Enabling mmWave spectrum for new uses

Auction design

Statement and consultation

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Annex

1. Overview

1.1 We are making large amounts of spectrum in the 26 GHz and 40 GHz bands (together, "mmWave spectrum") available for new services, including 5G.[1] The spectrum offers operators the opportunity to access very large contiguous blocks of frequencies, enabling innovative services and very high capacity and speeds.

1.2 In this document we set out the design of the auction for awarding licences for this spectrum.

What we have decided – in brief

The geographic scope of licences to be awarded in the auction will be subnational, with each licence authorising the licensee to use the relevant spectrum in all the major cities and towns ("high density areas") in which we expect the highest volume of deployment of mmWave spectrum.

There will be three categories of spectrum lots:

- 26 GHz lower (25.1-26.5 GHz);
- 26 GHz upper (26.5-27.5 GHz); and
- 40 GHz (40.5-43.5 GHz).

Each spectrum lot will comprise a block of 200 MHz.

Reserve prices will be £2m for each lot of 26 GHz lower and 26 GHz upper, and £1m for each lot of 40 GHz.

Bidding for frequency-generic lots, in the auction's principal stage, will decide the quantity of spectrum each bidder will be allocated in each lot category. The format of the principal stage will be a clock auction.

The assignment stage will follow the principal stage and will decide the precise frequencies of the quantities of spectrum allocated to each winner in the principal stage.

1.3 The split of the 26 GHz band into two lot categories reflects the limitations on deployment of new uses of the spectrum during the five years or so in which some incumbent fixed links continue to operate in the 25.1-26.5 GHz part of the band in and around the high density areas.

1.4 There will be a separate assignment stage round for each of the three lot categories. If necessary, a final assignment stage round for the whole 26 GHz band (25.1-27.5 GHz) will follow in addition, to guarantee that every winner's spectrum holding in the band will be contiguous once those fixed links cease to operate. The format of each round of the assignment stage will be a sealed bid auction, in which the sum of prices paid by participants in the winning combination of bids will be at least as high as the sum of any alternative combination of bids.

1.5 We have considered whether to include a negotiation period in the assignment stage, to give winners of spectrum in a band an opportunity to agree that their respective allocations

[1] September 2023 Statement.

of spectrum will be adjacent. Adjacency could help operators which share radio equipment to save costs. After assessing the evidence available to us, we have provisionally decided not to include a negotiation period. We are open to considering any further evidence before concluding on this aspect of the design of the auction, as well as comments on how the assignment stage would work if we were to include a negotiation period.

1.6 Once we make a final decision on whether to include a negotiation period, we will consult on draft legislation setting out the detailed procedures for implementing the design of the auction (the "Auction Regulations"). Rules on the drafting of legislation may require us at that time to make changes and adjustments to the procedures for implementing the design.

1.7 The overview section in this document is a simplified high-level summary only. The decisions and provisional decisions we have taken as well as our reasoning are set out in the full document.

2. Background

2.1 Spectrum in the 26 GHz and 40 GHz bands offers operators the opportunity to access very large contiguous blocks of frequencies, enabling innovative services and very high capacity and speeds. We published our decisions to award by auction licences to access spectrum in these bands in high density areas in a Statement on 27 September 2023.[2]

2.2 We will award licences authorising use of the following spectrum in the auction:

a) 25.1-27.5 GHz in the 26 GHz band, and
b) 40.5-43.5 GHz in the 40 GHz band.

2.3 We consulted initially on the design of the auction in May of 2022 (the "May 2022 Consultation") and proposed a detailed design in March 2023 (the "March 2023 Statement and Consultation").[3,4]

2.4 In this document, we discuss the comments on auction design that we received in response to the second consultation and set out our final decisions on most aspects of the design. Some of our decisions are provisional, because we are still open to considering evidence about whether we should include a negotiation period in the assignment stage of the auction and how the assignment stage would work if we were to include a negotiation period.

2.5 In reaching these decisions and provisional decisions, we have taken account of our policy objectives for mmWave spectrum, which derive from our statutory duties. We have also aimed to ensure that the criteria for spectrum allocation will be: (i) objectively justifiable in relation to the 26 GHz and 40 GHz bands; (ii) not unduly discriminatory; (iii) proportionate as to what they are intended to achieve; and (iv) transparent.[5]

2.6 In the following sections, we summarise our proposals, discuss stakeholders' comments and set out our decisions on each of the following aspects of the design:

- Structure of the auction and of lots – Section 3
  - > Combining high density areas into a sub-national geographic lot
  - > Size of frequency lots
  - > Lot categories in the 26 GHz and 40 GHz bands
- Reserve prices – Section 4
- Principal stage – Section 5
  - > Choice of format: clock vs simultaneous multiple rounds ascending (SMRA)
  - > Bidding process
  - > Eligibility points ratio
  - > Information policy
  - > Deposit
  - > Practicalities

[2] September 2023 Statement. Annex 10 contains the geographic definitions of the high density areas.
[3] May 2022 Consultation, Section 9.
[4] March 2023 Statement and Consultation, Section 9.
[5] Wireless Telegraphy Act 2006, Section 14(3B).

- Assignment stage – Section 6

2.7 We set out in Annexes 6 and 7 detailed descriptions of procedures of the principal and assignment stages respectively. These descriptions are illustrative, and will be set out definitively in the Auction Regulations.

Impact assessment

2.8 In reaching the decisions and provisional decisions set out in this document, we have considered their impact on relevant stakeholders, including citizens and consumers. We discuss stakeholders' comments on the impact of our proposals and explain how we have taken them into account in reaching our decisions, where relevant. As set out in paragraph 2.78 of the March 2023 Statement and Consultation, we do not consider that our decisions have equality implications under the 2010 Act or the 1998 Act.

3. Structure of the auction and of lots

Summary

3.1 In the March 2023 Statement and Consultation, we proposed that the auction will have two bidding stages: (i) the principal stage, which would determine the amount of spectrum won by bidders bidding for frequency generic lots and (ii) the assignment stage, which would determine the precise frequencies awarded.[6]

3.2 The structure we proposed is the same as the structure of the auctions we ran in 2018 and 2021. Stakeholders did not comment on this proposal, and we have decided to adopt it.

3.3 We have considered the comments stakeholders made on the structure of lots in the auction.

3.4 We have decided that the geographic scope of the licences we will award will combine all 68 high density areas, so that each licence will authorise spectrum use in all high density areas.

3.5 After considering stakeholders' comments on the sizes of lots, we have decided to auction the spectrum in lots of 200 MHz, rather than the 100 MHz which we had proposed.

3.6 We have also decided that we will auction the spectrum in three lot categories, as follows:

i) 26 GHz lower (25.1-26.5 GHz) – 7 x 200 MHz lots
ii) 26 GHz upper (26.5-27.5 GHz) – 5 x 200 MHz lots
iii) 40 GHz (40.5-43.5 GHz) – 15 x 200 MHz lots.

Subnational lot categories

Our proposals

3.7 In the March 2023 Statement and Consultation, we proposed to aggregate all the designated high density areas into subnational lot categories, as we had not seen evidence that any stakeholder would be interested in bidding for wide area licences for mmWave spectrum in individual cities.[7]

3.8 We said that we would consider disaggregating specific high density areas from the subnational lot categories if we saw likely demand in response to the consultation.

[6] March 2023 Statement and Consultation, Section 9, para. 9.2(a).
[7] March 2023 Statement and Consultation, paras. 9.5-9.18.

Summary of responses

3.9 All the MNOs agreed with our proposal. No stakeholder expressed interest in bidding for licences for individual high density areas.[8]

3.10 Specifically,

a) BT/EE[9], H3G[10] and VMO2[11] agreed with our proposal, expressing concerns about the complexity of disaggregating specific high density areas.
b) Similarly, Vodafone[12] and a confidential respondent [CONFIDENTIAL ✂][13] said that they are not interested in bidding for individual high density areas.

Ofcom's decisions

3.11 We have considered whether to award wide area licences for disaggregated cities and towns, rather than for a subnational aggregation of all 68 high density areas. We recognise that awarding disaggregated licences could facilitate entry and investment by local operators and encourage innovation and diversity of uses. On the other hand, we also recognise that disaggregated geographic licences would add some logistical complexity to national operators' deployments and increase complexity in the auction. Noting that no respondent to the March 2023 Statement and Consultation expressed potential interest in a licence for any disaggregated high density area, we have decided to award subnational licences.

Lot sizes

Our proposals

3.12 In the March 2023 Statement and Consultation,[14] we proposed that the lot size for all lot categories should be the same, as the ecosystems for the 26 GHz and 40 GHz bands have similar technical standards and identical lot sizes in the auction would make switching demand between bands easier.

3.13 We considered that a lot size of either 100 or 200 MHz would be appropriate and proposed a 100 MHz lot size to give bidders additional flexibility.

Summary of responses

3.14 We received the following responses on lot sizes:

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[8] We note that, in response to our proposal to disaggregating specific high density areas, NGED commented on the case for revocation of fixed links. (NGED response to the March 2023 Statement and Consultation, p.4, response to Q. 5). We did not consult on the revocation of fixed links licences in the March 2023 consultation. However, on 28 September we started the statutory process for revoking existing fixed link licences in the 26 GHz band and gave licensees, including National Grid Telecoms Limited, the opportunity to comment on the proposed revocation of their licences by 9 November.

[9] BT/EE response to the March 2023 Statement and Consultation, pp. 4-5, section 5.1.3, response to Q. 4.

[10] H3G response to the March 2023 Statement and Consultation, p. 6.

[11] VMO2 response to the March 2023 Statement and Consultation, p. 11 and p. 32, response to Q. 5.

[12] Vodafone response to the March 2023 Statement and Consultation, p. 6, response to Q. 5.

[13] [CONFIDENTIAL ✂] response to the March 2023 Statement and Consultation, response to Q. 5.

[14] March 2023 Statement and Consultation, paras. 9.19-9.29.

a) BT/EE[15] requested lots of 200 MHz for both the 26 GHz and 40 GHz bands. It referred to the requirement in the European Commission implementing decision on 26 GHz that is part of UK law (the "**26 GHz Decision**")[16] that "[t]he assigned block size shall be a multiple of 200 MHz" and suggested that the 40 GHz band is also awarded in 200 MHz block "to be consistent with 26 GHz and recognising the even larger bandwidth available in that band for award".
b) Vodafone[17] commented that it supports the use of either 100 MHz or 200 MHz lots sizes, but sees greater advantage in using 200 MHz lots.
c) VMO2 expressed a preference for 100 MHz lots in its response to the May 2022 Consultation.[18] Its updated view, based on the latest information from vendors, was that whilst 100 MHz lots would be acceptable, mobile operators were likely to want to acquire spectrum licences in units of at least 200 MHz. It also noted that increasing the lot size to 200 MHz would be a better way to address bidders' potential wish to avoid winning small amounts of spectrum than BT/EE's suggestion of a minimum spectrum requirement.[19]

Ofcom's decisions

3.15 In light of the preferences expressed by stakeholders in their responses to the consultation, we have decided to adopt a lot size of 200 MHz for both the 26 GHz and 40 GHz bands. We note that this decision is in line with the requirement in the 26 GHz Decision and is consistent with the benefits we identified of dividing all the spectrum in the auction into lots of the same size.

26 GHz lot categories

Our proposals

3.16 In the March 2023 Statement and Consultation,[20] we considered how to reflect in the award the constraints on new services operating in the 25.1 – 26.5 GHz portion of the 26 GHz band which would apply during the period of revocation of incumbent fixed link licences. We considered three options:

a) **One lot category**. In the principal stage, bidders would bid for generic lots that could be anywhere in the full band 25.1 – 27.5 GHz. Winning principal stage bidders could then bid in the assignment stage to reflect any differences in value between the encumbered and unencumbered spectrum.
b) **Two lot categories**. In the principal stage, bidders would bid for generic lots in two lot categories: (i) 26 GHz lower: 25.1 – 26.5 GHz (currently encumbered by fixed links); and (ii) 26 GHz upper: 26.5 – 27.5 GHz (unencumbered spectrum). There would then be one assignment stage which would determine specific frequencies within each lot category.

[15] BT/EE, pp. 5-6, section 5.1.5.
[16] Paragraph 2.2 of the annex to the 26 GHz Decision. The UK version of this legislation is set out in S.I. 784/2019 and S.I. 590/2020.
[17] Vodafone, p. 3.
[18] VMO2, pp. 22-23.
[19] VMO2, p. 18.
[20] March 2023 Statement and Consultation, paras. 9.30-9.43.

c) **Two lot categories with re-arrangement for long-term contiguity**. As in option (b), in the principal stage there would be two lot categories (25.1 – 26.5 GHz; 26.5 – 27.5 GHz). Winning principal stage bidders would then be invited to bid in two separate assignment stages. The first would determine specific frequencies bidders would hold in each lot category while the spectrum remains encumbered by fixed links during the notice period for revocation. The second would determine the contiguous frequency assignment bidders would hold after the end of the notice period.

3.17 Our preferred option was option (c), because it would enable bidders to express in the principal stage their valuation for the option of early deployment of services in the 26.5 – 27.5 GHz portion of the band, which is unencumbered by fixed links, while guaranteeing contiguity in the longer term for bidders who win spectrum in both portions of the band.

3.18 We also proposed to grant a six-month concurrent licence (in addition to an initial and a final licence) to facilitate the migration from the frequencies assigned in the first assignment stage to those assigned in the second assignment stage.

Summary of stakeholders' responses

3.19 BT/EE,[21] VMO2[22] and Vodafone[23] supported our preferred approach of two lot categories with re-arrangement for long-term contiguity (i.e. option (c) above). Other stakeholders did not express a view on this matter.

3.20 Vodafone also proposed that, instead of issuing a six-month concurrent licence in addition to the initial and final licence, the same outcome could be achieved by issuing only two licences containing a requirement to coordinate usage with the other relevant licensee during a six-month period.[24]

Ofcom's decisions

3.21 In light of the support expressed by respondents for our preferred option, we have decided to proceed with it.

3.22 We have considered Vodafone's suggestion that we grant two licences (without an additional "migration licence") with a six-month coordination requirement. We agree that a migration period can be implemented by authorising the relevant licensees to use the same frequency blocks (subject to coordinating usage between them) for a specified period under their respective licences, rather than issuing an additional concurrent licence.

[21] BT/EE, pp. 9-10, section 5.3, response to Q. 6.
[22] VMO2, pp. 32-33, response to Q. 6.
[23] Vodafone, pp. 6-7, response to Q. 6.
[24] An initial licence with an expiry date 5 years 6 months after the issuing of the revocation notices and a final licence with a commencement date 5 years after the issuing of the revocation notices.

40 GHz lot categories

Our proposals

3.23 In the March 2023 Statement and Consultation,[25] we proposed to auction the 40 GHz band as one lot category, since the constraints posed by fixed links in the band would likely be lower than those posed by fixed links in the 26 GHz band.

3.24 In particular, we considered that, in contrast with the 26 GHz band: (a) the constraints imposed by fixed links in the 40 GHz band would apply for a shorter period, due to the delayed development of the 40 GHz equipment and handset ecosystem; (b) bidders winning wide blocks of 40 GHz spectrum would be able to access at least some unencumbered spectrum from the date of the award, because the range of encumbered spectrum in the band is small compared to the amount of spectrum auctioned; and (c) bidders preferring narrower blocks could either bid in the assignment stage for unencumbered frequencies in the 40 GHz band or bid for spectrum in the 26 GHz band.

Stakeholders' responses

3.25 We did not receive any comments on this proposal in relation to the constraints imposed by fixed links in the 40 GHz band. However, as noted in paragraph 2.18 of the September 2023 Statement, Vodafone[26] sought clarifications in relation to the power limits for protecting the radio astronomy site in Cambridge and said that if such limits are "more extreme in the upper part" of the 40 GHz band, the differential might justify different lot types for the 40 GHz band.

Our decisions

3.26 We have decided to auction the 40 GHz band as a single lot category, in line with our consultation proposal.

3.27 Following the publication of the March 2023 Statement and Consultation and completion of the revocation process, we decided to revoke all of the 40 GHz licences with effect from 1 June 2028 and to offer to grant MBNL individual temporary licences – starting on 1 June 2028 and expiring on 1 January 2030 – for up to 500 of its existing fixed links that are outside the top 10 high-density areas and the transport hubs at Dover, Folkestone & Hythe and Stansted Airport.[27] We have considered to what extent these temporary licences will increase the constraints imposed on future award winners. Given the limitations attached to these temporary licences,[28] we consider that they will not materially increase the constraints imposed on future award winners, and as a result awarding the 40 GHz band as a single lot category remains appropriate.

3.28 In relation to Vodafone's comment about the power limits for protecting the radio astronomy site in Cambridge, we note that deploying medium power base stations in the Cambridge high density area is likely to be more challenging in 42.5-43.5 GHz[29] than in 40.5-

[25] March 2023 Statement and Consultation, paras. 9.44-9.47.
[26] Vodafone, p. 8.
[27] Ofcom's May 2023 Update on revoking licences in the 40 GHz band.
[28] Maximum 500 licences, for only 18 months and excluding both the top 10 high density areas and the traffic hubs.
[29] September 2023 Statement, para. 4.78.

42.5 GHz. However, also in 40.5-42.5 GHz the challenge is likely to remain substantial because medium power base stations using these frequencies could require additional mitigations, which could include height reduction or additional out-of-block filtering.[30]

3.29 For the avoidance of doubt, to the extent that the restriction on antenna elevation applying in relation to outdoor base stations transmitting in the top 1 GHz of the 40 GHz band (42.5-43.5 GHz)[31] results in differences in valuation between frequencies within the 40 GHz band, we note that the bidding mechanism in the assignment stage will already enable bidders to indicate their own preferred locations within the 40 GHz band.

[30] September 2023 Statement, paras. 4.79 and 4.80. As noted in the September 2023 Statement (para. 4.80), this assessment is subject to the uncertainties over the out-of-block emissions performance of real equipment.
[31] September 2023 Statement: (i) paras. 4.71—4.84; (ii) paras. 7.28-7.35; and (ii) the technical licence condition set out in paragraph 8 of Schedule 1 to the "Sample Award licence" in Annex A4.

4.Reserve Prices

Summary

4.1 The reserve price is the minimum price for one lot in a category. In the first round of the auction, the price of lots in each lot category is set to the corresponding reserve price.

4.2 Having considered responses to the March 2023 Statement and Consultation and relevant data from other auctions, we have decided to set the following reserve prices for the lot categories in the auction:

- 26 GHz lower: £2m per 200 MHz lot
- 26 GHz upper: £2m per 200 MHz lot
- 40 GHz: £1m per 200 MHz lot

Our proposals

4.3 In the March 2023 Statement and Consultation,[32] we proposed to use benchmarks of prices from auctions in other jurisdictions, and to set reserve prices which we think will be materially lower than possible market value. We considered the results of eleven spectrum awards – in both European and non-European countries – of 26 GHz spectrum (noting that no European countries have awarded the 40 GHz band) and primarily focused on European countries as they would provide a closer comparison to the UK.

4.4 We proposed that mmWave reserve prices should fall within the range £0.25m to £2m per 100 MHz lot to increase the likelihood of a market driven price and to allow for price discovery to occur. We provisionally considered that reserve prices of £1m for a 100 MHz lot in 26 GHz (both 26 GHz lower and 26 GHz upper) and £0.5m for a 100 MHz lot in 40 GHz would be appropriate, noting that the lower reserve price for 40 GHz lots reflects the less developed ecosystem compared to 26 GHz. We also sought views from stakeholders about whether we should reflect some difference across the upper and lower 26 GHz lot categories in the reserve price, based on their different usability in the first few years.

Stakeholders' responses

4.5 The MNOs (except Vodafone who expressed no view on the topic) generally supported our approach to setting reserve prices, the pricing differential between the 26 GHz and 40 GHz bands, as well as our chosen price range. BT/EE agreed with our preferred reserve prices for both the 26 GHz and 40 GHz band. VMO2 and H3G argued for a reserve price on the low end of the proposed £0.5m - £2m range for the reasoning described below.

4.6 Specifically, we received the following comments from stakeholders:

a) BT/EE[33] agreed with the reserve prices set by Ofcom as they strike the appropriate balance between being sufficiently low to encourage participation in the auction, but sufficiently high to discourage frivolous bidders entering the auction.

[32] March 2023 Statement and Consultation, paras. 9.107-9.122.
[33] BT/EE response to the March 2023 Statement and Consultation, p. 5, section 5.1.4.

b) VMO2[34] and H3G[35] agreed with the range of reserve prices set by Ofcom, but suggested Ofcom chooses the lowest prices in the range. VMO2 specified that this would be appropriate as most 26 GHz auctions in Europe closed at the reserve price, with, at times, some unsold spectrum. In its view, as the UK is auctioning more spectrum than its European counterparts, it would make sense to set very low reserve prices and let them increase over the course of the auction if there is excess demand. Additionally, as spectrum in 26 GHz upper is more valuable than in 26 GHz lower, "a lower reserve price for 26 GHz will create more room for the market to determine the price differential between the two sub-bands".

Our decisions

4.7 We maintain our position that the following reserve prices would be appropriate:

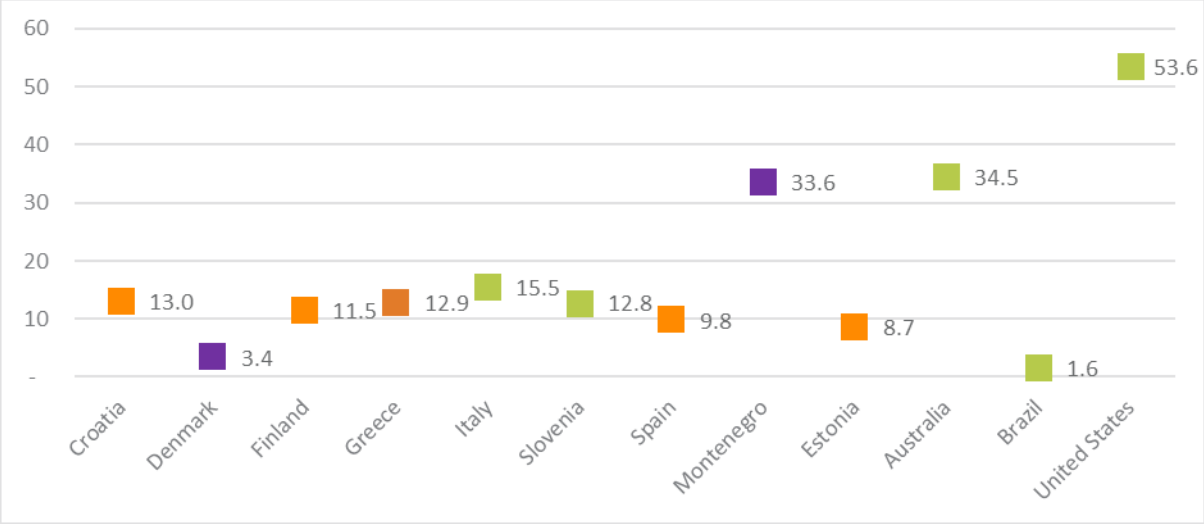
a) A reserve price of £2m for each 200 MHz lot in 26 GHz lower;
b) A reserve price of £2m for each 200 MHz lot in 26 GHz upper;
c) A reserve price of £1m for each 200 MHz lot in 40 GHz.

4.8 In our view, our preferred reserve prices are low enough to encourage entry and allow room for meaningful price discovery. We have accounted for the unsold spectrum resulting from awards in certain European countries (for example, Spain) and have chosen prices lower than the international benchmark from European countries (corresponding to an average price of £11m for each 200 MHz lot; see paragraph 4.11 below) to reduce this risk.

4.9 Since we published the March 2023 Statement and Consultation, there have not been any relevant auctions with final prices contradicting our analysis. VMO2 suggested Ofcom includes results from the auctions in Spain and Estonia, as they took place after the publication of the consultation.[36] We note that results from the auction in Spain had already been included in our analysis and we have now added results from the auction in Estonia. Our updated analysis is shown in Figure 4.1 below.

[34] VMO2 response to the March 2023 Statement and Consultation, p. 3 and pp. 12-13.
[35] H3G response to the March 2023 Statement and Consultation, p. 1.
[36] VMO2 response, pp. 12-13.

Figure 4.1: 26 GHz UK equivalent benchmarks for 200 MHz based on Q1 FY 2024/5 prices[37,38]



4.10 Reserve prices now reflect that lots will be of 200 MHz size. In the figure, green denotes that spectrum lots were sold above the reserve price (in Brazil, Italy, Slovenia, Australia and the United States); orange denotes that spectrum lots were sold at the reserve price (in Croatia, Finland, Greece, Spain and Estonia); and purple (for Denmark and Montenegro) denotes that whereas the data shown are the reserve prices, spectrum lots were not sold at those prices. In line with our initial analysis, we excluded the price from the Montenegro auction from the international benchmark because no lots were sold in that auction.[39] For Denmark, we used the reserve price because the award was combinatorial, so band-specific prices would be

[37] As specified in the March 2023 Statement and Consultation, para. 9.111, we applied a series of adjustments to the data to derive UK equivalent benchmarks:

- The discount factor we use is the pre-tax nominal cost of debt, 3.6% (see Ofcom's Statement "Wholesale Fixed Telecoms Market Review 2021-26", annexes 1-26, table A20.1), and the corporate tax rate, 19%.
- We use the pre-tax nominal Weighted Average Cost of Capital ("**WACC**") for the mobile sector in the UK, 7.8% (see Ofcom's Statement "Wholesale Voice Markets Review 2021-26", annex 1-4, p. 21).
- We use PPP conversion factors from the World Bank | World Development Indicators Database, World Bank | Eurostat-OECD PPP Programme.
- We use CPI data and forecasts from the Office for Budget Responsibility.
- We use population data from the World Bank.

[38] In the March 2023 Statement and Consultation, Figure 9.2, the results for Spain and Montenegro were incorrectly reported to be £5.0m and £17.1m per 100 MHz lot respectively (£10.0m and £34.2m per 200 MHz lot). We have now corrected this error to £9.8m and £33.6m per 200 MHz lot.

- The discount factor we use is the pre-tax nominal cost of debt, 3.6% (see Ofcom's Statement "Wholesale Fixed Telecoms Market Review 2021-26", annexes 1-26, table A20.1), and the corporate tax rate, 19%.
- We use the pre-tax nominal Weighted Average Cost of Capital ("**WACC**") for the mobile sector in the UK, 7.8% (see Ofcom's Statement "Wholesale Voice Markets Review 2021-26", annex 1-4, p. 21).
- We use PPP conversion factors from the World Bank | World Development Indicators Database, World Bank | Eurostat-OECD PPP Programme.
- We use CPI data and forecasts from the Office for Budget Responsibility.
- We use population data from the World Bank.

[39] March 2023 Statement and Consultation, para. 9.114.

difficult to derive accurately.[40] Some spectrum lots in the awards in Spain, Australia, Brazil and United States were also unsold.

4.11 The results show that, after considering the Estonian auction and excluding the Montenegrin auction, the internal benchmark from European countries is an average of £11.0m for each 200 MHz lot and a range of £3.4m to £15.5m. Therefore, our preferred reserve prices of £2m for 200 MHz of 26 GHz spectrum and £1m for 200 MHz of 40 GHz spectrum remain below the international benchmark from European countries. Additionally, we note that, Estonia auctioned and awarded 2.4 GHz of 26 GHz spectrum. This is the same amount of spectrum we are making available by auction in the 26 GHz band in the UK.

[40] March 2023 Statement and Consultation, para. 9.116(b).

5. Principal Stage

Summary

5.1 In this section we discuss the comments stakeholders made on the design of the principal stage in response to the March 2023 Statement and Consultation, and set out our decisions.

5.2 In summary, we have decided on the following key features of the principal stage:

a) **Clock format:** the principal stage will comprise of successive rounds with ascending prices and will end when there is no excess demand for spectrum in any lot category.
b) **Bidding process**: in the first round, bidders will specify the number of lots they wish to win in each lot category at the reserve prices. In every round after the first, Ofcom will announce a range of prices for each lot category. Bidders will be able to place one bid in each lot category, to specify whether they wish to maintain or change their demand for a certain number of lots in that category across the range of prices announced for each round. When placing a bid to change demand, bidders will be able to specify the price point at which their demand changes.
c) **Eligibility rule:** the maximum number of lots a bidder could bid for in each round will be constrained by an eligibility points-based activity rule. Bidders' eligibility cannot increase from one round to the next. This means that, in every round, a bidder will only be able to maintain or reduce its overall demand, measured in eligibility points, across all lot categories. The ratio of eligibility points between lots of 26 GHz and 40 GHz will be 2:1.
d) **Bids cannot cause unsold spectrum**: A bidder's bid to decrease its demand in a lot category will be applied only to the extent that the resulting excess demand in that lot category is not negative.
e) **'Applying' bids**:[41] Bids to maintain demand will be applied in full. Bids to increase or decrease demand may be applied in full, in part or not at all, based on the eligibility rule and the rule that bids to decrease demand cannot cause unsold spectrum.
f) **Two bid types for reducing demand:** To request a decrease in their demand by more than one lot, bidders can submit either a simple bid or an all or nothing bid. A simple bid to decrease demand may be applied in full, in part or not at all. All or nothing bids may either be applied in full or not at all, i.e. they will not be applied in part.
g) **Information policy:** After the end of each round other than the final round, we will inform bidders of the level of excess demand in each lot category. After the final round of the principal stage, Ofcom will publish the number of frequency generic lots won by each bidder in each lot category.

5.3 A more detailed description of the principal stage, with illustrative examples, is set out in Annex 6.

[41] For simplicity, in this document we refer to each of the bids to maintain, decrease or increase demand as single bids. However, as shown in the examples given in Annex 6, each of these bids effectively includes a set of commitments and, where relevant, a preference. In this document, we say that a bid to maintain demand is "fully applied" to indicate that, in a round, the EAS selects the bidder's request to keep its previous demand at any price level up to the clock price for that round. Similarly, we say that a bid to change demand is "fully applied", "partially applied" or "not applied at all" where the change in demand that the bidder would like to achieve is fully, partially, or not at all applied.

Principal Stage Format

Our proposals

5.4 Respondents to the May 2022 Consultation supported either a clock format or a simultaneous multiple round ascending format ("**SMRA**") for the principal stage.[42] In light of those responses, in the March 2023 Statement and Consultation[43] we proposed the clock format on the basis that it would be faster and simpler for bidders than an SMRA auction, partly because it does not have the "standing high bid" mechanism which is present in the SMRA.[44]

Stakeholders' responses

5.5 In summary, stakeholders expressed mixed views about their preferred format for the principal stage in their responses to the March 2023 Statement and Consultation. BT/EE and VMO2 supported the proposed clock auction format, with minor changes:

a) BT/EE[45] said that it was "content with Ofcom's proposal to use a clock auction format and in general are satisfied with the various rules that are proposed". BT/EE also had comments on the detailed rules. These are described in more detail below.
b) VMO2[46] said that it supports the clock auction format proposed by Ofcom, and it proposed some changes to the more detailed rules. We cover these comments below in the discussion on the bidding process.

5.6 On the other hand, Vodafone and H3G said that they would prefer the SMRA format that we used in previous auctions:

a) Vodafone[47] commented that "given the proposed lot structure is now similar to that used in other multiband auctions recently run by Ofcom (2.3/3.4 and 700/3.6), […] there is little justification in moving away from the clock/SMRA hybrid approach successfully adopted in those awards". In its view, "the speed advantage is not sufficient justification (…), as lower lot complexity allows faster rounds anyway". Vodafone also said that:

i) it was not aware of this level of intra-round bidding complexity in other auctions;
ii) an "Unexpected breach of budget [could occur] because an increase of demand in one band is accepted, while a decrease in another band is only partially accepted";
iii) if we proceed with a clock auction, it would prefer "a simpler format with exit bids" – "a 'best and final' offer for marginal lots whose point total is less than or equal to the reduction in eligibility that happens during a round". It said that this change would allow bids that decrease demand to cause unsold spectrum; and bidders

[42] VMO2 and Vodafone supported the use of the clock format. BT/EE noted that either a clock or an SMRA format would be appropriate for this award and expressed a slight preference for an SMRA format over the clock format, as it has been used in previous UK awards and BT/EE did not see a need for intra-round bids (March 2023 Statement and Consultation, paras. 9.51-9.52).
[43] March 2023 Statement and Consultation, paras. 9.53-9.56.
[44] As explained in the March 2023 Statement and Consultation (para 9.48b), in an SMRA auction Ofcom would allocate "standing high bidder" status to the bidder with the highest bid(s) in place on each lot category after each round; when the auction ends, these would become winning bids and bidders would pay the amounts they bid.
[45] BT/EE response to the March 2023 Statement and Consultation, p. 4, section 5.1.1.
[46] VMO2 response to the March 2023 Statement and Consultation, pp. 3 and 14.
[47] Vodafone response to the March 2023 Statement and Consultation, pp. 3-6 (response to Q.4).

would be able to place optional 'exit bids' when decreasing spectrum for the lots they have just decreased by. Vodafone also suggested the inclusion of "a secondary stage if there is any unsold spectrum";

iv) it considered that the clock format has indirect standing high bids due to the mechanism to reject bids that might lead to unsold spectrum, while it saw merit in the explicit assignment of standing high bids in the SMRA;

v) it found it helpful in the SMRA to have a 'right of reply' if its bids in the SMRA were not all assigned standing high bidder status, whereas it claimed that the clock does not have such a mechanism;

b) H3G[48] said that "Ofcom should adopt the SMRA format used in the UK's 2018 and 2021 auctions". In favour of this approach, and echoing Vodafone, H3G said: "the SMRA format worked well in 2018 and 2021 and is well understood by the four MNOs". It also said that "the clock auction adds unnecessary complexity and complicates bidders' attempts to change their demand". According to H3G, due to the lack of the standing high bid mechanism, in the clock auction format that we proposed "any bidder can submit bids to change their demand in every round" but "a bidder would not have certainty that such a bid would be accepted, which makes internal governance more difficult".

Our decision

5.7 We have decided to proceed with the clock auction format for the principal stage of the mmWave auction. We explain the reasons for our choice below. In Annex 5 we explain why we are not adopting Vodafone's proposal of a clock auction with exit bids.

5.8 In the principal stages of our last two auctions, we used an adaptation of the SMRA format, in which we asked bidders to bid for frequency-generic lots. The clock auction format has been used in many more auctions worldwide than this SMRA format. For example, the clock format has been recently employed in spectrum auctions in Australia, Canada, Slovenia and the US. Its widespread adoption means that more choice of expertise and software is available for the clock format than for the SMRA with generic lots.

5.9 Additionally, we consider that other features of the clock auction make it preferable to the SMRA:

- The clock auction is faster as prices will increase whenever there is excess demand in a lot category. In the SMRA, prices may take a few rounds to increase, lengthening the auction.
- The clock auction gives bidders flexibility to change demand at any price between the prices set by Ofcom, so that bidders can more precisely implement their valuations. In the SMRA, bidders can only place bids at the prices set by Ofcom.
- In a clock auction, all winners pay the same price in a lot category, while in the SMRA there can be a difference of one price increment between the final prices paid by different winners in the same lot category – an outcome which some may consider less fair.
- Excess demand in the clock auction is always accurate at the end of a round, whereas in the SMRA excess demand information is not accurate in rounds in which bidders use waivers. This could make a difference to bidding in some

[48] H3G response to the March 2023 Statement and Consultation, p. 1 and pp. 5-6.

circumstances, and the clock auction therefore provides greater assurance of efficiency in the allocation of spectrum.

Ofcom's consideration of stakeholders' comments

5.10 H3G[49] commented that the clock auction is complicated; the clock auction format renders the governance process more difficult since a bidder does not know whether its bid to change demand would be applied or not. We note that this issue – the uncertainty around the outcome of bid processing and thus the risk that a bidder can win an unwanted combination of lots – is present in both the clock and SMRA formats. In a clock auction this can happen when a bidder's request to change its demand is not fully applied, while in an SMRA it can happen when a subset of the lots in a bidder's standing high bid is displaced by another bidder and the price rises beyond the bidder's valuation for all the lots in that subset.

5.11 We think that concerns about complexity of bidding in the clock format are misplaced. Given the similarities between the formats, we expect bidders that are familiar with the SMRA to be able to adapt to the clock auction. We are advised that bidders, both large and small, experienced and inexperienced, have found it straightforward to bid in clock auctions.[50]

5.12 Vodafone commented that it sees little justification in moving to the clock auction, as (i) moving demand across lot categories in a clock auction could lead to budget breaches, specifically when moving demand from 26 GHz to 40 GHz, and (ii) the SMRA has a helpful 'right of reply' feature for when a bidder's standing high bid is displaced by other bids.

5.13 On Vodafone's first point, we consider that, although theoretically possible, this is unlikely as it would require a number of cumulative criteria to be met.[51] Even if it did occur, the increase in financial exposure would be limited as a bidder cannot bid above its eligibility point limit. In addition, bidders in a clock auction can submit "all or nothing" bids to avoid the possibility of a decrease bid being partially applied. We therefore do not think this is a material disadvantage of the clock format.

5.14 On the second point, we note that, in order for a bidder's standing high bid to be displaced by other bids in the SMRA, there must be excess demand in the relevant lot category. In a clock auction, bidding continues for at least one more round when there is excess demand. Therefore, the "right of reply" is a feature of both formats and applies in both cases only for prices at which there is excess demand.

5.15 H3G[52] commented that switching demand is more difficult in a clock auction. We disagree. Fundamentally, switching demand between lot categories is difficult in both formats when excess demand is low. We recognise that there are some differences between the formats in how this difficulty manifests itself. In the SMRA, switching is difficult for any bidder that has been made a partial standing high bidder, while in the clock there is the need to manage the

[49] H3G, pp. 5-6.
[50] We have been advised by Cramton Associates, which has substantial experience in designing, advising, and bidding in clock auctions.
[51] That is, (i) a bidder would need to move from a higher eligibility point category (26 GHz) to a lower eligibility point category (40 GHz); (ii) the bidder would need to bid for a lower number of lots than it could in the lower eligibility point lot category; (iii) the bid to decrease demand would need to be only partially applied; and (iv) the price ratio between the two lot categories would need to be smaller than the eligibility point ratio (i.e., the price of 40 GHz would have increased at a faster rate (relative to its reserve price) than 26 GHz had increased (relative to its reserve price)).
[52] H3G, pp. 5-6.

possibility that another bidder reduces demand in the same round. Mitigations to address the issues are possible in both formats: waivers in the SMRA and "all or nothing" bids in the clock design. The difficulties are therefore broadly equivalent in our view.

5.16 However, in the SMRA, information about excess demand is inaccurate in rounds in which any bidders use waivers, while excess demand in the clock format is always accurate at the end of a round. In our view excess demand information is an important tool for bidders in formulating their bidding decisions, hence helping to achieve optimal use of spectrum, and a clock auction format provides more reliable information than the SMRA format. We therefore consider the clock auction to have an advantage over the SMRA in this respect.

Bidding Process

Our proposal

5.17 We set out our proposed bidding process for the principal stage in the March 2023 Statement and Consultation.[53] In summary, we proposed the following:

i) Before the start of the auction, Ofcom will announce the available supply of lots and the reserve prices for each lot category. In the first round, bidders may demand a number of lots in each lot category at the category's reserve price.

ii) In each of the following rounds, Ofcom announces an opening price and a higher clock price for each lot category. Bidders may submit simple bids in each category to maintain, increase or decrease their demand from the previous round. Bidders may also submit "all or nothing" bids to decrease demand, as explained below.

iii) In every round after the first, a bidder can submit a bid to maintain its demand in a lot category throughout the category's entire range of prices, or submit a bid in that lot category to decrease or increase demand at any price in the range. We refer to bids placed at prices between the opening and clock prices as "**intra-round**" bids.

iv) At the end of each round, bids would be processed by the electronic auction system to determine whether or not Ofcom will apply the bidder's bid to maintain or change its previous demand for lots in each lot category, according to the following rules: (a) a bid to maintain previous demand is always applied in full; (b) a bid to increase demand in a lot category is applied only to the extent that it does not cause the bidder's demand across all lot categories to exceed the bidder's eligibility limit in that round; and (c) a bid to decrease demand in a lot category is applied only to the extent that it does not cause aggregate demand for that lot category to fall below supply, or to fall further if it is already below supply.

v) In accordance with rule iv (c) above, a bidder placing a simple bid to decrease demand in a lot category may have the bid applied by the EAS in full, in part or not at all.

vi) A bidder wishing to decrease demand in a lot category may alternatively choose to submit an "all or nothing" bid, which the EAS will process to only apply the decrease either by the exact number of lots the bidder specifies or not at all (if the decrease is not applied at all, the bidder would continue demanding its posted demand from the last round throughout the category's entire range of prices), again in accordance with rule iv (c) above. We considered that all or nothing bids could help mitigate

[53] March 2023 Statement and Consultation, paras 9.57-9.72 and Annex A9.

aggregation and substitution risks. Specifically, they could help bidders switching demand across lot categories avoid winning holdings split between bands if they prefer to win holdings in a single band; they could help bidders avoid winning an amount of spectrum which they consider sub-optimally small; and they could help bidders target specific amounts of spectrum, e.g. multiples of 200 MHz.

Stakeholders' responses

5.18 Vodafone made the following comments on our proposals for the bidding process in the principal stage:

a) it said that it was not aware of any previous clock auction with this level of intra-round complexity and was concerned that intra-round bids could lead to an unexpected breach of budget or an expected loss of eligibility.[54]
b) In relation to all or nothing bids, Vodafone was concerned about a risk of an "infinite loop", "where an all-or-nothing bid is made repeatedly, is repeatedly rejected (because it would lead to unsold spectrum), but then the clock price can't move forward".[55]

5.19 H3G commented on the clock format in general in its response to the consultation.[56] In relation to specific bid types, H3G said [CONFIDENTIAL✂][57]

5.20 VMO2 made the following comments:

a) It supported allowing bidders to submit multiple bids in the same lot category provided that they are directionally consistent, and thought this would provide more flexibility to bidders without adding significant complexity.[58]
b) It supported the option of all or nothing bids when bidding to decrease demand.[59] Although VMO2 thought all or nothing bids add complexity, it believed that they would help bidders manage the risk of an unwanted split assignment and they may be important in achieving an efficient auction outcome. It thought that this benefit outweighs the downside of added complexity.
c) It noted a change in the language we used to express bids compared with that used by the US FCC for similar auctions, which VMO2 described as "subtle, but material".[60] In other countries, bids in each category were expressed in the form of a change to existing demand, whereas in our proposal, bids are expressed in total demand. VMO2 said that it is inclined to support our bidding language, but requested two additions to the bidding rules to help bidders in certain situations when they fail to make a bid, and that we explain why we use different submission rules to those used by other regulators, to help prospective bidders analyse what it described as "this novel aspect of the auction rules".[61]

5.21 BT/EE did not comment on the bidding process.

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[54] Vodafone, pp. 3-4.
[55] Vodafone, pp. 3-4.
[56] H3G, pp. 5-6.
[57] [CONFIDENTIAL✂].
[58] VMO2, p. 17
[59] VMO2, p. 17.
[60] VMO2, pp. 14-15.
[61] VMO2, pp. 15-16.

Our decision

Intra-round bids and multiple bids

5.22 In our view, Vodafone's concerns about complexity of intra-round bids are misplaced. We consider that Vodafone's concerns relate to the bidding process in general and not specifically to intra-round bids. In particular, we discuss Vodafone's concern about an unexpected breach of budget above (see paragraphs 5.12-5.13) as we consider it relates to the choice of the principal stage format. We discuss Vodafone's concerns around an expected loss of eligibility and the risk of an "infinite loop" below because we consider that they relate respectively to the ratio of eligibility points between bands (see paragraphs 5.37-5.40) and to all or nothing bids (see paragraphs 5.27-5.30). Similarly, we discuss H3G's comments about the clock auction format above (see paragraphs 5.10-5.16).

5.23 Intra-round bidding has been used in several auctions, including spectrum auctions in Australia, Canada, Slovenia and the US.

5.24 Additionally, as we noted in the March 2023 Statement and Consultation,[62] use of intra-round bidding would be optional. The price associated with any bid to decrease demand would be set by default to the opening price of the round in the electronic auction system, so bidders who do not wish to use intra-round bids would simply not change the bid price.

5.25 Our proposals in the March 2023 Statement and Consultation would allow a bidder the option to place multiple intra-round bids for a lot category in every round after the first. They would help ensure efficient allocation of the spectrum in the auction by allowing all bidders to express without constraint all the prices, between opening and clock prices, at which their demands change in every lot category. Some stakeholders were concerned that the resulting bidding process could be overly complicated. We think that some of those concerns were misplaced. Nevertheless, we are also aware that we could, in principle, achieve a similar outcome if we were to make all price increments between rounds sufficiently small, but at the potential cost of prolonging the auction.

5.26 Taking all the considerations above into account, we have decided to allow the option of intra-round bidding, but to only allow a bidder to place one bid per lot category in every round after the first – i.e. to exclude the option of allowing a bidder to submit multiple bids in a lot category. We believe that this design would allow us to secure efficient allocation of the spectrum, while striking an appropriate balance between potential complexity and flexibility in the choice of price increments between rounds.

All or nothing bids

5.27 We recognise Vodafone and VMO2's concerns on additional complexity of all or nothing bids as it is an additional feature that the bidders would have to learn. We have also decided to increase lot sizes from 100 MHz to 200 MHz, so all or nothing bids may be less useful to those bidders wanting to acquire spectrum holdings in multiples of 200 MHz.

5.28 However, we note that Vodafone has misinterpreted certain characteristics of all or nothing bids and we provide further explanation below for clarification.

5.29 Vodafone[63] provided an example to explain its concern that all or nothing bids could cause an "infinite loop". In its example, if an all or nothing bid to decrease demand is not applied

[62] March 2023 Statement and Consultation, para 9.55.
[63] Vodafone, p. 4, (response to Q.4).

(due to insufficient excess demand), the posted price[64] would be set to the opening price of the round. We clarify that Vodafone's scenario of an infinite loop cannot occur in our proposed format. A bidder who submits an all or nothing bid to decrease demand commits to maintaining its previous demand at all prices in the range between and including the round's opening and clock prices if its request to decrease its demand is not applied. As the all or nothing bid is not applied, there likely remains excess demand in the lot category at the end of the round. Therefore, the posted price will be set to the clock price of the round, not the opening price.[65]

5.30 We remain of the view, therefore, that all or nothing bids to decrease demand are a useful tool to help bidders mitigate aggregation and substitution risks. We recognise that our decision to adopt lot sizes of 200 MHz diminishes aggregation risks for bidders. Nevertheless, we have decided to maintain the option of allowing bidders to submit all or nothing bids to decrease demand because we consider that this will help bidders manage substitution risks and remaining aggregation risks.

Language used to describe the bidding rules

5.31 In response to VMO2 comments, we note that, in accordance with the requirements of the Wireless Telegraphy Act 2006,[66] we will make regulations (the "**Auction Regulations**") to give effect to the design of the auction and consult on a full draft of the Auction Regulations before enacting them in a statutory instrument. Therefore, stakeholders will have an opportunity to comment on the terminology proposed for the Auction Regulations, which may be different from the terminology used in this document.

5.32 We comment on VMO2's requests for additional rules to address certain situations when bidders fail to make a bid at paragraphs 5.47-5.49 (in relation to grace rounds).

Eligibility points

Our proposals

5.33 In the March 2023 Statement and Consultation,[67] we proposed to set:

a) the same eligibility points for the 26 GHz lower lot category (25.1-26.5 GHz) and the 26 GHz upper lot category (26.5-27.5 GHz) and
b) a per MHz eligibility ratio of 1.5:1 between the 26 GHz and 40 GHz bands, which means that each 26 GHz lot would be associated with 1.5 eligibility points, while each 40 GHz lot would be associated with 1 eligibility point. The other ratios which we considered were 1:1 and 2:1.

5.34 We proposed the 1.5:1 eligibility point ratio because we considered that this would allow bidders to demand more spectrum if substituting 26 GHz with 40 GHz spectrum, while still reflecting the substitutability between the bands. In proposing this ratio, we considered

[64] The posted price of a lot category is the price per lot to which all bids in that lot category are committed at the end of the round, once all bids are processed.
[65] If there is no excess demand this is not an issue either. The posted price would be set to either the highest price bid to decrease that was applied (either fully or partially) in the lot category, or the posted price would be set to the opening price if no bid to decrease was applied. If there is no excess demand in any lot category the principal stage would conclude.
[66] In particular, section 14 of the Wireless Telegraphy Act 2006.
[67] March 2023 Statement and Consultation, paras. 9.73-9.87.

that, while we expect the two bands to be functionally substitutable in the long run, the state of development of the ecosystems for the two bands would enable earlier deployment of 26 GHz spectrum than 40 GHz spectrum, and that there is greater supply of spectrum in the 40 GHz band than in the 26 GHz band.

Stakeholders' responses

5.35 Stakeholders' responses on eligibility focused on two points:

a) their preferred eligibility ratio; and
b) the risk that bidders may inadvertently lose eligibility when switching between bands.

Eligibility ratio

5.36 On the first point, BT/EE and VMO2 supported the proposed 1.5:1 eligibility ratio, while Vodafone did not. H3G made no comment on the topic.

a) BT/EE[68] and VMO2[69] expressed their support for the proposed eligibility ratio. Furthermore, VMO2 commented that it agreed with Ofcom's decision "to use the same eligibility weightings for lots in the two lot 26 GHz categories" as well as "to use a lower eligibility weighting for lots in the 40 GHz category.
b) On the other hand, Vodafone[70] commented that the proposed fractional eligibility ratio is "unconventional". Vodafone suggested the use of either a 1:1 or 2:1 ratio instead.

Risk of inadvertent loss of eligibility

5.37 On the second point, BT/EE, VMO2 and Vodafone raised concerns that, as the proposed eligibility ratio is asymmetric between lot categories, switching between lot categories may result in an inadvertent loss of eligibility.

5.38 Vodafone provided an example in which a bidder trying to move demand for an even number of lots in the 26 GHz band to the 40 GHz band incurs the risk of inadvertently losing half an eligibility point in the switch, if its bid to decrease in 26 GHz is not fully applied. BT/EE and VMO2 provided similar examples.

5.39 Stakeholders made the following suggestions to address this issue:

a) Vodafone[71] supported the adoption of a different eligibility ratio. In its view, an eligibility ratio of 1:1 would solve the issue completely, while an asymmetric but not fractional eligibility ratio (e.g. 2:1) would solve the issue when bidders switch from the 26 GHz to the 40 GHz band (although not for the other way around).
b) Alternatively, BT/EE[72] and VMO2[73] suggested maintaining the proposed eligibility ratio but including a feature to prevent eligibility from dropping in a round if a request to move lots between bands is not fully applied due to insufficient excess demand.

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[68] BT/EE, p. 4, section 5.1.2.
[69] VMO2, pp. 16-18.
[70] Vodafone, p. 3.
[71] Vodafone, pp. 3-4.
[72] BT/EE, p. 2, para. 2; and pp. 6-8, section 5.1.6.
[73] To explain its concern, VMO2 (p.18) provided the following example: "In round n, Bidder A is active on 6 lots in the 40 GHz band and submits a decrease bid for 6 lots at 40 GHz and an increase bid for 4 lots at 26 GHz Upper. This is an eligibility points neutral move. However, suppose its decrease is partially denied and it is retained on 4 lots at 40 GHz. This frees up 2 points so only 1 lot of its increase bid at 26 GHz Upper will be processed. Consequently, Bidder A's processed activity will be only 5.5 points, not 6 points, a ½ point reduction in eligibility going into round n+1".

Ofcom's decision

5.40 In light of stakeholders' concerns about potential unintended loss of eligibility, we have decided to adopt a 2:1 eligibility ratio between the 26 GHz band and the 40 GHz band. For the reasons explained below, we have decided not to include any additional features for eligibility.

Eligibility ratio

5.41 We have decided to adopt an eligibility ratio of 2:1 rather than the previously proposed ratio of 1.5:1.

5.42 We consider that the appropriate eligibility ratio would assist bidders wishing to substitute their demand between lot categories without introducing unnecessary uncertainty. We acknowledge that a 1:1 ratio (as suggested by Vodafone) would make switching between bands more straightforward. However, assigning the same weight to both bands would not reflect the differences in the state of development of the ecosystems for the two bands, which would enable earlier deployment of 26 GHz spectrum than 40 GHz spectrum, and the greater supply of spectrum in the 40 GHz band than in the 26 GHz band.

5.43 The combination of a 2:1 ratio with the lot size of 200 MHz, rather than the previously proposed 1.5:1 ratio with a lot size of 100 MHz, makes switching easier, while maintaining a higher eligibility weight for the 26 GHz band. Additionally, this ratio eliminates the risk that bidders could inadvertently lose eligibility when moving demand from the 26 GHz band to the 40 GHz band, reflecting how bidders may substitute demand (although, not always when moving demand from the 40 GHz to the 26 GHz band, as explained in paragraph 5.46).

Inadvertent loss of eligibility points

5.44 We have decided not to include the additional features to retain eligibility in a round suggested by BT/EE and VMO2.

5.45 We recognise that, with the ratio of 1.5:1 we proposed previously, bidders could accidentally incur a loss of 0.5 eligibility points if their request to switch between bands was not fully applied.

5.46 With a 2:1 eligibility point ratio, this inadvertent loss of eligibility points could no longer occur when switching from 26 GHz to 40 GHz, as bidders would be switching from two eligibility points per lot to one eligibility point per lot. Although we recognise that the issue may still arise when switching from the 40 GHz band to the 26 GHz band, we believe that this direction of switching is less likely because bidders are likely to attach more value (relative to the reserve price) to spectrum in the 26 GHz band.

5.47 We have also considered whether grace rounds, as suggested by stakeholders, could mitigate the inadvertent loss of eligibility points. A grace round would allow a bidder with a lower processed demand to maintain its eligibility limit in the next round, and would protect the bidder from inadvertent loss of eligibility for one round. However, if, in the next round, the bidder is still not able to complete its switch (due to insufficient excess demand in one band), its eligibility would still decrease.

5.48 Furthermore, grace rounds may give bidders the opportunity for strategic gaming or may lead bidders to take less care in bidding, knowing that their eligibility would not drop for a round.

5.49 We have therefore decided not to allow grace rounds.

Information Policy for Principal Stage

Our proposal

5.50 In the March 2023 Statement and Consultation[74], we proposed to disclose the total number of qualified bidders and their identity before bidding starts. We also proposed to reveal the exact aggregate level of excess demand for each lot category at the end of each principal stage round.

Stakeholders' response

5.51 VMO2 and BT/EE commented on our proposed information policy:

a) VMO2[75] supported our proposals on information policy and thought that they strike an appropriate balance between helping bidders with price discovery and limiting risk of exploitation of the information to bid strategically.
b) On the other hand, BT/EE[76] commented that it would require access to the "full principal stage results (covering each bidder individually)", at the end of the principal stage to best prepare to bid in the assignment stage.

Ofcom's Decision

5.52 We have decided to maintain the proposed information policy and additionally publish the principal stage results before the beginning of the assignment stage. That is, we will reveal:

a) the total number of qualified bidders and their identity before the beginning of the principal stage;
b) the aggregate level of excess demand for each lot category at the end of each round in the principal stage; and
c) the full principal stage results[77] before the beginning of the assignment stage.

Deposit

Our proposals

5.53 In the March 2023 Statement and Consultation,[78] we proposed that:

a) Along with their application, applicants will be required to submit an initial monetary deposit which might be forfeited, in whole or in part, if the applicant subsequently breaches the award regulations.
b) Before the first round of the auction, qualified bidders will need to provide an additional deposit to Ofcom which will determine the bidder's initial eligibility level.
c) The initial eligibility will correspond to the maximum number of spectrum lots that could be won by a bidder using their total deposit at the reserve prices.

[74] March 2023 Statement and Consultation, paras. 9.88-9.89.
[75] VMO2, p. 20.
[76] BT/EE, pp. 8-9.
[77] These will include, for each lot category, the number of lots won by each bidder and the price they paid, as well as the number of any unsold lots.
[78] March 2023 Statement and Consultation, paras. 9.123-9.125 and A9.106-A9.114.

d) At any point during the auction, Ofcom may require bidders to increase their deposits up to an amount equal to the highest bid submitted so far by the bidder.

5.54 We said that we will publish more information on the deposit requirements, including guidance on the deposit requirements for all possible initial eligibility levels, closer to the start of the auction (e.g. in the bidder guidance document).

Clarification sought by VMO2

5.55 VMO2 acknowledged the important role of deposits to ensure that bids in the auction are real. It requested that we provide more detail about the process we will follow when we ask bidders to increase their deposits and about how much notice bidders will have to increase their deposits when asked.[79]

Ofcom's decisions

5.56 We intend to implement our proposals in relation to deposits. We understand that bidders would need to be aware of the process we will follow when we ask bidders to increase their deposits and how much notice we will provide. We will set this out in guidance for bidders nearer the time of the auction.

Auction Practicalities

Price Increments

Our proposal

5.57 In the March 2023 Statement and Consultation[80], we said that we intend to use small price increments for the principal stage rounds. Smaller price increments would mean that there will likely be fewer changes in demand during a round, and thus bidders would have more accurate excess demand information.

5.58 We said that we intended to publish further information on the matter in the guidance we will provide to bidders.

Stakeholders' responses

5.59 VMO2 expressed its support for small price increments and said that it prefers that we maintain small price increments but shorten the duration of rounds if we needed to speed up the auction. VMO2 added that we should set price increments as a percentage of the reserve prices rather than of prices from the previous round to avoid prices from increasing dramatically between rounds.[81]

Ofcom's comments

5.60 We note VMO2's comments. Our intention remains to publish further information on the matter in guidance to bidders.

[79] VMO2, p. 28.
[80] March 2023 Statement and Consultation, para 9.66.
[81] VMO2, pp. 20-22.

Extraordinary events (round extensions)

Our proposal

5.61 In the March 2023 Statement and Consultation[82], we indicated that we would retain the power to address extraordinary events that might otherwise compromise the auction, and thus the ability, amongst others, to rerun or reschedule a round; and to disregard some or all bids submitted by bidders.

Stakeholders' responses

5.62 Some MNOs expressed a concern that this may not be sufficient and requested a limited number of "automatic" round extensions (as proposed by BT/EE) or the same extension rules allowed in the 2013 award[83] (as proposed by VMO2). That is, on a limited number of occasions, and subject to certain conditions, a round would be extended for a predetermined period (e.g. thirty minutes) for any bidder who failed to submit any bid by the round closing time. In particular:

a) BT/EE[84] and VMO2[85] commented that technical problems, outside of the bidders' control, may cause bidders to fail to bid in a round. In this case, the bidders' demand would drop, and bidders would lose eligibility. Without sufficient eligibility, the bidders would not be able to regain their demand in the following rounds.
b) H3G and Vodafone did not comment on the matter.

Ofcom's decision

5.63 We have decided not to include the round extensions proposed by BT/EE and VMO2 for this award.

5.64 We have considered the concern expressed by BT/EE and VMO2, that bidders may incur technical or non-technical difficulties when bidding in the auction, and understand that bidders' ability to rely on a limited number of round extensions would alleviate these concerns.

5.65 However, the round extensions proposed by BT/EE and VMO2 could bring confusion to the auction schedule and would not help bidders experiencing difficulties for a prolonged period.

5.66 It is important to note that we will expect bidders to equip themselves with reliable and resilient systems and to adopt appropriate procedures to ensure that they bid within the time allotted in each round. We intend to make reasonable provision for eventualities in which bidders experience genuinely extraordinary difficulties. Ofcom, as the auctioneer, will have the power to revise the time for the start or the end of a round, notify bidders of an alternative method of participating in the award, rerun rounds, and disregard bids after the end of the round, if necessary.

[82] March 2023 Statement and Consultation, para A9.118.
[83] See, for example, reg. 53 of The Wireless Telegraphy (Licence Award) Regulations 2012.
[84] BT/EE, p. 8.
[85] VMO2, pp. 22-24.

Post-Auction Information Policy

Our proposal

5.67 In the March 2023 Statement and Consultation[86], we indicated that after the auction we intend to publish:

a) the names of the winning bidders and the frequencies won by those bidders (and licence fees paid); and
b) details of all principal stage bids and the assignment stage bids; and
c) the names of those winning bidders (if any) that failed to pay their total auction sum on time and who therefore failed to obtain licences in the auction, despite making winning bids.

Stakeholders' responses

5.68 VMO2 responded on the matter, and asked for confirmation that Ofcom plans, after the end of the auction, to publish the full bid set for the award."[87]

Our decision

5.69 It remains our intention to publish the information described in paragraph 5.67 above after the auction ends.

[86] March 2023 Statement and Consultation, para A9.121
[87] VMO2, p. 20.

6.Assignment Stage

Summary

6.1 In this section, we discuss stakeholders' views on the assignment stage of the auction and set out our decisions and provisional decisions. The assignment stage will determine the precise frequencies of the frequency-generic spectrum lots which bidders will have won in the principal stage.

6.2 Some of our decisions on the details of the design of the assignment stage are provisional because we are open to considering any additional evidence on whether to include a negotiation period, following requests from both VMO2 and Vodafone.

6.3 A negotiation period would allow winners of spectrum in a band to agree that their holdings will be adjacent in frequency, which could help reduce the costs of any radio equipment they may share. On the basis of the evidence we currently have on the benefits of including a negotiation period in this auction, we have provisionally decided not to include one because we consider that the likely benefits do not justify the additional complexity and costs which a negotiation period would entail.

6.4 Having considered stakeholders' responses to the March 2023 Statement and Consultation, we have decided to proceed with the following elements of the assignment stage:

a) **Sealed bid auction format:** Each round of the assignment stage will determine the precise frequencies of the spectrum allocations in a specific band or part of a band. The format of each round will be a sealed bid auction with a second price rule, where the sum of prices paid by participants in the winning combination of bids will be at least as high as the sum of any alternative combination of bids.

b) **Contiguous blocks within permissible assignment plans:** In each assignment stage round, each bidder will only be able to bid for contiguous blocks of spectrum within permissible assignment plans**.**

c) **Information policy**: We will publish the results of the principal stage ahead of the assignment stage (i.e., all bidders will know how much spectrum has been won by whom in every lot category). At the end of each assignment round, we will inform bidders about their own assignments. Bidders will find out the assignments held by other bidders at the end of the auction process.

d) **Assignment of the 26 GHz band:** We have designed the assignment process for the 26 GHz band to ensure that, in all circumstances, each licensee's holdings in the whole band will be contiguous after the deadline date for clearance of fixed links in the 26 GHz band (the "**26 GHz clearance deadline**").[88] In the first and second assignment rounds, bidding will decide the frequency assignments in the 26 GHz lower and 26 GHz upper lot categories respectively for the period up to the 26 GHz clearance deadline. A final round will decide the assignments in the whole 26 GHz band for the remainder of the 15-year

[88] We currently expect this date to be around 31 December 2028. We have started the statutory process in progress for revoking licences for fixed links in the 25.1 – 26.5 GHz range in and around high density areas, and will set the final deadline date as part of this process. We will consider any further representations that these licensees might want to make in response to our notices of proposed revocation before making a final decision on the revocation of their licences.

licence term. If the first and second rounds result in split holdings across the whole 26 GHz band for any licensee, bidding in the final assignment round will decide how the assignments will be rearranged after the 26 GHz clearance deadline, to secure contiguity for every licensee.[89] Otherwise, there will be no final assignment round and the assignments resulting from the two initial assignment rounds will apply throughout the 15-year licence period.

e) **Assignment of the 40 GHz band:** Bidders will bid in a single round for the assignment of the 40 GHz band, at the same time as first assignment round of the 26 GHz band.

6.5 A more detailed description of the assignment stage, with illustrative examples, is set out in Annex 7.

Our March 2023 consultation proposals

6.6 At the end of the principal stage, winning bidders will have won a number of generic lots in each lot category. The specific frequencies assigned to each winning bidder will be determined in the assignment stage. In the March 2023 Statement and Consultation[90] we proposed an assignment stage with the features described below.

Rounds

6.7 We proposed to include up to three rounds for the assignment of the 26 GHz band:

a) A round for the initial assignment of the 26 GHz lower frequencies (25.1-26.5 GHz) until the 26 GHz clearance deadline (the "**initial assignment**").
b) A round for the initial assignment of the 26 GHz upper frequencies (26.5-27.5 GHz).
c) A round for the final assignment of the 26 GHz frequencies (25.1-27.5 GHz), after the 26 GHz clearance deadline and until the end of the 15 year licence term (the "**final assignment**").

6.8 We also proposed a single assignment stage round for the 40 GHz frequencies.[91]

Bidding format

6.9 We proposed a sealed bid auction format with a second price rule,[92] given its speed and likelihood to achieve the most efficient allocation. In this format, the electronic auction system would generate all the potential assignment options that would be available to each bidder.

6.10 We proposed that, in every assignment stage round, bidders would only be invited to bid on options which meet certain requirements (the "**permissible assignment plans**"). In all permissible assignment plans, each bidder's holdings in the relevant lot categories would be contiguous in frequency.[93]

[89] As set out in paragraph 3.22, licensees will have a six-month migration period for rearranging their respective assignments.
[90] March 2023 Statement and Consultation, paras. 9.90-9.106 and A9.71-A9.105.
[91] We proposed that this assignment stage round for the 40 GHz frequencies would take place at the same time as the initial assignment stage round for the lower 26 GHz frequencies.
[92] The price to be paid by bidders will be determined using nearest-Vickrey pricing, which is a type of second price rule. The nearest-Vickrey pricing rules are set out in more detail in Annex 7.
[93] March 2023 Statement and Consultation, paras. 9.103 and A9.75-A9.80.

6.11 In any assignment stage round, a bidder would only be invited to bid if the permissible assignment plans offer more than one possible assignment of its frequencies. In that case, the bidder would be able to bid by specifying its value for each of those possible assignments. In the alternative case, where the permissible assignment plans would only offer the bidder one assignment, the bidder's holding will be assigned automatically.

6.12 We proposed that a bidder will be deemed to have submitted a bid of zero where it has the option to bid but does not submit one.

6.13 The winning permissible assignment stage plan in each round would be the one with the combination of bids with the highest combined value. The price paid by a bidder for the winning assignment would follow the nearest-Vickrey pricing rules.[94]

6.14 We also made proposals for the assignment stage which would apply in the event that we decided to disaggregate any high density areas as a separate geographic lots in the principal stage.[95] As we have decided not to disaggregate any high density areas into separate lots, we do not consider these proposals further in this document.

Information released at the end of the auction

6.15 We proposed to publish a breakdown of the spectrum won and the prices paid after the auction, including the frequencies won by bidders and any additional prices. As with the principal stage, we also proposed to publish details of all assignment stage bids.[96]

Unsold spectrum in the 26 GHz band

6.16 We proposed that:[97]

a) Any unsold spectrum in the 26 GHz lower lot category would be placed as a single contiguous block at the bottom portion of the 26 GHz band.
b) Any unsold spectrum in the 26 GHz upper lot category would be placed as a single contiguous block at the top portion of the 26 GHz band.

Rules for the assignment stage rounds

Scheduling of assignment stage rounds

6.17 We proposed that the timing of the rounds would be as follows:

a) **26 GHz lower and 40 GHz rounds**: The initial assignment stage round for the assignment of the 26 GHz lower frequencies (25.1-26.5 GHz) and the assignment stage round for the 40 GHz frequencies would take place in parallel. These rounds would take place first.
b) **26 GHz upper round**: Next, the initial assignment stage round for the assignment of the 26 GHz upper frequencies (26.5-27.5 GHz) would take place.
c) **Final 26 GHz round**: Finally, the final assignment stage round for the long term assignment of the 26 GHz frequencies (25.1-27.5 GHz) would take place.

[94] The nearest-Vickrey pricing rules are explained in greater detail in Annex 7.
[95] March 2023 Statement and Consultation, paras. 9.105-9.106.
[96] March 2023 Statement and Consultation, paras. A9.120-A9.121.
[97] March 2023 Statement and Consultation, para. A9.87.

Permissible assignment rules for the initial assignment of the 26 GHz band

6.18 We proposed the following rules to maximise contiguity across the entire 26 GHz band in the initial assignment rounds:[98]

a) **Restriction to the ends of the 26 GHz band for winners of spectrum in a single 26 GHz lot category**: Bidders who only won spectrum in 26 GHz lower during the principal stage would only be offered the option to bid for frequencies at the bottom of the 26 GHz band, while those who only won spectrum in 26 GHz upper would only be able to bid for frequencies at the top of the 26 GHz band.

b) **Restriction to the middle of the 26 GHz band for winners of spectrum in both 26 GHz lot categories**:

i) If only one bidder won spectrum in both the 26 GHz lower and the 26 GHz upper lot categories in the principal stage, it would automatically be assigned frequencies at the top of the 26 GHz lower lot category and frequencies at the bottom of 26 GHz upper lot category.

ii) For the 26 GHz lower lot category, if more than one bidder won spectrum in both 26 GHz lot categories, then each such bidder would be restricted to bidding for assignments at the top end of the 26 GHz lower lot category (above any bidders who only won spectrum in 26 GHz lower).

iii) For the 26 GHz upper lot category, the bidder who won the uppermost location in the initial assignment of the 26 GHz lower lot category would be automatically assigned the lowermost frequencies of the 26 GHz upper lot category. The other bidders who won spectrum in both 26 GHz lot categories would then be restricted to bidding on the remaining frequencies at the bottom of the 26 GHz upper lot category.

Permissible assignment rules for the assignment of the 40 GHz band

6.19 We did not propose to incorporate any additional permissible assignment rules in the assignment of the 40 GHz band. Only the general requirement that each bidder is assigned a contiguous frequency block would apply.

Permissible assignment rules for the final assignment stage round of the 26 GHz band

6.20 Following the initial assignment of 26 GHz upper, we proposed that only those who won spectrum in both 26 GHz lower and 26 GHz upper would be invited to submit bids for the final assignment of 26 GHz. Those who only won spectrum in one of the 26 GHz lot categories would not bid, as they would automatically be assigned their location from the initial assignment of the 26 GHz band.

6.21 We proposed that there would not be any bids submitted for the final assignment for the 26 GHz band if all bidders in the band had already been assigned contiguous frequency blocks following the initial assignment stage rounds. In that case, bidders would be automatically assigned their location from the initial assignment of the 26 GHz band until the end of the 15 year licence term.

[98] March 2023 Statement and Consultation, paras. 9.104 and A9.85-A9.86.

Stakeholders' responses

6.22 VMO2 and Vodafone requested that we include a negotiation period in the assignment stage, to allow a bidder to agree with another that their respective holdings will be adjacent.

6.23 In all other substantive respects, stakeholders generally supported our assignment stage proposals. In particular:

a) BT/EE[99] agreed with "the proposed initial assignment rounds for the two 26 GHz lot categories and the 40 GHz lot category followed by a further assignment round for the final 26 GHz band arrangement if necessary". BT/EE[100] inferred that we did not intend to publish the principal stage results before the assignment stage begun and urged us to publish the principal stage results for each bidder before the first assignment stage round.

b) VMO2[101] proposed that "Ofcom grant itself discretion to integrate unsold lots into the Assignment Round", so that "bidders that already won lots in the relevant category would be granted additional bid options that include one or more unsold lots". VMO2 also said that it supports our proposed approach of positioning "any unsold lots in the 26 GHz lower and Upper band (…) in contiguous blocks at the lower and upper boundaries of the band respectively".

c) In relation to the 26 GHz band, Vodafone[102] said that it supports "BT's proposal that successful bidders for only one lot type are placed at the extremities of the band so that they can be excluded from the migration exercise".

6.24 VMO2[103] sought clarifications on: (i) the information that we intend to publish at each stage of the award process and after the auction, (ii) the location of any unsold lot of 40 GHz, (iii) the scheduling of the assignment rounds "if there is only one winning bidder in 26 GHz lower, and no bidding is required", (iv) the reference to "the remaining part of the band" in paragraph A9.86 of the March 2023 Statement and Consultation and (v) the assignment bid options in an hypothetical assignment stage scenario.

Requests that we include a negotiation period

Stakeholders' comments

6.25 In response to the March 2023 Statement and Consultation, VMO2 and Vodafone commented on the importance of enabling bidders to obtain blocks of spectrum adjacent to specific other bidders. They suggested the inclusion of a negotiation period, similar to the one we included in the award of the 700 MHz and 3.6-3.8 GHz ("2021 Auction")[104] to achieve this. We summarise their comments below.

6.26 VMO2 said that for the allocation of the 40 GHz band and the final allocation of the 26 GHz band, bidders would be likely to have a preference to be allocated spectrum next to specific

[99] BT/EE response to the March 2023 Statement and Consultation, p. 8, section 5.1.8.
[100] BT/EE, pp. 8 and 9, section 5.1.8.
[101] VMO2 response to the March 2023 Statement and Consultation, pp. 27-28.
[102] Vodafone response to the March 2023 Statement and Consultation, p. 6.
[103] VMO2, pp. 27-28.
[104] Ofcom's 13 March 2020 Statement 'Award of the 700 MHz and 3.6-3.8 GHz spectrum bands', paras. 6.123 to 6.126

other bidders (for example, owing to network sharing arrangements).[105] It suggested that we should allow for industry negotiations to enable this. In particular, VMO2 said we should adopt a negotiation process similar to the one that we used for the 2021 Auction.[106] This means that sub-groups of bidders would have the opportunity to agree to be allocated a contiguous assignment of spectrum (making them adjacent), but in doing so they would lose the ability to indicate a preference for a particular position in the band.

6.27 VMO2 explained that a negotiation period would facilitate operators obtaining adjacent blocks of spectrum. This would in turn enable operators to deploy shared networks. VMO2 noted that "the current generation of equipment at 26 GHz for microcell mobile deployment has an IBW[107] of 1,400 MHz".[108] It argued that, as a result of this, operators which deploy shared networks using a single radio will only be able to use spectrum blocks that sit within a 1,400 MHz range.

6.28 VMO2 said that being unable to secure adjacent spectrum might prevent operators deploying a shared network and that this in turn may weaken and delay the business case for those operators to deploy mmWave spectrum across urban areas, through an absence of sharing efficiencies.[109] It added that while there was currently no equipment for 40 GHz, it is reasonable to suppose that there will be equivalent constraints on IBW as for 26 GHz.[110]

6.29 Vodafone commented that a negotiation period could play a role in facilitating sharing of spectrum between licensees in a club model, in which licensees would co-operate (in a manner compliant with competition law) to use each other's unused spectrum.[111]

Ofcom's considerations

6.30 A negotiation period in the assignment stage could benefit operators interested in sharing radio equipment. It would allow two principal stage winners of spectrum in the same band to agree that their spectrum holdings in that band will be adjacent in frequency. Adjacency could increase the choice of mmWave radio equipment available to operators for sharing, and potentially allow them to reduce their costs, but is not a prerequisite to make sharing possible.

6.31 VMO2 advocates that we should include a negotiation period for the longer-term assignment of the 26 GHz band – i.e. after the 26 GHz clearance deadline – and in the assignment of the 40 GHz band.

6.32 We explain in Annex 9 how the assignment stage would work if we were to include a negotiation period and set out our full consideration of whether we should include a negotiation period in Annex 8.

6.33 In summary, we recognise that a negotiation period could deliver benefits if the resulting assignment of frequencies leads to lower costs of deployment. Better outcomes, such as lower retail prices or earlier and/or more extensive deployments of mmWave spectrum,

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[105] VMO2, p. 26.
[106] Ofcom's 13 March 2020 Statement, 'Award of the 700 MHz and 3.6-3.8 GHz spectrum bands', paras. 6.97-6.126.
[107] We understand IBW is the instantaneous bandwidth of the equipment.
[108] VMO2, page 26.
[109] VMO2 confidential response to the March 2023 Statement and Consultation, p. 27.
[110] VMO2 confidential, p. 28.
[111] Vodafone, pp. 9-10, response to Q. 13.

may then follow for people and businesses. However, the cost savings that adjacency of spectrum holdings will make possible after the 26 GHz clearance deadline in the 26 GHz band, and in the 40 GHz band once equipment for that band is available, are unknown. It is also unknowable whether operators will ultimately share radio equipment (whether or not their spectrum holdings are adjacent), or, instead, prefer to deploy independently, in order to maximise flexibility to deploy, innovate or to differentiate services. In addition, as noted in Annex 8, it may be possible for operators to deploy shared networks even without adjacent spectrum holdings.[112] Therefore, the likelihood and extent of any reduction in costs that a negotiation period could deliver, and hence of any potential benefits, are currently unclear.

6.34 In addition, including a negotiation period would have the following downsides:

a) It could require one or more bidders to change frequencies after the 26 GHz clearance deadline, even though in the absence of a negotiation period they would have won contiguous holdings in the 26 GHz band without the need for any frequency rearrangement;[113]
b) Increased complexity of the auction rules; and
c) Extending the duration of the auction process by two to three weeks.[114]

6.35 Overall, we consider that the evidence currently available to us would not support including a negotiation period in the auction. Nevertheless, we are open to considering this question further. We therefore invite any further relevant evidence from stakeholders and comments on our reasoning and on how the assignment stage would work if we were to include a negotiation period.

6.36 We also note that operators considering sharing mmWave radio equipment would need to ensure compliance with competition law, taking into account that such arrangements may limit infrastructure competition and lead to "less choice, lower quality of services, as well as delays in innovation", in addition to providing potential benefits.[115]

Decisions on the assignment stage

6.37 The decisions set out in paragraphs 6.38 - 6.43 below would not change if, following consideration of any further evidence we receive in response to this consultation, we were to decide to include a negotiation period in the assignment stage.

Assignment stage rounds, format and permissible assignment plans

6.38 In light of stakeholders' comments, we have decided to implement the following features of the design we proposed in the March 2023 Statement and Consultation (as described in more detail above):

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[112] Annex 8, paragraphs A8.5-A8.8.
[113] We outline this issue in more detail and explain its potential impact in Annex 8 paragraphs A8.11-A8.15.
[114] As outlined in Annex 9, if the assignment stage was to include a negotiation stage, bidders would have up to 10 working days to attempt to form valid adjacency agreements with each other.
[115] CMA's August 2023 Guidance, 'Guidance on the application of the Chapter I prohibition in the Competition Act 1998 to horizontal agreements', paras. 5.137-5.150. See, in particular, paragraphs 5.143-5.145 about the risks associated with network sharing agreements.

a) including three assignment stage rounds for the assignment of the 26 GHz band, and a single round for the assignment of the 40 GHz band;
b) adopting a sealed bid auction format with a second price rule; and
c) allowing bidders to bid only on specified options in which their holdings in each (principal stage) lot category would be contiguous (the "**permissible assignment plans**").

Information released at the end of the auction

6.39 As discussed in Section 5, we will publish the results of the principal stage ahead of the assignment stage. Therefore, all bidders will know the total number of qualified bidders for each assignment round and, in the case of the initial assignment of 26 GHz, whether certain locations would be automatically assigned to certain bidders.[116]

6.40 In the March 2023 Statement and Consultation,[117] we said that after the auction Ofcom would publish details of all assignment stage bids, without specifying which information we would make available to bidders at the end of each assignment stage round. For clarification, we are now specifying that following the end of each assignment round, bidders will be informed about their own assignment. Bidders will only be informed of the assignments held by other bidders at the end of the auction process.

6.41 VMO2[118] asked whether we intend to publish full bid data at some point after the auction, adding that "VMO2 supports publication". We confirm that following the end of the auction process, we intend to publish the assignment stage bid data.

Unsold spectrum in the 26 GHz band

6.42 In line with our consultation proposals, we have decided that any unsold lot in the 26 GHz lower lot category will be placed as a single contiguous block at the bottom portion of the 26 GHz band and any unsold spectrum in the 26 GHz upper lot category will be placed as a single contiguous block at the top portion of the 26 GHz band.

No re-bidding for unsold spectrum

6.43 We have considered VMO2's suggestion that we integrate unsold lots into the assignment round and make these available to bidders through assignment stage bidding (at prices below the reserve price), which we consider is unnecessary. As noted in Section 5, we have set conservatively low reserve prices. Enabling bidding for lots during the assignment stage rounds would complicate bidding in the assignment stage and could distort the principal stage, since the potential for lower priced spectrum could incentivise bidders to withhold demand at the principal stage.

Provisional decisions on the assignment stage

6.44 We have provisionally decided that we would adopt the assignment stage rules for the final assignment stage round for the 26 GHz band and the single assignment stage round for the

[116] For example, if only one bidder won spectrum for both 26 GHz lower and 26 GHz upper in the principal stage, then all bidders would know that in the initial assignment of 26 GHz it would take the central location in the band. See para. 5.52.
[117] March 2023 Statement and Consultation, para. A9.121.
[118] VMO2, p. 28.

40 GHz band that we proposed in the March 2023 Statement and Consultation. We also provide below clarifications in response to queries set out in VMO2's response.

6.45 We discuss in Annex 9 how these provisional decisions would change if, following consideration of any further evidence we receive in response to this consultation, we were to decide to include a negotiation period.

Clarification on permissible assignment rules

6.46 Firstly, VMO2[119] sought clarifications on the scheduling of the assignment rounds when "there is only one winning bidder in 26 GHz lower, and no bidding is required". If there is no need to place bids for the assignment of 26 GHz lower, bids would only be placed for the 40 GHz band. If we do not include a negotiation period, the bids for 40 GHz would then be processed in advance of bidders submitting bids for the assignment of 26 GHz upper.

6.47 Secondly, VMO2[120] sought clarifications on the reference to "the remaining part of the band" in paragraph A9.86 of the March 2023 Statement and Consultation, where we proposed that "*[b]idders who have won both 26 GHz lower lots and 26 GHz upper lots, but have not won the uppermost portion of the 26 GHz lower lot category could only bid for assignments in the remaining part of the band*." We confirm that, in line with VMO2's understanding, such bidders could only bid for assignments in the 26 GHz upper lot category above that of the bidder assigned to the top of the 26 GHz lower lot category, but below any bidders that may have only won spectrum in the 26 GHz upper lot category.

6.48 Finally, we confirm that in the hypothetical assignment stage scenario described by VMO2[121] its interpretation of the assignment bid options is correct, assuming (i) that there would be other bidders who have won either only 26 GHz lower or only 26 GHz upper lots; and (ii) that the "bidder D" mentioned in the first bullet point on VMO2's response is actually "bidder B".

Clarification on unsold spectrum in the 40 GHz band

6.49 VMO2[122] asked us to clarify how the assignment of any unsold lot of 40 GHz would be determined.

6.50 We have considered whether it would be beneficial to incorporate rules governing the location of any unsold spectrum in the 40 GHz band, such as we have decided to do in the 26 GHz band. In this regard, we note that we have identified the following potential differences in value in the 40 GHz spectrum we are awarding:

a) The frequency blocks currently licensed to MBNL (40.50-40.75 GHz and 42.00-42.25 GHz) are the most intensively used parts of the 40 GHz band and the new users will have to coordinate around MBNL's fixed links until revocation of these links takes effect. Therefore, until the 40 GHz band is cleared of existing links in/around high density areas,

[119] VMO2, p. 28.
[120] VMO2, p. 27.
[121] VMO2, p. 27. Specifically, VMO2 asked us to consider a hypothetical scenario where "two bidders, B and C win spectrum in both 26 GHz categories", "B wins 3@26L and 5@26U", "C wins 3@26L and 3@26U", and "[n]o other bidders win split awards". VMO2 asked if "Bidders C and D [sic] will be assigned to the top 6 lots of 26L" and if "[t]hey must compete with each other for their position in this range". They also asked "if Bidders B and C will be assigned to the bottom 8 lots of 26U" and if "Bidder C wins the top 3 lots in 26L" then Bidder C would "be assigned to the bottom 3 lots and Bidder B to the 5 lots immediately above Bidder C" with no further bidding being required for 26 GHz upper.
[122] VMO2, p. 28.

new users' ability to deploy in the 40 GHz band is likely to be more constrained in these spectrum blocks.[123]

b) The restriction on antenna elevation that we have decided to include in the award licences (which could restrict licensees' ability to use the spectrum for integrated access and backhaul) will apply only in relation to outdoor base stations transmitting in the top 1 GHz of the 40 GHz band (42.5-43.5 GHz). Those transmitting in the bottom 2 GHz (40.5-42.5) will not be subject to this restriction;[124]

c) Deployments in 40 GHz will need to be coordinated within 50km of the radio astronomy site at Cambridge.[125] The practical impact is that deploying medium power base stations in the Cambridge high density area is likely to be more challenging in 42.5-43.5 GHz than in 40.5-42.5 GHz.[126] However, also in 40.5-42.5 GHz the challenge is likely to remain substantial because medium power base stations using these frequencies could require additional mitigations, which could include height reduction or additional out-of-block filtering.[127]

6.51 Despite these differences, we are minded not to include any assignment stage rules governing the location of unsold spectrum in the 40 GHz band, other than to require that any unsold 40 GHz lots are treated as a single contiguous block. This is because we consider the assignment stage bidding mechanism should already enable bidders to indicate their own preferred locations, which should mean any unsold spectrum ends up in the frequencies that are least favoured by bidders.

Consultation questions

Question 1: Do you agree with our provisional decisions to (i) adopt the assignment stage rules we initially proposed in the March 2023 Statement and Consultation, and (ii) not include any rules governing the location of unsold spectrum in the 40 GHz band beside requiring that any unsold 40 GHz lots are treated as a single contiguous block?

Question 2: Do you agree that, given the downsides of including a negotiation period in the award that we have identified, we should not include a negotiation period to give bidders the opportunity to agree 'adjacency agreements' with other bidders? If you consider that we should include a negotiation period, please provide evidence in support of your arguments.

Question 3: If you consider that we should have a negotiation period, do you agree with our proposed design for the negotiation period, as set out in Annex 9 (including our proposed approach to the assignment of unsold spectrum in the 40 GHz band)?

[123] September 2023 Statement, paras. 4.67—4.69. As noted in paragraph 4.68 (footnote 131) of the September 2023 Statement, we have offered to allow MBNL to continue to operate up to 500 fixed links until 1 January 2030, subject to a number of conditions. Should MBNL take up this option, we will continue to coordinate deployments around the relevant links until January 2030.

[124] September 2023 Statement, paras. 4.71—4.84 and paras. 7.28-7.35; and the technical licence condition set out in paragraph 8 of Schedule 1 to the "Sample Award licence" in Annex 4 (Sample Shared Access licence).

[125] September 2023 Statement, para. 4.82.

[126] September 2023 Statement, para. 4.78.

[127] September 2023 Statement, paras. 4.79 and 4.80. As noted in the September 2023 Statement (para. 4.80), this assessment is subject to the uncertainties over the out-of-block emissions performance of real equipment.

Next Steps

6.52 In early 2024, we intend to publish a statement setting out our final decisions as to whether or not we will include a negotiation period into the assignment stage of the auction and the specific assignment stage rules that will apply.

A1. Responding to this consultation

How to respond

A1.1 Ofcom would like to receive views and comments on the issues raised in this document, by 5pm on 9 January 2024.

A1.2 You can download a response form from https://www.ofcom.org.uk/consultations-and-statements/category-1/mmwave-spectrum-for-new-uses. You can return this by email or post to the address provided in the response form.

A1.3 If your response is a large file, or has supporting charts, tables or other data, please email it to mmWave.allocation@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet.

A1.4 Responses may alternatively be posted to the address below, marked with the title of the consultation:

Enabling mmWave spectrum for new uses
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 We welcome responses in formats other than print, for example an audio recording or a British Sign Language video. To respond in BSL:

- send us a recording of you signing your response. This should be no longer than 5 minutes. Suitable file formats are DVDs, wmv or QuickTime files; or
- upload a video of you signing your response directly to YouTube (or another hosting site) and send us the link.

A1.6 We will publish a transcript of any audio or video responses we receive (unless your response is confidential)

A1.7 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt of a response submitted to us by email.

A1.8 You do not have to answer all the questions in the consultation if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A1.9 It would be helpful if your response could include direct answers to the questions asked in the consultation document. The questions are listed at Annex 4. It would also help if you could explain why you hold your views, and what you think the effect of Ofcom's proposals would be.

A1.10 If you want to discuss the issues and questions raised in this consultation, please contact Roberto Borello by email to mmWave.allocation@ofcom.org.uk

Confidentiality

A1.11 Consultations are more effective if we publish the responses before the consultation period closes. This can help people and organisations with limited resources or familiarity with the issues to respond in a more informed way. So, in the interests of transparency and good regulatory practice, and because we believe it is important that everyone who is interested in an issue can see other respondents' views, we usually publish responses on the Ofcom website at regular intervals during and after the consultation period.

A1.12 If you think your response should be kept confidential, please specify which part(s) this applies to and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we don't have to edit your response.

A1.13 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.14 To fulfil our pre-disclosure duty, we may share a copy of your response with the relevant government department before we publish it on our website.

A1.15 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further in our Terms of Use.

Next steps

A1.16 Following this consultation period, Ofcom plans to publish a statement in early 2024.

A1.17 If you wish, you can register to receive mail updates alerting you to new Ofcom publications.

Ofcom's consultation processes

A1.18 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in Annex 2.

A1.19 If you have any comments or suggestions on how we manage our consultations, please email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

A1.20 If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact the corporation secretary:

A1.21 Corporation Secretary
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA
Email: corporationsecretary@ofcom.org.uk

A2. Ofcom's consultation principles

Ofcom has seven principles that it follows for every public written consultation:

Before the consultation

A2.1 Wherever possible, we will hold informal talks with people and organisations before announcing a big consultation, to find out whether we are thinking along the right lines. If we do not have enough time to do this, we will hold an open meeting to explain our proposals, shortly after announcing the consultation.

During the consultation

A2.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A2.3 We will make the consultation document as short and simple as possible, with an overview of no more than two pages. We will try to make it as easy as possible for people to give us a written response.

A2.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A2.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and aim to reach the largest possible number of people and organisations who may be interested in the outcome of our decisions. Ofcom's Consultation Champion is the main person to contact if you have views on the way we run our consultations.

A2.6 If we are not able to follow any of these seven principles, we will explain why.

After the consultation

A2.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish the responses on our website at regular intervals during and after the consultation period. After the consultation we will make our decisions and publish a statement explaining what we are going to do, and why, showing how respondents' views helped to shape these decisions.

A3. Consultation coversheet

Basic details

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

Confidentiality

Please tick below what part of your response you consider is confidential, giving your reasons why

- Nothing ☐
- Name/contact details/job title ☐
- Whole response ☐
- Organisation ☐
- Part of the response ☐

If you selected 'Part of the response', please specify which parts:

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

Yes ☐ No ☐

Declaration

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom aims to publish responses at regular intervals during and after the consultation period. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here.

Name Signed (if hard copy)

A4. Consultation questions

A4.1 We invite responses to the questions listed below.

Question 1: Do you agree with our provisional decisions to (i) adopt the assignment stage rules we initially proposed in the March 2023 Statement and Consultation, and (ii) not include any rules governing the location of unsold spectrum in the 40 GHz band beside requiring that any unsold 40 GHz lots are treated as a single contiguous block?

Question 2: Do you agree that, given the downsides of including a negotiation period in the award that we have identified, we should not include a negotiation period to give bidders the opportunity to agree 'adjacency agreements' with other bidders? If you consider that we should include a negotiation period, please provide evidence in support of your arguments.

Question 3: If you consider that we should have a negotiation period, do you agree with our proposed design for the negotiation period, as set out in Annex 9 (including our proposed approach to the assignment of unsold spectrum in the 40 GHz band)?

A5. Consideration of a clock auction with exit bids

A5.1 As set out in paragraph 5.6, Vodafone[128] said that if we proceed with a clock auction, it would prefer "a simpler format with exit bids" – "a 'best and final' offer for marginal lots whose point total is less than or equal to the reduction in eligibility that happens during a round". It said that this change would allow bids that decrease demand to cause unsold spectrum; and bidders would be able to place optional 'exit bids' when decreasing spectrum for the lots they have just decreased by.

A5.2 We set out our detailed analysis below. In summary, while Vodafone's proposed design could reduce aggregation and substitution risks for bidders, we will not adopt it for the mmWave award because:

i) it could cause unsold spectrum even after initial excess demand;
ii) it could incentivise gaming bids, and hence undermine truthful bidding;
iii) it could undermine price discovery;
iv) it would add complexity to the clock design; and
v) it is a less common design, which could pose challenges for some bidders.

A5.3 Vodafone's proposal of a clock auction with exit bids would fundamentally change the auction design. Such an auction would allow bidders to cause unsold spectrum, essentially making it a package auction, changing the benefits and drawbacks substantially compared to both the clock and SMRA designs.

A5.4 The benefit we see from allowing decreases in spectrum that allow unsold spectrum is that this would make it easier for bidders to change their demand irrespective of the amount of excess demand. Bidders would be freely able to decrease their demand, without the risk of winning an amount of spectrum in between their desired quantities. For example, a bidder that decreases its demand from 8 lots to 4 lots would not risk winning 7, 6 or 5 lots, and would be able to move any eligibility points freed up into other bands. Such a design would eliminate, or at least strongly mitigate, aggregation and substitution risks for the bidder.

A5.5 However, such a design would also introduce different risks. As acknowledged in Vodafone's response, such a design would introduce the risk of unsold spectrum in the situations where there is initially excess demand in a lot category. Vodafone's proposed design aims to mitigate this by allowing a bidder to submit additional bids (exit bids) for the lots it has decreased by. So, in the example above where a bid to decrease is from 8 to 4 lots, the bidder could additionally submit bids for up to 4 lots (effectively bidding for a total number of 8, 7, 6 and/or 5 lots) at lower prices than the clock price. In addition, exit bids themselves have their own complications, as suggested by Vodafone's proposal that bidders would need the ability to withdraw them in case this would cause a bidder to bid above their budget. Furthermore, the design proposed by Vodafone may need a further stage to sell spectrum in case there are still unsold spectrum lots caused by being able to change demand without being restricted by the amount of excess demand.

A5.6 Additionally, we see further issues caused by the design proposed by Vodafone, which are:

[128] Vodafone response to the March 2023 Statement and Consultation, pp. 4-5.

a) There are substantial gaming risks of allowing bidders to cause unsold spectrum. One example is that bidders can bid to increase prices for competitors and remove the benefit of price discovery. For example, a bidder could bid for a larger amount of spectrum than it wants, drive the price up for a number of rounds, and then reduce its demand substantially and cause unsold spectrum. This could be particularly problematic where a bidder doesn't want any spectrum in a lot category.
b) There is a risk that bidders can circumvent the eligibility rule, which is designed to encourage truthful bidding and to give bidders information to inform their bidding strategies. This can be done late in the auction (i.e. when excess demand is low in all lot categories) by decreasing demand in one lot category, submitting exit bids close to the clock price, and moving demand to other lot categories. The bidder in this case would have been able to effectively increase their total demand in eligibility points, by having exit bids that can win in the original lot category, as well as clock bids in the new lot category.

A5.7 Were we to adopt the design proposed by Vodafone, we would need to mitigate the risks outlined above, which would also limit the benefits of this format. Examples of how to do this could be that bidders could only cause unsold spectrum up to a certain number of lots and/or mandatory additional bids would have to be placed every certain number of lots a bidder decreases by.

A5.8 In light of the above, we consider that the design proposed by Vodafone would represent a large deviation from both the SMRA and clock auction we proposed in the consultation, and bidders who have not participated in such an auction before are likely to be less familiar with it. We also consider this to be a more complicated design generally, given (i): the potential to place additional bids in a round to get the most benefit, (ii) the need to potentially withdraw exit bids placed in earlier rounds, and (iii) bidders needing to anticipate potential gaming bids or actions from other bidders.

A6. Illustrative auction procedures for the principal stage

Introduction

A6.1 In Sections 3, 4 and 5, we set out our decisions on the lot structure and design of the principal stage of the auction of the 26 and 40 GHz bands, as well as on reserve prices and some practical aspects of the auction. The illustrative auction procedures set out in this annex are intended to provide a more detailed description of how the auction process would work for the principal stage.

A6.2 As noted in paragraph A9.1 of the March 2023 Statement and Consultation[129], we are providing these procedures for illustrative purposes only, so that stakeholders can obtain a more in depth understanding of the auction design that we have decided to adopt for the principal stage of the auction. However, there are strict rules on the drafting of legislation, and it might well be that there are changes and adjustments to the processes that are necessary for that reason.

A6.3 Next year, we will consult on a draft version of the regulations setting out the auction rules (the "**Auction Regulations**"). The terms used in this annex for illustrative purposes may not reflect those in the Auction Regulations. For the avoidance of doubt, in the case of any difference, the Auction Regulations will take precedence.

Application and initial deposit

A6.4 Applicants will be required to provide Ofcom with certain information in order to apply to participate in the auction. The information to be provided to Ofcom, the deadline for its submission and the form of submission will be specified by Ofcom.

A6.5 Along with their application, applicants will be required to submit an initial monetary deposit of £100,000, which might be forfeited in whole or in part if the applicant subsequently breaches the Auction Regulations. Any interest on deposits will be retained by Ofcom and passed to HM Treasury.

A6.6 After the deadline for applications, Ofcom will notify each applicant of the name of every other applicant and its "associates" (i.e., every person having a material interest in the other applicants' businesses). Applicants will then need to ensure they comply with the auction rules which will not allow for two or more associated applicants to participate in the auction (the "bidder association rules").[130] They will need to do so by a deadline specified by Ofcom, and it may be the case that some applicants have to withdraw their application to prevent another applicant from failing to qualify in the auction.

[129] March 2023 Statement and Consultation

[130] Other qualification criteria to ensure that applicants are suitable to hold a licence will also apply. The provisions for qualification are similar to those used in recent awards by Ofcom and will be specified in the Auction Regulations.

A6.7 After the deadline for complying with the bidder association rules, Ofcom will assess which applicants qualify to participate in the auction. To do so, Ofcom may require additional information from specific applicants.

A6.8 Following the last day for withdrawals from the award, Ofcom will determine the list of qualified applicants (i.e., "bidders"), and return the initial deposit to any applicants who fail to qualify. Only qualified applicants will be allowed to participate in the auction.

A6.9 Before the first round of the auction takes place, each bidder will need to provide an additional deposit to Ofcom of at least £900,000, which will determine the bidder's initial eligibility limit. This will be in addition to the initial monetary deposit of £100,000. The initial eligibility limit will determine the maximum number of lots that the bidder can bid for in the first round of the auction.

Electronic Auction System

A6.10 The auction will be run over the internet using an Electronic Auction System ("**EAS**"). No specialist hardware or software will be required on bidders' terminals, as the EAS interface will run on a standard web browser.

A6.11 Ofcom also expects to make a stand-alone version of the software available to applicants a few days after they have applied to participate in the auction. This software will replicate the EAS and will be available to bidders until shortly before the auction begins. Applicants will be able to use it to practise bidding, as part of their internal training.

Lot structure

Lot categories

A6.12 We will make licences for the relevant spectrum available for bidding in the following lot categories, which all relate to the use of spectrum in high density areas:

a) **26 GHz lower**: this lot category consists of 7x200 MHz lots of spectrum in the frequency range 25.1-26.5 GHz.
b) **26 GHz upper**: this lot category consists of 5x200 MHz lots of spectrum in the frequency range 26.5-27.5 GHz.
c) **40 GHz**: this lot category consists of 15x200 MHz lots of spectrum in the frequency range 40.5-43.5 GHz.

Eligibility

A6.13 The eligibility points associated with each lot within a lot category are:

a) 2 eligibility points for each of the 7 lots of spectrum in the 26 GHz lower lot category.
b) 2 eligibility points for each of the 5 lots of spectrum in the 26 GHz upper lot category.
c) 1 eligibility point for each of the 15 lots of spectrum in the 40 GHz lot category.

Principal stage

Use of frequency generic lots

A6.14 The first stage of the auction (the "principal stage") determines the number of frequency generic lots that each bidder would win in each lot category, and the associated prices for these lots. The specific frequencies are then determined in the assignment stage.

Clock auction format

A6.15 The principal stage uses the clock auction format.

Overview of the principal stage

A6.16 The principal stage consists of a number of rounds. In the first round, bidders request a number of lots, in each lot category, at the first round prices (which are equal to the reserve prices set by Ofcom).

A6.17 In each of the following rounds, Ofcom defines a range of prices for each lot in every lot category, by announcing an opening price and a clock price for each lot category. The opening price is the lowest price in the range and the clock price is the highest price in the range. Bidders must specify through bids how their demand changes (if at all) across the range of prices in each lot category. Bidders can either:

a) maintain their demand from the previous round at all prices up to and including the clock price by submitting a bid to maintain demand, or
b) request to change their demand from the previous round by specifying: (i) the bid type (i.e. a simple bid to decrease demand, an all of nothing bid to decrease demand or a bid to increase demand), (ii) the number of lots by which they wish to change their demand and (iii) the price (in the range) from which they request their demand to change. The nominated price of any changes in demand must be a price expressed in whole thousands of pounds and must be between, and including, the opening price and the clock price.

A6.18 At the end of each round, each bid to maintain demand is fully applied, while each bid to change demand is processed to check whether the change can be fully, partially, or not at all applied. A bid to decrease demand is fully applied if the change does not cause unsold spectrum in a lot category, while a bid to increase demand is fully applied if the change does not cause the bidder to exceed its eligibility limit.

A6.19 At the end of each round, if there is excess demand in at least one lot category, prices increase in all lot categories with excess demand and the principal stage continues. The principal stage ends when there is no excess demand in any lot category.

Scheduling of rounds

A6.20 Ofcom will inform bidders of the round schedule for each bidding day. We expect to set rounds that last between 15 to 45 minutes and intend to provide bidders with at least 15 minutes' notice before the start of a round.[131]

[131] We expect to set rounds with a longer duration early in the auction.

A6.21 When a round is scheduled, the start and the end time of the round will be announced by Ofcom.

First round in the principal stage

Prices

A6.22 The prices in the first round are the reserve prices set by Ofcom. Specifically, they are:

a) £2m for each of the 7 lots of spectrum in the 26 GHz lower lot category.
b) £2m for each of the 5 lots of spectrum in the 26 GHz upper lot category.
c) £1m for each of the 15 lots of spectrum in the 40 GHz lot category.

Bid submission

A6.23 In the first round, bidders request a number of lots at the first round prices in each lot category.

A6.24 Subject to their eligibility limit (which is described below), bidders can request any number of lots from zero up to the available supply in each lot category.

Bidder's eligibility limit for the first round

A6.25 Bidders begin the first round with a set number of eligibility points. This is their "**eligibility limit**" for the first round.

A6.26 Each bidder's eligibility limit for the first round is calculated as: the bidder's deposit divided by £1 million, up to a maximum of 39 eligibility points.[132]

A6.27 A bidder's combination of bids (for each lot category) in the first round must not exceed the bidder's eligibility limit in that round. For example, if a bidder's eligibility limit for the first round is 24 eligibility points, the bidder could place bids for 3 lots in 26 GHz lower, 3 lots in 26 GHz upper, and 12 lots in 40 GHz. This is for a total of (3x2) + (3x2) + (12x1) = 24 eligibility points, and thus within the limit.

A6.28 The bidder cannot submit bids for a total of eligibility points higher than its eligibility limit. The EAS will warn the bidder in such a situation.

End of the first round

A6.29 Each bidder ends the round committed to pay a certain price per lot (the "**posted price**"[133]) for a licence including a certain quantity of lots in each lot category (the "**posted demand**").

A6.30 At the end of the first round, each bidder's posted demand is equal to the number of lots requested in the bidder's first round bid, with posted prices equal to first round prices (and to the reserve prices).

A6.31 Excess demand in a lot category is calculated as the difference between the aggregate demand for lots and the available supply of lots. Excess demand can be positive (i.e., there is excess demand in the lot category), negative (i.e., there is excess supply in the lot category), or zero (i.e., aggregate demand is equal to supply).

[132] The calculation is rounded down to the nearest whole number in the event that the calculation results in a number that is not an integer.
[133] A separate posted price is associated with each lot category and is the same for all bidders.

Second and following rounds in the principal stage

Prices

A6.32 At the start of the second and following rounds in the principal stage of the auction, Ofcom will announce a range of prices for each lot category consisting of all price levels (i.e. all prices expressed in whole thousands of pounds) between an "opening price" and a "clock price". Specifically:

a) The **opening price** is the lowest price in the range; it is equal to the previous round's posted price.
b) The **clock price** is the highest price in the range; it is the maximum to which the price for that lot category can rise in the current round.

Bid submission

A6.33 Each bidder begins the round committed to pay the opening price for each lot included in its previous round's posted demand in every lot category. Bidders must specify through bids how their demand changes across the range of prices in each lot category.

A6.34 Each bidder can submit any one of the following types of bids in a lot category, which we outline in more detail below providing illustrative examples: [134]

a) Bid to maintain demand;
b) Simple bid to decrease demand;
c) All or nothing bid to decrease demand;
d) Bid to increase demand.

A6.35 Where a bidder submits a bid to change its demand in a lot category (bids (b), (c) or (d) above), such a bidder will be targeting a specific amount of lots. For ease of reference, in this annex we call this the "**targeted amount**", which is calculated by summing the bidder's posted demand from the previous round and the change in demand targeted by the bidder in the current round. Where a bidder maintains demand (bid (a) above), its targeted amount is the posted demand in the last round.

A6.36 For example, a bidder's posted demand in the previous round is 10 lots. In the current round, the bidder submits a simple bid to decrease demand by 2 lots. The targeted amount will therefore be: 10 – 2 = 8 lots.

Bid types

Bid to maintain demand

A6.37 A "**bid to maintain demand**" is a commitment to pay any price level from the opening price up to (and including) the round's clock price for each lot included in the posted demand from the previous round.[135]

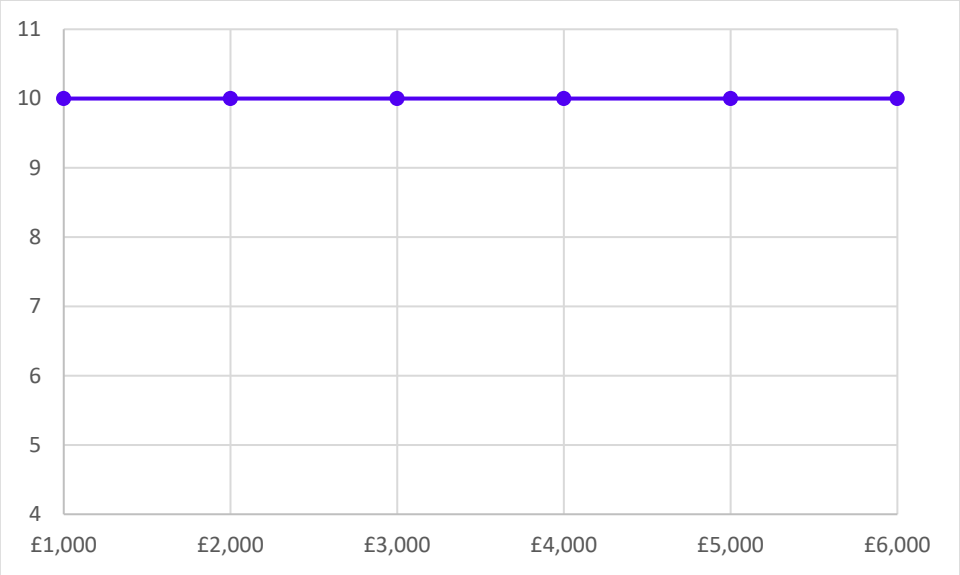
A6.38 For example, a bidder's posted demand in the previous round is 10 lots. In the current round, the opening and clock prices are £1,000 and £6,000 respectively. The bidder submits a bid to maintain demand. As shown in figure A6.1, this means that the bidder commits to

[134] For simplicity, in this annex, we refer to each of these types of bids as single bids. However, as explained in the examples given below, each bid to maintain, decrease or increase demand effectively includes a set of bids (or commitments), where each bid/commitment specifies a number of lots for each price level between the opening and the clock price.
[135] In essence, a bidder submits a bid to maintain demand when it wants to bid for the same number of lots in a round as its posted demand in the previous round at any price up to the clock price.

pay up to £6,000 (i.e. £1,000, £2,000, £3,000, £4,000, £5,000 or £6,000) per lot for a licence including 10 lots.

A6.39 When submitting a bid to maintain demand, a bidder only specifies that it maintains demand in a lot category. The bidder does not need to expressly specify a nominated price because a bid to maintain demand implies that the bidder is willing to pay any price level up to (an including) the clock price in order to maintain its posted demand from the previous round.

Figure A6.1: example of a bid to maintain demand[136]



The vertical axis represents the number of lots requested by the bidder in each lot category. The horizontal axis represents the price level the bidder is committed to pay for each lot.

Simple bid to decrease demand

A6.40 As set out above, a bid to decrease demand can be either a **"simple bid"** or an **"all or nothing bid"**. A bidder submits a bid to decrease demand, in a lot category, when it wants to bid for a lower number of lots in a round compared to its posted demand in the previous round.

A6.41 When submitting a "**simple bid to decrease demand"**, a bidder specifies: (i) by how many lots it wishes to decrease its previous round's posted demand and (ii) the price from which it wishes its decrease to be applied (the "**nominated price**"); this price can be any price level (expressed in whole thousands of pounds) between and including the opening and clock prices.[137]

A6.42 For example, a bidder's posted demand in the previous round is 10 lots. In the current round, the opening and clock prices are £1,000 and £6,000 respectively. The bidder submits a simple bid to decrease demand by 2 lots (so the targeted amount is 8 lots) at a price of £3,000 per lot (so the nominated price is £3,000). As shown in figure A6.2, this means that the bidder commits to pay:

- up to £3,000 (i.e. £1,000, £2,000 or £3,000) per lot for a licence including 10 lots;

[136] Each dot represents a commitment from the example above.
[137] By default, the EAS software will select the opening price for any bids to change demand, which bidders can then change and select a higher price level.

- £3,000 per lot for a licence including 8 or 9 lots (with a preference for 8 lots, rather than 9 or 10, if the price rises to £3,000 per lot; see the green dot in figure A6.2); or
- up to £6,000 (i.e. £4,000, £5,000, or £6,000) per lot for a licence including 8 lots, if the price rises above £3,000.

Figure A6.2: example of simple bid to decrease demand[138]

The vertical axis represents the number of lots requested by the bidder in each lot category. The horizontal axis represents the price level the bidder is committed to pay for each lot.

All or nothing bid to decrease demand

A6.43 A bidder submits an **"all or nothing bid to decrease demand"**, in a lot category, when it wants to bid for a lower number of lots compared to its posted demand in the previous round, and it does not wish to risk winning an amount in between its posted demand and the targeted amount**.** An all or nothing bid is therefore used when the bidder wishes to decrease its posted demand or, if such a decrease cannot be fully applied, maintain its posted demand from the previous round at any price level up to the clock price.

A6.44 As for a simple bid to decrease demand, when submitting an all or nothing bid to decrease demand, a bidder specifies: (i) by how many lots it wishes to decrease its previous round's posted demand and (ii) the nominated price from which it wishes its decrease to be applied. The nominated price can be any price level (expressed in whole thousands of pounds) between and including the opening and clock prices. To place an all or nothing bid to decrease demand, a bidder also needs to specify that the decrease is conditional on it being fully applied and that the bidder is otherwise wishing to pay up to the clock price for each lot included in its posted demand in the previous round. In practice, bidders will be able to express this commitment by selecting a relevant option in the EAS (i.e., the "All or Nothing" option).

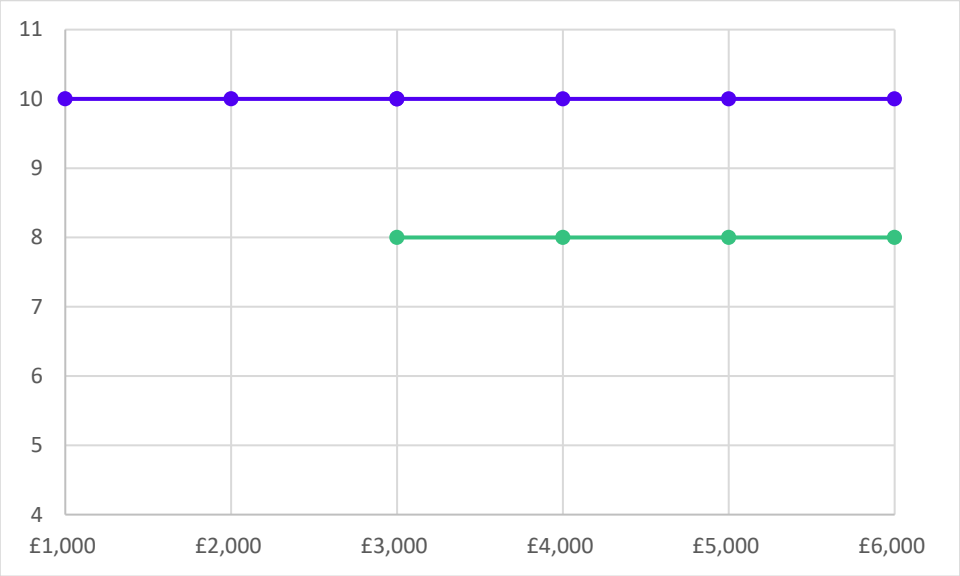
[138] Each dot represents a commitment from the example above. The green dot represents the bidder's preference where there are multiple commitments at the same price.

A6.45 An all or nothing bid to decrease can only be placed for a reduction of 2 or more lots (and not for a reduction of 1 lot).

A6.46 For example, a bidder's posted demand in the previous round is 10 lots. In the current round, the opening and clock prices are £1,000 and £6,000 respectively. The bidder submits an all or nothing bid to decrease demand by 2 lots (so the targeted amount is 8 lots) at a price of £3,000 per lot (so the nominated price for the decrease is £3,000). As shown in figure A6.3, this means that the bidder commits to pay:

- from £3,000 to £6,000 per lot (including £3,000 and £6,000) for a licence including 8 lots, which is the bidder's preference if (i) the price per lot rises to (or above) £3,000 and (ii) the decrease targeted by the bidder is fully applied; or
- from £1,000 to £6,000 per lot (including £1,000 and £6,000) for a licence including 10 lots, if (i) the price per lot does not rise above £3,000; or (ii) the price per lot rises above £3,000 and the decrease targeted by the bidder is not fully applied.[139]

Figure A6.3: example of an all or nothing bid to decrease demand[140]



The vertical axis represents the number of lots requested by the bidder in each lot category. The horizontal axis represents the price level the bidder is committed to pay for each lot.

Bid to increase demand

A6.47 A bidder submits a "**bid to increase demand"** when it wants to bid for a higher number of lots in a round compared to its posted demand.

A6.48 When submitting a bid to increase demand, a bidder specifies: (i) by how many lots it wishes to increase its previous round's posted demand and (ii) a price within and including the opening and clock prices (the nominated price). As explained in more detail from paragraph A6.56 below, in this case the nominated price is only used for establishing the order in which the bid is processed. In particular, if a bidder submits two bids to increase demand in two

[139] That is, the bidder prefers to finish the round with a commitment to pay for a licence including 8 lots, rather than 10, if the price per lot rises to £3,000 or higher.

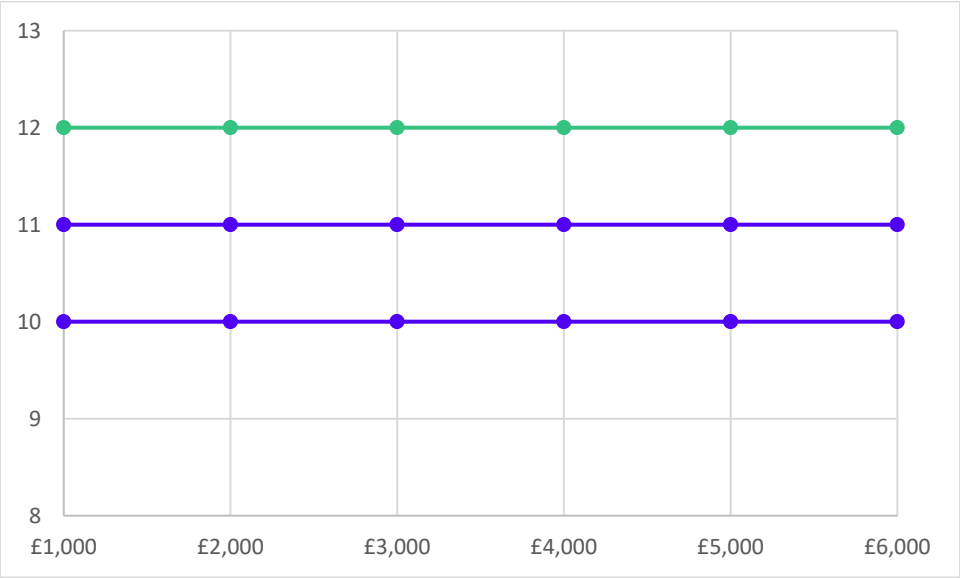
[140] Each dot represents a commitment from the example above. The green dots represent the bidder's preference where there are multiple commitments at the same price.

different lot categories within the same round, the bid with the lower nominated price will be processed first.

A6.49 A bid to increase demand is a commitment to pay any price level from the opening price up to (and including) the round's clock price for each lot included in the previous round's posted demand, the targeted amount, or any number of lots in between these quantities, with a preference for the targeted amount at any price level (in figure A6.4 below, see the green dots).

A6.50 For example, a bidder's posted demand in the previous round is 10 lots. In the current round, the opening and clock prices are £1,000 and £6,000 respectively. The bidder submits a bid to increase demand by 2 lots (so the targeted amount is 12 lots) at a nominated price of £3,000. The bidder commits to pay any price level between £1,000 and £6,000 (including £6,000) for a licence including 10, 11 or 12 lots, with a preference for 12 lots.[141]

Figure A6.4: Example of a bid to increase demand[142]



The vertical axis represents the number of lots requested by the bidder in each lot category. The horizontal axis represents the price level the bidder is committed to pay for each lot.

Submitting bids

A6.51 In each round, bidders will submit bids in the EAS. At any time before the end of the round, a bidder can modify its bids by submitting different bids. At the end of the round, the last submitted bid in each lot category is deemed the bidder's bid.

A6.52 Where a bidder does not specify a bid for a lot category, Ofcom will deem that the bidder has submitted:

[141] The bidder therefore commits to:
- 10 lots at a price per lot of £1,000, £2,000, £3,000, £4,000, £5,000 or £6,000;
- 11 lots at a price per lot of £1,000, £2,000, £3,000, £4,000, £5,000 or £6,000; or
- 12 lots at a price per lot of £1,000, £2,000, £3,000, £4,000, £5,000 or £6,000;

with a preference for 12 lots, instead of 10 or 11, at any price level.

[142] Each dot represents a commitment from the example above. The green dots represent the bidder's preference where there are multiple commitments at the same price.

a) a simple bid to decrease the previous round's posted demand to 0 lots, at the opening price, if the previous round's posted demand is greater than 0; or
b) a simple bid to maintain the previous round's posted demand, if the previous round's posted demand was 0.

Bidder's eligibility limit for the second and following rounds

A6.53 Bidders begin the second and following rounds with an eligibility limit equal to the eligibility points associated with their posted demand for each of the lot categories, processed in the previous round. Therefore, a bidder's eligibility limit for the next round is the sum of:

- 2 multiplied by the posted demand in 26 GHz lower;
- 2 multiplied by the posted demand in 26 GHz upper; and
- the posted demand in 40 GHz.

A6.54 When submitting bids in a round, a bidder cannot exceed its eligibility limit. This means that the eligibility used by a bidder for the submission of bids in a round (the "**used eligibility**") must be equal to, or lower than, the eligibility limit. The used eligibility is the sum of:

- 2 multiplied by the targeted amount in 26 GHz lower;
- 2 multiplied by the targeted amount in 26 GHz upper; and
- the targeted amount in 40 GHz.

A6.55 The bidder will be unable to submit its bids (for each lot category) in a round if its used eligibility would be higher than its eligibility limit. The EAS will warn the bidder in such a situation. An example is provided in box A6.1 below.

Box A6.1: Examples of how the eligibility limit works

Example 1

Suppose there are two lot categories, 26 GHz lower and 40 GHz. Suppose the bidder's posted demand from the previous round is:

- 5 lots in 26 GHz lower;
- 2 lots in 40 GHz.

The bidder's eligibility limit for the current round is therefore: (5x2) + (2x1) = 12.

In this round, the bidder tries to submit the following bids:

- In 26 GHz lower, a simple bid to decrease by 2 lots (to 3 lots);
- In 40 GHz, a bid to increase by 3 lots (to 5 lots).

The bidder's used eligibility would therefore be: (3x2) + (5x1) = 11.

As the bidder does not exceed its eligibility limit, it will be able to submit its bids.

Example 2

Suppose the same set up as before. However, in this example, the bidder tries to submit the following bids:

- In 26 GHz lower, a bid to maintain;
- In 40 GHz, a bid to increase by 3 lots (to 5 lots).

The bidder's used eligibility would therefore be: (5x2) + (5x1) = 15.

As the bidder would exceed its eligibility limit, it will not be able to submit its bids. The EAS will warn the bidder and it will be required to modify its bids.

Bid processing

A6.56 Once the round has ended, Ofcom collects all the bids and processes them to determine the round results. After bid processing is completed, Ofcom informs each bidder of the outcome of its bids (as explained in paragraph A6.70 below).

A6.57 As per the first round, each bidder will end each round committed to pay a certain price per lot (the "**posted price**"[143]) for a licence including a certain quantity of lots in each lot category (the "**posted demand**"). The process by which posted demand and posted prices are determined in the second and subsequent rounds is explained from paragraph A6.58 below.

Processing bids

A6.58 As noted above, associated with each bid to maintain, decrease, or increase demand are commitments for a number of lots, between the bidder's posted demand from the previous round and its targeted amount in the current round, at all price levels between the opening price and the clock price. For simplicity, we say that, at the end of the bid processing:

a) a bid to maintain or change demand is "**fully applied**" where Ofcom selects a bidder's commitment associated with its targeted amount;
b) a bid to change demand is "**partially applied**" where Ofcom selects a bidder's commitment associated with a number of lots which is different from its posted demand in the previous round and its targeted amount;
c) a bid to change demand is "**not applied at all**" where Ofcom selects a bidder's commitment associated with its posted demand in the previous round.[144]

A6.59 Bids to maintain or change demand are **fully applied** in these circumstances:

a) A bid to maintain demand is always fully applied.
b) A bid to decrease demand is fully applied if it does not cause excess demand in the bid's lot category to drop below (or further below) zero.
c) A bid to increase demand is fully applied if it does not cause the bidder's eligibility limit to be exceeded.

A6.60 As explained in more detail below, once all bids to maintain demand have been fully applied, all bids to change demand are processed starting with those whose nominated price is closer to the opening price of their lot category. Where two or more bids in the same lot category have the same nominated price, their processing order is randomly selected.

A6.61 In the event that a bid to increase or a simple bid to decrease cannot be fully applied, Ofcom would check whether it can be partially applied.[145] In the case of a:

a) bid to **decrease** demand, selecting the bidder's commitment with the smallest amount of lots that would not cause excess demand to drop below (or further below) zero; or

[143] A separate posted price is associated with each lot category, and is the same for all bidders.
[144] Bids can be processed multiple times. This is done to check whether a bid that is initially partially applied or not applied at all can later on be applied to a larger degree (or even fully applied) given the processing of other bids.
[145] All or nothing bids cannot be partially applied.

b) bid to **increase** demand, selecting the bidder's commitment with the largest amount of lots that would not exceed the bidder's eligibility limit.

A6.62 Box A6.2 below provides an example of a fully applied bid, a partially applied bid, and a bid which has not been applied at all.

Box A6.2: Example of bids which are fully applied, partially applied, and not applied at all

Suppose there is one lot category, 26 GHz lower. The opening price is 100[146] and the clock price is 105. Excess demand at the end of the last round was 5 lots.

Suppose the following bids are submitted and are processed in the following order:

1) Bidder A, bid to maintain.
2) Bidder B, simple bid to decrease by 2 lots (at a price of 100).
3) Bidder C, simple bid to decrease by 4 lots (at a price of 102).
4) Bidder D, simple bid to decrease by 3 lots (at a price of 104).

The bids are processed starting with those whose nominated price is closer to the opening price (as will be explained in more detail from paragraph A6.63 below). Specifically, the bids are processed as follows:

1) Bidder A, bid to maintain: fully applied as it does not violate either of the two rules: (i) **excess demand remains at 5 lots**; (ii) the bidder's eligibility limit is not exceeded as the same quantity is maintained.
2) Bidder B, simple bid to decrease by 2 lots: fully applied as it does not violate either of the two rules: (i) **excess demand is now equal to 3 lots**; (ii) the bidder's eligibility limit is not exceeded as the bidder has submitted a bid for a lower targeted amount.
3) Bidder C, simple bid to decrease by 4 lots: partially applied as applying it fully would cause negative excess demand (excess demand would be -1). Bidder C's posted demand is decreased by 3 lots. **Excess demand is 0**.
4) Bidder D, simple bid to decrease by 3 lots: not applied at all, as applying it fully or partially would cause negative excess demand.

Order of processing bids

A6.63 All simple bids to maintain are always processed first, and fully applied.

A6.64 All bids to change demand (that is, bids to increase, simple bids to decrease, and all or nothing bids to decrease) are processed starting with those whose nominated price is closer to the opening price of their lot category. Specifically, the processing order is determined as follows:

a) For each bid, the EAS calculates the "**price point**", which is a percentage calculated as the difference between the nominated price and the opening price, divided by the

[146] In the auction, prices will be expressed in whole thousands of pounds. In this and the following examples, prices are expressed in smaller amounts for simplicity.

difference between the clock price and the opening price. E.g. if, in a round, the nominated price, opening price, and clock prices are 105, 100, and 110 respectively, the price point is equal to 50% ([105 – 100] / [110 – 100]);

b) All the bids are sorted in ascending order of price points into a processing "**queue**" or "**ranking list**";

c) In the event of multiple bids with the same price point, those bids would be entered in the queue in a random order.

A6.65 When a bid to maintain, decrease or increase demand is:

a) Fully applied, it leaves the queue, which means that no further processing is needed in respect of that bid;

b) Partially applied, the part of the bid that was applied leaves the queue while the remaining part stays in its position in the queue;

c) not applied at all, the bid stays in its position in the queue.

A6.66 When a bid to maintain, decrease or increase demand is fully applied or, in the case of a bid to change demand, that bid is partially applied, processing restarts at the beginning of the queue to check whether preceding bids can now be fully or partially applied.

A6.67 Bid processing ends when all bids to maintain, decrease or increase demand in the queue have been processed and no bid remaining in the queue can be fully or partially applied. Those bids remaining in the queue can then be discarded.

A6.68 Box A6.3 below outlines how the EAS would process bids and execute the queue.

Box A6.3: Example of a step by step bid processing

Step (a) Process and fully apply all bids to maintain demand.

Step (b) Collect all remaining bids and calculate their price points.

Step (c) Sort all bids in ascending order of price points into a processing queue.

Step (d) Process the first bid in the queue (or go to step (f) if there are no more bids in the queue that can be applied fully or partially).

1) If the bid is applied fully, remove the bid from the queue. Then, move to step (e).

2) If the bid is partially applied, remove the part of the bid that can be applied from the queue and leave the remaining part in its position in the queue. Then, move to step (e).

3) If the bid is not applied at all, leave the bid in its position in the queue. Then, move to step (e).

Step (e) Process the next bid in the queue (or go to step (f) if there are no more bids in the queue that can be fully or partially applied):

1) If the bid is fully applied, remove the bid from the queue. Then, return to step (d).

2) If the bid is partially applied, remove the part of the bid that can be applied from the queue and leave the remaining part in its position in the queue. Then, return to step (d).

3) If the bid is not applied at all, leave the bid in its position in the queue. Then, return to step (e).

Step (f) Discard all bids remaining in the queue (that is, the bids that cannot be fully or partially applied).

A6.69 An example of bid processing is provided in box A6.4 below.

Box A6.4: Example of processing bids

Suppose there are two bidders (bidder A and bidder B) and one lot category (26 GHz lower).

- Bidder A's posted demand from the previous round is 5 lots, and its eligibility limit for the current round is equal to 5x2 = 10 eligibility points.
- Bidder B's posted demand from the previous round is 5 lots, and its eligibility limit for the current round is equal to 5x2 = 10 eligibility points.

Excess demand is 3 lots. The opening and clock prices for the round are 100 and 105 respectively.

In the current round, the bids are the following:

- Bidder A, simple bid to decrease by 5 lots (to 0 lots) at price 102, which means a price point of 40%
- Bidder B, all or nothing bid to decrease by 4 lots (to 1 lot) at price 100, which means a price point of 0%.

After the round ends, bids are processed in order of price points.

Step (a)*:* Bidder B, all or nothing bid to decrease by 4 lots (to 1 lot) at price 100, is processed first as it has the lowest price point (0%).

If the bid were fully applied:

- Bidder B's eligibility would be 1x2 = 2 and thus within the eligibility limit.
- Excess demand would be -1, and thus below zero.

Bidder B's bid cannot be fully applied as it would cause excess demand to drop below 0. As it is an all or nothing bid, it cannot be partially applied. Thus, the bid is not applied at all.

Step (b)*:* Bidder A, simple bid to decrease by 5 lots (to 0 lots) at price 102, is processed next.

If the bid were fully applied:

- Bidder A's eligibility would be 0x2 = 0 and thus within the eligibility limit.
- Excess demand would be -2, and thus below zero.

Bidder A's bid cannot be fully applied as it would cause excess demand to drop below zero. The bid can be applied partially; demand is decreased by 3 lots (to 2) instead of the full 5 lots. Excess demand is now zero.

We reassess the bids in the queue from the start since A's bid was partially applied. Bidder B's bid cannot be fully or partially applied. Next, Bidder A's bid cannot be

fully or partially applied. At this point, bid processing ends because all bids in the queue have been processed and no bid remaining in the queue can be fully or partially applied.

Bidder A's posted demand is **2 lots**.

Bidder B's posted demand is **5 lots**.

The posted price per lot is 102, and excess demand is 0.

End of the round

A6.70 After the end of the round, the EAS informs each bidder of the bidder's results, showing the following information:

a) Whether each bid was fully applied, partially applied, or not applied at all;
b) The bidder's posted demand in every lot category;
c) The posted price in each lot category (which are determined as explained below); and
d) The bidder's eligibility limit for the next round.

Determining the posted prices

A6.71 After the end of the second and following rounds, the posted price in a lot category is determined as follows:

a) If excess demand is greater than zero, the posted price is set to the clock price.
b) If excess demand is zero and at least one bid (simple or all or nothing) to decrease demand was applied (either fully or partially) in the lot category, the posted price is set to the highest nominated price among all bids to decrease demand that was applied (either fully or partially).
c) in all other cases, the posted price is set to the opening price.

We provide examples for each scenario (a) – (c) above. For these examples, the opening price is 100 and the clock price is 105.

- At the end of the round, excess demand is 2. The posted price is therefore set to 105.
- At the end of the round, excess demand is 0. The highest nominated price among all bids to decrease demand that were applied (partially or fully) was 104, associated with an all or nothing bid to decrease that was fully applied. The posted price is therefore set to 104.
- At the end of the round, excess demand is 0. No bid to decrease demand was applied. The posted price is therefore set to 100.

Conclusion of the principal stage

A6.72 The principal stage continues to a further round if, after the end of the current round, excess demand is greater than zero in at least one of the three lot categories.

A6.73 The principal stage ends if, at the end of the current round, excess demand is equal to or less than zero in all three lot categories. The round will be referred to as the "**final principal stage round"** and, for every lot category:

a) Each bidder would win its posted demand in the final principal stage round.
b) Each bidder would be committed to pay the sum which is equal to:

i) the posted demand in 26 GHz lower multiplied by the posted price (per lot) in 26 GHz lower;
ii) the posted demand in 26 GHz upper multiplied by the posted price (per lot) in 26 GHz upper; and
iii) the posted demand in 40 GHz multiplied by the posted price (per lot) in 40 GHz.

Information policy

Information released before the beginning of the principal stage

A6.74 Before the beginning of the principal stage, each bidder is informed of the following:

a) the start and end time for the first round;
b) the first round prices for each lot category; and
c) the bidder's eligibility limit for the first round.

Information released at the end of each principal stage round

A6.75 After the end of each principal stage round, except the final principal stage round, each bidder would be informed of the following:

a) a summary of bids submitted by the bidder in the most recent round;
b) the posted demand of the bidder for each lot category in the most recent round;
c) the posted price for each lot category in the most recent round;
d) the start and end time for the next principal stage round;
e) the opening and clock prices for each lot category for the next principal stage round;
f) the bidder's eligibility limit for the next principal stage round; and
g) the excess demand for each lot category in the most recent round.

Information released at the end of the principal stage

A6.76 At the end of the principal stage, each bidder is informed that the principal stage has concluded.

A6.77 Each bidder is informed of the following:

a) the bidder's total number of lots won in each lot category and the associated price; and
b) every other bidder's total number of lots won in each lot category and the associated price.
c) the number of unsold lots in each lot category, if any.

Example of bid submission and processing

A6.78 The following section illustrates how the principal stage works, through bidding and the processing of bids.

A6.79 For simplicity, both examples A6.1 and A6.2 assume only two lot categories (26 GHz lower and 40 GHz), instead of the three lot categories of the auction. The lot structure is the same as in the real auction (7 lots available in 26 GHz lower and 15 lots available in 40 GHz). The eligibility points for each band are also the same as in the real auction (2 eligibility points for

each 26 GHz lower lot and 1 eligibility point for each 40 GHz lot). Price increments between rounds are fixed and equal to 10 for 26 GHz lower and 5 for 40 GHz. There are two bidders (bidder A and B) with initial eligibility limits of 24 and 15 points respectively.

A6.80 Example A6.1 is from the point of view of bidder A, showing a stylised and simplified example of what the bidder sees and the bids it submits.

A6.81 Example A6.2 illustrates all bidders' actions (A and B), as well as the mechanics of bid processing as performed by Ofcom. Bidders would not be able to see the bid processing mechanism, but we have included this to illustrate the implementation of the rules.

Example A6.1: bid submission

Bidder A begins the auction with an eligibility limit of 24 points.

Round 1

At the beginning of the round, the EAS will present bidder A with the following information:

Table A6.1: information provided to bidder A at the beginning of round 1

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
First round price	100	50	
Bidder A			Eligibility limit: 24

Bidder A enters the following bids:

- 26 GHz lower, bid for 7 lots.
- 40 GHz, bid for 10 lots.

Bidder A's bids are:

- For a number of lots lower than or equal to each lot category's available supply.
- Within the bidder's eligibility limit: (7x2) + (10x1) = 24.

Thus, bidder A will be allowed to submit its bids.

At the end of the round, once bid processing is completed, the EAS informs Bidder A of the following results:

Table A6.2: information provided to bidder A at the end of round 1

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder A	Posted demand: 7 lots	Posted demand: 10 lots	Eligibility: (7x2) + (10x1) = 24
Excess demand	5 lots	0 lots	
Posted price	100	50	

The principal stage continues to round 2.

Round 2

At the beginning of the round, the EAS will present bidder A with the following information:

Table A6.3: information provided to bidder A at the beginning of round 2

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Opening price	100	50	
Clock price	110	55	
Bidder A	Posted demand from the previous round: 7 lots	Posted demand from the previous round: 10 lots	Eligibility limit: 24

Bidder A enters the following bids:

- 26 GHz lower, simple bid to decrease by 1 lot (to 6 lots), at a nominated price of 105 per lot;
- 40 GHz, bid to maintain demand (at 10 lots).

Bidder A's used eligibility is: (6x2) + (10x1) = 22. The eligibility limit is not exceeded.

Thus, bidder A will be allowed to submit its bids.

At the end of the round, once bid processing is completed, the EAS informs Bidder A of the following results:

Table A6.4: information provided to bidder A at the end of round 2

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder A submitted bid	Simple bid to decrease by 1 lot (to 6 lots) at price 105. **Fully applied.**	Bid to maintain (at 10 lots)	
Bidder A posted demand	6 lots	10 lots	Eligibility: 22
Excess demand	2 lots	4 lots	
Posted price	110	55	

The principal stage continues to round 3.

Round 3

At the beginning of the round, the EAS will present bidder A with the following information:

Table A6.5: information provided to bidder A at the beginning of round 3

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Opening price	110	55	
Clock price	120	60	
Bidder A	Posted demand from the previous round: 6 lots	Posted demand from the previous round: 10 lots	Eligibility limit: 22

Bidder A enters the following bids:

- 26 GHz lower, all or nothing bid to decrease by 2 lots (to 4 lots), at a nominated price of 113;
- 40 GHz, bid to maintain demand (at 10 lots).

Bidder A's used eligibility is 18. The eligibility limit is not exceeded.

Thus, bidder A will be allowed to submit its bids.

At the end of the round, once bid processing is completed, the EAS informs Bidder A of the following results:

Table A6.6: information provided to bidder A at the end of round 3

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder A submitted bid	All or nothing bid to decrease by 2 lots (to 4 lots) at price 113. **Fully applied**.	Bid to maintain (at 10 lots)	
Bidder A posted demand	4 lots	10 lots	Eligibility: 18
Excess demand	0 lots	4 lots	
Posted price	113	60	

The principal stage continues to round 4.

Round 4

At the beginning of the round, the EAS will present bidder A with the following information:

Table A6.7: information provided to bidder A at the beginning of round 4

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Opening price	113	60	
Clock price	123	65	
Bidder A	Posted demand from the previous round: 4 lots	Posted demand from the previous round: 10 lots	Eligibility limit: 18

Bidder A enters the following bids:

- 26 GHz lower, bid to maintain demand (at 4 lots);
- 40 GHz, all or nothing bid to decrease by 5 lots (to 5 lots), at a nominated price of 60.

Bidder A's used eligibility is 13. The eligibility limit is not exceeded.

Thus, bidder A will be allowed to submit its bids.

At the end of the round, once bid processing is completed, the EAS informs Bidder A of the following results:

Table A6.8: information provided to bidder A at the end of round 4

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder A submitted bid	Bid to maintain demand (at 4 lots)	All or nothing bid to decrease by 5 lots (to 5 lots) at price 60. **Not applied at all**.	
Bidder A posted demand	4 lots	10 lots	Eligibility: 18
Excess demand	0 lots	0 lots	
Posted price	113	65	

Bidder A will be informed that the principal stage has ended, how much spectrum it has won, and the corresponding price to pay.

- Bidder A wins 4 lots in 26 GHz lower and 10 lots in 40 GHz. Bidder A pays (4x113) + (10x65) = 1102.

Example A6.2: bid processing

Bidder A and bidder B begin the auction with an eligibility limit of 24 and 15 points respectively.

Round 1

The prices for the first round and the bids from the two bidders are as shown in the table below.

Table A6.9: prices and submitted bids for round 1

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
First round price	100	50	
Bidder A	Bids for 7 lots	Bids for 10 lots	Eligibility limit: 24 Used eligibility: (7x2) + (10x1) = 24
Bidder B	Bids for 5 lots	Bids for 5 lots	Eligibility limit: 15 Used eligibility: (5x2) + (5x1) = 15

In the first round, all bids are fully applied. Thus, at the end of the round, the results are as follows:

Table A6.10: results for round 1

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder A	Posted demand: 7 lots	Posted demand: 10 lots	Eligibility: (7x2) + (10x1) = 24
Bidder B	Posted demand: 5 lots	Posted demand: 5 lots	Eligibility: (5x2) + (5x1) = 15
Aggregate demand	12 lots	15 lots	
Excess demand (aggregate demand minus available supply)	5 lots	0 lots	
Posted price	100	50	

Since there is excess demand in 26 GHz lower, the principal stage continues to round 2.

Round 2

The prices for the second round and the bids from the two bidders are as shown in the table below.

Table A6.11: prices and submitted bids for round 2

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Opening price	100	50	
Clock price	110	55	
Bidder A	Simple bid to decrease by 1 lot (to 6 lots) at a nominated price of 105 per lot	Bid to maintain (at 10 lots)	Eligibility limit: 24 Used eligibility: 22
Bidder B	Simple bid to decrease by 2 lots (to 3 lots) at a nominated price of 107 per lot	Bid to increase by 4 lots (to 9 lots) at a nominated price of 53 per lot	Eligibility limit: 15 Used eligibility: 15

Once all bids are submitted, the EAS processes the bids as follows:

Step (a): process and fully apply all bids to maintain demand

As it is a bid to maintain the previous demand, Bidder A's bid in 40 GHz is processed first, and it is fully applied.

Step (b): collect all bids to change demand and calculate their price points

- Bidder A, 26 GHz lower: (105 – 100) / (110 – 100) = 50%
- Bidder B, 26 GHz lower: (107 – 100) / (110 – 100) = 70%
- Bidder B, 40 GHz: (53 – 50) / (55 – 50) = 60%.

Step (c): sort all bids in ascending order of price points into a queue

- Bidder A, 26 GHz lower, -1 (to 6 lots)[147], price point: 50%
- Bidder B, 40 GHz, +4 (to 9 lots), price point: 60%
- Bidder B, 26 GHz lower, -2 (to 3 lots), price point: 70%

[147] For simplicity, throughout this example, we identify:

- a simple bid to decrease with the notation (–) followed by the number of lots the bidder requests to decrease its demand by.
- a bid to increase with the notation (+) followed by the number of lots the bidder requests to increase its demand by.
- an all or nothing bid with the notation AON (-) followed by the number of lots the bidder requests to decrease its demand by.

Step (d): process the bids in the queue

Bidder A, 26 GHz lower, -1 (to 6 lots) is processed first. The bid is fully applied as bidder A stays within its eligibility limit for the round and does not cause excess demand to drop below 0. The bid is fully applied and leaves the queue. **Excess demand in 26 GHz is now 4 lots. Eligibility for bidder A is now: (6x2) + (10x1) = 22.**

Thus, the queue is now:

~~1) Bidder A, 26 GHz lower, -1 (to 6 lots), price point: 50%~~

2) Bidder B, 40 GHz, +4 (to 9 lots), price point: 60%

3) Bidder B, 26 GHz lower, -2 (to 3 lots), price point: 70%

Bidder B, 40 GHz, +4 (to 9 lots) is processed next. The bid cannot be fully or partially applied, as bidder B would exceed its eligibility limit for the round. This is because the bidder is already at its eligibility limit of 15. Therefore, the bid is not applied at all and remains in the queue. **Excess demand in 40 GHz is now 0 lots. Eligibility for bidder B is now: (5x2) + (5x1) = 15.**

Bidder B, 26 GHz lower, -2 (to 3 lots) is processed next. The bid is fully applied and leaves the queue. **Excess demand in 26 GHz is now 2 lots. Eligibility for bidder B is now: (3x2) + (5x1) = 11**

Thus, the queue is now:

~~1) Bidder A, 26 GHz lower, -1 (to 6 lots), price point: 50%~~

2) Bidder B, 40 GHz, +4 (to 9 lots), price point: 60%

~~3) Bidder B, 26 GHz lower, -2 (to 3 lots), price point: 70%~~

The queue is retested from the beginning. **Bidder B, 40 GHz, +4 (to 9 lots)** is processed next. The bid is fully applied and leaves the queue. **Excess demand in 40 GHz is now 4 lots. Eligibility for bidder B is now: (3x2) + (9x1) = 15**

Thus, the queue is now:

~~1) Bidder A, 26 GHz lower, -1 (to 6 lots), price point: 50%~~

~~2) Bidder B, 26 GHz lower, -2 (to 3 lots), price point: 70%~~

~~3) Bidder B, 40 GHz, +4 (to 9 lots), price point: 80%~~

Step (e): bid processing ends

At the end of the round, the results are as follows:

Table A6.12: results for round 2

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder A	Posted demand: 6 lots	Posted demand: 10 lots	Eligibility: 22

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder B	Posted demand: 3 lots	Posted demand: 9 lots	Eligibility: 15
Aggregate demand	9 lots	19 lots	
Excess demand (aggregate demand minus available supply)	2 lots	4 lots	
Posted price	110 (clock price, as excess demand is greater than zero)	55 (clock price, as excess demand is greater than zero)	

Since there is excess demand in 26 GHz lower and 40 GHz, the principal stage continues to round 3.

Round 3

The prices for the third round and the bids from the two bidders are as shown in the table below.

Table A6.13: prices and submitted bids for round 3

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Opening price	110	55	
Clock price	120	60	
Bidder A	All or nothing bid to decrease by 2 lots (to 4 lots) at a nominated price of 113 per lot	Bid to maintain (at 10 lots)	Eligibility limit: 22 Used eligibility: 18
Bidder B	Simple bid to decrease by 1 lot (to 2 lots) at a nominated price of 115 per lot	Bid to increase by 2 lots (to 11 lots) at a nominated price of 58 per lot	Eligibility limit: 15 Used eligibility: 15

Once all bids are submitted, the EAS processes the bids as follows:

Step (a): as it is a bid to maintain the previous demand, Bidder A's bid in 40 GHz is processed first, and it is fully applied.

Step (b):

Bidder A, 26 GHz lower: 30%

Bidder B, 26 GHz lower: 50%

Bidder B, 40 GHz: 60%.

Step (c):

Bidder A, 26 GHz lower, AON -2 (to 4 lots), price point: 30%

Bidder B, 26 GHz lower, -1 (to 2 lots), price point: 50%

Bidder B, 40 GHz, +2 (to 11 lots), price point: 60%

Step (d):

Bidder A, 26 GHz lower, AON -2 (to 4 lots) is processed first. The bid can be fully applied, so it is fully applied and leaves the queue. **Excess demand in 26 GHz is now 0 lots. Eligibility for bidder A is now 18.**

Thus, the queue is now:

~~1) Bidder A, 26 GHz lower, AON -2 (to 4 lots), price point: 30%~~

2) Bidder B, 26 GHz lower, -1 (to 2 lots), price point: 50%

3) Bidder B, 40 GHz, +2 (to 11 lots), price point: 60%

Bidder B, 26 GHz lower, -1 (to 2 lots) is processed. The bid cannot be fully or partially applied as it would cause excess demand to drop below 0 (excess demand would be -1). The bid remains in the queue. **Excess demand in 26 GHz is now 0 lots. Eligibility for bidder B is now 15.**

Bidder B, 40 GHz, +2 (to 11 lots) is processed. The bid cannot be fully or partially applied, as bidder B would exceed its eligibility limit for the round. This is because the bidder is already at its eligibility limit of 15. The bid remains in the queue. **Excess demand in 40 GHz is now 4 lots. Eligibility for bidder B is now 15.**

Thus, the queue is now:

~~1) Bidder A, 26 GHz lower, AON -2 (to 4 lots), price point: 30%~~

2) Bidder B, 26 GHz lower, -1 (to 2 lots), price point: 50%

3) Bidder B, 40 GHz, +2 (to 11 lots), price point: 60%

Step (e): Bid processing ends and the remaining bids in the queue are discarded. At the end of the round, the results are as follows:

Table A6.14: results for round 3

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder A	Posted demand: 4 lots	Posted demand: 10 lots	Eligibility: 18
Bidder B	Posted demand: 3 lots	Posted demand: 9 lots	Eligibility: 15
Aggregate demand	7 lots	19 lots	

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Excess demand (aggregate demand minus available supply)	0 lots	4 lots	
Posted price	113 (price associated to the last bid which caused excess demand to drop to zero)	60 (clock price, as excess demand is greater than zero)	

Since there is excess demand in 40 GHz, the principal stage continues to round 4.

Round 4

The prices for the fourth round and the bids from the two bidders are as shown in the table below.

Table A6.15: prices and submitted bids for round 4

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Opening price	113	60	
Clock price	123	65	
Bidder A	Bid to maintain (at 4 lots)	All or nothing bid to decrease by 5 lots (to 5 lots) at a nominated price of 60	Eligibility limit: 18 Used eligibility: 13
Bidder B	Bid to maintain (at 3 lots)	Simple bid to decrease by 4 lots (to 5 lots) at a nominated price of 65.	Eligibility limit: 15 Used eligibility: 11

Once all bids are submitted, the EAS processes the bids as follows:

Step (a): as they are bids to maintain the previous demand, Bidder A's bid in 26 GHz lower and Bidder B's bid in 26 GHz lower are processed first, and they are fully applied.

Step (b):

- Bidder A, 40 GHz: 0%
- Bidder B, 40 GHz: 100%.

Step (c):

1) Bidder A, 40 GHz, AON -5 (to 5 lots), price point: 0%

2) Bidder B, 40 GHz, -4 (to 5 lots), price point: 100%

Step (d):

Bidder A, 40 GHz, AON -5 (to 5) is processed first. The bid is not applied at all as it would cause excess demand to drop below 0 (excess demand would be -1). The bid cannot be partially applied as it is an all or nothing bid. The bid remains in the queue. **Excess demand in 40 GHz is now 4 lots. Eligibility for bidder A is now 18.**

Bidder B, 40 GHz, -4 (to 5) is processed next. The bid can be fully applied, so it is fully applied and leaves the queue. **Excess demand in 40 GHz is now 0 lots. Eligibility for bidder B is now 11.**

Thus, the queue is now:

1) Bidder A, 40 GHz, AON -5 (to 5 lots), price point: 0%

~~2) Bidder B, 40 GHz, -4 (to 5 lots), price point: 50%~~

The queue is reassessed from the beginning. No more bids can be applied.

Step (e): Bid processing ends and the remaining bids in the queue are discarded. At the end of the round, the results are as follows:

Table A6.16: results for round 4

	26 GHz lower (supply: 7 lots)	40 GHz (supply: 15 lots)	
Bidder A	Posted demand: 4 lots	Posted demand: 10	Eligibility: 18
Bidder B	Posted demand: 3 lots	Posted demand: 5 lots	Eligibility: 11
Aggregate demand	7 lots	15 lots	
Excess demand (aggregate demand minus available supply)	0 lots	0 lots	
Posted price	113	65	

Since there is no excess demand in any lot category, the principal stage ends. Bidders win their last posted demand and pay – for each lot – the corresponding posted price.

- Bidder A wins 4 lots in 26 GHz lower and 10 lots in 40 GHz. Bidder A pays (4x113) + (10x65) = 1102.
- Bidder B wins 3 lots in 26 GHz lower and 5 lots in 40 GHz. Bidder A pays (3x113) + (5x65) = 664.

Deposits

Top up deposits during the principal stage

A6.82 At any point during the principal stage, Ofcom may require a bidder to increase its deposit up to an amount equal to the bidder's posted demand from the previous round multiplied by the posted prices for the relevant lot categories.

A6.83 In the event Ofcom requires one or more bidders to increase its deposit, Ofcom would specify a deadline for the relevant bidders to make any additional deposits and provide details of how to make the additional deposit.

A6.84 If the relevant bidder does not provide Ofcom with the top up deposit as required, it would not be allowed to submit bids in the next principal stage round nor in any subsequent principal stage rounds.[148]

A6.85 The bidder would not be excluded from the award process for not having provided the sufficient top up deposit, and it would still win its last posted demand (if any) in the final principal stage round. However, the bidder would not be granted a licence for its final processed demand lots unless it provides Ofcom with the total auction sum payable, following the end of the assignment stage.

Required final principal stage deposit

A6.86 After the final principal stage round, by a deadline to be specified by Ofcom, bidders need to have on deposit at least the sum of the "**total base price**"[149] for each of the 26 GHz lower, 26 GHz upper, and 40 GHz lot categories.

A6.87 If the bidder does not provide Ofcom with the required final principal stage deposit, it would not be excluded from the award process. However, it would not be allowed to submit assignment stage bids and would be deemed to have made valid assignment stage bids with a value of zero pounds for all its assignment stage options. The bidder would not be granted a licence for its final processed demand lots unless it provides Ofcom with the total auction sum payable, following the end of the assignment stage.

A6.88 Bidders who breach the Auction Regulations may forfeit part or all of their deposits.

Emergencies and extraordinary events

A6.89 Ofcom will retain powers to address proven cases of emergencies or extraordinary events that might otherwise compromise the auction, such as the powers to reschedule or rerun rounds, provide bidders with alternative means to submit their bids, disregard bids and exclude bidders. We will publish more information on how we intend to act in a proven case of emergency in the bidder guidance.

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[148] The bidder would also be unable to submit bids in the assignment stage and will be deemed to have made a valid bid for a value of 0 pounds for each of its assignment options. The assignment stage rules are discussed in detail in A7.

[149] A bidder's total base price is the sum of the amounts payable in respect of each lot category where the bidder has won any lot(s), calculated as the number of lots associated with a bidder's posted demand in the final principal stage round multiplied by the corresponding posted price (per lot) for the lot category.

A7. Illustrative auction procedures for the assignment stage (with no negotiation period)

Introduction

A7.1 In Section 6, we set out our decisions on the format and core features of the assignment stage as well our provisional decisions on the specific assignment stage rules if we decide not to include a negotiation period. The illustrative auction procedures set out in this annex are intended to provide a more detailed description of how the auction process would work for the assignment stage if we decide not to include a negotiation period.

A7.2 As noted in paragraph A9.1 of the March 2023 Statement and Consultation[150], these procedures are being shared only for illustrative purposes, so that stakeholders can obtain a more in depth understanding of the auction design that we have decided to adopt for the assignment stage of the auction. However, there are strict rules on the drafting of legislation, and it might well be that there are changes and adjustments to the processes that are necessary for that reason.

A7.3 Next year, we will consult on a draft version of the regulations setting out the auction rules (the "**Auction Regulations**"). The terms used in this annex for illustrative purposes may not reflect those in the Auction Regulations. For the avoidance of doubt, in the case of any difference, the Auction Regulations will take precedence.

Overview

A7.4 In the assignment stage, bidders bid for the specific frequencies of the generic lots of spectrum won in the principal stage.

A7.5 The assignment stage comprises of multiple rounds, where each round has a sealed bid auction format with a second price rule.

A7.6 Bidders place bids on their preferred frequencies and Ofcom determines the highest value combination of bids which could be accommodated. At the end of each assignment stage round, each bidder is assigned the frequencies in accordance with the winning combination. The price each bidder pays is calculated using the nearest-Vickrey price method.

Assignment stage rounds

A7.7 For the 40 GHz band, Ofcom would run:

i) A single assignment stage round for 40 GHz (40.5-43.3 GHz).[151]

A7.8 For the 26 GHz band, Ofcom would run up to three assignment stage rounds:

[150] March 2023 Statement and Consultation.

[151] Winning bidders would each be granted a single licence for the full 15-year term, corresponding to their 40 GHz frequencies as determined in the single assignment stage round for 40 GHz.

i) An initial assignment stage round for 26 GHz lower (25.1-26.5 GHz);
ii) An initial assignment stage round for 26 GHz upper (26.5-27.5 GHz);
iii) If required, a final assignment stage round for 26 GHz lower and upper (25.1-27.5 GHz).

A7.9 The single assignment stage round for 40 GHz and the initial assignment stage round for 26 GHz lower would be scheduled for the same time. Afterwards, the other 26 GHz band assignment stages would run sequentially, according to the list in paragraph A7.8.

A7.10 For the 26 GHz band, the final assignment stage round would only take place if the initial assignment stage rounds do not produce an assignment that gives all bidders contiguous holdings. Otherwise, if all winning bidders have contiguous holdings after the initial rounds, the final assignment stage round would not take place. Winning bidders would each be licensed to use the same contiguous holdings for 15 years.

Permissible assignment plans

A7.11 In every assignment stage round, Ofcom determines a set of "**permissible assignment plans**". These are all possible combinations of allocations of specific frequencies that ensure that:

a) Each bidder is assigned a frequency block which corresponds to the bandwidth it won in the principal stage.
b) Each bidder is assigned a contiguous frequency block.
c) Any unsold spectrum in the 26 GHz band meets the requirement listed in paragraph A7.19.
d) Any unsold spectrum in the 40 GHz band forms a contiguous frequency block to be located anywhere in the band. This point reflects the proposed approach on which we are currently consulting (see paragraph 6.49-6.51).

A7.12 The complete permissible assignment plans are only visible by Ofcom. Bidders are, instead, able to see in the EAS their "**assignment options**", i.e., the frequency blocks, within each permissible assignment plan, available to the bidder.

A7.13 Below we provide an example of permissible assignment plans and assignment options.

Box A7.1: Example of permissible assignment plans and assignment options

Consider two winning principal stage bidders (A and B) of 26 GHz lower. Available supply in 26 GHz lower is 7 lots as in the award.

Suppose that in the principal stage:

- Bidder A wins 3 lots in 26 GHz lower;
- Bidder B wins 4 lots in 26 GHz lower.

Ofcom determines that there are two permissible assignment plans (AS.1 and AS.2 in table A7.1 below). Bidder A's assignment options are highlighted in yellow. Bidder B's assignment options are highlighted in red.

Table A7.1: Example of permissible assignment plans

26 GHz lower (GHz)							
	25.1-25.3	25.3-25.5	25.5-25.7	25.7-25.9	25.9-26.1	26.1-26.3	26.3-26.5
AS.1	A			B			
AS.2	B				A		

Within each permissible assignment plan, the bidder only sees its assignment options. Tables A7.2 and A7.3 indicate what bidder A and B would respectively see.

Table A7.2: Assignment options visible to Bidder A

26 GHz lower (GHz)							
	25.1-25.3	25.3-25.5	25.5-25.7	25.7-25.9	25.9-26.1	26.1-26.3	26.3-26.5
AS.1	A						
AS.2					A		

Table A7.3: Assignment options visible to Bidder B

26 GHz lower (GHz)							
	25.1-25.3	25.3-25.5	25.5-25.7	25.7-25.9	25.9-26.1	26.1-26.3	26.3-26.5
AS.1				B			
AS.2	B						

Additional rules for permissible assignment plans for the 26 GHz band

A7.14 In addition to the points listed in paragraph A7.11, the permissible assignment plans for the 26 GHz band follow additional rules (listed below) depending on how many bidders have won spectrum in both the 26 GHz lower and upper lot categories in the principal stage.

A7.15 In the case that no bidder has won both 26 GHz lower lots and 26 GHz upper lots,

i) In the initial assignment stage round for 26 GHz lower, only bidders who have won 26 GHz lower lots would be presented with assignment options in that frequency range.

ii) In the initial assignment stage round for 26 GHz upper, only bidders who have won 26 GHz upper lots would be presented with assignment options in that frequency range.

iii) The final assignment stage round would not take place.

A7.16 In the case that only one bidder has won both 26 GHz lower lots and 26 GHz upper lots, that bidder would automatically be assigned the uppermost frequencies in 26 GHz lower and the lowermost frequencies in 26 GHz upper. Following this:

i) In the initial assignment stage round for 26 GHz lower, bidders who have won only 26 GHz lower lots would only be presented with assignment options in the lower portion of that frequency range.[152]

ii) In the initial assignment stage round for 26 GHz upper, bidders who have won only 26 GHz upper lots would only be presented with assignment options in the upper portion of that frequency range.[153]

iii) The final assignment stage round would not take place.

A7.17 In the case that **multiple bidders have won both 26 GHz lower lots and 26 GHz upper lots**, the assignment options available to these bidders would not overlap with the assignment options available to bidders who have only won 26 GHz lower lots or 26 GHz upper lots. Specifically:

i) In the initial assignment stage round for 26 GHz lower, bidders who have won only 26 GHz lower lots would only be presented with assignment options in the lower portion of that frequency range. Conversely, bidders who have won both 26 GHz lower lots and 26 GHz upper lots would only be presented with assignment options in the upper portion of 26 GHz lower.

ii) In the initial assignment stage round for 26 GHz upper, the bidder who has won the uppermost portion of 26 GHz lower would automatically be assigned the lowermost portion of 26 GHz upper. Conversely, bidders who have won only 26 GHz upper lots would only be presented with assignment options in the upper portion of that frequency range. Bidders who have won both 26 GHz lower lots and 26 GHz upper lots but have not won the uppermost portion of 26 GHz lower would only be presented with assignment options in the remaining part of the frequency range.[154]

A7.18 In the final assignment stage round, bidders who have won lots in both 26 GHz lower and upper would only be presented with assignment options for the upper portion of 26 GHz lower and the lower portion of 26 GHz upper.[155]

A7.19 If there is unsold spectrum:[156]

i) any unsold lot(s) in 26 GHz lower would be placed as one contiguous block at the lowermost portion of the 26 GHz band; and

ii) any unsold lot(s) in 26 GHz upper would be placed as one contiguous block at the uppermost portion of the 26 GHz band.

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[152] The lower portion of the frequency range, in this case, indicates the frequencies below those automatically assigned to the bidder which has won lots across both 26 GHz lower and 26 GHz upper.

[153] The upper portion of the frequency range, in this case, indicates the frequencies above those automatically assigned to the bidder which has won lots across both 26 GHz lower and 26 GHz upper.

[154] "Remaining" means any spectrum: (i) above the spectrum assigned to the bidder that won the uppermost portion of 26 GHz lower, and (ii) below the spectrum assigned to any principal stage winners of only 26 GHz upper lots. Therefore, if there is only one such bidder, it would be automatically assigned specific "remaining" frequencies and would not need to bid.

[155] Bidders who won spectrum in only 26 GHz lower or 26 GHz upper would not participate in the final assignment stage round.

[156] These rules on unsold lots would apply for both the initial assignment stage rounds for 26 GHz lower and upper, as well as the final assignment stage round of 26 GHz.

Assignment stage bids

A7.20 As mentioned, Ofcom determines a set of permissible assignment plans that meet the requirements listed in A7.11, and from A7.14 – A7.19.

A7.21 If there is only one permissible assignment plan that meets these requirements, then bidders would be assigned the frequencies in accordance with this permissible assignment plan. If there are multiple assignment plans that meet these requirements, then the bidders who would be assigned alternative frequencies under these different plans are invited to submit bids for assignment options.

A7.22 When placing an assignment stage bid, bidders specify the assignment option and the bid amount. The bid amount must be in whole thousands of pounds and at least zero.

A7.23 Bidders do not have to submit assignment stage bids to be assigned the lots they won in the principal stage. Participation in the bidding process of the assignment stage is optional. If a bidder chooses not to bid in one or more assignment stage rounds, Ofcom will interpret this as the bidder having submitted a bid of zero for all of its assignment options.

Bid submission

A7.24 Bidders bid through the EAS. For every round, the interface of the EAS will provide an assignment stage form that lists all assignment options available to the bidder.

A7.25 To submit its list of assignment stage bids, a bidder needs to enter on its assignment stage form the bid amount for each of the assignment options it wishes to bid for (the bid amount for any options left blank would be set to zero).

Determining the winning permissible assignment plan

A7.26 At the end of the assignment stage, Ofcom independently determines the winning plan in each assignment stage round.

A7.27 For each permissible assignment plan, Ofcom calculates the plan's total value by summing the bids for the plan. The winning assignment plan is the one with the greatest total value. If multiple plans yield the greatest value, one is selected randomly.

A7.28 Each bidder will be assigned frequencies in accordance with the winning permissible assignment plan.

Determining the additional prices

A7.29 "**Additional prices**" are the additional amounts winners pay for their specific frequencies. They are calculated independently for each assignment stage round. The total additional price to be paid by a bidder is equal to the sum of the additional prices (if any) payable by the bidder as a result of the initial assignment stage round for 26 GHz lower, the initial assignment stage round for 26 GHz upper, the final assignment stage round for 26 GHz lower and upper, and the single assignment stage round for the 40 GHz band.

A7.30 Additional prices are based on nearest-Vickrey pricing, which we detail below. This is the same pricing method used in our previous auctions.

Additional price calculation based on the nearest-Vickrey pricing

A7.31 The first step in finding the additional price is calculating the Vickrey prices. A bidder's Vickrey price is the opportunity cost of the bidder winning. It is the smallest amount the bidder could have bid and not be displaced by the next best alternative plan. This amount is found by:

a) Setting the bidder's non-winning bids to zero.
b) Reducing the bidder's winning bid until an alternative plan has the same total value.
c) The Vickrey price is the greater of zero and the reduced bid calculated in (b).

A7.32 Steps (a), (b) and (c) are repeated for each bidder.

A7.33 In many circumstances, the Vickrey prices are the additional prices.

A7.34 Sometimes, the sum of the Vickrey prices is less than the total value of an alternative plan.[157] This shortfall implies one or more bidders are willing to pay more for an alternative plan than the Vickrey total. In such a case, the Vickrey prices are raised for some bidders to satisfy the following four requirements.

A7.35 **First requirement:** Each bidder's additional price is between zero and its bid.

A7.36 **Second requirement:** The sum of additional prices must be sufficiently large that no bidder or group of bidders is willing to pay more for an alternative assignment. In this calculation, winning bids used in alternative plans are included at the additional price rather than the bid, and non-winning bids are reduced by the difference between the bidder's winning bid and the additional price.

A7.37 **Third requirement:** If multiple sets of additional prices satisfy the first and second requirements, Ofcom selects one that minimises the sum of additional prices.

A7.38 **Fourth requirement:** If there are multiple sets of additional prices that satisfy the first, second, and third requirements, Ofcom selects the one that is closest to the Vickrey prices. Nearest-Vickrey implies that the winners with surplus contribute equally to eliminate the shortfall identified in the second requirement. Mathematically, Ofcom minimises the following sum across all bidders through the following formula: $\sum(p_A-c_A)^2$, where p_A is the additional price for bidder A, and c_A is the Vickrey price for bidder A.

Example of assignment stage

A7.39 In this section, we provide an example of how bid submission and frequency allocation would work in the assignment stage. We also show how additional prices are calculated. The additional prices in the box A7.2 example are without a shortfall, whereas the box A7.3 example has a shortfall calculation and distribution.

A7.40 For box A7.2, we consider four principal stage winning bidders (A, B, C, and D), and only two lot categories (26 GHz lower and 26 GHz upper). This example assumes the same structure of the award (7 lots available in 26 GHz lower and 5 lots available in 26 GHz upper).

[157] Winning bids used in alternative plans are included at the additional price rather than the bid, and non-winning bids are reduced by the difference between the bidder's winning bid and the additional price.

A7.41 For box A7.3, we consider three principal stage winning bidders (A, B, and C) and only one lot category (40 GHz). This example assumes the same structure of the award (15 lots available in 40 GHz).

A7.42 To show the assignment stage rules in detail, both examples provide the permissible assignment plans as they would be seen by Ofcom (with the assignment options for each bidder). However, in the real award, each bidder would only be able to see its assignment options in a round.

Box A7.2: Example of assignment stage with no shortfall

Suppose that in the principal stage:

- Bidder A wins 2 lots in 26 GHz lower and 2 lots in 26 GHz upper;
- Bidder B wins 3 lots in 26 GHz lower and 1 lot in 26 GHz upper;
- Bidder C wins 2 lots in 26 GHz lower and 0 lots in 26 GHz upper;
- Bidder D wins 0 lots in 26 GHz lower and 2 lots in 26 GHz upper.

Multiple bidders (A and B) have won spectrum in both 26 GHz lower and 26 GHz upper.

Round (i): initial assignment stage round for 26 GHz lower

Permissible assignment plans

Ofcom determines that there are two permissible assignment plans, as shown in Table A.4 below. For easy visualization, we highlight bidder A's assignment options within those plans in yellow, bidder B's in red, and bidder C's in green.

Table A7.4: Permissible assignment plans and assignment options for the initial assignment stage round for 26 GHz lower

26 GHz lower							
	25.1-25.3	25.3-25.5	25.5-25.7	25.7-25.9	25.9-26.1	26.1-26.3	26.3-26.5
AS.1	C		A		B		
AS.2	C		B			A	

Bidder C would automatically be assigned the lower portion of 26 GHz lower (25.1-25.5 GHz).

Bidder A would be presented with the assignment options of 25.5-25.9 GHz, and 26.1-26.5 GHz.

Bidder B would be presented with the assignment options of 25.9-26.5 GHz, and 25.5-26.1 GHz.

Assignment stage bids

Each bidder bids[158] for their assignment options within the two permissible assignment plans (as shown in table A.5 below)

Bidder A bids 0 for the 25.5-25.9 GHz frequencies, and 70 for the 26.1-26.5 GHz frequencies.

Bidder B bids 0 for the 25.5-26.1 GHz frequencies, and 50 for the 25.9-26.5 GHz frequencies.

Bidder C is presented with only one permissible assignment option, which is the 25.1-25.5 GHz frequencies. For this reason, they cannot bid.

Table A7.5: Assignment stage bids

	26 GHz lower						
	25.1-25.3	**25.3-25.5**	**25.5-25.7**	**25.7-25.9**	**25.9-26.1**	**26.1-26.3**	**26.3-26.5**
AS.1	**C - 0**		**A - 0**		**B - 50**		
AS.2	**C - 0**		**B - 0**			**A - 70**	

Determining the winning permissible assignment plan

Ofcom determines which of the permissible assignment plans yields the highest total value:

- Option 1 yields a total value of 0+0+50 = 50.
- Option 2 yields a total value of 70.

Thus, in this case, the winning permissible assignment plan is Option 2 as it yields the highest value of 70.

Determining the prices

Firstly, we need to find the Vickrey price for each bidder's winning bid. We start with bidder A. We:

- reduce all of A's non-winning assignment stage bids to 0 (this does nothing since A had no other bids greater than 0);
- incrementally reduce bidder A's winning bid of 70, until an alternative permissible assignment plan has the same bid value as Option 2. A's bid is reduced down to 50, at which point Option 2 has the same bid value as Option 1.
- The Vickrey price for bidder A is 50.

Table A7.6: Assignment options with A's reduced bids

	26 GHz lower						
	25.1-25.3	**25.3-25.5**	**25.5-25.7**	**25.7-25.9**	**25.9-26.1**	**26.1-26.3**	**26.3-26.5**

[158] For the examples, we assume that prices and commitments must be in whole pounds. For the actual auction prices and commitments are in whole thousands of pounds.

26 GHz lower			
AS.1	C – 0	A - 0	B - 50
AS.2	C - 0	B - 0	A – 50 (reduced, originally 70)

We repeat these steps for bidder B and C. Since both have winning bids of 0 in Option 2, both of their Vickrey prices are 0.

Next, we check whether there is a shortfall caused by Vickrey prices. There is no shortfall since the sum of Vickrey prices (50) is equal to the only alternative assignment stage option 1 (50).

The winning frequencies and corresponding prices to pay are:

- Bidder A wins the 26.1-26.5 GHz frequencies and pays 50 (in addition to the base price determined in the principal stage).
- Bidder B wins the 25.5-26.1 GHz frequencies and pays 0 (in addition to the base price determined in the principal stage).
- Bidder C wins the 25.1-25.5 frequencies GHz and pays 0 (in addition to the base price determined in the principal stage).

Round (ii): initial assignment stage round for 26 GHz upper

Permissible assignment plans

Ofcom determines that there is one permissible assignment plan, as shown in table A7.7 below.

Table A7.7: Permissible assignment plans and assignment options for the initial assignment stage round for 26 GHz upper

26 GHz upper (GHz)					
	26.5-26.7	26.7-26.9	26.9-27.1	27.1-27.3	27.3-27.5
AS.1	A		B	D	

In round 1, bidder A won the 26.1-26.5 GHz frequencies (i.e. the uppermost part of 26 GHz lower). Thus, bidder A will automatically be assigned the lowermost part of 26 GHz upper.

Bidder D is the only bidder to have won lots in only 26 GHz upper. Bidder D is therefore automatically assigned the uppermost frequencies.

Bidder B can therefore only win the remaining frequencies 26.9 – 27.1 GHz.

As there is only a single permissible assignment plan, bidders will be automatically assigned the frequencies without bidding in round 2. Thus,

- Bidder A is assigned the 26.5-26.9 GHz frequencies and pays 0.
- Bidder B is assigned the 26.9-27.1 GHz frequencies and pays 0.
- Bidder D is assigned the 27.1-27.5 GHz frequencies and pays 0.

Round (iii): Final assignment stage round for 26 GHz

Permissible assignment plans

Ofcom determines that there are two permissible assignment plans, as shown in table A7.8 below.

Table A7.8: Permissible assignment plans and assignment options for the final assignment stage round for 26 GHz

	26 GHz (GHz)											
	25.1-25.3	25.3-25.5	25.5-25.7	25.7-25.9	25.9-26.1	26.1-26.3	26.3-26.5	26.5-26.7	26.7-26.9	26.9-27.1	27.1-27.3	27.3-27.5
AS.1	C		A				B				D	
AS.2	C		B				A				D	

Only bidders A and B participate in round 3. This is because these bidders have won lots in both the 26 GHz lot categories. Bidder C and D will keep the frequencies won during the initial assignment stage rounds, at the lowermost and uppermost parts of the 26 GHz band respectively.

Assignment stage bids

Each bidder bids for their assignment options within the two permissible assignment plans (see table A7.9):

- Bidder A bids 0 for the 25.5-26.3 GHz frequencies, and 40 for the 26.3-27.1 GHz frequencies.
- Bidder B bids 10 for the 25.5-26.3 GHz frequencies, and 0 for the 26.3-27.1 GHz frequencies.

Table A7.9: Assignment stage bids

	26 GHz (GHz)											
	25.1-25.3	25.3-25.5	25.5-25.7	25.7-25.9	25.9-26.1	26.1-26.3	26.3-26.5	26.5-26.7	26.7-26.9	26.9-27.1	27.1-27.3	27.3-27.5
AS.1	C		A - 0				B - 0				D	
AS.2	C		B - 10				A - 40				D	

Determining the winning permissible assignment plan

The winning permissible assignment plan is Option 2 as it yields the highest value of 50. Option 1 yields a value of 0.

Determining the prices

The prices to be paid are determined with the same process as before. The winning frequencies and corresponding prices to pay are thus the following:

- Bidder A wins the 26.3-27.1 GHz frequencies and pays 0.

- Bidder B wins the 25.5-26.3 GHz frequencies and pays 0.

Therefore, at the end of the assignment stage:

- Bidder A wins the 26.1-26.5 frequencies and the 26.5-26.9 GHz frequencies for the initial licence and the 26.3-27.1 GHz frequencies for the final licence. It pays 50 (in addition to the base price determined in the principal stage).
- Bidder B wins the 25.5-26.1 GHz frequencies and the 26.9-27.1GHz frequencies for the initial licence and the 25.5-26.3 GHz frequencies for the final licence. It pays 0 (in addition to the base price determined in the principal stage).
- Bidder C wins the 25.1-25.5 GHz frequencies for the entire licence duration. It pays 0 (in addition to the base price determined in the principal stage).
- Bidder D wins the 27.1-27.5 GHz frequencies for the entire licence duration. It pays 0 (in addition to the base price determined in the principal stage).

Box A7.3: Example of assignment stage with a shortfall

Suppose that in the principal stage:

- Bidder A wins 3 lots in 40 GHz;
- Bidder B wins 3 lots in 40 GHz;
- Bidder C wins 9 lots in 40 GHz;

Round (i): final assignment stage round for 40 GHz

Ofcom determines that there are six permissible assignment plans, as shown in Table A7.10 below. In this example, for easy visualization, location 1 refers to frequencies 40.5-40.7 GHz; location 2 refers to frequencies 40.7-40.9 GHz; etc.; location 15 refers to frequencies 43.3-43.5 GHz. We highlight bidder A's assignment options within those plans in yellow, bidder B's in red, and bidder C's in green.

Table A7.10: Permissible assignment plans and assignment options for the final assignment stage round for 40 GHz

40 GHz														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AS.1	A			B			C								
AS.2	A			C									B		
AS.3	B			A			C								
AS.4	B			C									A		
AS.5	C									A			B		
AS.6	C									B			A		

Assignment stage bids

Each bidder bids for their assignment options within the permissible assignment plans (as shown in table A7.11 below)

- Bidder A bids 22 for location 1 to 3, 0 for location 4 to 6, 0 for location 10 to 12, and 0 for location 13 to 15.
- Bidder B bids 0 for location 1 to 3, 30 for location 4 to 6, and 0 for location 13 to 15.
- Bidder C bids 40 for location 1 to 9, 0 for location 4 to 12, and 0 for location 7 to 15.

Table A7.11: Assignment stage bids

40 GHz															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AS.1	A – 22			B – 30			C – 0								
AS.2	A – 22			C – 0									B – 0		
AS.3	B – 0			A – 0			C – 0								
AS.4	B – 0			C – 0									A – 0		
AS.5	C – 40									A – 0			B – 0		
AS.6	C – 40									B – 0			A – 0		

Determining the winning permissible assignment plan

Ofcom determines which of the permissible assignment plans yields the highest total value:

- Option 1 yields a total value of 22+30+0 = 52.
- Option 2 yields a total value of 22.
- Options 3, and 4 yield a total value of 0.
- Options 5, and 6 yield a total value of 40.

Thus, in this case the winning permissible assignment plan is Option 1 as it yields the highest value of 52.

Determining the prices

Firstly, we need to find the Vickrey price for each bidder's winning bid. We start with bidder A. We:

- Reduce all of A's non-winning assignment stage bids to 0 (this does nothing since A had no other bids greater than zero);
- Incrementally reduce bidder A's winning bid of 22, until an alternative permissible assignment round has the same bid value as Option 1. A's bid is reduced down to 10, at which point Option 1 has the same bid value as Options 5 and 6.
- The Vickrey price for bidder A is 10.

Table A7.12: Assignment options with A's reduced bids.

	40 GHz														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AS.1	A – 22 (reduced to 10)			B – 30			C – 0								
AS.2	A – 22 (reduced to 10)			C – 0									B – 0		
AS.3	B – 0			A – 0			C – 0								
AS.4	B – 0			C – 0									A – 0		
AS.5	C – 40									A – 0			B – 0		
AS.6	C – 40									B – 0			A – 0		

We repeat these steps for bidder B and C.

We incrementally reduce bidder B's winning bid of 30, until an alternative permissible assignment plan has the same bid value as Option 1. B's bid is reduced down to 18, at which point Option 1 has the same bid value as Options 5 and 6. The Vickrey price for bidder B is 18.

Since bidder C has a winning bid of 0 in Option 1, the Vickrey price for bidder C is 0.

Next, we check whether there is a shortfall caused by Vickrey prices. There is a shortfall since the sum of Vickrey prices (28) is lower than assignment stage option 5 and 6 (40). This is due to bidders A and B outbidding a larger bidder, C, for a location. We therefore need to raise the Vickrey prices for some bidders based on the four requirements.

First requirement

Bidder A's payment is between 0 and its bid of 22.

Bidder B's payment is between 0 and its bid of 30.

Bidder C's payment is 0.

Second requirement

The sum of additional prices must be sufficiently large that no bidder or group of bidders is willing to pay more for an alternative assignment.

In this case bidder C was willing to pay 40 more for option 5 and 6 than its final placement in option 1. However, bidder A and B's Vickrey prices sum to 28. Therefore, the sum of Vickrey prices for A and B must be raised to at least 40.

Third requirement

Ofcom must select the additional prices that minimise the additional payments.

The sum of additional prices from A and B must therefore be 40 and no larger. Therefore, the shortfall is 12 (40 – 28).

Fourth requirement

We split the shortfall equally amongst A and B, subject to the constraint that no winner pays more than its bid.

Bidder A's additional price is therefore 10 (Vickrey price) + 6 (shortfall share) = 16

Bidder B's additional price is therefore 18 (Vickrey price) + 6 (shortfall share) = 24

The additional prices of A and B are below each of their respective bids, so we do not need to reallocate any excess.

Therefore, at the end of the assignment stage:

- Bidder A wins location 1 to 3 (40.5 GHz – 41.1 GHz frequencies) and pays 16 (in addition to the base price determined in the principal stage).
- Bidder B wins location 4 to 6 (41.1 – 41.7 GHz frequencies) and pays 24 (in addition to the base price determined in the principal stage).
- Bidder C wins location 7 to 15 (41.7 – 43.5 GHz frequencies) and pays 0 (in addition to the base price determined in the principal stage).

Deposit

Required assignment stage deposit

A7.43 For each assignment stage round, by a deadline to be specified by Ofcom, bidders need to have on deposit at least the sum of the total base price for each of the 26 GHz lower, 26 GHz upper, and 40 GHz lot categories,[159] previous assignment stage round additional prices (if any), plus the amount corresponding to the bidder's highest assignment stage bid for the assignment stage round in question.

A7.44 If the bidder does not provide Ofcom with the assignment stage deposit, all the assignment stage bids for the assignment stage round in question submitted by the bidder (if any) would be deemed to be invalid.

A7.45 As a result, the bidder would be deemed to have made a valid assignment stage bid with a value of zero pounds for all available assignment stage options in that round.

Total auction sum

A7.46 After the end of the assignment stage, Ofcom will notify each bidder of the total auction sum payable by them.

A7.47 Where a bidder's total auction sum is less than the amount it has on deposit, Ofcom would specify a deadline by which it must pay the difference between the amounts.

A7.48 A bidder that does not provide the total auction sum payable by the deadline will not be entitled to the grant of any licences, nor a refund of its deposit. Such a bidder will also remain liable to pay the difference between its deposit and its total auction sum payable.

[159] See paragraph A6.86.

Information released at the end of each assignment stage round

A7.49 At the end of each assignment stage round, each bidder is informed of:

a) The frequencies assigned to the bidder;
b) The additional price to be paid for a licence authorising use of the frequencies;
c) The start and end time for the next assignment stage round (if any).

A7.50 Additionally, if no further assignment stage round is to take place, each bidder will receive a message indicating the end of the assignment stage.

Information released at the end of the auction

A7.51 The auction ends with the completion of the grant stage, in which the licences are awarded to the relevant parties. At this point, the following information would be released to all bidders:

a) the frequencies assigned to each bidder that has been awarded spectrum; and
b) the price paid by each bidder that has been awarded spectrum, including a breakdown of that bidder's base price and any additional prices.

A7.52 After the auction, Ofcom would also publish information on its website, including:

a) the names of the winning bidders and the frequencies won by those bidders (and licence fees paid);
b) the names of those winning bidders (if any) that failed to pay their total auction sum on time and who therefore failed to obtain licences in the auction, despite making winning bids; and
c) details of principal stage bids and assignment stage bids for all bidders and all rounds.

A8. Consideration of whether we should include a negotiation period

A8.1 As explained in Section 6, we have provisionally decided not to include a negotiation period in the assignment stage. In this annex we set out our full consideration of whether we should include a negotiation period.

Potential benefits of including a negotiation period

Potential for a negotiation period to assist shared network deployment

A8.2 A negotiation period would allow winners of spectrum in a band to agree that their holdings will be adjacent in frequency. We understand that this could give rise to efficiencies and strengthen the business case for deploying mmWave spectrum for bidders sharing radio equipment in their networks.

Likelihood of shared active equipment in network deployment

A8.3 As we explained in our 2022 review of our future approach to mobile markets and spectrum, network sharing arrangements between the MNOs have been a feature of the mobile sector over the last 10 years.[160] By entering into network sharing agreements, MNOs can reduce their average costs by benefitting from economies of scale.[161] If MNOs could reduce the cost of deploying mmWave by using network sharing agreements, this could result in greater deployment of mmWave spectrum.

A8.4 However, we also recognise that upon entering network sharing agreements MNOs give up a degree of control over their network, particularly when sharing active equipment. We have noted that this may in part be driving a move towards a greater emphasis on passive sharing in network sharing agreements.[162] While adjacency of spectrum holdings could drive efficiencies for partners in active sharing networks (involving the sharing of radio equipment), it would have no impact on efficiency for partners deploying passive sharing networks. The potential importance of facilitating adjacent spectrum with a negotiation period in this auction is therefore not clear.

Relevance of adjacent assignment to active sharing of mmWave equipment

A8.5 VMO2 said that equipment for microcell mobile deployment for the 26 GHz band has an instantaneous bandwidth ("IBW") of 1,400 MHz. This means that the equipment in question would not span the full 2,400 MHz of spectrum we will auction in the 26 GHz band, and that two operators sharing this equipment would only be able to utilise all of their respective spectrum blocks if those are within 1,400 MHz of each other.

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[160] Ofcom's 6 December 2022 Conclusions Paper, 'Ofcom's future approach to mobile markets and spectrum: Conclusions paper', para. A3.10.
[161] Ofcom's 2022 Conclusions Paper, para. A3.11.
[162] Ofcom's 2022 Conclusions Paper, para. A3.12

A8.6 We have engaged separately with some base station equipment vendors and understand that at least one vendor [CONFIDENTIAL ✂] has equipment for the 26 GHz band that has an IBW of 2,400 MHz or more ([CONFIDENTIAL ✂]). On the other hand, at least one vendor [CONFIDENTIAL ✂] has equipment with a smaller IBW ([CONFIDENTIAL ✂]).

A8.7 Therefore, network sharing partners may be able to buy equipment capable of working across the auctioned spectrum in 26 GHz, even if they win spectrum at opposite ends of the 26 GHz band.

A8.8 Adjacent spectrum may nevertheless still be beneficial, as it would enable operators to choose from a wider range of base station equipment from different vendors. This could offer: (i) cost savings through cheaper equipment, (ii) better performance on other metrics, such as operating bandwidth, or (iii) better integration with existing equipment.

Club model

A8.9 Vodafone said in its response that an issue for participants in a club model seeking to share each other's unused spectrum would be how to secure contiguity of spectrum between them, but that this issue would not be insurmountable, particularly if we were to include a negotiation period in the auction.[163]

A8.10 As set out in the March 2023 Statement and Consultation, we do not expect that operators will need to share spectrum to access as much mmWave spectrum as they may require.[164] We do not think that including a negotiation period to help facilitate a club model is therefore likely to add material benefits.

Potential downsides of including a negotiation period

Reassignments in the 26 GHz band are more likely with a negotiation period.

A8.11 Under the permissible assignment rules proposed in the March 2023 Statement and Consultation, certain bidders who obtained contiguous allocations of spectrum in the initial assignment of 26 GHz spectrum would retain their assignments for the final assignment of the 26 GHz band. Specifically, bidders who only obtained spectrum in one of the 26 GHz lot categories would not be expected to move their allocation to different frequencies for the final assignment of the 26 GHz band.[165] Furthermore, if all bidders have contiguous holdings across the 26 GHz band after the two initial 26 GHz assignment rounds, then all bidders would retain the same frequencies and there would be no final assignment round for the 26 GHz band. As set out in Annex 9, if we were to include a negotiation period, we would remove the permissible assignment rules for the final assignment of the 26 GHz band and necessarily run a 26 GHz final assignment stage round (even if the assignments resulting from the initial 26 GHz assignment rounds were all contiguous).

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[163] Vodafone response to the March 2023 Statement and Consultation, pp. 9-10, response to Q. 13.
[164] March 2023 Statement and Consultation, paras. 3.80-3.81.
[165] For example, a bidder who, in the principal stage, only won lots in the 26 GHz upper lot category would have been assigned frequencies in the upper part of the 26 GHz band for the initial assignment of 26 GHz upper. The bidder would then have maintained the same frequencies for the final assignment of the 26 GHz band.

A8.12 Removing the permissible assignment rules for the final 26 GHz assignment round could have a negative impact on those bidders who value retaining the same frequencies for the final assignment of 26 GHz as the initial assignment of 26 GHz, more than securing adjacency with another bidder. Furthermore, as shown in the example below, in some circumstances such bidders may have no ability to retain their initial assignment of 26 GHz.

A8.13 In summary, some bidders which may have to change frequencies after the 26 GHz clearance deadline if we include a negotiation period would not have to do so absent a negotiation period. Including a negotiation period may therefore cause these bidders to incur costs which they would not otherwise incur.

Example when bidders cannot retain their initial assignment in the 26 GHz band

A8.14 In the principal stage Bidder B and Bidder C only won lots in the 26 GHz lower lot category, while Bidder A only won spectrum in 26 GHz upper and Bidder D won spectrum for both lot categories in the 26 GHz band. For the initial assignment rounds for the 26 GHz band, the bidders are allocated according to Assignment 1, which is detailed below in Figure A8.1. If we do not include a negotiation period, bids would not be submitted for the final assignment of 26 GHz since all bidders already have contiguous allocations in the initial assignment. All bidders would therefore retain their locations, as in Assignment 1.

A8.15 For illustrative purposes, we now consider what would happen if we allowed a negotiation period and Bidders A and B agreed to form an adjacency agreement for the final assignment of the 26 GHz band. Permissible assignment plans would be limited to assignments where Bidder A and Bidder B would be adjacent, such as Assignment 2 and Assignment 3. However, due to the adjacency agreement, there would be no permissible assignments where Bidder C or Bidder D retained their initial allocation for 26 GHz, so Bidders C and D would be forced to change frequencies.

Figure A8.1: Example showing Bidders C and D would need to change frequencies from Assignment 1 if A and B enter into an adjacency agreement[166]

	26 GHz											
	25.1-25.3	25.3-25.5	25.5-25.7	25.7-25.9	25.9-26.1	26.1-26.3	26.3-26.5	26.5-26.7	26.7-26.9	26.9-27.1	27.1-27.3	27.3-27.5
1	B			C		D				A		
2	B			A			D				C	
3	D				C		B			A		

Additional complexity

A8.16 The description in Annex 9 of how the assignment stage with a negotiation period would work suggests that including a negotiation period would add some complexity to the assignment stage rules.

[166] Figure A8.1 does not set out an exhaustive list of all the possible assignments which could occur, in the event that bidders A and B form an adjacency agreement.

A8.17 The complexity would increase costs in the development of the Auction Regulations, the electronic auction system and its testing. It would also increase costs for potential bidders in understanding the rules and preparing for the auction.

Increased length of the auction

A8.18 Providing extra time for bidders to negotiate would increase the duration of the assignment stage. We would limit the period for negotiation to ten working days.

Alternative routes to adjacent spectrum assignments

A8.19 As set out in Section 6, paragraph 6.33, the likelihood and extent of any reduction in costs that a negotiation period could deliver, and hence of any potential benefits, are currently unclear. In light of this uncertainty, and the downsides that a negotiation period could have, we have provisionally decided not to include a negotiation period. We discuss below other routes we have considered for achieving adjacent assignments of frequencies.

Securing adjacency without a negotiation period

Post-Auction Trading

A8.20 Licensees whose holdings are not adjacent after the auction could secure adjacency by trading.[167]

A8.21 In some scenarios a single bilateral trade of frequencies may be sufficient to achieve adjacency. For example, if after the auction only one licensee holds spectrum between two licensees seeking adjacency, one of those two could agree a simple swap of frequencies with the licensee holding the middle block of frequencies between them. This could be a simple trade to negotiate.

A8.22 In other scenarios, multi-lateral trades may be required. For example, where there are more than three winners of spectrum in a band, and more than one operator's holdings between two licensees seeking adjacency, the relative sizes of the different holdings may mean that multi-lateral trades are necessary to achieve the adjacency while maintaining contiguous holdings for all licensees. Assignment 1 in Figure A8.1 above is an example of such a scenario. A trade either between A and C could achieve adjacency between A and B, but at the cost of splitting A's holdings; similarly, a trade between B and D could also achieve adjacency between A and B, but at the cost of splitting D's holdings. Achieving both adjacency for A and B and maintaining contiguity of holding for all licensees in this scenario would require multilateral trades, for example between A, C and D, or between B, C and D. Multi-lateral trades would be more complex to negotiate than bilateral ones, and could take time to agree, which, in turn, might delay network deployments.

A8.23 Relying on trading to provide a route to adjacency would allow licensees to reflect in negotiations any cost to them of changing frequencies, which may not be possible with a negotiation period. However, it is also possible that some licensees may have a strategic

[167] We note that any trades would be subject to Ofcom's process for assessing mobile spectrum trades, which Ofcom would carry out in accordance with the Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011, as amended.

incentive not to trade or expect a high price for any trade that would benefit their competitors.

A8.24 In summary licensees could achieve adjacency through post-auction trading, which would allow the costs of changing frequencies to be taken into account. However, post-auction trading would provide a less certain route to achieve adjacency than a negotiation period in the assignment stage of the auction.

Contingent bidding

A8.25 Before deciding to implement the negotiation period in the 2021 Auction, we considered contingent bidding as an alternative. This would involve allowing bidders to specify a preference as to who their neighbours are, as part of their assignment stage bids. However, our view was that this came with too many downsides. In particular, the bidding choices, assignment determination and pricing would become more complex, which would make it more difficult for bidders to develop bidding strategies.[168] Also in the case of mmWave spectrum, we consider that contingent bidding would not provide any significant advantages compared to incorporating a negotiation period.

[168] Ofcom, 2019. 'Defragmentation of spectrum holdings in the 3.4-3.8 GHz band', paragraphs 2.57 to 2.58.

A9. Illustrative auction procedures for the assignment stage with a negotiation period

A9.1 In this annex, we set out how our provisional decisions on the assignment stage would change if, following consideration of any further evidence we receive in response to this consultation, we were to decide to include a negotiation period. We also present worked examples of how assignment stage bids would be processed if there was an adjacency agreement.

A9.2 As noted in paragraph A9.1 of the March 2023 Statement and Consultation, we are providing these procedures for illustrative purposes only, to give stakeholders a more in depth understanding of how the assignment stage would work, if we decide to include a negotiation period. However, there are rules on the drafting of legislation, and it might well be that there are changes and adjustments to the processes that are necessary for that reason.

A9.3 Next year, we will consult on a draft version of the regulations setting out the auction rules (the "**Auction Regulations**"). If we decide to include a negotiation period, the terms used in this annex for illustrative purposes may not reflect those in the Auction Regulations. For the avoidance of doubt, in the case of any difference, the Auction Regulations will take precedence.

Assignment stage format and bidding

A9.4 If we decide to include a negotiation period, the format of the assignment stage would be the same as specified in Annex 7. Each of the three rounds for the assignment for the 26 GHz band, as well as the single assignment stage round for the 40 GHz band, would go ahead as a sealed bid auction with a second price rule.

A9.5 As explained in Annex 7 paragraph A7.11, Ofcom would only consider permissible assignment plans in which each bidder is assigned a contiguous frequency block.

A9.6 Furthermore, the winning permissible assignment plan and additional prices would be determined for each round as set out in paragraphs A7.31-A7.38 of Annex 7.

Initial assignment rounds for the 26 GHz band

A9.7 The initial assignment rounds for 26 GHz upper lots and 26 GHz lower lots would take place as set out in paragraphs A7.14-A7.17. The assignment stage with a negotiation period would only be different from the assignment stage without one in relation to the rounds for the final assignment of 26 GHz and the assignment of 40 GHz.

Final assignment of 26 GHz and assignment of 40 GHz

Submission of bids

A9.8 Bidders who won spectrum in the 40 GHz band would submit bids for the assignment of the 40 GHz band at the same time as bids are submitted for the initial assignment of the 26 GHz lower lots. If we decide to include a negotiation period, the bids for the initial assignment of the 26 GHz lower lots would be processed immediately (as they would in the absence of a negotiation period). Bids for the assignment of the 40 GHz band would not be processed immediately.

A9.9 Following the initial assignment of 26 GHz upper lots, all bidders who won spectrum in the 26 GHz band would be invited to submit bids for the final assignment of the 26 GHz band (even if all bidders in the 26 GHz band have been already assigned contiguous frequency blocks following the initial assignment stage rounds). Similar to the bids submitted for the assignment of the 40 GHz band, if we decide to include a negotiation period, these bids for the final assignment of the 26 GHz band would not be processed immediately.

Permissible assignment rules

A9.10 As set out in more detail below, if we decide to include a negotiation period, the only permissible assignment rules that would apply to the final assignment of the 26 GHz band and the assignment of the 40 GHz band, are: (i) the requirement for each bidder to be assigned a contiguous block of spectrum; and (ii) the rules relating to the treatment of unsold spectrum.

Contiguous blocks

A9.11 As with the process in the absence of a negotiation period, in each assignment stage round, each bidder could bid only for contiguous blocks of spectrum within permissible assignment plans.

Absence of certain rules for the final assignment of the 26 GHz band

A9.12 All winning principal stage bidders of 26 GHz spectrum would be invited to place bids for the final assignment of the 26 GHz band. Unlike the process in the absence of a negotiation period, there would be a final assignment stage round for 26 GHz even if all bidders in the 26 GHz band have been already assigned contiguous frequency blocks following the initial assignment stage rounds. Furthermore, there would be no automatic assignments for any of the spectrum won in the 26 GHz band.[169] In particular, those who only obtained spectrum in one 26 GHz lot category (e.g., 26 GHz lower) would not be automatically assigned to a specific location in the band (e.g., the bottom of the 26 GHz band) for the final assignment.

A9.13 This would apply whether an adjacency agreement was reached or not. We consider that applying automatic assignments only if there is no adjacency agreement would introduce unnecessary complexity into assignment stage and would provide limited benefit. This is especially the case since all bidders in the final 26 GHz round would have submitted

[169] The rules relating to automatic assignment of those who were assigned contiguous frequency blocks following the initial assignment stage round would not apply in any circumstances. This means these rules will also not apply in the scenarios where less than two bidders express a wish to participate in a negotiation period and where no bidders agree to form a valid adjacency agreement despite a negotiation period taking place.

assignment stage bids and can therefore reflect through monetary bids if they wish to retain the same frequencies.

Invitation to participate in a negotiation period

A9.14 Once all bidders have submitted their bids for the final assignment of the 26 GHz band, they would be asked if they wish to participate in a negotiation period in relation to the final assignment of the 26 GHz band and/or the assignment of the 40 GHz band.[170]

A9.15 If two or more winning principal stage bidders of spectrum in either the 26 GHz band or in the 40 GHz confirm to Ofcom that they wish to participate in a negotiation period, then Ofcom would pause the auction and there would be a negotiation period for up to 10 working days.

Formation of adjacency agreements

A9.16 During this negotiation period, bidders would have the opportunity to negotiate among themselves to agree to an 'adjacency agreement', which would ensure they obtain assignments adjacent to those of other bidders who are also party to the agreement. Certain rules under the Auction Regulations regarding the exchange of confidential information between bidders would not apply during the negotiation period, in order to enable the required negotiations to take place.[171]

A9.17 By the end of the negotiation period, bidders would notify Ofcom if they have formed an adjacency agreement in relation to either band, by submitting an 'adjacency agreement form'. Any adjacency agreement form would need to include the following information:

a) the band(s) to which the agreement relates,
b) the parties to the agreement, and
c) the order of the respective adjacent spectrum holdings which the parties have agreed.

Assignment outcomes following a negotiation period

A9.18 Ofcom would treat the spectrum won by any bidders in an adjacency agreement[172] as a single contiguous block for the purpose of determining the assignment stage outcome, and will invalidate any bids submitted by these bidders during the assignment stage bidding for the relevant band(s).[173] This single contiguous block will have a bid value of zero. These bidders would not be able to re-submit bids for the assignment of their single contiguous block.

A9.19 Ofcom would then determine the assignment that maximises the value of accepted bids, subject to the bidders in the adjacency agreement receiving adjacent assignments. The assignment stage round bids previously submitted by any other bidders (who did not form

[170] Bidders would only have the option of indicating a desire to participate in a negotiation period for both 26 GHz and 40 GHz, or indicating no desire to participate in a negotiation period for any band. The negotiation period would not relate to (and therefore pause the processing of bids for) only one of the bands.
[171] We note that bidders would need to ensure that all bidding, including negotiations, are compliant with competition law.
[172] Note that all bidders in an assignment stage could be part of the adjacency agreement.
[173] Treating the spectrum of such bidders as a contiguous block means that any assignment plans where parties to an adjacency agreement are not adjacent would be removed from the list of permissible assignment plans.

an adjacency agreement) in the final assignment stage round for 26 GHz and the assignment stage round for 40 GHz would remain valid for the purpose of determining the winning assignment. Therefore, the final assignments (and any assignment stage prices) would be determined only by the bids made by those who did not form an adjacency agreement.

A9.20 Since bidders who are party to an adjacency agreement would have their initial bids invalidated, they would not pay additional prices for their assignments. On the other hand, bidders who are not party to an adjacency agreement may be required to pay an additional price, calculated as set out in Annex 7, paragraphs A7.31 to A7.38.

A9.21 If no agreements are reached in the negotiation period or the negotiation period is not activated (i.e., fewer than two bidders agree to participate in any band), Ofcom will determine the assignment that maximises the value of accepted bids, by considering the bids that were submitted by all parties for the relevant band. All bidders may therefore be required to pay an additional price for their assignments.

Unsold spectrum

Unsold spectrum in the 26 GHz band

A9.22 Any unsold lot in the 26 GHz lower lot category would be placed as a single contiguous block at the bottom portion of the 26 GHz band and any unsold spectrum in the 26 GHz upper lot category would be placed as a single contiguous block at the top portion of the 26 GHz band.[174]

Unsold spectrum in the 40 GHz band

A9.23 As set out in paragraphs 6.49-6.51, if we do not include a negotiation period, we are minded to treat any unsold lots of 40 GHz spectrum as a single contiguous block and not place constraints on where that block would be placed in the band (thereby allowing the position of any unsold spectrum in the 40 GHz band to be determined by the bids placed by bidders).

A9.24 We note that we have provisionally decided to adopt the same approach to unsold spectrum in the 40 GHz band if we decide to include a negotiation period. In the event that we include a negotiation period and an adjacency agreement is reached, this approach would randomise the location of the unsold spectrum and the location of the parties to the adjacency agreement in the assignment.[175] It is therefore possible that parties to an adjacency agreement could be assigned certain frequencies that they may find less attractive,[176] which could otherwise have been occupied by unsold spectrum.

A9.25 We do not consider this to be a material issue. However, if stakeholders express concerns about this approach, we could either:

a) **Allocate unsold spectrum by a single adjacency agreement** – Where all bidders in the 40 GHz band are party to the same adjacency agreement, enable them to specify the location of any unsold spectrum in the band (provided it is a contiguous block); or

[174] This is the same approach we would take without a negotiation period, as set out in paragraph 6.42.
[175] This is because parties to an adjacency agreement and any unsold spectrum would both be allocated a bid value of zero.
[176] As explained in paragraph 6.50 there are reasons why some bidders may prefer not to be assigned frequencies covering 40.50-40.75 GHz, 42.00-42.25 GHz and 42.5-43.5 GHz.

b) **Automatically allocate unsold spectrum to the top of 40 GHz** – Any unsold spectrum would be automatically assigned to the top of the 40 GHz band, whether there was an adjacency agreement or not, because of the additional restrictions on use of this part of the band, as set out in Section 6, paragraph 6.50.

Worked examples of adjacency agreements

Example 1 – three winning principal stage bidders in the 40 GHz band

Step 1: Assignment stage bids

A9.26 In this example, there are three principal stage winning bidders (A, B and C) in the 40 GHz band. They have all won the same amount of spectrum (1,000 MHz). In the assignment stage they all place bids for specific frequencies in the band.

A9.27 Bidder A submits its highest bid of 10,000 for the bottom of the band, which is its preferred frequency location. Its next preference is the middle of the band, for which it submits a bid of 5,000. The bidder does not wish to be allocated the top of the band and therefore submits a bid of 0 (or equivalently, makes no bid) for this location. Bidder A's bids are illustrated in Figure A9.1 below.

Figure A9.1: Bidder A's bids in the assignment stage of 40 GHz

40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
10,000	5,000	0

A9.28 Bidders B and C also submit bids for the assignment stage, but we do not need to detail these for this example.

Step 2: Notification to participate in the negotiation

A9.29 All winning bidders notify Ofcom that they wish to participate in a negotiation period. Ofcom therefore announces that there will be a negotiation period of up to 10 working days.

Step 3: Outcome of negotiation period

A9.30 By the end of the negotiation period, bidders B and C notify Ofcom that they have formed an adjacency agreement, in which they have decided that bidder B would be assigned the lowest frequencies of their contiguous block.

Step 4: Eliminating assignment stage outcomes that are no longer relevant

A9.31 Ofcom therefore eliminates all possible assignment stage outcomes where bidders B and C are not assigned adjacent blocks of spectrum, and considers these two bidders' allocations as one contiguous block. The possible assignment stage options are therefore reduced to the two shown in Figure A9.2 below. As shown, it is no longer possible to assign bidder A the middle of the band.

Figure A9.2: Remaining assignment stage possibilities

	40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
Assignment 1	**A**	**B**	**C**

	40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
Assignment 2	**B**	**C**	**A**

A9.32 For completeness, the assignment stage options that are eliminated are shown in Figure A9.3 and A9.4. Figure A9.3 shows the assignment stage options that are eliminated due to bidders B and C deciding that they wish their spectrum to be considered as one contiguous block. A9.4 shows the assignment stage options that are eliminated due to bidder B not receiving the lower frequencies between B and C.

Figure A9.3: Assignments that are no longer possible as B and C are not adjacent

	40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
Assignment 3	**B**	**A**	**C**

	40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
Assignment 4	**C**	**A**	**B**

Figure A9.4: Assignments that are no longer possible as the negotiating parties have agreed that B will hold the lower frequencies

	40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
Assignment 5	**A**	**C**	**B**

	40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
Assignment 6	**C**	**B**	**A**

Step 5: Bids for the remaining assignment stage options

A9.33 For the remaining assignment stage options, Ofcom also reduces bidders B and C's assignment stage bids to zero. The bids (after this modification) for each of bidders A and the combination of bidders B and C are shown in brackets in Figure A9.5 below.

Figure A9.5: Remaining assignment stage possibilities after bidders B and C are treated as a contiguous block

	40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
Assignment 5	**A** (10,000)	**B & C** (0)	

	40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
Assignment 6	**B & C** (0)		**A** (0)

Step 6: Determining the outcome

A9.34 Ofcom now processes the assignment stage bids. Bidder A receives its preferred location. This is because only two combinations are possible, and the bids of bidders B and C are set to zero. Assignment 1 is the winning combination as this has a total bid value of 10,000 (whereas Assignment 2 has a total bid value of 0). As the final assignment stage prices are determined by a second price rule, none of the bidders are required to pay any amount in

the assignment stage in this scenario. The band plan that is the outcome of the assignment stage is shown in Figure A9.6.

Figure A9.6: Final 40 GHz band plan

40.50 - 41.05 GHz	41.50 - 42.50 GHz	42.50 - 43.50 GHz
A	**B**	**C**

Example 2 – four winning principal stage bidders in the final assignment of the 26 GHz band

Step 1: Assignment Stage Bids

A9.35 In this example, there are four principal stage winning bidders (A, B, C and D) in the 26 GHz band. They have all won the same amount of spectrum (600 MHz). In the final assignment round for the 26 GHz band, they all place bids for specific frequencies in the band. Here we examine bidder A and B's bids.

A9.36 Bidder A submits its highest bid of 10,000 for the bottom of the band (25.1 – 25.7 GHz) which is its preferred frequency location. Its next preference is to be second from the bottom in the band (25.7 – 26.3 GHz) and it submits a bid of 5,000 for this location. The bidder does not wish to be in the top half of the band and therefore submits bids of 0 for the top two locations. Bidder A's bids are shown in Figure A9.7. Bidder B has similar preferences, although at lower valuations. It submits bids of 4,000 for the bottom of the band, 1,000 for the assignment that is second from the bottom in the band, and zero for the other locations. Its bids are shown in Figure A9.8.

Figure A9.7: Bidder A's bids for the final assignment stage of the 26 GHz band

25.1 - 25.7 GHz	25.7 - 26.3 GHz	26.3 - 26.9 GHz	26.9 - 27.5 GHz
10,000	5,000	0	0

Figure A9.8: Bidder B's bids for the final assignment stage of the 26 GHz band

25.1 - 25.7 GHz	25.7 - 26.3 GHz	26.3 - 26.9 GHz	26.9 - 27.5 GHz
4,000	1,000	0	0

A9.37 Bidders C and D also submit bids in the final assignment stage round, but we do not need to detail these for this example.

Step 2: Notification to participate in the negotiation

A9.38 All winning bidders notify Ofcom that they wish to participate in a negotiation period. Ofcom therefore announces that there will be a negotiation period of up to 10 working days.

Step 3: Outcome of the negotiation period

A9.39 By the end of the negotiation period, bidders C and D notify Ofcom that they have formed an adjacency agreement, in which bidder D would be assigned the lowest frequencies of the contiguous block.

Step 4: Eliminating assignment stage outcomes that are no longer relevant

A9.40 Ofcom therefore eliminates all possible assignment stage outcomes where bidders C and D are not assigned adjacent blocks of spectrum, and considers these two bidders' spectrum as

a contiguous block. The possible assignment stage options are therefore reduced to the six shown in Figure A9.9 below. In this example, the remaining options include all the zero and non-zero bids of bidders A and B (who are not party to the adjacency agreement).

Figure A9.9: Remaining assignment stage possibilities

	25.1 - 25.7 GHz	25.7 - 26.3 GHz	26.3 - 26.9 GHz	26.9 - 27.5 GHz
Assignment 1	**A**	**B**	**D**	**C**
Assignment 2	**B**	**A**	**D**	**C**
Assignment 3	**A**	**D**	**C**	**B**
Assignment 4	**B**	**D**	**C**	**A**
Assignment 5	**D**	**C**	**A**	**B**
Assignment 6	**D**	**C**	**B**	**A**

A9.41 Figure A9.10 shows the assignment stage options that are eliminated due to bidders C and D's adjacency agreement.

Figure A9.10: Assignments that are no longer possible as C and D are not adjacent

	25.1 - 25.7 GHz	25.7 - 26.3 GHz	26.3 - 26.9 GHz	26.9 - 27.5 GHz
Assignment 7	**A**	**D**	**B**	**C**
Assignment 8	**A**	**C**	**B**	**D**
Assignment 9	**B**	**D**	**A**	**C**
Assignment 10	**B**	**C**	**A**	**D**
Assignment 11	**C**	**B**	**A**	**D**
Assignment 12	**C**	**B**	**D**	**A**
Assignment 13	**C**	**A**	**B**	**D**

	25.1 - 25.7 GHz	25.7 - 26.3 GHz	26.3 - 26.9 GHz	26.9 - 27.5 GHz
Assignment 14	**C**	**A**	**D**	**A**
Assignment 15	**D**	**B**	**C**	**C**
Assignment 16	**D**	**B**	**A**	**C**
Assignment 17	**D**	**A**	**C**	**B**
Assignment 18	**D**	**A**	**B**	**C**

A9.42 Figure A9.11 shows the assignment stage options that are eliminated due to bidders C and D agreeing that bidder D should be assigned the lowest frequencies of the contiguous block.

Figure A9.11: Assignments that are no longer possible as the negotiated parties have decided that D should have the lower frequency

	25.1 - 25.7 GHz	25.7 - 26.3 GHz	26.3 - 26.9 GHz	26.9 - 27.5 GHz
Assignment 19	**A**	**C**	**D**	**B**
Assignment 20	**B**	**A**	**C**	**D**
Assignment 21	**B**	**C**	**D**	**A**
Assignment 22	**C**	**D**	**A**	**B**
Assignment 23	**C**	**D**	**B**	**A**
Assignment 24	**A**	**B**	**C**	**D**

Step 5: Bids for the remaining assignment stage options

A9.43 For the remaining assignment stage options, Ofcom also reduces bidders C and D's assignment stage bids to zero. The bids (after this modification) for each of bidders A, B and the combination of bidders C and D are shown in brackets in Figure A9.12 below.

Figure A9.12: Remaining permissible assignments in light of bidders C and D's adjacency agreement

	25.1 - 25.7 GHz	25.7 - 26.3 GHz	26.3 - 26.9 GHz	26.9 - 27.5 GHz
Assignment 1	**A** (10,000)	**B** (1,000)	**D & C** (0)	
Assignment 2	**B** (4,000)	**A** (5,000)	**D & C** (0)	
Assignment 3	**A** (10,000)	**D & C** (0)		**B** (0)
Assignment 4	**B** (4,000)	**D & C** (0)		**A** (0)
Assignment 5	**D & C** (0)		**A** (0)	**B** (0)
Assignment 6	**D & C** (0)		**B** (0)	**A** (0)

Step 6: Determining the outcome

A9.44 Ofcom now processes the assignment stage bids. Assignment 1 is the winning combination as this has the highest total bid value of 11,000. Due to the second price rule, only bidder A is required to pay for its location, as it outbid bidder B for the bottom location. Bidder A is therefore required to pay 3,000 for this location, which is the difference between B's value of 4,000 to be at the bottom location and B's value of 1,000 to be at location 25.7 – 26.3 GHz. The band plan that is the outcome of the assignment stage is shown in Figure A9.13.

Figure A9.13: Final assignment of the 26 GHz band

25.1 - 25.7 GHz	25.7 - 26.3 GHz	26.3 - 26.9 GHz	26.9 - 27.5 GHz
A	**B**	**D**	**C**