
Award of the 700 MHz and 3.6-3.8 GHz spectrum bands

[Award of the 700 MHz and 3.6-3.8 GHz spectrum bands](#) – Welsh overview

STATEMENT:

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1. Overview

Reliable mobile services are now essential to how people live, work and travel in the UK. The mobile network operators (MNOs) need to keep pace with the growing demands of people and businesses by increasing their networks' capacity and coverage – and by adopting new technologies.

Ofcom manages the radio spectrum on which mobile communications depend. Ensuring better broadband and mobile services is one of our main priorities. In this document, we set out our decisions on an award of spectrum to enable the industry to provide services with greater capacity and wider coverage, and to support new wireless technologies, including 5G – the latest generation of mobile services.

There is strong competition in the UK market, with four networks and many other retail providers competing for customers. In the last year, all four mobile networks have launched 5G services. This makes the UK one of the few countries where customers have a choice of 5G packages operating on four different networks. But demand for faster speeds and greater capacity – from both people and businesses – is growing.

What we have decided – in brief:

- **Award national licences for 80 MHz in the 700 MHz band and 120 MHz in the 3.6-3.8 GHz band by auction.**
- **No coverage obligations in the licences to be awarded.** This is because the MNOs have committed to achieve more comprehensive mobile coverage in the Shared Rural Network programme than we would be able to require through coverage obligations in this award. Their commitments, now agreed with the Government, are included in their current spectrum licences and are legally binding.
- **A cap of 416 MHz (37%) on the total amount of spectrum designated for mobile services that any single MNO may hold,** to ensure that consumers and businesses continue to benefit from strong competition in the provision of mobile services.
- **The auction will include a principal stage, using a simultaneous multiple round ascending (SMRA) format,** in which bidding for frequency-generic lots will determine the amount of spectrum won by each bidder in each band; and an assignment stage to determine the precise frequencies of lots won in the principal stage.
- **The assignment stage will contain measures to help defragmentation of the MNOs' holdings in the wider 3.4-3.8 GHz band,** including a period for negotiation in which winners of lots in the 3.6-3.8 GHz band will be able to agree between them the precise frequencies of those lots.

This overview is a simplified high-level summary only. Our decisions and reasoning are set out in the full document.

The spectrum we are awarding

- 1.1 One of our statutory functions is managing the radio spectrum – the airwaves used by all wireless devices like mobile phones. This involves allocating spectrum and ensuring it is used for the benefit of UK citizens and consumers.
- 1.2 We are awarding **200 MHz** of spectrum: 80 MHz in the 700 MHz band and 120 MHz in the 3.6-3.8 GHz band. Both bands are likely to be used by mobile networks to meet the increasing demand for mobile broadband services, and to invest in new technologies, including 5G. Specifically:
 - a) The **700 MHz** band is well suited for providing mobile coverage over wide areas and indoors. We are currently clearing this band of transmissions of Digital Terrestrial Television (DTT) and by wireless microphones used in the entertainment industry. Spectrum in this band can be used to improve the level of mobile coverage across the UK, including mobile voice and data coverage in rural areas, inside buildings and in other harder-to-reach places. This band should become available for mobile use by 1 May 2020, subject to the DTT clearance completing to schedule.
 - b) The **3.6-3.8 GHz** band is also particularly suitable for the provision of mobile services. It is part of the 3.4-3.8 GHz band, which has already been harmonised for mobile services and identified as the primary band for 5G services in Europe. The spectrum we are making available in the 3.6-3.8 GHz band would allow network operators to provide high capacity and to connect large numbers of devices. We are clearing this band of its current fixed links and satellite uses. This band should become available for mobile use by **June 2020**, but some localised constraints may remain in place until the end of 2022.

Our decisions

Coverage

- 1.3 We have decided not to include coverage obligations in this award.
- 1.4 In December 2018 we proposed to offer discounts on auction prices for any two bidders committing to substantial coverage obligations, aimed at providing good quality mobile services in rural areas that currently have patchy coverage. Our coverage proposals prompted the MNOs to put forward their own proposals to deliver the Shared Rural Network programme, designed to improve mobile coverage by sharing infrastructure, which they have now agreed with the Government.¹
- 1.5 The Shared Rural Network will deliver better coverage than could have been delivered by our December 2018 proposals. The MNOs' commitments to deliver it have been entered

¹ See <https://www.gov.uk/government/news/shared-rural-network>

into spectrum licences as coverage obligations. We have therefore concluded that it is no longer necessary to include coverage obligations in this award.

Competition assessment

- 1.6 Having examined competition in the UK mobile services sector and evaluated a wide range of evidence, we consider that the current provision of mobile services is functioning well, with competition between the four MNOs delivering good outcomes for consumers. We consider nevertheless that certain extreme outcomes of the award could give rise to concerns about the strength of competition for mobile services in the UK. In particular, we would be concerned if the auction resulted in very asymmetric shares of spectrum amongst the mobile operators.
- 1.7 We have therefore decided to impose a cap based on limiting to 37% the proportion of spectrum designated for mobile services which a single mobile operator may hold as a result of the award. This cap is consistent with the policy we adopted in our 2018 spectrum auction.
- 1.8 In practice, the cap will allow an operator to hold up to 416 MHz of mobile spectrum after the award. This would mean that BT/EE, the operator with the largest current spectrum holdings, will be restricted to win a maximum of 120 MHz of the 200 MHz in this award. H3G could acquire up to 185 MHz and Vodafone could acquire up to 190 MHz; O2 would not be restricted by this cap.

Auction format

- 1.9 In December 2018, we proposed a combinatorial clock auction format because we considered that it would be the most likely to strike an appropriate balance between our objectives at that time to improve mobile coverage and secure the efficient allocation of the spectrum. In October 2019, following the mobile network operators' and Government's 'in principle' commitment to full funding of the Shared Rural Network programme, we considered that including coverage obligations in this award would no longer be necessary and consulted on proposals to run the auction using a Simultaneous Multiple Round Ascending (SMRA) format.
- 1.10 Having considered responses to the October 2019 consultation we have decided to go ahead with the SMRA format.
- 1.11 The auction will consist of a principal stage and an assignment stage:
- The **principal stage** will determine the amount of spectrum won by bidders, bidding for frequency-generic lots. It will comprise successive rounds with ascending prices and will end when there are no new bid decisions in a round.
 - The **assignment stage** will determine the precise frequencies awarded, and will be a sealed-bid, single-round format with a second-price rule. We have also included measures in the assignment stage for the 3.6-3.8 GHz band to facilitate post-auction trades for re-arranging the wider 3.4-3.8 GHz band – see below.

Defragmentation of spectrum holdings

- 1.12 We have decided to include measures in this auction to facilitate rearranging ('defragmenting') spectrum holdings in the wider 3.4-3.8 GHz band.
- 1.13 There is a general consensus that optimal deployment of 5G is best achieved through the use of large contiguous blocks of spectrum. However, in the UK, the current holdings in the band mean that, without rearrangement, some MNOs' holdings are likely to be fragmented after this award.
- 1.14 In June 2019 we consulted on proposals to facilitate defragmentation of the 3.4-3.8 GHz band. Having considered consultation responses, we have decided to adopt the following measures to facilitate defragmentation of the 3.4-3.8 GHz band:
- We will include a pause of up to four weeks before processing assignment stage bids, to allow a negotiation period in which bidders can agree the assignment of frequencies in the 3.6-3.8 GHz band among themselves. In the first phase of this period, winners of 3.6-3.8 GHz spectrum will have the opportunity to reach unanimous agreement on the assignment of frequencies in the 3.6-3.8 GHz band. If winners are unable to reach unanimous agreement, there will be a further period during which a sub-set of winning bidders will have the opportunity to agree to be assigned adjacent blocks of spectrum.
 - Winners of 20 MHz or less of 3.6-3.8 GHz spectrum will be restricted to bidding only for the top or bottom of the 3.6-3.8 GHz band in the assignment stage of the auction.

Coexistence and technical standards

- 1.15 We have considered the coexistence issues that may arise between new services in the 700 MHz and 3.6-3.8 GHz frequency bands and current or existing services, both in those bands and in neighbouring bands.
- 1.16 We will require the winning bidders for 700 MHz spectrum to make every reasonable effort to assist the small minority of TV viewers who may be affected by interference from mobile networks using 700 MHz spectrum, as appropriate.
- 1.17 In the 3.6-3.8 GHz band, we will apply technical conditions to maintain current spectrum quality levels for other existing users in the band during the notice period ahead of the revocation of licences for fixed links, and before we stop taking account of registered satellite earth stations for frequency management purposes.
- 1.18 We will align the technical conditions for the 3.6-3.8 GHz band with those in place for the 3.4-3.6 GHz band, awarded in April 2018. We will supplement these to add extra flexibility to facilitate the deployment of active antenna systems as appropriate.

Next steps

- 1.19 We are aware that during the course of our consultation process, a number of stakeholders have indicated that they might consider seeking judicial review of our final decisions.

- 1.20 In light of the fact that a significant part of this spectrum could be used now to provide services, we consider that any claim for judicial review should be brought promptly, with a request that the courts expedite the matter. We consider that promptness in this case means that any claim for judicial review should be brought within six weeks of the date of this statement.
- 1.21 We have also published a final draft of the Auction Regulations which will give effect to our decisions. We intend to make the Auction Regulations once we are certain that stakeholders will either not seek to challenge the decisions set out in this statement, or any such challenges have been disposed of.
- 1.22 The Auction Regulations will come into force after we formally make them – we will specify the date of entry into force in the final Regulations. Once the Regulations are in force, we will publish details of when and how potential bidders may apply to participate in the auction.
- 1.23 After the application date has passed and applications have been submitted we will conduct a formal qualification process and, when this is completed, publish a list of those applicants who have qualified as bidders.
- 1.24 There will then be a short period during which applicants may withdraw their applications, after which we will give notice of the date on which the principal stage of the auction will begin. We anticipate this will be two to three months after the Regulations come into force.

2. Introduction and approach to this award

- 2.1 As set out in our December 2018 consultation document, reliable mobile services are essential to how people live and work across the UK.² We want to see good quality mobile broadband available from a choice of providers.

The importance of radio spectrum

- 2.2 The radio spectrum comprises one part of the wider electro-magnetic spectrum, which includes all forms of electro-magnetic waves (such as visible light, infrared and X-rays). The significance of the radio spectrum is that it includes waves that can travel over significant distances, and in some cases through objects such as walls and over hills.
- 2.3 Radio waves can be modified by human action so that they can carry information. This allows people to communicate with each other reliably without the need for wires. The radio waves are defined by their frequency, which is the number of times that the wave oscillates per second.³
- 2.4 Radio spectrum is a scarce and finite resource. The spectrum itself is a major asset to the UK economy and society because it is the means by which all wireless communications devices operate. It is critical to areas such as mobile telephony and multimedia, radio and television broadcasting, satellite communications, air travel, emergency services, and public utilities.

The spectrum we are awarding

- 2.5 We are preparing to award 200 MHz of spectrum in total: 80 MHz in the 700 MHz band and 120 MHz in the 3.6-3.8 GHz band. Both of these bands are likely to be used by mobile networks to meet the increasing demand for mobile broadband services, and continue to invest in deploying new services, including 5G - the next generation of mobile technology.

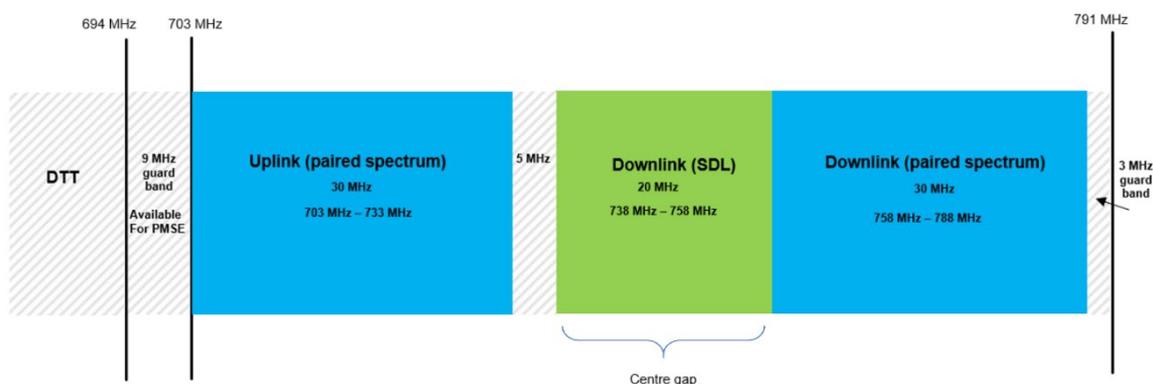
The 700 MHz band

- 2.6 The 80 MHz of spectrum available in the 700 MHz band sits within the 694-790 MHz frequency range. It is made up of two 30 MHz blocks of paired spectrum (703-733 MHz and 758-788 MHz), and a 'centre gap' of 20 MHz at 738-758 MHz, suitable for delivering supplemental downlink (SDL) for mobile services.

² https://www.ofcom.org.uk/data/assets/pdf_file/0019/130726/Award-of-the-700-MHz-and-3.6-3.8-GHz-spectrum-bands.pdf

³ The unit of frequency is a hertz (Hz), which is one oscillation per second. A thousand oscillations per second is referred to as a kilohertz (kHz), a million as a megahertz (MHz), and a thousand million as a gigahertz (GHz). Other types of electro-magnetic wave, such as light, have frequencies that are many orders of magnitude higher than radio. A group of radio frequencies that is contiguous is often referred to as a spectrum or frequency 'band'.

Figure 2.1 – The 700 MHz band



- 2.7 The 700 MHz band is currently being cleared of its existing use for the transmission of Digital Terrestrial Television (DTT) and by wireless microphones used in the entertainment industry for programme-making and special events (PMSE). The band should become available for mobile use by May/June 2020.
- 2.8 The 700 MHz spectrum is well suited for providing mobile coverage over wide areas and indoors. It can therefore be used to improve the level of mobile coverage across the UK, including mobile voice and data coverage in rural areas, and in buildings and other harder-to-reach places.

The 3.6-3.8 GHz band

- 2.9 The 120 MHz of spectrum we will be awarding in the 3.6-3.8 GHz band is a contiguous block between 3680 and 3800 MHz.
- 2.10 The spectrum is part of the 3.4-3.8 GHz band, which has already been harmonised for mobile services and identified as the primary band for 5G services in Europe. It is currently being used for fixed links and for satellite receive stations.
- 2.11 We are clearing fixed links from the band, and have given notice that satellite use will no longer be taken into account for spectrum management purposes. As a result, the 3.6-3.8 GHz band should become available for mobile use by June 2020 (although some localised constraints may remain in place until the end of 2022).
- 2.12 Like the 700 MHz band, this band is also suitable for the provision of mobile services using current technologies. Its use would allow network operators to support high data rates and provide high capacity to large numbers of connected devices (assuming they deploy the appropriate technology).

Our policy objectives for the award

- 2.13 Our objectives for awarding the 700 MHz and 3.6-3.8 GHz frequencies are based on our statutory duties and functions, which come from Parliament. Our principal duty is to further the interests of citizens and consumers in relation to communications matters. As

part of this, we must ensure that a wide range of electronic communications services is available across the UK, and that optimal use is made of the radio spectrum.⁴

2.14 Our objectives for this award are:

- Securing the optimal use of spectrum;
- Sustaining strong competition in mobile markets;
- Encouraging investment and innovation; and
- Ensuring the timely availability of spectrum.

Securing the optimal use of spectrum

2.15 Our main duty in relation to our spectrum management functions is to secure optimal use of the spectrum.

2.16 We consider that, in general, the optimal use of spectrum is most likely to be secured for society if spectrum is used efficiently, that is if it delivers the maximum benefits (or value) for society.

In our Spectrum Management Strategy Statement of 30 April 2014⁵ we said our statutory objective of delivering the optimal use of spectrum in circumstances where demand is likely to be greater than the amount of spectrum available is best achieved by relying on market mechanisms where possible and effective – but we also need to take regulatory action where necessary.

Promoting competition

2.17 In accordance with our duties to promote competition, we want to ensure that consumers and businesses continue to benefit from strong competition in the provision of mobile services. We believe the UK market is generally operating well with continuing innovation and relatively low prices compared to other markets internationally.

2.18 As with the 2018 spectrum auction, we do not consider there are reasons for us to be concerned about the credibility of any of the four main MNOs in the UK in terms of their ability to compete effectively in the market. However, we recognise that certain extreme outcomes of the award could give rise to concerns about the strength of that competition.

2.19 We discuss competition issues in more detail in section 4.

⁴ Section 3(2)(a) and (b) of the 2003 Act.

⁵ Ofcom's statement of 30 April 2014 entitled "Spectrum management strategy", available at:

https://www.ofcom.org.uk/data/assets/pdf_file/0021/71436/statement.pdf

Ofcom's strategic direction and priorities for managing spectrum over the next 10 years", paragraphs 1.10-1.13 and paragraphs 5.25-5.27; see <https://www.ofcom.org.uk/consultations-and-statements/category-1/spectrum-management-strategy>

Encouraging innovation and investment

- 2.20 We have also had regard to the economic and other benefits that may arise from the use of this spectrum, and the need to encourage the development of innovative services.
- 2.21 In addition to increasing capacity to meet demand for services delivered via existing mobile networks, there is the potential for this spectrum to be used for 5G services. Further development of 5G services has the potential to deliver significant benefits for UK consumers and businesses, including superfast broadband, greatly expanded capacity and innovative new services.
- 2.22 Both the 700 MHz and the 3.6-3.8 GHz bands have properties and characteristics that make them particularly suitable for mobile broadband use, including latest technologies. We consider it important to make these bands available in a timely manner to meet consumer demand, particularly for increasing capacity for mobile broadband services, and to enable the industry to take advantage of innovation opportunities.

Improving mobile coverage

- 2.23 In the December 2018 consultation we also identified improving mobile coverage as a key priority for this award. In light of this, we proposed to include coverage obligations in the award to ensure it delivered the maximum benefits (or value) for society, and help to secure optimal use of the spectrum.
- 2.24 These obligations would have allowed bidders to bid for discounts on the cost of the spectrum in return for binding commitments to improve coverage. We proposed a Combinatorial Clock Auction (CCA) format because it would allow bidders to bid on a package of spectrum 'lots' plus coverage obligations
- 2.25 Following publication of the December 2018 consultation, the four MNOs – BT/EE, O2, Three and Vodafone – decided to work with the Government on a voluntary 'Shared Rural Network' programme to improve mobile coverage through infrastructure sharing and Government funding of new coverage in total 'not spots'. The MNOs and the Government have now agreed to full funding of the programme - with the MNOs' commitments having been given effect through binding licence obligations.
- 2.26 These infrastructure-sharing commitments are capable of delivering better outcomes for consumers than we would be able to require through coverage obligations in the spectrum auction. In particular, the creation of a rural network based on voluntary infrastructure sharing will reduce the costs of providing coverage, allowing more comprehensive coverage to be delivered. We have therefore decided it is no longer necessary to include coverage obligations in the auction.

Award by auction

- 2.27 We have decided to award this spectrum through a single auction of licences for both the 700 MHz and for the 3.6-3.8 GHz spectrum. We consider this will enable winning bidders to

bring the spectrum into use as soon as possible, so that people and businesses can benefit quickly from improved services.

- 2.28 We award all spectrum in the way we consider appropriate to secure its efficient use, having regard to the characteristics of the particular bands and the circumstances at the time. In this case we have concluded that awarding national licences would be most likely to achieve optimal use of the spectrum.
- 2.29 We want to ensure all people in the UK and all locations can benefit from reliable mobile broadband services. Both the 700 MHz and the 3.6–3.8 GHz bands are particularly suitable for the provision of mobile broadband services, for which there is nationwide demand.
- 2.30 In October 2019 we consulted on the adoption of a Simultaneous Multiple Round Ascending (SMRA) auction instead of the CCA format proposed in the December 2018 consultation.⁶ We said the SMRA was a more appropriate format in the new circumstances, following the agreement to establish a Shared Rural Network.

This document

- 2.31 In the remainder of the main body of this statement we set out our decisions for this award. Where relevant, we summarise the proposals we set out in the December 2018, June 2019 and October 2019 consultations, the responses we have received to our proposals, and our assessment of those responses.
- 2.32 A list of relevant documents published in developing our proposals for the award of the 700 and 3.6-3.8 GHz spectrum can be found at annex 1.
- 2.33 In some places in this document and in the annexes we draw on evidence supplied to us in confidence. This evidence is redacted in the published version of this document. Where we have redacted passages of text or illustrations it is indicated by the [✂ REDACTED] symbol.

⁶ https://www.ofcom.org.uk/_data/assets/pdf_file/0028/172648/revised-proposal-auction-design.pdf

3. Legal framework

Introduction

- 3.1 Our statutory duties are set out in the Communications Act 2003 (the “**CA 2003**”) and the Wireless Telegraphy Act 2006 (the “**WTA 2006**”), which transpose the provisions of the Common Regulatory Framework⁷ for electronic communications networks and services including the Framework Directive and the Authorisation Directive, and any relevant Decisions of the European Commission which bind the UK as to the use of the spectrum to be awarded.
- 3.1 The UK ceased to be a member of the European Union on 31 January 2020. Under the terms of the Withdrawal Agreement, EU law will continue to apply in the UK until 31 December 2020. In reaching our decisions we have continued to apply the current legal framework, including the EU Framework.

UK national law

The Communications Act 2003 (the “**CA 2003**”)

- 3.2 Ofcom’s principal duties under section 3 of the CA 2003 are:
- a) to further the interests of citizens in relation to communications matters; and
 - b) to further the interests of consumers in relevant markets, where appropriate, by promoting competition.
- 3.3 By virtue of our principal duties, we are required to secure, amongst other things, the optimal use for wireless telegraphy of the electro-magnetic spectrum (CA 2003, s. 3(2)(a)) and the availability throughout the UK of a wide range of electronic communications services (CA 2003, s. 3(2)(b)).
- 3.4 In performing our duties we must also have regard to certain matters as appear to us to be relevant in the circumstances, including:
- a) the desirability of promoting competition in relevant markets (CA 2003, s. 3(4)(b));
 - b) the desirability of encouraging investment and innovation in relevant markets (CA 2003, s. 3(4)(d));
 - c) the desirability of encouraging the availability and use of high speed data transfer services throughout the UK (CA 2003, s. 3(4)(e));

⁷ The Common Regulatory Framework comprises the Framework Directive (Directive 2002/21/EC), the Authorisation Directive (Directive 2002/20/EC), the Access Directive (Directive 2002/19/EC), the Universal Service Directive (Directive 2002/22/EC) and the Directive on privacy and electronic communications (Directive 2002/58/EC), as amended by the Better Regulation Directive (Directive 2009/140/EC).

- d) the different needs and interests of all persons who may wish to make use of the electro-magnetic spectrum (CA 2003, s. 3(4)(f)); and
 - e) the different interests of persons in the different parts of the UK and persons living in rural and in urban areas (CA 2003, s. 3(4)(l)).
- 3.5 In performing our duties, we are required under section 3(3) of the CA 2003 to have regard in all cases to the principles under which regulatory activities should be transparent, accountable, proportionate, consistent and targeted only at cases in which action is needed.
- 3.6 Section 4 of the CA 2003 requires Ofcom to act in accordance with the six Community requirements, which give effect to the requirements of Article 8 of the Framework Directive. In summary, the Community requirements are requirements:
- a) to promote competition in communications markets;
 - b) to ensure that Ofcom contributes to the development of the European internal market;
 - c) to promote the interests of all European Union citizens;
 - d) to act in a manner which, so far as practicable, is technology neutral;
 - e) to encourage, to the extent Ofcom considers it appropriate, the provision of network access and service interoperability for the purposes of securing efficiency and sustainable competition in communications markets and the maximum benefit for the customers of communications network and services providers; and
 - f) to encourage such compliance with certain international standards as is necessary for facilitating service interoperability and securing freedom of choice for the customers of communications providers.

The Wireless Telegraphy Act 2006 (“the WTA 2006”)

Duties imposed by the WTA 2006

- 3.7 In carrying out our spectrum functions, we have a duty under section 3 of the WTA 2006 to have regard in particular to: (i) the extent to which the spectrum is available for use or further use for wireless telegraphy, (ii) the demand for use of that spectrum for wireless telegraphy and (iii) the demand that is likely to arise in future for the use of that spectrum for wireless telegraphy.
- 3.8 We also have a duty to have regard, in particular, to the desirability of promoting: (i) the efficient management and use of the spectrum for wireless telegraphy, (ii) the economic and other benefits that may arise from the use of wireless telegraphy, (iii) the development of innovative services and (iv) competition in the provision of electronic communications services (WTA 2006, s. 3(2)).

The Common Regulatory Framework

The Framework Directive

- 3.9 Article 8 of the Framework Directive sets out the objectives which national regulatory authorities must take all reasonable steps to achieve. These include:
- a) the promotion of competition in the provision of electronic communications networks and services by, amongst other things, ensuring there is no distortion or restriction of competition in the electronic communications sector and encouraging efficient use and effective management of radio frequencies (Art. 8(2));
 - b) contributing to the development of the internal market by, amongst other things, removing obstacles to the provision of electronic communications networks and services at a European level, and encouraging the interoperability of pan-European services.
- 3.10 In pursuit of these policy objectives, Article 8 requires national regulatory authorities to apply objective, transparent, non-discriminatory and proportionate regulatory principles by, among others:
- a) ensuring that, in similar circumstances, there is no discrimination in the treatment of undertakings providing electronic communications networks and services;
 - b) safeguarding competition to the benefits of consumers and promoting, where appropriate, infrastructure-based competition; and
 - c) promoting efficient investment and innovation in new and enhanced infrastructures.
- 3.11 Article 8 also requires Member States to ensure that, in carrying out their regulatory tasks, national regulatory authorities take the utmost account of the desirability of making regulations technologically neutral.
- 3.12 Article 9 of the Framework Directive requires Member States to ensure the effective management of radio frequencies for electronic communications services in accordance with Article 8, and to ensure that spectrum allocation used for electronic communications services and issuing general authorisations or individual rights of use of such radio frequencies are based on objective, transparent, non-discriminatory and proportionate criteria. Article 9 also requires Member States to promote the harmonisation of use of radio frequencies across the Community, consistent with the need to ensure effective and efficient use of frequencies. It further requires Member States to ensure technology and service neutrality.

The Authorisation Directive

- 3.13 Article 5 of the Authorisation Directive provides that where it is necessary to grant individual rights of use of radio frequencies, Member States must grant such rights through open, objective, transparent, non-discriminatory and proportionate procedures, and in accordance with the provisions of Article 9 of the Framework Directive. When granting

those rights, Member States are required to specify whether they can be transferred by the holder, and if so, under which conditions.

- 3.14 Article 6 of the Authorisation Directive provides that rights of use for radio frequencies may be subject only to the conditions listed in the Annex to the directive. Part B of the Annex, which sets out conditions which may be attached to such rights of use, includes an obligation to provide a service or to use a type of technology for which the rights of use for the frequency has been granted, including, where appropriate, coverage and quality requirements, as well as conditions relating to the effective and efficient use of frequencies.
- 3.15 Article 7 of the Authorisation Directive provides that where Member States decide to limit the number of rights of use to be granted for radio frequencies, they must, among other things, give due weight to the need to maximise benefits for users and to facilitate the development of competition.
- 3.16 The legal duties imposed on the UK by the Framework and Authorisation Directives are transposed into UK law and given effect to by the CA 2003 and the WTA 2006.

The Electronic Communications Code

- 3.17 We note that the Common Regulatory Framework has been replaced by the European Electronic Communications Code (the “**Code**”).⁸ The Code was published in the Official Journal of the EU on 17 December 2018, and Member States have until 21 December 2020 to implement the provisions in domestic law. The UK Government has indicated that it currently intends to implement the Code, notwithstanding the UK’s exit from the EU. As such, we have had the new provisions of the Code in mind in making our decisions for this award, and as appropriate we make reference to the Code in that context in this document.

European Commission decisions relevant to the 700 MHz and 3.6-3.8 GHz spectrum

The 700 MHz spectrum

- 3.18 The 700 MHz spectrum is the upper part of the 470-790 MHz frequency band (the “**UHF band**”) which is currently used for terrestrial broadcasting and wireless audio PMSE use.
- 3.19 On 17 May 2017, the European Parliament and the Council adopted Decision 2017/899 (the “**2017 UHF Decision**”)⁹, which requires Member States to repurpose the 700 MHz frequency band from its current TV broadcasting and wireless audio PMSE use to new

⁸ Directive 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code; see <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L.2018.321.01.0036.01.ENG>

⁹ Decision (EU) 2017/899 of the European Parliament and of the Council of 17 May 2017 on the use of the 470-790 MHz frequency band in the Union: <http://eurlex.europa.eu/legalcontent/EN/TXT/?qid=1515598100425&uri=CELEX:32017D0899>

mobile broadband use by 30 June 2020. In doing so, Member States must apply the technical conditions laid down in the Commission implementing decision adopted on 28 April 2016 to harmonise the technical conditions of use and band plan for the 700 MHz band.¹⁰

The 3.6-3.8 GHz spectrum

- 3.20 On 21 May 2008, the European Commission adopted Decision 2008/411/EC which harmonises the conditions for the availability and efficient use of the 3.4 GHz to 3.8 GHz frequency band for terrestrial systems capable of providing electronic communications services in the EU. The Decision provided that Member States should designate, by 1 January 2012, the 3.6 GHz to 3.8 GHz band on a non-exclusive basis for terrestrial communications networks in compliance with the technical parameters set out in the annex to the Decision.
- 3.21 On 2 May 2014, the European Commission adopted Decision 2014/276/EU, which amended Commission Decision 2008/411/EC, primarily in relation to the technical conditions in compliance with which the band should be made available.¹¹
- 3.22 On 24 January 2019, the Commission updated the relevant technical conditions applicable to the 3.4-3.8 GHz frequency band by introducing further amendments to Decision 2008/411/EC through its Decision 2019/235. Recital 10 of this decision, which concerns the defragmentation of the 3.4 to 3.8 GHz frequency band, reads as follows:

“Taking into account Article 54 of the European Electronic Communications Code, Member States should aim at ensuring a defragmentation of the 3 400-3 800 MHz frequency band so as to provide opportunities to access large portions of contiguous spectrum in line with the goal of gigabit connectivity. This includes facilitating trading and/or leasing of existing rights of use. Large contiguous spectrum portions of preferably 80-100 MHz facilitate the efficient deployment of 5G wireless broadband services, for example using Active Antenna Systems (AAS), with high throughput, high reliability and low latency in line with the policy objective of gigabit connectivity. This objective is of particular importance for a defragmentation.”

- 3.23 Article 54 of the Code, which is referred to above, includes the following provision on the 3.4-3.8 GHz frequency band:

¹⁰ Commission Implementing Decision (EU) 2016/687 of 28 April 2016 on the harmonisation of the 694-790 MHz frequency band for terrestrial systems capable of providing wireless broadband electronic communications services and for flexible national use in the Union: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L.2016.118.01.0004.01.ENG>

¹¹ The EC Decision (as amended) has been implemented into UK law by way of Statutory Instrument 2016 No. 495.

“(1) By 31 December 2020, for terrestrial systems capable of providing wireless broadband services, Member States shall, where necessary in order to facilitate the roll-out of 5G, take all appropriate measures to:

(a) reorganise and allow the use of sufficiently large blocks of the 3.4-3.8 GHz band;”

Allocation of spectrum by auction

- 3.24 Ofcom may allocate spectrum by way of auctions having regard to the desirability of promoting the optimal use of spectrum (WTA 2006, s. 14). In making auction regulations, Ofcom must satisfy itself that the criteria for spectrum allocation are:
- a) objectively justifiable in relation to the frequencies to which they relate;
 - b) not such as to discriminate unduly against particular persons;
 - c) proportionate to what they are intended to achieve; and
 - d) in relation to what they are intended to achieve, transparent (WTA 2006, s.14(3B)).
- 3.25 Auction regulations may make provisions with respect to the grant of the relevant licences and also the terms, provisions and limitations subject to which such licences are granted (WTA 2006, s. 14(2) and s. 14(3)(h)).

Licence conditions

- 3.26 S.9(1A) of the WTA 2006 confirms that the terms, provisions and limitations of a licence for the use of spectrum for the provision of an electronic communications network or service must fall within Part B of the Annex to the Authorisation Directive as set out above.
- 3.27 The terms, provisions and limitations of a spectrum licence must not duplicate the obligations already imposed on the licensee by the general conditions set by Ofcom under section 45 of the Communications Act (WTA 2006, s. 9(6)). The current general conditions, which came into force on 1 October 2018¹², do not include any of the obligations that we have decided to attach to the 700 MHz or 3.6 – 3.8 GHz licences.
- 3.28 Under section 9(7) of the WTA 2006, Ofcom may only impose terms, provisions and limitations which are:
- a) objectively justified in relation to the network and services to which they relate;
 - b) not unduly discriminatory;
 - c) proportionate to what they are intended to achieve; and
 - d) transparent in relation to what they are intended to achieve.

¹² The general conditions of entitlement: <https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/telecoms-competition-regulation/general-authorisation-regime>

4. Competition assessment

- 4.1 Ofcom has a statutory duty, where appropriate, to promote competition in relevant markets.¹³ One of our objectives in this award is therefore to ensure that consumers and businesses in the UK continue to benefit from strong competition in the provision of mobile services. In this section, we assess any potential competition concerns that might arise from the auction of 700 MHz and 3.6-3.8 GHz spectrum.
- 4.2 In summary, we have decided to impose a cap of 416 MHz (37%) on the overall volume of spectrum a single operator may hold. We have decided not to impose any ‘sub caps’ on holdings of low frequency or 3.4-3.8 GHz spectrum.
- 4.3 Our reasoning for these decisions, including our consideration of relevant stakeholder responses to our December 2018 and October 2019 consultations, is set out in this section. Supporting evidence is also contained in annexes 3 to 7.

Context for our assessment

The current UK mobile sector

- 4.4 There are four national mobile network operators (MNOs) in the UK: BT/EE, Vodafone, O2 and H3G (Three). O2 is currently the largest provider of wholesale mobile services, with a 34% share of subscribers. BT/EE is almost as large, with 32%, followed by Vodafone with 22% and H3G with 12%.
- 4.5 There are two network sharing arrangements in operation in the UK – the MBNL agreement between H3G and BT/EE, and the Beacon (or CTIL) agreement between O2 and Vodafone. These agreements allow operators to share passive network elements (such as masts, cabinets, antennas and mobile backhaul connections) and/or active elements such as radio base station equipment.¹⁴
- 4.6 MNOs use their mobile networks to provide retail services under their brand. They also provide mobile network services (wholesale services) to a number of mobile virtual network operators (MVNOs), such as Tesco or Virgin. Some of these MVNOs are owned by the MNOs and some are independent. Independent MVNOs, in total, account for around 11% of retail subscriptions.
- 4.7 The UK’s market concentration has gradually diminished since the merger of T-Mobile and Orange in 2010 and is now at a level comparable with other European countries that have

¹³ See s3 Communications Act 2003.

¹⁴ Vodafone and O2 have announced that the CTIL agreement will continue to be used in future for 5G rollout. O2 issued a [press release](#) (24 July 2019) saying they will share 5G active equipment, such as radio antennas, on joint network sites across the UK. They have also agreed to network autonomy on around 25% of combined network sites in larger cities and London. At these sites, each party will install their own radio equipment, fibre ‘backhaul’ connection and power supply while sharing the physical mast. The MBNL agreement between H3G and BT/EE already allows both parties to use shared passive infrastructure to deliver individual 4G networks, and this looks likely to continue for 5G.

four MNOs. The UK's prices for mobile services are among the lowest in Europe. Furthermore, customer satisfaction with UK mobile services remains high: 93% of customers reported that they were satisfied with their overall mobile service.¹⁵ All four MNOs experienced negative revenue growth in 2019, after a period of positive growth, while average revenue per subscriber (ARPU) has been fairly static or falling for the last few years.

- 4.8 In preparing for the 2013 4G auction and the 2018 2.3 and 3.4 GHz auction, we considered the importance of having at least four credible MNOs¹⁶. We defined an MNO (which we then referred to as a 'national wholesaler') as a company that controls wholesale access to national Radio Access Networks (RANs).¹⁷ We also said that by credible, we mean that each MNO exerts an effective constraint on its rivals in terms of factors such as the provision of high quality services, competitive prices, and choice and innovation. These factors contribute to the overall competitiveness of the market.¹⁸
- 4.9 As set out in our 4G auction statement and again in our 2.3 and 3.4 GHz auction statement, we continue to believe it is in consumers' interests for there to be at least four credible MNOs.¹⁹ The existence of four credible MNOs supports retail competition directly because MNOs are major competitors in supplying retail mobile services to consumers. It also supports retail competition indirectly because the MNOs compete to provide wholesale access to MVNOs.
- 4.10 Having looked at competition in the UK mobile services sector today and evaluated the wide range of evidence presented in annex 3, we consider that the current provision of mobile services is functioning well, with competition between the four MNOs delivering good outcomes for consumers.

Current allocations of spectrum

- 4.11 Existing spectrum shares, and how they might change as a result of this award, are at the core of our competition assessment. Figure 4.1 below presents the MNOs' current spectrum holdings.
- 4.12 BT/EE has the most spectrum across all mobile frequencies with 295 MHz; and O2 has the least (166.4 MHz), with particularly little spectrum in the mid frequency bands (1800 MHz to 3.8 GHz included). There is, therefore, an asymmetry in overall spectrum holdings. But we note that even the MNOs with less overall spectrum have strengths in certain bands.

¹⁵ Ofcom, [Comparing Service Quality 2018](#). See annex 3, paragraph A4.68.

¹⁶ In our July 2012 statement we used the term 'national wholesaler' to mean what we here refer to as MNO.

¹⁷ In practice, by 'national' RANs, we mean RANs that provide coverage to a high portion of the UK population. We used the term national wholesaler, since owners of sub-national RANs are also network operators, albeit on a much smaller scale. Additionally, national wholesalers could share or contract for access to national RANs and still be in a position of controlling wholesale access but not operating the network.

¹⁸ See paragraph 6.13 and 6.104 of the July 2017 Statement on the 2.3 and 3.4 GHz auction, and paragraphs 4.25 and 4.20 of the July 2012 Statement.

¹⁹ See, for example, paragraph 6.104 of the July 2017 statement on the 2.4/3.4 GHz auction:

https://www.ofcom.org.uk/data/assets/pdf_file/0022/103819/Statement-Award-of-the-2.3-and-3.4-GHz-spectrum-bands-Competition-issues-and-auction-regulations.pdf

- 4.13 O2 and Vodafone have large amounts of low frequency spectrum, whereas H3G and BT/EE have relatively little. H3G, however, has a large amount of spectrum in the wider 3.4-3.8 GHz band as a result of its purchase of UK Broadband (which holds spectrum licences in this band) as well as the 20 MHz it won in the 2018 auction.
- 4.14 In this auction, we will be awarding:
- 60 MHz of paired 700 MHz spectrum,
 - 20 MHz of downlink-only 700 MHz spectrum, and
 - 120 MHz of 3.6-3.8 GHz spectrum.
- 4.15 This additional spectrum represents an increase of around 18% of current overall spectrum holdings. The 700 MHz spectrum we are awarding represents a substantial addition to the current low frequency holdings: it is equivalent to 47% of all currently held low frequency spectrum, including 1400 MHz in this pool (and 62% of all sub-1 GHz spectrum). The 3.6-3.8 GHz spectrum we are awarding is equivalent to 44% of all spectrum in the wider 3.4-3.8 GHz band that is currently allocated.
- 4.16 We have made spectrum in some bands (including mmWave) available for shared access.²⁰ We do not, however, consider mmWave spectrum to be relevant for the competition assessment for this award because it is not seen as a substitute for sub-6 GHz spectrum and there is currently considerable uncertainty around how and when it will be used for mobile. We further discuss all current and potential mobile spectrum bands (including mmWave) in detail in annex 4.

²⁰ <https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation>

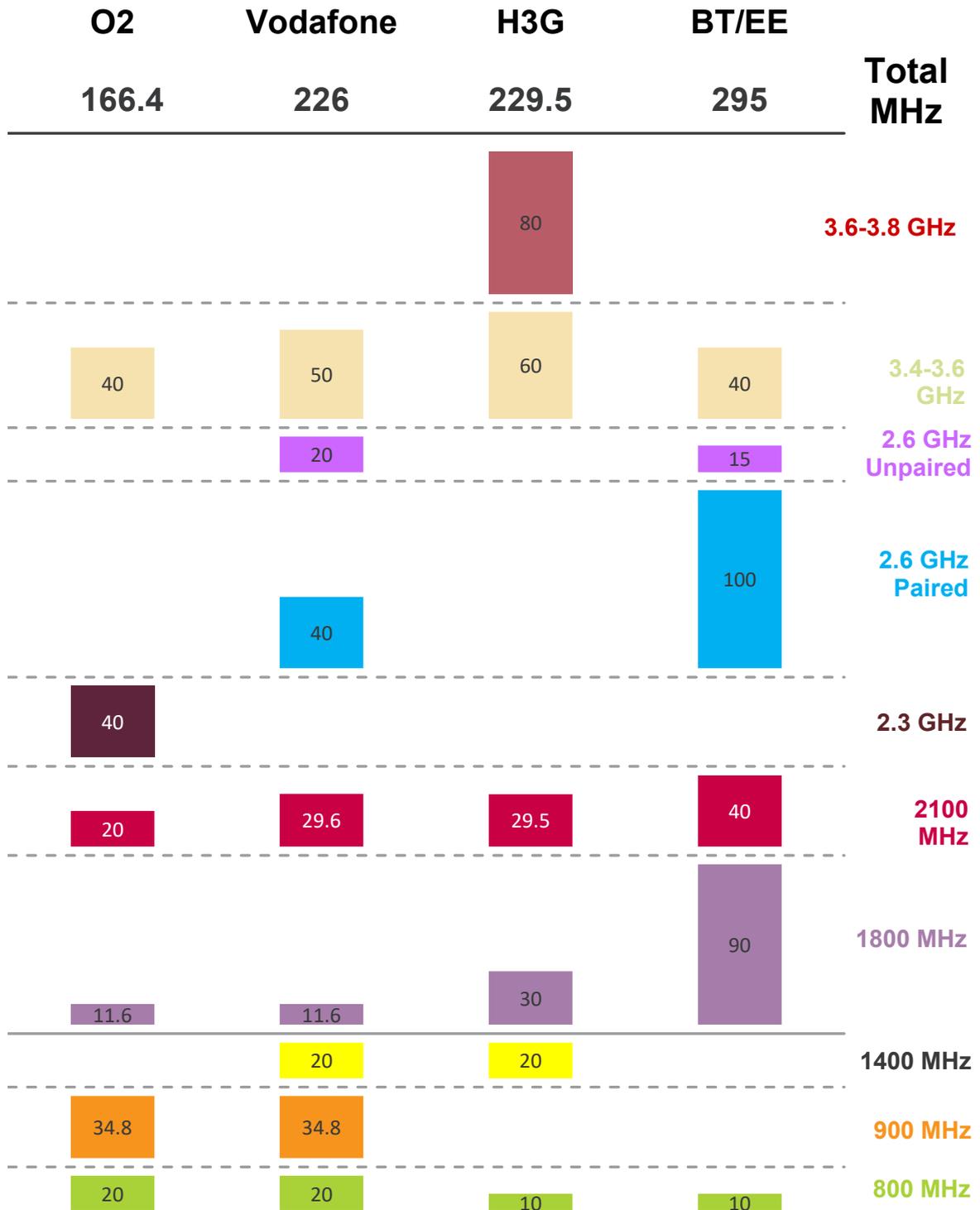


Figure 4.1: UK mobile spectrum holdings

The framework for our assessment

- 4.17 In the December 2018 consultation, we set out our proposed framework for evaluating competition concerns.²¹ We received no objections to this framework and have decided to apply it.
- 4.18 In summary, in line with the approach we have used in previous auctions,²² our analytical framework consists of the following elements:
- We consider which auction outcomes might give rise to competition concerns. By this, we mean post-auction distributions of spectrum holdings that could weaken future competition in the mobile market. For example, we might be concerned if an operator with a large amount of existing spectrum were to win all of the spectrum awarded in the auction.
 - We consider the potential severity of the effect on competition if these outcomes were to occur. For example, how detrimental it might be if O2 were to win no spectrum in the auction, or if BT/EE were to win all of the spectrum awarded.
 - We consider how likely it is that those outcomes would arise as a result of bidders' behaviour in the auction in the absence of any competition measures (such as caps). As part of this, we consider the bidders' likely value for the spectrum – either for the use they could make of it in supplying mobile services, or for strategic reasons in denying that spectrum to rivals.
 - We then set out which competition concerns are most relevant for the current auction.
 - We then set out our assessment of the competition measures that we have decided to impose to address our concerns.
- 4.19 The framework we use for assessing the *proportionality* of different options for addressing competition concerns, including the option of applying no competition measures, is based on the following principles:
- the measure must be effective to achieve the legitimate aim in question;
 - the measure must be no more onerous than is required to achieve that aim;
 - the measure must be the least onerous, if there is a choice of equally effective measures; and
 - in any event, the measure must not produce adverse effects which are disproportionate to the aim pursued.
- 4.20 In considering the effectiveness and potential downsides of the different options, we recognise the uncertainty that is an inevitable aspect of this forward-looking competition assessment. There are uncertainties, for example, over the potential effects of spectrum asymmetries, the evolution of technology and consumer demand, the likelihood of concerns arising without measures to prevent them and whether competition measures

²¹ Paragraphs 5.28 to 5.68.

²² The competition assessment for the 2.3 and 3.4 GHz auction (see https://www.ofcom.org.uk/_data/assets/pdf_file/0022/103819/Statement-Award-of-the-2.3-and-3.4-GHz-spectrum-bands-Competition-issues-and-auction-regulations.pdf, chapters 6 and 7) and the competition assessment for the 4G auction (see https://www.ofcom.org.uk/_data/assets/pdf_file/0031/46489/statement.pdf, paragraph 4.32).

might unintentionally lead to a worse outcome for consumers. These uncertainties mean that making decisions on the proportionality of the different options involves expert judgement. We have carried out our assessment and exercised our judgement taking account of all relevant facts and the submissions we have received from stakeholders.

- 4.21 As set out in the December 2018 consultation²³, competition measures may unintentionally harm consumers' interests if they prevent an outcome that would be beneficial. For example, if competition measures mean that spectrum is not allocated to operators that have the highest intrinsic value, and could therefore provide innovative and/or competitive services, they might be against consumers' interests.
- 4.22 In general, in light of the inevitable uncertainties involved in our assessment and the risk of unintended consequences, we have been cautious about imposing competition measures in this auction and sought to ensure that the level of intervention is the minimum necessary to achieve our policy objectives effectively.

The potential competition concerns

- 4.23 We now discuss the specific competition concerns that could potentially arise in the context of this award.

The risks to competition from asymmetric spectrum holdings

- 4.24 We consider the UK mobile market is generally working well, with four credible MNOs and a range of MVNOs supporting strong retail competition. Nonetheless, we would be concerned if increased spectrum asymmetry weakened competition between MNOs, particularly if large asymmetries were to persist in the medium to long term. Data traffic grew by 37% from 2017 to 2018²⁴, and we expect this trend to continue. According to Cisco VNI the average mobile-connected end user device will generate on average 11.4 GB of data traffic per month in 2022, compared to 2.3 GB in 2017.²⁵
- 4.25 Data traffic growth will require increasing capacity in order for MNOs to continue to provide a good quality of service to mobile consumers in a cost-efficient manner. There are different ways operators could potentially meet these needs, but deploying additional spectrum is likely to be very important.
- 4.26 Although it is absolute spectrum holdings that affect an MNO's capacity to supply its customers, we are also concerned about spectrum *shares*. A large difference in the relative holdings of spectrum could influence competition between the MNOs, both in terms of sub-groups or overall spectrum. Competition may be weaker either if one (or more) MNO has a very high share of spectrum, or one (or more) MNO has a very low share, though we do not consider that symmetrical shares of spectrum are necessary for competition to work well.

²³ At paragraph 5.66.

²⁴ See annex 3, figure A3.28.

²⁵ See annex 7, paragraph A7.7.

- 4.27 We consider that competition may be weaker if one (or more) MNO has a very high share of spectrum, for a number of reasons:
- a) **Unmatchable competitive advantage:** If one MNO has such a high relative share of spectrum that it is able to offer superior services that its rivals are unable to replicate. Whilst this may benefit consumers in the short term, it could lead to weaker competition and therefore higher prices or lower quality services in the longer term.
 - b) **Spectrum hoarding:** An MNO with a very high spectrum share could in principle make limited use of any additional spectrum it wins in an auction, whilst other MNOs with less spectrum might have put it to more immediate or productive use, and therefore may have competed more strongly if they had won the spectrum instead. In addition, in certain circumstances an MNO might try to acquire or hold onto a block of spectrum to prevent specific arrangements of spectrum holdings within the band.
 - c) **Excess spectrum capacity distorting the market:** There is a risk that an MNO with a very high spectrum share could credibly threaten to respond with aggressive price cuts if rivals sought to grow their market share through lower prices. The threat of provoking such a response may put rivals off seeking to compete more aggressively, and lead to a softening of competition. If the MNO with spare capacity became the only viable alternative for prospective MVNOs (because others did not have sufficient capacity to supply them) this could soften wholesale competition, which in turn would have adverse effects on retail competition.
 - d) **Greater ability to launch new services without affecting existing services:** An MNO could use its spare spectrum to launch new services before its competitors, leaving its other services unaffected, whereas rivals might need to re-purpose some of their existing deployments, potentially to the detriment of their legacy services. Again, although some customers might benefit from earlier availability of new services, there could be weaker competition in the longer term.
- 4.28 We also consider that competition could be weaker if one (or more) MNO had a relatively small share of spectrum. An MNO in this situation might struggle to provide adequate capacity, and therefore not be able to supply its customers with a minimum level of service. Operators can add network capacity in a number of ways, in addition to deploying more spectrum. These can include building more sites and/or making use of more efficient technologies. Alternatively, operators can use traffic management techniques or commercial strategies that make best use of their capacity.
- 4.29 MNOs with lower shares of licensed spectrum than rivals may therefore be able to deliver comparable levels of capacity by relying on approaches other than by deploying additional spectrum. However, some of the alternative methods to increase capacity can take a long time to deploy, can be technically challenging or may cost more than acquiring and deploying additional spectrum. Spectrum availability may, therefore, place a key constraint on an MNO's capacity to supply services to its customers, especially when data traffic growth is so significant. As a result, an MNO with a low share of spectrum could have reduced incentives to compete aggressively for new customers given the costly investment

in sites that would be required to serve additional customers (though we note that MNOs may in any case need to invest in sites to meet growing demand).

- 4.30 In general, therefore, spectrum holdings influence an MNO's ability to serve mobile users with a minimum quality of service and competition could be weaker if one or more MNOs had a relatively low share of overall spectrum.

Symmetrical spectrum shares are not necessary

- 4.31 Asymmetries in spectrum holdings are not negative *per se* – either in terms of overall spectrum or sub-groups of different frequencies. Such asymmetries can, in certain instances, be positive for competition and give rise to consumer benefits; they may also reflect differences in operators' commercial strategies and expectations about the future.
- 4.32 MNOs do not need to have the same, or close to the same, shares of spectrum in order for there to be strong competition:
- a) MNOs can have different market shares (that is, need different amounts of capacity to serve their customers well), may have compensating strengths in other areas (e.g. customer service or good coverage), or may still be able to deliver services to many consumers by choosing technical or commercial strategies that make best use of their capacity.²⁶
 - b) As noted above, spectrum is not the only way of adding capacity or improving services. Capacity can be added in many other ways, though these alternative means of increasing capacity may cost more or take longer than using additional spectrum. For example, we note that H3G (jointly with BT/EE) has the highest share of data traffic, despite H3G having had relatively low spectrum holdings (and it has by far the highest share of data traffic per subscriber and per MHz of spectrum held).²⁷
 - c) A degree of asymmetry in overall spectrum holdings may give rise to consumer benefits. For example, an operator with a large share of spectrum may use any additional spectrum in an innovative way, and an operator that has a lower share of spectrum may find innovative ways of attracting consumers to compensate e.g. targeting particular consumer groups or business segments, or by offering higher quality in other aspects of service.
- 4.33 In general, we are also more concerned about significant asymmetries that persist in the medium to longer term than in the very short term, particularly as we do not currently have any firm plans to award further low frequency or mid frequency spectrum in the medium term.

²⁶ However, we recognise that if very restrictive commercial strategies are adopted to cope with limited capacity, then competition for some users may become weaker.

²⁷ Note that this does not take into account the UK Broadband spectrum in the 3.4-3.6 GHz band which is only recently being deployed by H3G.

Consideration of ‘strategic bidding’

- 4.34 We have an established framework for considering strategic bidding within the context of spectrum auctions, which we have used in both the 2013 4G auction and the 2018 2.3 and 3.4 GHz auction²⁸, and proposed in our December 2018 consultation.. We consider this framework remains appropriate for this auction and summarise it here.
- 4.35 In an auction, the spectrum ought to be acquired by the bidder who has the greatest value for it. There may be circumstances, however, when allocating the spectrum to the MNO with the highest value can result in an allocation that weakens competition.
- 4.36 We distinguish two different sources of value (i.e. profits) for MNOs when bidding for spectrum: intrinsic value and strategic value.²⁹
- 4.37 Intrinsic value is the present value of additional profits a bidder expects to earn when holding the spectrum, compared to not holding it, from using it to supply (additional or improved) services to consumers or being able to reduce the cost of adding additional capacity. Intrinsic value does not take account of value obtained from strategic investment, which is the present value of additional expected profits earned from bids that deprive competitors of spectrum, and therefore affect the future structure of competition in mobile services.
- 4.38 Strategic bidding may also be motivated by considerations other than denying the spectrum to rivals, for example to acquire a small amount of spectrum to prevent other MNOs using their spectrum effectively or to drive up the price competitors pay for spectrum. We consider the risks for competition from price driving in section 5.
- 4.39 Bidding based on a high intrinsic value may still result in an allocation of spectrum that could weaken competition. In this case, there may be a trade-off for consumers between benefits from the spectrum going to the MNO which will make the best use of it, and weaker competition as a result of a more asymmetric allocation of spectrum. The net benefit may be positive or negative for consumers.
- 4.40 Where the bidding is based on strategic investment value, there is generally no trade off and the outcome is likely to be harmful for consumers.
- 4.41 When assessing the likelihood of outcomes which may cause concern, we consider the possibility of bids based on intrinsic value and strategic value.

Intrinsic value for spectrum

- 4.42 An MNO’s intrinsic value for spectrum will depend on the benefit the MNO can obtain from using the spectrum and the costs of deploying it. Benefits could arise either from being able to increase revenues (for example by supplying improved services that attract new

²⁸ Paragraphs 5.46 to 5.60.

²⁹ Even if MNOs do not necessarily make the distinction between these two sources of value in an explicit way when formulating their own valuation of spectrum, it is relevant for our analysis.

subscribers or increased revenue per subscriber), or from reduced costs in supplying these services.

- 4.43 The costs of deploying the spectrum will depend on the additional equipment needed to make use of it and on the MNO's existing network configuration.

Strategic investment can be costly and difficult to coordinate

- 4.44 Strategic investment occurs when an MNO bids in excess of its own intrinsic value for an amount of spectrum with the aim of denying that spectrum to competitors. Strategic investment may be attempted by a single bidder (unilaterally) or through tacit coordination between two or more bidders.
- 4.45 Tacit coordination occurs when, without discussing it or reaching an agreement, two or more MNOs combine their bids for spectrum in order to deny the spectrum to a rival. This can lower the cost of strategic investment by sharing this cost with other MNOs – but it can be difficult to achieve due, for example, to a lack of information on spectrum valuations or the inability to find a target outcome or a focal point of spectrum allocations to coordinate bids.
- 4.46 The incentive for a bidder to engage in strategic investment will depend on the cost and the pay-off of winning the spectrum. The cost will, in general, depend on the amount that an MNO needs to outbid its target to win the spectrum.
- 4.47 If a rival has a high (intrinsic) value for the spectrum, then strategic investment is likely to be extremely costly, especially if the strategic investor has a low value for the spectrum itself, aside from the strategic motive.
- 4.48 The pay-off will depend on the rival's competitive position being sufficiently weakened by being denied the spectrum, such that the strategic investor will be able to win customers or raise prices. If the rival has alternative means to maintain its competitive position – for example because it has considerable spectrum holdings in other frequencies or can build more mobile sites to increase coverage – then strategic investment is unlikely to be profitable.
- 4.49 We consider the likelihood of strategic bidding, including the potential incentives and ability to achieve it, in more detail below as it relates to our various potential competition concerns.

The potential competition concerns in this award

- 4.50 When considering which auction outcomes might give rise to competition concerns there are two broad types of concern.
- 4.51 The most serious potential concern would arise if one or more operator(s) might have a sufficiently small share of spectrum post-auction that they **cease to be credible**. That is, they would not exert an effective competitive constraint on rivals across a wide range of services valued by consumers and thus fail to contribute to the overall competitiveness of

the market (even if they do not exit the market). We consider it important that there remain at least four credible MNOs.

- 4.52 A second type of concern would arise if the auction resulted in **an allocation of spectrum which is significantly asymmetric and could potentially weaken competition** between MNOs. We may be concerned about the negative effects of very asymmetric spectrum shares on competition, even if we expect all operators to remain credible whatever the outcome of the auction. Competition problems due to asymmetry can arise either from one operator having a particularly large share of spectrum or from an operator having a particularly small share.
- 4.53 We have identified a number of potential competition concerns in relation to this award:
- a) **Competition concern 1:** The likelihood of very asymmetric mobile spectrum shares weakening competition (even if there are four credible MNOs) through:
 - i) a) asymmetry in overall spectrum;
 - ii) b) asymmetry in low frequency spectrum; or
 - iii) c) asymmetry in 3.4-3.8 GHz spectrum.
 - b) **Competition concern 2:** The likelihood of there ceasing to be four credible MNOs as a result of the auction.
- 4.54 We consider that all MNOs will have sufficient spectrum portfolios to remain credible whether or not they acquire any spectrum in this award. The bulk of our analysis, therefore, focuses on our potential concerns due to asymmetric spectrum holdings.
- 4.55 In our December 2018 consultation, as well as in previous auctions, we considered the same potential competition concerns.³⁰ In addition, we considered whether asymmetry in ‘capacity’ spectrum would be a cause for concern. We cover this briefly below but do not explore it in detail since we proposed not to impose any additional ‘capacity’ measures and stakeholders broadly agreed with this proposal.

Competition concern 1a: The risk of highly asymmetric overall spectrum shares

Summary

- 4.56 As in previous auctions, we consider that competition might be weaker if one (or more) MNO had a particularly high or low relative share of spectrum. Although overall spectrum shares have been less asymmetric since the 2.3 and 3.4 GHz auction in March 2018, spectrum shares in the UK remain relatively asymmetric (in particular, in relation to comparable international markets). We would be particularly concerned if BT/EE won all of the available spectrum in this award, as its share of overall spectrum could reach 44%. We

³⁰ Outlined in paragraphs 5.69 to 5.73.

have therefore considered whether it would be appropriate to impose a competition measure to prevent an MNO obtaining a highly asymmetric share of spectrum.

4.57 **We have decided to set a cap of 416 MHz (37%) on overall holdings of relevant spectrum.**

This will have the effect of restricting BT/EE to acquiring a maximum of 120 MHz of the 200 MHz to be awarded (H3G could acquire up to 185 MHz and Vodafone could acquire up to 190 MHz; O2 would not be restricted by this cap).

4.58 This position is in line with what we said in the December 2018 consultation, where we proposed the 37% cap on overall spectrum.³¹

4.59 We received the following comments from stakeholders, which we address below:

- a) Vodafone and H3G supported this measure, although Vodafone felt it was unlikely that BT/EE would need to acquire more than 120 MHz in this auction.³²
- b) O2 initially supported this measure³³ but later said that the cap was “too high”. It said that it would permit too much asymmetry in spectrum holdings and would not ensure that all operators had a ‘critical mass’ of spectrum.³⁴ O2 also said that additional precautionary caps were needed to prevent extreme outcomes in the auction³⁵ and that a cap on 5G spectrum was more important than a tighter cap on overall spectrum;³⁶ and
- c) BT/EE said that the cap was unnecessary and did not address the main risk to competition (which it said were asymmetries in low frequency spectrum).³⁷ It did not, however, present any arguments against imposing this measure.³⁸

³¹ Paragraphs 5.79 to 5.123.

³² Vodafone non-confidential response to the December 2018 consultation, page 39 and non-confidential response to the October 2019 consultation, page 2 (bullet point 3) and page 6 (section 2.3); H3G non-confidential response to the December 2018 consultation, page 33.

³³ O2 non-confidential response to the December 2018 consultation, paragraphs 21 and 104.

³⁴ O2 non-confidential response to the October 2019 consultation, paragraphs 98 to 104.

³⁵ O2 non-confidential response to the December 2018 consultation, paragraph 104.

³⁶ O2 non-confidential response to the October 2019 consultation, paragraph 76.

³⁷ BT/EE non-confidential response to the December 2018 consultation, paragraphs 6 and 3.146-3.147 and BT/EE non-confidential response to the October 2019 consultation, paragraph 3.21.

³⁸ BT/EE non-confidential response to the December 2018 consultation, paragraph 6.

What outcomes might we be concerned about?

Overall spectrum holdings are less asymmetric than they were before the 2.3 and 3.4 GHz auction

Figure 4.2: Shares of overall useable spectrum

	BT/EE	Vodafone	O2	H3G	Unallocated
Prior to the 2.3 and 3.4 GHz auction	42%	29%	14%	15%	
Currently allocated spectrum*	32%	24%	18%	26%	
Currently allocated, and future spectrum	26%	20%	15%	21%	18%

*This includes all allocated spectrum in the 800 MHz, 900 MHz, 1400 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz, 2.6 GHz, 3.4-3.6 GHz and 3.6-3.8 GHz bands. H3G is likely to have some restrictions of the use of its holdings in the 3.6-3.8 GHz band until mid-2020, as outlined in annex 4. Unallocated spectrum refers to the spectrum that will be included in this award: namely the 700 MHz paired, 700 MHz SDL and the unallocated spectrum in the 3.6-3.8 GHz band

4.60 BT/EE currently has the largest share of useable spectrum (32%), and O2 has the smallest (18%). Spectrum shares were considerably more asymmetric before the 2.3 and 3.4 GHz auction: at this point BT/EE had 42% of useable spectrum, whereas O2 had 14% and H3G had 15%.

4.61 O2's share has increased in a large part due to its acquisition of the 40 MHz of 2.3 GHz spectrum in this last award. H3G's share has principally increased due to the 120 MHz of spectrum it previously held in the 3.4-3.8 GHz band becoming useable for the provision of mobile services.³⁹

We are still concerned about potential asymmetry in spectrum holdings in the future

4.62 Although spectrum shares have become less asymmetric following the 2.3 and 3.4 GHz auction, they remain asymmetric. For example, O2 has 166.4 MHz of useable spectrum and BT/EE has 295 MHz, over 77% more. Since the 2.3 and 3.4 GHz auction, the level of asymmetry in spectrum allocation in the UK has become more comparable to other European countries with four operators; Denmark, Sweden and France have less spectrum asymmetry than the UK. While the Netherlands and Spain are more asymmetric than the UK. Spectrum shares do not map consistently onto market position:⁴⁰ for example, O2 has

³⁹ H3G acquired this spectrum in 2017 as a result of the acquisition of UK Broadband. H3G also acquired 20 MHz of 3.4 GHz spectrum in the previous auction.

⁴⁰ See annex 3, figure A3.12 and paragraphs A3.33 to A3.34 for more details.

the highest wholesale⁴¹ share of subscribers (34%) and just 18% of currently allocated spectrum.⁴²

- 4.63 Spectrum shares have the potential to change considerably as a result of this auction, since we are awarding spectrum equivalent to 18% of current allocations. If BT/EE were to win all of the available spectrum, its share would rise to 44% of useable spectrum. This would be above the level at which we would start to have concerns.
- 4.64 In terms of overall spectrum holdings, we do not have a particular concern about Vodafone or H3G winning a large amount of the total spectrum to be awarded.⁴³ Nonetheless, if either of them won all the spectrum, we would be concerned, as Vodafone's share of overall spectrum would reach 38% and H3G's would be 39%.
- 4.65 If O2 won no spectrum in this auction, then its share would be 15% of overall spectrum. We consider that O2 would have sufficient spectrum to remain a credible operator if it won no spectrum in this auction.⁴⁴ However, we consider that O2 could potentially have considerably lower capacity than its rivals with this share of overall spectrum, especially if BT/EE were able to obtain a 44% share of overall spectrum, although [REDACTED].⁴⁵
- 4.66 We do not have sufficient concerns about the effect of O2 not winning any spectrum in this award to impose such interventionist measures as a spectrum reservation. Notwithstanding that [REDACTED], we consider that a cap which restricts all MNOs to a maximum of 37% of overall spectrum should enable O2 to acquire additional spectrum in this auction, should it require more to maintain its competitive position.
- 4.67 We are not concerned about Vodafone or H3G winning none of the spectrum available, as their shares of overall spectrum would be 20% and 21% respectively in this event. We consider that they would each have sufficient shares of overall spectrum to compete strongly in the market.

What degree of asymmetry raises concerns?

- 4.68 If all four MNOs had an equal share of spectrum, they would all have 25%. We do not consider that it is necessary for each MNO to have around 25% of spectrum for competition to work well.
- 4.69 BT/EE noted that a 37% cap on overall spectrum would become increasingly inappropriate when mmWave bands were considered since the per operator bandwidth is potentially

⁴¹ Wholesale shares include both the MNOs' own retail subscribers and hosted MVNOs' subscribers.

⁴² This is not the same percentage as figure 4.2 above because it does not include the unallocated spectrum, though it refers to the same pool of relevant spectrum.

⁴³ We consider concerns relating to acquisitions in either spectrum band in the sections below.

⁴⁴ We have previously considered, and continue to believe, there is a material risk of an MNO not having sufficient spectrum to be credible if it holds less than 10 to 15% of overall spectrum. We specifically discuss the concern that one of more MNO might cease to be credible from paragraph 4.287 below.

⁴⁵ O2 confidential response to October 2019 consultation, paragraph 100.

much larger.⁴⁶ We have made some mmWave available on a shared licence basis.⁴⁷ Nonetheless, for the reasons discussed in annex 4, we do not consider that mmWave bands are in the pool of relevant spectrum for this award.

- 4.70 H3G's view is that MNOs' shares of overall spectrum should be maintained in the 20% and 30% range to maintain a four-player market structure.⁴⁸ As discussed above, we do not think that symmetrical (or close to symmetrical) shares are necessary to maintain strong competition.
- 4.71 O2 said that we placed too much focus on the share of single operators, considering whether a single operator with a share above 37% could exploit the benefits. It said we should instead consider whether allowing caps at this level would be compatible with all four operators having a 'critical mass' of spectrum. O2 noted that if two parties had 37% of overall spectrum, this would only leave 26% to share between the other two. O2 said that a lower cap on individual operators would make this outcome less likely.⁴⁹ We note that it is not possible for two players to both reach 37% of overall spectrum holdings as a result of this award,⁵⁰ and that there would necessarily be at least 35% of overall spectrum left between the operators with the lowest spectrum holdings after this award, even if BT/EE and H3G won all of the spectrum between them.⁵¹
- 4.72 O2 said that establishing a 'target range' for the level of asymmetry in spectrum holdings would be better.⁵² We do not think that this is a suitable policy, as the permitted spectrum holdings for any operator in O2's suggested measure would depend on the amount held by the others. It would not be straightforward to translate this into an absolute cap on holdings.
- 4.73 Whilst our cap on overall spectrum is not directly based on the concentration level of spectrum holdings, this is part of our assessment of competition in the UK mobile sector.⁵³
- 4.74 We also note, as does O2, that spectrum asymmetries in the UK are much lower than they have been previously, and that even the most asymmetric outcome possible in this award is only just above O2's suggested upper limit for such a target (and still well below the levels of overall spectrum asymmetry levels that have persisted since 2013).⁵⁴ We consider

⁴⁶ BT/EE non-confidential response to the December 2018 consultation, paragraph 3.147; BT/EE non-confidential response to October 2019 consultation, paragraph 3.22.

⁴⁷ Access to this spectrum is facilitated on a first come, first served basis. <https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation>

⁴⁸ H3G response, page 33.

⁴⁹ O2 non-confidential response to the October 2019 consultation, paragraph 99, part 2.

⁵⁰ For this to happen, EE would need to win 120 MHz and Three would need to win 185 MHz, and there is only 200 MHz available in the award.

⁵¹ See Figure 4.2 above for the spectrum shares, and amount of unallocated spectrum.

⁵² O2 non-confidential response to October 2019 consultation, paragraph 100 to 104. O2 said the target should be based on a range of the Herfindahl-Hirschman index (HHI) which is a commonly used measure for market concentration and can also be applied to shares of spectrum holdings. See annex 3, paragraphs A3.33 to A3.35 for further discussion of the HHI in spectrum holdings both in the UK and in comparable countries with four MNOs.

⁵³ See annex 3, paragraphs A3.11 to A3.12.

⁵⁴ For example, if BT/EE were to win the maximum permitted under this cap and O2 won the rest, the spectrum HHI would be below 2700. The potential outcome of the auction that produces the highest spectrum HHI – and therefore the highest

that such an asymmetric outcome is highly unlikely as it would involve both O2 and Vodafone not acquiring any spectrum.

- 4.75 O2 said that the current cap would allow the two largest spectrum holders (BT/EE and H3G) to acquire all of the spectrum in this award between them, and ‘completely block’ the other two players.⁵⁵ Whilst this is theoretically possible under the 37% cap, we consider that this is highly unlikely. O2 and Vodafone have told us that obtaining spectrum in this auction – especially in the 3.6-3.8 GHz band, is important for them to compete effectively. If this is the case, they are likely to have high intrinsic values for (at least some of) the spectrum in this award. In addition, we are awarding a large amount of spectrum in this auction (200 MHz) and it would be extremely expensive and difficult for BT/EE and H3G to coordinate a strategy to attempt to exclude Vodafone and O2 from acquiring any spectrum.
- 4.76 We still consider that a share of around 40% of overall spectrum may raise competition concerns. In a four-player market, if one MNO has a 40% share, then the other three MNOs will each have 20% of overall spectrum on average. The MNO with 40% of overall spectrum therefore has twice as much as the average of its rivals. We consider that some of the detrimental effects on competition outlined above may arise at this level of asymmetry.
- 4.77 In the context of potential competition measures in an auction, it is necessary to be more specific than ‘around 40%’ and set a cap at a particular level. In the 2013 4G auction,⁵⁶ we set a cap of 2 x 105 MHz of overall spectrum, which was equivalent to 37%. This was because of concerns that a more asymmetric distribution than this could weaken competition. After that auction, EE’s share of spectrum was 37%. It then rose to 42% on merging with BT (completed in early 2016).
- 4.78 In the 2016 consultation on the competition assessment for the 2.3 and 3.4 GHz auction,⁵⁷ we said that we considered that a share of ‘around 40%’ of overall spectrum might still raise competition concerns. In the July 2017 statement, we were more specific and outlined our judgement that a 37% share was generally an appropriate limit,⁵⁸ in line with the cap in 2013.
- 4.79 We recognise that being more specific involves the exercise of regulatory judgement. We consider that the 37% share at which we imposed an overall cap in the 2013 4G auction and the 2018 2.3 and 3.4 GHz auction is generally an appropriate limit.

concentration – would be for BT/EE to win 120 MHz and H3G to win the other 80 MHz. This produces an HHI of 2780, not much above the limit of 2700 suggested by O2.

⁵⁵ O2 non-confidential response to October 2019 consultation, paragraph 102.

⁵⁶ Ofcom’s “Assessment of future mobile competition and award of 800 MHz and 2.6 GHz”, paragraph 1.11; see https://www.ofcom.org.uk/data/assets/pdf_file/0027/55395/statement-summary.pdf.

⁵⁷ Ofcom’s statement of 11 July 2017 entitled “Award of the 2.3 and 3.4 GHz spectrum bands Competition issues and Auction Regulations”, paragraphs 4.30 to 4.36; see https://www.ofcom.org.uk/data/assets/pdf_file/0022/103819/Statement-Award-of-the-2.3-and-3.4-GHz-spectrum-bands-Competition-issues-and-auction-regulations.pdf.

⁵⁸ Ofcom’s statement of 11 July 2017, paragraphs 6.46 to 6.53; see https://www.ofcom.org.uk/data/assets/pdf_file/0022/103819/Statement-Award-of-the-2.3-and-3.4-GHz-spectrum-bands-Competition-issues-and-auction-regulations.pdf.

- 4.80 We do not consider that 37% represents an absolute, cliff-edge threshold to the extent that any share up to this level would always be acceptable and a share above would necessarily cause an immediate and severe weakening of competition. We consider, however, that having one or more MNOs with a spectrum share above around 40% for a sustained period is likely to weaken competition, and that 37% represents an appropriate limit to safeguard competition.
- 4.81 It remains our judgment that competition concerns about asymmetry in relation to capacity and average speeds may generally arise when one MNO has around 37% of overall spectrum.

Shares of overall spectrum should be considered in a different way from shares of sub-groups of spectrum

- 4.82 In BT/EE's view, a 37% cap on overall spectrum does not address what it considers to be the main competition concern, namely asymmetries in low frequency spectrum. It also said that our analysis was 'internally inconsistent' because we would potentially allow greater asymmetries in sub-groups of spectrum (such as sub-1 GHz and 3.4-3.8 GHz) than in overall spectrum.⁵⁹
- 4.83 We do not consider that the 37% level of the overall cap is necessarily relevant for any or all particular subsets of spectrum. The overall cap is a measure designed to prevent large asymmetries in overall spectrum capacity; either with one (or more) MNO becoming too large, or too small.
- 4.84 For a sub-group of spectrum, the potential competition concerns are likely to be different and, in particular, there may well be substitutes for a particular sub-group of spectrum that necessarily do not exist for overall spectrum holdings. For example:
- a) In our discussion of potential concerns on 3.4-3.8 GHz spectrum below, we outline all of the additional bands that are likely to be used to provide 5G services. In the discussion on low frequency spectrum, we note that large bandwidths of low frequency spectrum are not required for wide area coverage.
 - b) In terms of capacity-intensive services deep indoors, we consider that alternative solutions (such as WiFi) may be an effective substitute for mobile coverage in many deep indoor locations, and that capacity-intensive deep indoor coverage is a relatively minor subset of what concerns customers in choosing a mobile operator.
- 4.85 The potential competition concerns in low frequency and sub-1 GHz spectrum are discussed in more detail below.

⁵⁹ BT/EE non-confidential response to the December 2018 consultation, paragraphs 3.146 to 3.147, 3.35 and 3.139; and BT/EE non-confidential response to the October 2019 consultation, paragraph 3.21.

How likely is it that a highly asymmetric share of overall spectrum would arise in the absence of competition measures?

- 4.86 As we said in the December 2018 consultation,⁶⁰ we consider it is not particularly likely that BT/EE would win *all* the spectrum available in this auction, even without measures to prevent it.⁶¹ We are awarding 200 MHz of spectrum and it is likely to be costly for a single MNO to acquire it all, outbidding the intrinsic values of the other MNOs for any spectrum.⁶² Nevertheless, we consider that BT/EE might well have a high intrinsic value for both 700 MHz (as it has little low frequency spectrum at present) and 3.6-3.8 GHz spectrum, which it could use to deploy a 5G service alongside its existing holdings in the 3.4-3.6 GHz band.
- 4.87 We also consider that it is not particularly likely that either H3G or Vodafone would acquire sufficient spectrum to put their shares above 37% in the absence of caps, as H3G would need to obtain more than 185 MHz and Vodafone more than 190 MHz to reach this threshold.
- 4.88 Without a cap, nonetheless, it is possible that an MNO (other than O2) could acquire sufficient spectrum to take its share of overall spectrum to more than 37%. For example, we would be concerned about BT/EE winning more than 120 MHz, especially if it were bidding for strategic motives. Even if it were to have the highest intrinsic value for the spectrum⁶³ it would still deny that spectrum to competitors with much smaller shares of overall spectrum (see paragraph 4.39 above).
- 4.89 We have also considered whether it is possible that O2 might not win any spectrum at all in this auction. If O2 considers that it would indeed become a weaker competitor without any spectrum from this award, then it is likely to have a relatively high intrinsic value for this spectrum, and likely to be able to win it in the auction. On the other hand, if O2 really needs additional spectrum to remain a strong competitor, then we consider it possible that its rivals might benefit considerably from strategic bidding which denied this spectrum to O2. We now outline why we do not consider that such strategic investment will be likely in this award.

Strategic investment

- 4.90 We have considered whether strategic bidding might be likely to result in O2 winning none of the spectrum available as we consider that denying spectrum to the MNO with the lowest share is the most likely strategic aim of its rivals (in terms of overall spectrum).

⁶⁰ Paragraphs 5.124 to 5.132.

⁶¹ Vodafone also made this point in its response, page 39.

⁶² It is worth noting that to buy ALL of the spectrum, the winner has to pay more for its 'final' 20 MHz than any other MNO would value its 'first' 20 MHz, as it needs to make sure that no other bidder wins any.

⁶³ As noted above, even bidding on the basis of intrinsic value may result in a trade-off between benefits to consumers from the use of the spectrum and a potential weakening of competition.

- 4.91 **Unilateral** strategic investment against O2 would require one MNO to purchase all 200 MHz of spectrum available in the auction. This is likely to be extremely costly as the winner would need to outbid the other MNOs' intrinsic values for all of the spectrum.
- 4.92 We consider it highly likely that O2, Vodafone and BT/EE would all have a high intrinsic value for some 3.6-3.8 GHz spectrum, and that all four MNOs may well value some 700 MHz spectrum – either because they have little low frequency spectrum at present (BT/EE and H3G) or because they would use it to provide a 5G coverage layer in the shorter term.
- 4.93 Successful **tacitly coordinated** strategic investment could lower the cost for the MNO engaging in this practice by splitting it with another bidder. In general, such outcomes are difficult to achieve because they require two (or more) bidders to converge on their preferred outcome without explicit discussion.
- 4.94 It is also not clear that the payoff would be particularly high from strategically excluding O2 from additional spectrum. We consider that O2 can remain a credible competitor with its current spectrum holdings and it is unclear how much its position would be weakened if it failed to acquire more. [REDACTED].

We have decided to impose a 416 MHz (37%) cap on overall spectrum

- 4.95 We have explained that we would be concerned if any MNO's share of overall spectrum rose above 37%, as this could weaken competition in the mobile market. Although it could arise for several different MNOs, this is most likely to be for BT/EE and would occur if it bought more than about 120 MHz of the spectrum being awarded in this auction.
- 4.96 We have therefore decided to impose a cap of 416 MHz (37%) of overall spectrum and believe this will function as a 'safeguard cap'.
- 4.97 We have taken account of the minimum lot size in this award (5 MHz) and have decided to round up to the nearest feasible lot size that MNOs could acquire.⁶⁴
- 4.98 We note that O2 objected to this rounding up which would allow some bidders to acquire up to 37.2% of overall spectrum.⁶⁵ It said that we had rounded down from 37% to set the

⁶⁴ 37% of the 1116.9 MHz in the pool of useable spectrum is 413.3 MHz. Setting the cap at 413 MHz would allow BT/EE to purchase 118 MHz, Vodafone to purchase 187 MHz and H3G to purchase 183 MHz. Given that the smallest lot size is 5 MHz, these limits would effectively be 115 MHz for BT/EE, 185 MHz for Vodafone and 180 MHz for H3G. This produces an implied cap of 36.7% or 36.8%. We consider that it would not be proportionate to restrict MNOs to holdings below 37%. We therefore proposed to set the cap at 416 MHz to allow for some rounding up rather than rounding down. We have considered rounding the cap to 415 MHz (that is, the closest multiple of 5 MHz). However, current spectrum holdings are not in multiples of 5 MHz and this produces distortionary results. A cap of 415 MHz would allow BT/EE to purchase 120 MHz, Vodafone to purchase 189 MHz and H3G to purchase 185 MHz. Given lot sizes, the effective maximum purchase for Vodafone would be 185 MHz which, at the limit, would allow it to hold 36.8% of overall spectrum, whereas the effective cap on BT/EE and H3G would be just over 37.2% and 37.1% respectively. We have therefore decided to set the cap at 416 MHz (or 37.2%) of overall spectrum, as proposed in the December 2018 consultation.

⁶⁵ O2 non-confidential response to October 2019 consultation, paragraphs 105 to 109.

cap in the 2.3 and 3.4 GHz award, which is incorrect.⁶⁶ As noted above, 37% is not an absolute cut off, but the share of overall spectrum at which we would start to be concerned. We also consider that it is reasonable to take account of lot sizes when setting a cap. In this case, the 37% cap is not very restrictive and any operator would have to acquire a significant share of the available spectrum in order reach the limit of the cap, so it is unlikely that the small increments either side of 37% will be relevant.

- 4.99 Setting the level at 37% is consistent with the level of the cap on overall spectrum that we imposed in the 4G auction and the 2.3 and 3.4 GHz auction, and therefore will promote regulatory certainty.⁶⁷
- 4.100 We consider that this cap is appropriate and proportionate, for the following reasons.
- 4.101 The cap is effective in that it is capable of achieving our policy aim of avoiding competition concerns arising from highly asymmetric spectrum holdings. As noted above, it will prevent any MNO's spectrum holdings from increasing above 37%, which is the level at which we consider competition could be weakened in the mobile market.
- 4.102 We consider that the 37% cap is no more onerous than necessary to achieve our aims and do not consider that a more restrictive measure is needed. We note that the cap is not very restrictive on MNOs' ability to win spectrum in this auction,⁶⁸ and we do not consider that it will produce adverse effects which are disproportionate to the aims we are pursuing.

We are not imposing further measures to address additional capacity concerns

- 4.103 The concern over asymmetries in overall spectrum is driven by the relationship between spectrum shares and the ability to provide capacity. In the December 2018 consultation⁶⁹, we noted that certain spectrum might be particularly suitable for providing capacity and we therefore considered whether there was a case for an additional cap which would prevent significant asymmetries in these types of spectrum, if they could lead to an operator having an unmatched advantage in adding capacity.
- 4.104 We considered two alternatives:
- a) Mid-frequency spectrum (i.e. 1800 MHz to 3.8 GHz) because it is particularly suited to technologies such as massive MIMO (mMIMO) which are effective at increasing capacity; and

⁶⁶ The pool of relevant spectrum in the 2.3 and 3.4 GHz award was 916.9 MHz – not 920.9 MHz as suggested by O2 at paragraph 106 of its non-confidential response to the October 2019 consultation. 37% of 916.9 MHz is 339.25 MHz, which we rounded up to 340 MHz. See Table 6.2 (page 47) of our July 2017 statement on the 2.3 and 3.4 GHz auction, https://www.ofcom.org.uk/data/assets/pdf_file/0022/103819/Statement-Award-of-the-2.3-and-3.4-GHz-spectrum-bands-Competition-issues-and-auction-regulations.pdf

⁶⁷ See also the December 2018 consultation, paragraphs 5.133 to 5.138.

⁶⁸ As noted, BT/EE, the most restricted, could acquire 120 MHz of the 200 MHz to be awarded. H3G could acquire 185 MHz and Vodafone could acquire 190 MHz. O2 will not be restricted by the cap.

⁶⁹ Paragraphs 5.143 to 5.202.

- b) Downlink spectrum, since mobile networks currently carry mostly data and most of this traffic is generated by users downloading (rather than uploading) content.
- 4.105 We considered that the overall cap was sufficient to prevent any MNO getting a very large share in 'capacity' spectrum, and that all MNOs would have a sufficient share even if they did not win any more spectrum in this award.
- 4.106 In terms of mid-frequency spectrum, we noted that BT/EE could, in principle, get a large share (above 37%) of this spectrum if it bought all of the 3.6-3.8 GHz in the award. However, we said that:
- a) We did not consider that shares of mid-frequency or downlink-only spectrum represented a meaningful share of effective capacity;
 - b) It was not clear that the thresholds for capacity spectrum asymmetry would be the same as those for overall spectrum asymmetry (i.e. 37% was not necessarily the key threshold);
 - c) Our proposed overall cap would prevent BT/EE from acquiring more than 37% of overall spectrum. This would mean that BT/EE could not buy any 700 MHz spectrum if it acquired all of the 3.6-3.8 GHz. We considered that BT/EE would be likely to have a higher intrinsic value for some 700 MHz than all of the 3.6-3.8 GHz, given its small amount of low frequency spectrum.
- 4.107 We acknowledged that either Vodafone or H3G could get to a share of downlink capacity above 37% if they bought all of the 3.6-3.8 GHz band, all of the 700 MHz downlink-only and a large portion of the 700 MHz paired spectrum. However, we considered that this outcome was highly speculative, because it was unlikely that the intrinsic value of H3G or Vodafone would sufficiently outweigh that of the other MNOs for such a quantity of spectrum.

Stakeholders did not argue for additional 'capacity' measures

- 4.108 In response to the December 2018 consultation, Vodafone considered that we did not need to be concerned about significant asymmetry in capacity spectrum, in particular after O2's acquisition of 40 MHz of 2.3 GHz spectrum in the last auction.⁷⁰ O2 and H3G did not comment on this.
- 4.109 BT/EE said that our 37% overall cap did not recognise the different properties of the various spectrum bands, for example the ability of the 3.4-3.8 GHz band to deliver capacity.⁷¹ It suggested a sub-cap on 3.6-3.8 GHz spectrum, but no additional measures to address asymmetries in spectrum that is better for capacity in general. (We discuss the concerns in 3.4-3.8 GHz spectrum specifically below).

⁷⁰ Vodafone non-confidential response to the December 2018 consultation, page 39.

⁷¹ BT/EE non-confidential response to the December 2018 consultation, paragraph 3.147; and BT/EE non-confidential response to the October 2019 consultation, paragraph 3.21.

4.110 BT/EE said that, if we had a concern over asymmetries in mid-frequency spectrum, we should have similar concerns about low frequency spectrum.⁷² We note that we do not consider it appropriate to impose any competition measure to address asymmetries in mid-frequency spectrum, in addition to the overall cap.

We have decided not to impose any measures in addition to the overall cap

4.111 Therefore, having considered stakeholders' comments, we remain of the view that any potential asymmetries in 'capacity spectrum' are sufficiently addressed by our overall cap which restricts each MNO to a maximum of 37% of overall spectrum.

Competition concern 1b: Asymmetries in low frequency spectrum

Summary

- 4.112 Although there are currently considerable asymmetries in low frequency spectrum which could persist under certain auction outcomes, we consider that MNOs with little low frequency spectrum (i.e. BT/EE and H3G) are likely to remain strong competitors even if they did not acquire any 700 MHz spectrum in this award on the basis that:
- a) Indoor network coverage is just one factor considered by consumers when choosing a network provider, and provision of data-intensive services deep indoors (which is more likely to be impacted by a lack of low frequency spectrum) is very much a sub-set of consumers' concerns.
 - b) Currently, MNOs perform similarly in relation to coverage for basic services indoors despite large differences in low frequency spectrum holdings, and provision of data-intensive services deep indoors can be provided by other means, Wi-Fi in particular.
 - c) It is not clear that low frequency spectrum is essential for future 5G provision or in any case how important nationwide coverage of 5G services will be for competition.
 - d) MNOs with low holdings of low frequency spectrum are likely to have a high intrinsic value for obtaining more and therefore be able to bid successfully for it in the upcoming auction.
 - e) The likelihood of strategic bidding remains low.
- 4.113 We have therefore decided not to impose any specific sub cap on low frequency spectrum in this award. This position is in line with our proposal in the December 2018 consultation to not set a sub-cap on low frequency spectrum.⁷³
- 4.114 We received the following comments, which we address below:

⁷² BT/EE non-confidential response to the December 2018 consultation, paragraph 3.104 to 3.109.

⁷³ December 2018 consultation, paragraph 5.342.

- a) Vodafone agreed with our proposal to not impose a cap on low frequency spectrum;⁷⁴
- b) O2 agreed that there was not a strong rationale for a cap on low frequency spectrum, but said that it would have no objection to a precautionary cap of 40 MHz of 700 MHz (including the 700 MHz downlink-only spectrum) to prevent highly asymmetric allocation outcomes;⁷⁵
- c) H3G and BT/EE said that we had under-stated the competition concerns relating to asymmetries in low frequency spectrum and that we should impose a cap. H3G suggested a cap limiting each bidder to 2x10 MHz of 700 MHz FDD spectrum⁷⁶; BT/EE suggested a 75 MHz 'safeguard cap' (limiting Vodafone and O2 to 20 MHz each).⁷⁷

The pool of low frequency spectrum

- 4.115 Low frequency spectrum is better at covering large areas and penetrating into buildings than spectrum at higher frequencies. As set out in the December 2018 consultation⁷⁸, we consider low frequency spectrum to be all sub-1 GHz spectrum plus the 1400 MHz downlink-only spectrum.
- 4.116 No respondents to the consultation disagreed with the inclusion of 1400 MHz within the definition of low frequency spectrum, although Vodafone argued that additional, higher frequency bands such as 1800 MHz and possibly 2.1 GHz should also be included.⁷⁹ Further discussion of the definition of low frequency spectrum can be found in annex 6.⁸⁰
- 4.117 We note that BT/EE⁸¹ argued that the inclusion of 1400 MHz spectrum in the definition of low frequency spectrum did have a significant impact on their share of low frequency spectrum holdings.⁸² However, we consider that our overall view on competition concerns relating to low frequency spectrum is not dependent upon whether or not the 1400 MHz downlink-only spectrum is included in the pool of low frequency spectrum.⁸³

⁷⁴ Vodafone non-confidential response to the December 2018 consultation, page 41 and non-confidential response to the October 2019 consultation, page 6.

⁷⁵ O2 non-confidential response to the October 2019 consultation, paragraphs 110-111. In its response to the December 2018 consultation, O2 had proposed that such a precautionary cap should be imposed due to a risk of strategic bidding associated with the proposed CCA auction format. See O2 non-confidential response to the December 2018 consultation, paragraphs 21-22, 111 and 201. The report from NERA contains more detail on these arguments in section 6.1.

⁷⁶ H3G non-confidential response to the October 2019 consultation, paragraph 6.8 and 14.1-14.12. In its previous response to the December 2018 consultation, H3G had proposed a cap of 80 MHz (37%) of sub-1 GHz spectrum holdings, which would have limited Vodafone and O2 to 2x10 MHz of 700 MHz FDD and 5 MHz of 700 MHz SDL spectrum. See H3G non-confidential response to the December 2018 consultation, page 33.

⁷⁷ BT/EE non-confidential response to the December 2018 consultation, paragraphs 6 and 3.113-3.147 and non-confidential response to the October 2019 consultation, paragraphs 4 and 3.13.

⁷⁸ December 2018 consultation, paragraphs 5.296 to 5.297.

⁷⁹ Vodafone non-confidential response to the December 2018 consultation, page 41 and non-confidential response to the October 2019 consultation, page 6. See also annex 6, paragraphs A6.70 to A6.71 for more detail of Vodafone's argument.

⁸⁰ Annex 6, paragraphs A6.67-A6.69 and A6.72.

⁸¹ BT/EE non-confidential response to the December 2018 consultation, paragraph 3.36.

⁸² Including 1400 MHz spectrum in the low frequency definition reduces BT/EE's share of current low frequency spectrum holdings from 8% to 6% as set out in paragraph 3.36 of BT/EE's non-confidential response to the December 2018 consultation.

⁸³ December 2018 consultation, paragraph 5.297.

- 4.118 The MNOs' current holdings of low frequency spectrum are relatively asymmetric as set out above in Figure 4.2, with BT/EE and H3G holding substantially less low frequency spectrum than either O2 or Vodafone. However, in contrast to the 4G auction in 2013, all MNOs now hold at least some low frequency spectrum, enabling them to provide good quality coverage at least for less data-intensive services such as voice calls or web-browsing. We do not currently have any firm plans to auction further low frequency spectrum and therefore the outcome of this auction could have a long-term impact on holdings.
- 4.119 One of the key attributes of low frequency spectrum is that it is particularly good at providing wide area coverage. As set out in the December 2018 consultation⁸⁴, we consider that this is unlikely to be a competition concern, because all operators have at least some low frequency spectrum and users are sparse in rural areas. Additionally, in some cases, MNOs have deployed denser network grids (i.e. built more sites) to cover wider areas. In its response to the October 2019 consultation, H3G argued that consumers demanded good quality data services in rural areas⁸⁵, and that [REDACTED]^{86 87} and that therefore [REDACTED]. There were no other objections to our position on wide area coverage, and it remains our view that there is no material competition concern in relation to this.

Potential competition concerns relate to deep indoor coverage

- 4.120 In the December 2018 consultation⁸⁸, we said that low frequency spectrum might be the only spectrum able to reach users in harder-to-serve areas deep indoors. However, our initial analysis of coverage data suggested that existing low frequency holdings would be sufficient to provide less data-intensive services to a significant number of customers in most indoor scenarios⁸⁹, and that the main potential competition concern therefore arose from a potential inability to provide data-intensive services deep indoors.⁹⁰
- 4.121 We also noted that voice coverage might be more difficult to provide in deep indoor locations, although this was not a capacity issue and evidence suggested that MNOs were all currently performing well in this area.⁹¹ For this reason, and the fact that no respondents raised this as a concern, we have not discussed voice coverage in greater detail.
- 4.122 In the December 2018 consultation, we provisionally concluded that using data-intensive services deep indoors was very much a subset of consumers' concerns and therefore we did not consider that the ability of operators to compete for customers was likely to be materially affected by a relative disadvantage in this aspect of coverage. We also noted

⁸⁴ At Paragraph 5.316.

⁸⁵ H3G non-confidential response to the October 2019 consultation, paragraphs 9.13-9.20.

⁸⁶ H3G confidential response to the October 2019 consultation, paragraphs 9.22-9.31.

⁸⁷ For details of our analysis, see paragraph 4.140 and annex 6, paragraph A6.24 to A6.28.

⁸⁸ December 2018 consultation, paragraphs 5.273 and 5.287 to 5.295.

⁸⁹ For full details of our coverage modelling and results, see annex 6, paragraphs A6.73 to A6.132

⁹⁰ December 2018 consultation, paragraphs 5.304-5.307.

⁹¹ For further details see table A5.6 in annex 5 which shows that all MNOs currently have voice coverage rates of over 95%.

that in any case such coverage could be provided to a substantial extent by other technologies such as Wi-Fi.⁹² Below we explain why, having considered stakeholders' comments, this remains our view.

MNOs' responses: BT/EE and H3G said they would not be able to compete without more low frequency spectrum

- 4.123 In their responses to the December 2018 and October 2019 consultations, BT/EE and H3G argued that we had underestimated the potential for a negative impact on competition if MNOs with lower holdings of low frequency spectrum failed to acquire any 700 MHz spectrum in the auction.
- 4.124 Both respondents agreed that one of the key competition concerns relating to low frequency spectrum was about not having sufficient spectrum to provide capacity for data intensive services in deep indoor locations. Whilst BT/EE and H3G broadly agreed with the results of our modelling⁹³ (i.e. that low frequency spectrum is better at penetrating buildings and that more low frequency will increase throughput in indoor locations), they suggested that we had underestimated the importance of deep indoor coverage to consumers and overstated the ability of alternative technologies to provide these.
- 4.125 BT/EE claimed that it was currently facing ongoing and significant challenges in competing with the service levels offered by other MNOs in providing good quality indoor and deep indoor coverage due to its lack of sub-1 GHz spectrum. It suggested that the ability to offer coverage indoors, including in deep indoor locations, was critical to ensuring a reliable and consistent mobile data and voice service, and that having asymmetric shares of low frequency spectrum undermined competition for these services. It suggested that these indoor and deep indoor coverage issues were "not transient like capacity in the busy hour" but resulted in "ongoing and repetitive problems for customers", which in turn had a significant impact on churn and reputation.⁹⁴
- 4.126 Similarly, H3G claimed that we had understated the severity of the impact on competition of the potential situation where neither BT/EE nor H3G won any 700 MHz spectrum. H3G said that this situation did pose a material risk to competition due to the effect on the ability to provide coverage and capacity in harder-to-serve areas, which it argued was a key driver of competition and consumer choice⁹⁵ as consumers valued receiving a high quality service over the provision of a basic service.⁹⁶ H3G argued that holding a sufficient

⁹² December 2018 consultation, paragraphs 5.318 to 5.319.

⁹³This modelling compared the coverage that different networks could achieve when using different spectrum bands and carrier bandwidths and is set out in annex 10 of the December 2018 consultation.

⁹⁴ BT/EE non-confidential response to the December 2018 consultation, paragraphs 3.12 to 3.14 and non-confidential response to the October 2019 consultation, paragraphs 3.6 to 3.7.

⁹⁵ H3G non-confidential response to the December 2018 consultation, p.32 to 34 and non-confidential response to the October 2019 consultation, paragraph 6.5.

⁹⁶ H3G non-confidential response to the October 2019 consultation, paragraph 9.2.

bandwidth of low frequency spectrum was the only means by which an MNO could offer a good quality service to customers in these areas⁹⁷ and that [REDACTED].⁹⁸

- 4.127 Below, we explain why we do not believe that a material competition concern would arise in the situation where BT/EE and or H3G fail to win any additional low frequency spectrum in the auction.

Deep indoor coverage is just one factor considered by consumers

- 4.128 The importance of asymmetries in low frequency spectrum holdings for competition depends upon the extent to which consumers value being able to access data-intensive services in deep indoor locations. As outlined above, this is the key service provided by this type of spectrum which cannot be provided as easily by higher frequency spectrum.⁹⁹
- 4.129 BT/EE suggested that indoor coverage is currently less good for BT/EE and H3G compared to Vodafone and O2 – roughly a 5-percentage point difference¹⁰⁰ and that [REDACTED].¹⁰¹
- 4.130 BT/EE also argued that the increasing availability of tools to check coverage meant that it was becoming easier for consumers to choose the operator which provides the best indoor and deep indoor coverage [REDACTED].¹⁰²
- 4.131 BT/EE did not agree with our position in the December 2018 consultation that high capacity services were less important to consumers than basic coverage, or that existing spectrum allocations could meet demand for basic services. It claimed that Ofcom had misinterpreted the survey evidence discussed in the consultation, and that the concept of ‘reliability’ included being able to use high capacity services with seamless connectivity as well as accessing text and picture-based websites. It also suggested that, as technology moved from 4G to 5G, customers would continue to expect faster and higher capacity services without interruption in all locations.¹⁰³ BT/EE claimed that acquiring 700 MHz spectrum in the auction would be the only cost-effective solution for it to deliver seamless connectivity to customers.
- 4.132 H3G also argued that the ability to provide a good quality indoor service with sufficient capacity was a competitive differentiator and that customers expected in-building cellular coverage.¹⁰⁴ It defined a good quality 4G mobile service as being a download speed of at least 2Mbps and an upload speed of at least 1Mbps.¹⁰⁵ It also suggested that increasing

⁹⁷ H3G non-confidential response to the October 2019 consultation, paragraph 9.4.

⁹⁸ H3G confidential response to the October 2019 consultation, paragraphs 9.12.

⁹⁹ As outlined in paragraph 4.119, low frequency spectrum is also useful for providing wide area coverage, but we do not consider that this has the potential to impact competition for reasons outlined in this paragraph.

¹⁰⁰ We note that this figure is very similar to our own analysis of MNOs’ indoor data coverage, as set out in Figure 5.12 of the December 2018 consultation.

¹⁰¹ BT/EE confidential response to the December 2018 consultation, paragraph 3.15.

¹⁰² BT/EE confidential response to the December 2018 consultation, paragraph 3.16.

¹⁰³ BT/EE non-confidential response to the December 2018 consultation, paragraph 3.17-3.22 and non-confidential response to the October 2019 consultation, paragraphs 3.6-3.7, and 3.13.

¹⁰⁴ H3G non-confidential response to the December 2018 consultation, p.34, 41 and non-confidential response to the October 2019 consultation paragraph 9.14-9.22.

¹⁰⁵ H3G non-confidential response to the October 2019 consultation paragraph 9.22.

demand for video streaming, content-rich web pages and file downloads meant that higher data speeds (8-10 Mbps) would be required in the future.¹⁰⁶

- 4.133 In our view, the evidence provided in support of BT/EE's and H3G's claims that they are likely to lose a significant number of customers if they do not win any additional low frequency spectrum in the auction is not sufficient to support their argument. We have gathered further evidence on this point, in particular [REDACTED].^{107, 108}
- 4.134 We also note that BT/EE consistently performs very well in network tests and customer satisfaction surveys¹⁰⁹ and that it was able to compete successfully to win the Emergency Services Network (ESN) contract (requiring a high degree of network coverage), despite having a low share of low frequency spectrum. We also note that BT/EE performed strongly in terms of contract net additions in 2018-19, with a churn rate which was very similar to H3G and Vodafone.¹¹⁰
- 4.135 Similarly, H3G has seen steady contract net additions in 2019¹¹¹ despite performing relatively less well on coverage/network quality measures¹¹², with a churn rate very similar to other MNOs.¹¹³ This suggests that coverage performance may not be as important to consumers as has been claimed.
- 4.136 The above data suggests that loss of customers due to network reliability has not been a significant issue to date.
- 4.137 Whilst we agree with respondents that the demand for data usage is likely to increase over time, and that this will require more uplink capacity, we believe that this increased demand can be met to a large extent by using existing low frequency spectrum plus alternative technologies as explained in more detail in the next section. Although we accept that MNOs with lower shares of low frequency spectrum may find it more difficult to fully meet this increased demand, we do not believe that any such disadvantage will be large enough to lead to a material competition concern. Use of data-intensive services in deep indoor locations is just one of consumers' considerations when choosing a provider¹¹⁴, and we do not therefore consider that BT/EE and H3G are likely to lose large numbers of customers in the future for this reason.

¹⁰⁶ H3G non-confidential response to the December 2018 consultation, p.37 and H3G non-confidential response to the October 2019 consultation paragraph 9.18.

¹⁰⁷ [REDACTED]

¹⁰⁸ For further discussion of this evidence, see annex 3, paragraph A3.97 and Figures A3.39, A3.40 and A3.41.

¹⁰⁹ For further details see annex 3 (e.g. Figure A3.34) and annex 5 (e.g. paragraphs A5.14, A5.17, A5.25, A5.34, Table A5.5 and Figure A5.1 showing mobile performance and browsing/download speeds.

¹¹⁰ See figures A3.8 and A3.9 in annex 3 for full details.

¹¹¹ See figure A3.8 for further details.

¹¹² See annex 5 (Table A5.7) for further details.

¹¹³ See figures A3.9 for full details.

¹¹⁴ As set out in Table A3.1, consumers are strongly influenced by price, handset range and customer service as well as network quality when choosing a provider. In addition, Ofcom's research "The Consumer Mobile Experience" as summarised in annex 3 (paragraph 3.95) found that the most important services to consumers were general web-browsing followed by voice calls, with a higher proportion of consumers rating these as being important compared to data-intensive services such as streaming video and audio content and uploading/downloading large files. This all suggests that provision

- 4.138 We consider that BT/EE and H3G are likely to be able to compete strongly, even if they do not acquire any additional low frequency spectrum in this award.

The evidence does not point to a high level of capacity constraint indoors

- 4.139 BT/EE argued that its technical network analysis demonstrated that sub-1 GHz spectrum was critical to offering seamless mobile connectivity indoors and deep indoors. BT/EE claimed [REDACTED].¹¹⁵
- 4.140 H3G also argued that [REDACTED].¹¹⁶ In its response to the October 2019 consultation, H3G provided analysis which suggested that [REDACTED].^{117, 118, 119} Our view is that the evidence presented indicates that [REDACTED].¹²⁰
- 4.141 We also note that [REDACTED], consumer survey data suggests that satisfaction with BT/EE remains high,¹²¹ indicating that its ability to compete is not being significantly impacted at present. Likewise, H3G [REDACTED] has continued to make net gains to its subscriber base.¹²² In our view this suggests that even if [REDACTED] it is not having a significant impact on competition.

Deep indoor coverage can be provided by other means, in particular Wi-Fi

- 4.142 The importance of asymmetries in low frequency spectrum holdings for competition also depends upon the extent to which: (i) MNOs can use other means to provide good quality coverage in deep indoor locations and/or (ii) consumers can use other means of obtaining such coverage. We believe that, although such technologies (as outlined further below) have some limitations, they are able to mitigate and reduce the customer experience of poor indoor coverage to a large extent.
- 4.143 In the December 2018 consultation¹²³ we outlined that there were alternative ways of providing and accessing high capacity services in indoor locations including using repeaters, small cells and femto cells (deployed by MNOs) and Wi-Fi (used by consumers). Whilst we acknowledged that these solutions had some limitations, we argued that their use could help to enable MNOs to provide, and their customers to access, deep indoor coverage even without obtaining additional low frequency spectrum in the auction.

of data-intensive services in deep indoor locations is very much a subset of consumers' considerations when choosing a mobile provider.

¹¹⁵ BT/EE confidential response to the December 2018 consultation, paragraph 3.39-3.40. For further details of BT/EE's argument see also annex 6, paragraph A6.5.

¹¹⁶ H3G confidential response to the December 2018 consultation, p 34-37. For further details of H3G's argument see also annex 6, paragraphs A6.6-A6.7 and A6.9-A6.10

¹¹⁷ H3G confidential response to the October 2019 consultation, paragraph 7.4

¹¹⁸ H3G confidential response to the October 2019 consultation, paragraph 9.23-9.31 and Annex 1

¹¹⁹ H3G confidential response to the October 2019 consultation, paragraph 9.32-9.36.

¹²⁰ See annex 6, paragraph A6.25 to A6.28.

¹²¹ See annex 3, Figure A3.35.

¹²² See annex 3, Figure A3.8.

¹²³ December 2018 consultation, paragraphs 3.322-3.324.

- 4.144 H3G argued that these alternative technological solutions were either not commercially practical or would only have a marginal impact.¹²⁴
- 4.145 H3G suggested that, whilst small cells could be used to provide incremental additional capacity, it would not be commercially practical to do this on a large scale as this was a much more expensive solution than using 700 MHz spectrum. Similarly, repeaters would not be an effective solution to increasing the level of service (i.e. higher speeds or capacity) as they just provide an extension of coverage from the macro cell. In its view, femto cells are similarly expensive to deploy and subscribers are unlikely to be willing to bear these additional costs.¹²⁵
- 4.146 BT/EE also argued that such technologies were unlikely to be substitutes for deployment of sub-1 GHz spectrum on macrocells in terms of coverage benefits.¹²⁶ Little evidence was provided to support its argument on this point.
- 4.147 However, we note that, from an international perspective, Sprint in the US (which is similar to BT/EE in that it has a lot of mid-band spectrum but little low frequency spectrum) has deployed more than 260,000 ‘magic box’ small cells to provide indoor coverage.¹²⁷
- 4.148 In terms of alternative technologies which can be used to provide coverage in deep indoor locations in the absence of low frequency spectrum, our view is that it is likely to be Wi-Fi which makes the greatest contribution. Whilst we believe that other technologies, as mentioned above, can be used to improve coverage, we acknowledge that there may be limitations associated with these as outlined in the December 2018 consultation, and as mentioned by MNOs in their responses.
- 4.149 In contrast, use of Wi-Fi to improve coverage is already widespread. It can be used both in residential buildings where customers have a fixed broadband connection and is also increasingly available in commercial indoor settings such as cafes/restaurants, airports and hospitals. In most of these locations, mobile phones are able to connect seamlessly to a network which they have used before, making it easy for consumers to access enhanced coverage in this way, and reducing the time that customers experience poor coverage deep indoors. We expect that seamless connectivity between Wi-Fi and mobile networks is likely to continue to improve in the future.¹²⁸ Whilst we acknowledge that there are some

¹²⁴ H3G non-confidential response to the December 2018 consultation, p33, 36-39 and non-confidential response to the October 2019 consultation, paragraph 9.37. For further details of H3G’s arguments see also annex 6, paragraph A6.31 to A6.37.

¹²⁵ H3G non-confidential response to the December 2018 consultation, p38-39. For further details of H3G’s arguments see also annex 6, paragraph A6.35.

¹²⁶ BT/EE non-confidential response to the December 2018 consultation, paragraphs 3.50-3.52 and non-confidential response to the October 2019 consultation, paragraphs 3.9 and 3.13.

¹²⁷ “Sprint has distributed over 260,000 Magic Box small cells: CEO”, RCR Wireless, accessed on 25 June 2019, <https://www.rcrwireless.com/20180802/5g/sprint-has-distributed-over-260000-magic-box-small-cells-ceo-tag23>

¹²⁸ For example, Access Traffic Steering, Switching and Splitting (ATSSS) technology which allows for seamless handover between mobile and Wi-Fi networks is currently in the specification stage by both the Broadband Forum and 3GPP and is scheduled to be finalised as part of Release 16 in March 2020.

limitations associated with using Wi-Fi (e.g. the requirement to obtain a password to access it for the first time), in general it is a very effective solution.

- 4.150 In its response to the December 2018 consultation H3G claimed that Wi-Fi offload was not an effective solution for all deep indoor traffic. However, we consider that its evidence to support this claim was weak. It referred to survey evidence showing that, in many countries, smartphone users experienced faster average download speeds on mobile networks than on Wi-Fi and suggesting that this was likely to be the case in the UK when 5G is launched.¹²⁹
- 4.151 However, we note that this argument is based on limited, non-UK evidence which appears to be at odds with current UK experience, which sees Wi-Fi being widely used as the last connectivity hop of fixed broadband connections indoors. In fact, the same report suggested that currently download speeds over Wi-Fi in the UK are faster than those available over mobile networks¹³⁰. In its responses, BT/EE did not address the question of whether Wi-Fi was a good substitute for providing indoor coverage and did not present any arguments or evidence as to why it was not effective. In contrast, Vodafone agreed that Wi-Fi using a fixed broadband connection provides “a ready supply-substitute for indoor data”.¹³¹
- 4.152 There is also evidence to suggest that such alternative technological solutions are already being developed and rolled out by MNOs as a means of improving coverage indoors, in line with our views. For example, BT/EE’s fixed line services use Wi-Fi to provide data services to devices indoors, and similarly, BT/EE and H3G’s FWA services use Wi-Fi for the indoor coverage component.
- 4.153 Therefore, having considered all the available evidence in the round, we remain of the view that there are alternative technological solutions for providing coverage deep indoors, in particular Wi-Fi. Increasing use of such technologies will reduce the effect on competition of MNOs having smaller shares of low frequency spectrum. Customers will only notice a difference in the relatively uncommon situation of wishing to use data-intensive services in a deep indoor location where there is no Wi-Fi network available to improve coverage.

Use of low frequency spectrum for 5G services

- 4.154 In the December 2018 consultation¹³² we set out our initial view that low frequency spectrum did not offer a distinct competitive advantage in providing 5G services, although we acknowledged that 700 MHz spectrum might be a useful band for providing 5G coverage in the future, especially outside densely populated areas. We expected that 5G spectrum would initially involve the 3.4-3.8 GHz band but would grow over time to encompass the majority of existing UK mobile bands.

¹²⁹ H3G non-confidential response to the December 2018 consultation, p 39.

¹³⁰ See annex 6, paragraph A6.41 for further details.

¹³¹ Vodafone non-confidential response to the December 2018 consultation, p.41.

¹³² December 2018 consultation, paragraphs 5.204-5.207.

- 4.155 In their responses to the December 2018 and October 2019 consultations, both BT/EE and H3G argued that 700 MHz spectrum would be critical for the provision of widespread 5G coverage.
- 4.156 Specifically, BT/EE claimed that low frequency spectrum would be crucial for providing 5G services, in particular eMBB (enhanced mobile broadband)¹³³, service continuity in moving vehicles¹³⁴, IoT services¹³⁵ and URLLC¹³⁶ (Ultra-reliable and low latency communications).¹³⁷ It argued that the difference in good quality indoor coverage would be even more obvious as 5G mobile services were introduced, as customers would increasingly demand seamless connectivity using data intensive services indoors and deep indoors, and that therefore a good quality indoor coverage offering would become even more important to customers when choosing a network.¹³⁸⁻¹³⁹
- 4.157 H3G also argued that “traditional views on the amount of sub 1GHz spectrum that is needed to be competitive are no longer valid with 5G” and that ubiquitous coverage was the most important aspect of reliable connectivity, especially for massive IoT and critical communications.¹⁴⁰ It claimed that 700 MHz was important for IoT given its use as a 5G coverage layer and that there were many IoT use cases that would require deep in-building and underground access, for which 700 MHz would be important.¹⁴¹
- 4.158 BT/EE claimed that [REDACTED].¹⁴²
- 4.159 Similarly, H3G claimed that [REDACTED].¹⁴³ [REDACTED].¹⁴⁴
- 4.160 Having considered these comments, for the reasons set out below we remain of the view that 700 MHz is not the only way to provide 5G services. We also consider that it is unclear how much customers will value seamless 5G coverage for eMBB even when 5G becomes the dominant standard, because 4G technology will be able to provide a similar experience in this situation. In the case of massive machine-type communications (mMTC) and ultra-reliable low latency communications (URLLC) services, it is uncertain to what extent these

¹³³ BT/EE claimed that eMBB will need better and faster connectivity to handle higher quality video content and expectations of being able to use data with seamless connectivity.

¹³⁴ BT/EE claimed that sub-1 GHz spectrum performs better for this use as the distance over which it can be measured is greater. The performance gap cannot economically be overcome by densifying the network on transport routes.

¹³⁵ BT/EE claimed that without nationwide coverage of a single sub-1 GHz band, MNOs will not be able to compete for IoT applications requiring very long battery life and very demanding coverage.

¹³⁶ BT/EE argued that URLLC requires overlapping coverage from multiple sites which cannot economically be delivered in-building or outside dense urban areas without 700 MHz spectrum.

¹³⁷ BT/EE non-confidential response to the December 2018 consultation, paragraphs 3.53 – 3.62.

¹³⁸ BT/EE non-confidential response to the December 2018 consultation, paragraph 3.64.

¹³⁹ For further details of BT/EE’s arguments see also annex 6, paragraphs A6.51 to A6.52 and A6.59 to A6.60.

¹⁴⁰ H3G non-confidential response to October 2019 consultation, paragraph 6.4 and 10.6-10.8

¹⁴¹ H3G non-confidential response to the December 2018 consultation, p43.

¹⁴² BT/EE confidential response to the December 2018 consultation, paragraphs 3.58-3.61.

¹⁴³ [REDACTED]

¹⁴⁴ [REDACTED]

services will develop in the future and therefore be a driver of competition, and also to what extent 5G NR will be necessary to support these.

Other bands will be able to provide wide area 5G

- 4.161 In the short term, it is not clear that there is any 5G service that would require specifically sub-1 GHz (or any particular spectrum band) to operate. We recognise that there is more uncertainty about the need for 700 MHz for 5G services in the medium term as services such as massive machine-type communications (mMTC) or ultra-reliable low latency communications (URLLC) might require some dedicated resources.
- 4.162 However, whilst there may be some services for which low frequency spectrum would be useful, it is not clear at this stage that the majority of 5G services would be particularly suited to low frequency spectrum bands rather than higher frequency bands. For example, NB-IoT can be used with 4G or 5G to provide significant coverage in mid-frequency bands including 1800 MHz.
- 4.163 Whilst it is already technically possible to re-farm 800 MHz for 5G services¹⁴⁵, we accept that it may be difficult to do so if (a) this band is already capacity constrained and/or (b) not made available in devices and network equipment for 5G. However, we believe that Dynamic Spectrum Sharing (DSS) will allow H3G and BT/EE to use 800 MHz and 1800 MHz (as well as other 4G bands) to provide 5G services and that they will be able to achieve significant coverage using these bands¹⁴⁶ which is much higher than the [REDACTED].¹⁴⁷ In addition, evidence that we have gathered from industry suggests that handsets will be able to support these bands from 2020-21 onwards.¹⁴⁸

A similar service can be provided with 4G

- 4.164 In addition, 4G is likely to be around for some time: evidence on usage today suggests that seven years on from 4G deployment, a significant proportion of data traffic is still carried over 3G, despite 4G being the latest standard.
- 4.165 In May 2019, approximately 10% of total data traffic was still carried over 3G¹⁴⁹, and it appears likely that 4G will coexist with 5G for a significant time period going forward, potentially up to ten years.¹⁵⁰ We note that this is particularly relevant for H3G, whose customers are amongst the heaviest data users, suggesting H3G has competed successfully in marketing a 4G service, even though in practice a significant proportion of its traffic has been carried over 3G.

¹⁴⁵ This can be done through DSS to share 4G/5G eMBB resources or by assigning a small part of spectrum for URLLC or mMTC with a penalty on the capacity available for eMBB.

¹⁴⁶ See annex 6, paragraphs A6.62 to A6.63 for further details.

¹⁴⁷ [REDACTED]

¹⁴⁸ See annex 6, paragraph A6.64 for further details.

¹⁴⁹ Connected Nations 2019 report, p32.

¹⁵⁰ For further details, see annex 7, paragraphs A7.10-A7.12.

- 4.166 From the information that we have seen regarding planned roll-out of 5G by MNOs¹⁵¹ and what we have observed from its deployment so far, it appears that MNOs have initially focused on deploying 5G in densely populated areas such as cities, whilst relying on 4G coverage in more rural areas where demand for data is lower. Whilst eventually 5G coverage will be expanded to cover these rural areas too, this is likely to take several years to complete. This all supports our view that the ability to offer ‘widespread’ 5G¹⁵² is unlikely to be a material driver of competition at least in the short to medium term.
- 4.167 We expect that, initially, eMBB will be provided using both 4G and 5G and it does not appear to be the case that a sub-1 GHz carrier will be necessary for this service.¹⁵³ There may be some consumers who are in hard-to-reach areas that can only be served using sub-1 GHz spectrum, but the MNOs will still be able to achieve substantial coverage with spectrum above 1 GHz.¹⁵⁴ In low frequency bands, 5G NR capacity and peak speed is unlikely to be significantly better than LTE. The main technology contributing to greater capacity in future mobile networks is massive MIMO, which is unlikely to be feasible in low frequency bands (the antennas would be too big/heavy). Consumers may therefore not notice any significant difference in experience between eMBB served over 4G, 5G NR or a combination of the two.¹⁵⁵
- 4.168 Massive machine-type communications (mMTC) and ultra-reliable low latency communications (URLLC) services are two use cases which 5G technology seeks to support. However, neither of these services appear to be currently driving competition between mobile operators and it is still uncertain to what extent these services will grow in future. It is also unclear whether 5G NR will be essential to support these services because they can be supported to some extent by existing technology, including more recent versions of LTE and Wi-Fi, which are already available to use in spectrum accessible to mobile operators.
- 4.169 BT/EE said that 700 MHz was needed for URLLC because overlapping coverage from multiple sites was necessary to ensure that devices which require very high network reliability will always be able to communicate with at least one mobile base station at a time. It said that having larger coverage areas from each base station was an economically feasible way to deliver this reliability and that it could not use 800 MHz for 5G because the band was already heavily used for 4G.
- 4.170 We recognise that this overlapping coverage may be important for the delivery of URLLC services in some areas for the reasons outlined above and acknowledge that it may be easier to achieve this with low frequency spectrum due to its propagation characteristics. However, it is still possible to achieve this type of overlapping coverage with higher

¹⁵¹ See annex 7, paragraphs A7.40-A7.41 for further details.

¹⁵² By which we mean the provision of a 5G network which covers a large proportion of the UK landmass.

¹⁵³ LTE is a key enabler of early 5G, being necessary for the Non-Standalone network architecture which operators are likely to deploy during the first few years of rollout. This network architecture will jointly use LTE and 5G NR equipment in the RAN to achieve higher data speeds.

¹⁵⁴ For further detail see annex 6, paragraph A6.63.

¹⁵⁵ For further detail see annex 6, paragraphs A6.53 to A6.57.

frequency spectrum with more closely located base stations in the areas where overlapping coverage is necessary.^{156, 157}

- 4.171 We also consider that whilst it is possible that IoT applications may use wide bandwidths in the future, in the short and medium term these are likely to be focused on narrow bandwidths. We note that IoT technologies based on LTE¹⁵⁸ exist today and can use several frequency bands in the range 700 MHz to 2.6 GHz.¹⁵⁹ We also note that, due to the extended coverage of NB-IoT compared to LTE, an operator with a well-developed network in mid-band frequencies will see its network coverage extended to a high proportion of indoor (and deep indoor) locations to provide NB-IoT services.¹⁶⁰
- 4.172 Overall, therefore, it does not appear that 700 MHz spectrum will be required in order to provide 5G services. In any case, it is not clear that the ability to provide seamless 5G coverage will be a material driver of competition, as 4G technology will be able to provide a similar experience in many situations. We therefore believe that MNOs are likely to be able to compete in this area even without obtaining additional 700 MHz spectrum in the auction.

The wholesale market

- 4.173 In its responses, H3G also claimed that [REDACTED],^{161, 162} However, we consider that this is not a likely outcome, given that it appears that all MNOs will be able to compete strongly in the provision of 5G services even without obtaining any additional 700 MHz spectrum, as outlined in the sub-section above. We also consider that H3G's forecasts of [REDACTED].¹⁶³

Future network sharing arrangements

- 4.174 In its response to the October 2019 consultation, H3G argued that continued asymmetries in low frequency spectrum could critically undermine future network sharing arrangements as agreement on the single rural network (SRN) had only been possible due to the fact that the four MNOs' starting coverage 4G levels were reasonably close. It argued that Vodafone and O2 would have no incentive to participate in a 5G SRN based on infrastructure sharing

¹⁵⁶ For further detail see annex 6, paragraph A6.60

¹⁵⁷ We also consider that 5G NR is not necessary for JT-CoMP (Joint Transmission Coordinated Multi-Point) because this technology is also available in LTE Advanced Pro and that therefore operators could use their current 4G spectrum with JT-CoMP. For further details see annex 6, paragraph A6.60.

¹⁵⁸ Including Narrowband IoT (NB-IoT) and LTE-M

¹⁵⁹ We note that NB-IoT can be supported within a 5 MHz LTE carrier with minimal capacity reduction using as little as one or two of the 25 resource blocks available and that LTE-M can be supported in channel bandwidths of as narrow as 1.4 MHz. NB-IoT can also be deployed in the LTE guard bands which consumes none of the in-block carrier resources, however, the need to meet emissions limits may mean that NB-IoT deployed in guard bands may need to operate at reduced power and range. For further details see annex 6, paragraphs A6.65 to A6.66.

¹⁶⁰ For further detail see annex 6, paragraph A6.66.

¹⁶¹ H3G confidential response to the December 2018 consultation, p42-43 and confidential response to the October 2019 consultation paragraphs 11.21 to 11.22.

¹⁶² H3G confidential response to October 2019 consultation, paragraphs 11.16 to 11.20

¹⁶³ See paragraphs A6.25 to A6.28

if they were the only winners of 700 MHz spectrum in the auction, as sharing BT/EE and H3G's sites would not significantly improve their 5G coverage.¹⁶⁴ However, this argument is based on the assumption that [REDACTED]. As explained above, we do not believe that [REDACTED] as it does not appear that 700 MHz spectrum is the only route to providing 5G services.

All MNOs should be able to acquire 700 MHz spectrum if they need it

- 4.175 As outlined above, we consider that all MNOs are likely to continue to be able to compete strongly, even if they do not win additional low frequency spectrum in this award. We also believe that if an MNO has a sufficient need to obtain such spectrum, they should be able to do so.
- 4.176 In the December 2018 consultation¹⁶⁵, we said that BT/EE and H3G would be likely to have a relatively high intrinsic value for spectrum in the 700 MHz band due to currently having low shares of low frequency spectrum. We said that strategic investment by Vodafone and/or O2 would be unlikely due to the high costs of such a strategy, the difficulty of coordination and the fact that there was no material risk to competition even if BT/EE and H3G won no 700 MHz spectrum, making the expected pay-off very uncertain.
- 4.177 We received the following comments, which we address below:
- a) BT/EE argued that it was likely to be prevented from obtaining 700 MHz spectrum in the auction by strategic bidding from Vodafone and O2;
 - b) H3G also argued that [REDACTED].

Intrinsic value

- 4.178 As set out earlier in this section, we define the intrinsic value of spectrum as being the present value of additional profits that a bidder expects to earn when holding the spectrum, compared to not holding it, from using it to supply additional or improved services to consumers (or reducing costs). Intrinsic value will therefore be impacted by both the usefulness of the spectrum and the costs of deploying it. The costs of deployment will depend upon both the additional equipment needed to make use of it and on the MNO's existing network configuration.
- 4.179 In its response to the December 2018 consultation, BT/EE claimed that it had a lower intrinsic value for 700 MHz spectrum than would be expected as its costs of deployment were higher due to having an 1800 MHz grid which would require mast replacement/mast strengthening. It suggested that this cost disadvantage was at least [REDACTED] BT/EE - meaning that its valuation of the net benefit of 700 MHz would be lower than for a 900

¹⁶⁴ H3G non-confidential response to the October 2019 consultation, paragraphs 6.6 and 12.7-12.13

¹⁶⁵ December 2018 consultation, paragraphs 5.337-5.341.

MHz operator even if it had a high customer benefit.¹⁶⁶ Therefore, in its view there was a real risk that neither BT/EE nor H3G would win any 700 MHz spectrum.

- 4.180 H3G also made a similar argument in its response to the October 2019 consultation, claiming that Vodafone and O2 had a significant, enduring advantage in deploying low frequency spectrum due to the configuration of their grids and that this would increase their intrinsic valuation of 700 MHz spectrum and might therefore result in them winning all the available 700 MHz spectrum.¹⁶⁷
- 4.181 Our view is that the deployment costs faced by BT/EE and H3G are not likely to be as high as claimed and that they may also be due in part to previous commercial decisions taken e.g. not strengthening masts for 800 MHz. We also note that it is likely that operators will need to strengthen many masts in order to deploy 3.4-3.8 GHz mMIMO antennas and so these costs will not solely be attributable to deploying 700 MHz.
- 4.182 However, it appears likely that BT/EE and H3G will have a high intrinsic value for this spectrum if obtaining it is as important as they have claimed, as the potential cost of losing a significant number of customers (if indeed that is the likely outcome) could outweigh the costs of acquiring and deploying 700 MHz spectrum. As outlined above, we consider it is unlikely that any MNO would cease to compete strongly if it did not win any low frequency spectrum in the auction. We also believe that the risk of strategic bidding in this auction is low, as outlined in the following sub-section.

Strategic investment

- 4.183 As already noted, we define strategic investment as a situation where an MNO bids in excess of its intrinsic value for spectrum in an auction, in order to deny a competitor that spectrum. An MNO could have an incentive to act in this way if, by denying spectrum to its competitor, its competitor's position will be weakened sufficiently that the strategic investor can win customers or increase prices. The value of this payoff must be greater than the cost beyond the intrinsic value to the strategic investor of buying the spectrum. Strategic investment can be carried out by one MNO acting alone, or by two or more acting together through tacit co-ordination.
- 4.184 In the December 2018 consultation¹⁶⁸ we said that benefits from strategic investment in 700 MHz spectrum were likely to be limited and significantly outweighed by the costs, due to the fact that there was no material risk to competition even if BT/EE or H3G did not win any 700 MHz spectrum, and the fact that such investment would be costly as BT/EE and H3G would be likely to have high intrinsic values for the spectrum.
- 4.185 However, in its consultation response, BT/EE argued that Vodafone and O2 would only need to bid slightly more than their intrinsic value in order to prevent it and H3G from

¹⁶⁶ BT/EE non-confidential response to the December 2018 consultation, paragraphs 3.76-3.77 and non-confidential response to the October 2019 consultation, paragraphs 3.10-3.11.

¹⁶⁷ H3G non-confidential response to October 2019 consultation, paragraph 6.7 and 13.2-13-9.

¹⁶⁸ December 2018 consultation, paragraphs 5.337-5.338.

winning any 700 MHz spectrum, due to the structural cost disadvantage that the 1800 MHz operators had in deploying 700 MHz. It also argued that the proposed auction format of a CCA with a second price rule meant that Vodafone and O2 could act unilaterally to exclude BT/EE and H3G from winning 700 MHz very easily.¹⁶⁹

- 4.186 H3G also considered that [REDACTED].¹⁷⁰
- 4.187 In its response to the October 2019 consultation, Vodafone suggested that *“it can be readily shown that neither Vodafone or Telefonica have the realistic ability to bid to a level that would exclude both BT/EE and Three from acquiring 700 MHz spectrum (and further, the auction rules would preclude Vodafone or Telefonica being aware that they’re succeeding in a hypothetical strategy of excluding BT/EE and/or Three, rendering such an approach void)”*.¹⁷¹
- 4.188 Our view remains that the prospect of strategic investment is unlikely. Strategic bidding to foreclose 700 MHz spectrum to both BT/EE and H3G would involve O2 and Vodafone individually deciding to buy the 60 MHz of paired 700 MHz between them, outbidding the intrinsic value of BT/EE and H3G for all of this spectrum. The costs associated with this could be high as Vodafone and O2 currently have much more low frequency spectrum and the intrinsic value of additional spectrum tends to decline with the amount held.
- 4.189 Whilst we acknowledge that O2 and Vodafone might well have a high intrinsic value for some 700 MHz (for example for wide area 5G coverage), they are unlikely to have a high intrinsic value for the marginal lots required for strategic investment. Additionally, the payoff to Vodafone/O2 of depriving BT/EE and/or H3G of low frequency spectrum is likely to be small and uncertain as it is unlikely that this would have a material impact on competition, as discussed above.
- 4.190 Although the cost of strategic investment could be reduced by co-ordinated bidding, we believe that this would be difficult to achieve as it would require MNOs to effectively bid for spectrum jointly but without being able to communicate. Therefore, it appears that the incentive for MNOs to engage in strategic investment is limited and unlikely to occur.

It is not appropriate or proportionate to impose any specific cap on low frequency spectrum

- 4.191 In its response, BT/EE argued that the relevant test for whether competition measures were justified was whether competition could be ‘enhanced or improved’. It said:
- “Specifically, if competition in future mobile services can be materially enhanced by undertaking a pro-competitive, light-touch intervention today, then Ofcom is required to propose such measures. Especially where the benefits of the intervention outweigh the costs and where the measure has the highest net benefit of all options considered.”*¹⁷²

¹⁶⁹ BT/EE non-confidential response to the December 2018 consultation, paragraphs 3.94-3.98.

¹⁷⁰ [REDACTED]

¹⁷¹ Vodafone non-confidential response to the October 2019 consultation, page 6.

¹⁷² BT/EE non-confidential response to the December 2018 consultation, paragraph 3.72.

- 4.192 BT/EE also appeared to be suggesting that we should not award spectrum to the bidders with the highest intrinsic value, saying:
- ‘Within this assessment a key question for Ofcom is whether promoting static efficiency objectives i.e. that it is efficient for the bidder(s) with the highest valuation(s) to be awarded spectrum should be balanced with competition objectives to support innovation, choice and value for consumers.’¹⁷³*
- 4.193 We agree with BT/EE that ‘spectrum allocations should generally be left to the market, to promote economic efficiency, except where it makes sense for this objective to be balanced by competition objectives’.¹⁷⁴ However, as already discussed, the level of intervention should be the minimum necessary to achieve our policy objectives effectively.
- 4.194 One of our objectives in this auction is to sustain strong competition in mobile services in the UK. Since the market is currently working well, we consider it appropriate to impose only such measures that we consider necessary to prevent a significant risk that competition might be harmed by certain auction outcomes.
- 4.195 Similarly, in its response to the October 2019 consultation, H3G argued that imposing a 2x10 MHz cap on 700 MHz FDD spectrum would be appropriate, necessary, the least onerous of all equally effective measures and proportionate¹⁷⁵ and that such a cap should therefore be introduced. However, this argument is based on H3G’s assumption that a competition concern would arise in the event that it and/or BT/EE failed to win any additional 700 MHz spectrum in the auction. As we do not consider that there would be any such competition concern in this situation (for the reasons outlined above), we do not believe that any such measure is required.
- 4.196 BT/EE also argued that recent 700 MHz auctions in Italy and Switzerland had included sub-1 GHz spectrum caps, which suggested that other regulators had concluded that there was a material risk of asymmetric shares in low frequency spectrum leading to competition problems.¹⁷⁶ Similarly, in its responses, H3G argued that other regulators had taken a much more interventionist approach to the allocation of low frequency spectrum, with the US, Australia, Italy and Switzerland mentioned as specific examples of countries which had used sub-1 GHz spectrum caps, not allowed certain MNOs to participate in auctions for low frequency spectrum, or made spectrum reservations for specific bidders.¹⁷⁷
- 4.197 However, we have based our assessment on the relevant evidence and circumstances in the UK. We note that we have imposed a sub-1 GHz cap in the past in the 2013 4G auction,

¹⁷³ BT/EE non-confidential response to the December 2018 consultation, paragraph 3.2 and non-confidential response to the October 2019 consultation, paragraph 3.5.

¹⁷⁴ BT/EE non-confidential response to the December 2018 consultation, paragraph 3.114.

¹⁷⁵ H3G non-confidential response to the October 2019 consultation, paragraphs 14.1-14.12.

¹⁷⁶ BT/EE non-confidential response to the December 2018 consultation, paragraph 3.132-3.135 and non-confidential response to the October 2019 consultation, paragraph 3.13.

¹⁷⁷ H3G non-confidential response to the December 2018 consultation, section 4.7.3 and non-confidential response to the October 2019 consultation, paragraph 14.10.

as we explained in the December 2018 consultation¹⁷⁸, however we do not consider that the evidence justifies such an intervention in this award.

- 4.198 We also consider that it is questionable as to whether the 2x10 MHz cap on 700 MHz FDD spectrum as proposed by H3G and BT/EE would have the desired effect of ensuring that both these MNOs would be able to bid successfully for additional low frequency spectrum. Although Vodafone and O2 would be limited to obtaining a maximum of 2x10 MHz each in this scenario, it is still quite possible that either BT/EE or H3G would fail to obtain any additional low frequency spectrum, with all of the available 700 MHz spectrum being acquired by the other three MNOs. If the desired outcome is to ensure that both BT/EE and H3G are certain to acquire additional low frequency spectrum it would appear that an alternative – and more interventionist – remedy would be required.
- 4.199 Additionally, H3G could acquire low-frequency spectrum by trading, without winning 700 MHz in the auction. For example, H3G may have an incentive to trade or move its existing 3.4-3.8 GHz holdings to acquire more low frequency spectrum.¹⁷⁹ Vodafone and O2 have larger amounts of low frequency spectrum than H3G and may wish to acquire the H3G spectrum adjacent to their holdings in the 3.4 GHz band. This suggests that even if H3G were not to acquire any 700 MHz spectrum in the auction, there could be an alternative means for it to obtain additional low frequency spectrum.

Conclusions

- 4.200 For the reasons set out above, we have decided not to impose any specific cap on low frequency spectrum.

Competition concern 1c: Asymmetry related to 3.4-3.8 GHz spectrum

Introduction

- 4.201 In the December 2018 consultation, we considered whether we should impose a competition measure on 3.6-3.8 GHz spectrum (or the wider 3.4-3.8 GHz band). We noted that H3G already held 36% of the 3.4-3.8 GHz band but said that each MNO would be capable of providing a wide range of 5G services with its current spectrum holdings, both in 3.4-3.6 GHz and other bands. We therefore did not propose a cap on 3.4-3.8 GHz spectrum in this award.
- 4.202 In summary, we received the following comments:

¹⁷⁸ At paragraphs 5.300 to 5.303.

¹⁷⁹ We set out these incentives previously in “Variation of UK Broadband’s spectrum access licence for 3.6 GHz spectrum” December 2018 statement, paragraphs 4.23 to 4.25.

- a) H3G said that we were correct to find no competition concerns in relation to 5G spectrum;¹⁸⁰ and
- b) Vodafone, O2 and BT/EE disagreed with our analysis on 3.4-3.8 GHz spectrum. These MNOs said that competition may be harmed if they do not each obtain 80-100 MHz of contiguous spectrum.¹⁸¹ All three MNOs said we should impose a cap of 140 MHz across the 3.4-3.8 GHz band, meaning that H3G should not be allowed to bid for or acquire any more spectrum in this band.¹⁸² O2 also suggested a 'precautionary cap' of 80 MHz in the 3.6-3.8 GHz band.¹⁸³

Summary

- 4.203 Having considered stakeholders' comments, we remain of the view there is low risk of competition concerns related to 3.4-3.8 GHz spectrum from any auction outcome. We have therefore decided not to impose any competition measures in relation to 3.4-3.8 GHz spectrum.
- 4.204 The main potential competition concern that we and some respondents have identified is asymmetry in holdings, in particular the importance of 3.6-3.8 GHz spectrum for Vodafone, O2 and/or BT/EE's ability to deliver the 5G services that consumers will value in the future. In principle, concerns could arise either if Vodafone, O2 or BT/EE won no 3.6-3.8 GHz spectrum, or if they did win some but their resulting 3.4-3.8 GHz spectrum holdings were fragmented.
- 4.205 We have considered two time periods in our assessment:
- a) The short term lasting until around 2021, in which the 3.4-3.8 GHz band will be the main spectrum useable for 5G;
 - b) The longer term from around 2022, when we consider technological developments are likely to enable other bands to be used for 5G.
- 4.206 As a starting point for this assessment, we note:
- a) The UK mobile market is currently working well;
 - b) H3G, who would potentially be advantaged by asymmetry in the 3.4-3.8 GHz band, is currently the smallest player in the wholesale market (with a 12% share of subscribers). It has been slower to rollout 5G mobile services, and it is lagging its competitors on certain measures of network performance/reliability (see annex 5).
 - c) While 5G services will grow in importance, MNOs will continue to compete across a wide range of services and metrics.

¹⁸⁰ H3G non-confidential response to the December 2018 consultation, page 33.

¹⁸¹ By contiguous spectrum (or contiguity) we mean spectrum bands which are adjacent in frequency to one another and are held by a single licensee.

¹⁸² Vodafone non-confidential response to the December 2018 consultation, pages 13-16 and 39-40; O2 non-confidential response, paragraphs 23 and 127-154; BT/EE non-confidential response, paragraphs 3.136-3.143.

¹⁸³ O2 non-confidential response to the December 2018 consultation, paragraphs 12, 104, 111-112, 118 and 200-201.

- 4.207 In the short-term, each of the MNOs has at least 40 MHz of spectrum in the 3.4-3.8 GHz band to supply 5G services. Even if H3G has greater capacity, we consider that all MNOs' existing holdings are likely to be sufficient to supply the 5G services that consumers will value in the short term, principally because there is likely to be limited demand for 5G in the early stages of its rollout. It is unlikely that MNOs will need 80-100 MHz of 3.4-3.8 GHz spectrum to compete strongly in the short term.
- 4.208 In the longer term, other spectrum will be available for 5G. Vodafone, O2 and BT/EE all have spectrum which we consider could be used to supply 5G in the longer term, including the 1800 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz bands. We recognise there is some uncertainty over the precise timelines for technological developments and significant uncertainty over future demand for 5G services in the longer term.
- 4.209 Our assessment suggests that devices and base stations which can use these bands for 5G and other supporting technologies (such as non-contiguous carrier aggregation) are likely to be available in the timeframes required by MNOs. Thus, even if they do not win any 3.6-3.8 GHz spectrum in this award, MNOs are likely to be able to use other frequencies to increase their 5G capabilities in line with their needs. We therefore consider MNOs are unlikely to need 80-100 MHz of 3.4-3.8 GHz to compete strongly in the longer term.
- 4.210 Furthermore, even if MNOs really need to increase their holdings of 3.4-3.8 GHz spectrum to compete, we consider that they are also likely to be able to acquire some 3.6-3.8 GHz spectrum in this award. There is a low risk that H3G could successfully engage in strategic investment to either deny spectrum to its rivals or obstruct defragmentation.
- 4.211 There are potential auction outcomes which would leave some MNOs without 80-100 MHz of contiguous bandwidth. There is significant uncertainty over what future 5G services are likely to be important to consumers and what the associated technical requirements might be. However, we have not seen evidence suggesting there are likely to be future 5G services which would be of significant commercial importance and which would require 80-100 MHz of contiguous spectrum. Rather, our assessment suggests all MNOs are likely to be able to support a wide range of 5G services without such a large volume of contiguous bandwidth.
- 4.212 If Vodafone, O2 or BT/EE win additional spectrum, but their 3.4-3.8 GHz holdings are not contiguous, their increase in capacity may be less than if they could access the same amount of spectrum in a contiguous block. However, we consider the scale of any capacity impact from a lack of contiguity is unlikely to be large enough to undermine an MNO's ability to provide a wide range of 5G services to consumers or to compete strongly more generally.
- 4.213 Better technology over time is likely to allow MNOs to overcome the main technical challenges associated with having spectrum fragments far apart in frequency. While there may be associated cost implications, we consider the cost estimates submitted to us by stakeholders are overly pessimistic. We also consider that MNOs have incentives to address any challenges of fragmentation by trading between them. We have taken steps to facilitate such trading in the auction process.

4.214 The structure of this sub-section is as follows:

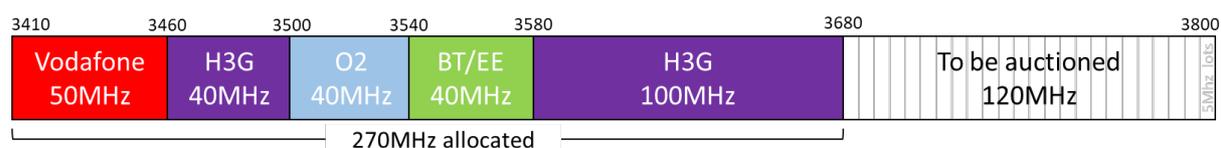
- We set out a summary of our potential competition concerns and position in the December 2018 consultation document;
- We present a summary of the MNOs' responses (we engage with the responses in more detail when considering the relevant evidence, and in annex 7);
- We consider evidence on which bands are likely to be supported for 5G and when;
- We consider evidence on 5G services and their spectrum requirements (including the importance of holding 80-100MHz contiguous spectrum in the 3.4-3.8 GHz band);
- We consider the disadvantages of and possible technical solutions to fragmented spectrum;
- We conclude that MNOs are likely to be able to compete strongly even if they do not acquire more 3.4-3.8 GHz spectrum in this award (or they do but their holdings are fragmented); and
- Finally, we consider whether MNOs are likely to win spectrum if they need it and assess the risk of strategic investment by H3G.

4.215 Annex 7 contains supporting information and evidence.

Potential competition concern: Will the other MNOs have the spectrum they need to compete in 5G mobile services?

4.216 In relation to the 3.4-3.8 GHz spectrum we have considered whether BT/EE, Vodafone and O2 will have the spectrum they need to deliver the 5G services valued by consumers and compete strongly with H3G. As shown below, H3G has 140 MHz in the 3.4-3.8 GHz band, considerably more than the other MNOs, and is the only MNO to hold 100 MHz of contiguous spectrum within the 3.4-3.8 GHz band.

Figure 4.31: Current holdings in the 3.4-3.8 GHz band



December 2018 consultation position and subsequent consultation responses

4.217 We assessed the following potential concerns in the December 2018 consultation:

- Asymmetry:** Whether H3G could hold an unmatched advantage if it acquired a large share of the 120 MHz available in the 3.4-3.8 GHz band.¹⁸⁴ This included consideration of whether MNOs would need 80-100 MHz of 3.4-3.8 GHz spectrum to compete strongly. Our provisional finding was that an MNO with a large share of 3.4-3.8 GHz spectrum would not have materially superior capabilities compared to an MNO with similar amounts of spectrum in different mid-frequency bands. We said it was thus

¹⁸⁴ Paragraphs 5.236 and 5.237.

unlikely that H3G would gain a material advantage over other operators, even if it were to acquire all of the 3.6-3.8 GHz being awarded.¹⁸⁵

- b) **Credibility:** Whether one or more MNOs would be unable to offer the 5G services valued by consumers in the longer term which could mean they cease to be a credible competitor. We considered that each MNO was likely to have a clear path to offering such services, even if it won no spectrum in the auction.¹⁸⁶
- c) **Fragmentation in the 3.4-3.8 GHz band:** Whether MNOs' competitive position could be weakened if fragmented holdings in the 3.4-3.8 GHz band denied them the benefits of spectrum contiguity or proximity of 5G carriers.¹⁸⁷ We said there was a potential risk that a lack of contiguity could make it challenging or impossible to supply certain services at the required levels of quality. Similarly, we said there was a potential risk that a lack of proximity could make it costlier or impossible to deploy active antenna systems on single masts covering the entire range of 3.4-3.8 GHz or make such deployments less effective (e.g. reduce effective capacity). Our provisional finding was that:
 - i) We expected technological developments to limit the impact of fragmentation, and
 - ii) Even if equipment limitations persisted and caused some cost inefficiencies in the early stages of 5G, they would be unlikely to affect MNOs' ability to compete, especially in the longer term.¹⁸⁸ We also said that spectrum trading provided a possible route to defragmentation.

4.218 In their responses to the December 2018 and October 2019 consultations, stakeholders identified three scenarios involving the 3.4-3.8 GHz band which they considered could weaken competition:¹⁸⁹

- a) If other MNOs were unable to compete strongly with H3G due to the relative scale of its spectrum holdings in the 3.4-3.8 GHz band. They said H3G could seek to achieve this through strategic investment, specifically by acquiring a volume of spectrum which deprived one or more of the other MNOs of the 80-100 MHz of 3.4-3.8 GHz spectrum which those MNOs potentially affected claim they need to compete.
- b) If the other MNOs were unable to compete strongly with H3G due to an inability to realise the benefits of contiguity and proximity.¹⁹⁰ They said H3G could seek to achieve

¹⁸⁵ Paragraph 5.253.

¹⁸⁶ Paragraphs 5.224 to 5.229.

¹⁸⁷ We define 'proximate' spectrum as being spectrum fragments which are close enough in frequency that they could be used by a single piece of base station equipment. Accordingly, we define 'non-proximate' spectrum as being spectrum fragments which are far away enough from each other in frequency that they would require two pieces of base station equipment to be deployed in order to be fully used.

¹⁸⁸ Paragraphs 5.255 to 5.263

¹⁸⁹ See [REDACTED] BT non-confidential response to the December 2018 consultation, paragraphs 3.140 - 3.143, O2 non-confidential response, paragraph 102; BT non-confidential response to the October 2019 consultation, paragraphs 3.14 - 3.20; O2 non-confidential response to the October 2019 Consultation, paragraphs 25, 81 and 82.

¹⁹⁰ On the scale of H3G's spectrum holdings, see, for example: [REDACTED] BT non-confidential response to the December 2018 consultation, paragraph 3.138, O2 non-confidential response to the December 2018 consultation,

this by acquiring spectrum at a position in the band that obstructed defragmentation.¹⁹¹

- c) If H3G drove up the prices payable by other MNOs for 3.6-3.8 GHz spectrum.

The main potential competition concern in the 3.4-3.8 GHz band is spectrum asymmetry

4.219 The main potential competition concern which could arise in the 3.4-3.8 GHz band is spectrum asymmetry. This could arise in two forms:

- a) First, there could be an asymmetry in the relative scale of holdings if H3G won a large share of the remaining 120 MHz available in the 3.4-3.8 GHz band. At the extreme, we could consider an outcome where BT/EE, O2 and Vodafone win no new spectrum in the 3.4-3.8 GHz band (i.e. if after the auction, the MNOs remain on their current, pre-auction holdings of 3.4-3.8 GHz spectrum - 40 MHz each for BT/EE and O2, and 50 MHz for Vodafone).
- b) Second, fragmented holdings in the band could prevent one or more MNOs from realising the benefits of contiguity or proximity.¹⁹² However, BT/EE, O2 and Vodafone's holdings in the band would only become fragmented if they won new spectrum in the 3.4-3.8 GHz band. MNOs should benefit from additional spectrum, even if it is not contiguous with current holdings, and so if we have little or no concern relating to the 'extreme' scenario set out in (a), we should also have little or no competition concern for any outcome featuring fragmented spectrum.

4.220 Such asymmetries could, in principle, weaken competition by giving H3G an unmatched advantage in providing a wide range of 5G services valued by consumers or if other MNOs struggle to provide these services or offer a minimum level of service quality.

4.221 We consider other concerns relating to credibility and price driving and the end of this section and in section 5 respectively.¹⁹³

When competition concerns might arise

We consider both the short-term and longer-term implications of spectrum asymmetry

4.222 The effect of asymmetry on competition is likely to change over time. This could be driven by various developments including: more spectrum bands being used or useable for 5G; availability of new or improved technology; changes in the services and the capacity MNOs deliver using their 5G networks, or the 5G services demanded by customers.

paragraph 135. On contiguity and proximity, see, for example: [REDACTED] and BT non-confidential response to the December 2018 consultation, paragraph 3.317.

¹⁹¹ We note some trades would be required for any of BT/EE, O2 or Vodafone to achieve contiguous holdings (in excess of their current holdings) in the 3.4-3.8 GHz band.

¹⁹² For the purposes of this competition assessment, we assume no trading of spectrum takes place either before, during or after the auction. This is the cautious approach, in terms of fragmentation, from a competition perspective. However, we discuss the possibility of trading at paragraph 4.288.

¹⁹³ We also note that [REDACTED].

- 4.223 In the December 2018 consultation we distinguished between two time periods:
- a) The short term (which we said was expected to be 2019-2020), the initial period after 5G technology was available when deployments were likely to focus on enhanced mobile broadband (eMBB) and MNOs were more reliant on the 3.4-3.8 GHz band to provide 5G services; and
 - b) The longer term (which we said started from the end of the short term until 5 to 10 years after the first 5G deployments) when consumer demand for 5G services, and MNOs' ability to provide those services, will mature.¹⁹⁴
- 4.224 The main scenario we have re-assessed in light of consultation responses includes both time periods, the short-term followed immediately by the longer term. However, we have refined our view of the timing of these periods since the December 2018 consultation. This is based on further evidence on the likely timing for the usability of other spectrum bands for 5G. We recognise the timing of these developments is uncertain, and therefore any forecast is at best approximate and subject to change due to market and technology developments. Despite this uncertainty, we consider it is useful to assess the competition concerns across these two broadly defined periods.
- 4.225 We consider the **short term** to be the period in which the 3.4-3.8 GHz band is the main spectrum useable for 5G services. Therefore, in principle the impact of any asymmetry in 3.4-3.8 GHz spectrum holdings on competition could be particularly significant in this period. The evidence set out in this section and annex 7¹⁹⁵ suggests this may last until **around 2021**, when other spectrum bands will start to become more widely useable for 5G. This also aligns with the edge of current vendor roadmaps/planning windows, beyond which any forecasts about future developments become less certain and more speculative. As set out below, we expect eMBB and possibly fixed wireless access (FWA) to be the most important 5G services in this period.
- 4.226 We consider the **longer term** to begin when MNOs are able to re-farm the large majority of their existing spectrum holdings to support 5G; the associated devices and base stations which can use these bands for 5G will have developed; and supporting technologies which may help mitigate the challenges of fragmentation will be available (e.g. intra-band non-contiguous carrier aggregation). The evidence set out in this section and annex 7 suggests the UK market should reach this position **by around 2022**. We do not expect any further potential competition concerns related to 3.4-3.8 GHz spectrum to arise beyond 2022.¹⁹⁶

¹⁹⁴ See, for example, paragraphs 5.224-5.226 and footnote 125 of the December 2018 consultation.

¹⁹⁵ See, for example, A7.6, A7.12, A7.20 to A7.36, A7.101 to A7.107.

¹⁹⁶ However, the market and technology will continue to evolve in the longer term. Based on the experience with previous technologies (e.g. 3G, 4G), it could perhaps be up to 10 years after initial deployments before 5G technology is close to fully developed, the key 5G services are established and customer demand has matured. At the same time, there is a very large degree of uncertainty for any forecasts beyond 5 years regarding technology, services and consumer demand.

We also consider an alternative scenario with a possible interim period between the short and longer term but our findings are not sensitive to this

- 4.227 Vodafone expressed concern about weakened competition in a period which does not easily fit into the above split between a short and longer term. It said there would be a time period when (i) MNOs would need to offer 5G services requiring contiguous bandwidth in excess of their existing holdings but (ii) neither re-farmed spectrum outside the 3.4-3.8 GHz band nor the associated devices and base stations which can use these bands for 5G would yet be ready to meet that demand, and thus competition would be weakened.¹⁹⁷ O2 also cited the importance of competition before the longer term.¹⁹⁸
- 4.228 Given this, we have also considered an alternative scenario allowing for a potential interim period, to capture the risk that customer demand for 5G services will temporarily outpace MNOs' ability to re-farm other frequency bands for 5G. We consider that the timing of this period would be sensitive to development of devices and base stations which can use these bands for 5G and supporting technologies such as extending carrier aggregation to particular band combinations.
- 4.229 Based on evidence on timelines drawn from manufacturers, vendors, and stakeholders' consultation responses, we consider that if this were to occur, it would most likely happen from **around 2021 to 2022**, with the longer term then starting later in 2022 or 2023. However, as set out below, we think there is a low risk that demand would outpace technology and deployments in this way. Additionally, we also consider any such divergence is likely to be short-lived and unlikely to prevent MNOs from competing strongly. Therefore, we find below that no new competition concerns arise from considering this potential interim period.

5G spectrum bands

- 4.230 We now set out our evidence and views on the spectrum bands which will be used to deliver 5G and when we expect this to happen.

Consultation position and responses

- 4.231 In the December 2018 consultation we said that what constituted '5G spectrum' would change over time depending on which bands were enabled for 5G use and available in devices for 5G use. Over time we expected many, if not all, of the existing UK mobile bands to be enabled for 5G use, and to be deployed for 5G use subject to chipset availability.¹⁹⁹ We also said MNOs were expected to launch 5G with existing holdings in the 3.4-3.8 GHz band in 2019.²⁰⁰

¹⁹⁷ Vodafone non-confidential response to the December 2018 consultation, pages 13-16 and 39-40.

¹⁹⁸ See O2 non-confidential response to the December 2018 consultation, paragraphs 123 to 128.

¹⁹⁹ Paragraphs 5.204, 5.210 and 5.213.

²⁰⁰ Paragraph 5.206.

- 4.232 In response, Vodafone said 3.4-3.8 GHz would be the main 5G band from 2020 until perhaps 2024, and that it was incorrect for Ofcom to conclude that re-farming the 2.3 GHz and 2.6 GHz bands for 5G would alleviate asymmetry concerns. It said these bands did not support 5G and a wide range of services requiring 80-100 MHz of bandwidth would be demanded before devices and base stations supporting 5G use of these bands developed. It also said that massive MIMO (mMIMO)²⁰¹ presented challenges for these bands due to the size and weight of equipment on masts, and that millimetre wave (mmWave) spectrum was not a substitute for sub-6 GHz frequency spectrum bands.²⁰²
- 4.233 BT/EE also commented on the importance of 3.4-3.8 GHz in the first years following the 5G launch.²⁰³ O2 said the 3.4-3.8 GHz band was the critical band for deployment of 5G, emphasising its importance in the near term. It also said 5G would be extended to other bands such as 1800 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz but this might not happen as quickly as Ofcom expected.²⁰⁴
- 4.234 The following sub-section and Figure 4.42 summarise our view of these responses and our updated assessment of the evidence.²⁰⁵ Our assessment reflects our current view based on the available evidence. We recognise such assessments inherently involve a material degree of uncertainty and thus we have taken a cautious approach to our assessment of the future usability of different spectrum bands.

²⁰¹ Massive MIMO is a term encompassing a range of techniques that use a large number of antenna elements to increase base station throughput and range.

²⁰² Vodafone non-confidential response to the December 2018 consultation, pages 13-16 and 39-40.

²⁰³ See BT's non-confidential response to the December 2018 consultation, paragraph 3.136.

²⁰⁴ O2 non-confidential response to the October 2019 consultation, paragraphs 79 - 83.

²⁰⁵ See A7.6 to A7.36 for further detail.

Figure 4.42: Conclusions on estimated timing of usability of different spectrum bands for 5G²⁰⁶

	Timing (approximate):	Comment
700 MHz	2020	
800 MHz	2020 or 2021	This band is likely be heavily used for LTE for many years and operators will need to decide the extent to which they use this band for 5G.
900 MHz	2021 or 2022	
1400 MHz	Unclear, unlikely to be useable by 2022	Limited demand could mean supporting devices and base stations develop more slowly.
1800 MHz	2021 or 2022	
2.1 GHz	2021 or 2022	
2.3 GHz	2021 or 2022	
2.6 GHz TDD	2020 or 2021	
2.6 GHz FDD	2021 or 2022	
3.4-3.6 GHz	Already useable	
3.6-3.8 GHz (H3G holdings)	Already useable	
3.6-3.8 GHz (to be awarded)	Useable after the award	

5G rollouts began last year and use the 3.4-3.8 GHz band

- 4.235 Initial 5G rollouts have started and now cover many urban locations in the UK, although we note that H3G was slower to launch 5G mobile services.²⁰⁷ We anticipate further rollout by MNOs, beyond what has already been publicly announced, will progress gradually and scale with the availability and take-up of 5G handsets (and the associated increased demand for data and new services).²⁰⁸
- 4.236 Speed and capacity enhancements provided by technology such as mMIMO are not exclusive to 5G standards but are nonetheless likely to be perceived as an important aspect of MNOs' 5G offerings in the UK.²⁰⁹ The 3.4-3.8 GHz band will contribute to delivering these improvements.

²⁰⁶ The framework for useability is set out in annex 4.

²⁰⁷ See paragraphs A7.40-A7.41 for further details of MNOs' 5G rollouts to date. These initial rollouts largely rely on the 3.4-3.6 GHz band in the UK for the 5G NR signal but also require an LTE signal "anchor" in a different mobile band.

²⁰⁸ Initial 5G rollouts have progressed similarly to early 4G rollouts, with an initial focus on urban areas and serving demand for a relatively small number of devices. Factors that influenced 4G rollout, such as balancing the cost of new base station equipment with serving demand in less populated areas will also be relevant for 5G rollout.

²⁰⁹ It is technically possible to deliver a service meeting 5G standards without mMIMO.

Other bands are already designated for 5G but will take some time to be useable for 5G

- 4.237 Most of the bands previously designated for LTE have been designated for 5G in 3GPP Release 15, in which 5G NR was first defined. MNOs' ability to use these bands for 5G also relies on the availability and development of devices and base stations which can use these bands for 5G and on user take-up of devices.
- 4.238 Each of the MNOs should be able to re-farm much of their existing spectrum holdings to deliver 5G. Each MNO will have access to at least 100 MHz of spectrum that can eventually be used for 5G. We recognise that different spectrum frequencies are not completely equivalent, and so there will be some limited variation in the extent to which they can substitute for 3.4-3.8 GHz spectrum.²¹⁰ Nonetheless, we expect that nearly all sub-3.4 GHz spectrum can contribute to delivering 5G services across macro-cell networks and so function as an alternative to 3.4-3.8 GHz spectrum in many circumstances.
- 4.239 In combination with developments in technology and investment in networks, this means each MNO is likely to be capable of providing a wide range of 5G services valued by consumers in the long-term.

2.3 and 2.6 GHz bands likely to support 5G

- 4.240 The 2.3 and 2.6 GHz bands are of interest as O2, BT/EE and Vodafone have holdings in these bands which we anticipate they should be able to use to deliver 5G services in the future.²¹¹ The availability of mMIMO systems in these bands could also be important for increasing 5G (and 4G) capacity in busy areas, and in that sense they will be similar to the 3.4-3.8 GHz bands.
- 4.241 The additional evidence we have gathered since the December 2018 consultation suggests that equipment and devices are likely to begin to support 5G use of the 2.6 GHz TDD band from around 2020 to 2021.²¹² The 2.6 GHz FDD band is less prominent in vendor roadmaps than 2.6 GHz TDD, and, more generally, we expect the FDD bands to lag behind the TDD bands in terms of support for 5G. We expect the 2.6 GHz FDD would be useable later than the TDD bands for 5G, possibly around 2021 or 2022.
- 4.242 The 2.3 GHz band has been awarded in fewer countries than the 2.6 GHz TDD band, and so the development of the devices and base stations which can use this band is likely to be somewhat slower, although the *overall* timeline is unlikely to be very different. We consider a reasonable estimate of the likely time range is 2021 to 2022.

²¹⁰ For example, it may be challenging to deploy more advanced mMIMO antenna in lower frequency bands (e.g. below 2 GHz), as larger and heavier antennas are required. By "more advanced" we are referring to higher MIMO rank mMIMO antennas such as those using 64T64R. It may be possible for MNOs to deploy 32T32R or 16T16R mMIMO antennas at lower frequencies, but this would provide less capacity than higher rank antennas. The need for a larger and heavier antenna is driven, amongst other things, by a need for a greater physical separation between antenna elements at lower frequencies.

²¹¹ O2 has 40 MHz TDD (unpaired) in 2.3 GHz band. Vodafone has 40 MHz FDD (paired) and 20 MHz TDD in the 2.6 GHz spectrum. BT has 100 MHz of FDD and 15 MHz of TDD 2.6 GHz spectrum.

²¹² [REDACTED]

- 4.243 MNOs, particularly those operating across many countries, can influence manufacturers' decisions on which bands are prioritised for support in chipsets. However, we recognise there is uncertainty over whether the UK device market alone is big enough to drive the mass adoption of a particular band by manufacturers if there is little or no demand in other markets.

Other spectrum bands

- 4.244 As summarised in the table above, our updated assessment, based on additional evidence gathered since the December 2018 consultation, suggests other bands below 2.3 GHz are likely to be useable for 5G between 2020 and 2022, with some variation among the bands.²¹³
- 4.245 We consider the mmWave, 3.8-4.2 GHz and licence-exempt bands are less relevant for our 3.4-3.8 GHz competition assessment. There is uncertainty over the extent to which they can be used in place of the 3.4-3.8 GHz band:
- a) The **mmWave bands** have been designated as 5G bands and may be used for possible future services which might benefit from large contiguous bandwidths. However, they have not yet been awarded for mobile services and it is uncertain how important they will be for offering those services that are important to competition between MNOs. We expect mmWave may be used and deployed differently to sub-6 GHz spectrum in many circumstances as these bands have quite different characteristics to sub-6GHz bands (e.g. worse propagation). We therefore do not consider it on the same basis as sub-6 GHz spectrum for the purposes of this competition assessment. We further discuss the use of **mmWave** bands for 5G services and how it differs from sub-6 GHz spectrum in at paragraphs A4.43-A4.54.
 - b) We have introduced a shared access regime for the **3.8-4.2 GHz band**, in which local licences will be issued on a first-come, first-serve basis.²¹⁴ This is intended to enable innovative and novel uses of spectrum and may be used for 5G services including FWA, IOT and industrial uses. However, licences are for low power use in local areas or on a per base station basis in rural areas for medium power use. The 3.8-4.2 GHz band is also not permitted to be used to provide national mobile broadband services.²¹⁵ We therefore expect this band will be used differently to the 3.4-3.8 GHz band, and MNOs are unlikely to see it as a close substitute. We also discuss the 3.8-4.2 GHz band at paragraphs A4.41-A4.42.

²¹³ Our competition assessment is based on the expectation that 1400 MHz SDL spectrum may not be available in this window.

²¹⁴ Ofcom's statement of 25 July 2019, entitled "Enabling wireless innovation through local licensing Statement", <https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation>, paragraph 1.6.

²¹⁵ See Ofcom's statement of 25 July 2019, entitled "Enabling wireless innovation through local licensing Statement", paragraph 1.6.

- c) **Licence exempt spectrum** used for services such as Wi-Fi can be an effective tool for providing capacity in areas where it is needed, however, these bands can only substitute for 5G services provided by the macro-cell network in certain circumstances.²¹⁶

When will 5G services and capabilities become important for competition and what spectrum will they require?

Consultation position and responses

- 4.246 In the December 2018 consultation, we distinguished between 5G services and improved network performance. We said 5G consumer demand would initially be for enhanced mobile broadband (eMBB), including fixed wireless access (FWA), and that MNOs would not need to offer all 5G services in the short term to remain competitive.
- 4.247 We noted some advantages of the 3.4-3.8 GHz band including that it would be one of the first enabled for 5G, that no migration from older technology was required and that it was well suited for mMIMO.²¹⁷ However, we said none of those advantages would enable H3G to offer services which other operators could not also offer.²¹⁸ We said that other operators' better performing LTE networks (e.g. in dimensions such as capacity and coverage) could offset any early advantage H3G derived from their 5G network, noting that there would be only a small initial performance difference between LTE and 5G networks and that 5G services would initially rely on both networks.²¹⁹
- 4.248 We recognised that MNOs said it was desirable to have 80-100 MHz of 3.4-3.8 GHz spectrum.²²⁰ However, we said there was no specified minimum bandwidth requirement for 5G and we were not aware of specific 5G services, or tiers of service, that could only be provided with specific spectrum portfolios.²²¹ We also said that if peak speeds became important to compete in the market, they could, if necessary, be achieved through carrier aggregation instead of large contiguous holdings of 3.4-3.8 GHz spectrum.²²²
- 4.249 We said it was unlikely that consumers would notice early speed differences between LTE and 5G networks when accessing the mobile services that they currently use and, even though some future services may require higher speeds, re-farming and improved technology would allow all MNOs to provide these services in the long term.²²³ We also noted that other dimensions of competition, such as price, network reliability and coverage, were likely to remain important.²²⁴

²¹⁶ We also discuss using licence-exempt spectrum at A6.27 to A6.47 and specifically for 5G services at A7.15 to A7.16.

²¹⁷ Paragraph 5.238.

²¹⁸ Paragraph 5.239.

²¹⁹ Paragraph 5.244.

²²⁰ Paragraph 5.220.

²²¹ Paragraphs 5.215 and 5.233.

²²² Paragraph 5.239.

²²³ Paragraphs 5.245 and 5.251.

²²⁴ Paragraphs 5.246 to 5.250 and 5.252.

- 4.250 In its response to the December 2018 consultation, Vodafone said we had under-estimated the importance of large contiguous bandwidths for 5G services in the longer term.²²⁵ It said services which relied on such holdings would develop because other countries have awarded large contiguous assignments in mid-bands. BT/EE said it was important that MNOs could acquire contiguous spectrum at the widest supported bandwidths to compete effectively.²²⁶
- 4.251 O2 said MNOs other than H3G might have enough spectrum to launch basic 5G services but had less than was needed to offer an equivalent service to H3G. It said the core spectrum requirement was large blocks of contiguous spectrum and MNOs would need something 'sufficiently close' to a 100 MHz 5G carrier. It also noted deployment and practical barriers when using non-contiguous spectrum in the 3.4-3.8 GHz band.²²⁷

Our view on the short term (until around 2021)

- 4.252 We now summarise our current view of 5G services and capabilities, the associated timings and bandwidth requirements in the short term based on the evidence available to us.²²⁸ Although the picture is somewhat clearer than the longer term, there is still uncertainty about how demand will develop in this period.
- 4.253 **Key 5G services for competition:** We expect that eMBB and, possibly, FWA are likely to be the most important services for competition initially.²²⁹ In this period, we expect MNOs will be able to use their existing 3.4-3.8 GHz and other holdings (e.g. their LTE networks) to provide these services. While H3G might be able to offer higher peak speeds than other MNOs using 3.4-3.8 GHz, peak speeds (which are achieved in ideal conditions) will rarely be experienced by consumers. There are many other elements of the consumer experience apart from peak speeds, such as coverage, average speeds and network reliability, and these are likely to remain important.²³⁰ However, we recognise the ability to offer higher peak speeds can play a prominent role in marketing materials and may be advantageous from a marketing perspective.
- 4.254 **Need for 80-100 MHz of 3.4-3.8 GHz bandwidth, contiguous or otherwise:** 5G technology requirements are defined by ITU IMT2020 in terms of throughput, latency, and reliability.²³¹ 5G does not have a specific bandwidth requirement, and while large bandwidths could help deliver throughput and capacity, we expect other options including deploying mMIMO

²²⁵ Vodafone non-confidential response to the December 2018 consultation, pages 13 and 39.

²²⁶ BT non-confidential response to the October 2019 consultation, paragraph 3.15.

²²⁷ O2 non-confidential response to the October 2019 consultation, paragraphs 78-83; O2 non-confidential response to the December 2018 consultation, paragraphs 157-161.

²²⁸ We present further detail in annex 7 (see, for example, A7.6 to A7.19 and A7.37 to A7.81) for both the short-term and long-term.

²²⁹ FWA is a separate service to mobile. As demand for FWA services is limited, and these services can be offered with bands other than 3.4-3.8 GHz, we do not anticipate any auction outcome weakening competition in FWA services.

²³⁰ See A3.68 to A3.97 for further discussion of the factors considered important in choosing a mobile provider.

²³¹ IMT 2020 is the set of requirements that ITU in partnership with the industry has issued to define the requirements for 5G networks, devices and service. Radio technologies are expected to develop to meet such requirements (such as 3GPP). See: <https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx>.

in more places and selective densification to play an important role in delivering throughput and capacity, particularly in urban areas. We remain unaware of any important 5G services requiring 80-100 MHz of 3.4-3.8 GHz spectrum, contiguous or otherwise, in the short term and so consider that there is a low risk of such services becoming important in the short term. Also, we note the bidding behaviour in the 2.3 and 3.4 GHz auction is consistent with a view that large contiguous holdings are desirable but not essential.²³²

- 4.255 **Capacity:** We expect demand for data, and thus the need for network capacity, will continue to grow. However, we expect there is likely to be a gradual user adoption of 5G-enabled devices and no sudden step-change in demand for 5G capacity. We expect 4G will continue to play a significant role in meeting capacity demands. Services such as eMBB and FWA will also continue to be delivered using existing 4G capacity as well as 5G.

Our view beyond the short term

- 4.256 We now summarise our view of 5G services beyond the short term (i.e. in a possible interim period and the longer term):
- 4.257 **Key 5G services for competition (and when they will become important):** Consumer demand for 5G, increased speeds and capacity are likely to grow over time, but beyond these capabilities the long-term picture is very uncertain. It is likely to take some years for demand for 5G services to mature, as user adoption of 5G is likely to be gradual, and other sectors will take some time to adjust to the opportunities offered by 5G. We recognise there will be 5G services in the long term other than eMBB and FWA (e.g. Ultra-reliable Low Latency Communications (URLLC), massive Machine Type Communications (mMTC)), and that some of these services might come to be of significant commercial and competitive importance in time in some areas. However, the evidence we have seen to date is unavoidably speculative, and so we have little certainty over which 5G services will become important or when that might happen.
- 4.258 **Need for 80-100 MHz of 3.4-3.8 GHz bandwidth, contiguous or otherwise:** In principle, large bandwidths could assist in delivering some hypothetical use cases.²³³ However, stakeholders have not provided any firm evidence of use cases which are likely to require 80-100 MHz of 3.4-3.8 GHz bandwidth (contiguous or otherwise) and are likely to be of significant commercial and competitive importance. Indeed, at this stage, any assessment of the commercial and competitive importance of these services would be inherently speculative. What we can say is that MNOs are likely to be able to support a wide range of 5G services with their current holdings (i.e. with channel bandwidths smaller than 80 MHz).²³⁴ If some new and important service that requires 80 MHz does emerge, then in our view there is a low risk that the necessary performance could not be achieved by

²³² See A7.42 to A7.46.

²³³ Such use cases would require a high throughput and low latency. Examples might include some implementations of augmented/virtual reality (requiring high downlink throughput and low latency) or very high-resolution professional quality video streaming (requiring high uplink throughput).

²³⁴ The results of our modelling (see A7.56 to A7.65) indicate that MNOs' existing spectrum holdings, in combination with mMIMO and carrier aggregation, are likely to be generally sufficient to deliver a representative set of potential 5G services derived from 3GPP guidelines.

alternative means including dual connectivity, carrier aggregation, Wi-Fi/Wi-Fi offload, or mmWave spectrum without too great a loss in quality of service.

- 4.259 **Capacity:** As in the short term, we expect capacity demands will continue to grow steadily in the longer term. MNOs will have access to increasingly large capacity over time due to re-farming existing spectrum for 5G, deployment of equipment supporting mMIMO and beamforming. LTE networks will also continue to contribute to meeting capacity needs. We have not identified any points at which capacity demands driven by 5G would diverge significantly from MNOs' ability to provide the required capacity.

Evidence on carrier aggregation and dual connectivity

- 4.260 We now consider the ability of carrier aggregation and dual connectivity to mitigate concerns posed by a lack of contiguity and to support the use of multiple bands for 5G services.
- 4.261 Carrier aggregation increases the peak data rates users can experience. It does this by assigning multiple blocks of frequency (i.e. carriers) to a single user. It can be used for either uplink or downlink connections, although is less usual in the uplink. There are several types of aggregation. **Inter-band** carrier aggregation involves multiple carriers from different bands (e.g. 800 MHz and 1800 MHz). **Intra-band** carrier aggregation involves different carriers within a single frequency band (e.g. two 5 MHz carriers in 1800 MHz). Carriers within the band can either be contiguous or non-contiguous. Whereas carrier aggregation is defined to be used for either LTE or 5G NR, **dual connectivity** involves the simultaneous use of two different carriers from different stations and can involve different technologies in either uplink and downlink (for example, LTE technology in 700 MHz and 5G NR in 3.6-3.8 GHz).

Consultation position and responses

- 4.262 In the December 2018 consultation we said:
- a) Non-contiguous intra-band carrier aggregation is not currently possible for the 3.4-3.8 GHz band,²³⁵ although it is supported for some 4G bands. It is unlikely that early 5G devices will support it.²³⁶ However, we said, in general, we expected technological limitations to reduce with time and technology to develop and provide MNOs with further solutions to offer competitive services (these comments also applied to solutions to proximity issues).²³⁷ This included a view that it was possible that non-contiguous intra-band carrier aggregation could be supported in the longer term.²³⁸

²³⁵ Non-contiguous intra-band carrier aggregation allows for say two 40 MHz carriers in 3.4-3.8 GHz to (almost) meet the same peak speeds as a single 80 MHz carrier to a single device. The impact of this not being available is that operators have to use dual connectivity to combine 40 MHz of 3.4-3.8 GHz with several of their LTE bands to achieve 80 MHz to a single device, increasing network complexity.

²³⁶ Paragraph 5.257.

²³⁷ Paragraphs 5.260 and 5.261.

²³⁸ Paragraph 5.260.

- b) Inter-band carrier aggregation and dual connectivity are likely to be available in the short term. They will enable MNOs to achieve a peak throughput similar to that of a single 80 or 100 MHz carrier by using other mobile bands in combination with 3.4-3.8 GHz spectrum.²³⁹
- c) Carrier aggregation can adequately substitute for contiguous spectrum by reaching similar peak speeds.²⁴⁰ However, with or without carrier aggregation, there are moderate capacity inefficiencies associated with using 5G NR in two non-contiguous spectrum blocks. We said this differential was likely to be in the range of 2-15%.²⁴¹

4.263 In response, both Vodafone and O2 said it was highly unlikely that intra-band carrier aggregation for uplink would be supported.²⁴² Additionally, O2 said that inter-band carrier aggregation might be limited to high-end devices, and combinations involving the 2.3 GHz band were not yet supported, preventing it from being used in early deployments.²⁴³ MNOs estimates of the capacity differential from carrier aggregation were in line with our 2-15% estimate.

Summary of updated evidence and analysis

4.264 We consider MNOs should be able to rely on their existing 3.4-3.8 GHz and other holdings (e.g. their LTE networks) to provide the services that matter for consumers in the short-term without carrier aggregation. In the longer term, it is unclear whether aggregating carriers to achieve bandwidths of 80 MHz would be necessary for MNOs to compete strongly. Nonetheless, we have assessed the prospects for carrier aggregation and dual connectivity and the likely implications for overall capacity.

4.265 Based on evidence including a review of vendor roadmaps and discussion with industry, we consider there are good prospects for *downlink* non-contiguous intra-band carrier aggregation in the 3.4-3.8 GHz band. Manufacturers have stated it is likely to be available for future downlink combinations (although not in the uplink). We expect this will be included in standards from 3GPP Release 16 in March 2020. While there is uncertainty about the timing, this could be available in chipsets by around late 2020 or 2021, and then in base station equipment and devices in 2021 or 2022. It is most likely to be available in high-end devices first and then mid-range devices at a later stage. Therefore, there may be limited support in the short term, but from 2022 it is likely that downlink non-contiguous intra-band carrier aggregation in the 3.4-3.8 GHz band will be widely supported.

²³⁹ Paragraph A7.51.

²⁴⁰ Paragraph 5.239.

²⁴¹ Paragraph 5.258.

²⁴² O2 (non-confidential) response to the December 2018 consultation, paragraph 156; Vodafone (non-confidential) response to the December 2018 consultation, page 13; [REDACTED].

²⁴³ O2 (non-confidential) response to the December 2018 consultation, paragraph 159.

- 4.266 Dual connectivity can also provide similar benefits to carrier aggregation when combining a 5G carrier in the 3.4-3.8 GHz band with 4G LTE holdings. It is already in standards and available in an increasing number of devices for some mid-frequency bands.²⁴⁴
- 4.267 We remain of the view that the capacity differential from inter-band and intra-band carrier aggregation will be in the 2-15% range, when compared with using the same amount of contiguous spectrum. To put the 2-15% capacity differential into context, our current evidence suggests that deploying massive MIMO could increase capacity by at least two to four times (that is, a 100% to 300% increase in capacity) when compared with lower order MIMO. This means potential peak speeds should be similar regardless of whether a service is delivered using carrier aggregation or contiguous spectrum. In practical terms, the difference will be apparent to users in only a small minority of cases and so is unlikely to have an impact on the overall user experience.
- 4.268 We recognise that large contiguous holdings could allow an MNO to provide somewhat higher peak speeds and a moderate increase in capacity compared to aggregating multiple separate carriers. However as discussed above, while peak speeds can play a prominent role in marketing, they are only one element of the mobile service experienced by a consumer. Capacity constraints are unlikely to have a material impact on consumers' experience in the short term whilst 5G networks are lightly loaded. In the longer term, operators are likely to have several ways to increase the capacity of their networks in the areas that they need to, for example, by selective densification.
- 4.269 In principle, there may be potential services which could benefit from *uplink* carrier aggregation (e.g. professional quality video-streaming), but any assessment of their likely commercial or competitive importance at this stage is particularly speculative. We acknowledge there may be greater technical challenges for *uplink* intra-band non-contiguous carrier aggregation. However, forecasts suggest the demand for speed and capacity, and thus the need for carrier aggregation, is likely to be much more important in the downlink than for uplink.
- 4.270 We set out the updated evidence and analysis regarding carrier aggregation in further detail at A7.66 to A7.81.

Evidence on solutions to mitigate a lack of proximity and associated costs

Consultation position

- 4.271 In the December 2018 consultation we acknowledged that there might be costs in having 3.4-3.8 GHz spectrum holdings which were far apart from each other.²⁴⁵ In particular, we said a single antenna system on a given mast may not be able to use the entire frequency range, reducing the effective capacity and peak speeds that an MNO could offer from the

²⁴⁴ Regarding the 2.3 GHz band, we note there are several dual connectivity options in the 3GPP standards, but combinations involving 2.3 GHz are unlikely to be in devices for some time because the band is not widely awarded in Europe.

²⁴⁵ Paragraph 5.259.

base station. We said deploying multiple antenna systems on each mast might solve this problem, with different antennas covering different frequency ranges in the 3.4-3.8 GHz band, but also noted this would be costly. We acknowledged that in some circumstances installing multiple antennas could be difficult or infeasible due to challenges related to space, weight, wind-load and power. We also said these problems could potentially be exacerbated by the presence of network sharing agreements.²⁴⁶

- 4.272 We also said the useable spectrum range for active antenna systems would be 200 MHz by the end of 2019, and we did not see any insurmountable challenges for future equipment to be useable over a range of 300 MHz in the longer term. However, we acknowledged challenges in reaching 400 MHz and that this seemed less likely. We noted this meant MNOs with holdings spanning more than 200 MHz could face additional challenges for their early deployments, although agreements with network sharing partners and technological developments could alleviate this in the longer-term.²⁴⁷

Consultation responses

- 4.273 In response to the December 2018 consultation, O2 said it was essential to avoid more than 300 MHz separation between spectrum blocks and preferable to avoid more than 200 MHz. It said vendors' roadmaps only included products with 100 MHz or 200 MHz bandwidths, and so, while it recognised 300 MHz would be available eventually, this would happen far later.²⁴⁸ Vodafone said mMIMO antennas did not support a bandwidth which covered the entire 3.4-3.8 GHz band [REDACTED].²⁴⁹ It also said a lack of proximity would mean multiple mMIMO antennas were needed with a consequent impact on site operational costs (e.g. poorer power efficiency) and site strengthening costs (e.g. to cope with greater wind-loading).
- 4.274 Additionally, in response to our June 2019 consultation on defragmentation of the 3.4-3.8 GHz band, O2 said fragmented spectrum would harm consumers, and modelled the costs of fragmentation (i.e. both contiguity and proximity). [REDACTED].²⁵⁰

Summary of updated evidence and analysis

- 4.275 We recognise there would be extra costs associated with deploying additional antennas on masts, however extra antennas would only be necessary in those areas where traffic demands were large, capacity was constrained, and no other solutions were available. We consider that O2's assessment of the costs of defragmentation is a pessimistic view.²⁵¹

²⁴⁶ Network sharing agreements mean that multiple MNOs use a single mast. Masts have space and weight restrictions. Network sharing agreements mean that multiple MNOs use a single mast, decreasing the available space and increasing the cumulative weight of installed equipment. This may restrict the ability of MNOs to install further equipment to counter the challenges of proximity.

²⁴⁷ Paragraphs A7.49-A7.50, 5.260 and 5.261.

²⁴⁸ O2 (non-confidential) response to the December 2018 consultation, paragraphs 156 and 158.

²⁴⁹ Vodafone (non-confidential) response to the December 2018 consultation, page 13; [REDACTED].

²⁵⁰ O2 response to the June 2019 consultation, Annex 1. See also O2 non-confidential response to October 2019 consultation, paragraph 83.

²⁵¹ See A7.88 to 7.100.

- 4.276 An alternative to deploying additional antennas is for MNOs to deploy equipment with 'split-mode'. This means splitting the base station antenna array in half and using one half to transmit on one spectrum fragment and the other half to transmit on another spectrum fragment. This is an existing technology, although with some cost and performance penalties (i.e. a capacity differential of [REDACTED] in the worst case scenario [REDACTED] when compared to using the whole array to transmit a single contiguous carrier. We understand that split-mode designs exist today for 2.6 GHz TDD in combination with either 3.4-3.6 GHz or 3.6-3.8 GHz; however, designs which support 3.4-3.6 GHz in combination with 3.6-3.8 GHz may be developed in the longer term.
- 4.277 Equipment with a bandwidth of 200 MHz is available now. We understand that both 300 MHz and 400 MHz designs are in development, but there are technical challenges, and it remains uncertain when exactly these designs will be available for deployment.²⁵² We understand that it may be possible to manufacture active antenna systems with 400 MHz of bandwidth and we anticipate these designs might be available by 2022. However, we also note equipment with higher bandwidth is likely to have a somewhat higher cost and vendors could have a lower stock of this equipment.
- 4.278 We set out the updated evidence and analysis regarding proximity in more detail from A7.82 to A7.107.

Low risk that asymmetries in the relative scale of holdings in the 3.4-3.8 GHz band would prevent MNOs from competing strongly

- 4.279 As a starting point, we note certain factors lessen the scope for a potential concern arising:
- a) The UK mobile market is currently working well;
 - b) While 5G services will grow in importance, they are just one element of the wide range of services and metrics across which MNOs will continue to compete. For example, we also note that MNOs do not appear to be attaching a price premium to 5G services currently, as they did for early 4G services.
 - c) Any potential advantage for H3G in 5G services should be seen in the context of its existing competitive position, in which it is currently has the fewest subscribers among MNOs (12% retail and wholesale share) and is lagging behind its competitors on certain measures of network performance and reliability (see annex 5). Related to this, concerns might be greater if H3G could benefit from some first-mover style advantage, but in fact other MNOs rolled out 5G mobile services before H3G.
 - d) While it is possible that competition concerns could arise over a short time horizon, there is inherently less scope for competition concerns in such settings.
- 4.280 The key initial 5G services are likely to be eMBB and, possibly, FWA. We expect MNOs are likely to be able to provide a good quality of service for these with their existing 3.4-

²⁵² See also A7.101 to A7.103. Note, if the available bandwidth reached 300 MHz but not 400 MHz, then only one MNO (Vodafone) would suffer from a lack of proximity with their current holdings.

3.8 GHz holdings in the short term (until around 2021). MNOs are unlikely to require 80-100 MHz within the 3.4-3.8 GHz band, contiguous or otherwise, in the short term. Additionally, we expect only a limited number of 5G-enabled devices to be available in this period, and for consumer uptake and demand for 5G to grow gradually in the short-term. It is unlikely that demand will grow more quickly than expected in this period. This will limit both the need for further 3.4-3.8 GHz spectrum and the importance of 5G in the short term.

- 4.281 In the longer term (from around 2022), we expect that more intensive use of eMBB and FWA and demand for other 5G services is likely to generate greater demand for speed and capacity. However, it is unclear which other 5G services, if any, will be of significant competitive importance or when they would become important. MNOs are likely to be able to support a wide range of 5G services valued by consumers in the future by re-farming existing spectrum and using technologies such as carrier aggregation (i.e. without amassing 80-100 MHz of 3.4-3.8 GHz spectrum).
- 4.282 While there may be some variation among MNOs in their ability to provide some 5G services in the longer term, we consider any such variation would be too small to materially weaken competition (including in the event that O2, BT/EE or Vodafone won no 3.6-3.8 GHz spectrum). Indeed, we might expect that such variations would occur from time to time in a competitive market, and particularly as a new technology is developed and deployed.
- 4.283 In any case, even if demand grew more quickly than expected (or otherwise departed from our expectations), other factors could mitigate any competition concerns which might arise:
- a) The initial difference in capabilities between advanced 4G and 5G are likely to be limited, meaning bands outside the 3.4-3.8 GHz band using advanced 4G technology could be used to deliver eMBB and FWA with a similar quality of service. Indeed, take-up of 5G devices will shift traffic from 4G to 5G networks, reducing the demand for capacity on 4G networks, further increasing their ability to offset any capacity concerns on 5G networks. After the short term, non-5G services supported by existing technology and networks are also likely to remain important to competition for some time to come.
 - b) Even if H3G did acquire further spectrum, it might use it to offer a better quality, lower cost or more widely available FWA services, with ensuing benefits for consumers.
- 4.284 Vodafone said there was a risk to competition in a period with potential demand for 5G services which some MNOs would not be able to serve. We therefore assessed the risks for competition in an alternative scenario with a potential interim period between the short and longer term. Differences in MNOs' spectrum holdings and networks could lead to variation in their 5G rollouts, but such variations can occur in competitive markets as new technologies are introduced. Even if BT/EE, O2 or Vodafone fail to acquire further 3.4-3.8 GHz spectrum, we consider their ability to supply 5G services valued by consumers is unlikely to fall substantially behind H3G's:

- a) While there is uncertainty about future services, we expect demand for 5G services to develop gradually and broadly in line with MNOs' ability to supply them. Neither we nor stakeholders have identified specific 5G use cases which are likely to be both important and which MNOs could not deliver without further 3.4-3.8 GHz spectrum.
- b) Even if demand develops unexpectedly, MNOs are likely to have levers to mitigate any adverse competitive impact. They will have some influence over the 5G-enabling technologies provided by manufacturers (e.g. device support, base station equipment, support for carrier aggregation); some ability to shape consumer demand (e.g. through marketing and pricing); and a degree of flexibility over the rollout of their own networks, which gives them an ability to mitigate any emerging competitive gaps.
- 4.285 In the unlikely case that any competitive gap did emerge between MNOs for some potential interim period, the scope for harm to competition is likely to be small and short-lived, and its impact on competition would be unlikely to persist. We also note the contrast with our more concrete concerns in the 2.3 GHz transition period for the 2.3 and 3.4 GHz auction, where we said *"(our) concerns about weaker competition during the first transitional period are increased by there being a risk that [REDACTED] [REDACTED] may encounter difficulties adding sufficient capacity to provide average speeds that allow [REDACTED] to compete strongly in the first transitional period without 2.3 GHz spectrum"*.²⁵³
- 4.286 Therefore, there is a low risk that BT/EE, O2 and Vodafone would be unable to compete strongly with H3G in the short or longer term, even if they acquired no 3.6-3.8 GHz spectrum in this award. Considering an alternative scenario with a potential interim period between the short and longer term does not change our view that there is a low risk to competition. Additionally, as discussed below, we consider it likely that BT/EE, O2 and Vodafone will be able to win spectrum if they need it.

Low risk that fragmentation in the 3.4-3.8 GHz band would prevent MNOs from competing strongly

- 4.287 We set out above why there is a low risk of a competition concern even if BT/EE, O2 and Vodafone win no 3.6-3.8 GHz spectrum. This implies there would be no more than a low risk of competition concerns if MNOs have fragmented holdings in the 3.4-3.8 GHz band i.e. if these MNOs win additional spectrum in the 3.4-3.8 GHz band but do not manage to consolidate their holdings into a contiguous block or the additional spectrum is not sufficiently close to existing holdings to realise the benefits of proximity. Nonetheless, for completeness, we set out our views on the impact of fragmentation on competition.
- 4.288 We note that defragmentation may be partially or completely addressed through trading between MNOs. We consider that MNOs have incentives to address challenges of fragmentation by trading between them - and we have taken steps to facilitate such trading in the auction process. We discuss our measures to assist defragmentation in

²⁵³ Ofcom's statement of 11 July 2017 entitled "Award of the 2.3 and 3.4 GHz spectrum bands", paragraph 6.71.

sections 5 and 6. These opportunities for defragmentation reduce the overall risk of fragmentation-related competition concerns.

- 4.289 As with our assessment of asymmetries in the relative scale of holdings, the scope for concern due to fragmentation is lessened due to factors including the UK mobile market currently working well for consumers, 5G services being just one of the many elements of competition, and H3G being the MNO with fewest subscribers.
- 4.290 While we recognise there may be benefits to defragmentation, it is unlikely that a lack of large contiguous holdings for O2, Vodafone or BT/EE would harm competition (including a situation in which these MNOs lacked 80-100 MHz of contiguous 3.4-3.8 GHz spectrum), as:
- a) In the short term, it is unlikely that MNOs would need at least 80 MHz of contiguous spectrum to provide the services demanded by consumers.
 - b) Regarding the longer term, we have not seen evidence suggesting there are likely to be future 5G services which would be of significant commercial importance and which would require 80-100 MHz of contiguous spectrum. Rather, our assessment suggests that MNOs are likely to be able to support a wide range of 5G services by re-farming existing spectrum.
 - c) In any case, carrier aggregation and dual connectivity are likely to offer similar capabilities to contiguous bandwidth and so, despite some residual inefficiencies (e.g. somewhat reduced capacity), they should allow MNOs to overcome the main potential challenges posed by a lack of contiguous spectrum.
- 4.291 Similarly, it is unlikely that a lack of proximity for some MNOs would harm competition, as:
- a) Split-mode technology already allows operators to span up to 400 MHz, although with some cost and performance penalties in some circumstances.
 - b) In many circumstances – particularly in the short term and in areas where capacity is rarely constrained – users may not perceive differences in service quality if an MNO is using only 40 MHz or 50 MHz rather than 80 MHz.
 - c) While there is uncertainty in the longer term, equipment with up to 400 MHz bandwidth is likely to become available, possibly by around 2022.
- 4.292 We consider O2's assessment of the costs of fragmentation are pessimistic. We do not infer from this analysis that those costs would be so significant as to necessarily have an impact on competition.
- 4.293 Therefore, there is a low risk that BT/EE, O2 and Vodafone would be unable to compete strongly with H3G in the short or longer term if their holdings in the 3.4-3.8 GHz band are fragmented.

Low overall risk of competition concerns related to asymmetry in the 3.4-3.8 GHz band

4.294 We have considered the risk to competition from asymmetry in the relative scale of holdings or fragmentation in the 3.4-3.8 GHz band, including scenarios where Vodafone, O2 and BT/EE acquire no further 3.4-3.8 GHz spectrum in this award. There is inherent uncertainty about future market and technological developments. We cannot definitively rule out the possibility of some weakening of competition but taking account of all the relevant factors in the round, our view is that there is a low risk of competition concerns related to asymmetry in the 3.4-3.8 GHz band.

MNOs should be able to acquire 3.6-3.8 GHz spectrum if they need it

4.295 Despite the low risk of competition concerns, for completeness, we also consider the likelihood of those auction outcomes which, in principle, might raise potential competition concerns.

4.296 As set out above, BT/EE, Vodafone and O2 have raised concerns that H3G would bid strategically for 3.6-3.8 GHz spectrum to deprive their competitors of the volume of 3.6 GHz spectrum they might need to compete strongly. They are also concerned that H3G might acquire spectrum to obstruct defragmentation. They said that H3G would need to bid strategically for these outcomes to come about as other MNOs are generally likely to have higher intrinsic values for significant amounts of this spectrum.

H3G is unlikely to be able to weaken competition by depriving other MNOs of 3.6-3.8 GHz spectrum

- 4.297 We consider that H3G is unlikely to be able to successfully deprive other MNOs of 3.6-3.8 GHz spectrum and prevent them from competing strongly as:
- a) Other MNOs have a strong incentive to acquire 3.6-3.8 GHz spectrum if they need it to compete strongly, increasing the cost of strategic bidding for H3G.²⁵⁴
 - b) There would be a limited impact on competition if H3G deprived merely one competitor of spectrum. We have set out above why spectrum asymmetry in the 3.4-3.8 GHz band is unlikely to give H3G a significant competitive advantage. In particular, there is limited scope for one MNO lagging slightly behind the others in this single dimension of competition to have an adverse impact on competition. Depriving more than one competitor would be very costly for H3G (at the limit it would need to purchase all 120 MHz of the 3.6-3.8 GHz available), and so seems unlikely.
 - c) These considerations suggest that H3G may have little rational incentive for strategic investment which is intended to prevent other MNOs from reaching a certain scale of 3.4-3.8 GHz holdings.

²⁵⁴ Alternatively, if other MNOs did not have a strong incentive to acquire 3.6-3.8 GHz spectrum, this could suggest that the underlying potential competition concern is not relevant.

- 4.298 Also, while other MNOs may have a higher intrinsic value, we consider it is possible that H3G has some intrinsic value for further 3.6-3.8 GHz spectrum (as discussed in section 5).

H3G is unlikely to successfully obstruct defragmentation via strategic bidding in the auction

- 4.299 We set out above why we consider there is a low risk that fragmentation would prevent MNOs from competing strongly, which implies a low risk that H3G would see a high value in frustrating defragmentation by strategic investment in the auction.
- 4.300 We have taken steps to assist trading and defragmentation by including a negotiation period within the assignment stage of the auction. Our assignment rules dictate that any bidder which wins 20 MHz or less can only be placed at the top or the bottom of the band. This makes it more difficult for any such bidder to obstruct post-auction trades by winning a ‘toe-hold’ amount of spectrum and inserting itself between other bidders, and so lowers the likelihood of this form of strategic bidding.²⁵⁵

Conclusion

- 4.301 We consider there is a low risk of H3G successfully engaging in strategic investment and harming competition by either depriving competitors of 3.6-3.8 GHz spectrum or obstructing defragmentation. MNOs should be able to acquire 3.6-3.8 GHz spectrum if they need it.

It is not appropriate or proportionate to impose any competition measures related to 3.6-3.8 GHz spectrum

- 4.302 For the reasons set out above, we consider there is a low overall risk of competition concerns related to asymmetry in the 3.4-3.8 GHz band. We also consider that MNOs should be able to acquire 3.6-3.8 GHz spectrum if they need it. As set out in section 5, the risk to competition from price driving is limited and it is possible that H3G has some intrinsic value for 3.6-3.8 GHz spectrum. Given this, we do not consider that it would be appropriate or proportionate to impose any competition measures for the 3.6-3.8 GHz band.

Competition concern 2: Risk of there ceasing to be four credible operators

- 4.303 In the December 2018 consultation, we said that it was important to maintain four credible MNOs in the UK and that competition would be considerably weaker with fewer credible players. **We considered that all four MNOs would have sufficient spectrum to remain**

²⁵⁵ We also note that, even without winning any further spectrum, H3G is already in a position to block full defragmentation by maintaining its existing holdings in their current position. However, depending on the outcome of the auction, a bilateral trade may allow two MNOs to defragment their respective spectrum holdings without involving H3G. To block defragmentation through strategic bidding in the auction of more MNOs than it already could might be difficult and/or costly for H3G.

credible even if they won none in this award. We did not therefore propose any competition measures (such as spectrum reservations) to promote credibility of MNOs.

4.304 In summary, we received the following comments:

- a) Vodafone agreed that there was no risk that one or more operators would cease to be credible 'from a spectrum perspective' as a result of this award;²⁵⁶
- b) O2 said that caps in 3.4-3.8 GHz were needed to ensure that all MNOs could offer sufficient 5G services to remain credible;²⁵⁷
- c) H3G agreed that the auction posed no risk to the credibility of any MNO;²⁵⁸
- d) BT/EE did not comment on credibility.

It is important to maintain four credible MNOs

4.305 As noted above, we still consider it is important to retain at least four credible MNOs.²⁵⁹ Barriers to entry are high in mobile services and if the number of MNOs were to decrease from four to three, any resulting weakening of competition could be long lasting and difficult to reverse, as new entrants might face high barriers to entry even if competition were not working as well for consumers, such as through higher prices or less innovation.

4.306 We believe that it is likely that competition between the MNOs would be considerably weaker if there ceased to be four credible competitors. We would be very concerned if we believed that this was a likely outcome of spectrum distributions arising from this auction.

4.307 By 'credible' we mean that an MNO is able to exert an effective constraint on its rivals – in terms of factors such as the provision of high-quality services, competitive prices, innovation and a wide range of services valued by consumers – and so contribute to the overall competitiveness of the market. The loss of a credible competitor would mean that the UK effectively became a three-player market, even if the MNO did not actually cease to operate and exit the market. This would likely be detrimental to consumers, for example through higher prices and/or a deterioration in the quality of services.

Factors which affect credibility

4.308 An MNO's competitive position – and therefore, at the limit, its credibility – is not only dependent on its spectrum holdings. For example, scale of operations may be important, as well as brand image and financial viability. In this analysis, however, we consider the role of spectrum in maintaining credibility and focus on capacity, coverage and the ability to deploy 5G.

²⁵⁶ Vodafone non-confidential response to the December 2018 consultation, page 39.

²⁵⁷ O2 non-confidential response to the December 2018 consultation, paragraphs 126-127.

²⁵⁸ H3G non-confidential response to the December 2018 consultation, page 33.

²⁵⁹ In our 4G auction in 2013, we reserved some of the available spectrum for an MNO other than the three largest MNOs to avoid consolidation down to three MNOs as a consequence of the auction. H3G obtained this reserved spectrum.

- 4.309 We consider that an MNO must have a spectrum portfolio to enable it to be sufficiently strong in terms of capacity, quality of coverage and to offer services that are important to consumers (e.g. 4G and, in the longer term, 5G) to remain credible.
- 4.310 This is consistent with our approach in the competition assessment for the 2.3 and 3.4 GHz auction,²⁶⁰ and the 2013 4G auction:
- In 2013, we concluded that spectrum capability for a minimum level of coverage and capacity were both necessary to enable an MNO to remain credible. We said that providing the highest peak speeds was not necessary for credibility. We considered services with other LTE advantages (e.g. lower latency) and concluded that it was unclear whether they were necessary for credibility in the short term, but that they were necessary to remain credible in the long term.
 - In the July 2017 statement, we again said that a minimum level of capacity and coverage were both necessary and that in the longer term a route to 5G might be necessary. Since all MNOs were already providing LTE services, we concluded that this dimension was no longer relevant.

We consider that all four MNOs will have sufficient spectrum to remain credible, whatever the result of this auction

- 4.311 In the July 2017 statement we decided that all four MNOs would have spectrum portfolios to remain credible, whatever the outcome of the auction.²⁶¹ We had some concerns about [REDACTED], but we did not consider that it would cease to be credible if it did not obtain any more spectrum.
- 4.312 Given their spectrum portfolios and that spectrum distribution is less asymmetric than prior to the 2.3 and 3.4 GHz auction, we consider it even less likely that any of the four MNOs would cease to be credible as a result of any outcome in this auction.
- 4.313 The operator with the smallest spectrum holding, O2, will have 15% of overall spectrum even if it wins none in this auction. This is at the top end of the 10 to 15% range below which we consider there is a material risk of an MNO not having sufficient spectrum to remain credible. We also note that all four MNOs are financially viable, as outlined in paragraphs A3.53 to A3.61 of annex 3.
- 4.314 O2 said that a 10% to 15% share of overall spectrum was the wrong metric, and that what mattered was the overall quantity of spectrum.²⁶² It said that the minimum viable quantity of spectrum had been “rising rapidly through the 4G and 5G eras”. We acknowledge

²⁶⁰ Annex 8 to Ofcom’s statement of 11 July 2017 entitled “Award of the 2.3 and 3.4 GHz spectrum bands”, paragraphs A8.52 onwards; see https://www.ofcom.org.uk/data/assets/pdf_file/0013/104305/Statement-annexes-Award-of-the-2.3-and-3.4-GHz-spectrum-bands.pdf.

²⁶¹ Ofcom’s statement of 11 July 2017 entitled “Award of the 2.3 and 3.4 GHz spectrum bands”, paragraphs 6.104 onwards; see https://www.ofcom.org.uk/data/assets/pdf_file/0022/103819/Statement-Award-of-the-2.3-and-3.4-GHz-spectrum-bands-Competition-issues-and-auction-regulations.pdf.

²⁶² O2 non-confidential response to the October 2019 consultation, paragraph 99, part 3.

above²⁶³ that absolute holdings do matter for capacity, while also explaining why it is meaningful to consider asymmetry.

- 4.315 O2 said that [REDACTED].²⁶⁴ We note that, although we accept that [REDACTED], O2 won more than 40% of the spectrum awarded in 2018, and almost doubled its overall spectrum holdings as a result of this award.
- 4.316 We, therefore, consider that, even if they win no further spectrum in this auction, it is highly likely that each MNO's spectrum portfolio will enable it to:
- have sufficient **capacity** to remain credible;
 - have a long-term route to a wide range of **5G** services; and
 - have good **coverage** for enough of the population (including harder-to-serve areas) to remain credible.

Stakeholders agreed that no MNO would cease to be credible in terms of overall spectrum holdings, though they did raise concerns about holdings in certain spectrum bands

- 4.317 Vodafone said that it did not consider that there was a risk that one or more MNOs would cease to be credible 'from a spectrum perspective' as a result of this award,²⁶⁵ though it did suggest that differences in the ability to supply 'high-bandwidth services' (which we take to mean 5G) may threaten credibility.²⁶⁶
- 4.318 O2 also said that there would be a risk to four-player competition in the long run if the other MNOs lacked the ability to compete with H3G in offering 5G services.²⁶⁷ We agree that offering the 5G services valued by consumers in future is likely to be necessary to be a credible player in the long-run. We have addressed this concern in the section above on potential competition concerns in 3.4-3.8 GHz spectrum²⁶⁸, where we conclude that all MNOs have a route to 5G in the long term with their existing spectrum holdings and that they should be able to acquire additional 5G spectrum in this award if they need it to compete.
- 4.319 [REDACTED].²⁶⁹ As we have set out above²⁷⁰, we do not consider that there is a risk to competition from asymmetric holdings in low frequency spectrum, and that MNOs should be able to acquire additional low frequency spectrum in this award if they need it to compete.
- 4.320 Other stakeholders did not comment further on the need to introduce competition measures in this award to ensure credibility.

²⁶³ Paragraph 4.27.

²⁶⁴ O2 confidential response to the October 2019 consultation, paragraph 100.

²⁶⁵ Vodafone non-confidential response to the December 2018 consultation, page 37 and 39.

²⁶⁶ Vodafone non-confidential response to the December 2018 consultation, page 4.

²⁶⁷ O2 non-confidential responses to the December 2018 consultation, paragraphs 125 to 127.

²⁶⁸ At paragraphs 4.201 to 4.301.

²⁶⁹ H3G confidential response to the October 2019 consultation, paragraph 11.3.

²⁷⁰ At paragraphs 4.112 to 4.200.

We are not imposing any measures to address the potential concern about future credibility

4.321 In light of the above, we do not consider that any further measures – such as a spectrum reservation – are appropriate or proportionate to address the concern that there would cease to be four credible operators.

5. Auction design

- 5.1 This section of the statement sets out our decisions on the design of the 700 MHz and 3.6-3.8 GHz spectrum band auction and our supporting reasoning.

Summary of our auction design decision

- 5.2 In the October 2019 consultation, we proposed a revised auction format using a Simultaneous Multiple Round Ascending (SMRA) design, without coverage obligations. We noted there were some residual risks associated with the SMRA format (e.g. increased aggregation risk and substitution risk), but we considered these to be manageable for bidders and did not warrant adopting a combinatorial auction format such as the Combinatorial Clock Auction (CCA). We also proposed some mitigations to the identified risks in the detailed rules.
- 5.3 Our proposed detailed rules for the SMRA design were similar to the design we adopted for our 2018 auction of the 2.3 GHz and 3.4-3.6 GHz bands.
- 5.4 Having considered stakeholder responses to the October 2019 consultation, we have decided to award the spectrum using an SMRA format, with the following features:
- a) **A principal stage and an assignment stage** – The principal stage will determine the amount of spectrum won by bidders, bidding for frequency-generic lots. It will comprise successive rounds with ascending prices and will end when there are no new bid decisions in a round. The assignment stage will determine the precise frequencies awarded, and will be a sealed-bid, single-round format with a second-price rule. In the 3.6-3.8 GHz band, there will also be a restriction on the assignments for ‘small winners’ and an opportunity for negotiation between bidders to determine the outcome of the 3.6-3.8 GHz assignment stage.
 - b) **Spectrum lots** – There will be three categories of spectrum lots:
 - i) 60 MHz in six lots of 2x5 MHz of 700 MHz frequency division duplex (FDD) spectrum, with a reserve price of £100m per lot. These lots have four eligibility points each.
 - ii) 20 MHz in four lots of 5 MHz of 700 MHz Supplemental Downlink (SDL) spectrum, with a reserve price of £1m per lot. These lots have one eligibility point each.
 - iii) 120 MHz in 24 lots of 5 MHz of time division duplex (TDD) 3.6-3.8 GHz spectrum, with a reserve price of £20m per lot. These lots have one eligibility point each.
 - c) **Ranking mechanism for standing high bids** – Where there is excess demand in a lot category, Ofcom will randomly rank the bidders to determine which bids should be allocated as ‘standing high bids’ for that round. This rule means that, at most, only one bidder in each band may become a standing high bidder on fewer lots than it bid for. If all lots have been allocated as ‘standing high bids’ at the current round price in a lot category, the price will increase in that category for the next round.

- d) **Activity rule and ‘waivers’** – There will be an eligibility points-based activity rule, which will constrain the maximum number of bids a bidder can make in a round. Bidders will only be able to maintain or reduce their demand, measured in eligibility points, as bidding progresses. Bidders will be allowed up to three ‘waivers’ where they may abstain from bidding without affecting their eligibility for the next round.
- e) **A minimum bid of 10 MHz in the 3.6-3.8 GHz band** – Bidders wishing to submit bids for 3.6-3.8 GHz spectrum must bid on a minimum of 10 MHz (two lots) in the band. Bidders may still be made standing high bidder on, and win, a single 5 MHz lot. We have introduced this rule as an additional mitigation to the risk of price driving in the 3.6-3.8 GHz band, in light of stakeholder responses.
- f) **No withdrawals or minimum requirement** – Bidders will not be permitted to withdraw their bids, or specify a minimum requirement in any band.
- g) **Information policy** – After the end of each principal stage round, we will inform bidders of the level of excess demand in rounded categories:
 - i) 3.6-3.8 GHz – we will reveal excess demand rounded up to the nearest higher positive multiple of 20 MHz (i.e. excess demand is strictly less than 20 MHz, less than 40 MHz, less than 60 MHz, etc.)
 - ii) 700 MHz FDD – we will reveal excess demand rounded up to the nearest higher positive multiple of 20 MHz, equivalent to increments of 2x10 MHz (i.e. excess demand is strictly less than 20 MHz (2x10 MHz), less than 40 MHz (2x20 MHz), less than 60 MHz (2x30 MHz), etc.)
 - iii) 700 MHz SDL – we will reveal excess demand rounded up to the nearest higher positive multiple of 10 MHz (i.e. excess demand is strictly less than 10 MHz, less than 20 MHz, less than 30 MHz, etc.)

5.5 We received comments from O2, BT/EE, Vodafone and H3G on our auction design proposals in response to the October 2019 consultation. We have taken account of these comments in reaching our final decisions on auction design. In the rest of this section, we summarise and respond to the relevant comments we received from stakeholders. We have summarised and responded to stakeholder comments on non-auction design issues received in response to the October 2019 consultation in the relevant sections of this statement and in annex 2.

Auction format – pros and cons of SMRA and CCA formats

5.6 In the October 2019 consultation, we considered two possible auction formats for this award: the Simultaneous Multiple Round Ascending (SMRA) auction and the Combinatorial Clock Auction (CCA).

5.7 An SMRA is an open ascending auction for spectrum that takes place over a number of rounds. Bids are placed for individual lots, in multiple lot categories, at the same time. The auction proceeds through successive rounds with increasing prices until there are no new bids. Bidders typically receive information on the level of excess demand which helps

inform their bidding strategies. Bids are subject to an activity rule, meaning bidders must maintain or decrease their demand from one round to the next. The highest bids on each lot are called the 'standing high bids' in each round. When the auction ends, the standing high bids are the winning bids and bidders pay the amounts they bid. With generic lots, bidders are awarded a number of lots at the end of the principal stage of the auction, and then proceed to an assignment stage to determine the exact location of their frequencies.

- 5.8 A CCA is an auction format which features package bidding. In the first stage, bids are submitted on packages of lots during multiple rounds, subject to activity rules. Similar to an SMRA, the auction proceeds through successive rounds with increasing prices until there is no excess demand for any lot category. This is known as the Primary Bid Phase. Bidders then have a further opportunity to submit bids in a single, sealed bid round known as the Supplementary Bids Round. Winners are determined by finding the combination of bids which maximise total auction value and bidders pay a price such that no other bidder, or combination of bidders, would have been willing to pay more. As in the SMRA, the winners of spectrum go on to participate in the second stage, in which the assignment of the exact frequencies of the spectrum to be awarded is determined.²⁷¹
- 5.9 We considered the main advantages of the SMRA to be: simplicity, as the SMRA is intuitively easier to understand; a reduced risk of surprise outcomes, as bidders have a larger degree of certainty when they submit their bids; and budget constrained bidders have clearer information on the prices they will pay.
- 5.10 The main disadvantages to the SMRA we set out were: bidders risk winning fewer lots than they bid for ('aggregation risk'); bidders may be limited in their ability to substitute demand across different lot categories ('substitution risk'); and bidders may strategically reduce their demand to obtain lower spectrum prices ('strategic demand reduction'). We also noted that the risk of bidders tacitly colluding to obtain lower spectrum prices ('market division') is more prominent in an SMRA.
- 5.11 We considered the main advantages of the CCA to be: elimination of aggregation risk due to package bidding; elimination of substitution risk as bidders can express their valuations across all packages of spectrum; decreased risk compared to an SMRA of strategic demand reduction; and reduced risk of tacit collusion.
- 5.12 We considered the main disadvantages of the CCA to be: bidders face a degree of uncertainty on the final outcome and prices of spectrum; budget constrained bidders may face challenges in their bidding decisions; and there may be a greater risk compared to an SMRA of bidders bidding to raise rivals' costs ('price driving').

Stakeholder responses

- 5.13 BT/EE, O2 and Vodafone strongly agreed with our proposal to use an SMRA format for this award, while no respondents raised any specific objections to the proposed format. BT/EE,

²⁷¹ For a full description of the main pros and cons of both formats, see our December 2018 consultation, paragraphs 7.54-7.83.

for example, agreed that the SMRA is more appropriate than the CCA for this award, citing in particular the benefit of simplicity and transparency – which may reduce possibilities for gaming, and enable a process that is easier to explain and which has greater certainty as to the outcome and costs compared to the CCA.²⁷² Vodafone claimed, with coverage lots now removed from the auction, there is little inter-band aggregation risk to justify the use of the CCA.²⁷³ O2 said it “strongly supports” our proposal to adopt the SMRA format, saying that the format offers multiple advantages over other formats, including predictable outcomes, fair pricing, speed, and robustness to strategic play.²⁷⁴

- 5.14 While O2 noted that the SMRA design is less vulnerable than the CCA to price driving, it claimed that, without further measures, there was a risk that the award will not deliver an efficient outcome. It was particularly concerned about the vulnerability of the auction to strategic bidding, especially price driving in the 3.6-3.8 GHz band.²⁷⁵ We discuss price driving in more detail below.

Our decision

- 5.15 Having considered all the comments from stakeholders, and noting the strong support among respondents, we have decided to proceed with the proposed SMRA format for this auction. In the rest of this section, we set out respondents’ comments on and our decisions on the detailed rules for the SMRA design.

SMRA format risks

- 5.16 In developing our proposed auction rules in the October 2019 consultation, we considered and sought to mitigate appropriately the risks associated with the SMRA format. We describe these risks and how they may apply in this auction in more detail below.
- a) **Aggregation risk** – This occurs when a bidder values a combination of lots more than the sum of its values for the individual lots in that combination. In an SMRA, this means bidders face a risk of winning less spectrum than they bid for, at prices that exceed their valuation for this smaller amount of spectrum. While we did not consider there to be significant cross-band aggregation risk in this award, due to the limited complementarities between bands, we noted that there may be some in-band aggregation risk within the award bands.
 - b) **Substitution risk** - Bidders face substitution risk if they wish to change the band they are bidding in, but are not able to switch demand effectively between bands. Some stakeholders have suggested there is low substitution risk in this award as there is limited substitutability between 700 MHz FDD and 700 MHz SDL, and no

²⁷² BT/EE non-confidential response to our October 2019 consultation, page 5 paragraph 2.2

²⁷³ Vodafone non-confidential response to our October 2019 consultation, page 2

²⁷⁴ O2 non-confidential response to our October 2019 consultation, page 21 paragraph 51

²⁷⁵ Ibid, paragraph 55

substitutability between 700 MHz and 3.6-3.8 GHz. Nonetheless we consider some bidders may still wish to substitute between bands at certain prices.

- c) **Strategic demand reduction and market division** - Strategic demand reduction occurs where a bidder reduces its demand early, instead of competing for more spectrum, in an attempt to reduce the final prices it will pay. Market division is a form of tacit collusion with several bidders jointly reducing demand to lower the final prices that they must pay. Both are greater risks in the SMRA than the CCA and may reduce efficiency, if bidders end up winning less spectrum than they otherwise would have won through intrinsic value bidding. We considered these may be particular concerns for our award, due to the potential predictability of demand. Predictable allocations may increase bidders' incentives to strategically reduce demand, or co-ordinate market division.
- d) **Price driving** – The potential for predictability of demand in our auction may also increase the risk of price driving in this award. While the SMRA is typically less vulnerable to price driving than the CCA, it is still a relevant risk if demand from other bidders is sufficiently predictable. This is because a price driving bidder may still be able to submit 'low risk' bids in the SMRA, aimed purely at driving up competitors' prices, with reduced probability of it inadvertently winning spectrum. Price driving, even if it affects the prices paid in the auction, may not change the allocation of spectrum, so may not raise any efficiency concerns. However, we also recognised there is potential for price driving to have an adverse effect on efficiency if it results in a change to the allocation that would otherwise have occurred in the absence of price driving.

Stakeholder responses

- 5.17 Stakeholder comments on these risks of the SMRA format were generally in line with our October 2019 assessment. In making our final decisions on the principal stage rules set out below, we have taken these comments into account.
- 5.18 O2 and Vodafone agreed that aggregation risk was limited in this auction, with Vodafone commenting that that "bidders' demand for 700 MHz spectrum will not be influenced by their demand for 3.6 GHz spectrum to any meaningful extent" and O2 labelling it not an "important concern".²⁷⁶ H3G said that any complementarities within each band can be managed through bidding or, in the case of the 700 MHz SDL, specifying a minimum requirement.²⁷⁷ BT/EE reiterated its view that bidders will face in-band aggregation risk, and suggested we allow bidders the option of specifying a minimum amount of spectrum they would be prepared to win ('minimum requirement') in the 3.6-3.8 GHz band to help

²⁷⁶ O2 non-confidential response to the October 2019 consultation, page 23, paragraph 55; Vodafone non-confidential response to the October 2019 consultation, page 6

²⁷⁷ H3G non-confidential response to October 2019 consultation, page 33, paragraph 17.4

- bidders manage this risk.²⁷⁸ We discuss minimum requirements below in paragraphs 5.121-5.137.
- 5.19 On substitution risk, O2 said it considered the spectrum bands available in this award to be only “weak substitutes”.²⁷⁹ [REDACTED].²⁸⁰ Vodafone also said that the spectrum on offer does not represent sufficiently close substitutes to justify auction rules that facilitate changing of demand between lot types, although it did not rule out the flexibility for bidders to do so.²⁸¹
- 5.20 Regarding strategic demand reduction, O2 agreed that an SMRA is generally more vulnerable to demand reduction. It noted, however, that demand reduction often has no impact on efficiency. If bidders have reasonably accurate expectations regarding the efficient outcome, then they will drop demand in a way that has the same impact on the outcome as straightforward valuation-based bidding.
- 5.21 O2 and [REDACTED] expressed particular concerns about the risk of price driving in the 3.6-3.8 GHz band, claiming this was a greater risk in this auction. O2 said that price driving is more likely to occur in situations where there are asymmetries between bidders, which introduce predictable differences in demand between bidders that can be exploited. It said that there is an asymmetry between MNOs in the 3.6-3.8 GHz band due to H3G’s pre-existing 5G spectrum holdings. O2 stated that this “creates an obvious opportunity for H3G to exploit price driving tactics at 3.6 GHz, perhaps with the primary objective of tacitly ‘persuading’ its rivals to inefficiently reduce demand in the 700 MHz band”.²⁸² [REDACTED].²⁸³
- 5.22 Some stakeholders argued that we should impose a spectrum cap that would prevent H3G from bidding in the 3.6-3.8 GHz band. O2 claimed the best approach to mitigate price driving would be to impose a cap of 140 MHz on 3.4-3.8 GHz spectrum.²⁸⁴ BT/EE also suggested a 140 MHz cap in response to our December 2018 consultation as a solution to address its concerns in the 3.6-3.8 GHz band, including the risk of H3G price driving.²⁸⁵ [REDACTED].²⁸⁶
- 5.23 Vodafone, O2 and BT/EE also suggested amendments to the details of the design as alternative measures to mitigate the risk of price driving, including changes to lot sizes, eligibility point ratios, and introducing a minimum bid in the 3.6-3.8 GHz band. We discuss these when setting out our decisions on the principal stage rules.
- 5.24 We set out our assessment of price driving below, including the appropriate mitigation measures we have implemented within our auction.

²⁷⁸ BT/EE non-confidential response to October 2019 consultation, page 7, paragraphs 2.17-2.18

²⁷⁹ O2 non-confidential response to the October 2019 consultation, page 24, paragraph 59

²⁸⁰ [REDACTED]

²⁸¹ Vodafone non-confidential response to the October 2019 consultation, page 7

²⁸² O2 non-confidential response to the October 2019 consultation, page 26, paragraph 65

²⁸³ [REDACTED]

²⁸⁴ O2 non-confidential response to the October 2019 consultation, page 44, paragraph 119

²⁸⁵ BT/EE non-confidential response to the December 2018 consultation, page 5, paragraphs 3.143-3.145

²⁸⁶ [REDACTED]

Price driving in the 3.6-3.8 GHz band

5.25 As noted above, price driving may have no impact on efficient allocation even if it raises the prices paid by winning bidders, but there are possible ways that it can have an adverse effect in auctions. We would be concerned if there were a material risk of price driving negatively affecting competition or the efficient allocation of spectrum. We set out our assessment of these two potential effects below, and what we consider to be the appropriate mitigations in light of this assessment.

Low risk of price driving affecting competition or investment

5.26 We do not consider price driving to be a significant concern for competition, even if it were to result in a change to the allocation of spectrum. As set out in section 4, we believe there is a low risk of competition concerns related to 3.4-3.8 GHz spectrum from any auction outcome.

5.27 It is possible that additional auction expenditure as a result of price driving could, in principle, reduce an MNO's investment and therefore affect competition. For example, [REDACTED] claimed that investment in spectrum has significant impacts on the availability of subsequent funding for network investment, and argued that price driving would impact on deployment of 5G networks.²⁸⁷

5.28 However, it is unclear that such a reduction in investment would occur in practice. This would require a link between auction expenditure and later investment. Possible channels for such an effect might be if MNOs relied on internal funds for investment or if their cost of capital increased, for example due to higher debt. However, MNOs are large sophisticated firms with access to capital markets (although we acknowledge some MNOs may already have non-trivial levels of debt). It is also unlikely that the scale of increase in auction expenditure due to price driving would be sufficiently material either relative to MNOs' capital expenditure programmes²⁸⁸ or to change firm-wide metrics which might influence credit ratings. Rather, financial markets might penalise MNOs who were perceived to be failing to invest efficiently.

Potential for impact on spectrum efficiency

5.29 Price driving may not reduce efficiency if it does not result in a change to the allocation of spectrum. Indeed, the objective of a price driving bidder is not to win the spectrum on which it is price driving, but to fail to win it and push up prices for others.

5.30 One possible way for price driving to reduce efficiency is if a price-driving bidder misjudges other bidders' demand and inadvertently wins spectrum. Price driving is less likely to cause such a change to the allocation of spectrum if demand is predictable, as some stakeholders have claimed is the case for our auction.²⁸⁹ This is because the price driver will be able to

²⁸⁷ [REDACTED]

²⁸⁸ For example, O2's UK capital expenditure was just under £800m in 2018 (see annex 3).

²⁸⁹ For example, see O2 non-confidential response to the October 2019 consultation, page 27, paragraph 68; and [REDACTED]

more accurately judge when to stop bidding once prices are sufficiently high, without winning unwanted spectrum.

- 5.31 Nonetheless, as demand will never be perfectly predictable, we recognise it is possible for price driving to change the allocation of spectrum, and therefore reduce efficiency. It is also possible for price driving to reduce efficiency if the price driver exhausts the budgets of its competitors in one band (e.g. 3.6-3.8 GHz), resulting in a potential change to the allocation in another band (e.g. 700 MHz). This is less likely if the efficient winners, with the highest intrinsic values, are also well-resourced and do not face tight budget constraints.
- 5.32 Overall, we do not rule out the possibility of adverse effects on efficiency from price driving, but we do not consider these risks to be large.

Measures to mitigate price driving

- 5.33 Any measures to mitigate price driving should be proportional to the impact that price driving may have on the auction. This is consistent with our approach to imposing competition measures, where we have sought to ensure that the level of intervention is the minimum necessary to achieve our policy objectives effectively.
- 5.34 We do not consider a cap in 3.6-3.8 GHz would be a proportionate measure to mitigate price driving for this auction. We typically have not used spectrum caps as a measure to restrict price driving, which would be a high level of intervention that may unduly restrict intrinsic value bidding.
- 5.35 Some MNOs have suggested the proportionality threshold should be low as H3G will have little or no intrinsic value for further 3.6 GHz spectrum.²⁹⁰ However, we cannot rule out that it may have some intrinsic value for additional 3.6-3.8 GHz spectrum. H3G won 20 MHz of 3.4-3.6 GHz spectrum in our 2018 auction (despite already holding 120 MHz in the wider 3.4-3.8 GHz band). H3G bid for a larger amount of 3.4-3.6 GHz than it won and indeed was the last bidder to drop demand for 3.4-3.6 GHz in that auction.²⁹¹ H3G noted in its response that, as “highest losing bidder for 3.4 GHz in 2018, Three may have been expected to win some 3.6 GHz spectrum in 2020”.²⁹² We do not interpret this evidence of bids in the 2018 auction as providing a reliable indication of efficient winners in the forthcoming 3.6-3.8 GHz auction. However, it serves to illustrate the risks of assuming that H3G has little or no intrinsic value for further 3.6-3.8 GHz spectrum.
- 5.36 Additionally, there are other measures within the auction design intended to reduce the risk of price driving. Compared to a spectrum cap, we think auction design mitigations are a more appropriate level of intervention which are more proportional to the potential impacts of the price driving. It is important, however, that these measures strike a balance

²⁹⁰ See [REDACTED] O2 non-confidential response to the December 2018 consultation, page 5, and to the October 2019 consultation, pages 36-37; BT/EE non confidential response to October 2019 consultation, pages 19-20, paragraphs 3.18-3.20

²⁹¹ In the 2018 auction for 2.3 GHz and 3.4-3.6 GHz, H3G dropped demand by 10 MHz from 30 MHz at a price of £37.8m to 20 MHz, which ended the auction in round 67.

²⁹² H3G non confidential response to the October 2019 consultation, page 5, paragraph 2.3

between mitigating price driving and not unduly restricting straightforward bidding in line with bidders' intrinsic values.

- 5.37 Our October 2019 auction design proposals already included several measures intended to reduce the risk of price driving, including the use of an SMRA format, the information policy, and not allowing bidders the option of withdrawing or specifying a minimum requirement (explained below).
- 5.38 Having considered stakeholder responses, we have decided to also introduce a minimum 10 MHz bid in 3.6-3.8 GHz as an additional mitigation to price driving. This means bidders that wish to bid in 3.6-3.8 GHz must bid on at least two lots, and so will prevent a price driving bidder from bidding on a sole 5 MHz lot in to increase prices for others. This raises the minimum bid amount for a prospective price driving bidder and potentially increases the risk of it accidentally winning spectrum. We describe this in more detail in paragraphs 5.76-5.81

Annual licence fees

- 5.39 In the context of arguments relating to the potential for price driving, we have considered representations made to us by Vodafone and H3G relating to annual licences fees (ALFs). Both Vodafone and H3G said Ofcom should confirm that it will review (different) ALFs in light of the auction bidding and outcome, to reduce the risk of price driving or aggressive bidding in the auction.
- 5.40 Vodafone argued that Ofcom should make clear that H3G's future ALFs will definitely be reviewed in light of the auction outcome in order to align its incentives with other bidders.²⁹³ Vodafone was concerned about the potential for H3G to disrupt the 3.6-3.8 GHz band in the auction by driving up prices for its competitors "largely with impunity", or securing a small amount of spectrum to disrupt defragmentation of the wider 3.4-3.8 GHz band, if it did not face a consequent increase in the ALFs it pays for the spectrum it already holds in this band.
- 5.41 H3G also made submissions to us in relation to our position on revisiting the ALFs payable for the 3.6-3.8 GHz spectrum and the 900/1800 MHz spectrum in light of the 700 MHz auction outcome, and Vodafone's comments above. H3G was conversely concerned that its rivals could bid aggressively on all spectrum in the auction (to H3G's detriment in the 700 MHz band) without risking any wider impacts on them outside the auction, if they did not face the possibility that the ALFs they currently pay for use of the 900/1800 MHz spectrum would be open for revision in light of bidding in this auction. It contrasted this to the position if we were to commit to or be likely to review its ALFs in the 3.6 GHz band in light of the auction, in which case H3G said it would face risks of increasing its own ALFs if it competes for the 3.6-3.8 GHz spectrum here.²⁹⁴

²⁹³ Vodafone non-confidential response to the October 2019 consultation, page 9-10, section 3.1

²⁹⁴ [REDACTED]

- 5.42 Specifically, H3G's concern was that if we were suggesting that we might revise its ALFs in the 3.6-3.8 GHz spectrum after the auction, but not O2 and Vodafone's ALFs in the 900 MHz spectrum, this would risk inefficiency, discrimination and the distortion of competition in the auction.
- 5.43 H3G explained that it was concerned that we were adopting an inconsistent approach to the circumstances in which we would revise the ALFs which it pays in respect of the frequencies it holds in the 3.4-3.6 GHz spectrum, compared in particular to the circumstances in which we would revise the ALFs payable by O2 and Vodafone in respect of the frequencies they hold in the 900 MHz spectrum.
- 5.44 While H3G acknowledged that Ofcom had stated in respect of both bands that it would not change the level of fees unless a "material misalignment" arises, it was concerned that because we had stated that we would be unlikely to review ALFs in the 900 MHz spectrum in the next five years (from 2018) save in very exceptional circumstances, some might perceive a difference in approach. In light of this H3G stated that it expects Ofcom to clarify that it will take the same approach in relation to both 3.4-3.8 GHz and 900/1800MHz ALFs.
- 5.45 Ofcom revised the ALF fees for the 900 and 1800 MHz spectrum in December 2018. In that decision, we explained that we consider there is a benefit in a period of relative certainty for licensees, and that we would therefore be unlikely to review ALFs in the following five years save in very exceptional circumstances. We said we would also propose to retain the fees beyond that date unless there were grounds to believe that a material misalignment had arisen between the level of those fees and the value of the spectrum, in keeping with our general policy on fee reviews.
- 5.46 We set the ALF fees for the 3.4-3.6 GHz spectrum in June 2019. In that decision, we similarly explained that we consider there is benefit for licensees in a period of certainty on fees. We said that this remains our general position, and that we intend to retain the fees as set unless there is strong evidence that a material misalignment has arisen between the level of the fees and the value of the spectrum. In light of representations that had been made to us at the time, we noted that we always retain the ability to revise fees in the future in appropriate circumstances, including after the forthcoming auction of 700 MHz and 3.6-3.8 GHz spectrum, if we consider there is evidence to suggest a revision to fees is warranted.
- 5.47 Our approach has been and remains consistent (albeit that we did not use exactly the same words in explaining it in each case). When setting ALFs, which we set by reference to market value, our intention is to provide a period of certainty for licensees by not being quick to revisit those fees unless there are good reasons to do so.
- 5.48 In giving effect to our statutory duties, as a public authority we are always required to take an evidence-based approach. Accordingly, whilst our approach remains consistent and our intention is to provide certainty, we cannot preclude that we may need to revisit fees if a material misalignment between fees payable and the value of the relevant spectrum occurs.

Principal stage rules

5.49 In this sub-section, we set out the detailed rules proposed for the principal stage, as well as stakeholder responses on our proposals and our final positions.

Generic lots

5.50 We proposed that the principal stage would involve generic spectrum lots for each of the three lot categories (700 MHz FDD, 700 MHz SDL and 3.6-3.8 GHz). This means that bids in the principal stage would not relate to specific frequencies, but to lots of specified bandwidths with unspecified frequencies. Winners of generic spectrum lots in the principal stage could bid to determine the exact location of their frequencies in the assignment stage. This has the benefit of minimising the risk of fragmentation of the auctioned spectrum, allows for simplicity of bidding, encourages a speedier auction, and is more flexible than a frequency-specific auction with a single bidding stage.

5.51 O2 and H3G supported our proposal to use generic lots, noting that approach has been used successfully in other auctions.²⁹⁵ No other stakeholders commented on our proposal to use generic lots. We have therefore decided to proceed on the basis of our proposal.

Lot structure

5.52 In our October 2019 consultation, we proposed the following lot structure:

- six lots of 2x5 MHz for 700 MHz FDD;
- four lots of 5 MHz for 700 MHz SDL; and
- twenty-four lots of 5 MHz of 3.6-3.8 GHz.

5.53 In deciding appropriate lot sizes for this award, we are seeking to achieve a balance between mitigating the aggregation risk bidders face and providing bidders with the flexibility to win spectrum in the exact amounts they want.

5.54 We proposed, on balance, that it would be appropriate to provide bidders with more flexibility in each of the lot categories. We preferred not to preclude options for bidders by using unduly large lot sizes, noting that aggregation risk for the spectrum we are awarding is limited.

5.55 We set out below our final decisions on lots sizes, taking into account stakeholder responses to our October 2019 consultation.

700 MHz FDD

5.56 All stakeholders agreed with the proposed lot size for 700 MHz FDD. BT/EE said this provided flexibility to bidders and was compatible with standardised equipment

²⁹⁵ O2 non-confidential response to our October 2019 consultation, page 43, paragraph 113; H3G non confidential response to October 2019 consultation, page 33, paragraph 17.1

bandwidths.²⁹⁶ H3G noted examples of low-frequency auctions in Europe where bidders have won a block of 2x5 MHz, suggesting it is the minimum useable bandwidth attractive to bidders.²⁹⁷ O2 stated bidders may wish to target either 2x5 MHz or 2x15 MHz and therefore favoured the flexibility of a 2x5 MHz lot size over a larger lot size.²⁹⁸

5.57 We have decided to adopt our proposals for a lot size of 2x5 MHz for 700 MHz FDD spectrum.

700 MHz SDL

5.58 We received comments from H3G, Vodafone and BT/EE on the proposed 5 MHz lot size for 700 MHz SDL. H3G and Vodafone agreed with the proposed lot size, whereas BT/EE argued for a 10 MHz lot size.²⁹⁹

5.59 H3G stated that, although the minimum use case was likely 10 MHz, bidders may demand 15 MHz.³⁰⁰ A 10 MHz lot size would prevent bidders from bidding for this amount. H3G also stated 5 MHz was consistent with international practice as “700 MHz SDL can be aggregated with 800 MHz in 5, 10, 15 and 20 MHz SDL carriers”. However, noting the likely 10 MHz minimum use case, H3G also considered that bidders should be able to specify a minimum requirement of 10 MHz in the band. We address H3G’s comments on minimum requirements below from paragraph 5.126.

5.60 BT/EE considered that a 5 MHz lot size could encourage non-straightforward bidding, “for example, by lowering the risks or costs of accidentally winning spectrum for a price driving bidder.”³⁰¹ BT/EE commented use cases for 5 MHz were speculative. It stated that any bandwidth less than 10 MHz for 700 MHz SDL would not sufficiently incentivise manufacturers to develop equipment for the 700 MHz SDL ecosystem.

5.61 On balance, we continue to favour giving bidders more flexibility in their bidding options for this spectrum. There are options for deploying 700 MHz SDL spectrum in 5 MHz or 15 MHz, in addition to 10 MHz and 20 MHz bandwidths, as H3G also noted. We have received no further technical evidence suggesting that either 10 MHz or 20 MHz of SDL is necessary for any specific use cases.

5.62 We recognise that a bidder may face some aggregation risk in this band if it does not wish to win an odd increment of 5 MHz. However, a bidder is only affected by this aggregation risk if another bidder has a relatively high intrinsic value for 5 MHz or 15 MHz blocks. In this case, we did not think it would be appropriate to preclude options for either bidder. Furthermore, BT/EE’s suggestion that less than 10 MHz bandwidth would disincentivise equipment manufacturers also appears speculative, given the eco-system for 700 MHz SDL is still developing.

²⁹⁶ BT/EE non-confidential response to our October 2019 consultation, page 5, paragraph 2.4

²⁹⁷ H3G non-confidential response to our October 2019 consultation, page 33, paragraph 17.5

²⁹⁸ O2 non-confidential response to our October 2019 consultation, page 43, paragraph 114

²⁹⁹ Vodafone non-confidential response to our October 2019 consultation, page 7, section 2.5

³⁰⁰ H3G non-confidential response to our October 2019 consultation, page 33, paragraph 17.8

³⁰¹ BT/EE non-confidential response to our October 2019 consultation, page 5, paragraph 2.5

- 5.63 We note that, in general, there may be slightly greater risk of non-straightforward bidding with 5 MHz lots, compared to a larger lot size of 10 MHz. For example, 5 MHz lot sizes may reduce the risks or costs to a price driving bidder of accidentally winning spectrum it does not want.
- 5.64 However, we consider any price driving bidder would face significant risks of winning unwanted spectrum, particularly in this band given the uncertain demand for 700 MHz SDL.³⁰² Given this risk, we consider our other mitigations for price driving are appropriate measures to deter price driving behaviour with a 5 MHz lot size.
- 5.65 We have therefore decided to adopt our proposals for a lot size of 5 MHz for 700 MHz SDL spectrum.

3.6-3.8 GHz

- 5.66 Comments from H3G, BT/EE, O2 and Vodafone on our proposed 3.6-3.8 GHz lot size showed a split in their views. H3G agreed with the proposed lot size, while BT/EE and O2 argued for a 10 MHz lot size. Vodafone proposed a 5 MHz lot size could be appropriate, in conjunction with a minimum bid.
- 5.67 H3G agreed with the proposed lot size, as there are equipment options to deploy 15 MHz of 3.6-3.8 GHz spectrum. H3G also said it expected equipment options for 25 MHz to be standardised in Q1 2020.³⁰³
- 5.68 BT/EE³⁰⁴ and O2³⁰⁵ argued for a 10 MHz lot size, maintaining that use cases for 3.6-3.8 GHz spectrum were in 10 MHz steps as these are the base units for 5G NR carriers. BT/EE noted the sole exception was the 15 MHz size carrier, which it claimed no one was likely to deploy. Both stakeholders also were concerned a 5 MHz lot size could encourage strategic bidding behaviour, including price driving. BT/EE argued that 5 MHz could reduce the risks or costs to a price driving bidder of accidentally winning unwanted spectrum.
- 5.69 Vodafone proposed a 5 MHz lot size combined with a minimum bid, as an alternative to increasing the lot size to 10 MHz.³⁰⁶ Vodafone stated that there were compelling arguments for a 10 MHz lot size [REDACTED].³⁰⁷ However, at the margins, Vodafone acknowledged there could be a use case for 3.6-3.8 GHz spectrum in odd multiples of 5 MHz, “e.g. [a] 25 MHz bandwidth, particularly if the bidder wished to use a non-standard frame structure hence needed guardbands.” To avoid ruling out such use cases and to alleviate concerns around a strategic bidder price driving on a single lot, Vodafone proposed a 5 MHz lot size combined with a minimum bid.

³⁰² Of the recent spectrum awards for 700 MHz in European countries, 700 MHz SDL has not sold in two awards (Sweden and Italy) and the spectrum was not available for auction in four awards (Norway, Finland, France and Germany).

³⁰³ H3G non-confidential response to our October 2019 consultation, page 34, paragraph 17.11-17.13

³⁰⁴ BT non-confidential response to our October 2019 consultation, page 6, paragraph 2.8-2.10

³⁰⁵ O2 non-confidential response to our October 2019 consultation, page 43, paragraph 115

³⁰⁶ Vodafone non-confidential response to our October 2019 consultation, page 11, section 3.3

³⁰⁷ [REDACTED]

- 5.70 Having reviewed stakeholder responses, we consider it is still important to maintain flexibility and avoid precluding options for bidders in 3.6-3.8 GHz. We maintain that bidders will be able to make use of this spectrum in multiples of 5 MHz for 5G, given there are equipment options for 15 MHz. We also note H3G's comment in which it expects 25 MHz carriers to be standardised in Q1 2020. Furthermore, there is evidence of demand for 5 MHz increments from the 2.3 and 3.4-3.6 GHz auction. While no bidders were awarded 3.4-3.6 GHz spectrum in multiples of 5 MHz, bids were submitted in multiples of 5 MHz specifically by Vodafone, O2, and Airspan (although, we recognise that O2 now favours a lot size of 10 MHz).
- 5.71 There is also potential for deployment of technologies, such as LTE, which supports options for deploying spectrum in multiples of 5 MHz.
- 5.72 We also continue to consider that there may be minimal aggregation risk in this band for MNOs. MNOs may be able to combine any spectrum won in 3.6-3.8 GHz with their existing holdings in 3.4-3.8 GHz, for example through post-auction trades or deploying multiple carriers. If an operator does win a multiple of 5 MHz, it would still be able to use this spectrum to deploy 5G because a carrier of 15 MHz is defined in the 5G standards.
- 5.73 We recognise stakeholders' concerns around strategic bidding, including price driving, with a 5 MHz lot size. We note that there may be slightly greater risk of non-straightforward bidding with 5 MHz lots, compared to a larger lot size of 10 MHz. For example, 5 MHz lot sizes may reduce the risks or costs to a price driving bidder of accidentally winning spectrum it does not want.
- 5.74 However, we do not think it would be appropriate to adopt a 10 MHz lot size to address these concerns, given this could preclude viable bid options for bidders. We have also incorporated other mitigations in our design to address price driving, including the use of an SMRA format, the information policy, and not allowing bidders the option of withdrawing or specifying a minimum requirement. In addition, we have considered and decided to adopt Vodafone's proposal of including a minimum bid in 3.6-3.8 GHz as a further mitigation, as set out below.
- 5.75 Therefore, in order to maintain flexibility and not preclude options for bidders, we have decided to adopt our proposals for a lot size of 5 MHz for 3.6-3.8 GHz spectrum.

Minimum bid in 3.6-3.8 GHz

- 5.76 Vodafone suggested introducing a "minimum bid" in the 3.6-3.8 GHz band, as an alternative price driving mitigation to increasing the lot size. This would mean a bidder that wishes to bid in 3.6-3.8 GHz would need to bid on a minimum number of lots, and ensure a bidder could not price drive by repeatedly bidding on a single 5 MHz lot. This would also still allow bidders the flexibility to submit bids in increments of 5 MHz, for which Vodafone

acknowledged there may be use cases. It said, however, that there was no “realistic use case” for a single 5 MHz licence.³⁰⁸

- 5.77 Vodafone’s minimum bid proposal would only restrict the minimum number of lots a bidder may place bids on, rather than the minimum number of winning bids. Therefore, it proposed that a bidder that is made standing high bidder on less than the minimum bid would still be able to win that spectrum. Its preference would be for a minimum bid of four lots (20 MHz), but acknowledged that two or three would be alternatives.
- 5.78 The minimum bid would increase the potential cost of adopting a price driving strategy, at least doubling the minimum amount to invest in such a strategy. It would also potentially increase the risk of a price driving bidder inadvertently winning spectrum. For example, absent a minimum bid, a price driving bidder could submit low risk bids for a single 5 MHz lot with the expectation that other bidders prefer to bid in multiples of 10 MHz (as BT/EE and O2 have claimed). However, with a 10 MHz minimum bid, the price driving bidder would need to bid on at least 15 MHz to follow the same strategy. It would then face a greater risk of accidentally winning 10 MHz, if other bidders then end up dropping their demand in increments of 10 MHz.
- 5.79 We consider there to be merit in Vodafone’s suggestion of a 3.6-3.8 GHz minimum bid, which we see as a preferable mitigation for price driving compared to increasing the lot size. As set out above, we do not wish to preclude the option for bidders to bid on increments of 5 MHz, given that there are equipment options in multiples of 5 MHz for both 5G and non-5G deployments. For that reason, we also think an appropriate minimum bid amount would be 10 MHz (i.e. two lots), given this is likely to be the minimum amount of spectrum required for deployment in practice.
- 5.80 While a 10 MHz minimum bid would preclude the option of bidding on a single 5 MHz lot, we believe this is unlikely to affect intrinsic value bidding in practice. The minimum useable bandwidth for 5G is 10 MHz, while any deployments that are not harmonised with 5G in the future are likely to require larger bandwidths than 5 MHz to accommodate guard bands.
- 5.81 We have therefore decided to adopt a minimum bid of 10 MHz (two lots) in 3.6-3.8 GHz. We see limited downsides to implementing this change, which has the benefit of further reducing the risk of price driving in combination with the other mitigations within the design.

Standing high bidders and ranking mechanism

- 5.82 We proposed to assign ‘standing high bids’ to bidders at the end of each round, using a ranking rule. Under our proposed approach, only one bidder in each lot category may

³⁰⁸ Vodafone non-confidential response to the October 2019 consultation, page 11

become standing high bidder on fewer lots than the number of lots they bid for (a 'partial standing high bidder').³⁰⁹ This proposed rule reduces aggregation risk.

- 5.83 We also proposed that, whenever bidders wish to place new bids at a new round price, they will need to resubmit any standing high bids they may hold at the previous price level at the new round price. This means that a bidder cannot hold standing high bids at different round prices in the same lot category, and would allow for a speedier bidding process with little downside.
- 5.84 Only O2 commented on our proposal, saying that "these rules worked well in 2018 and we expect them to work well for this auction".³¹⁰
- 5.85 We have decided to adopt the proposed approach.

Pricing rule and round price increments

- 5.86 An implication of our approach to assigning and ranking standing high bids is that winning bidders may end up paying prices that are one round price increment higher or lower than other winning bidders in the same lot category.
- 5.87 We received additional comments from O2 and BT/EE on this pricing rule and price increments they believed Ofcom should adopt between rounds during the auction.
- 5.88 While O2 supported our proposals for assigning and ranking standing high bids, it noted that the pricing rule could lead to large differences in the amount paid by bidders for the same spectrum. It said Ofcom could address this by switching to a uniform price rule, and/or run the auction with modest absolute bid increments so that the maximum price differences cannot be too large.³¹¹
- 5.89 BT/EE also said that Ofcom should specify, in advance of the auction, a range for the round price increment percentage or at least maximum percentage increment, to enable bidders to plan and prepare for when key decisions are likely to be required and to inform governance.³¹² BT/EE said it would welcome round price increments of no more than 5%, which it did not think would unduly prolong the auction.
- 5.90 O2 proposed an SMRA with a uniform price rule in response to our December 2018 consultation. As set out in paragraphs 3.47 of our October 2019 consultation in response to this, we maintain that a uniform pricing rule would not be appropriate as it may encourage non-straightforward bidding.
- 5.91 The price increments we use between rounds will be subject to our discretion. This is in order to enable us to best respond to circumstances in the auction as they unfold. We are mindful that bidders may want more certainty on the price increments we may use during the auction in order to better forecast their potential financial exposure. As in previous

³⁰⁹ See paragraphs 3.37-3.47 of our October 2019 consultation for a full description of our standing high bidders and ranking proposals

³¹⁰ O2 non-confidential response to our October 2019 consultation, page 47, paragraph 130

³¹¹ Ibid, pages 49-50, paragraphs 134-135

³¹² BT/EE non-confidential response to our October 2019 consultation, page 8, paragraph 2.25

auctions, we will use appropriate judgement in setting round price increments, and our expectation is not to use increments above 20% or smaller than 2%. We have provided further detail in our 'Process guidance for potential applicants and bidders in the auction' published alongside this document.

Activity rule

- 5.92 We proposed that the bidding process for the principal stage would proceed over one or more rounds. Bidding would be subject to a points-based activity rule to ensure that bidding is progressive, preventing bidders from withholding demand until relatively late in the auction.
- 5.93 These rules are designed to prevent bidders from expanding their demand as prices increase, and therefore deter bidders from strategically withholding their true demand early in the bidding process.³¹³
- 5.94 We received no comments from stakeholders on our activity rule proposals and have decided to adopt our proposals.

Eligibility points

- 5.95 We proposed the following eligibility points for the spectrum lot categories, which we consider would appropriately facilitate switching between the bands:
- a) Four points for a 2x5 MHz 700 MHz FDD lot;
 - b) One point for a 5 MHz 700 MHz SDL lot;
 - c) One point for a 5 MHz 3.6-3.8 GHz lot.
- 5.96 The ratio of eligibility points between lot categories can affect bidders' options to substitute their demand between bands (for lots on which they are not the standing high bidder). We considered that bidders may seek to substitute between lot categories in response to changes in relative prices for technical or commercial reasons, or due to budget reasons. The proposed ratios on a per MHz basis were 2:1 between 700 MHz FDD and SDL and between 700 MHz FDD and 3.6-3.8 GHz.
- 5.97 Our proposals were informed by comparison of relative-value benchmarks for 700 MHz FDD and the UK price of 3.4-3.6 GHz spectrum, and the practicalities of switching in different directions between the two bands. We noted that there was significant uncertainty about the relative prices of 3.6-3.8 GHz and 700 MHz FDD in the auction. We also considered that that a 4:1 ratio would make it materially more difficult in practice to substitute from 3.6-3.8 GHz spectrum to paired 700 MHz spectrum, compared to a 2:1 ratio.
- 5.98 On balance, given the evidence on relative prices was inconclusive, and the impact of higher ratios on the practicality of switching in both directions between the 700 MHz FDD

³¹³ See paragraphs 3.48-3.53 of the October 2019 consultation for a full description of our activity rule proposals

and 3.6-3.8 GHz bands, we were minded to favour a ratio of 2:1 as more appropriate for these bands.

- 5.99 We also considered a 2:1 eligibility ratio for 700 MHz FDD and 700 MHz SDL to strike a reasonable balance for facilitating both technical substitution and budget-based switching, given the likely lower value of 700 MHz SDL compared to 700 MHz FDD.

Stakeholder responses

- 5.100 We received comments on our eligibility point proposals from all four MNOs. H3G and Vodafone agreed with the proposed eligibility points for all bands.³¹⁴ ³¹⁵ BT/EE and O2 agreed with the 2:1 per MHz eligibility ratio between 700 MHz FDD and SDL, with O2 stating it was the maximum ratio feasible for switching.³¹⁶ ³¹⁷ BT/EE and O2 disagreed with the 2:1 per MHz eligibility ratio between 3.6-3.8 GHz and 700 MHz FDD. No stakeholder made specific comments on the eligibility points for SDL.
- 5.101 BT/EE proposed a 4:1 per MHz eligibility ratio between 3.6-3.8 GHz and 700 MHz FDD to [REDACTED] and because it considered a 4:1 per MHz ratio would be a better reflection of relative values.³¹⁸
- 5.102 O2 argued the proposed 2:1 per MHz eligibility ratio between 3.6-3.8 GHz to 700 MHz FDD makes switching between the bands “too easy”. O2 argued that, as the two bands are not close substitutes, it is likely switching will be driven by strategic rather than intrinsic considerations. To reduce the pay-off from price driving, O2 proposed creating separate eligibility silos for 700 MHz and for 3.6-3.8 GHz to entirely prevent switching across the two bands. Alternatively, O2 proposed Ofcom select a sufficiently high eligibility ratio between the two bands such that it is only possible to switch one-way from 700 MHz to 3.6-3.8 GHz.³¹⁹
- 5.103 In contrast, H3G commented that [REDACTED], bidders may still find it desirable to switch between them in the auction (including for budget reasons).³²⁰ While noting that the spectrum on offer does not represent sufficiently close substitutes to justify auction rules that facilitate changing of demand between lot types, Vodafone also said it would not rule out the flexibility for bidders to do so.³²¹

Decision

- 5.104 We disagree with BT/EE’s suggestion that a 4:1 per MHz eligibility ratio between 700 MHz FDD and 3.6-3.8 GHz is necessarily a better reflection of relative market prices between the

³¹⁴ H3G non-confidential response to our October 2019 consultation, page 32, paragraph 15.5

³¹⁵ Vodafone non-confidential response to our October 2019 consultation, page 7, section 2.6

³¹⁶ BT/EE non-confidential response to our October 2019 consultation, page 6, paragraph 2.11;

³¹⁷ O2 non-confidential response to our October 2019 consultation, page 45, paragraph 122

³¹⁸ [REDACTED] BT/EE non-confidential response to our October 2019 consultation, page 6, paragraph 2.13

³¹⁹ O2 non-confidential response to our October 2019 consultation, page 44-45, paragraph 117 - 122

³²⁰ [REDACTED] H3G non-confidential response to our October 2019 consultation, page 32, para 16.3

³²¹ Vodafone non-confidential response to the October 2019 consultation, page 7

two bands. As noted in our October 2019 consultation, we examined two pieces of evidence to estimate a relative-value ratio between these two bands, and found the evidence to be inconclusive on whether a 4:1 or 2:1 ratio was a more appropriate reflection of relative values.³²² First, we examined a comparison of relative-value benchmarks of 700 MHz FDD and the UK price of 3.4-3.6 GHz and explained how the evidence could have suggested either a 4:1 or 2:1 relative value ratio. Second, we directly compared the auction prices of the two bands in European benchmark countries which have awarded both bands, and found the relative market prices spanned a range which included ratios of both 2:1 and 4:1.³²³ We note that BT/EE has not supplied any new evidence to support its assertion that a 4:1 ratio is a better reflection of relative values.

- 5.105 We considered an important consideration in the choice of eligibility ratio was the practicality of being able to switch in both directions between the two bands, to facilitate straightforward bidding. We are concerned that with a 4:1 eligibility ratio, bidders may face greater restrictions substituting in one direction – from 3.6-3.8 GHz to paired 700 MHz – than the other.
- 5.106 A 4:1 ratio would make it materially more difficult in practice to substitute from 3.6-3.8 GHz spectrum to paired 700 MHz spectrum, compared to a 2:1 ratio, due to the larger quantities of spectrum required to switch. For example, an eligibility ratio of 4:1 would require a bidder to substitute 80 MHz of 3.6-3.8 GHz spectrum to have sufficient eligibility to bid for 2x10 MHz of paired 700 MHz spectrum. It is not clear to us that bidders will find it useful to substitute from such large quantities of spectrum in 3.6-3.8 GHz, which represent a significant proportion of the spectrum available in the auction. By contrast, in the other direction, a 4:1 ratio would allow a bidder to switch from 2x10 MHz of 700 MHz FDD spectrum to any amount of spectrum in 3.6-3.8 GHz up to 80 MHz.
- 5.107 We disagree with O2's suggestions to make switching between the two bands impossible or only possible in one direction. We consider there could be intrinsic value or budget-based reasons for bidders to switch demand across bands. If switching was materially more difficult, or made impossible through eligibility silos, bidders could have incentives to deviate from straightforward bidding to manage the difficulties of shifting demand from 3.6-3.8 GHz to paired 700 MHz or vice versa.³²⁴ In turn, this could have impacts for efficiency.
- 5.108 We do not consider it appropriate to restrict straightforward bidding and risk inefficiency in this manner in order to mitigate the risk of price driving. We discuss our mitigations to price driving above in paragraphs 5.33 to 5.38.

³²² Since our October 2019 consultation, there have been no new awards in either 700 MHz FDD or 3.6-3.8 GHz spectrum.

³²³ For a detailed discussion of this evidence, see our October 2019 consultation, page 19-21, paragraphs 3.60-3.67

³²⁴ For example, with separate eligibility silos, bidders may find it advantageous to maintain higher eligibility limits than they would otherwise in both bands. This would allow the flexibility to respond to relative price changes across bands, toward the end of the auction. Or, if bidders bid straightforwardly, they risk winning spectrum in their less-preferred spectrum band, as they become 'siloes' on a band which becomes relatively more expensive and are unable to switch demand to their preferred spectrum band.

- 5.109 The available evidence about relative prices outlined above and set out in detail in the October 2019 consultation is neither entirely reliable, nor conclusive about the appropriate eligibility ratio. On balance, given the risks of higher ratios for the practicality of switching in both directions between the 700 MHz FDD and 3.6-3.8 GHz bands, we prefer a ratio of 2:1.
- 5.110 We have therefore decided to adopt our proposals for the eligibility point structure, which are:
- a) Four points for a 2x5 MHz 700 MHz FDD lot;
 - b) One point for a 5 MHz 700 MHz SDL lot;
 - c) One point for a 5 MHz 3.6-3.8 GHz lot.

Waivers

- 5.111 We proposed that bidders would be allowed three 'waivers', which would allow a bidder to waive its right to bid in a round without losing any eligibility points. Waivers may be useful for bidders to manage aggregation risk or substitution risk, allowing a partial standing high bidder to 'sit out' a round and see if it is outbid before deciding its next move. Waivers could also be useful for a bidder experiencing difficulties, technical or otherwise, which prevent them from submitting a bid. In the circumstances where the failure to submit a bid would result in a loss of eligibility, we proposed that a default waiver would be used on behalf of the bidder.
- 5.112 We noted that there are some risks associated with waivers, such as undermining the price discovery process or bidders using waivers as an attempt to signal each other. However, we considered that the benefits of allowing bidders a limited number of waivers (three) to manage bidding risks and technical difficulties using waivers, outweighed the associated downsides.³²⁵
- 5.113 We received unanimous support for our proposed approach to waivers. Vodafone, H3G and O2 agreed with the benefits of waivers we outlined in the consultation, including providing bidders with a safeguard against technical failure and some flexibility when deciding whether to bid to a new price level.^{326 327 328} BT/EE and H3G also agreed that three is an appropriate number of waivers to allow bidders, with BT/EE saying this strikes the right balance between discouraging non-straightforward bidding and managing risk in exceptional circumstances.³²⁹
- 5.114 H3G said that Ofcom should allow bidders to use a waiver in the first round. Under our proposed rules, bidders would not be permitted to use a waiver in the first round and

³²⁵ See paragraphs 3.75-3.80 of our October 2019 consultation.

³²⁶ Vodafone non-confidential response to our October 2019 consultation, page 7

³²⁷ H3G non-confidential response to our October 2019 consultation, page 36, paragraph 19.4

³²⁸ O2 non-confidential response to our October 2019 consultation, page 51, paragraph 142

³²⁹ BT/EE non-confidential response to our October 2019 consultation, page 7, paragraph 2.14

would be excluded unless they submit a bid. We continue to consider that this is an appropriate approach, as the primary benefits of waivers set out in the paragraph 3.76 of the October 2019 consultation only apply after the first round.³³⁰ However the downsides of waivers are still relevant in the first round, i.e. reducing price and package discovery. For example, a bidder could use a waiver in the first round to strategically hide demand, giving the impression of lower level of excess demand to other bidders at the start of the auction than is actually the case.

- 5.115 We have therefore decided to adopt our proposals to allow bidders up to three waivers during the principal stage, and not to permit bidders to use a waiver in the first round.

Withdrawals

- 5.116 We proposed not to allow bidders to withdraw their standing high bids. We noted that there are risks to allowing withdrawals in the auction. For example, withdrawals may facilitate price driving behaviour, and/or result in a less efficient outcome than otherwise would have been the case if withdrawals result in spectrum going unsold.
- 5.117 While we included withdrawals in our 2018 auction for the 2.3 GHz and 3.4-3.6 GHz bands, this added complexity to the auction design. This complexity would be greater for the current award, due to the larger number of lot categories that bidders could in theory switch between using withdrawals (i.e. there are three bands, as opposed to two in the last auction). We also considered that there would be less substitution risk compared to the 2018 auction, as we do not consider the bands in this auction to be close substitutes.
- 5.118 Given the scope for strategic bidding and unsold spectrum, as well as the complexity withdrawals add to the auction design, we therefore considered that for this auction the downsides of withdrawals outweigh the benefits of withdrawals.³³¹
- 5.119 BT/EE, Vodafone, H3G and O2 all agreed with our proposal to not include withdrawals in the auction design, and broadly the reasoning behind our proposals, including limited substitutability between bands, the risk of unsold spectrum, strategic bidding and complexity.^{332 333 334 335} We received no other comments.
- 5.120 Given the agreement from stakeholders to not allow withdrawals, we have decided to proceed on this basis.

³³⁰ The exception to this is the benefit of waivers in helping bidders to manage technical difficulties preventing a bidder from submitting a bid. Under these circumstances, there is a further process specified in the regulations to allow a bidder to submit a bid by alternative methods.

³³¹ See paragraphs 3.81-3.86 of our October 2019 consultation

³³² BT/EE non-confidential response to our October 2019 consultation, page 7, paragraph 2.16

³³³ Vodafone non-confidential response to our October 2019 consultation, page 7

³³⁴ H3G non-confidential response to our October 2019 consultation, page 36, paragraph 19.1

³³⁵ O2 non-confidential response to our October 2019 consultation, page 51, paragraph 143

Minimum requirement

- 5.121 We proposed not to allow bidders to specify a minimum requirement in any lot category in this award. Minimum requirements would have allowed a bidder to specify a minimum amount of spectrum it would be willing to win in a lot category, and have guaranteed that it would not be allocated less spectrum than this amount. The purpose of the minimum requirement would be to help bidders manage in-band aggregation risk, protecting them against the risk of being stranded with a quantity of spectrum which is below a minimum threshold. When minimum requirements are implemented, the minimum requirement threshold is usually set where there is the most significant source of value complementarity between lots.
- 5.122 While a minimum requirement would help to address aggregation risk, there are potential downsides to allowing bidders to specify a minimum requirement per band. For example, it may allow bidders to place strategic bids which have a relatively low chance of becoming winning bids, which may facilitate price driving or cause unsold spectrum. This could result in a less efficient outcome than would otherwise be the case.
- 5.123 In the 700 MHz bands, we considered that a minimum requirement would not be appropriate due to the small number of lots available in these bands. If spectrum were to go unsold as a result of allowing a minimum requirement in these bands, this could comprise a significant proportion of the total amount of spectrum available.
- 5.124 In the 3.6-3.8 GHz band, we thought that the potential predictability of demand in the 3.6-3.8 GHz band may magnify the risks of strategic bidding behaviour to raise prices in the band. The risks to a bidder of engaging in price driving would be significantly reduced by allowing bidders to specify a minimum requirement in 3.6-3.8 GHz. We also noted that, for MNOs, the aggregation risk associated with winning a small amount of spectrum in the 3.6-3.8 GHz band is reduced as they all have pre-existing holdings across the 3.4-3.8 GHz band. There may therefore be less need for MNOs to specify a minimum requirement in the 3.6-3.8 GHz band, compared to in the 2018 auction for the 3.4-3.6 GHz frequencies.
- 5.125 We said we would consider allowing 'new entrant' bidders that do not have spectrum holdings in the 3.4-3.8 GHz band at the time of the auction to specify a minimum requirement in the 3.6-3.8 GHz band, if we saw strong reasons for including such a measure as a result of responses to the consultation. This was because we consider it unlikely that such bidders would have strategic incentives to create unsold spectrum or to increase prices for other bidders, as they would be less likely to be direct competitors to MNOs in downstream markets. However, at the time of the October 2019 consultation, we had limited evidence of demand for such a measure from prospective bidders with no pre-existing 3.4-3.8 GHz holdings.

Stakeholder responses

- 5.126 We received comments from BT/EE, O2, Vodafone and H3G on minimum requirements.

- 5.127 O2 and Vodafone agreed with our proposal not to allow bidders to specify minimum requirements in any band. Vodafone said bidders are able to express a requirement for a minimum amount of spectrum by re-bidding, should they fail to become full standing high bidder in a particular round. On 700 MHz FDD specifically, Vodafone noted that H3G and BT/EE's holdings in the 800 MHz band demonstrate that there is a use case for 2x5 MHz.³³⁶ In addition, they noted that to a degree the 3.6-3.8 GHz award represents "a second bite of the cherry", with all operators already having at least 40 MHz of similar spectrum. O2 also said that it agreed that there should be no minimum requirements, in light of prior consultation responses and our conclusion that aggregation risk is not a significant concern.³³⁷
- 5.128 H3G said that bidders should be allowed to specify a 10 MHz minimum requirement in the 700 MHz SDL band, though agreed that bidders should not have this option in 700 MHz FDD and 3.6-3.8 GHz. It said that it is unlikely to be economic for MNOs to deploy only 5 MHz of 700 MHz SDL, and so bidders wanting a minimum of 10 MHz will face an aggregation risk. It said that the minimum requirement would give bidders the flexibility to bid for 15 MHz, while also protecting other bidders from winning an unwanted 5 MHz block. It suggested that the efficiency losses associated with unsold spectrum and the risk of strategic bidding were lower in the 700 MHz SDL compared to the other award bands.³³⁸
- 5.129 BT/EE argued in favour of allowing bidders the option of specifying a minimum requirement of up to 20 MHz in the 3.6-3.8 GHz band. While it said it would prefer the option of specifying a minimum requirement for 700 MHz FDD, it sees this as less important than for the 3.6-3.8 GHz bands. BT/EE said that it sees "little value in deploying a second carrier in the 3.6-3.8 GHz band of less than 20 MHz."³³⁹
- 5.130 BT/EE considered that, at the level of the minimum requirement it proposed (up to 20 MHz), any risk of price driving is very low. It said there are two ways in which the minimum requirement might influence price driving behaviour: (i) if it were to allow a potential price driving bidder more certainty that other bidders would outbid it; or (ii) if it were somehow to allow a potential price driving bidder to reduce the risk that its bid (or a part of it) would win. It suggested that these effects would not be material at the level of minimum requirement proposed:
- a) *"With regards to (i), if anything we think the incentive works the other way. As discussed above, price driving is more likely if the 'price driver' expects other bidders to outbid it (because its strategy is to drive prices up without winning the spectrum). If bidders find themselves standing high bidder for a quantity which is insufficient for their usage requirements, then they are more likely to continue to bid. Therefore, all else equal, price driving becomes more likely because the risk of driving and not being outbid is lower.*

³³⁶ Vodafone non-confidential response to our October 2019 consultation, page 7

³³⁷ O2 non-confidential response to our October 2019 consultation, page 51-52, paragraph 144

³³⁸ H3G non-confidential response to our October 2019 consultation, page 34-36, paragraph 18.1-18.17

³³⁹ BT/EE non-confidential response to our October 2019 consultation, page 7-8, paragraph 2.17-2.24

- b) *With regards to (ii), as discussed above, price driving is deterred if there is a high risk of inadvertently winning. Therefore, in order not to be deterred, a price driver specifying a 20 MHz minimum requirement would need to believe that the risk of inadvertently winning 20 MHz was low, because the likelihood of being outbid was high. However, if the likelihood of being outbid for 20 MHz is high, then the likelihood of being outbid for a slightly lesser amount, say 10 MHz, must also be high. This, in turn, implies that the risk of being stranded with 10 MHz is already low; and that a minimum spectrum requirement, therefore, does not make price driving more attractive (by removing this stranding risk)."*

Our decision

- 5.131 With regards to H3G's comments on 700 MHz SDL, we acknowledge that some bidders may face aggregation risk associated with winning an unwanted 5 MHz, and that the risk of price driving is lower compared to the other award bands. However, we think that bidders should be able to manage this aggregation risk through bidding. We also note that the ecosystem for SDL is still developing, and it is possible some prospective bidders may be willing to win 5 MHz. If a bidder does win a single 5 MHz lot, which it considers unviable, it also has the option of trading this spectrum after the auction.
- 5.132 We consider that the benefits of allowing bidders to specify a minimum requirement in SDL would be very small, particularly given the lower value of the SDL spectrum compared to the other bands. In light of the limited benefits, we do not consider it would be appropriate to allow bidders to specify a minimum requirement in 700 MHz SDL, given the risk of unsold spectrum (although we recognise the inefficiency of unsold spectrum may be lower compared to the other award bands).
- 5.133 In response to BT/EE, we recognise that the minimum requirement in 3.6-3.8 GHz would be a mitigation to aggregation risk to an extent and would therefore offer bidders more scope to stop bidding when faced with the prospect of prohibitively high prices. We acknowledge that this may, under certain circumstances, make it harder for a price driving bidder to effectively increase prices for its competitors. This deterrent to price driving would be limited to scenarios where other bidders are bidding on amounts close to their minimum requirement, or where the price driving bidder at least believes this to be the case.
- 5.134 However, we disagree with BT/EE's second point that a 3.6-3.8 GHz minimum requirement does not significantly reduce the risk of a price driving bidder inadvertently winning spectrum. In particular, we do not agree that it necessarily follows that, if a price driving bidder is likely to be outbid on 20 MHz, then it is also likely to be outbid on 10 MHz. We note that operators have told us that 80-100 MHz is the optimal amount of 3.4-3.8 GHz spectrum required for 5G. Given that all existing operators hold at least 40-50 MHz in 3.4-3.8 GHz spectrum, and that we are awarding 120 MHz in 3.6-3.8 GHz, we consider there are several plausible demand scenarios which would result in a price driving bidder facing a material risk of inadvertently winning spectrum, including 10 MHz.
- 5.135 We continue to think that the risks associated with offering a minimum requirement in 3.6-3.8 GHz outweigh the benefits, particularly the risk that the minimum requirement could

be exploited by a price driving bidder and the risk of unsold spectrum. This is also in light of the fact that other respondents, O2, H3G, and Vodafone, agreed with our view that a minimum requirement is not necessary to help manage aggregation risk in 3.6-3.8 GHz.

- 5.136 We have also received no further evidence of demand for a minimum requirement in 3.6-3.8 GHz from prospective new entrants.
- 5.137 We have therefore decided to proceed with our proposal to not allow bidders to specify a minimum requirement in any lot category in this award.

Information policy

- 5.138 We proposed to disclose the total number of qualified bidders and their identities before the auction. This is the same approach as proposed in the December 2018 consultation, and as we took in our previous auctions such as the 2018 award of the 2.3 GHz and 3.4-3.6 GHz bands. O2 agreed with this proposal, while no other stakeholders commented.³⁴⁰ We have therefore decided to adopt this proposal.
- 5.139 During the auction, we proposed to reveal limited information on excess demand at the end of each round. This is in the interest of maintaining a balance between mitigating the risk of strategic bidding, while still allowing sufficient information to make informed bidding decisions.
- 5.140 We recognised that some information about the level of aggregate demand may be useful to help bidders address risks in the auction. For example, demand information can help bidders to manage aggregation risk as it helps bidders identify what packages they are most likely to win. In circumstances where there is common value uncertainty (i.e. the value of the spectrum is common but unknown to bidders), information about the level of aggregate demand in each frequency lot category also allows bidders to improve estimates about spectrum value.
- 5.141 However, we were concerned that revealing precise levels of aggregate demand during the principal stage could facilitate strategic demand reduction or market division. As set out above, these are greater risks in the SMRA format compared to the CCA, and may be a particular concern for this award. Alternatively, revealing precise levels of demand may facilitate price driving in the SMRA. For example, a bidder that wishes to price drive could use precise aggregate demand information to more accurately predict bids to increase prices for other bidders in a band, while also minimising the risk that it ends up winning spectrum it does not actually want.
- 5.142 We therefore proposed to reveal the following demand information to bidders after the end of each principal stage round:
- a) For the 3.6-3.8 GHz band – excess demand rounded up to the nearest higher positive increment of 20 MHz. This would mean reporting excess demand as strictly less than

³⁴⁰ O2 non-confidential response to our October 2019 consultation, page 55, paragraph 156

20 MHz, at least 20 MHz but less than 40 MHz, at least 40 MHz but less than 60 MHz, etc.

- b) For the 700 MHz FDD band – excess demand rounded up to the nearest higher positive increment of 20 MHz, equivalent to multiples of 2x10 MHz. This would mean reporting excess demand as strictly less than 20 MHz (2x10 MHz), at least 20 MHz (2x10 MHz) but less than 40 MHz (2x20 MHz), at least 40 MHz (2x20 MHz) MHz but less than 60 MHz (2x30 MHz), etc.
- c) For the 700 MHz SDL band - we proposed to reveal information rounded up to the nearest higher positive increment of 10 MHz. This would mean reporting excess demand as strictly less than 10 MHz, at least 10 MHz but less than 20 MHz, at least 20 MHz but less than 30 MHz, etc.

Stakeholder responses

- 5.143 We received comments from O2 and BT/EE on our proposed information policy, who argued that Ofcom should reveal more information about demand after each round. In particular, they both considered that we should reveal exact levels of aggregate demand after each round.^{341 342} BT/EE also asked that Ofcom consider going further and reveal the identity of standing high bidders, and the number of lots on which they were standing high bidder, on the basis that bidders' valuations may be dependent on the spectrum that others may win.³⁴³
- 5.144 O2 suggested that the information policy would not act as a deterrent to price driving for H3G. It claimed that the risk of H3G inadvertently winning a substantial quantity of 3.6-3.8 GHz spectrum is very low, "owing to the predictable demands of its three MNO rivals". It also claimed that the risk of H3G inadvertently winning a small amount of spectrum would be offset by the strategic upsides of blocking others from securing sufficient 5G spectrum or strengthening its position in post-auction trades to defragment the band.³⁴⁴
- 5.145 O2 and BT/EE both raised the point that the proposed limited information policy can give rise to information asymmetries. This is because of the reasons discussed in the October 2019 consultation, i.e. when excess demand is low, a partial standing high bidder will know the exact level of demand in that particular round, and therefore the precise amount by which they would need to drop their demand in order to bring the principal stage to a close.³⁴⁵ O2 suggested that this information asymmetry was particularly problematic for this auction, due to H3G's pre-existing holdings in the 3.6-3.8 GHz band, and "the predictable focal points of demand for the other three MNOs, which will necessarily limit

³⁴¹ O2 non-confidential response to our October 2019 consultation, page 52-55, paragraphs 145-156

³⁴² BT non-confidential response to our October 2019 consultation, page 8-9, paragraph 2.29

³⁴³ BT non-confidential response to our October 2019 consultation, page 8-9, paragraph 2.30

³⁴⁴ O2 non-confidential response to our October 2019 consultation, page 52, paragraph 147

³⁴⁵ Paragraph 3.42 of our October 2019 consultation

their flexibility to drop demand in steps.” It claimed that H3G had more flexibility to change its demand, and so may be better positioned to benefit from information asymmetries.³⁴⁶

Our decision

- 5.146 We accept that, in circumstances where demand is very predictable, revealing only limited demand information may be a less effective mitigation to price driving and strategic demand reduction than would otherwise be the case. Stakeholders have suggested that this may apply to our auction, in particular in 3.6-3.8 GHz. We recognise that if there are clear focal points for demand, bidders will be able to make more accurate predictions to inform and maximise the pay-off from a strategic bidding strategy.
- 5.147 However, we consider that there is limited upside to revealing precise levels of aggregate demand information compared to our proposed policy of revealing only limited information. A bidder who has been made partial standing high bidder when there is low levels of excess demand will know the precise level of aggregate demand, regardless of the information policy. They will therefore be able to make informed bidding decisions based on the precise level of aggregate demand. When there are low levels of excess demand, the obfuscation of demand only affects full standing high bidders, who do not need to bid in that round. We therefore consider that there is limited downside to obfuscating the precise levels of excess demand for the purpose of bidders being able to make informed bids, whereas the upside of obfuscation is that it can help mitigate signalling and tacit collusion.
- 5.148 Regarding BT/EE’s suggestion of adopting a fully transparent information policy, we consider that this would give rise to a significantly increased risk of strategic bidding, including signalling and, under extreme scenarios, tacit collusion. We also consider that our proposal to reveal some, but not all, information about excess demand should allow for a sufficient amount of price and package discovery to inform bidders’ valuations as the auction progresses. Given our view of the risk of a full information policy undermining the integrity of the award process, we do not consider BT/EE’s suggestion appropriate for this award.
- 5.149 We still think there are advantages to revealing only some demand information to bidders at the end of each round in reducing the risk of strategic bidding. As demand can never be perfectly predictable, we think there remains merit in introducing some uncertainty on the precise levels of excess demand as a mitigation to price driving and strategic demand reduction. Given the limited upsides to revealing full aggregate demand information, we therefore do not see any strong reasons for deviating from our consultation proposals.
- 5.150 We have therefore decided to adopt our proposals to reveal limited information as follows:
- a) For the 3.6-3.8 GHz band – excess demand rounded up to the nearest higher positive increment of 20 MHz. This means we will report excess demand as strictly less than

³⁴⁶ O2 non-confidential response to our October 2019 consultation, page 55, paragraph 153

20 MHz, at least 20 MHz but less than 40 MHz, at least 40 MHz but less than 60 MHz, etc.

- b) For the 700 MHz FDD band – excess demand rounded up to the nearest higher positive increment of 20 MHz, equivalent to multiples of 2x10 MHz. This means we will report excess demand as strictly less than 20 MHz (2x10 MHz), at least 20 MHz (2x10 MHz) but less than 40 MHz (2x20 MHz), at least 40 MHz (2x20 MHz) MHz but less than 60 MHz (2x30 MHz), etc.
- c) For the 700 MHz SDL band - we propose to reveal information rounded up to the nearest higher positive increment of 10 MHz. This means we will report excess demand as strictly less than 10 MHz, at least 10 MHz but less than 20 MHz, at least 20 MHz but less than 30 MHz, etc.

Deposits during the principal stage

- 5.151 We proposed the same approach to deposits that we adopted for the 2018 auction of the 2.3 GHz and 3.4-3.6 GHz bands, which was also an SMRA.
- 5.152 We proposed that applicants would need to submit an initial monetary deposit which might be forfeited, in whole or in part, if the applicant subsequently breaches the Auction Regulations. In addition, before the first round of the auction, qualified bidders would need to provide an additional deposit to Ofcom which would determine the bidder's initial eligibility level. Any interest made by Ofcom while holding the deposits would be paid into the Consolidated Fund.
- 5.153 We proposed that a bidder's initial eligibility would correspond to the maximum number of spectrum lots it could acquire using its total deposit at the reserve price(s). We also proposed that, at any point during the auction, Ofcom may require bidders to increase their deposits up to an amount equal to the value of the highest bid submitted so far by the bidder.
- 5.154 O2 supported the proposed approach as it "provides an appropriate mechanism to deter insincere bidding."³⁴⁷ BT/EE also said it was content with the same deposit proposals in its response to the December 2018 consultation.³⁴⁸
- 5.155 We have therefore decided to adopt our proposed approach.

Assignment stage

- 5.156 Upon completion of the principal stage of the auction, which determines the amount of spectrum that each bidder wins in each lot category, we will hold an assignment stage where bidders can bid for the exact location of the spectrum they have won.

³⁴⁷ O2 non-confidential response to our October 2019 consultation, page 56, paragraph 157

³⁴⁸ BT non-confidential response to our December 2018 consultation, page 74, paragraph 5.67

700 MHz and 700 MHz SDL bands

- 5.157 For the 700 MHz FDD and 700 MHz SDL bands, we proposed a single-round, sealed bid auction where bidders would be invited to bid for the exact location of their frequencies among permissible assignment plans. For each band separately, we would then identify the highest value combination of bids that can be accommodated. Assignment stage prices, which are additional to base prices from the principal stage, are calculated using a second price rule.
- 5.158 This was the same approach that we followed in previous auctions. The second price rule is intended to incentivise bidders to bid their true valuations, which is more likely to result in an efficient outcome. By contrast, a pay-as-bid rule may incentivise bidders to bid below their valuations in an attempt to minimise costs, bidding in accordance with their expectations on how other bidders are likely to bid. If bidders' expectations are wrong, this may result in them not being assigned frequencies in line with their valuations.

Stakeholder responses

- 5.159 We received comments from O2 on our assignment stage proposals for 700 MHz FDD and 700 MHz SDL. O2 supported our proposal to use a standard combinatorial sealed bid second price format, noting that this aligns with international best practice.³⁴⁹ BT/EE also said it was content with these proposals in response to our December 2018 consultation.³⁵⁰
- 5.160 O2 previously suggested in its response to our December 2018 consultation that we should prioritise adjacent placement between the upmost 700 MHz SDL lot (753-758 MHz) and the lowest downlink 700 MHz FDD lot (758-763 MHz), in the case where one or more bidders won spectrum in both bands. We addressed our reasoning for not adopting this in paragraph 3.122 of our October 2019 consultation.
- 5.161 In response, O2 said that if Ofcom did not wish to mandate adjacency between the 700 MHz bands, we should consider combining assignment rounds for the 700 MHz bands. It requested that each bidder that won both 700 MHz FDD and 700 MHz SDL in the principal stage would be provided with an additional combined assignment option, where the highest 700 MHz SDL frequencies would be adjacent to the lowest 700 MHz FDD downlink frequencies.
- 5.162 In a meeting with Ofcom in January 2020, an MNO [REDACTED] proposed that we should consider allowing bidders to express preferences for the identity of their neighbours in the 700 MHz FDD band. This may involve, for example, allowing bidders to make contingent assignment stage bids, or extending the scope of the negotiation period for 3.6-3.8 GHz winners to include winners of 700 MHz FDD.³⁵¹ It suggested that this would benefit any winners of just 2x5 MHz of 700 MHz FDD spectrum, who may wish to engage in spectrum pooling or post-auction trades to achieve larger blocks of low frequency

³⁴⁹ O2 non-confidential response to our October 2019 consultation, page 56, paragraph 158

³⁵⁰ BT non-confidential response to our December 2018 consultation, page 74, paragraph 5.68

³⁵¹ The negotiation period is discussed in section 6

spectrum. For example, if two bidders each won 2x5 MHz of 700 MHz FDD spectrum and both also held adjacent spectrum in the 800 MHz band, these winners could swap frequencies to each achieve larger contiguous holdings in the 700 MHz and 800 MHz bands respectively.

Our decision

- 5.163 We have considered O2's proposal for a combined assignment stage for the 700 MHz FDD and SDL bands, which we see may allow bidders to better express their preference for adjacent assignments. We understand that the benefits of adjacent assignments at the boundaries of the 700 MHz FDD and SDL bands may reduce deployment costs, as operators would not need to purchase additional filters. We also note that non-adjacent assignments across the 700 MHz bands would still be useable, and therefore there is limited risk to spectrum efficiency or to the quality of services provided to consumers.
- 5.164 The benefits of a combined 700 MHz assignment stage would only apply in a limited set of circumstances, specifically if there are multiple winners in 700 MHz SDL that have also won 700 MHz FDD spectrum. Where only a single bidder has won the SDL spectrum, then the bid options in a combined and separate 700 MHz assignment stage would be the same.
- 5.165 As we set out in the October 2019 consultation, bidders can already express bids to achieve adjacent placements in the band (albeit with some aggregation risk). In the event that a winner of both 700 MHz bands did not receive its most preferred assignment, there could also be a simple post-auction trade (such as a swap of assignments) for them to achieve adjacency. We therefore consider that the incremental benefits of O2's proposal would be limited.
- 5.166 We have also considered the proposal from an MNO [REDACTED] of allowing bidders to express preferences about their neighbours in 700 MHz FDD. As we noted in our October 2019 consultation, bidders may face an aggregation risk of just winning a single 2x5 MHz lot of 700 MHz FDD spectrum.³⁵² This suggestion may help to reduce the impact of this aggregation risk, under certain circumstances.
- 5.167 As set out in our June 2019 consultation, we consider there would be material risks to allowing contingent bidding in the assignment stage. These risks include adding complexity to bidder choices, increasing scope for strategic bidding, and bidders bidding against each other if they have different views on their preferred neighbour.
- 5.168 It is also not clear that there would be a significant gain to extending the scope of the negotiation period to 700 MHz FDD. While there may be some aggregation risk in this band, we consider that 2x5 MHz would still be a useable amount of spectrum. The benefits of making this change would also likely only be relevant in a limited set of circumstances, notably where there are two winners of 2x5 MHz of 700 MHz FDD, that also have adjacent holdings in the 800 MHz band, and that would be willing to swap frequencies. However,

³⁵² See paragraphs 3.20-3.22 of our October 2019 consultation.

under these circumstances, those winners can still bid to express a preference to be next to one another, e.g. bidding highly for the frequencies second from the bottom or top.

- 5.169 In addition, there would be some downsides to adopting this proposal from [REDACTED]. For example, it could facilitate price driving in the principal stage by reducing the impact to a price driving bidder of accidentally winning a small amount of spectrum in 700 MHz FDD, as it would more easily be able to set up a post auction trade as a mitigation. Noting that the MNO made this proposal after the initial consultation period, pursuing it at this stage would likely have an impact on auction timelines, including likely need to re-consult.
- 5.170 We have therefore decided not to adopt these alternative proposals, and will proceed with our October 2019 proposals for the 700 MHz FDD and 700 MHz SDL assignment stage. We consider that these suggestions would have limited incremental benefits. We also note that these changes would also have practical implementation issues, requiring time and cost to make changes to the regulations and software, and potentially re-consult.

3.6-3.8 GHz band

- 5.171 As set out in section 6, we have decided to follow a similar approach to bidding in the 3.6-3.8 GHz band as in the 700 MHz band, but have also decided to include additional measures to facilitate defragmentation of the wider 3.4-3.8 GHz band.
- 5.172 We are therefore proceeding with the following measures:
- a) **a restriction on winners of 20 MHz or less of 3.6-3.8 GHz spectrum** to bidding for (and winning) either the top or the bottom of the band in the assignment stage of the auction; and
 - b) **a pause of up to four weeks before processing assignment stage bids, to allow a negotiation period where bidders can agree the assignment of 3.6-3.8 GHz spectrum.** During the initial phase of this period, winners of 3.6-3.8 GHz spectrum will have an opportunity to agree unanimously on the assignment of the 3.6-3.8 GHz band. In the event that bidders are unable to reach unanimous agreement during this period, there will be an additional phase during which one or more subset(s) of bidders may agree to be assigned blocks of spectrum which are adjacent to each other.³⁵³ We have also included a rule with the effect that if any bidders agree to be assigned adjacent blocks of spectrum, any bids they had made during assignment stage bidding would be reduced to zero, meaning they would not be able to express a preference for their location in the band.

³⁵³ Winners of 3.6-3.8 GHz spectrum are not restricted on which other parties they can negotiate with during the negotiation period, which may also include bidders that have not won spectrum in the band.

5.173 Further detail on stakeholders' comments on our proposals and reasoning for our decision is set out in section 6 and in the draft final Auction Regulations that we have published alongside this consultation.³⁵⁴

Reserve prices

5.174 We proposed the following ranges of reserve prices:

- a) for 700 MHz FDD spectrum, within the range of £100m-£240m per 2x5 MHz lot;
- b) for 700 MHz SDL spectrum, £1m per 5 MHz lot;
- c) for 3.6-3.8 GHz spectrum, within the range of £15m-£25m per 5 MHz lot.

5.175 We generally adopt a conservative approach to setting reserve prices. We proposed to set reserve prices that are materially lower than our benchmarks for possible market value (where meaningful benchmarks are available).³⁵⁵ This would provide room for relevant price discovery, while still mitigating concerns about tacit collusion and strategic demand reduction.³⁵⁶

5.176 In determining our conservative approach, we considered the risks and trade-offs associated with setting higher or lower reserve prices:

- a) Low reserve prices may provide incentives for bidders to tacitly collude by increasing the pay-off from such behaviour in winning cheap spectrum. For a similar reason, they may also incentivise individual bidders to engage in strategic demand reduction (i.e. bid for a lower number of lots than they would otherwise, with the expectation that this would allow them to win less spectrum, but at a lower price).
- b) High reserve prices may increase the risk of unsold spectrum. They also reduce the margin for price discovery during the principal stage of the auction. Price discovery allows bidders to improve their individual expectations about the likely value of the spectrum, and adapt their bidding strategy accordingly, which is desirable.
- c) A high reserve price may also discourage participation, particularly from smaller bidders. There are many possible uses and users for the spectrum, and we believe the auction should not unduly preclude bidders from having an opportunity to compete in the auction.

5.177 We based our range of reserve prices for 700 MHz FDD by examining spectrum awards in European countries which included the 700 MHz and 800 MHz bands. We used prices from

³⁵⁴ https://www.ofcom.org.uk/data/assets/pdf_file/0018/192411/auction-regulations-award-700mhz-3.6-3.8ghz-spectrum.pdf

³⁵⁵ This is different from the approach Ofcom uses for setting Annual Licence Fees (where we also use evidence on benchmarks for market value). In setting Annual Licence Fees, Ofcom takes a conservative interpretation of the evidence to determine market value, whereas in this auction we wish to set reserve prices below market value to avoid unsold spectrum, encourage participation and allow a margin for price discovery.

³⁵⁶ A full explanation of our approach to setting spectrum reserve prices in the December 2018 consultation at paragraphs 7.233-7.238

these awards to derive UK-equivalent absolute value benchmarks by band and calculated the relative values between these bands in the benchmark countries.

- 5.178 We proposed a low reserve price of £1m per 5 MHz lot of 700 MHz SDL spectrum, in the absence of meaningful benchmarks for market value. We noted that there had been recent auctions in Switzerland and Denmark in which 700 MHz SDL spectrum was awarded, where the reserve prices were above our proposed reserve price. However, the final price of the spectrum band was not published in either auction. We also noted that 5 MHz of SDL spectrum went unsold in Switzerland. We said that, before our final statement we would see if meaningful benchmarks could be obtained from auctions taking place between our consultation and now.
- 5.179 To assess a reserve price for spectrum in the 3.6-3.8 GHz band, we looked at market prices in the UK's 3.4-3.6 GHz band as a benchmark. In the principal stage of the 2.3 and 3.4 GHz auction, spectrum in the 3.4-3.6 GHz band was won by three of the four mobile operators at the price of £37.8m per 5 MHz.³⁵⁷ We considered this to be the most reliable benchmark, as the bands are very similar and using a UK benchmark instead of international benchmarks for this band allows us to accommodate UK-specific market characteristics, meaning that fewer adjustments are necessary.
- 5.180 In our December 2018 consultation we also considered factors which may influence the market value of spectrum of 3.6-3.8 GHz, such as existing 5G spectrum holdings and usability of the band. We believed that, although all four operators already hold useable 5G spectrum in the 3.4-3.6 GHz band, it was sufficiently clear that we intended to auction the 3.6-3.8 GHz band, and that this would be factored into operators' valuations of spectrum in both bands. On usability, we considered that the 3.6-3.8 GHz spectrum may be useable slightly later than the 3.4-3.6 GHz band.
- 5.181 We found it appropriate to set a higher reserve price for the 3.6-3.8 GHz band than we did for the 3.4-3.6 GHz band. The reserve prices for 3.4-3.6 GHz were set when market values were less clear, whereas market evidence from the previous auction is now available to inform our reserve prices for 3.6-3.8 GHz.
- 5.182 In this section, we set out stakeholder responses to our proposals and final decisions on reserve prices for each band.

700 MHz FDD

- 5.183 All stakeholders agreed with a reserve price within the proposed range of reserve prices for 700 MHz FDD. Vodafone agreed with the proposed range, given the costs involved in clearing the band.³⁵⁸ H3G, O2 and BT/EE argued for reserve prices on the lower end of the proposed range.

³⁵⁷ O2 won 40 MHz of spectrum in the 3.4 GHz band at a higher cost of £39.7m per 5 MHz.

³⁵⁸ Vodafone non-confidential response to our October 2019 consultation, page 7, section 2.5

- 5.184 H3G and O2 argued for a reserve price of £100m per lot, both claiming that low reserve prices would increase the potential for price discovery and reduce the risk of unsold spectrum.³⁵⁹ ³⁶⁰ O2 disagreed with the relative value benchmark approach, in which Ofcom based the reserve price for 700 MHz FDD on the UK market price of 800 MHz. O2 stated that, in the relative benchmark evidence presented, there were awards in which the 700 MHz FDD spectrum or 800 MHz spectrum were awarded at reserve price, which suggested prices were driven by factors other than market value. O2 considered the conservative approach would be to set the reserve price at the low end of the relevant range, i.e. £100m per lot.³⁶¹ BT/EE also argued for a reserve price closer to the lower limit so the reserve price would be materially lower than the benchmarks for possible value.³⁶²
- 5.185 We do consider there to be a potential risk of tacit collusion or strategic demand reduction in this band. For example, if there were three bidders expected to bid in the band, there may be a clear focal point at 2x10 MHz for each bidder. This could result in bidders bidding for less spectrum than they otherwise would, resulting in inefficiency. This could suggest a higher reserve price is appropriate.
- 5.186 However, we acknowledge that there is uncertainty regarding the market value of 700 MHz FDD. Our UK-equivalent relative benchmarks gave a wide range of values for 2x5 MHz of 700 MHz FDD which spanned from £95m to £507m.³⁶³ Uncertainty over market value suggests it would be appropriate to pick a reserve price on the lower end of the range in order to mitigate the risk of unsold spectrum and allow bidders a greater margin for price discovery during bidding rounds in the principal stage. It could also mitigate the risk of discouraging participation, particularly of smaller bidders. Given the uncertainty in market value, we consider these risks outweigh the potential risk of tacit collusion or strategic demand reduction.
- 5.187 Therefore, we have decided to set the reserve price at £100m per lot for 2x5 MHz of 700 MHz FDD, which is the lowest point on the consultation range.

700 MHz SDL

- 5.188 BT/EE, Vodafone and O2 agreed with the proposed reserve price of £1m per lot for 700 MHz SDL, with O2 noting “This band has no established ecosystem and its value is uncertain, so it is prudent to allow the market maximum freedom to set the price.”³⁶⁴ We received no other comments.

³⁵⁹ H3G non-confidential response to our October 2019 consultation, page 38, section 21

³⁶⁰ O2 non-confidential response to our October 2019 consultation, page 45, paragraph 123

³⁶¹ O2 non-confidential response to our October 2019 consultation, page 45, paragraph 127

³⁶² BT non-confidential response to our October 2019 consultation, page 12, paragraph 2.48

³⁶³ In response to O2, we take into account that there may be a risk that awards included within our benchmarks may be over- or understated. For example, as we stated in the December 2018 consultation, in our view, bidding in the 700 MHz band in the German 2015 auction may have been affected by strategic demand reduction and bid signalling. We concluded in the 2015 statement on annual licence fees for 900 MHz and 1800 MHz that there was a risk that the price of 900 MHz understated market value in Germany.

³⁶⁴ BT non-confidential response to our October 2019 consultation, page 12, paragraph 2.49; O2 non-confidential response to our October 2019 consultation, page 47, paragraph 128; Vodafone non-confidential response to our October 2019 consultation, page 7, section 2.5.

- 5.189 We note that there have been no further auctions since our October 2019 consultation to provide any meaningful benchmarks for 700 MHz SDL.
- 5.190 We still consider the market value of 700 MHz SDL spectrum to be uncertain. Therefore, we have decided to set the reserve price at £1m per lot for 5MHz of 700 MHz SDL.

3.6-3.8 GHz

- 5.191 Stakeholders generally favoured a lower reserve price for 3.6-3.8 GHz. O2 argued for a reserve price on the low end of the proposed £15m-£25m range. BT/EE and Vodafone argued for the reserve price to be lower than the proposed range.
- 5.192 BT/EE was concerned that our proposed range of reserve prices for 3.6-3.8 GHz, which was based on market prices for 3.4-3.6 GHz, may be set too high.³⁶⁵ BT/EE argued the UK market value of 3.4-3.6 GHz is likely to be higher than that of 3.6-3.8 GHz. It said this was due to the uncertainty of the availability of the 3.6-3.8 GHz spectrum at the time of the 3.4-3.6 GHz award, which led to an ‘artificial scarcity premium’, and the associated value of 3.4-3.6 GHz being the first spectrum to be released for 5G services. BT/EE said that, if Ofcom’s estimate of market value for 3.6-3.8 GHz was significantly wrong, this could impede price discovery or result in unsold spectrum. It therefore said that Ofcom should adopt a reserve price for 3.6-3.8 GHz spectrum which is closer to the reserve prices used in the 2018 auction for 3.4-3.6 GHz.
- 5.193 Vodafone also suggested that the value of 3.6-3.8 GHz may not be as high as for 3.4-3.6 GHz.³⁶⁶ Vodafone noted that the reserve price for 3.4-3.6 GHz spectrum was £1m per lot, in contrast with our proposed range of £15m-25m for 3.6-3.8 GHz. It questioned this difference given that, in its view, the opportunities for tacit collusion in 3.6-3.8 GHz are unchanged and the clearance costs are arguably lower. Vodafone also considered that the proposed range of reserve prices may impose a need for extreme levels of upfront deposits, which could cause issues for participants obtaining internal approvals. It also suggested that the deposit requirements may make it more difficult for a bidder who wished to speculatively bid on large amounts of spectrum in the early stages of the auction.
- 5.194 O2 argued for a reserve price at the lower end of the range, at £15m per lot.³⁶⁷ O2 said this would represent a conservative approach given the variability in prices in 3.4-3.8 GHz observed in European awards. O2 calculated ‘UK Equivalent’ prices for awards in various European countries and highlighted that multiple countries have awarded 3.6-3.8 GHz spectrum at below the proposed £15m-£25m range.
- 5.195 One role for the reserve price is to help mitigate concerns around tacit collusion, which we consider to be a greater risk in this auction compared to the previous award, given the potential greater predictability of demand. In addition, the auction of 3.4-3.6 GHz spectrum in 2018 significantly reduced the degree of uncertainty about market value. In

³⁶⁵ BT non-confidential response to our October 2019 consultation, page 12-13, paragraph 2.50-2.56

³⁶⁶ Vodafone non-confidential response to our October 2019 consultation, page 11, section 3.4

³⁶⁷ O2 non-confidential response to our October 2019 consultation, page 45, paragraph 124

- response to O2, we still consider that the UK 3.4-3.6 GHz price provides more reliable evidence on market value than relative-value benchmarks derived from overseas auctions.
- 5.196 Therefore, in our view, it would not be appropriate to use the same reserve price for this award as in the 2.3 GHz and 3.4-3.6 GHz auction, as Vodafone and BT/EE have argued. Additionally, in response to Vodafone, given that the range is much lower than the benchmark price of 3.4-3.6 GHz (e.g. the mid-point is 47% lower), we do not consider that any implications for bidders' deposits are unreasonable.
- 5.197 We disagree with BT/EE that there was an 'artificial scarcity' premium for 3.4-3.6 GHz spectrum. At the time of the 3.4-3.6 GHz spectrum award, we consider that it had been made sufficiently clear we intended to auction spectrum in the 3.6-3.8 GHz band, and that this would be factored into operators' valuations of spectrum in both bands. BT/EE also asserted there was a 'first mover' premium attached to the price of 3.4 GHz spectrum, [REDACTED]. We do not consider there to be clear evidence that the price of 3.4-3.6 GHz spectrum reflected a 'first mover' premium, noting that BT/EE have presented no evidence to suggest there is a significant impact [REDACTED]. As set out in our 2019 statement "Annual Licence Fees for UK Broadband's 3.4 GHz and 3.6 GHz spectrum", we did not consider the 2018 auction reflected a premium to launch 5G services. We reached this conclusion based on planned rollout of 5G services in 2019 and unclear evidence on the long-term impact of being first to 5G.³⁶⁸
- 5.198 We therefore maintain it is appropriate to set a higher reserve price for 3.6-3.8 GHz than we did for the 3.4-3.6 GHz band in the 2018 auction, when market values were less clear. Stakeholders face less uncertainty over the value of the 3.6-3.8 GHz spectrum compared to the previous auction, as market evidence from the previous auction is now available.
- 5.199 In determining the appropriate level of the reserve price, we have considered the particular risks associated with setting the price higher or lower within the proposed range as they apply to the 3.6-3.8 GHz band. We consider there to be a low risk of unsold lots with our proposed range of reserve prices, given the UK market price of 3.4-3.6 GHz, which suggests it is unnecessary to set the reserve price at the bottom of the range. As discussed above, we consider tacit collusion may be a particular risk for this award which suggests a reserve price toward the higher end of the range may be more appropriate. However, we also would not want to unduly reduce the margin for price discovery or discourage participation from smaller bidders by setting the reserve price at the very top of the range.
- 5.200 Therefore, we have decided on a reserve price of £20m per 5 MHz of 3.6-3.8 GHz, which was the mid-point of our proposed range.

³⁶⁸ Annual Licence Fees for UK Broadband's 3.4 GHz and 3.6 GHz spectrum, page 51, paragraph A1.37.

6. Defragmentation of the 3.4-3.8 GHz band

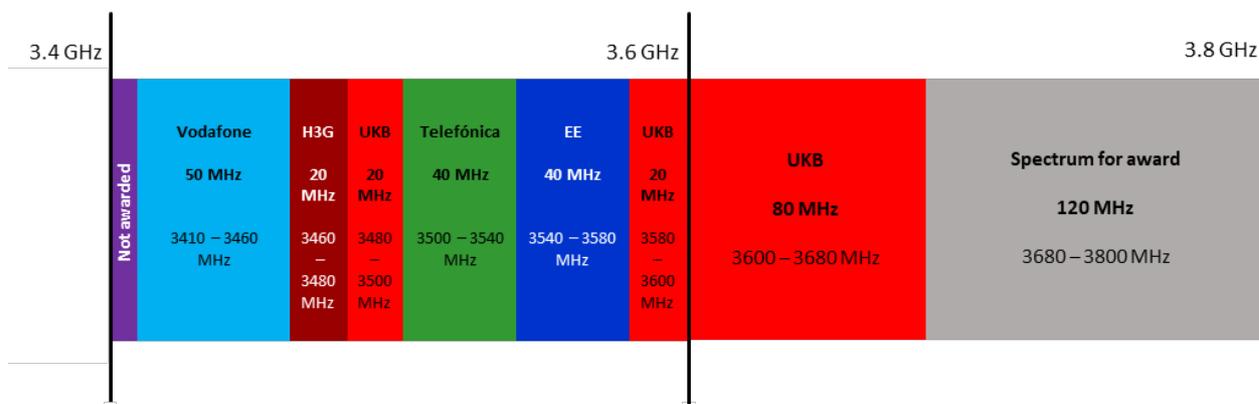
Summary of our decision

- 6.1 In this section, we set out our decisions on the measures we are including in the assignment stage of the auction to facilitate defragmentation of the 3.4-3.8 GHz band, which are:
- a) a restriction on winners of 20 MHz or less of 3.6-3.8 GHz spectrum to bidding for (and winning) either the top or the bottom of the band;
 - b) a pause of up to four weeks before processing assignment stage bids, to allow a negotiation period where bidders can agree the assignment of 3.6-3.8 GHz spectrum among themselves. The negotiation period will allow agreement between a subset of bidders if unanimous agreement is not reached; and
 - c) not to publish the assignment stage bids in the 3.6-3.8 GHz band, to eliminate the potential negative impact that publishing this information could have on post auction trades to defragment the band.

Introduction

- 6.2 The arrangement of spectrum holdings in the 3.4-3.8 GHz band ahead of the auction is illustrated in Figure 6.1 below.

Figure 6.1 – The 3.4-3.8 GHz band



- 6.3 We awarded the majority of the bottom half of the band (3.4-3.6 GHz) in the 2018 2.3 GHz and 3.4-3.6 GHz auction.³⁶⁹ We decided it was appropriate to award these frequencies separately from the frequencies in the upper part of the 3.6-3.8 GHz band for a number of reasons, including in particular that the lower frequencies were cleared and available for

³⁶⁹ The licences authorising use of 3480-3500 MHz and 3580-3600 MHz were auctioned by the Radiocommunications Agency in June 2003, and were acquired by the company that became UK Broadband. The separate licences were combined by Ofcom into a single 3.4 GHz licence in March 2007. The licence authorising the use of 3600-3680 MHz was initially granted in 1992 by the Radiocommunications Agency. It was then traded several times during the 1990s and sold to UK Broadband in 2010.

use at the time, whereas the higher frequencies were not necessarily expected to be cleared nationwide until 2022 (although operators were expected to be able to launch mobile services in many areas from around 2020). We anticipated that operators would be likely to use the frequencies awarded in 2018 to roll out 5G services before July 2020, and each of the four MNOs has now done so.

6.4 Like this auction, the 2018 2.3 and 3.4 GHz auction had two stages: a principal stage and an assignment stage. Bidders in the auction made bids for specific frequencies in the assignment stage as follows:³⁷⁰

- a) EE bid £50m for 3540-3580 MHz (and paid £1m for 3540-3580 MHz);
- b) H3G bid £25m for 3460-3480 MHz (and paid £13m for 3460-3480 MHz);
- c) O2 bid £1m for 3540-3580 MHz (it was not required to pay for its final allocation at 3500-3540 MHz); and
- d) Vodafone bid £13m for 3430-3480 MHz (it was not required to pay for its final allocation at 3410-3460).³⁷¹

6.5 The sums bid for particular frequencies within the 3.4-3.6 GHz band indicate that licensees placed value in winning rights to particular frequencies and that these constitute a central term of the spectrum licences concerned.

6.6 As a result of the current allocation, absent shifts of existing frequency assignments, mobile network operators' holdings in the 3.4-3.8 GHz band after the auction will be fragmented. We recognise that defragmentation – by which we mean a reduction in the distance between operators' holdings (proximity) or elimination of fragmentation of spectrum holdings (contiguity) – could yield benefits. Firstly, operators with separate spectrum block holdings sufficiently close together could avoid some costs, e.g. of deploying more than one active antenna on each of a large number of masts. Secondly, any operator consolidating its separate holdings into a contiguous block could derive some additional benefits, e.g. by maximising the traffic capacity it deploys. We note, however, that shifts of existing frequency assignments could also give rise to costs, e.g. to replace equipment already deployed.

6.7 The rest of the section is structured as follows:

- a) A summary our consultation proposals, from paragraph 6.8;
- b) Our reasoning for not imposing a reassignment of the whole 3.4-3.8 GHz band, from paragraph 6.26; and
- c) The measures we are including in the 3.6-3.8 GHz assignment stage to facilitate post auction trades, from paragraph 6.86.

³⁷⁰ The bids and amounts paid shown here are rounded to the nearest million pounds.

³⁷¹ See <https://www.ofcom.org.uk/spectrum/spectrum-management/spectrum-awards/awards-archive/2-3-and-3-4-ghz-auction>

Our consultation proposals

- 6.8 One of the issues we have been considering is whether it would be appropriate for us to include measures in this auction to facilitate defragmentation of the 3.4-3.8 GHz band, and if so, what measures it would be appropriate to include. We have consulted on this three times:
- a) In December 2018, we consulted on our provisional view that the most effective approach would be to allow the market to determine the best allocation of spectrum - first through the auction and then through spectrum trading.³⁷² In particular, we set out and explained our provisional view that requiring a complete re-organisation of the 3.4-3.8 GHz band would not be a proportionate measure.
 - b) Having considered stakeholders' responses to the December 2018 consultation, we consulted again in June 2019 on measures we proposed to include in the assignment stage of the auction (i.e. the small winner restriction and the negotiation period).
 - c) In October 2019, we consulted again on some changes to our June 2019 proposals, in light of comments made by stakeholders.
- 6.9 We set out the proposals we have consulted on in more detail below.

December 2018 consultation

- 6.10 In the December 2018 consultation, we acknowledged the general consensus – including among mobile network operators (MNOs) and European regulatory bodies – that optimal deployment of 5G will be best achieved through large contiguous spectrum blocks.
- 6.11 We also acknowledged that it is clear that the EU legislation considers that making large amounts of contiguous spectrum available is desirable. However, we noted that none of the relevant EU legislation requires Member States to guarantee the allocation (or the contiguous allocation) of 80-100 MHz to each operator.
- 6.12 We recognised that defragmentation of the 3.4-3.8 GHz band may well be desirable given the benefits that contiguity of spectrum holdings could bring.
- 6.13 We said that in the absence of contiguous spectrum, an operator may benefit from having its separate blocks of 3.4-3.8 GHz spectrum sufficiently close to each other. This may allow it to avoid higher costs of equipment e.g. it may avoid having to deploy more than one antenna to make use of frequency bands that are wide apart.
- 6.14 We referred to this as the 'proximity' of an operator's spectrum blocks. We considered there were advantages in proximity, although contiguity was likely to be a better outcome.
- 6.15 We considered whether there were steps we could take to facilitate defragmentation of the wider 3.4-3.8 GHz band, so that all or most operators were able to have contiguous

³⁷² See section 6 of the December 2018 consultation.

holdings – or, at least, holdings in which blocks allocated to each operator were in close proximity to each other.

- 6.16 We also set out our provisional view that requiring a complete re-organisation of the band (much of which was awarded in the recent 2.3 and 3.4-3.6 GHz auction, and in relation to which current licensees were prepared to pay significant sums for their particular locations) would not be proportionate. We further noted that a complete re-organisation of the band might well entail a revocation of existing licences in the band, in which case we would not be able to implement it without significant notice.³⁷³
- 6.17 We set out our provisional view that the most effective approach to defragmentation of the wider 3.4-3.8 GHz band was to allow the market to determine the best allocation of spectrum - first through the 700 MHz and 3.6-3.8 GHz auction and then through spectrum trading. We considered three particular options to facilitate post auction trades through the assignment stage. At the time, we proposed to proceed with a conventional assignment stage of the 3.6-3.8 GHz band for the auction, without any of these options, and invited comments.

June 2019 consultation

- 6.18 On 11 June 2019, following consideration of stakeholders' responses to the December 2018 consultation, we published revised proposals for part of the award process, with the aim of facilitating defragmentation (the '**June 2019 consultation**').³⁷⁴

Small winner restriction

- 6.19 We said we were minded to impose a restriction on winners of less than 20 MHz of 3.6-3.8 GHz spectrum to bidding only for the top or bottom of the 3.6-3.8 GHz band in the assignment stage of the auction (the '**small winner restriction**').³⁷⁵ This would enable winners of large blocks of spectrum to be assigned adjacent blocks, which would facilitate trading between them. It would also remove the possibility of a bidder winning a small amount of spectrum and strategically bidding for the middle of the band purely to frustrate post-auction defragmentation trades between other bidders.

Negotiation period

- 6.20 In addition, we said that we were minded to include a negotiation period within the assignment stage of the auction. During this period, winners of 3.6-3.8 GHz spectrum would have the opportunity to agree between themselves the assignment of frequencies in the band and, at their discretion, they may also choose to provisionally agree any post-auction trades.

³⁷³ See paragraphs 6.15 – 6.25 of the December 2018 consultation.

³⁷⁴ Ofcom's consultation of 11 June 2019, entitled "Defragmentation of spectrum holdings in the 3.4-3.8 GHz band"; see <https://www.ofcom.org.uk/consultations-and-statements/category-3/defragmentation-spectrum-holdings>

- 6.21 We set out two possible sub-options of the negotiation period. One sub-option, which we considered in the December 2018 consultation and June 2019 consultation, would require **unanimous agreement** among the winning bidders of 3.6-3.8 GHz spectrum. We said that if we implemented this, there would still be a conventional assignment stage in which winning bidders of 3.6-3.8 GHz spectrum could bid for assignments in different parts of the band. However, following bidding in the assignment stage, we would pause the auction to allow winners of 3.6-3.8 GHz spectrum to attempt to reach unanimous agreement on the assignment of the 3.6-3.8 GHz frequencies. We said that if such agreement was successfully reached, Ofcom would assign the 3.6-3.8 GHz frequencies according to that plan, and Ofcom would not process or publish the assignment stage bids that had been made.
- 6.22 The other sub-option, which we set out in the June 2019 consultation, would allow for **partial agreement** in the absence of unanimous agreement. This option would allow a subset of winners of 3.6-3.8 GHz spectrum to reach an agreement during the negotiation period that they would be assigned adjacent blocks of spectrum, but would not be able to specify a preference for a particular location in the band (which the auction rules would put into effect by setting their 3.6-3.8 GHz assignment stage bids to zero).³⁷⁶ In the June 2019 consultation, we said that, as a minimum, we were minded to adopt the unanimous agreement negotiation period.

October 2019 consultation

- 6.23 Having considered responses to the June 2019 consultation, we set out in the October 2019 consultation our provisional conclusions on the measures we would include in the auction to facilitate defragmentation of the wider 3.4-3.8 GHz band plan. We continued to be minded to include a restriction on small winners of spectrum to the top or bottom of the 3.6-3.8 GHz band. We considered, however, that the restriction should apply to winners of 20 MHz or less, rather than to winners of less than 20 MHz. We thought this would increase the probability of the 3.4-3.8 GHz band being defragmented through post auction trades as a winner of 20 MHz would not be able to frustrate trades.
- 6.24 In addition, we said that we were minded to include a negotiation period of up to four weeks.³⁷⁷ During the first three weeks of this period, we would give winners of 3.6-3.8 GHz spectrum the opportunity to reach unanimous agreement on their assignments. If this were unsuccessful, winners of 3.6-3.8 GHz spectrum would have an additional one-week period during which a subset of winners could agree to be assigned blocks of spectrum which are adjacent to each other.
- 6.25 We noted that, whereas we normally publish all auction bid data alongside the results of an auction, it might be appropriate to take a different approach to the 3.6-3.8 GHz

³⁷⁶ A fuller summary can be found in paragraph 2.54 of the June 2019 consultation. We also set out examples of the partial agreement mechanics in annex 1 of the June 2019 consultation and annex 11 of this statement.

³⁷⁷ We were not minded to include any restrictions during the negotiation period on winners of 3.6-3.8 GHz spectrum as to the choice of parties with whom they could negotiate, regardless of whether those parties had won spectrum in the 3.6-3.8 GHz band.

assignment stage bid data. This was because we considered there to be a risk that publication of this data could adversely affect or undermine future commercial trading negotiations that may help to defragment holdings in the 3.4-3.8 GHz band. We therefore considered whether it would be appropriate to delay publication of 3.6-3.8 GHz assignment stage bid data, or not to publish the 3.6-3.8 GHz assignment stage bid data at all. We provisionally concluded that we should not publish 3.6-3.8 GHz assignment stage bid data.³⁷⁸

Reassignment of the whole 3.4-3.8 GHz band

Summary of our decision

- 6.26 Vodafone and O2 have asked us to use this auction to carry out a full reassignment of the wider 3.4-3.8 GHz band. They argue that it is necessary for us to intervene to re-organise the band in this way, to fulfil our statutory duties, and that a failure to do so would be a breach of those duties.
- 6.27 What they are asking us to do is to make a highly intrusive regulatory intervention, which would entail us mandating significant changes to existing spectrum rights. We have given the matter careful thought.
- 6.28 We agree that achieving greater spectrum proximity or contiguity through defragmentation of the 3.4-3.8 GHz band would provide consumer benefits. We do not agree that we are required by our statutory duties to guarantee full contiguity in the band. We have considered whether it would nevertheless be appropriate and proportionate to intervene to guarantee it.
- 6.29 Having taken account of the relevant circumstances, including stakeholders' comments, we do not consider it would be appropriate to use this auction to impose a full reassignment of the whole 3.4-3.8 GHz band. We consider that the MNOs can achieve improved proximity or greater or full contiguity through spectrum trading and have sufficient incentives to do so. In order to facilitate such trades and taking account of stakeholder responses, we have decided to provide for additional measures in the assignment stage of the auction. These measures will give the MNOs the opportunity to negotiate and agree the assignment of the 3.6-3.8 GHz spectrum, in preparation for post-auction trading.
- 6.30 The regulatory measures requested by Vodafone and O2 would have required us to mandate significant changes to the existing spectrum licences. We do not consider such an intervention would be proportionate, for the reasons we set out below. We also consider that such regulatory intervention would likely amount to a revocation of existing licences, which we could not – without the consent of all relevant licensees – give effect to except on at least 5 years' notice (or nearly 20 years' notice in the case of the licences awarded in the 2.3 and 3.4 GHz auction).

³⁷⁸ See paragraphs 3.141-3.145 of the October 2019 consultation.

Stakeholders' arguments in favour of imposing a full reassignment of the wider 3.4-3.8 GHz band

- 6.31 In response to the above consultations (and an earlier consultation concerning a variation of the UK Broadband's licence), some of the MNOs argued that we should impose a reassignment of holdings in the wider 3.4-3.8 GHz band. In particular:
- a) In response to our **June 2018 consultation** on UK Broadband's request for a licence variation, BT/EE³⁷⁹, Vodafone³⁸⁰ and O2³⁸¹ suggested that we should achieve further defragmentation of the 3.4-3.8 GHz band through a reassignment.³⁸²
 - b) In response to the **December 2018 consultation**, Vodafone said that Ofcom has a duty to *"ensure that large contiguous blocks are made available for operator usage"*. It accepted that Ofcom could only vary H3G's licence with five years' notice, but suggested that *"if Ofcom were to issue notice now to vary Three's licence in five years, Three would very quickly come to the table to resolve the issue"*.³⁸³ O2 said that Ofcom should *"insist that bidders consent to a variation of frequencies as a condition of entry to the auction"* and said it considered that to do so would be *"consistent with Ofcom's powers"*. It also said that Ofcom could use revenues from the auction to offer compensation for costs of moving frequencies and refunding fees from the assignment round of the 3.4-3.6 GHz auction where appropriate.³⁸⁴
 - c) In response to the **June 2019 consultation**, Vodafone³⁸⁵ and O2³⁸⁶ reiterated their view that Ofcom should make it a condition of entry into the award process that bidders put their existing spectrum up for reassignment in order to guarantee defragmentation and to ensure long term efficiency of spectrum. Vodafone suggested that we should devise an assignment stage where bidders could make negative bids for outcomes which would require them to move some or all of their existing holdings.³⁸⁷ O2 suggested we could make participating in full band assignment more attractive for H3G, e.g. by giving H3G first choice of frequency position in the reconfigured band and refunding assignment round fees from the 3.4-3.6 GHz award as a credit against auction payments or future annual licence fees.³⁸⁸ Both O2³⁸⁹ and Vodafone³⁹⁰ suggested that a failure by Ofcom to implement a full band reassignment would constitute a breach of

³⁷⁹ BT/EE non-confidential response to the June 2018 consultation, page 6.

³⁸⁰ Vodafone non-confidential response to the June 2018 consultation, page 9.

³⁸¹ O2 non-confidential response to the June 2018 consultation, paragraphs 5 and 61-68.

³⁸² See Ofcom's statement of 14 December 2018, paragraphs 4.12-4.15, available here:

https://www.ofcom.org.uk/data/assets/pdf_file/0014/130253/Statement-UK-Broadbands-spectrum-access-licence-3.6-GHz.pdf.

³⁸³ Vodafone confidential response to the December 2018 consultation, pages 50 and 51.

³⁸⁴ O2 non-confidential response to the December 2018 consultation, paragraphs 167-173.

³⁸⁵ Vodafone non-confidential response to the June 2019 consultation, page 5.

³⁸⁶ O2 non-confidential response to the June 2019 consultation, paragraphs 6-12 and 25-45.

³⁸⁷ Vodafone non-confidential response to the June 2019 consultation, pages 5-6.

³⁸⁸ O2 non-confidential response to the June 2019 consultation, paragraph 8(e).

³⁸⁹ O2 non-confidential response to the June 2019 consultation, paragraph 11 and 28.

³⁹⁰ Vodafone non-confidential response to the June 2019 consultation, page 3 and 5.

Ofcom's statutory duties. O2 also provided further detail on its estimates of the costs to operators of having non-contiguous spectrum in the wider 3.4-3.8 GHz band³⁹¹,³⁹².

- d) Following publication of our **October 2019 consultation**, O2 wrote to Ofcom to reiterate its position that full band reassignment was the only way to guarantee defragmentation, and noted that in its view Ofcom had "*failed to conduct a proper evidence-based assessment of the proposal by reference to its statutory duties*".³⁹³ In addition, in response to our October 2019 consultation, Vodafone³⁹⁴ and O2³⁹⁵ reiterated their arguments that we should use the auction to reassign the full 3.4-3.8 GHz band. Vodafone also noted the "*massive eco-impact*" of fragmented spectrum.³⁹⁶

Our assessment

- 6.32 A full band reassignment would entail Ofcom including the 3.4-3.6 GHz spectrum, for which licences have already been granted, in the assignment stage of the 3.6-3.8 GHz auction.

Legal framework

- 6.33 We have assessed stakeholders' arguments for a full reassignment of the wider 3.4-3.8 GHz band in light of our legal duties, which are summarised in section 3 (*Legal framework*). In particular, in line with the approach that we have taken in our competition assessment, the framework we have used for assessing the proportionality of different options for facilitating defragmentation is based on the following principles:

- a) any measure that we decide to impose must be effective to achieve the legitimate aim in question;
- b) the measure must be no more onerous than is required to achieve that aim;
- c) the measure must be the least onerous, if there is a choice of equally effective measures; and
- d) in any event, the measure must not produce adverse effects which are disproportionate to the aim pursued.

- 6.34 We have also considered whether such a regulatory intervention would unduly discriminate against any particular operator. Most obviously, H3G, given its existing holdings in the relevant spectrum bands.

³⁹¹ O2 non-confidential response to the June 2019 consultation, Annex 1.

³⁹² Ofcom's consideration of these costs is set out in Annex 7 at paragraphs A7.87-A7.99.

³⁹³ Letter from Lawrence Wardle to Gideon Senensieb dated 13 November 2019.

³⁹⁴ For example, Vodafone said that we "should incentivise Three's participation in a full 3.4-3.8 GHz defragmentation programme by making it a condition of their entry to the auction; there is every justification for such an approach on both spectrum management and competition grounds". See Vodafone non-confidential response to the October 2019 consultation, section 3.2.

³⁹⁵ O2 non-confidential response to the October 2019 consultation, paragraphs 5-8, and 14-49.

³⁹⁶ Vodafone non-confidential response to the October 2019 consultation, section 3.2.

Spectrum trading regime

- 6.35 We have considered stakeholders' comments in the context of the existing regime for spectrum trading. In 2011, Ofcom introduced trading for mobile telephony licences by the making of specific Mobile Trading Regulations. Those Regulations have been amended from time to time to bring new spectrum bands within the trading regime. This now includes both the 3.4-3.6 GHz spectrum which is already allocated to licensees, and the 3.6-3.8 GHz spectrum which we are auctioning.³⁹⁷
- 6.36 As set out below, the spectrum trading regime is an important part of the regulatory regime for spectrum, as it enables licensees, rather than only the regulator, to play a part in deciding what the efficient allocation of spectrum is. We also note that operators can reflect their individual relocation costs and the benefits they expect to achieve from improved proximity or contiguity in spectrum trading negotiations.

80 MHz of contiguous spectrum

- 6.37 In their responses to the June 2019 and December 2018 consultations, Vodafone and O2 argued that our duties require us to ensure that all operators can achieve at least 80 MHz of contiguous spectrum for the roll-out of 5G services; that we will have failed in our duties if we do not achieve this; and as a result we should provide for full band reassignment.
- 6.38 The relevant EU law (set out in an EC Decision on the 3.4-3.8 GHz band³⁹⁸ and the European Electronic Communications Code) says that:
- a) *“Taking into account Article 54 of the European Electronic Communications Code, Member States should aim at ensuring a defragmentation of the 3.4-3.8 GHz frequency band so as to provide opportunities to access large portions of contiguous spectrum...of preferably 80-100 MHz”* (see recital 10 of Decision 2019/235);
 - b) *“Within the 3.4-3.8 MHz frequency band... there shall be spectrum available providing the opportunity to access sufficiently large portions of contiguous spectrum, preferably 80-100 MHz, for wireless broadband electronic communications services”* (see the Annex to Decision 2019/235, Part B para 3); and
 - c) *“By 31 December 2020, for terrestrial systems capable of providing wireless broadband services, Member States shall, where necessary in order to facilitate the roll-out of 5G, take all appropriate measures to: (...) reorganise and allow the use of sufficiently large blocks of the 3.4-3.8 GHz band”* (Article 54(1)(a) of the European Electronic Communications Code, which is referred to in recital 10 above).

³⁹⁷ We have also permitted partial transfers of the rights and obligations in relation to the use of the 3605-3689 MHz frequency band under the “Spectrum Access” licence that UK Broadband currently holds, which were not allowed under the General Trading Regulations. See para 3.8 of Ofcom’s notice of 21 May 2019:

https://www.ofcom.org.uk/data/assets/pdf_file/0029/148880/statement-auction-regulations.pdf

³⁹⁸ See Decision 2019/235 of 24 January 2019 <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D0235&from=EN>

- 6.39 It is clear from this that the EU legislation considers that making large amounts of contiguous spectrum available is desirable, and we agree with this.³⁹⁹ However, it is also clear that neither the provisions of the recitals, nor the binding elements of the Annex to Decision 2019/235 and Art. 54 of the European Electronic Communications Code, require Member States to guarantee the allocation (or the contiguous allocation) of 80-100 MHz to each operator.
- 6.40 Through the previous auction of rights to use the 3.4-3.6 GHz frequencies, the UK Broadband licence variation, and this auction of the 3.6-3.8 GHz frequencies, we will have made the full band available for mobile use. In doing so, we will have implemented measures which, when coupled with the existing spectrum trading regime, are aimed at ensuring a defragmentation of the band and at providing operators with the opportunity to access sufficiently large portions of contiguous spectrum. As such, we consider that we have met the requirements of the EC Decision and the European Electronic Communications Code referred to above. We do not consider that we have wider obligations to guarantee specific outcomes. Specifically, we do not agree that our duties require us to guarantee full defragmentation of the band and/or make contiguous spectrum available to all operators.
- 6.41 We have considered whether we should go further and intervene to guarantee full defragmentation of the wider 3.4-3.8 GHz band, as some of the operators have urged us to do. For the reasons set out below, we have decided not to do so.

Imposing a full reassignment of the wider 3.4-3.8 GHz band

Contiguous spectrum and the provision of 5G services

- 6.42 We continue to consider that 80 MHz of contiguous spectrum is desirable to deliver 5G services. However, we do not think it is necessary.
- 6.43 As set out in section 4 of this statement, we do not consider that it is necessary for any of the incumbent MNOs to win spectrum in this award in order to remain credible competitors and, in our view, there is low risk of competition concerns related to 3.4-3.8 GHz spectrum from any auction outcomes, including if one or more MNOs had fragmented holdings in the 3.4-3.8 GHz band.⁴⁰⁰ This is because we are unaware of any important 5G services requiring 80-100 MHz, contiguous or otherwise, of 3.4-3.8 GHz spectrum in the short term or longer term. Even if some new and important service were to emerge that requires 80-100 MHz, there is a low risk that the necessary performance could not be achieved by alternative means without too great a loss in quality of service.⁴⁰¹
- 6.44 We note that the capacity losses associated with non-contiguous holdings are moderate, in the range of 2-15%, and that there are other much larger sources of capacity gains (such as

³⁹⁹ See, for example, paragraphs 6.3 and 6.7 of the December 2018 consultation, paragraphs 2.4 and 2.31 of the June 2019 consultation, paragraph 4.30 of the UK Broadband licence variation statement.

⁴⁰⁰ See also section 4, paragraphs 4.287-4.293 of this statement.

⁴⁰¹ See also section 4, paragraphs 4.254 and 4.258 of this statement.

at least 100% to 300% increase from deploying mMIMO). In addition, capacity constraints are unlikely to have a material impact on consumers' experience in the short term whilst 5G networks are lightly loaded. In the longer term, operators are likely to have several ways to increase the capacity of their networks in the areas that they need to, for example, by selective densification.⁴⁰² Finally, we note the bidding behaviour in the 2.3 and 3.4-3.6 GHz auction is consistent with a view that large contiguous holdings are desirable but not essential.

- 6.45 As such, we do not consider that any existing operator requires at least 80 MHz of contiguous spectrum to provide 5G services, and there is of course no guarantee that all current operators will win further spectrum in this auction in any event.

Potential benefits of defragmentation of the 3.4-3.8 GHz band

Greater capacity and other technical and economic benefits

- 6.46 Both O2 and Vodafone have argued that achieving full defragmentation of the wider 3.4-3.8 GHz band would result in significant benefits, including the ability to offer higher headline speeds, lower latency and an increase in capacity, as well as avoiding extra costs associated with deploying additional antennas on masts (which could arise from a lack of proximity in holdings). O2 estimated that it would need to spend [REDACTED] to replicate the capacity of a large contiguous block using two non-contiguous blocks.⁴⁰³ In response to our consultation on varying UK Broadband's licence, Vodafone estimated that the capacity penalty associated with using two non-contiguous blocks would be in the range of 13-17%, and O2 estimated this capacity penalty to be in the range of 7-15%.⁴⁰⁴
- 6.47 We accept that contiguous spectrum holdings would be likely to result in greater spectrum efficiency. In particular, we recognise that there are moderate capacity inefficiencies associated with using two non-contiguous spectrum blocks (as opposed to a single block of at least 80 MHz) to deliver 5G services. This reduction in capacity is in our view likely to be in the range of 2-15%.⁴⁰⁵ However, as explained in section 4, we consider there is a low risk that fragmented holdings in 3.4-3.8 GHz would prevent MNOs from competing strongly.

Reduced distortions to bidding in the auction

- 6.48 We also acknowledge that there is a risk that bidding in the principal stage of the auction may be distorted if we do not require a full reassignment of the 3.4-3.8 GHz band. This is because, without a reassignment, Vodafone, O2 and BT/EE would have a strong incentive each to acquire 40 MHz of 3.6-3.8 GHz spectrum – the amount most suitable for post-auction swaps or trades to achieve defragmentation – even if they would otherwise have bid on a different amount of spectrum based on their intrinsic values.

⁴⁰² See also section 4, paragraphs 4.267-4.268 of this statement.

⁴⁰³ O2 non-confidential response to the June 2019 consultation, paragraph 8(b) and Annex 1, paragraph 2.

⁴⁰⁴ See paragraphs 4.67-4.68 of Ofcom's statement on varying UK Broadband's licence:

https://www.ofcom.org.uk/data/assets/pdf_file/0014/130253/Statement-UK-Broadbands-spectrum-access-licence-3.6-GHz.pdf

⁴⁰⁵ See paragraph 4.267 in the Competition Assessment Section, which is Section 4.

- 6.49 This would be a concern if it resulted in a material change to the outcome of the auction. A reassignment would eliminate this risk because the MNOs would know they would be guaranteed contiguous blocks of spectrum and would not need to rely on post auction trades to achieve contiguity, regardless of the quantity of spectrum they win.
- 6.50 Although this is a risk, it is unclear how significant an impact it would have on the auction outcome in practice. For example, despite any distortions to bids, a similar allocation of spectrum is a plausible auction outcome.

Potential adverse effects of full band reassignment

- 6.51 Given the potential benefits of proximity or contiguity, we have considered whether it would be appropriate and proportionate in the circumstances for us to intervene to guarantee contiguous spectrum holdings for all operators. For the following reasons we do not consider it would be.

Relocation costs

- 6.52 A reassignment of the 3.4-3.8 GHz band would necessarily impose re-location costs on any MNO who is required to relocate their existing frequencies. O2 and Vodafone have suggested that the costs that individual operators would have to incur to move their holdings would be significantly less than the benefits that would result from each operator having contiguous spectrum. Whilst we do not necessarily agree with all of the figures that they have put forward⁴⁰⁶, for the purposes of our assessment, we have assumed that the economic benefits of guaranteeing contiguous spectrum would outweigh the combined costs that the operators would have to bear to move their frequencies. However, even if those economic benefits do outweigh the costs when considered in isolation, we do not consider it automatically follows that any intervention to achieve those benefits is necessarily justified, as other factors are in our view also relevant.

Effects on H3G

- 6.53 H3G is in a different position from the other MNOs, in that it already holds more than 80 MHz of relevant contiguous spectrum. Like the other MNOs, it also has existing rights, set out in its licences, which govern its use of the spectrum. We believe it is relevant for us to consider the likely effect of imposing a reassignment of the 3.4-3.8 GHz band on H3G, including whether such a reassignment would unduly discriminate against H3G, given its existing holdings in the relevant band. We understand that H3G would not consent to a full band reassignment.
- 6.54 As set out above, H3G would need to incur costs to move its frequencies. The costs would depend on whether the move in frequencies required H3G to use frequencies which were outside the frequency range supported by the equipment it has already installed. A small move in frequencies might only involve a small cost to H3G because it could change the frequencies it is using without changing the hardware it has installed. However, a large move in frequencies, outside the range supported by the equipment it has installed, might

⁴⁰⁶ As set out in Annex 7 of this statement, we consider that O2's analysis is likely to present a pessimistic view of the cost of fragmentation.

require H3G to dismount the equipment, return it to the vendor for adjustment or replacement and then remount the equipment at each affected site.

- 6.55 A mandatory reassignment would also mean H3G would lose the potential to trade and extract a commercial return. Whilst H3G's ability to make a commercial return on any trade is not relevant to an efficiency analysis of full band reassignment⁴⁰⁷, it is in our view a further relevant factor in deciding whether a mandatory full band reassignment is appropriate and proportionate, given the existence of a statutory trading regime for this spectrum.
- 6.56 We note that as part of the licence variation we effected in 2018 in relation to the UK Broadband licence in the 3.6 GHz spectrum, H3G agreed to surrender 4 MHz of 3.6 GHz spectrum in order for us to relocate its existing blocks in the band to form a single contiguous block.⁴⁰⁸ That relocation of spectrum has enabled us to award 120 MHz of contiguous spectrum in the 3.6-3.8 GHz band in this award, as opposed to 116 MHz split into separate 5 MHz and 111 MHz blocks around H3G's spectrum holding in the band. It may not have consented to this surrender of rights, if it had anticipated that we would impose a reassignment of the whole band as part of this auction. As we noted at the time, we expect that being able to offer an increased amount of usable spectrum in this auction will benefit the customers of bidders in the auction.⁴⁰⁹

Certainty

- 6.57 We have also taken into account that imposing a reassignment of the wider 3.4-3.8 GHz band could reduce licensees' certainty over their spectrum rights in the future or in other circumstances, which could impact their future investment and roll-out plans, as well as the way they bid in future spectrum auctions (particularly in the assignment stage).

Alternative ways to facilitate defragmentation of the 3.4-3.8 GHz band

- 6.58 We have considered whether there would be alternative ways to defragment the band, and if so, whether imposing a reassignment of the 3.4-3.8 GHz band goes beyond what is necessary. As set out below, there are other options which we consider are likely (but not guaranteed) to result in greater defragmentation of the band than at present, and may well result in full defragmentation.

Spectrum trading

- 6.59 The MNOs could have sought to agree spectrum trades before the auction, and they can seek to do so after it. Depending on the outcome of this auction, defragmentation could be delivered for all MNOs through relatively simple bilateral trades. For example, it would

⁴⁰⁷ This is because efficiency concerns the outcome of defragmentation and the efficiency gains that would bring, such as more efficient use of spectrum from avoiding the capacity loss (enabling more or better services to be delivered to consumers from the same amount of spectrum). The money that H3G would obtain from a commercial trade is, in economic terms, a transfer from the other MNOs to H3G.

⁴⁰⁸ See Ofcom's December 2018 statement on varying UK Broadband's licence: <https://www.ofcom.org.uk/consultations-and-statements/category-2/variation-uk-broadbands-spectrum-access-licence-3.6-ghz>

⁴⁰⁹ See paragraphs 1.6 and 4.33 of Ofcom's December 2018 statement on varying UK Broadband's licence.

require only two separate bilateral trades to achieve full defragmentation in a number of plausible outcomes to the principal stage of the 3.6-3.8 GHz auction, in light of current holdings. If operators are unable to achieve full defragmentation through post auction trades, there are likely to be various possibilities for the MNOs to improve the proximity of their holdings through post-auction trading. We also note that operators can reflect their individual relocation costs and the benefits they expect to achieve from improved proximity or contiguity in negotiations about spectrum trades.

6.60 Given the representations they have made to us about the importance of large contiguous blocks of spectrum, we expect EE, O2 and Vodafone to have incentives to engage in trades that defragment the band. We also believe H3G has incentives to trade. This is because there are likely to be benefits from wider defragmentation of the band, and H3G will only be able to profit from this if it trades some or all of its current location in the band. To the extent that the gains to other operators from obtaining contiguous spectrum are significant, they would be able to provide an incentive for H3G to sell or move some of its existing holdings. H3G would have an incentive to trade in order to share in these gains.⁴¹⁰

6.61 H3G may also have incentives to trade its 3.4 GHz holdings for spectrum in other bands. Whilst H3G has a strong position in relation to 3.4-3.8 GHz spectrum, it does not have such an advantage in relation to spectrum bands which are useful for other aspects of a mobile operators' competitive offering. For example, H3G currently holds very little sub-1 GHz spectrum and may therefore have an incentive to trade its 3.4 GHz holdings to gain access to more low frequency spectrum. Further, H3G wrote to us confirming that its willingness to trade has not decreased as a result of our decision to vary its 3.6 GHz licence⁴¹¹ and set up a process last year where it attempted to arrange trades of its 3.4-3.6 GHz spectrum before the auction. We consider that these actions provide support for our view that it has incentives to trade.

Auction measures to facilitate post-auction trades

6.62 In order to further facilitate post auction trading to defragment the spectrum, we have decided to include a negotiation period during the assignment stage of the auction. This negotiation period will allow for either full or partial agreement between winning bidders. As such, it could result in an outcome where – with subsequent trades – all licensees have contiguous spectrum, or where most of them do.

6.63 A difference between this option and imposing a full reassignment of the 3.4-3.8 GHz band is that the latter would guarantee that every operator would be granted a contiguous block of spectrum. We consider that spectrum trades, in combination with the negotiation

⁴¹⁰ We also do not consider that H3G is likely to have an incentive to refuse a trade in order to benefit from a distortion of competition through denying one or more other MNOs contiguous holdings. This is because: (i) we consider there is low risk of competition concerns related to 3.4-3.8 GHz spectrum from any auction outcome; and (ii) in any case, it is likely that at least one other MNO would achieve contiguity from our assignment stage process, such that H3G would not be the sole MNO with a large contiguous block (which would reduce any payoff from such strategic behaviour).

⁴¹¹ [REDACTED].

period, are likely to be an effective way to defragment the band, and are a less intrusive means to do so.

Implementation of full band reassignment

- 6.64 In order to give effect to a full reassignment of the 3.4-3.8 GHz band, Ofcom would need to be able to swap the frequencies authorised by the existing 3.4-3.6 GHz licences for new frequencies. In order to do so, Ofcom would need to be able to either:
- a) **revoke** the existing 3.4-3.6 GHz licences, and issue new licences which give effect to the wider reassignment; or
 - b) **vary** the existing 3.4-3.6 GHz licences.
- 6.65 Whether a change to particular term of a licence amounts to a variation of that licence, or a revocation and re-issue of a new licence depends on a case-by-case assessment and the circumstances of each case. In this case, Ofcom's view is that imposing a full band reassignment is likely to constitute a revocation of the existing 3.4-3.6 GHz licences. However, we set out below why we do not consider it would be appropriate to implement a full band reassignment, whether through mandated licence revocations or variations.

Revocation of existing 3.4-3.8 GHz licences

- 6.66 Spectrum between 3410 and 3680 MHz is currently allocated to the MNOs. 150 MHz of this spectrum was allocated to them in the 2.3 and 3.4 GHz auction in 2018. A further 124 MHz was allocated many years ago by the Radiocommunications Agency (one of Ofcom's predecessors), and following several trades and company acquisitions, is now held by UK Broadband (which is itself owned by H3G).⁴¹² The licences authorising use of 3410-3680 MHz (the "**existing 3.4 GHz licences**") provide that Ofcom may not revoke the licence except in certain given circumstances, including by consent or, for spectrum management reasons, on five years' written notice. In the case of the licences we awarded in the 2.3 and 3.4 GHz auction such notice may not be given before 15 years from the date of the licence; in other words, those licences cannot effectively be revoked, without the consent of the licensee, before 2038. Further, the WTA 2006 provides that Ofcom may not revoke any licence unless the proposed revocation is objectively justifiable.⁴¹³
- 6.67 As a result, Ofcom has no power to revoke the existing 3.4 GHz licences without the consent of the licensees unless it gives at least five years' notice (in the case of the licences currently held by UK Broadband), and unless it gives 5 years' notice in 13 years' time (in the case of the recently auctioned licences). As set out earlier in this statement, one of our objectives for this award is to ensure the timely availability of the spectrum. We therefore do not consider it would be appropriate to plan for a reassignment of the band which could

⁴¹² UK Broadband surrendered 4 MHz of its 124 MHz when we varied its 3.6 GHz spectrum access licence. See Ofcom's statement of 14 December 2018: https://www.ofcom.org.uk/data/assets/pdf_file/0014/130253/Statement-UK-Broadbands-spectrum-access-licence-3.6-GHz.pdf

⁴¹³ Schedule 1, paragraph 6A, WTA 2006.

not take effect for 5 years (or nearly 20 years in the case of the recently auctioned spectrum).

- 6.68 Therefore, to the extent that a reassignment of the band would require revocation of any of the existing 3.4-3.6 GHz licences, Ofcom would not have the power to give effect to it now without the consent of all the current relevant licensees. We consider below whether it would be appropriate to attempt to elicit this consent as a condition of entry to the auction, as suggested by Vodafone and O2.

Consent to reassignment as a condition of entry to the award

- 6.69 Vodafone and O2 have both proposed we require bidders to consent to moving their frequencies as a condition of entry to the auction.⁴¹⁴ As set out above, Ofcom has the power to revoke the existing licences if it gains the consent of the licence holders.
- 6.70 We have considered whether consent to full band reassignment could properly be elicited by making entry into the auction conditional on agreement to the inclusion of existing licensed spectrum in a full reassignment. In our view, requiring such consent as a pre-condition to entering the auction would be susceptible to legal challenge, on the basis that it would be an unreasonable entry condition, or on the basis that in the circumstances, consent had not been lawfully obtained.
- 6.71 This is because the forthcoming auction is for frequencies which are likely to be important for the future delivery of 5G and other services in the UK. It is therefore an auction in which we expect each MNO, for its own commercial reasons, to want to participate.
- 6.72 We are therefore concerned that any MNO which did not otherwise wish to consent to the inclusion of its pre-existing spectrum holdings in the assignment stage of this auction, may feel it had no choice but to agree in order to participate in the auction. Consent given under such circumstances would in our view not be consent given on a voluntary basis, and would not therefore be likely to constitute valid consent for the purposes of revocation of their existing licences, despite O2's suggestion that we would guarantee a licence for the same number of frequencies elsewhere in the wider band. Any revocation based on invalid consent would itself be invalid.
- 6.73 Alternatively, if an MNO chose not to participate in the award under these terms, the auction would fail to achieve defragmentation because that MNO's existing spectrum holdings would not be included in any reassignment in any event.

Variation of existing 3.4-3.8 GHz licences

- 6.74 Some of the MNOs have argued that changing the frequencies to implement a reassignment of the band would amount only to a variation of the relevant licences, and

⁴¹⁴ In particular O2 said that s14 WTA 2006 gives Ofcom a power to require applicants to consent to licence variations as a condition of entry to the award (O2 non-confidential response to the June 2019 consultation, paragraph 31). See also section 3.2 of Vodafone non-confidential response to the October 2019 consultation.

not a revocation.⁴¹⁵ The existing 3.4-3.6 GHz licences and the recently auctioned licences do not contain the same notice requirements in respect of a variation, as they do for a revocation. The WTA 2006 provides that Ofcom may not vary a licence unless the proposed variation is objectively justifiable.⁴¹⁶ We also have a general duty not to discriminate unduly between operators and to ensure that our interventions are proportionate, consistent and targeted only at cases in which action is needed.⁴¹⁷

- 6.75 Reassignment of the 3.4-3.8 GHz band would entail a significant amendment to the frequency usage rights that the existing 3.4-3.6 GHz licensees have previously held. We consider that such changes would be likely to amount to a revocation of those licences and the issue of new licences. As set out above, Ofcom does not have the power to revoke the existing 3.4-3.6 GHz licences without giving at least 5 years' notice (and in the case of the licences awarded in the 2.3/3.4-3.6 GHz auction, 5 years' notice from 2033).
- 6.76 Even if a reassignment of the 3.4-3.8 GHz band could be implemented through variations to the existing 3.4-3.6 GHz licences rather than revocations, having considered all of the relevant factors in the round as set out above, we remain of the view that such variations would not be objectively justifiable and proportionate.

Other implementation issues and alternative proposals

- 6.77 We also note that if we were to impose a reassignment of the 3.4-3.8 GHz band, we would have to take into account other relevant considerations, which we set out below.

Reimbursement of assignment stage fees for 3.4-3.6 GHz licences

- 6.78 We note that two of the bidders in the 2.3 and 3.4-3.6 GHz auction paid to secure specific frequencies (H3G paid £13m for its current location in the 3.4-3.6 GHz band, and EE paid £1m). Unless we were able to include a mechanism in the auction for reimbursing this money, a full band reassignment would reduce or remove entirely the value H3G/EE has gained from those assignment stage bids.
- 6.79 We have considered O2's suggestion that assignment stage fees paid in the 2.3 and 3.4-3.6 GHz auction could be reimbursed through a "reduction against either winning bids in the auction or future payments of annual licence fees".⁴¹⁸ However, it is not clear to us that we do have the power to reimburse this money. This is because Ofcom paid receipts from the 2.3 and 3.4-3.6 GHz auction to the Consolidated Fund in accordance with s400 CA 2003. As Ofcom does not have general powers to make payments to the MNOs,⁴¹⁹ the only way that Ofcom could reimburse MNOs for the amounts they paid in the assignment stage

⁴¹⁵ O2 said that moving a block of spectrum to different frequencies "within the same band and with the same technical characteristics constitutes a variation rather than a revocation of the existing licence". See O2 non-confidential response to the June 2019 consultation, paragraph 35.

⁴¹⁶ Schedule 1, paragraph 6A, WTA 2006.

⁴¹⁷ Section 3(3) CA 2003.

⁴¹⁸ O2 non-confidential response to the June 2019 consultation, paragraph 38.

⁴¹⁹ Ofcom's only powers to make payments are specific powers, such as grant making powers under s1 WTA 2006, which would not apply in these circumstances.

of the 2.3 and 3.4-3.6 GHz auction would therefore be to seek to repay them through this auction, for example by offering them a discount on their fees. However, it is not clear that s14 WTA 2006 allows for this. We acknowledge that Government could also make separate payments to them, but this is not within Ofcom's control.

Negative bids in the assignment stage

6.80 We have also considered Vodafone's suggestion that we should devise an assignment stage where bidders could make negative bids for outcomes which would require them to move some or all of their existing holdings.⁴²⁰ Vodafone states that this would involve "BT, Telefonica and Vodafone's bids act[ing] to provide a discount on the amount payable by Three". In the negotiation period that we have decided to implement, it will be possible for bidders to pay H3G to move its existing holdings, as appropriate. We therefore do not see a clear additional benefit to Vodafone's proposal. Furthermore, we consider that this option would likely increase the complexity of the auction. We also note that our powers to accept negative bids from a bidder in the assignment stage of the award would be limited to the final amount paid by that bidder during the principal stage of the award.

Consolidation of H3G's existing holdings at the bottom of the 3.4-3.8 GHz band

6.81 In response to the December 2018 consultation, Vodafone suggested that "if Ofcom were to issue notice now to vary Three's licence in five years, Three would very quickly come to the table to resolve the issue".⁴²¹

6.82 We note that it would be possible to consolidate H3G's entire 140 MHz into the bottom of the 3.4-3.6 GHz band without moving the 20 MHz it won in the 2018 2.3 and 3.4-3.6 GHz auction. The licences issued to UK Broadband could be revoked and re-issued for spectrum management purposes on 5 years' notice (in contrast to the recently awarded licences which essentially require 5 years' notice from 2033).

6.83 We have therefore considered whether it would be appropriate to give notice to revoke or vary those licences now, in order to seek to force H3G to negotiate moving its placement in the band or consent to a mandatory reassignment as Vodafone suggested. However, we do not have the power to revoke any spectrum licence, even if we give adequate notice, unless we consider that the revocation would be objectively justifiable (Schedule 1, paragraph 6A, WTA 2006). As set out above, we consider there are alternative ways to defragment the band which are less interventionist than revoking UK Broadband's licences. We do not therefore consider that revoking H3G's licence would be objectively justifiable.

Conclusion on re-assignment of the wider 3.4-3.8 GHz band

6.84 In the circumstances, we do not consider that it is appropriate or proportionate for us to intervene to guarantee spectrum contiguity for all operators. Contiguous spectrum, whilst desirable, is not strictly necessary for the future provision of services. We consider that

⁴²⁰ Vodafone non-confidential response to the June 2019 consultation, page 5.

⁴²¹ Vodafone confidential response to the December 2018 consultation, page 51.

there are less onerous means of suitably defragmenting the spectrum than mandatory reassignment, namely the measures that we have decided to put in place in the assignment stage of this auction (see paragraphs 6.86 - 6.126 below), operating together with the existing spectrum trading regime. We believe that these measures should facilitate the MNOs to agree any trades they choose to undertake to defragment the wider 3.4-3.8 GHz band after the auction, and that the MNOs have sufficient incentives to engage in such trades. We consider these measures are sufficient to meet our objectives. In any event, we are doubtful we have the power to impose a re-assignment of the wider 3.4-3.8 GHz band.

6.85 We have therefore decided not to take measures to implement a mandatory reassignment of the wider 3.4-3.8 GHz band.

Measures to facilitate post auction trades

6.86 We continue to think that post-auction trades are the most appropriate route to defragmentation of the wider 3.4-3.8 GHz band. As set out above, we proposed several measures in the June and October 2019 consultations to facilitate post auction trades. These were:

- a) **A restriction on winners of 20 MHz or less of 3.6-3.8 GHz spectrum** to bidding for (and winning) either the top or the bottom of the band in the assignment stage of the auction; and
- b) A pause of up to four weeks before processing assignment stage bids, to allow a **negotiation period where bidders can agree the assignment of 3.6-3.8 GHz spectrum**. During the first phase of this period, we proposed to give winners of 3.6-3.8 GHz spectrum the opportunity to agree unanimously on the assignment of the 3.6-3.8 GHz band. In the event that bidders are unable to reach unanimous agreement during this phase, we proposed to include an additional second phase during which we would allow a subset of bidders to agree to be assigned blocks of spectrum which are adjacent to each other.^{422 423}

6.87 We also proposed in our October 2019 consultation not to publish any bid data from the 3.6-3.8 GHz assignment stage. This was due to the risk that this data could adversely affect or undermine post-auction trades.

6.88 In this section, we summarise stakeholder responses and our decisions on these proposed measures.

⁴²² We note that we are not proposing to include any restrictions during the negotiation period on winners of 3.6-3.8 GHz spectrum negotiating with other parties, regardless of whether they have won spectrum in the band. See paragraph 6.120 for a more detailed explanation.

⁴²³ We expect the first phase of the negotiation period to last three weeks, and the second phase to last one week.

Small winner restriction

- 6.89 O2 and BT/EE agreed with our proposal to include a restriction on small winners bidding for assignments at the top and bottom of the band, while H3G disagreed. Vodafone previously supported a small winner restriction in response to the June 2019 consultation, saying that “this is the best approach and provides safeguards against bidders acquiring relatively small amounts of spectrum solely to fragment the band.”⁴²⁴
- 6.90 O2 and BT/EE also agreed with our proposal to increase the small winner restriction to 20 MHz or less. O2 stated that it would reduce the risk that a small winner could insert themselves between two larger winners which could block defragment trades across the broader 3.6–3.8 GHz band. It said “This must outweigh any downside associated with restricting the frequency placement option for small bidders”.⁴²⁵ BT/EE claimed that 20 MHz or less was a suitable threshold as trades were likely to be between winners of more spectrum.⁴²⁶
- 6.91 H3G thought that we should not implement a small winner restriction. It believed that this would be unnecessary if partial agreement between bidders were allowed in the negotiation period as this would prevent a small winner from inserting itself between two or more trading partners.⁴²⁷
- 6.92 H3G also disagreed with our proposal to extend the small winner restriction from ‘less than 20 MHz’ to ‘20 MHz or less’. It said that “The prospect that a bidder may win 20 MHz purely for the purpose of frustrating trades aimed at defragmenting the band is fanciful.”⁴²⁸ It claimed that the cost of winning that spectrum would be around £150m based on the 3.4-3.6 GHz auction price, with that winner having little prospect of recouping the investment. Furthermore, it also thought that the increase of the small winner threshold may increase the amount of spectrum won at the bottom of the band by small winners, which could increase “the disruption to other bidders who may value that position”.⁴²⁹

Our decision

- 6.93 We continue to consider that there is a risk that bidders would strategically bid for a small amount of spectrum to insert themselves between other bidders in the 3.6-3.8 GHz band. The purpose of this strategic bidding could be to stop defragmentation trades occurring, or to profit from allowing defragmentation trades.
- 6.94 In the circumstance where the 3.6-3.8 GHz assignment stage is determined by bidding rather than by agreement(s) in the negotiation period, we consider the small winner restriction is still an appropriate safeguard measure to facilitate post-auction trades. We recognise that this has downsides, such as limiting the placement of small winners to the

⁴²⁴ Vodafone non-confidential response to the June 2019 consultation, pages 2 and 5.

⁴²⁵ O2 non-confidential response to the October 2019 consultation, paragraph 162, page 57.

⁴²⁶ BT/EE non-confidential response to the October 2019 consultation, paragraph 2.38, page 10.

⁴²⁷ H3G non-confidential response to the October 2019 consultation, paragraph 25.1, page 40.

⁴²⁸ H3G non-confidential response to the October 2019 consultation, paragraph 26.2, page 41.

⁴²⁹ H3G non-confidential response to the October 2019 consultation, paragraph 26.5, page 42.

edge of the band, and that large winners would be less likely to win the bottom or top of the band if they wish to be placed there. However, we consider these limited downsides are justified by the wider value that would be achieved by increasing the likelihood of defragmenting the band.

- 6.95 We note an alternative would be to lift the small winner restriction if there is one (or more) partial agreement(s) in the 3.6-3.8 GHz band. Under these circumstances, the benefits of the small winner restriction may be reduced, as a small winner would not be able to insert itself between the winners who have entered into a partial agreement. However, it is not clear this change would always be beneficial, given the potential combinations of winners that might enter into a partial agreement. While relaxing the small winner restriction may better allow bidders to bid freely in line with their valuations, it may also work the other way to increase incentives to price drive during the principal stage. Given the uncertain benefits, we do not think this change would be appropriate.
- 6.96 We have decided to maintain the definition of a ‘small winner’ to one that has won 20 MHz or less. We acknowledge that it is unlikely that a bidder would bid for 20 MHz in the principal stage just to try to insert themselves between trading partners, as H3G stated. However, we are concerned that a winner of 20 MHz or less in the principal stage, who bid for intrinsic value reasons, may then have strategic incentives to bid in the assignment stage in a way that blocks trades in the assignment stage. We already took account of the point H3G raised that increasing the small winner restriction also makes it less likely that large winners win the edges of the band. We concluded that, while this increased the downsides of the small winner restriction, the incremental benefits are still greater than the incremental costs. We see no further evidence from stakeholders to change this assessment.

Negotiation period

Stakeholder responses

- 6.97 All the MNOs supported the inclusion of at least a unanimous negotiation period. BT/EE and O2 also supported the inclusion of partial agreements in the last week of negotiations, while H3G and Vodafone opposed the inclusion of partial agreements.
- 6.98 H3G considered that both partial agreement and unanimous agreement had merit. However, it considered that only unanimous agreement should be implemented, claiming that the inclusion of partial agreement “may deny excluded parties the ability to bid for and secure their preferred locations.”⁴³⁰ It considered two example outcomes in which, it claimed, a bidder may not secure its optimal placement due to the partial agreement option.⁴³¹ In its first example, all MNOs won a share of 3.6-3.8 GHz spectrum and [REDACTED]. In the second example, it claimed that a bidder (Vodafone in the example),

⁴³⁰ H3G non-confidential response to the October 2019 consultation paragraph 24.2, page 40.

⁴³¹ H3G non-confidential response to the October 2019 consultation paragraph 24.2 to 24.4, page 40.

would not be able to bid for and secure the middle of the band, if the only other two winning bidders entered into a partial agreement (BT/EE and O2 in the example).

- 6.99 In response to the June 2019 consultation, Vodafone opposed the inclusion of the option for winners to reach partial agreement during the negotiation period, claiming that this would be discriminatory against Vodafone (and if not discriminatory, then unfair).⁴³²
- 6.100 A confidential respondent said that the partial agreement option may introduce distortions into the principal stage. [REDACTED].⁴³³
- 6.101 BT/EE and O2 strongly supported including the partial agreement option in the negotiation period, to enable post auction trades to defragment the wider 3.4-3.8 GHz band. BT/EE considered that “the partial agreement option is important to prevent any party from vetoing or obstructing agreements that could facilitate defragmentation”.⁴³⁴ O2 considered that “absent the better alternative of full band renegotiation, allowing partial adjacencies is optimal, as it could help some MNOs without harming others”.⁴³⁵
- 6.102 In response to the June 2019 consultation, BT/EE was concerned about how the winner determination rule might work if there were multiple sets of partial agreements formed, since each of the parties would have their assignment stage bids zeroed.⁴³⁶ It considered that Ofcom should have a particular rule to address the circumstance where there were multiple agreements formed.
- 6.103 A confidential respondent [REDACTED] requested clarification on how existing licence holders that have not won any 3.6-3.8 GHz spectrum would be able to participate in the negotiation period.
- 6.104 In response to the June 2019 consultation, BT/EE and O2 requested we clarify what rules would apply to the exchange of confidential information during the negotiation period.⁴³⁷

⁴³⁸

Our decision

Bidders being denied their preferred locations

- 6.105 We have considered H3G’s claim that potential bidders may be denied their preferred placement. In H3G’s first example, all MNOs win spectrum in the 3.6-3.8 GHz band. [REDACTED]. We do not consider this point to be relevant because, in H3G’s example, the partial agreement would be considered as a single block with a bid of zero, whereas the bidder that was not party to the agreement would be able to express bids for the top and bottom of the band and receive its preferred placement for free. [REDACTED].

⁴³² Vodafone non-confidential response to the June 2019 consultation, pages 3 and 4.

⁴³³ [REDACTED]

⁴³⁴ BT/EE non-confidential response to the October 2019 consultation, paragraph 2.41, page 11.

⁴³⁵ O2 non-confidential response to the October 2019 consultation, paragraph 167, page 58.

⁴³⁶ BT/EE non-confidential response to the June 2019 consultation, page 6.

⁴³⁷ BT/EE non-confidential response to the June 2019 consultation, page 6.

⁴³⁸ O2 non-confidential response to the June 2019 consultation, paragraphs 52, 77-78.

6.106 In H3G's second example, it claimed that a bidder (Vodafone in the example), would not be able to bid for and secure the middle of the band, if the only other two winning bidders entered into a partial agreement (BT/EE and O2 in the example).⁴³⁹ We agree with H3G that two bidders entering a partial agreement can prevent another bidder from being awarded the middle of the band. However, we do not consider that this presents a material risk to intrinsic value bidding. We consider that the only likely reasons for a bidder to prefer spectrum in the middle of the 3.6-3.8 GHz band would be: (i) to attract more potential trading partners or (ii) to gain strategic advantage in any post-auction trading negotiations. In our view, a bidder will already be able to attempt to arrange trades in the assignment stage negotiations, and therefore the intrinsic value reason to be in the middle (point (i) above) can already be expressed, even if imperfectly, in the negotiation period. In addition, it is likely that a bidder that was not successful in its negotiation would wish to secure the bottom (or lower end of the band), in order to increase proximity with its existing holdings.

Discrimination/unfairness

- 6.107 We have considered Vodafone's suggestion that we will have discriminated against it if measures we put in place facilitate some but not all operators in achieving contiguity. We do not consider this to be the case. As we have explained above, our aim is to facilitate defragmentation but we are not seeking to guarantee it for all operators. We recognise that some operators may have more straightforward routes to achieve defragmented holdings than others, but that is because they are factually in different starting positions. For example, H3G already holds 100 MHz of contiguous spectrum in the band, and by virtue of their existing holdings, O2 and BT/EE could in certain circumstances achieve contiguous holdings through a bilateral trade with each other.
- 6.108 Given the position of its existing spectrum holdings in the 3.4-3.6 GHz band, Vodafone's most straightforward route to achieving contiguity may be through a bilateral trade with H3G (which holds spectrum immediately above Vodafone's current holdings).
- 6.109 Whether any of the MNOs agree post-auction trades in the circumstances will be a matter for commercial negotiation between them, based on their own assessment of the costs and benefits to them of trading or taking alternative measures to maximise their use of the frequencies they hold.
- 6.110 Given that the operators are not all in the same position going into the auction, we do not consider that any differential effect on them of measures we take to facilitate defragmentation of the band is necessarily unduly discriminatory per se.
- 6.111 Vodafone also claimed that partial agreement is unfair to it, because others can use it to achieve contiguity, while it is not able to. Vodafone also claimed that it gives an unfair advantage to bidders who reach partial agreement.
- 6.112 Firstly, as set out above, due to the current positioning of Vodafone's holdings at the bottom of the 3.4-3.6 GHz band, with H3G holding the frequencies just above, Vodafone is

⁴³⁹ Vodafone raised a similar point, without providing an example. It claimed that a bidder may have a higher valuation for a frequency compared to two bidders in a partial agreement.

unlikely to achieve contiguity without trading with H3G (were it to win spectrum in the 3.6-3.8 GHz band). It is therefore likely that Vodafone will have to trade with H3G in order to achieve contiguity and offer H3G an incentive to do so (monetary or some other incentive). This is the case regardless of whether or not we include the partial agreement option.

- 6.113 Secondly, we consider that there are ways that Vodafone could benefit from the partial agreement option to facilitate it achieving proximity. [REDACTED].⁴⁴⁰

Distortions to principal stage bids for 3.6-3.8 GHz spectrum

- 6.114 In relation to the potential for distorted bidding, we accept that there may be some distortions to principal stage bidding as a result of there being no guarantee of contiguity for bidders. We note that no auction mechanism would guarantee contiguity for all operators other than mandatory full band assignment, which we explore above.
- 6.115 Given that contiguity will not be guaranteed, we recognise that one of the factors bidders are likely to take into account when bidding in the principal stage is the likely amounts of spectrum that are suited to post-auction trades. This is because post-auction trades offer a way to defragment the wider 3.4-3.8 GHz band.
- 6.116 However, this is likely to be the case regardless of whether we include an option for partial agreement. We therefore do not consider that the partial agreement option unduly worsens the risk of distortion to the principal stage.
- 6.117 We also consider it unlikely that the downsides of non-contiguous holdings would discourage operators from participating in the auction. This is because our understanding of the capacity losses associated with non-contiguous holdings are in the range of 2-15%.⁴⁴¹ There is also the opportunity for operators to achieve contiguity between their existing holdings and any new winnings through post-auction trades.

Benefits of partial agreement

- 6.118 There is a risk that negotiations may fail between all principal stage winners in the 3.6-3.8 GHz band. If unanimous agreement was the only option during the negotiation period, then failed negotiations may deny adjacency between a subset of bidders that wish to trade after the auction. It may be difficult for bidders to secure adjacency with prospective trading partners through bidding alone, as they are unable to express preferences for the identity of their neighbours in their bids. Given the potential benefits of contiguous or proximate holdings in the 3.4-3.8 GHz band and the potential trades that may be required to achieve this for some stakeholders, we consider the partial agreement option is beneficial in the case that all principal stage winners do not agree a band plan.

Conclusion

- 6.119 We have decided to include the partial agreement option, as well as the unanimous agreement option. This is because we consider that the potential downsides in having the partial agreement option are more than offset by the upsides, as discussed above. We

⁴⁴⁰ [REDACTED]

⁴⁴¹ See paragraph 4.267 in the Competition Assessment Section, which is Section 4.

consider it preferable for all principal stage winners to unanimously agree the band plan, as this is likely to facilitate the greatest level of defragmentation in the wider 3.4-3.8 GHz band. The negotiation period will therefore have two distinct phases. During the first phase of the negotiation period, winners of 3.6-3.8 GHz spectrum will be able to reach unanimous agreement on the allocation of frequencies within the 3.6-3.8 GHz band. If winners of 3.6-3.8 GHz spectrum are unable to reach unanimous agreement in the first phase, we will extend the negotiation period to a second phase, during which winners of 3.6-3.8 GHz spectrum will be able to reach either unanimous or partial agreements with one another. We will determine the exact start and end times of each phase of the negotiation period before it begins, however, we expect the first phase to last up to three weeks, and the second phase, if triggered, to last one week.⁴⁴² See the draft final regulations and accompanying statement for more information on the procedure for the negotiation period.⁴⁴³

- 6.120 We note that any company may participate in the negotiation period, although only winners of 3.6-3.8 GHz spectrum may enter into an adjacency agreement. This means it would be possible for winners of 3.6-3.8 GHz spectrum to include any existing licence holder of 3.4-3.8 GHz spectrum in negotiations to discuss potential post-auction trades, regardless of whether they have won any spectrum in the award. However, any full or partial adjacency agreement can necessarily only relate to the assignment of frequencies in the 3.6-3.8 GHz band.
- 6.121 We also note that the outcome of any successful unanimous or partial negotiation agreement is likely to be the first step in defragmenting the band, and that after the auction winners of 3.6-3.8 GHz spectrum are likely to wish to enter into trades of their newly acquired 3.6-3.8 GHz spectrum and their existing 3.4-3.6 GHz spectrum in order to further defragment the band. Any post-auction trades will be subject to the procedures set out in the Mobile Trading Regulations,⁴⁴⁴ and must therefore be submitted to Ofcom after the auction. We note that as we said in the June 2019 consultation,⁴⁴⁵ we would expect to look favourably on any post-auction trades which result in any level of defragmentation of the 3.4-3.8 GHz band. Given the analysis set out in section 4 of this statement we do not expect to conduct any further competition assessment in relation to any trades which relate only to spectrum in the 3.4-3.8 GHz band, and will as far as possible expedite such processing of trading applications.

⁴⁴² We have included a provision in the draft final regulations to draw the first phase to an early close, in the event that a unanimous agreement is achieved sooner

⁴⁴³ [‘Statement on the final draft regulations for the award of spectrum in the 700 MHz and 3.6-3.8 GHz bands’](#), published 13 March 2020.

⁴⁴⁴ <http://www.legislation.gov.uk/ukxi/2011/1507/contents/made>

⁴⁴⁵ See paragraph 2.47 of the June 2019 consultation.

- 6.122 With regards to O2 and BT/EE's request for clarification on the rules for exchanging confidential information, we have provided more information in our Statement on the draft final Regulations, published alongside this document – see paragraphs 3.31-3.36.⁴⁴⁶

Publication of 3.6-3.8 GHz assignment stage bid data

- 6.123 BT/EE and Vodafone agreed with our approach to not publish any bid data from the 3.6-3.8 GHz assignment stage. BT/EE said that “it would be concerning if publishing information on assignment bids were to adversely affect or undermine future commercial trading negotiations, and thereby reduce the likelihood of successful trades which support defragmentation of holdings within the 3.4 - 3.8 GHz band”.⁴⁴⁷ Vodafone considered that publishing assignment stage bid data “would reveal confidential information that would totally destroy any chance of reaching [post-auction agreement].”⁴⁴⁸ Vodafone also considered that the amount of information visible to Ofcom colleagues should be limited to a need-to-know basis. It gave examples of procedures that would implement this.
- 6.124 O2 disagreed with our approach to not publish any assignment stage bid data and instead favoured delaying the publication of the bid data until it was no longer sensitive.⁴⁴⁹ It stated that Ofcom and its stakeholders used bid data from spectrum auctions to analyse spectrum prices and valuations. It also said that bid data was useful to support academic research into auctions. It therefore considered it to be contrary to public interest to indefinitely delay publication of bid data.
- 6.125 We agree with O2 that there may be potential benefits of publishing assignment stage bid data with a delay, however, it is not clear to us how material these benefits are. This is especially true given that this only applies to the assignment stage bidding in 3.6-3.8 GHz, and not the principal stage bids. In the October 2019 consultation we also noted that there were potential implementation issues concerning when the assignment stage bid data would be published, were we to publish the data with a delay. No stakeholder came back to us with a suggestion of a timeframe within which we could publish the assignment stage bid data without any risk that the data would adversely affect future trades. Stakeholders also did not comment on other implementation issues.
- 6.126 We have therefore decided to not publish the assignment stage bid data for the 3.6-3.8 GHz band. If we did seek to publish the assignment stage bid data at a later date, this would be subject to Ofcom's usual process for publishing commercially sensitive data, and would require the consent of all of the relevant parties. Regardless of publication, the assignment stage bid data will also be subject to Ofcom's usual internal controls for handling sensitive commercial data.

⁴⁴⁶ See our ‘Statement on the making of regulations for the award of spectrum in the 700 MHz and 3.6-3.8 GHz bands’, published 13 March 2020.⁴⁴⁷ BT/EE non-confidential response to the October 2019 consultation, paragraph 2.46, page 11.

⁴⁴⁷ BT/EE non-confidential response to the October 2019 consultation, paragraph 2.46, page 11.

⁴⁴⁸ Vodafone non-confidential response to the October 2019 consultation, page 8.

⁴⁴⁹ O2 non-confidential response to the October 2019 consultation, paragraphs 168-170, page 59.

Alternative proposals from stakeholders

Automatic contiguity to the holder of 3675-80 MHz

- 6.127 H3G proposed an approach where the holder of spectrum at 3675-80 MHz is given contiguity with existing holdings, were it to win any additional spectrum in the 3.6-3.8 GHz band.⁴⁵⁰ It considered that would guarantee contiguity for a bidder and would prevent further fragmentation of the band. It also considered that Ofcom had “rejected this proposal because a bidder (other than the 3675-80 MHz holder) may want to express its value for the lower part of the 3.6-3.8 GHz band, but [that it] considered this concern to be misplaced”.⁴⁵¹ [REDACTED]. H3G also considered that this was a superior approach to the small winner restriction that Ofcom was implementing.⁴⁵²
- 6.128 While O2 initially proposed H3G should receive adjacency with any new 3.6-3.8 GHz spectrum with its existing holdings in response to the December 2018 consultation, it agreed with our proposed approach where H3G would not be guaranteed adjacency in response to the June 2019 consultation.⁴⁵³ ⁴⁵⁴ It said that it would be inappropriate to prioritise adjacency for H3G where it is not willing to cooperate in moving its frequency holdings to allow other bidders to also secure contiguous spectrum in the wider 3.4-3.8 GHz band. A confidential respondent was also against prioritising adjacency for H3G were it to win spectrum.⁴⁵⁵
- 6.129 In the June 2019 consultation, we recognised that this amendment would ensure contiguity to the holder of the top of the 3.4-3.6 GHz band, and potentially ensure more efficient use of the spectrum.⁴⁵⁶ However, we also recognised that other potential bidders with 3.4-3.6 GHz holdings may also wish to be placed at the bottom of the 3.6-3.8 GHz band to reduce the gap between their existing holdings in 3.4-3.6 GHz and their newly won 3.6-3.8 GHz spectrum. Our view was that it would not be appropriate to deny other bidders the opportunity to bid to be located at the bottom of the 3.6-3.8 GHz band. [REDACTED]. We have therefore decided not to introduce this measure.

Winners that do not have holdings in the 3.4-3.6 GHz band to be automatically placed at the top of the band

- 6.130 H3G suggested that new entrants should be automatically assigned the top of the band. It saw this as an additional measure to prevent further fragmentation and hindering MNOs’ future prospects of contiguity and proximity.⁴⁵⁷

⁴⁵⁰ H3G non-confidential response to the October 2019 consultation, page 40, paragraph 25.

⁴⁵¹ H3G non-confidential response to the June 2019 consultation, page 7, paragraph 5.1 and 5.2.

⁴⁵² H3G non-confidential response to the October 2019 consultation, page 40, paragraph 25.2.

⁴⁵³ O2 non-confidential response to the December 2018 consultation, paragraph 175.

⁴⁵⁴ O2 non-confidential response to the June 2019 consultation, paragraph 17, page 6.

⁴⁵⁵ [REDACTED]

⁴⁵⁶ See paragraph 2.59 of the June 2019 consultation.

⁴⁵⁷ H3G non-confidential response to the June 2019 consultation, paragraph 5.4, page 7.

- 6.131 O2 had previously suggested, in their response to the December 2018 consultation, that new entrants to the 3.4-3.8 GHz band should be placed at the top of the band. It considered that this rule “would prevent speculators from being able to target spectrum in the middle of the band and extract rent from the industry in return for participating in defragmentation.” It also considered that the rule would reduce the risk that an “existing license holder could be left with spectrum spread over a bandwidth greater than 300MHz”.⁴⁵⁸
- 6.132 In the June 2019 consultation we stated that we could see merit in this suggestion as it would allow all the MNOs to be assigned adjacent blocks of spectrum across the 3.4-3.8 GHz band, which may facilitate post-auction trades.⁴⁵⁹ However, we were already proposing measures to facilitate post-auction trades (a negotiation period and restricting the assignments of small winners). We did not wish also to deny new entrants the opportunity to bid for other locations, which they may prefer to the top of the band. We therefore decided not to propose the measure that new entrants in the 3.4-3.8 GHz band would be placed at the top of the 3.6-3.8 GHz band. We have seen no further evidence from stakeholders to change this assessment, and therefore have decided not to introduce this measure.

⁴⁵⁸ O2 non-confidential response to the December 2018 consultation, paragraph 175.

⁴⁵⁹ See paragraph 2.60 of the June 2019 consultation, paragraph 2.60.

7. Coexistence issues

- 7.1 Whenever we award new spectrum rights, we consider the impact on other users of the award frequencies and neighbouring frequencies.
- 7.2 In our December 2018 consultation we assessed the impact of new mobile services in both the 700 MHz and the 3.6-3.8 GHz band and set out proposals on how coexistence should be addressed (see sections 8 and 9).⁴⁶⁰
- 7.3 Having considered stakeholder responses, we set out below our conclusions on issues for the 700 MHz and 3.6-3.8 GHz bands in turn, beginning with the 700 MHz band.

700 MHz band – summary of our decisions

700 MHz coexistence

- 7.4 A small number of digital terrestrial television (DTT) viewers may experience interference from new mobile services operating in the 700 MHz band, including services operating in the two 30 MHz blocks of paired spectrum and the ‘centre gap’ of 20 MHz at 738-758 MHz. In the December 2018 consultation we set out proposals for ensuring that the holders of licences granted in the award (i.e. both those for the paired spectrum and the ‘centre gap’) assist consumers affected by interference.
- 7.5 Having taken account of stakeholders’ responses, we have decided to adopt the approach to 700 MHz coexistence that we proposed in the consultation.
- 7.6 We will provide a 10-week window following the award of the 700 MHz licences for the 700 MHz licensees to submit to Ofcom a joint plan setting out their proposed scheme to provide advice and assistance to viewers suffering undue interference from mobile services. We will assess the plan in accordance with our objective to ensure that 700 MHz mobile services do not cause undue interference to DTT viewers – and, if they do, that new mobile licensees take appropriate and proportionate measures to address any undue interference. We will respond to the licensees within six weeks, retaining the ability to impose a fallback plan if a satisfactory plan is not submitted.
- 7.7 Our decision will be implemented through provisions in the future 700 MHz licences. An example licence can be found at annex A1 of the Information Memorandum which is published alongside this statement.⁴⁶¹ Guidance to licensees on consumer support is set out in annex A3 of the Information Memorandum.

⁴⁶⁰ Award of the 700 MHz and 3.6-3.8 GHz spectrum bands, December 2018, https://www.ofcom.org.uk/data/assets/pdf_file/0019/130726/Award-of-the-700-MHz-and-3.6-3.8-GHz-spectrum-bands.pdf

⁴⁶¹ https://www.ofcom.org.uk/data/assets/pdf_file/0019/192412/information-memorandum-award-700mhz-3.6-3.8ghz-spectrum.pdf

Interim multiplexes

- 7.8 The centre gap frequencies in the 700 MHz band we are awarding (738-758 MHz) are currently used by interim DTT multiplexes. In a decision set out in October 2016⁴⁶², we said that if the parties acquiring 700 MHz centre gap frequencies for mobile services do not deploy immediately, we were minded to allow the interim multiplexes to have continuing access using the centre gap frequencies until the mobile services are actually switched on.
- 7.9 That remained our position in the December 2018 consultation. We proposed to grant Arqiva a new licence for a duration it would agree with the new licensees, subject to some conditions.
- 7.10 Having taken account of stakeholders' responses, we have decided largely to adopt the approach to licensing the interim multiplexes set out in the consultation, with two minor adjustments:
- a) the 700 MHz licensees will be required to give at least three months' notice of their intention to start using the centre gap to both Ofcom and Arqiva; and
 - b) any interim licence that Arqiva might hold at that time will be extended to match the date the MNOs intend to start using the centre gap, as notified to Ofcom and Arqiva.
- 7.11 We will implement this through a licence condition in the future 700 MHz operator licences.

Nature and scale of interference risk from mobile to DTT

- 7.12 We expect that new mobile services will use frequencies formerly used for DTT transmissions. DTT will continue to operate in frequencies adjacent to the award bands. In the December 2018 consultation we summarised our conclusions from our earlier analysis indicating that the impact of interference from mobile base stations into DTT would not exceed more than 0.2% of DTT households in the UK, and that receiver filters would be the most technically effective means to mitigate interference from handsets and base stations.⁴⁶³
- 7.13 In the consultation we set out that the coexistence scenario for mobile and DTT coexistence in the 700 MHz band resembles the one experienced following the introduction of mobile services into the 800 MHz band. We auctioned this band for mobile use in 2013.
- 7.14 We identified two key learnings from the 800 MHz experience. These were as follows.

⁴⁶² Maximising the benefits of 700 MHz clearance: Enabling acceleration of 700 MHz clearance and use of the 700 MHz centre gap, October 2016, https://www.ofcom.org.uk/data/assets/pdf_file/0031/92659/Maximising-the-benefits-of-700-MHz-clearance-Statement.pdf

⁴⁶³ Coexistence of new services in the 700 MHz band with digital terrestrial television (Update), December 2017, https://www.ofcom.org.uk/data/assets/pdf_file/0025/108655/update-coexistence-700-mhz.pdf. Receiver filters are small devices that can typically be plugged into the back of a TV set to resolve interference issues. They work by allowing wanted signals (DTT) to pass through while reducing unwanted interfering signals.

- i) It is very challenging to target accurately communications and assistance to affected consumers, and this drives costs.
- ii) The framework for consumer support, including KPIs, should allow for operational flexibility.

Our proposed approach to developing and assessing policy options

Assessment criteria

- 7.15 We used four criteria to assess policy options for the form that any intervention should take. These were as follows.
- a) Will the option avoid undue consumer harm?
 - b) Will the option be proportionate?
 - c) Is the option scalable?
 - d) How does the option impact the benefits of introducing mobile into the 700 MHz band?

Summary of our proposal

- 7.16 We assessed three policy options under these criteria. These were:
- a) require 700 MHz licensees to provide support, with broadcasters delivering the ‘front line’ of that support;
 - b) require 700 MHz licensees to provide viewer support with detailed requirements set by Ofcom; and
 - c) our preferred option – a less prescriptive approach in which 700 MHz licensees would be required to provide consumer support.
- 7.17 Having assessed these policy options, we proposed option 3.
- 7.18 We proposed to impose a high-level obligation to set up and operate a scheme to provide advice and assistance to viewers suffering undue interference from mobile services and to ensure the 700 MHz licensees take appropriate and proportionate measures to resolve any undue interference to DTT viewers. The licence condition would not prescribe in detail how licensees should set up and run the scheme. However, we did propose a requirement for licensees to submit to us a joint plan setting out the approach they would take, which we would assess.
- 7.19 We proposed that this viewer support should assist DTT-only viewers and that it should make special provisions for vulnerable viewers. We said that viewers with Pay TV and indoor aerials should receive a level of assistance or advice that is proportionate to the more limited harm they will experience. We said that the viewer support scheme should not be required to assist viewers who lose services carried by the interim multiplexes.

- 7.20 We said that we would provide an indication of what we might normally expect to see in this joint plan in the form of guidance. We provided draft guidance in an annex to the consultation.
- 7.21 We proposed that any plan from the licensees would need to make provisions in at least four areas:
- a) engaging with consumers;
 - b) assisting consumers who experience problems;
 - c) helping vulnerable consumers; and
 - d) operational functions.
- 7.22 We proposed that Ofcom should retain the power to impose a fall-back plan in the event that the 700 MHz licensees did not submit a satisfactory joint plan. We said we would have the power to take enforcement action against licensees who did not comply with their licence conditions and that this fall-back option would likely include the components set out in our guidance.
- 7.23 We proposed including the following condition in the licences for 700 MHz spectrum.

“During the period this Licence remains in force, unless consent has otherwise been given in writing by Ofcom, the Licensee shall operate the Scheme and comply with its obligations in the Scheme Notice⁴⁶⁴. The Licensee shall provide to Ofcom and any entity established as part of the Scheme, in such manner and at such times as they may reasonably require, such documents or other information as they may require for the purposes of the Scheme’s operation, monitoring that operation and assessing its appropriateness and effectiveness.”

- 7.24 We asked the following questions.

Question 7: Do you agree with the proposed approach to coexistence in the 700 MHz band?

Question 8: Do you have any comment on the proposed licence obligation and guidance note (annex 19)?

Stakeholder responses

- 7.25 Stakeholders concentrated on three issues:
- our characterisation of the interference risk;
 - our overall proposed approach to coexistence; and
 - support scheme design and operation.

⁴⁶⁴ The expression ‘Scheme Notice’ will be defined in the licence setting out the details of the way the Scheme will operate. It will reflect the Scheme as approved by Ofcom in response to the licensees’ joint plan or imposed by us

- 7.26 Below we set out each issue in turn. In each case we summarise our consultation position and stakeholder responses, then give our final view.

Interference risk from 700 MHz mobile services

Likely scale of 700 MHz interference

- 7.27 In the December 2018 consultation we noted our conclusion from our December 2017 technical consultation that the vast majority of households will not experience interference from 700 MHz mobile services. We said that the impact of mobile base station interference into DTT will not exceed 36,000 households and there will be minimal risk of interference from mobile handsets.
- 7.28 The BBC and techUK commented on the technical assumptions underlying our calculations of the number of potential interference cases. The BBC noted that there are differences between the 800 MHz experience and likely interference into DTT once mobile operates in the 700 MHz band: higher base station power levels will be permitted for 700 MHz than was the case for 800 MHz. They argued that therefore the interference risk from 700 MHz is effectively higher.⁴⁶⁵
- 7.29 We have considered these responses as follows:
- a) Network design principles suggest that, in practice, only a few base stations will reach the maximum power (as otherwise they might interfere with each other, or reach handsets that are too far away to reliably transmit back to the base station), so an increase in the power ceiling is likely to have a limited effect. We have analysed⁴⁶⁶ an existing 800 MHz macrocell network in England and Wales and have included planned macrocells until 2020. Only a small proportion of macro cells are using powers above 60 dBm / 5 MHz.⁴⁶⁷ Therefore, we do not expect many base stations will be using powers above 60 dBm / 5 MHz for the 700 MHz band and do not believe that allowing 65 dBm / 5 MHz will significantly change the interference risk.
 - b) There is a risk that a small number of households may be affected by interference. We believe few base stations will in practice operate at the maximum power limit (see above). But even for those base stations that do reach the 700 MHz power limit, it is not clear that there will be a significant increase in cases of interference to DTT receivers. This is because causes of real-life interference are driven by many factors, such as being in close proximity to a 700 MHz base station, whether aerials are pointing in the direction of the base station, and quality of installation.

⁴⁶⁵ BBC consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0018/143280/bbc.pdf, p.4.

⁴⁶⁶ Site Data from Telefonica as a response to Ofcom formal request for information submitted on 26/04/19 for the purpose of informing Ofcom's work on the future award of spectrum in the 700 MHz and 3.6-3.8 GHz bands, including any coverage obligations that may be offered in that award.

⁴⁶⁷ The average power is 57 dBm / 5 MHz.

- c) As the licensees will have to bear the costs of remedying interference if it does occur, if a solution to the interference problem is reducing the total transmit power from a base station, they will have the right incentive to decide whether operating at the higher power available to them under the 700 MHz is worth it.
- 7.30 techUK said that while the estimate of the number of interference cases we gave in the consultation will capture the interference cases into DTT via rooftop aerials, secondary viewing via set-top aerials will also occur.⁴⁶⁸ When interference via set-top aerials is included, the scale of the interference problem is greater.
- 7.31 As set out in our December 2017 update, rooftop aerials are the recommended means to enjoy reliable DTT reception. Viewers who rely on portable or set-top aerials will be more likely to experience reception problems and interference from a wide range of sources, of which this would be only one. This is consistent with advice from the Radio and Television Investigation Service, which is managed by the BBC.⁴⁶⁹ For this reason, we do not think it proportionate to protect portable or set-top aerial reception. Therefore, we have not included interference to DTT received via set-top aerials in our coexistence impact estimates.
- 7.32 An individual respondent to the October 2019 consultation asked for confirmation that mobile in the 700 MHz band will not affect their television reception.⁴⁷⁰ We continue to think that the impact of mobile base station interference into DTT will not exceed 36,000 households and set out our decision on assistance for consumers affected in this chapter.

Number of consumers affected by 800 MHz mobile transmission

- 7.33 In the consultation we identified similarities between the case of 700 MHz coexistence and earlier coexistence issues related to mobile's entry into the 800 MHz band. We said that we could learn from 800 MHz coexistence mitigation to inform our approach to 700 MHz coexistence.
- 7.34 Some respondents raised issues related to the comparison made in the consultation between 700 MHz interference the case of 800 MHz interference.
- 7.35 Digital UK and Digital Mobile Spectrum Limited (DMSL), responding on behalf of all four current mobile network operators, said that the 25,000 interference cases we pointed to in the consultation as the number of confirmed interference cases to August 2018 represent only the number of interference cases confirmed via an installer or audit visit. DMSL said that it estimates the number of unique properties where the help scheme is deemed to have positively addressed interference at 264,100.⁴⁷¹ Digital UK noted that the 800 MHz

⁴⁶⁸ techUK consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143716/techuk.pdf, p. 2

⁴⁶⁹ Coexistence of new services in the 700 MHz band with digital terrestrial television, https://www.ofcom.org.uk/_data/assets/pdf_file/0025/108655/update-coexistence-700-mhz.pdf, p. 18.

⁴⁷⁰ Mr D. Bentley response to the October 2019 consultation, https://www.ofcom.org.uk/_data/assets/pdf_file/0030/189552/dbentley.pdf

⁴⁷¹ DMSL consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 3.

support scheme has handled c.531,000 contacts and highlighted that focusing on the 25,000 cases confirmed by an engineer visit could lead to misleading dimensioning assumptions for the support scheme.⁴⁷²

7.36 We agree the estimates provided by DMSL and DUK are likely to be useful for those who will design the scheme, in addition to the number of confirmed cases we quoted.

Our proposed solution

Merits of a non-prescriptive approach

7.37 In the consultation we proposed adopting a flexible approach to coexistence in which 700 MHz licensees would be subject to a high-level obligation to set up and operate a scheme to provide advice and assistance to viewers suffering undue interference from mobile services and to ensure the 700 MHz licensees take appropriate and proportionate measures to resolve any undue interference to DTT viewers.

7.38 Most stakeholders, including Nokia, DMSL and Nottinghamshire City Council, supported our preferred non-prescriptive approach to coexistence.⁴⁷³ Some stakeholders also highlighted concerns regarding the alternative options we set out. These comments reflected respondents' broad support for the proposed approach (option 3):

- Digital UK said that a formal role for the broadcasters in the scheme to deliver the front line of consumer support (option 1) would impose costs and reputational risks linked to issues for which the broadcasters were not responsible.⁴⁷⁴
- DMSL said that a more rigid and prescriptive scheme (option 2) would take time to adjust to actual levels of demand for assistance and risks exacerbating consumer harm.⁴⁷⁵
- H3G said that a scheme that involved broadcasters and licensees both taking an active role in remedying interference issues (option 1) would overcomplicate matters, risking inconsistent consumer outcomes. It also argued that a prescriptive approach (option 2) would rely on successfully predicting the scale of interference, which would be a difficult task.⁴⁷⁶

⁴⁷² Digital UK and Freeview consultation response,

https://www.ofcom.org.uk/data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 7.

⁴⁷³ Nokia consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0016/143314/nokia.pdf, p. 2; DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 1; Nottinghamshire County Council consultation response,

https://www.ofcom.org.uk/data/assets/pdf_file/0024/143529/nottinghamshire-county-council.pdf, p. 2.

⁴⁷⁴ Digital UK and Freeview consultation response,

https://www.ofcom.org.uk/data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 8.

⁴⁷⁵ DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 3.

⁴⁷⁶ Hutchinson 3G consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0024/143493/three.pdf, p. 55.

- 7.39 Immediate Media TV and North Yorkshire Council raised concerns regarding a non-prescriptive approach. They asked how consumers would fare under such an approach.⁴⁷⁷ Immediate Media TV said that our proposed approach had the potential to create multiple coexistence solutions and a confusing landscape for viewers, particularly vulnerable people.⁴⁷⁸
- 7.40 We consider that requiring 700 MHz licensees to present a joint plan, as opposed to having several uncoordinated schemes, will ensure that a confusing landscape for viewers does not emerge. In particular, we make it clear in the guidance that we expect licensees to provide a sole point of contact for viewers.
- 7.41 Digital UK supported our approach, so long as provisions are made on monitoring and enforcement action.⁴⁷⁹ We agree and we will be ready to monitor and take enforcement action where appropriate, in line with our duties and powers.
- 7.42 The objective of our approach to coexistence is to ensure that 700 MHz mobile services do not cause undue interference to DTT viewers – and, if they do, that new mobile licensees take appropriate and proportionate measures to address any undue interference. We consider that a flexible approach to interference, one that adapts to reflect the scale of the issue and takes account of learnings as roll out of mobile services takes place, is well-placed to mitigate the risk that consumers will experience harm.
- 7.43 The obligation to operate the viewer support scheme will be a condition in the 700 MHz band licences. The 700 MHz licensees will therefore be required to meet this obligation and take appropriate and proportionate measures to protect viewers.

Source of funding

- 7.44 In the consultation we said our preferred approach was that licensees would be required to provide consumer support, at their own cost.
- 7.45 techUK agreed with the approach in our preferred option, saying that that incumbent users should not be faced with incremental costs incurred as a result of change of usage of adjoining bands.⁴⁸⁰ Digital UK echoed this view.⁴⁸¹

The scope of assistance

- 7.46 In the consultation we said that DTT-only viewers should receive full assistance, for example in the form of filters, installer support and advice. We said that viewers with pay

⁴⁷⁷ Immediate Media TV consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0018/143307/immediate-media-tv-ltd.pdf, p. 2; North Yorkshire County Council consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0020/143525/north-yorkshire-county-council.pdf, p. 4.

⁴⁷⁸ Immediate Media TV consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0018/143307/immediate-media-tv-ltd.pdf, p. 2.

⁴⁷⁹ Digital UK and Freeview consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 7.

⁴⁸⁰ techUK consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0022/143716/techuk.pdf, p. 2.

⁴⁸¹ Digital UK and Freeview consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 7.

TV and indoor aerials should receive advice but not mitigation assistance. We made it clear that the scheme is limited to DTT interference cases caused by mobile in the 700 MHz band.

- 7.47 DMSL agreed that the viewer support scheme should be limited to DTT interference cases specifically related to mobile in the 700 MHz band.⁴⁸²

Groups eligible for assistance

- 7.48 We indicated in the consultation and draft guidance that we would not require the support scheme to supply filters for consumers with Pay TV (i.e. those viewers who do not depend on DTT as their sole source of TV reception) or people with indoor aerials. We said that the licensees should consider proportionate means of assisting these viewers.
- 7.49 Digital UK said that viewers who are not reliant on DTT services to view TV (for example because they have satellite or cable) should be offered a filter. Digital UK said that this struck a better balance between proportionality and effectiveness than the proposal set out in the consultation.⁴⁸³ DMSL echoed this view, saying that filters should also be offered to viewers dependent on DTT and to those who have set-top antennas.⁴⁸⁴
- 7.50 Which specific measures would be appropriate and proportionate to protect DTT viewers from undue interference will depend on the circumstances of each case. The approach set out in the guidance represents the minimum necessary that we would normally expect from the 700 MHz licensee. However, we would welcome 700 MHz licensees going beyond the expectations set out in our guidance, which seems in line with DMSL's comment that filters should also be offered to viewers dependent on DTT and to those who have set-top antennas.

The need for a fallback plan

- 7.51 In the consultation we said that if the 700 MHz licensees do not present us with an acceptable plan for mitigating interference then we will impose our own plan, with the costs borne by the licensees.
- 7.52 DMSL said that both it and its shareholders (the existing MNOs) are confident that they will be able to agree a joint plan. It said that there is no need for Ofcom to mandate a fallback plan.⁴⁸⁵
- 7.53 We expect that the 700 MHz licensees will be able to agree and submit to us a satisfactory joint plan. If this happens, the fallback provisions will remain unused. That said, in the interests of protecting UK consumers and citizens from harm, we remain of the view that it

⁴⁸² DMSL consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 4.

⁴⁸³ Digital UK and Freeview consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 8.

⁴⁸⁴ DMSL consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 4.

⁴⁸⁵ DMSL consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 2.

is important to retain a regulatory fallback option in case a satisfactory plan is not submitted. In this regard we note that, while the response from DMSL represents the views of the existing MNOs, the 700 MHz spectrum may be won by other operators.

Applicability of the licence obligation

- 7.54 Vodafone said that it was not explicitly stated in the consultation that the obligation to operate a support scheme applies equally across the paired spectrum and the centre gap.⁴⁸⁶
- 7.55 We said in the consultation that the obligation would apply to ‘700 MHz licensees’, i.e. including the 700 MHz ‘centre gap’ spectrum. We set out in the draft guidance that viewer support obligations are included in “licences for spectrum in the 700 MHz band (694-790 MHz)”. We confirm that the licence obligation to provide viewer support includes the centre gap spectrum.

Scheme design and operation

Limits on scheme obligations

- 7.56 The MNOs said that Ofcom should limit the financial obligations associated with the support scheme, as well as the term over which 700 MHz licensees must support viewers affected by interference.
- 7.57 DMSL, in a response on behalf of all current MNOs, said that Ofcom should cap the costs associated with the scheme and that this would be consistent with the approach taken for 800 MHz.⁴⁸⁷ In an additional response, H3G argued for a similar approach, with the shortfall to be met by Government. H3G said that an upper limit would provide prospective bidders with certainty that their financial obligations would not exceed a certain amount were they to secure 700 MHz spectrum. This in turn would allow bidders to better understand the value of the spectrum to them.⁴⁸⁸
- 7.58 We do not agree that we should set a limit on the overall funding liability the 700 MHz licensees will face for the support scheme. While the UK Government set a limit on the costs faced by the licensees for the scheme to address 800 MHz, there was considerably greater uncertainty surrounding the scale of these costs than there is for 700 MHz. The 800 MHz scheme provides prospective 700 MHz licensees with an indication of the scale of costs they are likely to face in providing viewer support. Moreover, we consider that the 700 MHz licensees will have some control over the costs associated with the support scheme (e.g. the specific elements of scheme design identified by DMSL in its consultation response and discussed below at paragraph 7.73). This will allow the prospective bidders to

⁴⁸⁶ Vodafone consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0027/143496/vodafone.pdf, p. 50.

⁴⁸⁷ DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 9.

⁴⁸⁸ Hutchinson 3G consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0024/143493/three.pdf, p. 55.

form an assessment of the costs they are likely to face and understand the value of the spectrum to them.

- 7.59 DMSL said that as well as an overall limit on the costs of providing consumer support, appropriate and reasonable funding limits should be agreed for service restoration. DMSL said that service restoration costs would be significantly less than the upper limit for 800 MHz restoration work, i.e. £10,000.⁴⁸⁹
- 7.60 We agree that in the interests of proportionality there should be a limit on the cost of service restoration. We consider it would be appropriate to agree this limit as part of the plan that the 700 MHz licensees submit to Ofcom. We have amended the guidance to reflect this.
- 7.61 DMSL said that taking account of Ofcom's comments on proportionality, the obligation to mitigate interference should not continue indefinitely. It indicated that a time limit of no longer than five years would be appropriate.⁴⁹⁰
- 7.62 Any support scheme should be proportionate to the scale of the problem identified. We consider that it would be appropriate to agree a timeframe for the support scheme. This should be part of the plan the 700 MHz licensees submit to Ofcom. We have amended the guidance to reflect this. In assessing an appropriate timescale, we will be mindful of the likely duration of rollout of mobile services in the 700 MHz band, given that the 800 MHz rollout has lasted for more than five years.

Scheme notice text

- 7.63 In the consultation we set out a draft licence obligation that would require the 700 MHz licensee to operate the scheme and comply with its obligations in the scheme notice. We said that the scheme notice will reflect the scheme as approved by Ofcom in response to the licensees' joint plan or imposed by us.
- 7.64 DMSL said that the actual text of the scheme notice must be agreed by Ofcom, the licensees and the scheme operator.⁴⁹¹
- 7.65 We do not consider that it is necessary for Ofcom to agree the scheme notice with the scheme operator(s). Ofcom will impose the relevant obligation on the 700 MHz licensees only, and it will be incumbent on them to comply with such obligation. They are free to involve other parties as they see fit in developing a scheme, but not required to do so.

700 MHz coexistence and the rollout of mobile services

- 7.66 In the consultation, we proposed to allow 10 weeks from the award of the 700 MHz licences for the licensees to submit to Ofcom a joint plan about how they propose to implement the support scheme. We said we would evaluate the scheme within 6 weeks.

⁴⁸⁹ DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 10.

⁴⁹⁰ DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 3.

⁴⁹¹ DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, 3.

We also set out in the consultation that any solution we adopt for 700 MHz coexistence should not adversely affect roll-out of mobile services in the band.

- 7.67 DMSL and Digital UK both commented on the connection between readiness to implement interference mitigation in the 700 MHz band and the rollout of mobile services in the 700 MHz band. DMSL said that any joint scheme agreed between 700 MHz licensees should provide a timeline for set up of the scheme against any start dates for 700 MHz rollout. This will ensure readiness of the scheme prior to rollout commencing.⁴⁹² Digital UK said that the 700 MHz support scheme should be operationally ready to assist viewers by the time MNOs begin to deploy mobile services.⁴⁹³
- 7.68 We agree that the scheme needs to be ready to assist viewers by the time the winners of the 700 MHz licences begin to deploy mobile services. Any plan whereby these licensees deploy services before the support scheme is ready would clearly fail to help consumers. The requirement for the licensees to submit to Ofcom a satisfactory scheme therefore prevents this possibility.
- 7.69 Digital UK expressed concern about the allowance of up to 16 weeks for the rollout plan developed by the 700 MHz licensees to be submitted and approved by Ofcom. It said that Ofcom should therefore consider requiring parties interested in bidding for the 700 MHz spectrum to agree the joint scheme before the award.⁴⁹⁴ In its view, this would avoid the risk of delay to rollout while the licensees submit a joint scheme to Ofcom and Ofcom considers it.
- 7.70 We agree that interference mitigation must not unnecessarily hold up the roll out of mobile services and that the scheme will need to be operationally ready to assist DTT viewers by the time deployment of the 700 MHz centre gap begins. We remain of the view that a maximum of 10 weeks for the submission of a joint plan and a maximum of 6 weeks for Ofcom's assessment represent appropriate and proportionate timescales to achieve these objectives. We also note that the auction winners will be able to submit a scheme early if they so wish.

Need for input from broadcasters

- 7.71 Some stakeholders highlighted the need for involvement from the broadcasters in delivering consumer support. Tech UK called for engagement with Digital UK as soon as possible to ensure a joined-up approach to addressing interference into DTT from mobile.⁴⁹⁵ Digital UK echoed the need for engagement with broadcasters, also stating that

⁴⁹² DMSL consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p.3.

⁴⁹³ Digital UK and Freeview consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 8.

⁴⁹⁴ Digital UK and Freeview consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 8.

⁴⁹⁵ Tech UK consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143716/techuk.pdf, p. 2

broadcasters should be involved in an oversight capacity.⁴⁹⁶ DMSL also noted the potential for broadcasters to be involved at the level of oversight.⁴⁹⁷

7.72 We welcome this indication of a desire on the part of mobile network operators and broadcasters to work together on mitigating interference and monitoring the success of approaches. We will encourage continuing collaboration between different parties to ensure that 700 MHz mobile services do not cause undue interference to DTT viewers – and, if they do, that new 700 MHz licensees take appropriate and proportionate measures to protect DTT viewers.

Specific comments on scheme design from DMSL

7.73 DMSL set out a range of further comments. These included recommendations in the following areas:

- the use of a multi-channel approach involving telephone access, website, email and social media channels would be more effective for assisting consumers than just operating an advice line;
- the use of multiple social media mechanisms to advertise the scheme to viewers;
- the adoption of metrics to track performance, particularly the use of customer satisfaction results;
- an understanding of mobile rollout plans in order to manage the support provided by the scheme;
- conducting pilot schemes to test assumptions and better understand viewer expectations;
- a modelling of costs followed by further discussion with Ofcom; and
- modelling to identify which consumers are likely to be affected by interference.⁴⁹⁸

7.74 We recognise that delivering a scheme to effectively mitigate interference will demand detailed planning on the part of the scheme operator (e.g. in the area of modelling DTT viewers likely to be affected by interference). We do not intend to be highly prescriptive in these areas, considering that the 700 MHz licensees will be best placed to determine how best to meet the obligation to ensure they take appropriate and proportionate measures to protect DTT viewers.

7.75 We have not made changes to our proposed guidance on the grounds that licensees will be best placed to determine the appropriate approach in these instances.

⁴⁹⁶ Digital UK and Freeview consultation response,

https://www.ofcom.org.uk/data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 8.

⁴⁹⁷ DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 9.

⁴⁹⁸ DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, pp. 6-10.

Other issues

- 7.76 Some stakeholders raised other issues related to coexistence that were not directly relevant to the policy issues raised in the consultation. We have set these out below.
- 7.77 Nominet suggested that Ofcom should consider use of a Dynamic Spectrum Access model to enable coexistence in the 700 MHz band.⁴⁹⁹ It is clear from the response that Nominet is talking about coexistence between 700 mobile users and additional users in the 700 MHz band. They did not address the policy issue in this section – between 700 MHz mobile and DTT in an adjacent band.
- 7.78 Telint suggested the licence obligation and guidance should be amended to facilitate sharing, but did not provide a rationale for the suggestion, or any specifics about what amendment they had in mind.⁵⁰⁰
- 7.79 Telint also said that Ofcom needs better modelling tools. The approach to coexistence proposed in the consultation, and adopted now, does not involve any additional modelling to be performed by Ofcom, and we therefore do not consider this suggestion to be relevant in the circumstances.⁵⁰¹

Interim multiplexes

Our consultation proposals

- 7.80 In the December 2018 consultation we proposed that Arqiva could continue to use the centre gap under the following terms.
- We would issue a new licence to Arqiva, running from 21 June 2020 for a duration that Arqiva would agree with the relevant licensees.
 - Arqiva would be subject to fees that would be a pro-rating of the fees that applied under Arqiva's existing licence.
 - Arqiva would be required to communicate with viewers when the interim multiplexes are terminated. We also restated a further condition for Arqiva's use of the centre gap, which we set out in our decision to award the centre gap to mobile services in 2016.
 - Arqiva would not be allowed to cause interference to any other services and would be responsible for resolving interference from mobile into DTT services provided by the interim multiplexes. (The interim multiplexes would therefore fall outside the measures on coexistence set out above.)
- 7.81 In the consultation we also proposed to require the 700 MHz centre gap mobile licensee(s) to give us three months advance notice of their intention to start using this spectrum to

⁴⁹⁹ Nominet consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0019/143524/nominet.pdf, p. 20.

⁵⁰⁰ Telint consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0022/143491/telint.pdf, p. 3.

⁵⁰¹ Telint consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0022/143491/telint.pdf, p. 3.

enable us to decide whether and when to serve notice of revocation on any relevant licence on Arqiva.

Stakeholder responses

7.82 We have set out the issues raised by stakeholders below, as well as our views and decisions on these issues.

Usage of the centre gap

7.83 Digital UK and Arqiva questioned the basis of our 2016 decision to make the centre gap available for mobile services. Digital UK said that Ofcom shows a questionable preference for a future uncertain spectrum use over a current, certain use of spectrum.⁵⁰² Arqiva said that for the next 3-5 years the most valuable use of the centre gap could conceivably be DTT. It said that Ofcom should seek to allow viewers to continue to benefit from these services if mobile services are not ready to deploy in a commercially viable manner.⁵⁰³

7.84 We note the responses from stakeholders. We set out and explained our decision to make the 700 MHz centre gap spectrum available for mobile use in October 2016,⁵⁰⁴ and we are not re-opening that decision as part of the decisions we are now making on the auction. We consider that making the centre gap available for mobile data while allowing the interim multiplexes to remain in the centre gap until such time as mobile data services are deployed there will give best effect to our duties to secure optimal use of the spectrum and to further the interests of citizens and consumers.

Protection of centre gap from interference

7.85 In the consultation we proposed that Arqiva would be responsible for resolving interference from mobile services to the DTT services provided by the interim multiplexes.

7.86 Arqiva said that Ofcom should consider whether its statutory duties extend to a role in minimizing the interference into the DTT operating in the centre gap from mobile services in the 700 MHz band. In particular, Arqiva said that, for example, Ofcom should clarify its role in resolving any issues where there is evidence that adjacent mobile users were operating in breach of their technical licence conditions.⁵⁰⁵

7.87 In our 2016 decision we said that we would not generally expect other users of the 700 MHz band to manage the risk of interference to the interim multiplexes. We will not reopen our 2016 decision on this matter. However, Ofcom will consider any alleged breach

⁵⁰² Digital UK and Freeview consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 10.

⁵⁰³ Arqiva response to the December 2018 consultation, https://www.ofcom.org.uk/data/assets/pdf_file/0026/143279/arqiva.pdf, p. 8.

⁵⁰⁴ https://www.ofcom.org.uk/data/assets/pdf_file/0031/92659/Maximising-the-benefits-of-700-MHz-clearance-Statement.pdf

⁵⁰⁵ Arqiva response to the December 2018 consultation, https://www.ofcom.org.uk/data/assets/pdf_file/0026/143279/arqiva.pdf, p. 12.

of a licence condition that is reported to us on a case-by-case basis on its merits, in line with our normal reporting procedures.

Duration of interim multiplex licences

- 7.88 In the consultation we proposed that Arqiva could reach an agreement with the winner(s) of the centre gap spectrum on the duration of its licence for use of the centre gap.
- 7.89 Arqiva and Digital UK said that it is unfeasible to expect negotiations between Arqiva and the MNOs to occur. Arqiva said that there is a risk of an appearance of collusion should they engage with bidders prior to the auction. It said there is limited time for negotiation between the auction and spectrum becoming available for use. It also said that Ofcom has accepted the limitations of commercial agreements between spectrum licensees and access seekers in our *Enabling opportunities for innovation* consultation.⁵⁰⁶ Digital UK said that the inexpensiveness of the centre gap for the MNOs will provide them with little incentive to engage with Arqiva to allow the ongoing operation of COM 7 and 8.⁵⁰⁷
- 7.90 We note the comments from Arqiva and Digital UK. However, if the interim multiplex licence is a valuable commercial asset to Arqiva, it can provide a financial incentive for MNOs to negotiate. If it is not a valuable asset then there is little risk of harm to consumers should negotiations prove unsuccessful. When we originally granted the interim multiplex licence we made clear that these multiplexes would operate on a temporary basis.⁵⁰⁸
- 7.91 We did identify limitations of commercial agreements between spectrum licensees and access seekers in our *Enabling opportunities for innovation* consultation. However, that statement was made in the context of saying that leasing creates responsibilities for current licensees that act as a disincentive to them to enter into leasing agreements. This is not applicable to the 700 MHz licensees, who would not be leasing their spectrum to Arqiva and would therefore acquire no equivalent responsibilities.

Licence duration in the event of no agreement

- 7.92 In the consultation we proposed that if the mobile licensees have not switched on their services but are unable to reach an agreement with Arqiva, we would be minded to grant Arqiva licences with a duration of a month at a time.
- 7.93 Several stakeholders, including tech UK, Digital UK and Arqiva, commented on issues related to this proposed one-month licence duration. techUK said it is unclear how one month rolling notice periods can give certainty to broadcasters.⁵⁰⁹ Digital UK said that a one

⁵⁰⁶ Arqiva response to the December 2018 consultation, https://www.ofcom.org.uk/_data/assets/pdf_file/0026/143279/arqiva.pdf, pp. 11-12; Ofcom, *Enabling opportunities for innovation: Shared access to spectrum supporting mobile technology*, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/130747/Enabling-opportunities-for-innovation.pdf.

⁵⁰⁷ Digital UK and Freeview consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 11.

⁵⁰⁸ Award of the 600 MHz band, July 2013, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/54652/600_mhz_statement.pdf, p. 17.

⁵⁰⁹ Tech UK consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143716/techuk.pdf, p. 3.

month licence duration could have a material impact on viewers, including the possibility that uncertainty may lead broadcasters to pre-emptively abandon the DTT platform.⁵¹⁰ Arqiva also responded on this issue, both in its response to the December 2018 consultation and the October 2019 consultation on auction design. In its response to the October 2019 consultation on auction design it emphasised that a one month notice period does not take into account the commercial realities of the markets Ofcom regulates.⁵¹¹

7.94 Some stakeholders suggested longer licence durations. PBS America requested a three month (rather than one month) notice period to facilitate communication with viewers.⁵¹² Together said that a one month notice period is not manageable in terms of its supplier agreements and that a 12 month notice period would be required for it to exit some of them in an orderly way.⁵¹³ Services Sound and Vision Corporation said that it would need a notice period in the region of 6–12 months and certainly no less than three months.⁵¹⁴ Arqiva also proposed longer notice periods: 12 months in its response to the December 2018 consultation and 6 months in its response to the October 2019 consultation.⁵¹⁵

7.95 We note the comments from stakeholders. We have decided to adopt the approach set out in the consultation insofar as we will grant Arqiva a one-month licence duration if no agreement is reached between Arqiva and the mobile licensee(s). We consider that this is the best way to ensure that the centre gap licensees can access the spectrum as soon as they are ready to deploy services, while making the most efficient use of the spectrum by allowing Arqiva to operate DTT in the centre gap until the licensees begin deployment. When we decided to grant the interim multiplexes it was on a temporary basis to support the ongoing provision of DTT, but with the objective of enabling the future release of the 700 MHz band.⁵¹⁶

7.96 However, in light of stakeholders' comments, we have decided to amend our consultation proposals in the following way. We will require the licensee(s) to also inform Arqiva when they serve their 3-month notice of intention to use the centre gap spectrum. At that time, we will also extend Arqiva's temporary licence so that the end date for the interim multiplex licence matches the date in the notice received from the MNOs. This is set out in figure 7.1 below. This will not alter the point at which the 700 MHz licensee will be able to start using the centre gap spectrum. However, in practice, it will provide more time for Arqiva and broadcasters to prepare for the cessation of services on the interim multiplexes

⁵¹⁰ Digital UK and Freeview consultation response,

https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 10-11.

⁵¹¹ Arqiva response to the December 2018 consultation,

https://www.ofcom.org.uk/_data/assets/pdf_file/0026/143279/arqiva.pdf, pp. 8-11; Arqiva response to the October 2019 consultation, https://www.ofcom.org.uk/_data/assets/pdf_file/0026/189341/arqiva.pdf, p. 2.

⁵¹² PBS America consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0018/143532/pbs-america.pdf.

⁵¹³ Together consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0025/143494/together.pdf, p. 1.

⁵¹⁴ Services Sound and Vision Corporation, https://www.ofcom.org.uk/_data/assets/pdf_file/0024/143538/services-sound-vision-corporation.pdf, p. 2.

⁵¹⁵ Arqiva response to the December 2018 consultation,

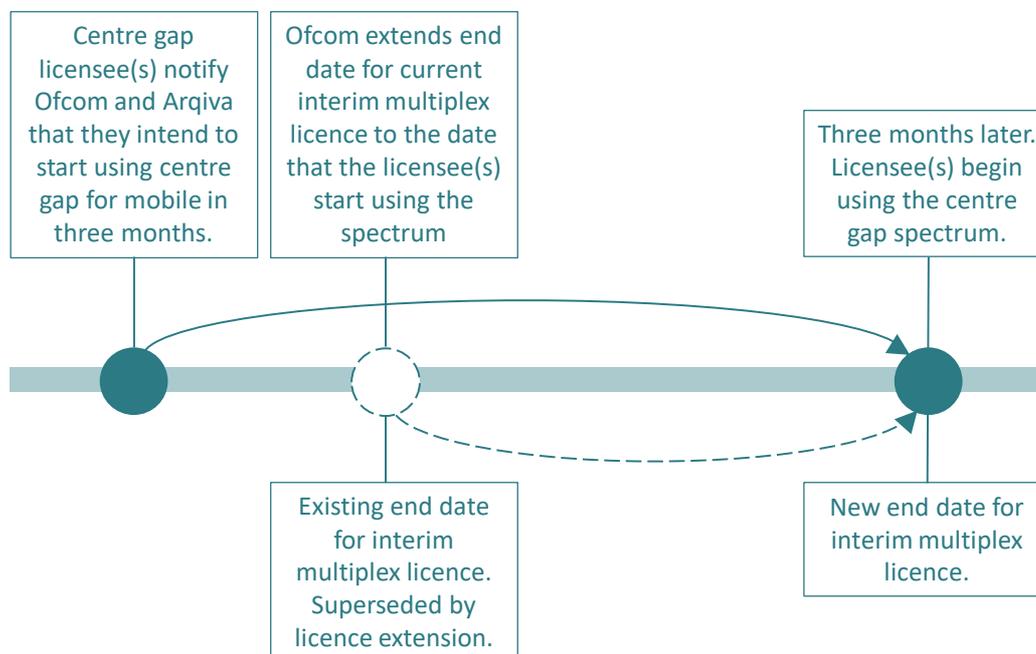
https://www.ofcom.org.uk/_data/assets/pdf_file/0026/143279/arqiva.pdf, p. 2; Arqiva response to the October 2019 consultation, https://www.ofcom.org.uk/_data/assets/pdf_file/0026/189341/arqiva.pdf, p. 3.

⁵¹⁶ Award of the 600 MHz spectrum band, July 2013,

https://www.ofcom.org.uk/_data/assets/pdf_file/0022/54652/600_mhz_statement.pdf, p. 3

by providing them with the three-month notice period that some respondents indicated was the minimum they would need.

Figure 7.1: Licensing extension following notification



Timeline for use of SDL

- 7.97 Some stakeholders, including Digital UK and Arqiva, indicated that handsets for SDL are not currently available. They said that it may take some time for them to become available. Digital UK said that to date no consumer handsets for sale in Europe support SDL use of the centre gap and it would take several more years to establish a “viable critical base of addressable devices”.⁵¹⁷ Arqiva suggested that comparisons with the availability of L-Band handsets indicated that handsets configured for the centre gap may become available by about 2021, though lack of international alignment and technical challenges may mean that they do not become available until later.⁵¹⁸ Both in its response to the December 2018 consultation and the response to the October 2019 consultation Arqiva said that duplex-gap dependent services are unlikely to deploy in the UK near the time of the award.⁵¹⁹
- 7.98 We consider that it will be up to the centre gap licensee(s) to decide when they deploy SDL. Should they decide to significantly delay, then Arqiva may continue to operate in the centre gap until they are ready to deploy. We will therefore adopt the proposal as set out in the consultation.

⁵¹⁷ Digital UK and Freeview consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 10.

⁵¹⁸ Arqiva response to the December 2018 consultation, https://www.ofcom.org.uk/_data/assets/pdf_file/0026/143279/arqiva.pdf, p. 7.

⁵¹⁹ Arqiva response to December 2018 consultation, https://www.ofcom.org.uk/_data/assets/pdf_file/0026/143279/arqiva.pdf, p. 2; Arqiva response to October 2019 consultation, https://www.ofcom.org.uk/_data/assets/pdf_file/0026/189341/arqiva.pdf, p. 3

Impact of United Kingdom's exit from the European Union

- 7.99 In the consultation, we said that we did not envisage the short-term arrangements to facilitate Arqiva's use of the centre gap lasting beyond 30 June 2022 at the maximum, in line with the relevant EU decision.
- 7.100 Arqiva and Digital UK raised the impact of the UK's exit from the EU on the timeline for the removal of DTT from the 700 MHz band on this timeline. Arqiva said that uncertainties over the UK's exit from the EU mean that Ofcom cannot say that, legally speaking, DTT must vacate the 700 MHz duplex gap by 2022. It said that at a minimum Ofcom should ensure that its policy is flexible to cover a range of Brexit outcomes.⁵²⁰ Digital UK said that Ofcom should explicitly allow the option that the 2022 legal deadline may not necessarily apply.⁵²¹
- 7.101 The UK ceased to be a member of the European Union on 31 January 2020. Under the terms of the Withdrawal Agreement, EU law will continue to apply in the UK until 31 December 2020. In reaching our decisions we have continued to apply the current legal framework, including the EU Framework.
- 7.102 In addition, as noted above, we will not reopen our 2016 decision on the removal of DTT from the 700 MHz band.

Use of higher standard receiver filtering

- 7.103 In the consultation we said that Arqiva would have the right to use the centre gap on a non-interference and non-protected basis.
- 7.104 In a letter to Ofcom, Arqiva said that Ofcom needed to advise MNOs that they must have filtering as indicated in CEPT Report 53, otherwise a SDL/SDO service in the duplex gap operated within the terms of the auctioned licence could interfere with the mobile service operating in the paired spectrum. In its view, Ofcom does not necessarily need to mandate this. Instead, if the MNOs do not use this filtering, then Ofcom should not consider any interference they experience as a result.⁵²²
- 7.105 We remain of the view that it is not necessary to impose any such requirements. Our decision is in line with Commission Decision 2016/687, which does not include any filtering requirements.
- 7.106 We would expect FDD operators to consider SDL and SDO use in their base station design before deploying their network. However, we do not know the actual SDL or SDO deployment scenarios or the way an operator or operators may use this spectrum. Differing ways in which the spectrum is integrated into networks could dictate differing filtering requirements. MNOs operate services of broadly similar power and deployment

⁵²⁰ Arqiva response to the December 2018 consultation, https://www.ofcom.org.uk/data/assets/pdf_file/0026/143279/arqiva.pdf, p. 8.

⁵²¹ Digital UK and Freeview, https://www.ofcom.org.uk/data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, p. 11.

⁵²² [REDACTED]

densities, and they are able to coordinate their deployments and services to achieve coexistence.

- 7.107 In response to Arqiva's comment on the issue of the enforcement against 700 MHz base stations into DTT, Ofcom will consider any alleged interference or breach of a licence condition that is reported to Ofcom on its merits on a case-by-case basis, in line with our normal procedures.
- 7.108 In conclusion, we have decided to implement the licence conditions concerning the use of the centre gap as set out in our consultation proposals.

Communication with viewers

- 7.109 In the December 2018 consultation we said that Arqiva should be required to communicate with viewers before switching off the interim multiplexes.
- 7.110 Arqiva said that the one month rolling notice period means that it would be difficult to communicate to viewers, risking a disorderly switch-off of channels.⁵²³ Digital UK said that the preparatory steps for informing viewers about the switch off by the interim multiplexes will require "several months".⁵²⁴
- 7.111 We consider that it is still appropriate for Arqiva to inform viewers before the interim multiplexes are switched off. Recent experience from the 700 MHz clearance programme shows that once a plan is in place ahead of time, almost all action is taken very close to the date of the interim multiplex switch off. We have therefore decided to adopt the consultation proposal. Given the amendment we have made to our consultation proposals, Arqiva will in practice have three months advance notice of interim multiplex switch off, providing more time to notify viewers.

Impact of filters on reception of interim multiplexes

- 7.112 In the consultation we restated our view that receiver filters will be the most technically effective means to mitigate interference from handsets and base stations to DTT sets.
- 7.113 Some stakeholders, including the BBC and DMSL, said that filters installed to mitigate interference from mobile services in the 700 MHz band will prevent viewers from receiving services from the interim multiplexes that may operate in the 700 MHz centre gap into 2020.⁵²⁵ DMSL said that the licensees' joint plan for coexistence should ensure the appropriate handling of viewers who, with a 700 MHz filter, may lose access to such services.⁵²⁶

⁵²³ Arqiva response to the December 2018 consultation, https://www.ofcom.org.uk/data/assets/pdf_file/0026/143279/arqiva.pdf, p. 9.

⁵²⁴ Digital UK and Freeview consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0022/143293/digital-uk-and-freeview.pdf, pp. 10-11.

⁵²⁵ BBC consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0018/143280/bbc.pdf, p. 6; DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 5.

⁵²⁶ DMSL consultation response, https://www.ofcom.org.uk/data/assets/pdf_file/0021/143292/digital-mobile-spectrum-ltd.pdf, p. 5.

7.114 We recognise that filters designed to protect DTT receivers from interference from the 700 MHz band will also almost certainly cut off DTT services operating in the 700 MHz band centre gap. We understand that the scheme will need an approach to deal with this issue, for example by providing explanations to viewers who lose the interim multiplexes as a consequence of installing the filter. We agree that this should be addressed in the joint plan that stakeholders present to Ofcom.

Arqiva's fees for use of the centre gap

7.115 In the consultation we proposed that Arqiva would be subject to fees that would be a pro-rating of the fees that applied under Arqiva's existing licence, until the end-date of its new licence.

7.116 Vodafone queried whether the approach to fees proposed by Ofcom was appropriate. The new centre gap licensee will pay a market-based fee for use of the spectrum. However, Ofcom will continue to charge Arqiva an annual licence fee (ALF) to use the spectrum until the date Arqiva stops using the spectrum. Vodafone said that Ofcom will effectively be "having its cake and eating it". In its view, the fee should be passed either to the new centre-gap licensee or the organisation put in place to provide interference mitigation services. Alternatively, Ofcom could continue to receive the ALF from Arqiva but the licence term on the new award licences for the centre gap should commence at the point that the licensee serves notice to Arqiva.⁵²⁷

7.117 The fees charged to Arqiva reflect the costs that Ofcom incurs in administering the spectrum. The fact that we have auctioned the spectrum does not affect this rationale for charging fees to Arqiva. We will therefore adopt the licence fee regime set out in the consultation.

3.6-3.8 GHz band – summary of our decisions

7.118 In the December 2018 consultation, we noted there would be a period of time between the award of the 3.6-3.8 GHz spectrum and the dates at which variation or revocation of existing satellite and fixed links authorisations in the band came into effect. We said that we would need to maintain protections for these users during this interim period. We proposed that new licensees in the 3.6-3.8 GHz band should submit technical information to Ofcom about each new base station they intend to deploy during this period.

7.119 After consideration of stakeholder responses, we have decided:

- to maintain the current protection for fixed links and satellite earth stations in the 3.6-3.8 GHz band during the interim period only.
- to put 1km restriction zones around five satellite earth stations for operators who told us that they wished to continue operating on a non-interference non-protected basis in the 3.6-3.8 GHz band, once the interim period has lapsed.

⁵²⁷ Vodafone consultation response, https://www.ofcom.org.uk/_data/assets/pdf_file/0027/143496/vodafone.pdf, p. 50.

- that we will not require coordination to manage adjacent band coexistence.

Coexistence issues for the 3.6-3.8 GHz band

7.120 In the December 2018 consultation, we said new users of spectrum in the 3.6-3.8 GHz band would need to coexist with other in-band spectrum users as well as users of adjacent bands. Frequencies in the 3.6-3.8 GHz band are currently used for fixed links, fixed satellite services (to receive space-to-Earth transmissions) and wireless broadband (provided by UK Broadband). As set out in our consultation (paragraphs 2.29-2.34), the 3.6-3.8 GHz band should become available for mobile use by June 2020, but some localised constraints may remain in place until the end of 2022.⁵²⁸

7.121 Below, we address stakeholders' comments on the following issues and set out our decisions on:

- Protections for registered 3.6-3.8 GHz band users during the interim period;
- In-band restriction zones around satellite earth stations during the interim period and after; and
- Coexistence with users in the 3.8-4.2 GHz band.

Protections for registered 3.6-3.8 GHz band users during the interim period

Our proposals

7.122 In the December 2018 consultation, we noted there would be a period of time between the award of the 3.6-3.8 GHz spectrum and the dates at which variation or revocation of existing satellite and fixed links authorisations in the band come into effect. We said that we would need to maintain protections for these users during such periods.

7.123 Accordingly, we proposed that during the interim period prior to the dates at which variation or revocation of existing satellite and fixed links authorisations in the band come into effect, new licensees in the 3.6-3.8 GHz band would need to submit to Ofcom technical information about each new base station they intend to deploy. Ofcom would use that information to assess whether the new base station would be likely to undermine benchmark spectrum quality for existing registered satellite earth stations and fixed links. New licensees would not be permitted to transmit from new base stations unless the planned deployment passes the assessment process.

⁵²⁸ In particular, in our February 2018 update on the clearance of the 3.6-3.8 GHz band, we confirmed that we had:

- issued notices to revoke all fixed links licences in the band, with an effective date of 23 December 2022;
- varied 12 Permanent Earth Station licences and three grants of RSA, with an effective date of 1 June 2020; and
- varied one grant of RSA with an effective date of 1 September 2020.

We also said that we would work with fixed links licensees with the aim of migrating fixed links operations to alternative frequencies or technologies by June 2020 where possible. See

https://www.ofcom.org.uk/_data/assets/pdf_file/0018/110718/3.6GHz-3.8GHz-update-timing-spectrum-availability.pdf

Stakeholders' comments

- 7.124 A range of stakeholders⁵²⁹ responded to our proposal for interim protection of registered licensees in 3.6-3.8 GHz band. In summary, the BBC highlighted that the interference protection levels for RSAs⁵³⁰ are based on single entry interference and the introduction of dense mobile deployments may impact receive only earth stations due to increased aggregate interference level.⁵³¹ Two confidential respondents⁵³² noted that protection of existing earth stations should be maintained during the interim period without being subject to interference. In particular, [REDACTED].
- 7.125 [REDACTED] noted that it did not support our decision to revoke satellite earth station licences and suggested that there should be a coordination process to protect earth stations beyond 2020. It noted the European Commission's view that spectrum should be made available for mobile on a non-exclusive basis. [REDACTED] believed that this would give operators longer term confidence to operate in the 3.6-4.2 GHz band.

Our reasoning and decisions

Decision to consider a single, dominant interferer when protecting satellite earth stations

- 7.126 We have considered the BBC's comment⁵³³ that aggregate interference may impact receive only earth stations. However, for the following reasons we anticipate that the aggregate interference levels will be similar to those calculated for a single dominant interferer.⁵³⁴ Most of the registered users in the band are in rural areas where the density of mobile deployments is unlikely to be high and so the aggregation of interference is likely to be low.
- 7.127 Our previous studies⁵³⁵ based on a simulated future UK-wide 5G macrocell network showed that the aggregate interference risk from such a network was no greater than the single-entry interference risk⁵³⁶ for the same network. Interference aggregation is only significant in scenarios where interferers are contributing similar levels of interference power at a victim receiver. However, our studies showed that one base station tends to dominate because base stations in a mobile network have varying distances, and antenna pointing

⁵²⁹ Specifically, we received comments from BBC, Nokia, Vodafone, H3G, University of Strathclyde, Nominet, Telint, [REDACTED], [REDACTED] and [REDACTED].

⁵³⁰ RSA: Recognised Spectrum Access

⁵³¹ BBC response to December 2018 consultation, paragraphs 15-21

⁵³² [REDACTED], and [REDACTED]

⁵³³ BBC response to December 2018 consultation, paragraph 20, BBC argued that in the presence of 40 BS, the aggregated interference seen by the earth station receiver is $10 \cdot \log(40) = 16$ dB

⁵³⁴ Interference analyses considering a single dominant interferer are also referred to as "single entry" analyses.

⁵³⁵ Annex 8, Coexistence issues for the 3.6-3.8 GHz band, see also December 2018 consultation annex 15,

https://www.ofcom.org.uk/data/assets/pdf_file/0021/130737/Annexes-5-18-supporting-information.pdf

⁵³⁶ Annex 8, Table A8.7, Number of interfering BS sectors within 70km of each BS, see also December 2018 consultation annex A15, Table A15.9 https://www.ofcom.org.uk/data/assets/pdf_file/0021/130737/Annexes-5-18-supporting-information.pdf] shows that the number of impacted base stations is the same for both the single entry and aggregate scenarios

directions with respect to the earth station receivers, and the radiated power of those base stations will vary depending on the coverage needs.

Decision to protect incumbent users during the interim period

7.128 One confidential respondent highlighted the need for Ofcom to ensure protection of satellite earth stations during the interim period. As we said in our October 2017 statement⁵³⁷, we will continue to maintain appropriate protections for registered band users whose licence(s), or grant(s) of RSA, are revoked or varied (as applicable) until the relevant notice period had lapsed. Therefore, if existing registered band users are affected by any undue interference during the interim period, we will consider taking enforcement action where appropriate.

Decision not to extend protection of 3.6-3.8 GHz satellite earth stations beyond 2020

7.129 We set out our decision to vary existing permanent earth station licences in our July 2017 statement⁵³⁸ and in our February 2018 statement.⁵³⁹ We noted in that statement that we would continue to maintain appropriate protections for registered band users whose licence(s), or grant(s) of RSA, were revoked or varied (as applicable) until the relevant notice period had lapsed. These decisions are therefore outside the scope of this statement.

7.130 We have decided to implement a 1km restriction zone for those earth stations which choose to continue to operate on a non-interference non-protection basis in 3.6-3.8 GHz after the interim period and we discuss this in more detail later in this section.

Implementing the coordination process with registered 3.6-3.8 GHz band users during the interim period

Our proposals

7.131 We proposed to adopt the same approach to managing new base station deployments by new licensees as we currently take to co-ordinating new UK Broadband base station deployments with other registered users in the band.⁵⁴⁰ We noted that we would not be able to enter into detailed discussion or offer additional services in relation to base station coordination.

7.132 We proposed that licensees should submit coordination requests in batches of at least 100 base stations, unless a smaller batch size was agreed beforehand. We said that this was because it would be not practical for us to process requests relating to individual base

⁵³⁷ Statement: Improving consumer access to mobile services at 3.6 to 3.8 GHz, https://www.ofcom.org.uk/data/assets/pdf_file/0019/107371/Consumer-access-3.6-3.8-GHz.pdf

⁵³⁸ Statement and consultation: Improving consumer access to mobile services at 3.6GHz to 3.8GHz, https://www.ofcom.org.uk/data/assets/pdf_file/0017/103355/3-6-3-8ghz-statement.pdf

⁵³⁹ Updated statement on timing of spectrum availability: Improving consumer access to mobile services at 1.6GHz to 3.8GHz, https://www.ofcom.org.uk/data/assets/pdf_file/0018/110718/3.6GHz-3.8GHz-update-timing-spectrum-availability.pdf

⁵⁴⁰ December 2018 consultation, paragraphs 9.9 – 9.12.

stations. Overall, it is more efficient to process larger batch sizes since the submission of multiple small batches is likely to delay the results of the coordination process.⁵⁴¹

Stakeholders' comments

- 7.133 H3G thought it was appropriate to adopt a similar approach to the one we currently use to coordinate new UK Broadband base station deployments.⁵⁴² Some other responses from mobile operators and equipment vendors focused on the implementation aspects of the coordination process.
- 7.134 Nokia⁵⁴³ and Vodafone⁵⁴⁴ suggested that, given the small number and the location of the registered users in the band, Ofcom should only consider coordination of new mobile deployments located within 100km of the registered users in the band. Vodafone suggested that Ofcom should allow licensees to submit new deployments based on batches of "expedient" numbers of base stations, rather than setting a minimum requirement of batches of at least 100, in order to not compromise operational flexibility. H3G requested more clarity on what assistance will be offered to new 3.6-3.8 GHz licensees whose new deployments fail the coordination process, and questioned why Ofcom is not prepared to offer more assistance to fixed links and satellite earth station operators that fail the coordination process. H3G said that the lack of coordination assistance on offer from Ofcom did not seem to be reasonable or to fulfil Ofcom's statutory duties for making efficient use of licensed spectrum.⁵⁴⁵
- 7.135 Some responses also included more general comments regarding our coordination approach. Telint⁵⁴⁶ suggested that Ofcom should use more sophisticated tools for coordination, while Nominet⁵⁴⁷ and the University of Strathclyde⁵⁴⁸ suggested that more flexible spectrum management would make it easier to protect registered users. Google suggested that an automated admissions system could be more efficient, and the adoption of a dynamic sharing approach would allow Ofcom to better manage the coexistence challenges.

Our reasoning and decisions

Location of new mobile base stations

- 7.136 We have considered Nokia's and Vodafone's suggestion that we should only consider coordination of new mobile deployments located within 100km of registered users in the band. However, taking this approach would mean changing the protection criteria for the existing registered services.

⁵⁴¹ December 2018 consultation, paragraphs 9.13 – 9.17.

⁵⁴² H3G response to December 2018 consultation, section 7.2.

⁵⁴³ Nokia response to December 2018 consultation, response to question 9

⁵⁴⁴ Vodafone response to December 2018 consultation, response to question 9

⁵⁴⁵ H3G response to December 2018 consultation, section 7.2.

⁵⁴⁶ Telint response to December 2018 consultation, response to question 9

⁵⁴⁷ Nominet response to December 2018 consultation, Annex 1, response to question 9

⁵⁴⁸ University of Strathclyde response to December 2018 consultation, response to question 9

- 7.137 In the coordination process we already have in place for services in the 3.6-3.8 GHz band, we consider any emissions to and from stations located up to 287 km (depending on the service) from the location of a new site submitted to us for coordination. Even if it is unlikely that any interference would be caused by a base station that far away, reducing the search radius from 287 km to 100 km for potential interference sources would be inconsistent with our decision to maintain the same level of protection for registered users in the band during the interim period.
- 7.138 In addition, the coordination distance of 287 km practically means that base stations throughout the majority of the UK landmass will require coordination. Therefore, in line with our consultation proposal, we will require new licensees in the 3.6-3.8 GHz band to submit to Ofcom technical information about each new base station.

Coordination batch sizes

- 7.139 In response to Vodafone's comment regarding the coordination batch submission size, we have decided to maintain our position as proposed in our December 2018 consultation, that new licensees in 3.6-3.8 GHz spectrum should submit technical details of their new base station deployments in batches of at least 100, unless agreed beforehand. This is because it is more efficient for Ofcom to process larger batch sizes. Licensees are encouraged to submit batches that are as large as possible, however, licensees who plan to submit batches of less than 100 base station deployments during the interim period should contact Ofcom to agree the batch size before submission.

Coordination assistance from Ofcom

- 7.140 In response to H3G's comment regarding clarity on feedback, we will provide a 'pass'/'fail' result for each base station processed through the coordination tool and for the failed base stations we will provide the margin of failure. By providing the margin of failure by which each base station exceeds the interference protection thresholds, licensees will be able to modify the operational parameters and resubmit their deployment requests, avoiding additional delays in the coordination process.
- 7.141 In response to H3G's query about assistance for satellite earth stations and fixed link operators, we observe that we decided to make 3.6-3.8 GHz available for mobile services through a future award and we also decided that the band will not remain open for new satellite earth station and fixed links licences in our July 2017 statement⁵⁴⁹. We do still offer assistance and continue to engage with licensees in other bands which are still open for new satellite earth stations and fixed links assignments.

Suitability of Ofcom's coordination tools

- 7.142 We remain of the view that the tools we have in place are appropriate to ensure interference protection of registered services from new base station deployments in the 3.6-3.8 GHz band. Our tools have been in use for years and they provide a reliable

⁵⁴⁹ Improving consumer access to mobile services at 3.6GHz to 3.8GHz,
https://www.ofcom.org.uk/_data/assets/pdf_file/0017/103355/3-6-3-8ghz-statement.pdf

coordination mechanism. Developing new coordination software just for the duration of the interim period would likely introduce further delays to the award.

- 7.143 However, we will continue to engage with stakeholders to improve our tools to accurately reflect real life conditions and we welcome pragmatic suggestions that could help to enable sharing between different users and ensure efficient use of spectrum in other bands.⁵⁵⁰ We discuss the development of an automated admissions system and the adoption of a dynamic sharing approach for more efficient interference calculations further in our July 2019 shared access to spectrum statement.⁵⁵¹

Conclusions

- 7.144 In conclusion, we have decided that we will continue to maintain the same level of protection for the registered users in the band between the date of the grant of new licences and the end of their variation or revocation notice period. During this period, new 3.6-3.8 GHz spectrum holders will be required to submit technical details of their new deployments to Ofcom to ensure compliance with our coordination process. Submission of new deployments should be in batches of 100, unless otherwise agreed beforehand.
- 7.145 Ofcom will assist operators whose new deployments fail the coordination process by providing the margins by which each coordination request has failed so that operators can adjust their requests accordingly before resubmitting them. We will keep our coordination process under review to ensure that it remains appropriate as 3.6-3.8 GHz spectrum holders roll out their networks and the revocations of incumbent licences come into effect.

In-band restriction zones around satellite earth stations in 3.6-3.8 GHz after the interim period

Our proposals

- 7.146 In our October 2017 statement⁵⁵² we said that satellite earth stations could continue to operate in the band on a non-interference, non-protected⁵⁵³ basis following the end of their notice periods (while noting that their ability to continue to receive without suffering interference could vary between sites).
- 7.147 We said we would explore the possibility of applying localised restrictions in future licences to facilitate continuing operation of satellite services in the 3.6-3.8 GHz band, where these would not have a material impact on mobile deployment. New licensees wishing to deploy

⁵⁵⁰ For more information, see our statement on enabling wireless innovation through local licensing, Ofcom, July 2019, accessed 31 July 2019,

<https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation>

⁵⁵¹ Enabling wireless innovation through local licensing

https://www.ofcom.org.uk/data/assets/pdf_file/0033/157884/enabling-wireless-innovation-through-local-licensing.pdf

⁵⁵² Improving consumer access to mobile services at 3.6GHz to 3.8GHz

https://www.ofcom.org.uk/data/assets/pdf_file/0019/107371/Consumer-access-3.6-3.8-GHz.pdf

⁵⁵³ Non-interference, non-protected means that the equipment must not cause harmful interference to any other authorised services and that no protection will be given from harmful interference received from other authorised services.

base stations within these restriction zones would need to plan their deployments to respect the relevant signal threshold.

- 7.148 In the December 2018 consultation we proposed that, for any base station within 1km of the sites shown in Whitehill and Woofferton, the licensee would be required to ensure that the calculated signal power at the satellite earth station location within any 5 MHz portion of the operating bandwidth of the satellite earth station is no greater than -43dBm/5MHz.⁵⁵⁴

Stakeholders' comments

- 7.149 A range of stakeholders responded to our proposals for in-band restriction zones. In particular, BT/EE⁵⁵⁵ and [REDACTED]⁵⁵⁶ requested more clarity on the assumptions behind the derivation of the -43dBm/5MHz protection threshold.
- 7.150 Google highlighted that our radius approach on protecting satellite earth stations doesn't take account of "either the orientation of the satellite antenna or obstructions (like buildings and terrain) that lie between the potential source of interference and the satellite dish", which it said are highly relevant to the interference potential.⁵⁵⁷ Nokia supported our proposal in principle and suggested that we should consider the presence of permanent obstacles in the direct path between the base station and the satellite earth station.⁵⁵⁸ Nokia also suggested that in those cases we should use a more appropriate propagation model than free space path loss.
- 7.151 MOD suggested we consider 5km restriction zones as they are already used to protect military satellite earth stations from fixed links.⁵⁵⁹ Moreover, [REDACTED]. BT/EE⁵⁶⁰ and a confidential respondent, [REDACTED]⁵⁶¹, requested we add more sites (including Madley and Goonhilly) to the list of protected sites. BT/EE highlighted that the 1km protection zone might have some benefit in limiting blocking, but the interference threshold would not sufficiently protect reception in 3.6-3.8 GHz.

Our reasoning and decisions

- 7.152 In response to BT/EE and [REDACTED], requesting more clarity about how we had calculated the interference protection threshold, the assumptions include a typical base station radiated power of 61dBm/5MHz EIRP⁵⁶², a receive antenna side lobe gain equal to $G_r = 0$ dBi⁵⁶³ and the free space propagation losses for 1km at 3.8 GHz equal to $FSPL = 104$

⁵⁵⁴ December 2018 consultation, paragraphs 9.18 – 9.24.

⁵⁵⁵ BT/EE response to December 2018 consultation, paragraphs 6.4 - 6.5.

⁵⁵⁶ [REDACTED]

⁵⁵⁷ Google response to December 2018 consultation, page 18.

⁵⁵⁸ Nokia response to December 2018 consultation, response to question 10

⁵⁵⁹ MOD response to December 2018 consultation, response to question 10

⁵⁶⁰ BT/EE response to December 2018 consultation, paragraphs 6.6 - 6.7.

⁵⁶¹ [REDACTED]

⁵⁶² The typical BS EIRP value of 61dBm/5MHz was based on our knowledge of the typical transmissions in existing macrocell network deployments across the country.

⁵⁶³ The assumption of 0 dBi side lobe antenna gain is a recognised methodology in coexistence studies to account for the elevation of the main lobe.

dB. By using the Friis transmission equation we derived the interference protection threshold of -43dBm/5MHz.

- 7.153 Regarding Google and Nokia’s suggestion to consider the real path profiles between the base stations and satellite earth stations when calculating the interference levels at the satellite earth station receiver, our view is that a simple free space path loss model remains appropriate because operators are most likely to deploy macrocell 5G base stations in the rural areas near satellite earth stations.
- 7.154 Macrocells are expected to have antenna heights of 20m or more and therefore, the interference path will most probably be an unobstructed line-of-sight-path. In addition, it might not be possible to get precise path profiles because the protected NGR coordinate may be at the centre of a site containing multiple satellite earth station antennas spread out across that site. We therefore continue to consider that the simple free space path loss model is appropriate for calculating the propagation losses over these distances.
- 7.155 Google commented that our 1km circular restriction zones do not take account of factors such as the orientation of the satellite antenna. However, we note that multiple satellite dishes may exist within a single satellite earth station site. Our intention was to derive the interference threshold in a way to protect all the satellite dishes within a site irrespective of their pointing direction. We therefore consider that the approach we described in our December 2018 consultation with regards to the calculation of the interference level within the 1km restriction zones remains appropriate.
- 7.156 MOD suggested in its response that we should consider 5km restriction zones rather than 1km, however, we have not seen any technical evidence to justify this. Moreover, a 5km protection zone will significantly restrict mobile deployments and, therefore, we have decided to maintain the size of the in-band restriction zones to 1km.
- 7.157 Finally, we have considered the request from BT/EE and [REDACTED] and we have decided to include Madley and Goonhilly and so the five earth stations shown in Figure 8.2 are those to which we will apply the 1km restriction zones.

Figure 8.2 List of earth stations with a 1km restriction zone.

Station name	NGR location
Goonhilly	SW 72270 21070
Madley 1	SO 42106 37742
Madley 2	SO 42730 36967
Whitehill	SP 47862 18634
Woofferton	SO 50964 68171

Coexistence with users in the adjacent 3.8-4.2 GHz band

Our proposals

- 7.158 In our October 2017 statement, we said that the potential for new 3.6-3.8 GHz licensees to cause interference to users of the 3.8-4.2 GHz band was likely to be limited to small areas around earth stations or along the path of fixed links operating above 3.8 GHz. We said there were a range of options for mitigating these risks.
- 7.159 In the December 2018 consultation⁵⁶⁴, we set out three possible approaches to mitigating the risk of interference:
- a) doing nothing;
 - b) setting more restrictive out-of-band limits at the 3.8 GHz boundary; and
 - c) including coordination requirements in new licences.
- 7.160 We noted that option (b), setting more restrictive out-of-band limits, would impose stricter conditions than in the rest of Europe. Regarding option (c), we noted it was not generally our policy to impose coordination requirements in relation to adjacent band coexistence issues except in exceptional circumstances.
- 7.161 In line with this decision, we proposed in the December 2018 consultation that no specific licence conditions were necessary to mitigate the risk of interference to users in the 3.8-4.2 GHz band.

Stakeholders' comments

- 7.162 We received a number of responses regarding our proposal to not set any specific licence conditions to mitigate the potential risk of adjacent channel interference into the 3.8-4.2 GHz band.
- 7.163 The BBC⁵⁶⁵, Intelsat⁵⁶⁶, Arqiva⁵⁶⁷ and two confidential respondents, [REDACTED]⁵⁶⁸ and [REDACTED]⁵⁶⁹, disagreed with our conclusion that the risk of adjacent channel interference was small. They said that the analysis we had carried out showed that base stations deployed near earth stations still presented a risk of interference to satellite services in 3.8-4.2 GHz, especially those operating near the 3.8 GHz band edge. One confidential respondent, [REDACTED], requested more clarity on how the results presented in our December 2018 consultation led to the conclusion that no specific conditions are necessary because it believed that Ofcom had incorrectly identified the risk as small. It also highlighted that in Ofcom's analysis the potential risk of interference from mobile handsets has not been considered and it argued that [REDACTED].
- 7.164 Intelsat, Arqiva and a confidential respondent, [REDACTED] said that giving protection to satellite earth stations operating above 3.8 GHz would not significantly constrain the ability of 3.6-3.8 GHz licensees to deploy mobile networks. Intelsat and Arqiva said that this

⁵⁶⁴December 2018 consultation, paragraphs 9.50-9.59.

⁵⁶⁵BBC response to December 2018 consultation, paragraphs 22-25

⁵⁶⁶Intelsat response to December 2018 consultation, response to question 11

⁵⁶⁷Arqiva response to December 2018 consultation, section Media Networks - Satellite

⁵⁶⁸[REDACTED]

⁵⁶⁹[REDACTED]

was because their sites were in sparsely populated areas where early 3.6-3.8 GHz deployments are unlikely to be prioritised. The confidential respondent, [REDACTED] said that planning a mobile network in a way to avoid base stations pointing to the boresight of existing satellite users would not require special site redesign or non-standard equipment. It believed that re-planning 5G coverage was a very minor inconvenience which can be implemented without detrimental effects on coverage and service availability.

- 7.165 Arqiva, Intelsat and TechUK⁵⁷⁰ thought that giving additional protections to satellite earth stations would give additional certainty to satellite operators when planning their services, especially those that they expect to deliver over long periods of time. Moreover, Arqiva provided results of its interference analysis indicating the required separation distances to protect its satellite earth stations at Martlesham Heath, Crawley Court and Morn Hill. The separation distances it presented were 6km, 1.3km – 3km⁵⁷¹ and 7.6km respectively and it added it was keen to work with Ofcom to minimise the interference risk to existing services.
- 7.166 The BBC⁵⁷² and a confidential respondent, [REDACTED], said that receiver filtering may not be an effective solution for reducing the risk of interference and may not be effective for preventing satellite earth station receiver blocking. The BBC said that Ofcom’s proposed mitigation to insert a high-pass waveguide filter implies a cost that the incumbent satellite earth station user will have to bear. Furthermore, the BBC stated that even though the filters shown in Ofcom’s consultation document present an impressive performance, they would not provide sufficient attenuation to prevent receiver blocking when the satellite earth station is receiving at the 3.8 GHz band edge.
- 7.167 BT/EE⁵⁷³ said that it would like to continue interference free operation of its satellite earth station in Madley above 3.8 GHz and it suggested, since receiver blocking wasn’t analysed in December 2018 consultation, the 1km restriction zone proposed by Ofcom for satellite earth stations in 3.6-3.8 GHz to also be extended to services in 3.8-4.2 GHz to reduce the interference risk of satellite earth station receiver blocking.
- 7.168 [REDACTED].

Our reasoning and decisions

Risk of adjacent channel interference

- 7.169 In general, we do not impose coordination requirements in relation to adjacent band coexistence. As we noted in our December 2018 consultation document⁵⁷⁴, there are a small number of spectrum users immediately above 3.8 GHz and most of them are located in rural areas. The density of mobile networks in rural areas is likely to be lower and the

⁵⁷⁰ TechUK response to December 2018 consultation, response to question 11

⁵⁷¹ 1.3km when Crawley court antenna was pointing West and ~3km when the antenna was pointing East.

⁵⁷² BBC response to December 2018 consultation, paragraphs 26-27

⁵⁷³ BT/EE response to December 2018 consultation, paragraph 6.8

⁵⁷⁴ December 2018 consultation document, paragraphs 9.54-9.59

operators will most likely be able to have more flexibility in adopting measures to reduce the probability of interference in those areas.

- 7.170 In addition, some of the parameters we used were worst-case values which would tend to make our modelling results conservative. Therefore, we continue to consider that the risk of adjacent channel interference is theoretically small within the distances presented in our coexistence analysis.
- 7.171 We have also considered the comment of the confidential respondent, [REDACTED], that we did not examine interference from handsets in our December 2018 analysis. The radiated power levels assumed in our area analysis modelling are much higher than the radiated power levels of mobile handsets (by around 40 dB) and so base stations represent the dominant interfering source. We therefore consider that it was not necessary for us to model handsets as part of our analysis.
- 7.172 Furthermore, in response to [REDACTED] argument that some ground stations need to operate with high availability, we note that where there is evidence of harmful interference, Ofcom can take the necessary enforcement action.
- 7.173 We have also considered the analysis that Arqiva provided in its response. However, the separation distances that were presented are similar to the distances we presented in our December 2018 consultation. Therefore, this does not constitute new evidence to suggest that we should change our normal policy of not imposing any restriction measures for adjacent channel coexistence.
- 7.174 [REDACTED] This means that mobile networks will not be required to coordinate in the adjacent channel and we will impose no additional technical licence conditions.

Impact on mobile networks

- 7.175 We have also considered the arguments that imposing additional protections for satellites would not materially affect the mobile networks operating in the adjacent band. As we set out in the December 2018 consultation, it is our normal policy not to impose coordination requirements in relation to adjacent band coexistence issues. Furthermore, as set out above, we expect that in the rural locations of satellite earth stations, mobile operators are likely to be able to adopt measures that reduce the probability of interference to adjacent spectrum users operating in close geographical proximity.
- 7.176 We note that we will continue to maintain the current levels of protection to satellite earth station services in 3.8-4.2 GHz from interference coming from other in-band services (including mobile) as described in our July 2019 statement⁵⁷⁵ on shared access to spectrum.

Satellite earth station receiver filtering

- 7.177 In our December 2018 consultation, we suggested that filtering at the receiver will be an effective mitigation for managing coexistence risks related to out-of-band receiver selectivity and blocking. We identified a number of commercially available high pass filters

⁵⁷⁵Statement: Enabling wireless innovation through local licensing, <https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation>

having a 3.8 GHz band edge and we suggested that satellite earth station operators can protect their receivers from adjacent band interference by retro-fitting such filters. We still consider that these filters are likely to be effective and that we continue to consider that the technical analysis we performed in our December consultation indicates that the interference risk is minimal. We note that in cases where there is evidence of harmful interference, Ofcom can take the necessary enforcement action.

- 7.178 The effectiveness of a filter is based on the appropriate selection of rejection performance by the satellite earth station operator in the adjacent band. We acknowledge that the cost of filter insertion has to be covered by the incumbent user and we consider that it is appropriate for us to expect incumbent users to take this reasonable measure to improve their receiver selectivity and protect themselves from harmful interference.
- 7.179 In response to BT/EE's suggestion that the 1km restriction zone presented as an in-band protection measure could also be extended in the 3.8-4.2 GHz band as a mitigation against blocking, we note that our normal policy is not to consider measures against adjacent channel blocking. Our view remains that the use of filters as suggested in our December 2018 consultation will also offer protection from adjacent band blocking.
- 7.180 Finally, based on the comments that we received to our December 2018 consultation, we have seen no further technical evidence to justify that we should change from our general policy on adjacent channel coordination. Therefore, we have decided to maintain our policy proposal to not impose coordination requirements in relation to adjacent band coexistence issues in this band.

8. Licence conditions

- 8.1 Licences issued for use of radio spectrum are intended to contain the minimum necessary restrictions on the permitted use of the frequencies. Any restrictions are intended to avoid harmful interference, and to ensure compliance with our statutory duties and international obligations.
- 8.2 In the December 2018 consultation (sections 10 and 11) we set out the licence conditions we proposed to apply to the 700 MHz and 3.6-3.8 GHz bands. Below, we set out our decisions, having taken account of consultation responses. Sample licences for the 700 MHz and 3.6-3.8 GHz bands are attached as annexes A1 and A2 of the Information Memorandum, which is published alongside this document.⁵⁷⁶

Non-technical licence conditions

Licence commencement and duration

- 8.3 In the December 2018 consultation (paragraph 10.6), we proposed that the licences for both the 700 MHz and 3.6-3.8 GHz band would be:
- issued for an indefinite duration;
 - issued soon after the conclusion of the award, when winning bidders have made any outstanding payments to cover their licence fees (the licence fee for the initial period will be as determined through the award process);
 - issued for an initial period of 20 years starting from the date of issue;
 - revocable before the expiry of the initial period only on certain limited grounds set out in the licence (i.e. at the request or with the consent of the licensee; for non-payment or late payment of the relevant licence fee; for breach of any of licence terms; for breach of auction regulations; for breach of trading regulations; for national security or to comply with international agreements; or under direction of the Secretary of State); and
 - revocable from any point after the expiry of the initial period on the grounds set out above and, additionally, for spectrum management reasons, subject to five years notice. We said that, once the initial period has expired, the licence would remain in force and continue to be held by the licensee. However, there may be circumstances in which regulatory intervention is justified in the public interest (for example, to overcome a specific market failure). A power to take regulatory action, if justified,

⁵⁷⁶ https://www.ofcom.org.uk/_data/assets/pdf_file/0019/192412/information-memorandum-award-700mhz-3.6-3.8ghz-spectrum.pdf

would be achieved by us having the power to revoke the licence on spectrum management grounds after the end of the initial period.

- 8.4 In its consultation response, Vodafone⁵⁷⁷ said that it makes sense for an initial term of 20 years to run from the availability of the spectrum or the grant of the licence. However, it suggested that the licence term for the 700 MHz centre gap should commence from the date that the relevant licensee served notice to Arqiva that it wished to use that spectrum.
- 8.5 We acknowledge that MNOs may not wish to use the frequencies in the centre gap to deliver mobile services immediately. However, the spectrum will be awarded and available to use at broadly the same time as the rest of the 700 MHz spectrum (subject only to giving notice to Arqiva). We have therefore decided not to apply a different commencement date.

Territorial extent of licences

National licences

- 8.6 In our December 2018 consultation (paragraphs 10.7-10.10), we proposed to award the 700 MHz and 3.6-3.8 GHz licences on a UK-wide basis.
- 8.7 We noted that some stakeholders had argued in response to earlier consultations that all or part of the spectrum - particularly that in the 3.6-3.8 GHz band - should be made available through regional or local licences.⁵⁷⁸ In response to the December 2018 consultation, we received further comments in favour of regional or local licences, which we address in annex 2.
- 8.8 We remain of the view that it is appropriate to award the licences for the 700 MHz and 3.6-3.8 GHz band on a UK-wide basis. We award all spectrum in the way which we consider appropriate to secure its efficient use, having regard to the characteristics of the particular bands and the circumstances at the time. In this case we have concluded that awarding national licences would be most likely to achieve optimal use of the spectrum.
- 8.9 Both the award bands are suitable for the provision of mobile broadband services - for which there is nationwide demand - and their particular propagation characteristics make them attractive to MNOs currently delivering UK-wide networks. Additionally, licences already awarded in the 3410 to 3680 MHz range – part of the broader 3.4-3.8 GHz identified for 5G mobile broadband – are UK-wide licences.
- 8.10 It is not feasible for Ofcom to anticipate which smaller geographic areas the existing operators may or may not choose to serve with 3.6-3.8 GHz spectrum. We consider the option of creating multiple local/regional ‘lots’ would result in an overly complicated auction that is not justified in this case.

⁵⁷⁷ Vodafone response to the December 2018 consultation, pages 49-50.

⁵⁷⁸ We addressed the arguments submitted on local/regional licences in annex 5 of our December 2018 consultation.

Geographical boundaries

- 8.11 In the December 2018 consultation (paragraph 10.7), we proposed that the 700 MHz and 3.6-3.8 GHz licences would not extend to the Channel Islands and the Isle of Man. We also proposed that, unlike the 700 MHz licences, the licences in the 3.6-3.8 GHz band would not extend to UK territorial waters (which is consistent with licences in the 3.4 GHz band, awarded after the 2018 auction). We have received no comments on this proposed approach and decided to adopt it.

The payment of licence fees

- 8.12 In the December 2018 consultation (paragraphs 10.11-10.12), we proposed to include a licence condition that would enable Ofcom to impose an on-going additional annual fee after the expiry of the initial period. We said that before introducing any such fee, we would consult as appropriate and give notice of our specific proposals.
- 8.13 We did not receive comments on this approach and we have decided to adopt it.

The tradability of licences

Trading

- 8.14 In the December 2018 consultation (paragraphs 10.13 and 10.15), we proposed to make the award licences tradable.
- 8.15 On 31 January 2019,⁵⁷⁹ we published a notice in respect of our proposals to make certain statutory instruments in connection with the award of the 700 MHz and 3.6-3.8 GHz spectrum. In particular, we proposed to include the 700 MHz and 3.6-3.8 GHz bands within The Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011 (the ‘Mobile Trading Regulations’) and to bring the frequencies in the 3.6-3.8 GHz band which are currently licensed to UK Broadband within those regulations.
- 8.16 On 21 May 2019,⁵⁸⁰ we gave notice of our decision to make the proposed regulations. Stakeholders’ comments on our proposal to make the award licences tradable, including the comments made in response to the December 2018 consultation, are discussed in our statement of 21 May 2019.

Leasing

- 8.17 In the December 2018 consultation (paragraph 10.14), we proposed not to include leasing provisions in the award licences. However, we said that we would keep this position under

⁵⁷⁹ See <https://www.ofcom.org.uk/consultations-and-statements/category-2/regulations-award-700-mhz-3.6-3.8-ghz>

⁵⁸⁰ Ofcom’s statement entitled “Statement on the making of certain regulations in connection with the award of 700 MHz and 3.6-3.8 GHz spectrum. Notice of making a limitation order and amending the mobile trading and the register regulations”; see <https://www.ofcom.org.uk/consultations-and-statements/category-2/regulations-award-700-mhz-3.6-3.8-ghz>

review and consider extending leasing if there are likely to be net benefits, including sufficient evidence of demand to lease spectrum.

- 8.18 In its response to the December 2018 consultation,⁵⁸¹ H3G suggested that leasing should be extended to all spectrum bands that are subject to the Mobile Trading Regulations. Likewise, in its response to our consultation of 31 January 2019, BT/EE⁵⁸² said that there remains a wider issue to be resolved, which is *“whether a more consistent approach is appropriate as to whether licences for mobile spectrum permit leasing, and whether leasing should be more widely permitted for mobile licences”*.
- 8.19 Having considered these comments, we continue to believe it is appropriate for us to keep the position regarding leasing under review. However, we have decided not to include any conditions permitting leasing in the draft licences set out in annexes A1 and A2 of the Information Memorandum.

Non-technical restrictions on use

- 8.20 In the December 2018 consultation, we did not propose to impose any non-technical restrictions which would limit the use to which the 700 MHz and 3.6-3.8 GHz spectrum could be put (such as specifying the type of service that should be offered, the technology that should be deployed or the equipment that should be used). We have received no comments on these proposals and therefore have decided to implement them.

Spectrum sharing

- 8.21 In the December 2018 consultation (paragraph 10.16), we noted that licences issued by Ofcom do not guarantee exclusive use of the spectrum awarded. We said that in the future we may grant additional authorisations to allow the use of all, or part, of the spectrum, including the 700 MHz and 3.6-3.8 GHz spectrum.
- 8.22 Alongside our December 2018 consultation, we published a further consultation setting out our proposals on new approaches to sharing spectrum (the **‘December 2018 spectrum sharing consultation’**).⁵⁸³ It discussed means by which alternative users could seek access to *any* awarded mobile spectrum in locations where we agree this won’t impact upon the incumbent licensee.
- 8.23 A number of stakeholders submitted responses to the December 2018 consultation which addressed issues related to the sharing of spectrum. These included suggestions of how the spectrum available in this award might be shared e.g. by allowing access to unused spectrum to fill coverage gaps in rural areas, and/or to supply additional services through neutral hosting etc.

⁵⁸¹ H3G response to the December 2018 consultation, section 7.3.1.

⁵⁸² See https://www.ofcom.org.uk/_data/assets/pdf_file/0025/146851/BT-EE.pdf

⁵⁸³ Ofcom’s consultation of 18 December 2018 entitled “Enabling opportunities for innovation. Shared access to spectrum supporting mobile technology”; <https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation>

- 8.24 These issues are addressed in our spectrum sharing statement, which we published on 25 July 2019 (the '**July 2019 spectrum sharing statement**').⁵⁸⁴ However, responses which make particular reference to the 700 MHz and 3.6-3.8 GHz auction are considered in annex 2 of this statement document.
- 8.25 In conclusion, our general policy remains that licences issued by Ofcom do not guarantee exclusive use of the spectrum awarded. Our position on spectrum sharing is now set out in the July 2019 spectrum sharing statement.

Roaming

- 8.26 In the December 2018 consultation (paragraph 10.22), we said that we did not rule out the possibility of looking to impose roaming conditions, as appropriate, in the 700 MHz licences in the future, noting in particular that these are licences of at least 20 years' duration.
- 8.27 Some stakeholders - including H3G - proposed the introduction of a requirement to provide network roaming as part of the coverage obligations that we proposed in the December 2018 consultation, so that mobile customers who cannot get a signal on their own network in a particular area could 'roam' onto an alternative network. H3G⁵⁸⁵ said this would be a more effective way of addressing coverage issues than the coverage obligations proposed in the December 2018 consultation.
- 8.28 A number of other respondents made similar and related points about the benefits of the inclusion of roaming requirements in the new licences.⁵⁸⁶ Further details of submissions on roaming are noted in annex 2 of this statement.
- 8.29 We note that since publication of the December 2018 consultation the MNOs have decided to work with the Government on a voluntary 'Shared Rural Network' programme to improve mobile coverage through infrastructure sharing and Government funding of new coverage in total 'not spots'. The MNOs and the Government have now agreed to full funding of the programme - with the MNOs' commitments having been given effect through binding licence obligations.
- 8.30 These infrastructure-sharing commitments are capable of delivering better outcomes for consumers than we would be able to require through coverage obligations in the spectrum auction. As a result we are no longer including coverage obligations in the auction.
- 8.31 However, we do not rule out the possibility of looking to impose roaming conditions, as appropriate, in 700 MHz licences in the future, noting in particular that these are licences

⁵⁸⁴ Ofcom's statement of 25 July 2019 entitled "Enabling wireless innovation through local licensing. Shared access to spectrum supporting mobile technology"; <https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation>

⁵⁸⁵ H3G response to the December 2018 consultation, pages 12 to 24.

⁵⁸⁶ Respondents to the December 2018 consultation supporting roaming included the Scottish Government, The Local Government Association, Which?, The Country Land and Business Association, Rural Services Network, The Communications Consumer Panel, Kent County Council, Professor Stephen Temple and others (please see annex 2).

of at least 20 years' duration. Any future proposals would be subject to detailed analysis and consultation at the time, in line with our general approach.

Roll-out obligations ('use-it-or-lose-it')

- 8.32 In the December 2018 consultation (paragraphs 10.18-10.21), we proposed not to apply any licence conditions requiring spectrum holders who acquire spectrum in the 700 MHz and 3.6-3.8 GHz bands to make use of the frequencies in a timely manner - or risk having them taken away (i.e. 'use-it-or-lose-it').
- 8.33 In response to our consultation, some stakeholders argued that licensees should forfeit their licences if they do not make use of the spectrum frequencies within a particular timeframe.
- 8.34 The Welsh Government⁵⁸⁷ said use-it-or-lose-it could be applied in specific geographic areas to give market innovators the ability to provide services where others cannot. The Scottish Government⁵⁸⁸ said that if Ofcom was not inclined to pursue use-it-or-lose-it obligations, we should instead consider how MNOs might be required to work with alternative providers in areas where they had no planned use of their spectrum.
- 8.35 The Communications Consumer Panel and Advisory Committee for Older and Disabled people (ACOD)⁵⁸⁹ also supported use-it-or-lose-it terms. It said no provider should have control over spectrum without using it to improve consumers' and micro businesses' experiences.
- 8.36 Ruckus Networks⁵⁹⁰ said use-it-or-lose-it can be a useful tool for freeing up under-used spectrum on a local area basis, where the spectrum has been allocated on a national basis. In its view, a national licence holder may have insufficient economic incentive to provide a service, but a local area operator, operating on a different cost model, can.
- 8.37 Google⁵⁹¹ said proposals set out by Ofcom in the consultation published alongside the December 2018 consultation on the 700 MHz and 3.6-3.8 GHz award (and now addressed in the July 2019 spectrum sharing statement) provided a compelling alternative to use-it-or-lose-it.
- 8.38 We have considered these responses, and have decided not to include use-it-or-lose-it conditions in the licences for the reasons stated in our December 2018 consultation:
- such conditions are very difficult to make workable in practice because of the problem of defining what constitutes 'use' and therefore what the trigger for a licence revocation would be;

⁵⁸⁷ Welsh Government response to the December 2018 consultation, page 2. The Welsh Government said the spectrum could revert back to Ofcom, to a public sector body, or be provided to another operator after a given period of time if the primary holder had no plans to use it.

⁵⁸⁸ Scottish Government response to the December 2018 consultation, page 4.

⁵⁸⁹ Consumer Panel response, page 2.

⁵⁹⁰ Ruckus Networks response to the December 2018 consultation, page 2.

⁵⁹¹ Google response to the December 2018 consultation, page 19.

- there may be entirely legitimate reasons for spectrum remaining unused. For example, -the licensee may be holding back until it sees a suitable commercial opportunity or until the technology it wishes to use is ready;
- imposing such an obligation also has the potential to distort and/or chill the incentives to invest in the spectrum, and so reduce the benefits for consumers and citizens which the award would otherwise create.

8.39 As noted above under ‘Spectrum sharing’, licences issued by Ofcom are not exclusive, and we have discretion to authorise use of these or any other frequencies, for other purposes, in line with our statutory duties. Issues relating to spectrum sharing, as raised in the Scottish Government response, are addressed in the July 2019 spectrum sharing statement.

Access and inspection

8.40 In the December 2018 consultation (paragraph 10.24), we proposed that, in accordance with our standard spectrum licence conditions, licensees would be required to permit any person authorised by Ofcom to have access to and to inspect the radio equipment specified in the licence at all reasonable times. We received no comments on this proposal and have therefore decided to implement it.

Modification, restriction and closedown

8.41 In the December 2018 consultation (paragraph 10.25), we proposed that, in line with standard provisions, the licences would contain a provision permitting Ofcom to require that the radio equipment (or any part of it) be modified, restricted in use or temporarily or permanently closed down if: (i) a licensee breaches the terms of its licence; (ii) the use of radio equipment is or may be causing or contributing interference to the operation of other authorised radio equipment; or (iii) it appears necessary or expedient in the event of a national or local state of emergency. We received no comments on this proposal and have therefore decided to implement it.

Provision of information to facilitate optimal spectrum use

Information requirements for all the award licences

8.42 In the December 2018 consultation (paragraphs 10.26-10.28), we proposed to include a condition in the licences requiring licensees to provide, on request, general information regarding their equipment and use of frequencies, or the roll-out of their network.

8.43 We said that the provision of this information could help identify areas where other companies might wish to provide additional services. If appropriate, it could be open to others to gain access to spectrum in those areas by trading with licensees. We noted that this would help secure optimal use of the spectrum.

8.44 We also noted that we have powers under both the Communications Act 2003 (section 135 to 146) and the WT Act (sections 32 to 34) to require third parties to provide us with information in certain circumstances. However, we said that we consider that there

remains a benefit in requiring licensees to compile and maintain basic details relating to the radio equipment that they are using pursuant to the licence so that it is readily available in the event that it is needed, for example, in cases of alleged interference.

- 8.45 Vodafone⁵⁹² said it agreed with most of the information requirements in the draft licence attached to the December 2018 consultation. However, it said the wording of the requirement to supply information about prospective mast deployments was unacceptable in its current form, because it did not set out a timeframe. Vodafone said it would be unduly onerous to supply forecast information for any more than one year in advance.
- 8.46 We note Vodafone's comment. However, we do not consider it appropriate to limit our ability to seek information that may be helpful for spectrum management, for example in assessing whether particular spectrum frequencies may be suitable for other uses. We would normally expect to seek general indications of likely use. However, we may consider it appropriate to seek more detailed information on intended roll-out plans in specific cases. We do not believe this will impose a disproportionate burden on the licensees since we will consider the proportionality of each information request on a case-by-case basis. In light of the above, we have decided to impose the proposed information requirements, without making any changes.

Additional information requirements for the licence(s) to use the 700 MHz centre gap frequencies

- 8.47 In the December 2018 consultation (paragraphs 10.29-10.35), we also proposed to include additional information requirements in the licence(s) to use the 700 MHz centre gap frequencies (733–758 MHz).⁵⁹³ In particular, we said that it would be necessary for Arqiva to provide us with evidence of any agreement(s) it reaches with the auction winner(s) of the licence to use such frequencies and for these winners to give us a three-months advance notice of when, how and where they intend to start using the spectrum.
- 8.48 Vodafone⁵⁹⁴ said the three months' notice was sufficient from a mobile operator's point of view, but doubted whether Arqiva would be able to withdraw the DTT multiplex on that timescale. No other respondent commented on the proposed licence condition. In light of the above, we have decided to apply the proposed licence condition to the 700 MHz licence(s). Broader issues connected with on-going use of the 700 MHz centre gap for DTT are addressed in section 7 of this document.

Technical licence conditions

- 8.49 As with the non-technical licence conditions, many of the technical conditions we proposed for the 700 MHz and 3.6-3.8 GHz licences are standard conditions, which we include in all spectrum licences. Accordingly, no consultation responses were received in relation to many of the conditions.

⁵⁹² Vodafone response to the December 2018 consultation, page 49-50.

⁵⁹³ The decision to allow Arqiva on-going access to these frequencies is discussed in section 7 of this statement.

⁵⁹⁴ Vodafone response to the December 2018 consultation, page 50.

- 8.50 Conditions relating to out-of-block and out-of-band emissions were established through European decisions and remain mandatory. We have greater discretion as to the technical conditions applied *within* bands, particularly in relation to in-band power levels and synchronisation between users.
- 8.51 We proposed to define emissions limits on a ‘per antenna’ or a ‘per cell’ basis in line with the approach set out in CEPT Report 67 for the 3.6-3.8 GHz band, which was subsequently adopted in the Commission Implementing Decision (EU) 2019/235 for the 3.4-3.8 GHz band on 24 January 2019, and Commission Implementing Decision (EU) 2016/687 for the 700 MHz band (the ‘700 MHz Commission Decision’).
- 8.52 In our December 2018 consultation we set out our proposals, which we grouped by:
- technical licence conditions common to the 700 MHz and 3.6-3.8 GHz licences;
 - 700 MHz licence conditions; and
 - 3.6-3.8 GHz licence conditions.

Technical licence conditions common to the 700 MHz and 3.6-3.8 GHz licences

Requirements for recording radio equipment deployments

- 8.53 In the December 2018 consultation (paragraphs 11.7-11.9) we proposed updating the requirements for the recording of radio equipment deployments by licensees to reflect changes in technology and the way radio equipment is deployed:

We proposed to require radio equipment records to at least 10m resolution

- 1) For the 700 MHz and 3.6-3.8 GHz licences we said a 10m resolution was both suitable for spectrum management purposes and could reasonably be achieved by licensees, for example, using GPS.

We proposed not to require postal address records for femtocells and repeaters

- 2) We noted the address of femtocells and repeaters may not always be accurately recorded. For example, a user may move home and take their femtocell or repeater with them or may get their femtocell or repeater delivered to a location but choose to use it elsewhere.

- 8.54 No stakeholders commented on our proposed requirements for recording radio equipment deployments. We have therefore decided to implement our consultation proposals.

Cross-border coordination

- 8.55 We proposed that both the 700 MHz and 3.6-3.8 GHz licences would require compliance with cross-border coordination procedures notified to the licensees by Ofcom.⁵⁹⁵ We have

⁵⁹⁵ See the December 2018 consultation, paragraphs 11.10-11.11.

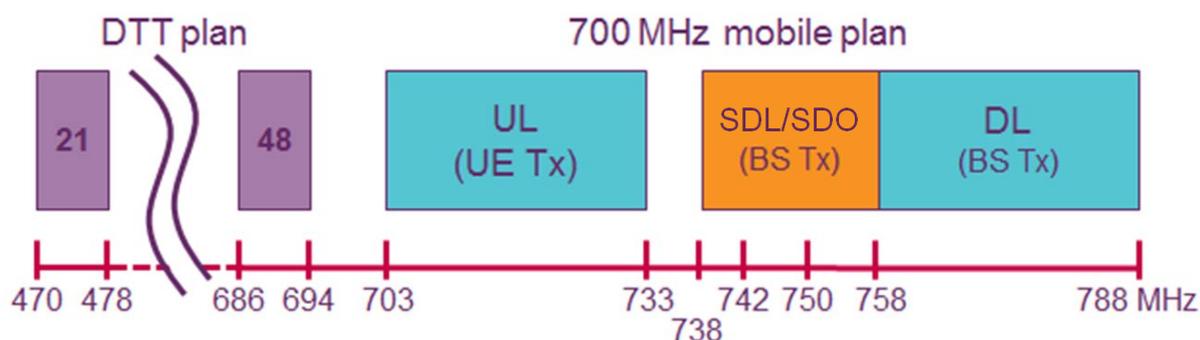
worked with our neighbouring administrations including France, the Channel Islands and Ireland to establish memoranda of understanding for cross-border coordination.

- 8.56 No stakeholders commented on our proposed requirements for compliance with cross-border coordination procedures. We have therefore decided to implement our consultation proposals.

700 MHz technical licence conditions

- 8.57 In the December 2018 consultation we noted our decision to award the 700 MHz band with 703-733 MHz paired with 758-788 MHz and Supplementary Downlink only or Standalone Downlink (SDL/SDO) in 738-758 MHz as shown below. We noted this was in accordance with the European Commission Decision (EU) 2016/687 on the harmonisation of the 694-790 MHz frequency band.⁵⁹⁶

Figure 8.1: The band arrangement after the 700 MHz award



Emissions limits for base stations

Ofcom's proposals

- 8.58 We proposed an in-block base station power limit of 64 dBm/(5 MHz) EIRP per antenna. This was in line with the 700 MHz Commission Decision which does not set a mandatory in-block downlink power limit but states that: *"In case an upper bound is desired by an administration, a value may be applied, which does not exceed 64 dBm/(5 MHz) per antenna."*⁵⁹⁷
- 8.59 We said we believed this limit would provide adequate protection for adjacent DTT services. We said power limits on out-of-block and out-of-band emissions were in line with the 700 MHz Commission Decision, noting there was some flexibility on defining the emissions limits and measurement bandwidth:

⁵⁹⁶ "Commission Implementing Decision (EU) 2016/687 of 28 April 2016 on the harmonisation of the 694-790 MHz frequency band for terrestrial systems capable of providing wireless broadband electronic communications services and for flexible national use in the Union",

<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AAOJ.L.2016.118.01.0004.01.ENG>

⁵⁹⁷ 700 MHz Commission Decision, Table 2 ("Base station in-block power limit").

- | | |
|---|--|
| We proposed a 5 MHz measurement bandwidth for the uplink and downlink band emissions limits | 1) We proposed to award the 700 MHz band in lots of 5 MHz bandwidth. We therefore proposed to adopt a 5 MHz measurement bandwidth for out-of-block emissions in both the uplink band (703-733 MHz) and the downlink band (738-788 MHz). |
| We proposed to use the transitional power limits in the 5 MHz which is not part of the award | 2) In line with the 700 MHz Commission Decision, we proposed to apply the transitional power limits in the 5 MHz of the centre gap that is not part of the award (733-738 MHz). |
| We proposed a 3 MHz measurement bandwidth for the transitional power limits above 788 MHz | 3) We said base station transitional power limits in the 800 MHz guard band (788-791 MHz) should be considered over a measurement bandwidth of 3 MHz. This is because we are not aware of any reason why a higher resolution measurement bandwidth is necessary to prevent harmful interference. |

Stakeholders' comments and Ofcom's assessment

- 8.60 Vodafone⁵⁹⁸ sought confirmation that the language used for the transmitted power limits of base stations is correct. We confirm the maximum mean power for base stations using 700 MHz spectrum is 64dBm / 5 MHz EIRP per antenna.
- 8.61 The BBC⁵⁹⁹ highlighted that the maximum base station power for 700 MHz is higher than the power level set for 800 MHz. It said the higher power levels are more likely to interfere with DTT receivers (by overloading) and questioned our conclusion that there will not be higher levels of interference to DTT reception from 700 MHz band base stations than there were from 800 MHz base stations.
- 8.62 As discussed in section 7 of this statement (in sub-section headed 'Interference risk from 700 MHz mobile services'), we have decided to include the power limits we proposed in the December 2018 consultation of 64 dBm / 5 MHz EIRP per antenna.

Emissions limits for terminal stations

Ofcom's proposals

- 8.63 We proposed to include the mandatory limits set out below on in-block and out-of-band emissions limits for uplink transmissions in the new licences which apply to terminals, which in a few exceptional cases do not fulfil the requirements of a separate licence exemption regime.

⁵⁹⁸ Vodafone's response to the October 2019 consultation, section 4, page 13.

⁵⁹⁹ BBC response to the December 2018 consultation, page 6, paragraph 28.

Figure 8.2: Summary of proposed 700 MHz uplink (703-733 MHz) power limits

In-block power limit	<i>Radio equipment</i>	
	<i>Terminal station</i>	<i>Maximum mean power limit*</i>
		23 dBm
Out-of-band power limit	<i>Frequency Range</i>	
	<i>Maximum mean power limit*</i>	
	470–694 MHz	-42 dBm / 8 MHz
	694–698 MHz	-7 dBm / 4 MHz
	698–703 MHz	2 dBm / 5 MHz

* The power limits are specified as equivalent isotropically radiated power (EIRP) for terminal stations designed to be fixed or installed and as total radiated power (TRP) for terminal stations designed to be mobile or nomadic. The maximum mean power relates to the EIRP or TRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas. This value is subject to a tolerance of up to + 2 dB, to take account of operation under extreme environmental conditions and production spread.

Stakeholders' comments and Ofcom's assessment

8.64 The BBC⁶⁰⁰, Digital UK and Freeview⁶⁰¹ considered that the licences should be clearer in stating that the 2 dB manufacturing tolerance for 700 MHz terminals should apply to in-block emissions limits only and should not apply to out-of-block emissions. The BBC⁶⁰² added that our proposed draft Interface Requirement (set out in Annex 20 to the December 2018 consultation) did not specify any out-of-block power limit requirements.

8.65 We agree that the 2 dB tolerance should only apply to the in-block emission limit, and we have revised the draft licence in annex A1 of the Information Memorandum to clarify this (this tolerance is also in line with the EU Decision 2019/235).⁶⁰³ The out-of-block limits are specified in the licence conditions, and so we do not consider it necessary to include these limits in the Interface Requirements. Condition 10 of schedule 1 to the sample 700 MHz licence in Annex A1 of the Information Memorandum sets out the out-of-block emissions limits.

8.66 We have therefore decided to include the emissions limits we proposed in the 700 MHz licences, with the modification explained in the paragraph above.

'Cooperation clause'

8.67 We did not propose to include any specific licence clause requiring cooperation between licensees to prevent harmful interference in the 700 MHz licences, because there will not

⁶⁰⁰ BBC response to the December 2018 consultation, pages 6-7, paragraph 28.

⁶⁰¹ Digital UK and Freeview responses to the December 2018 consultation, page 7.

⁶⁰² BBC response to the December 2018 consultation, page 7.

⁶⁰³ COMMISSION IMPLEMENTING DECISION (EU) 2019/235,

<https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1549615962331&uri=CELEX:32019D0235>

be any TDD operation in the 700 MHz band, and therefore we did not consider there was a risk of inter-operator interference.⁶⁰⁴

8.68 No stakeholders commented on our proposals to not require a ‘cooperation clause’ in the 700 MHz licences. We have therefore decided to implement our consultation proposals.

3.6-3.8 GHz technical licence conditions

8.69 In the December 2018 consultation we set out proposals on technical conditions for the 3.4-3.8 GHz band. We noted that an EU Decision on harmonised conditions had not yet been finalised, but said our proposals were consistent with the most recent CEPT reports.⁶⁰⁵ Subsequently, the Commission Implementing Decision (EU) 2019/235 for the 3.4-3.8 GHz band has been published, which aligns with both our proposals and the relevant CEPT Reports.

Synchronisation

Ofcom’s proposals

8.70 In October 2016, we confirmed our intention to award the 3.6-3.8 GHz band on a TDD basis.⁶⁰⁶ Therefore, synchronisation or semi-synchronisation may be necessary in this band between base stations which are not isolated from one-another.

8.71 In the December 2018 consultation, we proposed to require licensees to synchronise or semi-synchronise their base stations with each other,⁶⁰⁷ which means that base stations must time align frames and operate using one of two specified frame structures:

Full synchronisation

Frame Structure A

Permissive mask

1) The fully synchronised frame structure is a 10 ms frame with a 1:3 uplink/downlink ratio⁶⁰⁸ and we observed that TD-LTE frame configuration 2 using special sub-frame configuration 6 is compatible with this frame structure. A licensee operating radio equipment which uses this frame structure must comply with the permissive emissions mask.

⁶⁰⁴ December 2018 consultation, paragraphs 11.22-11.23.

⁶⁰⁵ December 2018 consultation, paragraphs 11.24-11.27.

⁶⁰⁶ “Improving consumer access to mobile services at 3.6GHz to 3.8GHz”, Ofcom, 26 October 2016, https://www.ofcom.org.uk/_data/assets/pdf_file/0019/107371/Consumer-access-3.6-3.8-GHz.pdf

⁶⁰⁷ Low power, indoor base stations are exempt from the synchronisation requirements.

⁶⁰⁸ Frame Structure A has a DSUDDDSUDD structure where each character represents a 1 ms sub-frame and “D” means downlink; “U” means uplink; and “S” is a special sub-frame which contains a guard period.

Semi-synchronisation 2) The semi-synchronised frame structure is a 10 ms frame which contains three synchronised sub-frames and seven flexible sub-frames which can be used for either downlink or uplink.⁶⁰⁹ This is compatible with all TD-LTE frame configurations. A licensee operating radio equipment which uses this frame structure must comply with the restrictive mask which is required to reduce the risk of interference to adjacent mobile networks in the absence of full synchronisation.

Frame Structure B
Restrictive mask

8.72 We said 5G NR could be made to work with the frame structures in existing 3.4 GHz licences because there are 5G NR frame structures which are supported within the defined frame structures. However, we noted that the synchronisation requirements in the 3.4 GHz licences may be less suitable for the provision of the lower latency services that could be enabled by some 5G technologies than they were for 4G technologies. We proposed to include the same synchronisation requirements in the 3.6-3.8 GHz licences as those set out in the 3.4 GHz licences (see paragraphs 11.32-11.36 of the December 2018 consultation).

Stakeholders' comments

8.73 Some stakeholders observed that the frame structure we proposed for TDD operation in the 3.6-3.8 GHz band might not be suitable for all possible future 5G use cases. However, no stakeholders said that the frame structure would preclude early 5G use cases which are likely to include enhanced mobile broadband and fixed wireless access.

8.74 Nokia⁶¹⁰ agreed with Ofcom's proposal to include the same synchronisation requirements in the 3.6-3.8 GHz licenses as those already set out in the 3.4-3.6 GHz licenses, as doing so will mean users can work without a guard band between blocks attributed to licensees just below and just above 3.6 GHz. BT/EE⁶¹¹ stated that the proposed technical conditions included in the draft licences are designed for 4G technology and, like the 3.4 GHz auction licences, will prevent operators from realising key features of new 5G technology such as low latency capabilities. BT/EE therefore requested *"that Ofcom supports technical licence conditions that are optimised for 5G New Radio deployments and not 4G technology in the 3.4-3.8 GHz band"*.

8.75 BT/EE⁶¹² highlighted ECC Report 296 which explains that partially synchronised frame structures, even when used with the permissive spectrum mask, will result in only very limited interference between operators. The limited impact (cost) of such interference would be outweighed by the substantial benefits that will arise from facilitating deployment of low latency capabilities.

⁶⁰⁹ Frame Structure B has a DSUXXXXXXX structure where "X" is a flexible sub-frame which can be either uplink or downlink.

⁶¹⁰ Nokia response to the December 2018 consultation, Q13, p.4.

⁶¹¹ BT/EE response to the December 2018 consultation, paragraph 7.1.

⁶¹² BT/EE response to the December 2018 consultation, paragraph 7.2.

- 8.76 Dense Air⁶¹³ said that the TDD synchronisation and frame structure rules proposed preclude 5G NR technologies delivering new services focused on vertical markets, and suggested that spectrum holders should work together to agree what is the best frame structure for the 3.4-3.8 GHz band and that this should not be a matter for Ofcom to mandate.

Ofcom's assessment

We have decided to mandate synchronisation requirements

- 8.77 It is important that the licensees can start using the spectrum as soon as possible after the auction and we consider that synchronisation was necessary to prevent harmful interference. We said this would give bidders more certainty about the proposed synchronisation profile, and allow them to make more informed bidding choices.
- 8.78 We consider that the argument in favour of mandating synchronisation requirements remains the same for the 3.6-3.8 GHz band as for the 2.3 and 3.4 GHz bands which we previously awarded.
- 8.79 The 3.6-3.8 GHz band is contiguous with the 3.4 GHz band and so needs to have the same synchronisation requirements to avoid undue interference.

We consider that the synchronisation requirements strike an appropriate balance between preventing harmful interference and enabling future use cases

- 8.80 We recognise that the proposed synchronisation requirements may not be optimal for some future 5G NR uses which require lower latencies, however they are suitable for a wide range of 5G services, many of which will not need the lower latencies that alternative frame structures would allow. Mobile operators have already deployed 5G services which comply with the same synchronisation requirements in the 3.4-3.6 GHz band. The ECC 3.4-3.8 GHz Synchronisation Report, ECC Report 296, states that *"every LTE-TDD frame configuration has at least one compatible 5G NR equivalent configuration"*.
- 8.81 We acknowledge that the proposed synchronisation requirements might not be optimal for all verticals use cases whose business cases may be different than providing mobile broadband, however, we remain of the view that they are suitable for a wide range of use cases. We also note that many verticals use cases may be indoors, and we have exempted low power indoor base stations from the requirement to synchronise when there is no risk of harmful interference to outdoor networks.
- 8.82 None of the responses suggested an alternative frame structure or indicate that the synchronisation requirements should change now for the 3.4-3.6 GHz band or the 3.6-3.8 GHz band. We are aware that industry is currently considering options for 5G NR synchronisation and frame structures in the future.
- 8.83 After completion of the award, the holders of the 3.6-3.8 GHz licences can coordinate with the current 3.4-3.6 GHz licensees to consider whether new synchronisation requirements

⁶¹³ Dense Air response to the December 2018 consultation, Q13, p.5.

would be appropriate for the whole 3.4-3.8 GHz band. Any future agreement of new synchronisation requirements in 3.4-3.8 GHz would require a licence variation, which the licensees could request through our normal processes.

8.84 We have therefore decided to adopt the synchronisation requirements we proposed in the December 2018 consultation.

Emissions limits for base stations

Ofcom's proposals

8.85 We proposed to include out-of-band baseline power limits for new mobile base station active antenna systems (AAS), taking into account coexistence with adjacent systems, and reclassify the existing limits to be for non-AAS only.

8.86 Below, we summarise our proposals for new emissions masks for AAS and updates for the non-AAS emission masks:

- i. For non-AAS, we proposed to include the same limits as those in the 3.4 GHz licences, with the exception of the out-of-band limits below 3390 MHz and above 3.8 GHz⁶¹⁴.
- ii. For AAS, we proposed out-of-block and out-of-band emissions limits from CEPT Report 67.
- iii. We observed that CEPT Report 67 does not mandate any in-block power limit for base stations. We converted the non-AAS EIRP limit in the 3.4 GHz licences (65 dBm / 5 MHz per cell) to a TRP limit for AAS (44 dBm / 5 MHz per cell) by considering a typical sector antenna with 21 dBi gain. We said that this in-block limit for AAS would be appropriate for protecting other spectrum users because it is derived from the existing non-AAS power limits and so will have a similar impact on other users.
- iv. We said that we believed that the in-block power limit of 44 dBm / 5 MHz TRP per cell would not be a material constraint on operators' ability to deploy 5G.
- v. We observed that CEPT Report 67 clarifies that the radar protection baseline for non-AAS should be applied on a 'per antenna' basis. We proposed to use this definition in the new 3.6-3.8 GHz licences.
- vi. We observed that CEPT Report 67 provides out-of-band emissions limits for both non-AAS and AAS above 3.8 GHz. We proposed to include both limits in the 3.6-3.8 GHz licences.

⁶¹⁴ We have subsequently received a licence variation request from the 3.4 GHz licensees to align the Spectrum Access 3.4 GHz, 3.5 GHz and 3.6 GHz licences. The 3.4 GHz licences were updated. For further information see <https://www.ofcom.org.uk/consultations-and-statements/category-3/proposal-vary-3.4ghz-radio-spectrum-licences>

- vii. We also said that we were considering whether the emissions limit below 3390 MHz could be relaxed for indoor small cells.

Stakeholders' comments

- 8.87 Vodafone⁶¹⁵ has sought confirmation that the language used for the transmitted power limits of base stations is correct.
- 8.88 Dense Air⁶¹⁶ believed that the 3.6-3.8 GHz frequencies could be used for network densification delivering high data capacity in targeted locations (mostly indoor). This would be delivered by deploying small (low power) cells close to the end users.
- 8.89 Dense Air was concerned that licence conditions allowing conventional cell sites (rooftops or towers) with high radiated power levels could pose operator coexistence challenges as well as creating health and safety concerns in public areas. It requested that lower radiated power limits should be considered (in the order of 5 W EIRP) in order to encourage a deployment model that enables network densification and maximises overall network spectral efficiency.
- 8.90 Nokia⁶¹⁷ said it was not clear from the draft licence conditions whether the out-of-band emissions requirement for coexistence with military radar (-50dBm / MHz EIRP emissions limit below 3390 MHz) should apply to indoor small cells. It said the radar limit set in CEPT was for outdoor deployments and that it is too onerous to be applied to indoor small cells. It recommended that the limits below 3390 MHz should be relaxed by 15-20 dB.

Ofcom's assessment

In-block emission limits for base stations

- 8.91 We confirm that a non-AAS base station has a maximum mean power of 65 dBm / 5 MHz EIRP per cell and an AAS base station has a maximum mean power of 44 dBm / 5 MHz TRP per cell.
- 8.92 Our technical licence conditions allow for different types of base stations from macrocells to small cells. Our technical licence conditions for the 3.6 GHz band are consistent with the conditions for licensees in the adjacent 3.4 GHz band and the synchronisation requirements will help to mitigate any coexistence issues between 3.4-3.8 GHz licensees.
- 8.93 We consider that the licensees of the spectrum are best able to make the judgement about the densification that is appropriate for their networks. Evidence from early 3.4 GHz deployment of 5G in the UK suggests a demand for macrocells. We have no reason to expect that the deployment of the 3.6 GHz band would be different. We acknowledge that smaller lower power cells might be more spectrally efficient in some circumstances, as they enable spectrum to be reused at a greater rate over smaller areas. However, we would expect that if we limited the power of base stations to 5W, it would likely take much longer

⁶¹⁵ Vodafone's response to the October 2019 consultation, section 4, p13.

⁶¹⁶ Dense Air's response to the December 2018 consultation, Q13.

⁶¹⁷ Nokia's response to the December 2018 consultation, Q13.

for a licensee to bring these frequencies into use for the benefit of consumers across a wide area. We consider that the in-block power limits we have set appropriately balance spectral efficiency and facilitating the rollout of national networks. In response to the December 2018 consultation, we received further comments in favour of regional or local licences, which we address in annex 2.

- 8.94 Dense Air's comment about the risk of creating health and safety concerns in public areas is discussed in annex 2.
- 8.95 In conclusion, we have decided to adopt the in-block power limits for base stations that we proposed in the December 2018 consultation.

Out-of-band emissions below 3390 MHz for small cells

- 8.96 In respect to Nokia's point, we note that it was the only response that raised this issue. No similar responses were received from the current licensees in the 3.4 GHz band, who also did not request this change in their recent 3.4 GHz licence variation request. However, we note that Ericsson did raise a similar concern to Nokia in its response to the 3.4 GHz variation consultation.⁶¹⁸
- 8.97 The 2019 Implementing Decision (EU) 2019/235) suggests that, for indoor deployments, Member States may define a relaxed limit below 3390 MHz for indoor small cells. In the UK, the out-of-band limit below 3390 MHz is to protect airborne radars, and it was calculated considering the aggregate effect of emissions from terrestrial base stations. Any changes to the emission limit for indoor small cells would need to be carefully considered to ensure they would not adversely impact airborne radar.
- 8.98 We are not proposing to vary the emission limits below 3390 MHz at this time. Therefore, all base stations need to adhere to the limits in the licence and there is no exemption for indoor small cells. If we receive a future request from a licensee to vary the limits below 3390 MHz, we will consider it at that time.

In-block emissions limits for terminal stations

- 8.99 We proposed to include the power limit of 28 dBm TRP for terminals in the new 3.6-3.8 GHz licences. This power level is consistent with the 2019 Commission Decision. There were no comments from stakeholders and we have decided to adopt the in-block power limits for terminals that we proposed in the December 2018 consultation.

Sample licences

- 8.100 Sample licences for 700 MHz and 3.6-3.8 GHz frequencies which reflect the decisions explained in this section are set out in the annexes A1 and A2 of the Information Memorandum published alongside this statement.

⁶¹⁸ <https://www.ofcom.org.uk/consultations-and-statements/category-3/proposal-vary-3.4ghz-radio-spectrum-licences>

8.101 We note that Vodafone⁶¹⁹ suggested that Ofcom should provide different specimen licences for the paired spectrum and ‘centre gap’ because not all terms apply to all frequencies. We do not consider this is necessary because all licences are issued for specific frequencies on a bespoke basis and they are clear about which particular terms apply to which frequencies.

We also note that, as set out in Annex 2, we have recently published a consultation setting out proposals to include a condition in spectrum licences (and other spectrum authorisations) that will require spectrum users to ensure they comply with the levels for general public exposure from the ICNIRP Guidelines. This consultation closes on 15 May 2020.^[1] We will publish a statement in 2020. If we proceed with the proposals and do so prior to the grant of the licences, we will revise the licences accordingly before grant. If we decide to proceed with the proposals after grant of the licences, then we will vary the licences to include the new conditions.

⁶¹⁹ Vodafone response to the December 2018 consultation, page 50.

^[1] Ofcom’s consultation of 21 February 2020 entitled “Proposed measures to require compliance with international guidelines for limiting exposure to electromagnetic fields (EMF)”; see <https://www.ofcom.org.uk/consultations-and-statements/category-1/limiting-exposure-to-emf>

9. Next steps

9.1 In this section of the statement we set out the next steps in our progress towards the start of the auction of the 700 MHz and 3.6-3.8 GHz spectrum

9.2 As noted, this statement is published alongside other relevant documents:

- A statement on the making of regulations in connection with the award.⁶²⁰ This sets out the Auction Regulations which give effect to our decisions.
- An Information Memorandum⁶²¹. This sets out information of relevance to those parties considering bidding in this award process for one or more Wireless Telegraphy Act 2006 (WT Act) licences for the 700 MHz and 3.6-3.8 GHz bands.
- A document containing guidance on the auction process for potential applicants and bidders.⁶²²

Timetable

9.3 This timetable is provided for illustrative purposes. Further information on indicative timings is provided in our process guidance document:

- The Auction Regulations will come into force after we formally make them – we will specify the date of entry into force in the final Regulations.
- Shortly after the Auction Regulations come into force, we will invite applications from potential bidders in the auction. We will publish full details on our website, including notification of the date on which we will accept the applications. All applications must be delivered to Ofcom by hand on the designated day.
- Following submission of applications and payment of initial deposits, Ofcom will provide details of how applicants may access a training version of the electronic auction software we will be using in the auction, together with bidder and auctioneer manuals setting out instructions on use of the software. This will enable applicants to familiarise themselves with the bidding process and to conduct their own internal mock auctions and training.
- Once we have received applications, we will conduct a formal qualification stage to assess applicants for potential overlaps between bidder groups, and for general fitness to hold a licence. We will then publish a list of those applicants who have qualified as bidders and give notice of the final date for withdrawal of applications.
- Once the final date for withdrawal of applications has passed, we will publish a final list of bidders and notify them of the date on which the principal stage of the auction will begin. We will also issue notice of the deadline for payment of additional deposits.
- Bidding begins.

⁶²⁰ https://www.ofcom.org.uk/data/assets/pdf_file/0018/192411/auction-regulations-award-700mhz-3.6-3.8ghz-spectrum.pdf

⁶²¹ https://www.ofcom.org.uk/data/assets/pdf_file/0019/192412/information-memorandum-award-700mhz-3.6-3.8ghz-spectrum.pdf

⁶²² : https://www.ofcom.org.uk/data/assets/pdf_file/0027/192474/process-guidance-700mhz-3.6-3.8ghz-auction.pdf