPI_0 \right)$$

where—

"*S*" means the total sum;

"CPI_t" means the most recent CPI value that is available on 30th September of the year in which the charges are due;

"CPI_0" means the CPI value for April 2018; and

"CPI value" means the number given in respect of that month in the monthly all items consumer prices index published by the Statistics Board.

(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.

Licence charges payable for the 1800 MHz frequency band

5.—(1) On 31st October 2019 and on each payment date thereafter, the 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 paragraphs (2) and (3), 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—

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[a] S.I. 2011/1128, amended by S.I. 2012/1075, 2013/917, 2014/1295, 2015/1334, 2015/1995, 2016/643. S.I. 2015/1709 amended SI 2011/1128 but was quashed by an order of the Court of Appeal on 22nd November 2017.

$$S = £322,000 \times \left(CPI_t \div CPI_0 \right)$$

where—

"*S*" means the total sum;

"CPI_t" means the most recent CPI value that is available on 30th September of the year in which the charges are due;

"CPI_0" means the CPI value for April 2018; and

"CPI" means the number given in respect of that month in the monthly all items consumer prices index published by the Statistics Board.

(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.

Payment by instalments

6.—(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 either regulation 4 or regulation 5, the licensee—

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

(b) shall make payment of the sum in ten equal instalment payments with the first instalment to be paid to OFCOM on the payment date 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), all of the outstanding instalment payments, if any, shall become immediately due for payment.

One-off licence charge payable in instalments by holders of licences for the 900 MHz and the 1800 MHz frequency bands

7.—(1) Each holder of a licence on 31st January 2019 authorising the use of frequencies in the 900 MHz frequency range shall pay to OFCOM £331,322.00 for each authorisation of use of a paired 200 kHz channel in that range.

(2) The total sum due under paragraph (1) is "total x".

(3) Each holder of a licence on 31st January 2019 authorising the use of frequencies in the 1800 MHz frequency range shall pay to OFCOM £244,020.00 for each authorisation of use of a paired 200 kHz channel in that range.

(4) The total sum due under paragraph (3) is "total y".

(5) Total x shall be divided into seven equal portions and one portion shall paid on each of the 31st January 2019, 28th February 2019, 31st March 2019, 30th April 2019, 31st May 2019, 30th June 2019 and 31st July 2019.

(6) Total y shall be divided into seven equal portions and one portion shall paid on each of the 31st January 2019, 28th February 2019, 31st March 2019, 30th April 2019, 31st May 2019, 30th June 2019 and 31st July 2019.

(7) If any instalment payment under paragraph (5) or (6) is not paid on the day it falls due all of the outstanding instalment payments, if any, under both paragraph (5) and paragraph (6) shall become immediately due for payment.

(8) Sums payable under this regulation are in addition to any sums which may be payable to OFCOM under regulation 4 of the 2011 Regulations.

Concurrent licences

8. In the case of a concurrent licence, the "holder of a licence" or "licensee" in these Regulations shall refer to all the concurrent holders of the licence.

Philip Marnick
Group Director, Spectrum Group
14th December 2018 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 charges for these licences from Schedule 2 of the Wireless Telegraphy (Licence Charges) Regulations (S.I. 2011/1128, amended by S.I 2012/1075, S.I. 2013/917, S.I. 2014/1295, S.I. 2015/1334, S.I 2015/1995 and S.I. 2016/643) with effect from 30th October 2019.

In relation to the definition of these regulations in regulation 2, the footnote mentions an amending statutory instrument which was quashed by an order of the Court of Appeal on 22nd November 2017. The judgment was in the case of EE Limited v Office of Communications [2017] EWHC Civ 1873 and may be found at www.bailii.org.

Regulations 4 and 5 prescribe the fees payable on each 31st October after these Regulations commence.

The Statistics Board is at 1 Drummond Gate, London, SW1V 2QQ. Its executive function is known as the Office of National Statistics and the monthly all items consumer prices index is available on its website at www.ons.gov.uk. Telephone number: 0845 604 1857.

Regulation 6 allows the holders of these licences to pay fees by ten equal monthly instalments.

Regulation 7 prescribes additional fees payable from 31st January 2019 by instalments.

A regulatory impact assessment of the effect of these Regulations has been prepared. Copies of the impact assessment are available to the public from the Ofcom library at Riverside House, 2a Southwark Bridge Road, London SE1 9HA, telephone 020 7981 3000 or on the OFCOM website at http://www.ofcom.org.uk. Copies of this assessment have also been placed in the library of the Houses of Parliament.