
Variation of UK Broadband's spectrum access licence for 3.6 GHz spectrum

STATEMENT:

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About this document

UK Broadband holds a spectrum licence which authorises it to use 168 MHz of radio spectrum in two separate 84 MHz blocks at 3605 – 3689 MHz and at 3925 – 4009 MHz. In May 2018 UK Broadband requested a number of changes to this licence concerning the lower frequency block (3605 – 3689 MHz), including: shifting it down by 5 MHz, surrendering 4 MHz of spectrum in that block, and changing the applicable technical conditions.

On 27 June 2018, Ofcom published a consultation setting out its provisional view that it was minded to agree to the variation request. This document sets out Ofcom's decision to grant the variation.

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1. Executive summary

1.1 This document sets out our decision to exercise our spectrum management functions to vary UK Broadband's ("**UKB**") licence to use spectrum in the 3.6 – 3.8 GHz band, by amending the frequencies and technical requirements specified in the licence. For the reasons explained in more detail in this decision, we consider that it is in the interests of consumers for Ofcom to vary this licence in accordance with UKB's request.

The variation request

1.2 UKB, which was acquired by Hutchison 3G UK Limited ("**H3G**") in 2017, holds a Spectrum Access licence (the "**UKB Licence**") authorising it to use two non-adjacent blocks of 84 MHz at 3605 – 3689 MHz (the "**lower frequency block**") and 3925 – 4009 MHz (the "**upper frequency block**").¹

1.3 On 29 May 2018, UKB requested Ofcom, as the relevant licensing authority, to make the following changes to the UKB Licence:

- to shift its lower frequency block down by 5 MHz to make it adjacent to the 20 MHz spectrum block licensed to UKB at 3580 – 3600 MHz;
- to reduce its frequency holding in the lower frequency block by 4 MHz, so that it would hold 80 MHz from 3600 – 3680 MHz (rather than 84 MHz from 3605 – 3689 MHz);
- to align the technical requirements that would apply to the frequencies 3600 – 3680 MHz with the technical requirements that currently apply to UKB's spectrum access licence in the 3.4 – 3.6 GHz band; and
- to allow a transitional period during which UKB would continue to be authorised to use 3605 – 3689 MHz under the current technical requirements, whilst also being authorised to deploy 3600 – 3680 MHz under the new technical requirements. This transitional period would end nine months from the date of the licence being varied.

1.4 On 27 June 2018, we published a consultation (the "**June 2018 consultation**")² setting out our provisional conclusion that it was appropriate to grant the variation, and that we were minded to do so. We received five responses (BT/EE, H3G/UKB, Telefónica, Vodafone and Nominet) and published all non-confidential responses on our website.

Our decision to grant the variation

1.5 Having considered the comments made by stakeholders, we have decided, in light of our relevant spectrum management functions and statutory duties, to grant the variation. We consider that granting the variation meets our duties to further the interests of citizens and

¹ https://www.ofcom.org.uk/_data/assets/pdf_file/0019/83800/SA-3.6-LICENCE-UK-Broadband-0823615-11-01-18w.pdf

² Ofcom, June 2018. Variation of UK Broadband's Spectrum Access Licence for 3.6 GHz spectrum, Consultation. <https://www.ofcom.org.uk/consultations-and-statements/category-2/variation-uk-broadbands-spectrum-access-licence-3.6-ghz>

consumers, to secure optimal use of the spectrum, to promote competition, and to promote the efficient management and use of the spectrum.

- 1.6 Granting this variation simplifies the holdings in the 3.6 – 3.8 GHz band. It also increases the amount of contiguous spectrum that is usable by all operators that can be made available in our planned award of spectrum in the 3.6 – 3.8 GHz band by 10 MHz. We expect this to benefit the customers of bidders in the auction, as it means we can make available more usable spectrum in the award than would be the case absent the variation.
- 1.7 Following the variation, H3G will hold 100 MHz of contiguous spectrum, compared with the 84 MHz lower frequency block and separate 20 MHz from 3580 – 3600 MHz. We expect the variation to provide H3G with a small to moderate incremental increase in capacity (c.2 – 18%), which will allow it to offer higher average speeds in heavily loaded cells. This may mean a slower degradation in H3G's mobile and fixed wireless access (FWA) customers' quality of experience than would otherwise be the case as H3G's future 5G network becomes more heavily loaded. We also expect an increase in the peak speeds it can offer due to using a larger single carrier, and potentially better 5G coverage by having higher transmit power levels.
- 1.8 We have considered whether any benefit accruing to H3G from the variation could have an adverse impact on competition, to the detriment of consumers more broadly. We recognise that UKB already has the largest spectrum holding in the 3.4 – 3.8 GHz band, including 84 MHz of contiguous spectrum, independent of the variation. We do not consider it likely that the benefit to H3G described above would be so significant as to provide H3G with an unmatched competitive advantage over its competitors. Moreover, there are a number of dimensions to competition, and capacity and 5G speeds are only one aspect of the competitive offering. We therefore do not consider the variation is likely to have an adverse impact on competition such that we should not consent to it.
- 1.9 In reaching our conclusions, we have taken into account the comments made by BT/EE, Vodafone and Telefónica in their consultation responses, which focused primarily on the current fragmentation of spectrum holdings in the wider 3.4 – 3.8 GHz band and H3G's existing greater amount of contiguous spectrum relative to other mobile operators. These respondents suggested that we should have considered other options to defragment the band further, such as allowing or requiring the holders of the existing licensees of spectrum in the 3.4 – 3.8 GHz band to make that spectrum available in the assignment stage of the forthcoming 3.6 – 3.8 GHz award. Although we recognise that further defragmentation of the 3.4 – 3.8 GHz band may well be desirable given the benefits that contiguity of spectrum holdings can bring, it is our view that this licence variation does not offer the opportunity to achieve such an outcome. We have considered whether granting the licence variation will make defragmentation of the wider band less likely, and do not think this is the case. In the consultation on the upcoming award of 3.6 – 3.8 GHz spectrum, we will consider possible ways that the award could address or facilitate further defragmentation through that award, if appropriate.
- 1.10 Finally, we have considered whether the variation would have an adverse impact on other spectrum users, and have concluded that it would not. The requested changes to technical

conditions will not impact the benchmark spectrum quality currently received by existing Permanent Earth Station and Fixed Links licensees or holders of grants of Recognised Spectrum Access for Receive Only Earth Stations in the 3.6 – 3.8 GHz band, due to continued coordination of UKB deployments. Specifically, the more permissive out of band emissions mask in the new technical requirements will be included in the existing coordination tool, and UKB will continue to be required to abide by the existing coordination procedure for all of its new sites and for changes to its existing sites. We will continue to coordinate UKB deployments with registered users, until fixed links and satellite earth stations have vacated the band or earth stations are no longer taken into account for frequency management purposes.

Next steps

- 1.11 We have issued UKB with a varied licence, with all the amendments coming into force today. The transitional period requested by UKB will come to an end on 14 September 2019. A copy of the varied licence is set out in Annex A2.

2. Introduction

Ofcom's spectrum management functions

- 2.1 Parliament has given Ofcom the task of managing radio-spectrum in the UK. Ofcom's functions in this regard are set out in the Wireless Telegraphy Act 2006 (the "**2006 Act**") and Ofcom exercises those functions in light of its general statutory duties in the Communications Act 2003 (the "**2003 Act**") and its specific spectrum-related duties in the 2006 Act. We set out our relevant functions and duties in more detail in section 3.
- 2.2 One of Ofcom's main spectrum management functions is to grant licences authorising the use of spectrum frequencies, subject to such terms, provisions and limitations as Ofcom thinks fit.
- 2.3 Ofcom also has powers to vary spectrum licences, either on its own instigation or as a result of a licence variation request from the licensee. In either case, Ofcom must decide whether varying a licence would give effect to its statutory duties, and must act in accordance with the applicable procedures set out in the 2006 Act which apply to licence variations.

The UK Broadband licence

- 2.4 UK Broadband ("**UKB**"), which was acquired by Hutchison 3G UK Limited ("**H3G**")³ in 2017, holds a Spectrum Access licence (the "**UKB Licence**") authorising it to use two non-adjacent blocks of 84 MHz at 3605 – 3689 MHz (the "**lower frequency block**") and 3925 – 4009 MHz (the "**upper frequency block**").⁴
- 2.5 The UKB Licence was initially administratively granted in 1992 by the Radiocommunications Agency (one of Ofcom's predecessors) to Millicom, on the instruction of the relevant government minister at the time. It was granted with an indefinite duration, subject to revocation provisions and the payment of annual licence fees. The licence was traded several times during the 1990s, eventually to a company called GX Networks. In 2003, Pipex Communications (which subsequently changed its name to Freedom4) acquired GX Networks. Freedom4 then sold the licence to UKB in 2010.

The variation request

- 2.6 On 29 May 2018, we received an application from UKB for variation of the lower frequency block of the UKB Licence, followed by some clarifications on the changes to the technical requirements requested. On 27 June 2018, we published a consultation document, 'Variation of UK Broadband's Spectrum Access Licence for 3.6 GHz spectrum' (the "**June**

³ For ease of reference, where we refer to H3G in this document, we are also referring to its subsidiary, UKB.

⁴ https://www.ofcom.org.uk/data/assets/pdf_file/0019/83800/SA-3.6-LICENCE-UK-Broadband-0823615-11-01-18w.pdf

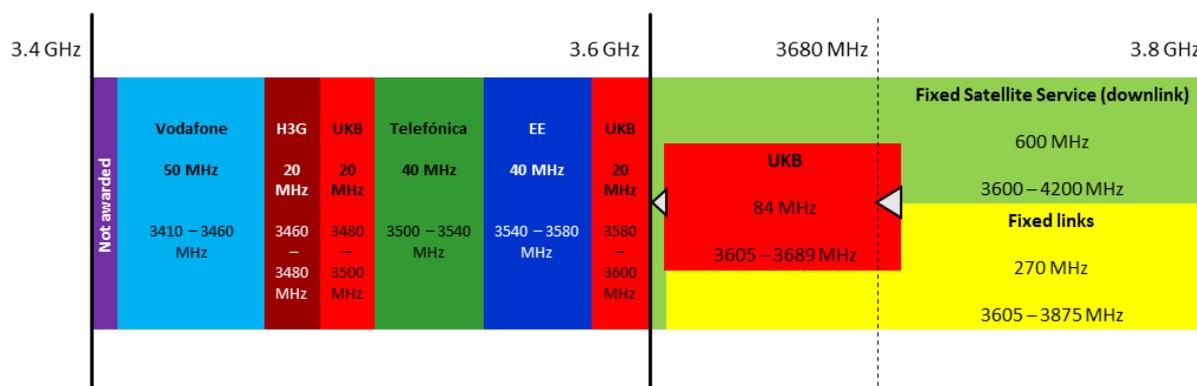
2018 consultation”),⁵ in which we set out our provisional conclusion that it was appropriate to grant the variation and we were minded to do so.

2.7 UKB requested the following changes to the UKB Licence:

- to shift its lower frequency block down by 5 MHz;
- to reduce its frequency holding in the lower frequency block by 4 MHz, so that it would hold 80 MHz from 3600 – 3680 MHz;
- to align the technical requirements that would apply to the frequencies 3600 – 3680 MHz with the technical requirements that apply to the Spectrum Access licence authorising UKB to use two non-adjacent blocks of 20 MHz in the 3.4 – 3.6 GHz spectrum band, at 3480 – 3500 MHz and 3580 – 3600 MHz (the “UKB 3.4 – 3.6 GHz Licence”); and
- to allow a transitional period during which UKB would continue to be authorised to use 3605 – 3689 MHz under the current technical requirements, whilst also being authorised to deploy 3600 – 3680 MHz under the new technical requirements.

2.8 Figure 1 below shows current spectrum authorisations in the 3.4 – 3.8 GHz band. The arrows show the effects of the variation request on the frequencies of the lower frequency block. We have previously announced plans to award the 116 MHz in the 3.6 – 3.8 GHz band that is not already licensed to UKB. We expect the auction to take place in early 2020.⁶ As a result of the current allocation of the UKB Licence, the spectrum available for a future award is split into 5 MHz from 3600 – 3605 MHz and 111 MHz from 3689 – 3800 MHz, with the lower frequency block at 3605 MHz to 3689 MHz.

Figure 1: Current spectrum authorisations at 3.4 – 3.8 GHz⁷



2.9 Below we describe in more detail the elements of UKB’s variation request.

⁵ Ofcom, June 2018. Variation of UK Broadband’s Spectrum Access Licence for 3.6 GHz spectrum, Consultation. https://www.ofcom.org.uk/data/assets/pdf_file/0017/115343/Variation-UK-Broadband-Licence-3.6-GHz-spectrum.pdf

⁶ We refer to this as the future award throughout the document.

⁷ There are no fixed links in channels 1 to 3 (3605 – 3695 MHz paired with 3925 – 4015 MHz).

Shifting down and reducing the lower frequency block

- 2.10 UKB asked to move its lower frequency block down by 5 MHz so that it would be immediately adjacent to one of its existing spectrum holdings under the UKB 3.4 – 3.6 GHz Licence.
- 2.11 A move down by 5 MHz would result in the lower frequency block moving to 3600 – 3684 MHz. In addition to this move, UKB proposed to surrender 4 MHz of spectrum from the lower frequency block, to result in a final licensed allocation of 80 MHz at 3600 – 3680 MHz.
- 2.12 The variation would lead to UKB holding a contiguous block of 100 MHz at 3580 – 3680 MHz. UKB has indicated that this variation would allow them to use this spectrum to offer a “100 MHz 5G service”.⁸

Transitional arrangements

- 2.13 In order to manage the transition from the current use of 3605 – 3689 MHz to future use of 3600 – 3680 MHz, UKB has requested a transitional period during which equipment on some sites could continue to operate temporarily in the 3605 – 3689 MHz range to avoid adversely affecting existing customers. Equipment on upgraded sites would operate in the new 3600 – 3680 MHz range during this period. Subsequent to the submission of the variation request, UKB requested that:⁹
- access to the 3600 – 3680 MHz range be granted under technical requirements consistent with those in the UKB 3.4 – 3.6 GHz Licence (as shown in the new Schedule 1 of the varied licence at Annex A2); and
 - access to the 3605 – 3689 MHz range continue under the existing technical requirements of the UKB Licence, with this access to be withdrawn from the later of 1 September 2019 or nine months from the date of the licence variation taking effect.

Aligning the technical requirements for 3600 – 3680 MHz with the UKB 3.4 – 3.6 GHz Licence

- 2.14 The effect of aligning the technical requirements that apply to the frequencies 3600 – 3680 MHz with the technical requirements that already apply to the UKB 3.4 – 3.6 GHz Licence, and all other spectrum access licences in the 3.4 – 3.6 GHz band, is to:
- update the applicable “Interface Requirement”, from IR2015 to IR2097;¹⁰
 - increase the maximum power for base stations; and

⁸ UKB's licence variation request, page 1.

⁹ UKB initially requested that “For the Lower Frequency Block only, UKB requests that Ofcom delete paragraphs 2, 6 and 7 of Schedule 1 to the existing 3.6 GHz Licence and replace them with paragraphs 2 and 8 to 15 inclusive of the 3.4 – 3.6 GHz Licence (with the frequency offsets referenced in paragraph 14 of the 3.4 – 3.6 GHz Licence amended appropriately for the 3.6 GHz Licence variation).” However, UK Broadband subsequently requested the changes described in paragraph 2.9

¹⁰ IR 2097: https://www.ofcom.org.uk/_data/assets/pdf_file/0017/85031/ir_2097_2015_final.pdf

- introduce specific transmission masks, frame structures and inter-operator synchronisation requirements.

2.15 The differences between the current technical requirements of the UKB Licence and the UKB 3.4 – 3.6 GHz Licence are summarised in Table 1 below.

Table 1: Summary of differences between technical requirements in the existing UKB Licence and those in the UKB 3.4 – 3.6 GHz licence

	Existing technical requirements in the UKB Licence	Technical requirements in the UKB 3.4 – 3.6 GHz Licence
Synchronised Operation	No synchronised frame structure Must comply with the specified out-of-band emissions mask	Synchronised operation must: <ul style="list-style-type: none"> • Use Frame Structure A¹¹; and • Time align with neighbours; and • Comply with the Permissive mask
Unsynchronised Operation	Unsynchronised use permitted Must comply with the specified out-of-band emissions mask	Unsynchronised operation not permitted, however semi-synchronisation is permitted and must: <ul style="list-style-type: none"> • Use Frame Structure B; and • Time align with neighbours; and • Comply with the Restrictive mask
Base station in-block power limits	60 dBm / 5 MHz EIRP per Equipment	65 dBm / 5 MHz EIRP per Equipment
Fixed terminal in-block power limits	60 dBm / 5 MHz EIRP per Equipment	35 dBm / 5 MHz EIRP per Equipment

2.16 As set out in Table 1, UKB is currently required to comply with a specific out-of-band emissions mask in 3605 – 3689 MHz and is not required to synchronise with its neighbours. The requirements that apply to the UKB 3.4 – 3.6 GHz Licence and the other spectrum access licences in the 3.4 – 3.6 GHz band (i.e. the requirements which UKB has requested we incorporate into the UKB Licence) encourage users to synchronise uplink and downlink time slots by allowing users who synchronise to use the Permissive mask, which is more relaxed than the out-of-band emissions mask in the UKB Licence. Details of the relevant frame structures and masks are set out in the Schedules of the varied UKB Licence in Annex A2.

¹¹ Frame Structure A provides a downlink / uplink ratio of 3:1.

Responses to the consultation

- 2.17 We received five responses to the June 2018 consultation, which closed on 8 August 2018.¹² All non-confidential responses are available on our website.¹³ We also issued further technical questions to two respondents.
- 2.18 Having carefully considered all responses to the June 2018 consultation and the answers to the additional technical questions, for the reasons set out in this document we have decided to grant the variation. We have therefore amended the UKB Licence as requested. A copy of the varied UKB Licence is set out in Annex A2 to this statement.

Structure of this document

- 2.19 The rest of this document is structured as follows:
- **Section 3** – Legal framework;
 - **Section 4** – Assessment of the variation request;
 - **Section 5** – Other considerations;
 - **Section 6** – Conclusions;
 - **Annex A1** – Assessment of further comments made in response to the June 2018 consultation;
 - **Annex A2** – Varied licence;
 - **Annex A3** – Glossary.

¹² We received responses from H3G/UKB, Telefónica, Vodafone, BT/EE and Nominet.

¹³ <https://www.ofcom.org.uk/consultations-and-statements/category-2/variation-uk-broadbands-spectrum-access-licence-3.6-ghz>

3. Legal framework

- 3.1 This section provides an overview of the main UK and European legislative provisions relevant to spectrum licensing and to the requested licence variation.
- 3.2 The applicable legal framework derives from our duties and powers under both domestic and European legislation. Specifically, from:
- the Communications Act 2003 (the “**2003 Act**”) and the Wireless Telegraphy Act 2006 (the “**2006 Act**”); and
 - the European Common Regulatory Framework¹⁴ for electronic communications networks and services. In particular, the Framework Directive and the Authorisation Directive, together with a number of Decisions that apply to these specific spectrum bands.

Licence variation

Ofcom's spectrum management functions and licensing powers

- 3.3 As noted in section 2, Parliament has conferred on Ofcom spectrum management functions and powers in the UK. These are set out in the 2006 Act. Such powers include (under sections 9 and 10), the general power to grant wireless telegraphy licences subject to such terms, provisions and limitations as Ofcom thinks fit, and to revoke or vary such licences, subject to any restrictions Ofcom has written into the relevant licences. Schedule 1 of the 2006 Act sets out a process for the variation of wireless telegraphy licences.
- 3.4 Ofcom has a duty set out in section 9(7) of the 2006 Act, reflecting Article 6 of the EU Authorisation Directive 2002/20/EC, to ensure that wireless telegraphy licence conditions are objectively justified in relation to networks and services to which they relate, non-discriminatory, proportionate and transparent.
- 3.5 Ofcom has a broad discretion under paragraph 6 of Schedule 1 of the 2006 Act to vary licences, subject to certain limitations:
- pursuant to paragraph 6A of Schedule 1 of the 2006 Act, any variation of a wireless telegraphy licence must be objectively justifiable;
 - UK obligations under European law or international agreements where use of spectrum has been harmonised: Ofcom will not agree to remove restrictions from licences or other changes that would conflict with the UK's obligations under international law;
 - section 5 of the 2003 Act and section 5 of the 2006 Act enable the Secretary of State to give directions to Ofcom in respect of the carrying out of our spectrum functions;

¹⁴ The European 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.

- Ofcom must act in accordance with its statutory duties, including the duty to secure optimal use of the spectrum, our duties under section 3 of the 2006 Act and obligations under the Authorisation Directive (2002/20/EC); and
- general legal principles, which include the duties to act reasonably and rationally when making decisions and to take account of any legitimate expectations.

3.6 Ofcom exercises its spectrum management functions having regard to its statutory duties, which are described below.

The licence variation process

3.7 Schedule 1 of the 2006 Act sets out a process for the variation of wireless telegraphy licences. In cases where a variation is proposed by the licensee, we are under no obligation (under the 2006 Act) to consult on the proposal.

3.8 Section 7 of the 2003 Act provides that where we are proposing to do anything for the purposes of, or in connection with, the carrying out of our functions, and it appears to us that the proposal is important, then we are required to carry out and publish an assessment of the likely impact of implementing the proposal, or a statement setting out our reasons for thinking that it is unnecessary to carry out such an assessment. Where we publish such an assessment, stakeholders must have an opportunity to make representations to us about the proposal to which the assessment relates.

3.9 These provisions implement Article 14 of the Authorisation Directive which requires Member States to ensure that, except where proposed amendments are minor and have been agreed with the licensee:

- notice of the proposed change is given in an appropriate manner; and
- interested parties, including users and consumers, are allowed a sufficient period of time to express their views on the proposed amendments (such time to be no less than four weeks except in exceptional cases).

3.10 We consider that the variation requested by UKB is important for the purposes of section 7 of the 2003 Act. On that basis, we published for consultation our proposal to vary this licence and our initial assessment of the likely impact of doing so, to give interested third parties an opportunity to make representations. Having considered stakeholders' responses, we are now publishing our decision to grant the variation. We have made this decision in light of our statutory duties, which are summarised below.

Ofcom's general duties

3.11 Section 3 of the 2003 Act states the general duties of Ofcom. Under section 3(1) it is the principal duty of Ofcom in carrying out its functions:

- to further the interests of citizens in relation to communications matters; and
- to further the interests of consumers in relevant markets, where appropriate by promoting competition.

3.12 In doing so, Ofcom is required to secure, amongst other things (under section 3(2)):

- the optimal use for wireless telegraphy of the electro-magnetic spectrum; and
 - the availability throughout the UK of a wide range of services.
- 3.13 In performing its duties, Ofcom must have regard to, amongst others, the following matters:
- the desirability of promoting competition (section 3(4)(b));
 - the desirability of encouraging investment and innovation (section 3(4)(d));
 - the desirability of encouraging availability and use of broadband services throughout the UK (section 3(4)(e)); and
 - the different needs and interests of persons in different parts of the UK (section 3(4)(l)).
- 3.14 The management of the UK radio spectrum is carried out within a framework set out by the European Common Regulatory Framework, which aims to harmonise the regulation of electronic communications networks and services throughout the European Union. Related to that, section 4 of the 2003 Act requires Ofcom, when carrying out its spectrum functions, to act in accordance with “six community requirements” when managing the UK spectrum. These requirements, which give effect to the requirements of Article 8 of the Framework Directive and are to be read accordingly, include:
- the requirement to promote competition (section 4(3));
 - the requirement to secure that Ofcom’s activities contribute to the development of the European internal market (section 4(4)); and
 - the requirement to promote the interests of all persons who are citizens of the European Union (section 4(5)).

Ofcom’s duties when carrying out spectrum functions

- 3.15 In carrying out its spectrum functions it is the duty of Ofcom (under section 3 of the 2006 Act) to have regard in particular to:
- the extent to which the spectrum is available for use or further use, for wireless telegraphy;
 - the demand for use of that spectrum for wireless telegraphy; and
 - the demand that is likely to arise in future for the use of that spectrum for wireless telegraphy.
- 3.16 It is also the duty of Ofcom to have regard, in particular, to the desirability of promoting:
- the efficient management and use of the spectrum for wireless telegraphy;
 - the economic and other benefits that may arise from the use of wireless telegraphy;
 - the development of innovative services; and
 - competition in the provision of electronic communications services.
- 3.17 Where it appears to Ofcom that any of its duties in section 3 of the 2006 Act conflict with one or more of its general duties under sections 3 to 6 of the 2003 Act, priority must be given to its duties under the 2003 Act.

3.18 We have had regard to our duties in deciding to grant UKB's licence variation request.

4. Assessment of the variation request

Summary of our decision

- 4.1 Having considered the responses to the consultation, we have decided to grant the variation as requested. We plan to award spectrum in the 3.6 – 3.8 GHz band and the variation will increase the amount of spectrum available in the award to 120 MHz of contiguous spectrum which is usable by all, compared to two separate blocks of 5 MHz and 111 MHz of which only 110 MHz would be useable by operators other than H3G. The variation will simplify the holdings in the 3.6 – 3.8 GHz band and promote spectrum efficiency.
- 4.2 We expect that the variation will provide an incremental benefit to citizens and consumers, as well as to H3G. We do not consider it likely that any benefit to H3G of gaining access to 100 MHz of contiguous spectrum, as opposed to separate 84 MHz and 20 MHz blocks, will be so significant as to provide H3G with an unmatchable and enduring competitive advantage over its competitors. We also do not believe that granting the variation will make defragmentation of the 3.4 – 3.8 GHz band less likely.
- 4.3 In this section we set out our assessment of the variation request.

Ofcom's analytical framework

- 4.4 The radio spectrum is a finite national resource of considerable economic and social value.
- 4.5 As set out in the June 2018 consultation,¹⁵ in considering the variation of individual licences and taking account of our duties, the factors that we take into account include:
- securing optimal spectrum use;
 - promoting competition;
 - securing benefits for consumers and citizens; and
 - the impact on spectrum users in the same and adjacent bands.
- 4.6 In reaching our final decision, we have had to balance the advantages and disadvantages of varying the UKB Licence as requested by UKB, in light of the relevant factors and evidence, including consultation responses, in order to reach an outcome that appropriately meets our relevant statutory duties.
- 4.7 We now set out our analysis under this framework below.

¹⁵ Variation of UK Broadband's Spectrum Access Licence for 3.6 GHz spectrum. Paragraphs 4.3 to 4.4.
https://www.ofcom.org.uk/data/assets/pdf_file/0017/115343/Variation-UK-Broadband-Licence-3.6-GHz-spectrum.pdf

Securing optimal use of spectrum

- 4.8 Our view is that the variation is likely to have a positive impact on the optimal use of spectrum. The lower frequency block of the UKB Licence currently splits the 116 MHz of spectrum available for a future award into a 5 MHz block from 3600 – 3605 MHz, and a 111 MHz block from 3689 – 3800 MHz. The variation will increase the amount of spectrum available for the award to a contiguous 120 MHz block.
- 4.9 Nominet agreed that it was appropriate to grant the request, as it would help defragment the 3.6 – 3.8 GHz band, which would ultimately benefit consumers. BT/EE, Telefónica and Vodafone accepted that the variation would produce some benefits.¹⁶ However, they argued that we should reject the licence variation for reasons that focused primarily on the wider context of MNOs' holdings in the 3.4 – 3.8 GHz band overall, and H3G's greater amount of contiguous spectrum relative to other operators. Before setting out the rest of our assessment, we explain why we consider it appropriate to consider the impact of the variation request on its own merits in light of our statutory duties, and the relevance we place on the wider fragmentation of the 3.4 – 3.8 GHz band in this context.

Fragmentation of the 3.4 – 3.8 GHz band

- 4.10 The direct effect of the variation is to increase H3G's contiguous holdings from 84 MHz to 100 MHz. MNOs' responses did not present evidence such as to persuade us that this incremental increase would provide H3G with an enduring and unmatched advantage. Rather, the MNOs focused on their own disadvantage(s) relative to H3G (even without the variation), as they expect not to have an easy route to a sufficiently large contiguous block of spectrum.¹⁷ The other MNOs suggested that granting the variation as requested would effectively remove any possibility of a reorganisation of the band to allow H3G's competitors to achieve similar contiguity. They said that we should have considered other options to address the fragmentation of the wider 3.4 – 3.8 GHz band, which we address below.
- 4.11 The variation does not alter the fact that H3G/UKB already holds rights to use a large block of contiguous spectrum in the 3.4 – 3.8 GHz band.¹⁸ Further, the variation will not affect the location of other operators' existing spectrum holdings, and the fact that these are not contiguous with the spectrum which is available for award. We do not consider that the variation request before us from H3G is an appropriate vehicle to seek to secure some form of re-organisation of the wider 3.4 – 3.8 GHz band, noting that this variation is not a

¹⁶ BT/EE's response to the June 2018 consultation, paragraph 3. Vodafone's response to the June 2018 consultation, page 9. Telefónica's response to the June 2018 consultation, paragraph 89.

¹⁷ Industry view is that 80 to 100 MHz is a sufficiently large block of spectrum and considered ideal to deliver high throughput, low latency and high reliability 5G services.

¹⁸ H3G currently holds 20 MHz at 3460 – 3480 MHz, and UKB holds 2 x 20 MHz at 3480 – 3500 MHz and 3580 – 3600 MHz, and 84 MHz at 3605 – 3689 MHz, or 144 MHz in total.

negotiation process between Ofcom and H3G, as some respondents have implied.¹⁹ We have considered whether granting the variation makes defragmentation of the wider 3.4 – 3.8 GHz band less likely. For the reasons we set out below, we do not think that it does.

Reassignment of the 3.4 – 3.8 GHz band

4.12 BT/EE,²⁰ Vodafone²¹ and Telefónica²² all suggested that we should achieve further defragmentation of the 3.4 – 3.8 GHz band, and sought to tie the decision on this variation request into these wider issues. Their suggestions included:

- “*mandatory reassignment*” - requiring H3G/UKB to put all of its spectrum holdings within the 3.4 – 3.8 GHz band in the assignment stage of the 3.6 – 3.8 GHz auction as a condition of the granting of the licence variation or as a condition of participation in the auction which would apply, more generally, to any bidders; or
- “*voluntary reassignment*” - allowing existing licensees, including UKB, to enter voluntarily their 3.4 – 3.8 GHz spectrum holdings in the assignment stage of the 3.6 – 3.8 GHz auction.

Mandatory reassignment

4.13 We do not consider mandatory reassignment to be a feasible route to defragmentation. To give effect to such proposals would mean reassigning some or all of the 3.4 – 3.8 GHz frequencies which have already been allocated. The rights to use those frequencies are set out in the wireless telegraphy licences that we issued at the end of the 3.4 – 3.6 GHz auction, and in UKB's licences which were awarded previously. This would be a very significant amendment to the frequency usage rights that they previously held, both in terms of the frequencies themselves and the fact that some parts of the band require currently greater coordination with other users than other parts. We consider that significant changes such as those suggested by the MNOs to the licences could amount to a revocation of the existing licences and the issue of new licences.

4.14 In that event, absent the consent of the licensee, our power to revoke the existing licences of spectrum in the 3.4 – 3.8 GHz band (i.e. the 3.4 – 3.6 GHz licences that we awarded in April 2018 and the UKB licences) is subject to limitations written into those licences. In particular, our power to revoke these licences for spectrum management reasons is subject to a 5-year written notice period and, in the case of the 3.4 – 3.6 GHz licences that we awarded in the last auction, such notice may not be given before 15 years from the date of the licence (i.e. not before April 2033, so any revocation would not take effect until April 2038). We also note that a mandatory reassignment would have to take into account any other relevant considerations. In particular, two of the bidders in the previous auction

¹⁹ Telefónica suggested that we should treat the variation request “as an ‘opening gambit’ rather than a final offer”. Telefónica's response to the June 2018 consultation, paragraph 24. Telefónica also said that we should not “make the mistake of assuming that H3G's ‘opening offer’, as set out in UKB's application, is its best offer”, and that we “should call H3G's bluff” and give 5 years notice to revoke its licence (paragraph 11).

²⁰ BT/EE's response to the June 2018 consultation, page 6.

²¹ Vodafone's response to the June 2018 consultation, page 9.

²² Telefónica's response to the June 2018 consultation, paragraphs 5 and 61-68.

paid very significant sums to secure specific frequencies and these sums have been paid into the appropriate Consolidated Fund in accordance with the 2003 Act.

- 4.15 In addition, we do not think it would be appropriate to refuse the variation and make participation in the award conditional on H3G including some (or all) of its existing spectrum holdings in the assignment stage of that award. Even if such a condition of participation in the award could be justified, there is no certainty that H3G would enter the award on these terms. This is because the value that H3G places on winning new spectrum in the award may be less than the value it places on being able to engage in trading using its existing licences (see the further discussion below about H3G's incentives to trade), considered together with any cost of moving its spectrum holdings or any payment it may need to make as far as possible to retain its current frequencies. We consider that an outcome in which H3G does not participate in a mandatory assignment round in the future award, and the additional 4 MHz is not released for award by H3G, would result in an outcome that was worse in terms of spectrum efficiency than granting the variation.

Voluntary reassignment

- 4.16 We also do not think it would be appropriate to refuse the variation and forego the benefits we consider would flow from it, in order to seek to increase the likelihood that H3G participates in a voluntary reassignment stage. As we set out in paragraph 4.15, there is considerable uncertainty over whether H3G would choose to participate in a reassignment even if we were to refuse the variation. This is particularly so if the inclusion of existing spectrum holdings in the wider reassignment round were voluntary, such that H3G could bid for the 5 MHz at 3600 – 3605 MHz without having to include (and therefore potentially move) its existing holdings in that process. In that scenario, H3G would still be able to gain the benefits of having 100 MHz of contiguous spectrum, but we would not have released the additional 4 MHz for award.

Licence revocation

- 4.17 Telefónica argued we should “require UKB to surrender 44 MHz of spectrum in return for the licence variation to exclusive use”.²³ If H3G did not consent to surrendering 44 MHz, Telefónica suggested that we should revoke UKB's rights to use the 84 MHz authorised under the UKB Licence (i.e. from 3605 to 3689 MHz) on spectrum management grounds by giving 5-years' notice and auction all these frequencies, which would become available for use by the winning bidder(s) once the 5-year notice period had expired.²⁴
- 4.18 As we note above, Ofcom has powers to revoke the UKB Licence for reasons related to the management of the radio spectrum, with at least five years' notice. We may only revoke a wireless telegraphy licence where the proposed revocation is objectively justifiable.²⁵ Any such decision would be a separate consideration from this licence variation request, given that H3G has not requested the variation that Telefónica is proposing. For completeness,

²³ Telefónica's response to the June 2018 consultation, paragraphs 7, 78 and 92.

²⁴ Telefónica's response to the June 2018 consultation, paragraphs 75-78.

²⁵ 2006 Act, Schedule 1, paragraph 6A.

we nonetheless address the arguments made by Telefónica in annex A1 and set out why we are not minded to revoke the UKB Licence.

Shifting UKB's spectrum holding to the top of the 3.6 – 3.8 GHz band

4.19 Vodafone suggested that rather than granting the requested variation, which would result in UKB's licences covering 100 MHz from 3580 MHz – 3680 MHz, we should instead shift H3G's frequencies up to 3700 – 3800 MHz.²⁶ As noted above in respect of Telefónica's alternative proposals, Vodafone's proposal is fundamentally different to the variation request that H3G has put to us for consideration. Like mandatory reassignment (see paragraph 4.13), we consider that an amendment such as this would entail such a significant change to the licence that, absent consent, it could amount to revocation of the licence rather than a licence variation, with the consequent limitations on us that we set out above.

Making the 5 MHz at 3600 – 3605 MHz available in the award

4.20 As discussed above (paragraph 4.10), both Vodafone and Telefónica suggested that granting the variation as requested would effectively remove any possibility of a re-organisation of the band to allow H3G's competitors to achieve similar contiguity. In particular, Vodafone said that having been granted contiguous spectrum, H3G would have an incentive to ensure that defragmentation was not realised.²⁷ Telefónica argued that the variation would make whole band realignment very unlikely to be achieved through a secondary market transaction involving H3G since, in a scenario where H3G has a 100 MHz contiguous holding, "H3G has strong incentives to refuse to engage in discussions with other operators".²⁸

4.21 We do not consider it would be appropriate to forego the benefits of the licence variation for what we consider to be the unlikely possibility that another operator might be able to win the 5 MHz in the forthcoming award, in order to use their rights of use over it as a strategic tool to achieve wider defragmentation by incentivising trades which would not otherwise occur.

4.22 We consider H3G does have incentives to trade if the variation is granted. 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 its current location in the 3.4 GHz band. Regardless of whether or not we grant this licence variation, if the gains to other operators from obtaining contiguous spectrum are significant, they would be able to offer H3G a financial inducement to sell or move its 40 MHz, and as such H3G will have an incentive to trade in order to share in these gains.

4.23 H3G also has 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

²⁶ Vodafone's response to the June 2018 consultation, page 9.

²⁷ Vodafone's response to the June 2018 consultation, pages 2, 6 – 7.

²⁸ Telefónica's response to the June 2018 consultation, paragraph 34. In particular, [3<]

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 low frequency spectrum (just 10 MHz of 800 MHz spectrum, which is less than 10% of all currently allocated sub-1 GHz spectrum). H3G may have an incentive to trade its 3.4 GHz holdings to acquire some more low frequency spectrum.

- 4.24 In relation to its incentives to trade, H3G has said, [36] It further noted, "And one final point, if Ofcom has concerns that our willingness to consider a trade prior to the next auction might decrease when the variation is granted, I can give assurance that it doesn't. [36]"²⁹
- 4.25 We do not consider that refusing the variation would be likely to facilitate trades which would not otherwise occur. As we have just described, H3G does have incentives to trade even if the variation is granted. In contrast, the additional incentives for H3G to trade its location in 3.4 GHz in exchange for the 5 MHz strip at 3.6 GHz (if the variation were not granted) are likely to be more limited. As we discuss in more detail below, the benefits to H3G from having 100 MHz of contiguous spectrum rather than 84 MHz + 20 MHz are likely to be small to moderate, whereas the benefits of wider defragmentation (which H3G could share in financially if it traded) are potentially far larger. H3G is also likely to value the ability to acquire spectrum holdings in bands where it currently has comparatively less spectrum (e.g. low frequency bands) more highly than increasing the size of its contiguous block of spectrum.
- 4.26 We do not believe that another MNO could use the 5 MHz in a way that would be significantly disruptive to H3G.³⁰ In any event, H3G would have scope to deploy in the top 80 MHz of its existing 84 MHz and allow some distance from its lower neighbour, if needed.
- 4.27 There may be some strategic benefits to H3G from holding onto its 3.4 GHz to make it harder for other operators to gain contiguity. However, if these are sufficiently large to offset the incentives for trade offered by the opportunity to share in the financial gains from defragmentation and/or acquire low frequency spectrum, they are unlikely to be surmounted by the small incremental benefits H3G would gain from the 5 MHz. In any event, we consider any strategic benefits to not trading or selling the 3.4 GHz will be reduced if the variation is granted. In this scenario, there will be 120 MHz of contiguous

²⁹ [36]

³⁰ As we note in paragraph 4.60, we would in any event propose to amend the technical licence conditions which apply to H3G's 84 MHz so as to align them with the technical licence conditions that will apply to 3.4 – 3.6 GHz band. We consider it is probable that H3G will run their network in the band on a fully synchronised basis in order to take advantage of the Permissive mask. It is unlikely to be feasible for an MNO to operate the 5 MHz semi-synchronised using the restrictive mask because of the filtering challenges of doing so. If both H3G and the MNO in the 5 MHz were operating fully synchronised, there would be a very low risk of interference. It is in our view unlikely, but possible, that H3G would want to operate semi-synchronised. In that case there would be a risk of interference, but it would be bi-directional and would also risk interference to and from H3G's other spectrum neighbours not just the 5 MHz. However, the co-operation clause in the licences should mitigate these risks. Even if an MNO found a way to operate the 5 MHz semi-synchronised, the co-operation clause would mitigate the risk of interference to H3G in the adjacent spectrum bands.

spectrum available for award (rather than 110 MHz), which could enable at least two operators to obtain contiguity through a mutual trade not involving H3G.

- 4.28 As the 5 MHz is unlikely to facilitate trades which would not in any event occur, the business case for an operator looking to acquire the 5 MHz to use as a bargaining chip is likely to be weak. It is therefore unclear that an operator would find it attractive to acquire the 5 MHz in the award for this purpose, particularly given the potentially significant sums of money involved.
- 4.29 On balance, we consider this variation is more helpful for defragmentation than refusing it would be. It defragments H3G's holdings in the 3.6 – 3.8 GHz bands and makes more spectrum available for award, increasing the likelihood that one or more of the other MNOs is able (through post auction trading) to obtain large blocks of contiguous spectrum.

Our view on efficient use of spectrum

- 4.30 In summary, we recognise that further defragmentation of the 3.4 – 3.8 GHz band may well be desirable given the benefits that contiguity of spectrum holdings can bring. However, it is our view that this licence variation does not offer the opportunity to achieve such an outcome.³¹ We have considered whether granting the licence variation will make defragmentation of the wider band less likely, and do not think this is the case for the reasons set out above.
- 4.31 We consider that we should assess the proposed variation on its own merits, compared to the situation where the 5 MHz at 3600 – 3605 MHz is awarded in the future award and the 9 MHz at 3680 – 3689 MHz remain licensed to UKB. We remain of the view that this counterfactual, that we also considered in the consultation, is appropriate. We proceed with the rest of the assessment on this basis.
- 4.32 In its current position, the 5 MHz block at 3600 – 3605 MHz is likely to be of limited use to MNOs other than H3G for future mobile services (including 5G), because of the small amount of bandwidth available. In particular, we note that it is too small for a 5G carrier; the minimum channel size defined by 3GPP for 5G NR in this band is 10 MHz and it is recognised that 5G services require larger contiguous bandwidths. The block could be used for alternative technologies (e.g. 4G LTE), however it would be of greater use if it could be used as part of a larger 5G NR channel.
- 4.33 Shifting the lower frequency block down as requested will result in a larger contiguous block of spectrum for award. The total amount of spectrum available in the future award will increase to 120 MHz as a result of the surrender of 4 MHz, which will also increase the usability of the 1 MHz of the 111 MHz block.³² The variation will therefore have the effect

³¹ We note that there are other potential means to achieve greater contiguity, for example through spectrum trading between licensees.

³² 5G NR channel sizes in this frequency range vary in size from a minimum of 10 MHz to a maximum of 100 MHz. As it is not usable within these block sizes, 1 MHz of a 111 MHz / 116 MHz block is likely to be of no, or limited, use in the award. Options defined by 3GPP for 5G NR channel bandwidth in the 3400 – 3800 MHz range: 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100 MHz

of increasing by 10 MHz the amount of contiguous spectrum that is available to all bidders in the auction. We consider that the variation will have a positive impact on the efficient use of spectrum, by allowing this spectrum to be won by the user with the highest value for it.

- 4.34 We note that UKB's variation request will result in it having temporary access to 5 MHz more spectrum than is currently authorised in its licence. We remain of the view that this is proportionate to achieve the benefits set out above. UKB will not be authorised to use the full 89 MHz to serve any particular customer at any one time. This is ensured by the terms of the amended licence, which stipulates that, at any point in time, any piece of radio equipment must use either 3605 – 3689 MHz or 3600 – 3680 MHz (see paragraph 5 of Schedule 2 to the varied licence).

Promoting competition

- 4.35 We now assess the effects on competition of H3G having a contiguous block of 100 MHz in the band and awarding 120 MHz of contiguous spectrum following the variation in the forthcoming auction that we will hold. We compare this to the counterfactual where H3G has two separate blocks of 84 MHz and 20 MHz and we award separate blocks of 111 MHz and 5 MHz of spectrum in the future auction. As a result of this variation, H3G will gain the incremental advantage of a larger contiguous block of spectrum and a change in the technical conditions of the UKB Licence in advance of the future award.
- 4.36 In summary, while we consider the licence variation will give rise to some benefits to H3G, we do not consider these will be sufficiently material as to have a detrimental effect on competition more widely. We do not believe that the increment in contiguous spectrum gives H3G the ability to provide any particular services that would not be possible with its current holdings. Rather, it may provide H3G with a performance improvement. We consider that H3G will obtain a small to moderate increase in capacity on these spectrum blocks, of c.2 to 18%, when using a 100 MHz carrier rather than an 80 MHz carrier and separate 20 MHz carrier. Although this is not immaterial, it is nonetheless a relatively small increase when viewed in the context of the overall amount of spectrum available for mobile services.
- 4.37 This capacity increase will result in a commensurate increase in average speeds in heavily loaded cells. It may also mean a slower degradation in consumers' quality of experience than would otherwise be the case as H3G's future 5G network becomes more heavily loaded.³³ Being able to use a larger single carrier will also increase peak speeds.³⁴ However, we consider that the performance improvement in terms of 5G capacity and speeds deriving from this variation will not be significant enough to give H3G a material and enduring competitive advantage in the market. H3G will not obtain more overall spectrum in the long term as a result of this variation – indeed, its holdings will reduce by 4 MHz. We

³³ See paragraph 4.71

³⁴ If non-contiguous intra-band carrier aggregation is developed in 3.4 – 3.8 GHz then the peak speed advantage that H3G gets from this variation may be reduced.

consider that competition between the MNOs must be considered more broadly, across all services and features that they offer, and not just in terms of their 5G capacity, peak speeds or average speeds.

- 4.38 Neither the overall capacity of the other MNOs, nor their ability to provide services, is adversely affected by the licence variation. As we discuss above, we do not consider that granting the variation makes future defragmentation of the wider 3.4 – 3.8 GHz band less likely. Moreover, given that more contiguous spectrum will be available for award in the forthcoming auction as a result of the variation, there will be more spectrum available for bidders to win.

It is appropriate to consider this variation separately to the competition assessment for the future award

- 4.39 In relation to the scope of our competition assessment, BT/EE argued that the competition assessment of the variation could not be considered in isolation from the competition assessment for our future award. It said that we needed to fully assess the variation in a broader context, against the capability of other MNOs and how that might change in the auction.³⁵ Similarly, Telefónica said that we should not be considering this variation without clarifying our views on whether H3G could purchase more 3.6 – 3.8 GHz spectrum in the future award, because of H3G's already large holdings in this band.³⁶
- 4.40 Any concerns relating to the amount of 3.4 – 3.8 GHz spectrum held by H3G will be considered as part of our competition assessment in the consultation on the upcoming award. Our assessment of the impact on competition below considers H3G's relative position with and without the variation. We have taken into account operators' existing holdings, which will not change as a result of the variation (apart from H3G's, which will slightly reduce). In our assessment below we explain why we consider that all operators will be able to offer 5G services with their existing holdings. We also set out our view that any advantage H3G holds as a result of its larger contiguous holdings will therefore be in relation to its 5G performance, rather than being able to offer services unavailable to others. We also explain why we consider that the incremental improvement in H3G's performance (in terms of 5G capacity and speeds) resulting from the variation will be too small to have a material impact on competition.
- 4.41 Whilst we consider the ability of other MNOs to acquire spectrum in the forthcoming award is one reason why any advantage H3G does gain from the variation is unlikely to be enduring, it is not the only reason. Technological developments are also likely to be important, including the potential for MNOs to use spectrum bands other than 3.4 – 3.8 GHz to deploy 5G. Moreover, our conclusion does not rely on other operators gaining additional large contiguous blocks of spectrum as a result of the award (or indeed on any other particular outcome obtaining from the award).

³⁵ BT/EE's response to the June 2018 consultation, paragraph 4 and section 3.

³⁶ Telefónica's response to the June 2018 consultation, paragraph 83.

What changes as a result of the variation

4.42 To assess the impact on competition, we must first identify what changes as a result of the variation, and what does not. We therefore first assess the impact of the variation on H3G in terms of performance and services that can be offered, and also consider the impact on other MNOs.

Impact on the other MNOs

4.43 As set out above, consultation responses focused on the potential disadvantage to the other MNOs of not having 80 MHz or 100 MHz of contiguous spectrum in the 3.4 – 3.8 GHz band. The variation would not affect other operators' existing holdings and, indeed, would give them the opportunity to win additional spectrum in this band in the forthcoming award.

4.44 Granting the variation does not result in any absolute change in the position of the other MNOs as regards their ability to win: (i) contiguous spectrum, or (ii) spectrum that is sufficiently close to their existing holdings (in terms of frequency separation) to be able to use a single antenna. To the extent there are disadvantages of having non-contiguous or non-proximate holdings, these will exist with or without the variation.

4.45 The only effect on Telefónica, BT/EE and Vodafone would therefore be in terms of their relative position in the market, to the extent that H3G gains any advantage from the variation.

Impact on H3G

4.46 As UKB requested the variation, we consider that it is likely to provide a net benefit to H3G. In its variation request, UKB argued that the variation would result in certain benefits for H3G:³⁷

- i) H3G's customers would benefit from "fast 5G fixed wireless access services" from [X] and from "fast 5G mobile services" [X].
- ii) H3G estimated that these new services could offer average download speeds of as much as 475Mbit/s in lightly loaded cells.
- iii) H3G would be able to use 3580 – 3680 MHz as a single 100 MHz contiguous block and not have to use carrier aggregation. H3G also highlighted that in the absence of a modification to the technical requirements, any deployment by UKB of the 3.6 – 3.8 GHz spectrum on the same sites as those used for the 3.4 – 3.6 GHz spectrum would potentially leave large gaps in coverage because of the lower power levels in the UKB Licence.
- iv) Allowing phased implementation of the variation will ensure that H3G will be able to maintain its service levels to existing customers.

³⁷ UK Broadband's licence variation request, pages 1, 19, 24, 29 and 30.

4.47 As we have noted, it is important to focus on the particular effects of moving from separate holdings of 84 MHz plus 20 MHz to a single holding of 100 MHz. We consider that H3G could offer fast fixed wireless access (FWA) services and fast 5G services (point (i) above) even with its pre-existing holdings and configuration of spectrum.

4.48 We consider that there are two broad benefits to H3G of the variation:

- one stemming from being able to take advantage of the changes to certain technical conditions earlier than would otherwise be the case; and
- another from the benefits of spectrum contiguity³⁸ and having a block of 100 MHz rather than 84 MHz plus 20 MHz.

4.49 We consider each of these in turn. In terms of the benefits of contiguity, we consider the performance effects of having greater capacity, and the possibility that H3G could offer additional services as a result of the variation.

4.50 We briefly first consider the deployment cost benefits of having spectrum blocks that are close together ('proximity'), which was raised by the other MNOs in their consultation responses.

Proximity of spectrum holdings

4.51 In their responses, Vodafone and Telefónica offered evidence that they would be disadvantaged relative to H3G after the future award. In their view, this is because any spectrum they might win in the 3.6 – 3.8 GHz band may be too far away (in terms of frequency separation) from their current holdings to use a single active antenna system for both blocks.^{39 40}

4.52 The variation does not affect the proximity of the other MNOs' spectrum holdings to the spectrum which will be available in the future award.⁴¹ As such, Telefónica and Vodafone presented an argument for the need to achieve defragmentation in the wider 3.4 – 3.8 GHz band, rather than a reason to refuse the variation.

4.53 We accept that there may be costs where an operator does not have proximity of its spectrum holdings in the 3.6 – 3.8 GHz band, at least in the short term. However, as we say above, it is our view that the variation is not the appropriate vehicle for seeking to achieve further defragmentation of the 3.4 – 3.8 GHz band, and that granting the variation does not in our view make such defragmentation less likely.

The change in technical conditions does not provide H3G with a relative advantage

4.54 As described in Section 2, the requested changes to technical requirements would increase the maximum power for base stations and relax the out of band emissions limits when using the fully synchronised frame structure and using the Permissive mask.

³⁸ This should be distinguished from service contiguity, referred to at point (iv) above.

³⁹ Telefónica's response to the June 2018 consultation, paragraph 45.

⁴⁰ Confidential version of Vodafone's response to the June 2018 consultation, pages 8-9.

⁴¹ Beyond the 9 MHz that will be removed from any potential 'gap' by H3G moving down 5 MHz and giving up 4 MHz.

- 4.55 These changes would likely impact the network that UKB could deploy in this spectrum. H3G noted in its submission for the licence variation that not aligning the maximum power limits in this band with those for the 3.4 GHz licences could result in H3G having holes in its coverage. Without the increase in power, in order to increase coverage H3G might have to build more sites.
- 4.56 As a result of the change in technical conditions, we expect H3G to be able to improve the coverage it can provide using its 3.6 – 3.8 GHz spectrum in areas where cell size is the main constraint on coverage (e.g. medium to low density areas including suburban and rural) earlier than might have been the case. This is subject to any short term constraints arising from the interim coordination requirement with fixed links and satellite earth stations.⁴² This benefit was also noted by UKB in its licence request.⁴³ Some H3G customers may therefore benefit if H3G's ability to provide increased coverage means 5G services are available to them sooner, although we consider that there may be minimal effects on customers during this initial period.
- 4.57 In its response to the consultation BT/EE said that it is not opposed in principle to a future increase in power limits to bring the licence in to alignment with harmonised technical conditions. However, in their view this is relevant to the auction competition assessment and should be considered as part of the overall proposals for the 3.6 – 3.8 GHz award.
- 4.58 As we say at 4.41, we consider that it is appropriate to consider this variation in advance of the competition assessment for the future award. The requested technical requirements are in line with the technical requirements for licensees in the 3.4 – 3.6 GHz band.
- 4.59 We anticipate that the technical conditions that will apply to the spectrum to be awarded in the 3.6 – 3.8 GHz band will be at least as permissive and at equivalent power levels. After the variation H3G is therefore not able to do anything with its spectrum that other MNOs cannot currently do with their 3.4 GHz spectrum or will not be able to do with any 3.6 – 3.8 GHz spectrum that they win in the future award.
- 4.60 We also note that, even if UKB had not requested a variation, we would have proposed to change the technical requirements for UKB's 3.6 – 3.8 GHz spectrum at the same time as those to be awarded in the 3.6 – 3.8 GHz band. As such, any possible benefit to H3G arising from these technical requirement changes is likely to be limited to the period between granting of the variation and the upcoming award, which we expect to take place in early 2020. As we have said, we do not consider that there will be a significant effect on customers during this period.
- 4.61 We note that BT/EE made other comments related to technical conditions, specifically on the implications of the variation for the band edge requirements in existing 3.4 spectrum access licences, and the frame structures which apply across the 3.4 – 3.8 GHz band. As these points relate to other licences in 3.4 – 3.8 GHz band, or future technical

⁴² See paragraph 4.154.

⁴³ UKB licence variation request, page 19.

requirements which are not part of UKB's variation request, we discuss these in Section 5 ('Other considerations').

Benefits of contiguity – improvement in performance

- 4.62 UKB has indicated⁴⁴ that this variation would allow them to use this spectrum to offer a "100 MHz 5G service", rather than using two separate 80 MHz⁴⁵ and 20 MHz carriers.
- 4.63 We understand that it is currently not possible to aggregate carriers in non-contiguous holdings within the 3.4 – 3.8 GHz band (e.g. aggregate two carriers of 80 MHz and 20 MHz as previously held by H3G). Therefore, we have compared the impact of having 100 MHz contiguous spectrum with a counterfactual of two separate 80 MHz and 20 MHz carriers.
- 4.64 Non-contiguous intra-band carrier aggregation, as this type of aggregation is known, is currently available for 4G technology in certain bands. It is not yet specified in the 5G standards for 3.4 – 3.8 GHz and is therefore unlikely to be supported in early 5G devices. Aggregation allows the combination of individual component carriers into a single wider bandwidth carrier and therefore offers the ability to transmit and receive at higher peak data rates.
- 4.65 The other MNOs' consultation responses provided evidence on the benefits of contiguity in general. However, much of the reasoning concerned the disadvantage to other MNOs of not having 80 or 100 MHz of contiguous spectrum themselves. Following the consultation, we engaged in discussions with vendors and mobile operators to gather further information on the particular advantage of combining block of 80 MHz and 20 MHz into a single block of 100 MHz. In annex A1, we set out a summary of the more detailed reasons why the MNOs argued that granting the variation would give H3G a competitive advantage as a result of the contiguity they would achieve.

The variation will give H3G a small to moderate increase in 5G capacity

- 4.66 We agree that there is an advantage to using contiguous spectrum compared to fragmented spectrum. An MNO with contiguous spectrum can achieve a higher spectral efficiency and, therefore, a higher capacity than an MNO with fragmented spectrum. This is because contiguous spectrum requires lower control overheads and fewer guard bands than fragmented spectrum. We find that H3G will benefit from a small to moderate increase in capacity and speeds as a result of operating 100 MHz of its holdings in the 3.4 – 3.8 GHz band as a single contiguous block.
- 4.67 Telefónica and Vodafone observed in their responses^{46/47} that H3G would have a greater network capacity when using a 100 MHz contiguous block when compared with two separate blocks of the same total spectrum. Vodafone reported that its supplier had told it

⁴⁴ UK Broadband's licence variation request, page 1.

⁴⁵ As noted above (footnote 32), the largest carrier that could be used with 84 MHz is 80 MHz.

⁴⁶ Telefónica's response to the June 2018 consultation, paragraph 45.

⁴⁷ Vodafone's response to the June 2018 consultation, page 8.

that the capacity penalty associated with two separate blocks would be in the range of 13 - 17%.

- 4.68 In our further discussions with Telefónica, it assessed the penalty associated with two separate blocks to be 7% - 15%.⁴⁸ We also reviewed the ECC report on defragmentation.⁴⁹ Having taken all of this evidence into account, we consider that a single contiguous block could have a 2 – 18% capacity advantage⁵⁰ when compared with two separate spectrum blocks of the same total spectrum.⁵¹

H3G will be able to offer higher peak and average 5G speeds to customers

- 4.69 We expect that H3G may improve the **peak** speeds it can offer due to using a larger single carrier. In the short term, while non-contiguous intra-band carrier aggregation is not possible, peak speeds will be proportional to the size of the largest single carrier. In this case, the peak speed available from a 100 MHz carrier will be approximately 25% greater than from an 80 MHz carrier.⁵²
- 4.70 In the longer term, it is possible that non-contiguous intra-band carrier aggregation may become available. This would allow higher peak speeds to be achieved with two separate carriers and would mean that H3G could have increased peak speeds even absent the variation. However, we acknowledge that a single contiguous carrier will provide higher peak speeds (c.8 – 18%) than using carrier aggregation over two separate carriers of the same total bandwidth.⁵³ We consider that the variation does, therefore, allow H3G to achieve higher peak speeds but that this difference may reduce to some extent if technological solutions develop (e.g. non-contiguous intra-band carrier aggregation).
- 4.71 The 2 – 18% gain in H3G's capacity discussed at 4.68 will also allow it to offer higher **average** speeds in heavily loaded cells, at busy times. Average speeds could be between 2 and 18% higher in these circumstances, compared to what they would have been had H3G used two separate carriers. It is worth noting that this benefit from using a single carrier will not be experienced by H3G's 5G customers as an increase in speeds as such. Rather, it will be experienced as a slower degradation in consumers' quality of experience than

⁴⁸ Email from Telefónica to Ofcom dated 6 September 2018.

⁴⁹ "Guidance on defragmentation of the frequency band 3400-3800 MHz", ECC Report 287, 26 October 2018, <https://www.ecodocdb.dk/document/7245>

⁵⁰ A 7 to 15% capacity *penalty* (as suggested by Telefónica) when considering 80 + 20 MHz instead of 100 MHz translates to roughly an 8 to 18% capacity *increase* when considering 100 MHz instead of 80 + 20 MHz.

⁵¹ The 2 – 18% range considers several scenarios when operating a single contiguous 100 MHz carrier instead of separate 80 and 20 MHz carriers. The lower end of this range considers the gain associated with fewer guard bands only. The middle of this range also accounts for the typical gains associated with not having to use non-contiguous intra-band carrier aggregation or load balancing in a heavily loaded network. The higher end of this range is based on the maximum gain associated with contiguity as reported to us in further discussions with Vodafone and Telefónica.

⁵² It is not exactly 25% because of small differences in spectrum utilisation and protocol overheads between 5G NR using an 80 MHz carrier and a 100 MHz carrier.

⁵³ This range considers the typical gains associated with not having to use intra-band carrier aggregation in a heavily loaded cell. The penalty might be slightly higher than this for some consumer handsets if single-user MIMO (SU-MIMO) is only available for a limited number of component carriers when aggregating carriers. However, this penalty might be small if we did not grant the variation to H3G because handsets could use SU-MIMO for the 80 MHz carrier with no SU-MIMO for the 20 MHz carrier and so will still derive most of the benefit from SU-MIMO overall.

would otherwise be the case as H3G's 5G network becomes more heavily loaded. For example, they will experience less buffering or higher picture quality when streaming video.

- 4.72 In lightly loaded cells, H3G could serve 5G users with speeds approaching peak speeds.⁵⁴ As set out at paragraph 4.71, the peak speed available from a 100 MHz carrier will be approximately 25% greater than from an 80 MHz carrier. This will be experienced by only a very small number of users, perhaps during the period when there is low device penetration or in lower traffic areas in the longer term.
- 4.73 As a result of this capacity increase, we therefore expect H3G to be able to offer small to moderately higher average and peak speeds *when using this block of spectrum* than without the variation.

MNOs' responses on performance advantages

- 4.74 Vodafone argued that H3G could launch 5G services before others have access to the 3.6 – 3.8 GHz band. H3G “uniquely will have a 100 MHz block of spectrum which could allow it to launch headline 5G services”.⁵⁵
- 4.75 Much of the advantage that Vodafone refers to here is to do with differences in current holdings rather than a reason to refuse the variation. The other MNOs will have the opportunity to win spectrum in the 3.6 – 3.8 GHz band in the forthcoming award. As we discuss below, H3G will only realise limited benefits from the variation in the short term, until 5G handsets are widely available. To the extent that it is an argument that fragmented holdings will not be as valuable as contiguous spectrum, this is an argument for the benefits of wider defragmentation of the 3.4 – 3.8 GHz band. As we have already said, we do not think that this variation makes defragmentation less likely.
- 4.76 Telefónica argued that H3G “would be the only operator able to exploit fully the benefits (speed, capacity and latency) associated with 5G and supporting network infrastructure, such as higher order MIMO, available from 2019.”⁵⁶
- 4.77 We have considered whether H3G would have an advantage in terms of low latency services. In further discussions, Telefónica told us that latency was related to capacity and that it saw a latency of [X] in lightly loaded LTE cells, but this increased to [Y] for more heavily loaded LTE cells.⁵⁷
- 4.78 We consider that it is unlikely that a 100 MHz carrier would have a significantly improved latency performance over an 80 MHz carrier. We acknowledge that heavy cell loading can increase network latency and that this can be relieved by higher capacity. However, we consider that the capacity increase will be small to moderate, as discussed above, and that cells are unlikely to be heavily loaded in the first few years of 5G. Therefore, this increased

⁵⁴ Absent any other constraints such as the speed and capacity of backhaul.

⁵⁵ Vodafone's response to the June 2018 consultation, pages 6 – 7.

⁵⁶ Telefónica's response to the June 2018 consultation, paragraph 30.

⁵⁷ Email from Telefónica to Ofcom dated 6 September 2018.

capacity is unlikely to impact the latency experienced by consumers during this period. In any case, total latency will depend on several factors other than carrier bandwidth, including frame structure, frame synchronisation,⁵⁸ network loading and core network latency, which may well outweigh the performance advantage from a block of 100 MHz compared to 80 MHz.

Benefits of contiguity – H3G's ability to offer certain services

- 4.79 We do not believe the variation is likely to allow H3G to introduce any particular services which it otherwise would not be able to.
- 4.80 In our March 2018 document 'Enabling 5G in the UK',⁵⁹ we grouped the types of services and applications 5G is likely to support into three broad categories or usage scenarios: enhanced mobile broadband, massive machine type communications and ultra-reliable low-latency communications.
- a) Enhanced Mobile Broadband (eMBB): The evolution of 4G networks will support faster speeds, more capacity and a better quality of experience. 5G is expected to provide additional capacity to mobile users at lower costs.
 - b) Massive machine type communications (mMTC) or Internet of Things (IoT): Consumers are already taking advantage of some IoT devices, especially in the areas of smart homes and wearable technology such as fitness and health devices. Until 5G becomes available, the evolution of 4G and other wireless technologies will likely be capable of addressing much of the growing demand for IoT devices over the next few years. 5G may therefore initially play a limited role in the development of IoT. But future 5G evolutions are likely to target IoT, offering capacity for many more devices than other wireless technologies, as well as improved battery life and innovative capabilities, such as instant response communications.
 - c) Ultra-reliable low-latency communications (URLLC): 5G may also lead to the development of new applications given its very low latency capabilities. This is particularly the case when used in conjunction with other technologies such as robotics, automation, machine learning and artificial intelligence.
- 4.81 In addition to the three categories highlighted above, 5G technologies are likely to be an enabler of enhanced FWA services. UKB already offers FWA services via their Relish product. At present this is targeting urban areas (in London and Swindon) and uses LTE technology.
- 4.82 Some indication of what 5G services may consist of, and how they may be delivered, is set out in Recommendation ITU-R M.2083.⁶⁰ This Recommendation establishes the vision for

⁵⁸ The draft ECC report on synchronisation in 3.4 – 3.8 GHz is currently being consulted on and contains information on the latency associated with several candidate 5G NR frame structures.

⁵⁹ Ofcom, March 2018. Enabling 5G in the UK, Discussion document.

https://www.ofcom.org.uk/data/assets/pdf_file/0022/111883/enabling-5g-uk.pdf

⁶⁰ IMT-2020 Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond

<https://www.itu.int/rec/R-REC-M.2083-0-201509-l/en>

IMT-2020, by describing potential user and application trends, growth in traffic, technological trends and spectrum implications, and by providing guidelines on the framework and the capabilities for IMT-2020 (IMT-2020 is what the ITU generally refers to as 5G). The development of new services and use cases beyond eMBB is still fairly speculative, however, particularly as regards low latency services. There is uncertainty both in terms of what they might consist of and what demand would be for such services. 5G services, at least initially, are therefore likely to focus on eMBB and represent an improvement on 4G rather than a step change. As indicated above, FWA is also a service that can be delivered using 5G technology.

- 4.83 In the short term, operators may need to use their existing LTE networks to support early deployments of 5G NR in a Non-Standalone mode. This enables an MNO with an existing LTE network to support early deployments of 5G without the need to upgrade the core network infrastructure. In this case, the quality of 5G services will depend on the quality of both the LTE and 5G NR networks operated by MNOs.⁶¹
- 4.84 We consider that early 5G services (including FWA) are unlikely to require the maximum speeds that a 100 MHz carrier can provide, at least initially, as Telefónica recognised.⁶² With regard to 5G services more widely, it is worth noting that the ECC report on defragmentation in the 3.4 – 3.8 GHz band says that industry has said that 5G networks may ideally make use of 80 to 100 MHz of contiguous spectrum (i.e. 100 MHz is not seen to be different from 80 MHz in terms of services that can be offered).⁶³ Especially for a network that is used to simultaneously provide both FWA and mobile broadband services, the additional small to moderate capacity increase that a 100 MHz carrier brings (as opposed to 80 MHz plus 20 MHz carriers) is going to be beneficial. However, as UKB's current Relish network is not heavily loaded⁶⁴ and it is limited in its geographical extent, it is unlikely that the small to moderate capacity gain will significantly alter its ability to serve FWA customers in the short to medium term. Of far greater significance for H3G will be the switch to 5G NR. Even without the variation they will be able to deploy a single 80 MHz 5G NR carrier instead of multiple 20 MHz LTE carriers.
- 4.85 Report ITU-R M.2410 sets out the minimum requirements related to technical performance for IMT-2020 radio interface(s).⁶⁵ This report specifies the aggregate bandwidth capability of IMT-2020 radio interface(s) for the purpose of evaluating candidate IMT-2020 standards of at least 100 MHz (in spectrum bands below 6 GHz).

⁶¹ While 4G standards (LTE) are still evolving, standardisation of 5G is underway in 3GPP. The first technical 5G standard, 3GPP Release 15 comes in two versions, Standalone and Non-Standalone (published in June 2018). The Non-Standalone version of Release 15 specifies how to use 5G NR carriers with an LTE access and core network, using a technique called *Dual Connectivity*. This is expected to ease the transition towards 5G but may not be the preferred option for all operators, some of whom may choose to migrate straight into a full Standalone 5G network.

⁶² In its response to the June 2018 consultation (paragraph 97), Telefónica made the following comment: "Ofcom may be correct in its assessment that any short-term advantage for H3G from having a larger contiguous block may be modest, for the following reasons: 1. 5G is still in development and most applications used by consumers do not yet need the high speeds associated with 100 MHz blocks".

⁶³ ECC Report 287, 26 October 2018, <https://www.ecodocdb.dk/document/7245>

⁶⁴ In 2017, Relish had around 17,000 customers. <http://www.threemediacentre.co.uk/news/2017/ukb-completion.aspx>

⁶⁵ <https://www.itu.int/pub/R-REP-M.2410-2017>

However, this aggregated system bandwidth does not need to be a single contiguous carrier but can be made up of individual component carriers in different spectrum bands. It should be stressed that M.2410 only uses 100 MHz for evaluation purposes: it does not say this is a minimum required bandwidth for individual IMT-2020 deployments.

- 4.86 Overall, this evidence suggests that 100 MHz is unlikely to offer capabilities that are significantly different from those that can be obtained with 80 MHz plus 20 MHz. In fact, we are not aware of any 5G services that require a minimum amount of spectrum (at least beyond the 40 to 50 MHz already licensed to the other MNOs in the 3.4 – 3.6 GHz band). The same can be said of FWA services, going from 80 MHz plus 20 MHz to a 100 MHz carrier will not be transformative. Our discussions with vendors suggest 80 to 100 MHz may be optimal for the delivery of 5G services. However, it is our view that these services could be deployed over smaller blocks of spectrum – though, in certain cases, perhaps at a lower quality because greater capacity can offer higher average speeds or lower latency.

Benefits of contiguity – timing of the effect of the variation

- 4.87 The effect of the variation on H3G and its customers is likely to depend on the time horizon being considered.
- 4.88 In the short term, H3G will gain an additional advantage in having larger contiguous spectrum holdings in a pioneer band for 5G. However, the impact on its customers may be very limited over this time frame. For H3G's customers to benefit from the increased capacity and speeds that H3G could provide using a 100 MHz carrier, H3G will need first to roll out its 5G network, which is likely to take some time. Once this has happened, any customer taking up a 5G-enabled handset will then be able to benefit from the increased capacity and higher speeds. In addition, other customers may benefit as those with 5G handsets are moved onto the 3.4 – 3.8 GHz spectrum, freeing up capacity on other bands. Current Relish FWA subscribers will potentially benefit sooner if (as we expect) H3G upgrades their existing UKB sites and sends out new customer premises equipment (CPEs) to its customers.
- 4.89 We note, however, that H3G will need to co-ordinate its deployments in the 3.6 – 3.8 GHz band with satellite earth stations until mid-2020, and that widespread take-up of mobile handsets for the 3.6 – 3.8 GHz band is likely to happen around early 2020 (around 12 months after their initial introduction, which is expected to be early 2019).⁶⁶ To see a noticeable improvement in the capacity of its mobile network more generally, H3G will need its customers to take-up 5G-enabled devices (e.g. its 3G and 4G networks will, in time,

⁶⁶ Regarding introduction and take-up of handsets, see for example: Qualcomm, 2018. Qualcomm Announces the Latest and Smallest Additions in its Family of 5G NR mmWave Antenna Modules. <https://www.qualcomm.com/news/releases/2018/10/22/qualcomm-announces-latest-and-smallest-additions-its-family-5g-nr-mmwave> [Accessed 25 October 2018]; Skyworks, 2018. 5G New Radio Solutions: Revolutionary Applications Here Sooner Than You Think. http://www.skyworksinc.com/downloads/literature/Skyworks-5G%20White-Paper_Part2.pdf [Accessed on 25 October 2018]; 5G.co.uk, 2018. When will we see a 5G iPhone? <https://5g.co.uk/news/when-5g-iphone/4518/> [Accessed on 25 October 2018].

benefit as more user traffic starts to be carried over 5G thus freeing up 3G and 4G resources

- 4.90 In the longer term, take-up of 5G is likely to be more widespread and so H3G and its customers may benefit to a greater extent from the variation. As we have said, there is a great deal of uncertainty about what future 5G services might consist of and we cannot rule out that there may be use cases that may function noticeably better on a 100 MHz carrier than an 80 MHz carrier.
- 4.91 On the other hand, technological developments such as carrier aggregation⁶⁷ may erode some of the benefits of the variation (as they may mean H3G could achieve similar speeds in the future without the variation).

Effect on competition

- 4.92 The 10 MHz effective increase in the amount of usable spectrum in the upcoming award (which is a direct result of granting the variation) is likely to have a beneficial impact on competition. It will have the result that at least one operator will be able to win more 3.6 – 3.8 GHz spectrum than they would absent the variation, and therefore offer a larger volume, lower cost or better quality mobile broadband service than it otherwise would, benefiting consumers.
- 4.93 We have also assessed the potential for the variation to lead to a distortion of competition to the detriment of consumers, against which we would need to balance the benefits to consumers.
- 4.94 In assessing the effect on competition, it is important to separate these two points:
- a) what H3G can do with its existing holdings that other MNOs may not be able to do if they do not obtain 80 to 100 MHz of contiguous spectrum in the 3.4 – 3.8 GHz band; and
 - b) what H3G can do as a result of the variation that it could not otherwise do, e.g. what is enabled by having 100 MHz of contiguous spectrum as opposed to separate 20 and 84 MHz blocks.
- 4.95 The former is not affected by the variation as the variation does not increase H3G's current holdings. Nonetheless we do discuss H3G's potentially advantageous starting point below (in the context of whether the variation may represent a tipping point or first-mover advantage).
- 4.96 We now discuss the effect on competition of the latter – the effect of the variation itself.

H3G will not be able to provide any services that it could not already provide

- 4.97 We have seen no evidence that there are any specific services that can only be offered with 100 MHz that could not also be offered with 80 MHz. We therefore do not consider

⁶⁷ We specifically mean non-contiguous intra-band carrier aggregation within 3.4 – 3.8 GHz or dual connectivity / inter-band carrier aggregation with carriers in operators' other mobile spectrum.

that the variation will have a material effect on competition in terms of services that can be offered as a result. In general, we expect that there might be a performance improvement in terms of capacity and speeds from having a larger contiguous block of spectrum, as we have already said, but it is unlikely that additional services can be brought into play.

4.98 Vodafone argued that carrier aggregation of LTE services would not “have the halo effect of being branded 5G”.⁶⁸ We disagree, as all UK MNOs have announced the trial and launch of what they are branding as “5G” services from next year, using their current spectrum holdings:

- BT/EE has announced plans to launch 5G in 16 cities in 2019, starting with London, Cardiff, Edinburgh, Belfast, Birmingham and Manchester.⁶⁹ BT/EE is currently trialling a number of 5G sites in East London.⁷⁰
- In April 2018 Telefónica published a document on the benefits 5G deployment will bring to the UK,⁷¹ and in November launched a trial of Massive MIMO technology in Kings Cross and Marble Arch using its 2.3 GHz spectrum.⁷² It has also announced plans to launch a 5G test bed at the O2 venue in London later this year.⁷³
- Vodafone has switched on a 5G trial in Salford, Greater Manchester⁷⁴, with plans to commence 5G trials soon in a further six cities before the end of the year.⁷⁵ In September, it used 5G technology to conduct a live holographic call. Vodafone has also outlined plans to have 1,000 5G sites by 2020.⁷⁶

4.99 It is also not clear that H3G will benefit significantly from the variation prior to other operators obtaining access to spectrum in the 3.6 – 3.8 GHz band. As we have said above (paragraph 4.88), it is likely to take time for H3G to roll out its 5G network and we consider that it will be 2020 before compatible handsets are widespread. Moreover, even if H3G is able to offer some 5G services ahead of other operators as a result of its large contiguous holdings in the 3.4 – 3.8 GHz bands, it could have done that using the 84 MHz it already held even without the variation.

4.100 Given the considerable uncertainty about the future development of 5G, in terms of technological capabilities, use cases and consumer demand, it might be useful to consider a ‘worst-case scenario’ for the competition effects of the variation. We have considered the circumstances under which an increase from 80 MHz to 100 MHz of contiguous spectrum might produce a significant harm to competition in terms of new services. Such an outcome would require a number of factors to hold:

⁶⁸ Vodafone’s response to the June 2018 consultation, page 7.

⁶⁹ <https://newsroom.ee.co.uk/ee-announces-5g-launch-locations-for-2019/>

⁷⁰ <https://newsroom.ee.co.uk/ee-switches-on-5g-trial-sites-in-east-london/>

⁷¹ <https://d10wc7q7re41fz.cloudfront.net/wp-content/uploads/2018/03/Smart-Cities-Report.pdf>

⁷² <https://news.o2.co.uk/press-release/o2-launches-pilot-to-boost-london-network-ahead-of-5g/>

⁷³ <https://news.o2.co.uk/press-release/o2-launch-5g-test-bed-o2/>

⁷⁴ <https://mediacentre.vodafone.co.uk/news/vodafone-first-full-5g-in-the-uk/>

⁷⁵ <https://mediacentre.vodafone.co.uk/pressrelease/5g-trial-seven-cities/>

⁷⁶ <https://mediacentre.vodafone.co.uk/news/vodafone-makes-uks-first-holographic-call-using-5g/>

- that there was a service that could only be offered with 100 MHz of contiguous spectrum in the 3.4 – 3.8 GHz band and could not be offered with another combination of spectrum holdings;
- that this was a mainstream service that was required by the majority of consumers; and
- that no other MNO had obtained 100 MHz of contiguous spectrum.

4.101 We do not consider this outcome is very likely. Even if a new service, of which we are not currently aware, were to become possible as a result of the variation, it is unlikely to be so important to customers that it becomes a fundamental driver of competition. We note, in particular, that MNOs compete across a number of dimensions, and the services which are currently important to consumers are likely to remain so for some time. We consider that it would be unlikely that there would be a service that could only be offered with 100 MHz of contiguous spectrum in the 3.4 – 3.8 GHz band and that, because all of the other MNOs have additional spectrum beyond the 3.4 – 3.8 GHz band, they would be likely to be able to find another way to supply it if it became business critical to do so.

4.102 In conclusion, while there is currently considerable uncertainty about 5G services and use cases, aligning two spectrum blocks into one larger contiguous block might result in an increase in the capacity and speeds that H3G could provide and allow H3G greater future flexibility relative to its current holdings. We are, however, unaware of any specific examples of services that are critically dependent on contiguous 100 MHz carriers that would not also work on an 80 MHz carrier.

4.103 However, we do not consider it appropriate to forego the benefits of the variation for such a speculative theory of harm which we consider is unlikely to arise.

A moderate advantage could in theory be concerning when enhancing an existing advantage

4.104 We acknowledge that there may be circumstances where even a minor incremental advantage may be a cause for concern. For example, if a small increase in capacity were to enable a noticeable step change in service quality or the range of services offered by a market participant who already has a significant competitive advantage. In this case, a small additional gain may be a tipping point into an unmatchable and enduring advantage.

4.105 We do not believe that this variation is likely to represent a tipping point. H3G does not currently hold a significant advantage over other mobile operators when competing for customers. Instead, as we discuss in more detail below, it has the lowest retail share by some margin and evidence on its performance in relation to customer satisfaction does not suggest it currently holds a significant advantage.⁷⁷ Although H3G is likely to have some advantage in the provision of 5G services due to its large contiguous holdings in the 3.4 – 3.8 GHz bands, we have not found any services that H3G could introduce as a result of the

⁷⁷ We recently looked at whether the mobile market was working well for consumers in the context of the PSSR statement, and concluded that it was. This review did not find any evidence to suggest H3G held a significant advantage over other operators when competing for mobile customers. See <https://www.ofcom.org.uk/consultations-and-statements/category-1/award-of-the-spectrum-bands>

variation that it could not deliver with its existing holdings. The performance benefits conferred by the variation are, at most, moderate and the effect of it on overall competition in the UK mobile sector is likely to be limited.

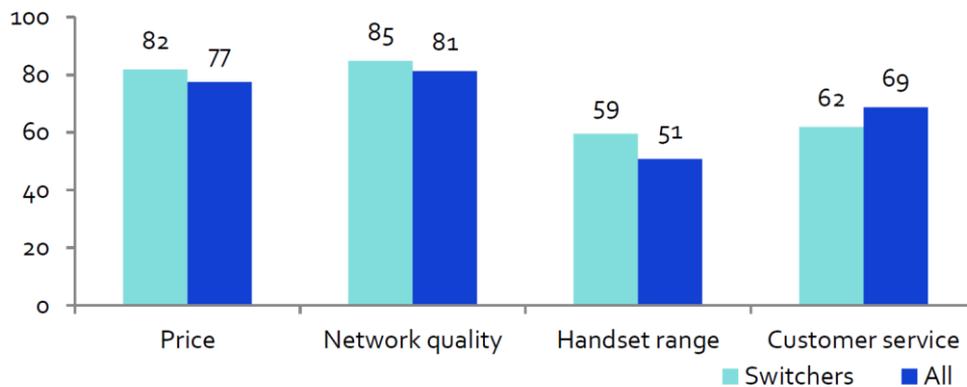
Small to moderate differences in capacity, and peak and average speeds, are unlikely to be major drivers of competition

- 4.106 While H3G may be able to achieve, and advertise, higher peak and average speeds, we do not consider that the increment will materially affect competition. The increment itself is small to moderate, and H3G does not have an existing significant advantage in competing with other MNOs for customers (see discussion below). Not all of H3G's customers will benefit from any improvement in average and peak speeds. The speeds individual users receive will depend on factors other than the amount of spectrum deployed, such as how many other users are demanding data in the cell and whether that user is close to the base station or is at the edge of the cell.
- 4.107 It is also likely to take time for H3G's customers to benefit from these increased speeds, as explained above. By the time they are able to benefit, other operators may have acquired comparable contiguous holdings in the 3.4 – 3.8 GHz band (by winning spectrum in the future award and/or trading). In the longer term other bands may become available for 5G, eroding any relative advantage H3G may gain as a result of the variation. Even if other operators do not catch up, we do not consider the incremental improvement in speeds resulting from the variation to be sufficient to have a material impact on competition.
- 4.108 There are a number of dimensions to retail competition, not all of which depend on spectrum holdings. Speeds and capacity are only one aspect of the competitive offering that will affect customers' choice of mobile operator in the future. Some consumers may value other aspects of their service, such as price, customer service, handset choice, or contract terms.
- 4.109 Most consumers rarely experience peak speeds, and peak speeds may not provide any obvious benefit for most consumers most of the time. For this reason, we do not consider that peak speeds are particularly relevant to competition, although high peak speeds may provide some marketing advantage.⁷⁸ Increased capacity allows an operator to offer higher average speeds in heavily loaded cells, and may mean a slower degradation in consumers' quality of experience than would otherwise be the case as H3G's 5G network becomes more heavily loaded. For example, they will experience less buffering or higher picture quality when streaming video. However, evidence suggests that a moderate difference in the average speeds offered by one MNO would not significantly affect the competitive landscape.

⁷⁸ Ofcom, July 2017. *Award of the 2.3 and 3.4 GHz spectrum bands: Annexes to the statement*, paragraph A2.34. 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

4.110 For example, research by Enders⁷⁹ shows that customers value price almost as much as “network quality” when choosing a network. Customer service and handset range are also important.

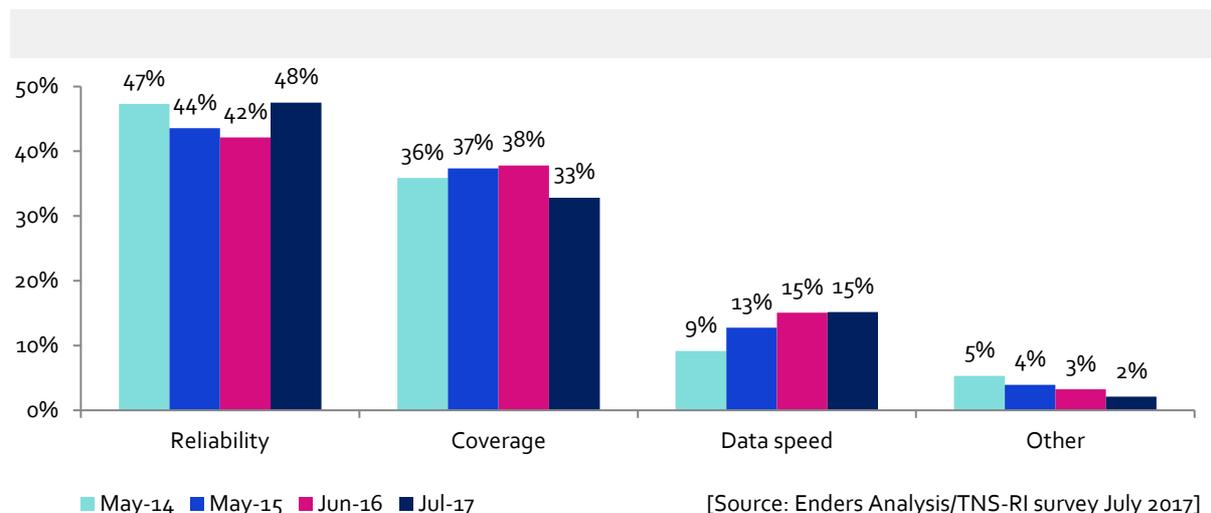
Figure 2: Enders Analysis’ assessment of factors that are important when choosing a mobile provider



Base: Mobile phone owners 16+; switchers comprise the subset of users that switched operators in the 24 months to July 2017
 Figures rebased from scale where 1 = not at all important and 5 = most important
 [Source: Enders Analysis/TNS-RI survey July 2017]

4.111 Network quality is a broad concept, covering aspects such as reliability, coverage, download and upload speeds, latency, webpage browsing times, call quality and call success rates. In terms of what network quality means to customers, evidence suggests that data speeds are not the most important factor in choosing a provider. For example, Enders Analysis has shown that customers value reliability and coverage much more highly than data speeds (Figure 3 below).

⁷⁹ <http://www.endersanalysis.com/publications?date%5Bvalue%5D%5Bdate%5D=&title=covert+growth+in+mobile> published in 2018 based on 2017 survey.

Figure 3: Most important factor in the quality of a network for respondents

- 4.112 Global Wireless Solutions⁸⁰ also reports that, when asked to consider the five most important factors for choosing a network, respondents were twice as likely to identify reliability than network speed. According to the survey, the most important phone functions for UK adults are making calls (69%), texting (53%) and browsing the internet (43%), while only 3% of UK adults listed watching videos as a top priority, suggesting that less data intensive services are currently more important to consumers. Higher 5G speeds are likely to only make a difference when using data-intensive applications such as streaming HD videos (or possible future services that do not yet exist), rather than for phone functions such as making calls, texting or browsing the internet, which are currently more important.
- 4.113 In addition, video quality – which affects the customer experience – is not only dependent on data speeds. For example, OpenSignal has published a ‘State of Mobile Video’ report,⁸¹ which analyses how consumers experience video over mobile networks in 69 countries around the world, awarding each country a video experience score. These scores account for performance in picture quality, video loading time and stall rate. The results of the analysis show that high speeds do not necessarily equate to a good video experience. For example, South Korea had the highest overall download speed which was over 5Mbit/s ahead of its closest rival, but it only achieved 16th place in the overall video experience analysis. Czech Republic was rated as the top country for video experience but was not in the top ten countries for overall download speed.
- 4.114 In the UK, each MNO achieved a score within OpenSignal’s ‘Good’ category. ‘Good’ and ‘Fair’ categories are characterised by sluggish video load times, stops and stutters mid-stream being common to varying degrees, and connections often having trouble coping with higher-resolution formats. The scores of the four MNOs were fairly similar, with H3G

⁸⁰ <http://news.gwsolutions.com/2018/04/24/poor-signal-drives-half-a-million-millennials-to-throw-their-phones-in-anger/>

⁸¹ OpenSignal The State of Mobile Video report, measurements took place during the period from May – August 2018. <https://opensignal.com/reports/2018/09/state-of-mobile-video>

scoring lowest.⁸² Vodafone achieved the highest score of 62.21 out of 100, followed by BT/EE on 62.15, Telefónica (O2) on 58.45 and H3G (Three) on 56.31.

We must consider competition in the round across all dimensions

- 4.115 The strength of competition between the four MNOs depends on multiple factors and it is unlikely that H3G gaining a moderate additional advantage in its 5G capacity and average and peak speeds could significantly affect the dynamics of competition for mobile services in the UK.
- 4.116 While network quality is important to customers, this is dependent on factors in addition to spectrum holdings. It is important to stress that overall network performance and the quality of service that is perceived by customers is a function of many parameters, including the overall spectrum holdings, network investment and network topology. Differences in these spectrum holdings will not simply be offset by an operator being able to join up two separate parts of its existing spectrum holdings.
- 4.117 We consider that each MNO has different strengths and weaknesses, some of which are a result of their portfolio of spectrum. While H3G has a large amount of spectrum in the 3.4 – 3.8 GHz band, including 84 MHz of contiguous spectrum, it has very small holdings of low frequency spectrum (which is particularly well suited to coverage) and the lowest share of currently useable spectrum (14%).⁸³ The other MNOs, therefore, all have larger overall spectrum holdings until the 3.4 – 3.8 GHz spectrum is useable.
- 4.118 Available evidence on H3G’s position in the retail market is mixed, but there is nothing to suggest it currently holds a significant advantage. Ofcom’s Customer Satisfaction Tracker survey 2018⁸⁴ found that customer satisfaction with H3G was lower than for BT/EE and Telefonica and just above that for Vodafone.

Table 2: Customer satisfaction with mobile providers

	Average mobile	BT/EE	giffgaff	Telefónica	Tesco Mobile	H3G	Virgin Mobile	Vodafone
Satisfaction with overall service	91%	93%	98%	92%	97%	89%	86%	88%

⁸² <https://opensignal.com/blog/2018/10/23/europe-shone-in-our-mobile-video-experience-analysis-but-the-winner-wasnt-who-you-d-expect/>

⁸³ We have not included 3.4 GHz spectrum as currently useable because, as we set out in the Statement for the 2.3 and 3.4 GHz award 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, we consider that this will become available in 2019 when handsets are available.

⁸⁴ Ofcom, May 2018. *Choosing the best broadband, mobile and landline provider: Comparing Service Quality 2017* https://www.ofcom.org.uk/_data/assets/pdf_file/0023/113639/full-report.pdf

	Average mobile	BT/EE	giffgaff	Telefónica	Tesco Mobile	H3G	Virgin Mobile	Vodafone
Satisfaction with reception or signal strength	84%	83%	91%	83%	88%	82%	86%	84%

Source: 2018 Ofcom Customer Satisfaction Tracker

4.119 On the other hand, a Which? Survey found that H3G scored better than the other MNOs in terms of customer satisfaction.⁸⁵

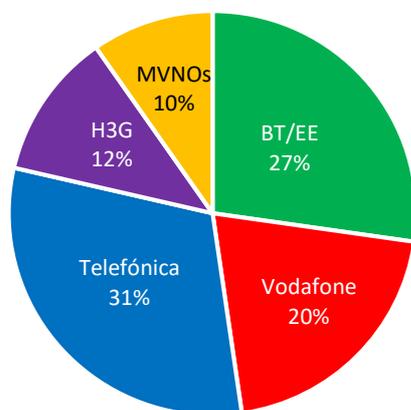
Table 3: Which? Overall customer satisfaction scores, February 2018

	BT/EE	Telefónica	H3G	Vodafone
Customer score	56%	61%	64%	49%

Source: Which?

4.120 H3G currently has the lowest retail market share of all the four MNOs, by some margin. Even if it were to gain customers as a result of this variation, it is unlikely to increase its share by a very significant amount. H3G will only gain a small to moderate incremental advantage in 5G capacity and speeds as a result of the variation and the other dimensions of competition discussed above are likely to remain important to customers.

Figure 4: Retail market shares, December 2017



Source: Enders Analysis⁸⁶

⁸⁵ Which? conducts an annual satisfaction survey of mobile networks, asking almost 3,700 people about a number of aspects of their mobile phone service including customer service, ease of contact and value for money. It also awards each provider an overall customer score by considering how satisfied each person is with their provider and how likely they were to recommend it. In total, 13 MNOs and MVNOs were considered in its most recent survey.

<https://www.which.co.uk/reviews/mobile-phone-providers/article/best-mobile-networks-overview>

⁸⁶ From Enders Analysis report entitled “Covert growth in UK mobile”. Figure 14, page 10.

- 4.121 Vodafone argued that H3G's lower market share in 3G/4G should not distract Ofcom from looking at the impact of the competitive distortion in the market for 5G services. It stated that we imposed a restriction on the 3.4 GHz auction rules as a safeguard to ensure that no operator could acquire a large share of that band and target segments of high data throughput before more spectrum was available, and argued that the variation raises similar concerns.⁸⁷
- 4.122 We have looked at the impact of the variation on competition in the provision of early 5G services.⁸⁸ As set out above, we consider there is likely to be a small to moderate increase in the capacity and speeds of the 5G services that H3G could provide as a result of the variation, but that this incremental advantage is not sufficient to lead to a distortion of competition. We recognise that H3G's current market share is in relation to the provision of 3G/4G services, but still consider this to be a reasonable guide as to how the market is likely to evolve. As we explain above, initial 5G services are likely to depend on the availability of both LTE and 5G NR networks.⁸⁹

The advantage due to the variation will not produce an enduring detriment to competition

- 4.123 Other MNOs also argued that the advantage that H3G would gain would be enduring. Telefónica argued that Ofcom "is wrong to conclude that the variation raises no long-term competition concerns. The variation as proposed would likely lead to a situation where only one operator (H3G) has a contiguous block of spectrum of more than 50 MHz."⁹⁰ Telefónica argued that there were advantages to having larger blocks of spectrum and that it was not clear that other MNOs would be able to replicate the advantages that H3G will have.⁹¹
- 4.124 BT/EE also argued that H3G's advantage would be enduring because the other three MNOs did not have a route at present to 100 MHz of contiguous spectrum and it was unclear whether technological developments would erase the advantages of having such a block.⁹² It said that whether the advantage will be enduring depends 'entirely' on the outcome of the 3.6 GHz award and any subsequent moves to defragment the 3.4 – 3.8 GHz band. Vodafone said there was the potential for H3G to get a monopoly in the provision of ultra-high speed / ultra-high bandwidth services, which would have been created solely by being awarded privileged access to spectrum that was unavailable to its competitors.⁹³ It argued that even if another MNO were to secure 100 MHz of contiguous spectrum, the first mover advantage might persist.⁹⁴

⁸⁷ Vodafone's response to the June 2018 consultation, page 7.

⁸⁸ We principally consider early 5G enhanced mobile broadband services, acknowledging that URLLC and IoT could become important in the longer term.

⁸⁹ When using dual connectivity, both an LTE and a 5G NR carrier are required to deliver a 5G service.

⁹⁰ Telefónica's response to the June 2018 consultation, paragraph 9.

⁹¹ Telefónica's response to the June 2018 consultation, paragraph 98.

⁹² BT/EE's response to the June 2018 consultation, page 7.

⁹³ Vodafone's response to the June 2018 consultation, page 7.

⁹⁴ Vodafone's response to the June 2018 consultation, page 7.

- 4.125 It is possible that the situation might persist in which H3G is the only MNO with a contiguous block of more than 50 MHz. This would depend on the outcome of the future spectrum award and any potential secondary trades or other reassignment of holdings. However, granting this variation does not affect the ability of other MNOs to obtain larger blocks of contiguous spectrum. Indeed, it may even improve their ability to do so as making 120 MHz of contiguous spectrum available for award may allow two other operators to obtain contiguous holdings more easily through a mutual trade. In any event this is, again, an argument that we should have pursued wider defragmentation of the 3.4 – 3.8 GHz band, and we do not consider that the variation request before us from H3G is an appropriate vehicle to do so.
- 4.126 The other MNOs all have 40 MHz or 50 MHz in the 3.4 – 3.6 GHz band. As we said above, Telefónica, BT/EE and Vodafone have already announced plans to launch a 5G service with their current spectrum holdings. The forthcoming award offers them the opportunity to win more spectrum in the 3.6 – 3.8 GHz band, which could reduce the difference between the total spectrum held by others and by H3G in this band.⁹⁵ Indeed, the variation would effectively make an additional 10 MHz of useable spectrum available in the award. Though we do not expect non-contiguous intra-band carrier aggregation to be supported by early 5G devices, it may be supported in the long-term.
- 4.127 We disagree with BT/EE, however, that any advantage H3G gains from the variation will depend entirely on the outcome of the 3.6 GHz award. If none of the other MNOs acquire spectrum in the 3.6 GHz band, H3G may enjoy an enduring advantage in the quality of 5G services it can provide. However, it would have this advantage both with or without the variation as in both scenarios it would continue to be the only operator with more than 50 MHz of contiguous 3.4 – 3.8 GHz spectrum.
- 4.128 It is also possible that the advantage H3G gains from the variation may reduce over time. Technological developments may be such that some advantages of contiguity and proximity are eroded, though we accept this is uncertain. Our current understanding is that dual connectivity will allow inter-band carrier aggregation (i.e. the aggregation of multiple carriers across different spectrum bands) between 4G and 5G carriers that could allow for higher peak speeds.⁹⁶
- 4.129 5G NR Release 15 includes the technical specifications for all legacy 2G/3G/LTE spectrum that Vodafone and BT/EE currently hold⁹⁷ and 5G NR Release 15 part 2 includes the 2.3 GHz

⁹⁵ The amount of spectrum in the 3.6 – 3.8 GHz award means that it is only possible for one company to obtain the same amount of total spectrum in the 3.4 – 3.8 GHz band, or to obtain the same amount of contiguous spectrum in the 3.6 – 3.8 GHz award as H3G holds. However, we do not consider it necessary for providers to hold identical spectrum holdings in order to be effective competitors.

⁹⁶ As an example, dual connectivity will allow for control information to be sent over a 4G channel and for user data to be sent over up to 3x 4G carriers (e.g. 20 MHz each) aggregated with a single 5G channel (e.g. 80 MHz). This could provide a similar throughput to that available from a single 100 MHz 5G NR channel.

⁹⁷ See http://niviuk.free.fr/nr_band.php. All current and future UK Mobile bands below 3.8 GHz were included in Release 15, with the exception of 700 MHz SDL.

spectrum that Telefónica holds.⁹⁸ It is therefore reasonable to expect that, in time, the other MNOs will be able to use many of their existing bands to offer 5G. For this reason, it is not appropriate to assess long-term 5G capabilities while focusing solely on the 3.4 – 3.8 GHz band. We acknowledge that the implementation of 5G NR in other bands may take time, but we also note that other UK MNOs have the ability to influence this process.

- 4.130 We do not consider that granting the variation will result in H3G gaining an enduring first-mover advantage in 5G. In the first instance, it is unclear that H3G will have any first mover advantage in 5G. As noted above, all of the operators already have plans to launch 5G services within a similar timeframe: so H3G will not be the first MNO to be able to market its services as “5G”. It is also not clear H3G will have a significant advantage in the provision of early 5G applications. As we explain above, early 5G services are likely to depend on the availability of both LTE and 5G NR networks and other operators (particularly BT/EE) have more extensive LTE networks than H3G. There is also no reason why any first mover advantage in 5G would be enduring. If another operator acquired 100 MHz contiguous spectrum, there is no reason it could not successfully market any advantages in terms of the 5G service it would then be able to offer to customers. Mobile operators do market upgrades to their networks when they occur and there are no significant barriers to switching at the retail level. In any event, any early advantage that H3G does have over other operators will be predominantly as a result of being the only operator with a large block of contiguous spectrum, which would be the case both with and without the variation. The scale of the advantage conferred by the variation is also unlikely to create a significant distortion to competition.
- 4.131 Telefónica noted in its response that the scale of benefits associated with having a larger contiguous block (such as 100 MHz) for 5G compared to having equivalent but fragmented bandwidth is uncertain, but they stressed the short term technical advantages which other operators will not be able to replicate. Telefónica acknowledged that our analysis reflected this uncertainty but said that we were inconsistent in assessing the implications of the uncertainty. In particular, Telefónica said that our position relied on the assertion that technological developments will erode the advantages of having contiguous spectrum, while such developments remain uncertain.⁹⁹ As we have said, the other MNOs may be able to replicate H3G's advantage, to some extent, in time but our analysis does not rely on this possibility.
- 4.132 In addition, other mobile operators could choose other ways to improve the quality of their networks, which we expect would allow them to reduce the magnitude of any advantage H3G holds to a sufficient extent for any competition concern to be diminished. These include (but are not limited to):
- building more sites (including small cells) to improve coverage and capacity in their networks;

⁹⁸ The fact that the latest version of 3GPP includes 2.3 GHz is a strong indication that Release 16 (due to be published at the end of 2019) may include 2.3 GHz. This would mean that 5G 2.3 GHz could be in handsets from mid-2020 onwards, depending on global demand.

⁹⁹ Telefónica's response to the June 2018 consultation, paragraph 29.

- re-farming their existing spectrum holdings to 5G NR and accessing future mobile bands; and
- investing in new technologies such as massive MIMO.

4.133 The options would, of course, involve additional costs. In the statement for the 2.3 and 3.4 GHz auction, we provided examples where the deployment of small cells had increased capacity in the area of a particular macro cell (around 100% increase).¹⁰⁰ To put the c.2 – 18% capacity increase 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.¹⁰¹ As such we consider that the gain from the variation provides H3G with an incremental advantage rather than having a transformative effect.

4.134 We also do not consider that any technological advantage H3G may have, even if it does persist, would necessarily translate into an enduring harm to competition. The effect on competition will depend on how this advantage will translate into superior services such that customers would switch to H3G, or that the competitive constraint imposed upon H3G by other providers could be lessened, allowing it profitably to raise its prices or reduce the quality of its offering, to the detriment of consumers.

4.135 We do not consider that consumers would be likely to be harmed by this variation. Rather, certain consumers (those of H3G) may experience a slower degradation in their quality of experience than would otherwise be the case as H3G's 5G network becomes more heavily loaded (see 4.71 – 4.72). Customers of other MNOs may also experience benefits, if these MNOs are incentivised to innovate or otherwise improve services to keep up with H3G. Taking competition in the round – considering the MNOs' overall spectrum portfolios, network architecture, brand reputation, pricing strategies and customer base – we do not consider that this variation will give H3G an unmatched or enduring advantage, such that competition for mobile services will be weaker.

4.136 We therefore do not consider the variation is likely to have an adverse impact on competition and thus we have decided to grant the variation.

H3G's incentives for strategic behaviour

4.137 Telefónica argued that if the variation is granted, H3G would be incentivised to: (i) bid strategically in the award to the extent that it is permitted to participate notwithstanding its existing spectrum assets; (ii) challenge any attempt by Ofcom to control such strategic

¹⁰⁰ Paragraph A6.27, Award of the 2.3 and 3.4 GHz spectrum bands: Annexes to the statement, Ofcom, 11 July 2017, https://www.ofcom.org.uk/_data/assets/pdf_file/0013/104305/Statement-annexes-Award-of-the-2.3-and-3.4-GHz-spectrum-bands.pdf.

¹⁰¹ Qualcomm's response to Ofcom Consultation "Award of the 2.3 and 3.4 GHz spectrum bands. Competition issues and auction regulations", Qualcomm, January 2017, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/98131/Qualcomm.pdf
Page 22, "Powered Evolution to 5G", Windsor Place Consulting, October 2018
<https://gsacom.com/paper/5g-powered-evolution/>

behaviour by the imposition of a spectrum cap; and (iii) otherwise engage in strategic litigation with the effect of delaying the award, so as to prolong its advantage in total 5G holdings and delay future payments of AIP based on the award price outcome.¹⁰²

- 4.138 With regards to possible strategic behaviour by H3G, even if contiguity were as important as some of the respondents have argued, H3G already has an advantage based on its existing holdings of 84 MHz of contiguous spectrum and, therefore, any such incentive would already be present, even without the variation.
- 4.139 However, as we have previously noted, the performance improvement (in terms of increased capacity and speeds) that H3G would gain as a result of the variation is moderate and, therefore, we do not believe it is likely to change its behaviour in the award or its incentives to reach agreements with other MNOs.
- 4.140 Furthermore, it is worth noting that the variation could actually increase the number of possible combinations of spectrum in the 3.6 – 3.8 GHz award that could facilitate a future trade without requiring H3G's participation because we will be awarding 120 MHz of contiguous spectrum, rather than separate blocks of 111 MHz and 5 MHz.
- 4.141 As we said above, the function we are exercising here is to decide whether to agree to H3G's variation request on its merits. We do not consider it a useful exercise to speculate as to H3G's future incentives to seek judicial review of our decisions for the future auction, and we do not consider that we should refuse the variation on this basis.

Conclusion on competition effects

- 4.142 We do not consider it likely that any benefit to H3G of gaining access to 100 MHz of contiguous spectrum, as opposed to separate 84 MHz and 20 MHz blocks, would be so significant as to provide H3G with an unmatched and enduring competitive advantage over its competitors. We also consider that the other MNOs will benefit from the increased amount of contiguous spectrum that will be made available in the future award as a result of this variation.

Benefits for citizens and consumers

- 4.143 In general, consumers benefit where services are available earlier, at a higher quality or at a lower price than they would otherwise be. As we said in the June 2018 consultation, we consider that the variation is likely to benefit consumers.
- 4.144 The customers of bidders in the auction will benefit from the increased amount of usable spectrum in the award, which will allow at least one other operator to win more spectrum than it would absent the variation, and therefore offer a larger volume, lower cost or better quality mobile broadband service than it otherwise would.
- 4.145 The nature and extent of the benefit to H3G's mobile and FWA customers from the incremental effects of the variation will depend on the time horizon being considered. We

¹⁰² Telefónica's response to the June 2018 consultation, paragraphs 12 and 26.

note that the scale of the benefit to H3G customers is correlated with the scale of benefits to H3G.

- 4.146 As a result of the change in technical conditions, we expect H3G to be able to improve the coverage it can provide using its 3.6 – 3.8 GHz spectrum earlier than might have been the case. Some H3G customers may therefore benefit if this means 5G services are available to them sooner. However, as we say at 4.60, we anticipate that we would have proposed to change the technical requirements at the same time as those to be awarded in the 3.6 – 3.8 GHz band, even if UKB had not requested a variation. As such, the benefit from the variation is likely to be limited to the period between the variation being granted and the upcoming award, which we expect to take place in the second half of 2019.
- 4.147 As we set out at 4.89, widespread take-up of mobile handsets for the 3.6 – 3.8 GHz band is likely to happen around early 2020 (around 12 months after their initial introduction, which is expected to be early 2019).¹⁰³ In the short term while device penetration is low, the impact of the variation on H3G's mobile customers may be very limited. However, those users that do have 5G handsets may experience higher speeds than they would absent the variation. In lightly loaded cells H3G could serve 5G users with speeds approaching peak speeds and, as set out at paragraph 4.69, peak speed may be 25% higher as a result of the variation. This will be experienced by only a very small number of users.
- 4.148 It is possible that UKB's current FWA customers may benefit relatively early if H3G target the upgrade of the existing UKB sites and replacement CPEs are made available. However, we note that the switch to 5G NR will be of far greater significance than the incremental benefit of the licence variation, as even without the variation H3G would be able to deploy a single 80 MHz NR carrier instead of 4 x 20 MHz LTE carriers.
- 4.149 The variation will give H3G a small to moderate increase in 5G capacity. As we have said, this will result in a commensurate increase in average speeds in heavily loaded cells and may mean a slower degradation in consumers' quality of experience than would be the case without the variation as H3G's 5G network becomes more heavily loaded.¹⁰⁴ Cells are unlikely to be heavily loaded in the first few years of 5G, so this increased capacity is unlikely to impact consumers' experience during this period. However, in the longer term, the additional small to moderate capacity increase that a 100 MHz carrier brings (as opposed to 80 MHz plus 20 MHz carriers) is likely to be beneficial.
- 4.150 More generally, an increase in the capacity and speed of the 5G services that H3G could be able to provide could stimulate a competitive response from other providers in terms of other aspects of their offering, to the benefit of consumers. There is likely to be a

¹⁰³ Regarding introduction and take-up of handsets, see for example: Qualcomm, 2018. Qualcomm Announces the Latest and Smallest Additions in its Family of 5G NR mmWave Antenna Modules. <https://www.qualcomm.com/news/releases/2018/10/22/qualcomm-announces-latest-and-smallest-additions-its-family-5g-nr-mmwave> [Accessed 25 October 2018]; Skyworks, 2018. 5G New Radio Solutions: Revolutionary Applications Here Sooner Than You Think. http://www.skyworksinc.com/downloads/literature/Skyworks-5G%20White-Paper_Part2.pdf [Accessed on 25 October 2018]; 5G.co.uk, 2018. When will we see a 5G iPhone? <https://5g.co.uk/news/when-5g-iphone/4518/> [Accessed on 25 October 2018].

¹⁰⁴ See paragraph 4.71

correlation between the scale of any gain to H3G and the likelihood of a competitive response from other MNOs.

Stakeholder responses

- 4.151 In its response, Telefónica argued that we have failed to consider broader consumer benefits and government objectives. According to Telefónica, without realignment of the 3.4 – 3.8 GHz band, there is a risk that only H3G's subscribers will realise the benefit of larger blocks of contiguous spectrum for 5G. It also said that a situation where only a small proportion of UK mobile users have access to the highest level of 5G services possible is contrary to the Government's objectives to be a leader in 5G and that, "given that there is an alternative, with band realignment, where all networks could have the potential to utilise larger bandwidths, Ofcom's proposal is obviously not in the best interests of UK citizens."¹⁰⁵
- 4.152 As we state in paragraphs 4.10 – 4.29 we do not think the variation makes defragmentation of the band less likely. Therefore, we remain of the view that the variation, considered on its own merits, is likely to result in benefits for citizens and consumers.

Impact on other spectrum users

- 4.153 We have considered the impact of the variation request on other spectrum users (in band and in adjacent bands).¹⁰⁶
- 4.154 UKB shares the band on a first-come-first-served basis with existing fixed links and fixed satellite services (to receive space-to-Earth transmissions), coordinated through Ofcom, and this will continue to be the case after the variation. We will continue to coordinate UKB deployments with registered users, until fixed links and satellite earth stations have vacated the band or earth stations are no longer taken into account for frequency management purposes.¹⁰⁷
- 4.155 In the consultation we set out our provisional view that, whilst there is a potential risk of increased interference to satellite earth station operating under licence exemption, the variation would not degrade the benchmark spectrum quality that existing registered users¹⁰⁸ receive in the 3.6 – 3.8 GHz band.

¹⁰⁵ Telefónica's response to the June 2018 consultation, paragraphs 102 – 104.

¹⁰⁶ At the 3600 MHz boundary, the adjacent user to a varied UKB Licence would be UKB itself. We have therefore not considered the impact on this licensee.

¹⁰⁷ Revocation of all fixed links in the band will take effect by the end of 2022 (although many fixed links will vacate the band by March 2020); authorisations of satellite earth stations in the band will end by June 2020 (and in one case September 2020).

¹⁰⁸ In this document we use the term "registered users" to denote satellite earth station receiver components which appear in Schedule 2 of a Permanent Earth Station licence or Schedule 1 of a grant of Recognised Spectrum Access for Receive Only Earth Stations registered with frequencies in the range 3.6 – 3.8 GHz; and, where relevant, authorised licensed fixed links in this range.

- 4.156 None of the respondents to the consultation commented on the impact on these spectrum users, and our view remains unchanged. Following the granting of the licence variation, we will continue to coordinate new UKB deployments with registered users and will add the new emission mask to the existing coordination tool. Any request to change the technical characteristics of existing deployments will need to be coordinated again.
- 4.157 In future, the adjacent user above 3680 MHz will be whichever operator wins that spectrum in the future 3.6 – 3.8 GHz award. We will consult on the technical conditions for the new 3.6 – 3.8 GHz licences to be awarded in due course.

Stakeholders' comments on grants of new rights

- 4.158 In its consultation response, Telefónica argued that the variation request would constitute an award of new rights to use the 5 MHz of spectrum between 3600 – 3605 MHz (the location to which we would be moving the UKB lower frequency block), which should be subject to Article 7 of the Authorisation Directive.¹⁰⁹ In Telefónica's view, we should therefore use a selection procedure based on objective, transparent, non-discriminatory and proportionate selection criteria which give due weight to the achievement of the objectives set out in Article 8 of the Framework Directive.¹¹⁰
- 4.159 Similarly, Vodafone said that licensing UKB to use the frequencies 3600 – 3605 MHz would mean awarding the rights to use these frequencies, which requires a comprehensive assessment of issues, including the level of demand and the impact on other stakeholders.¹¹¹
- 4.160 We note that on 29 August 2018, an MNO (not H3G) [3<] wrote to us informing us that it was interested in being awarded a licence to use those 5 MHz of spectrum.¹¹²
- 4.161 We do not agree that granting the variation constitutes a grant of new rights as Telefónica and Vodafone argue. Telefónica in particular appears effectively to be arguing that whenever Ofcom is considering changing the frequencies licensed to a licensee, it must first offer those frequencies to any interested party in an open award process. If this was correct in all cases, it would mean that Ofcom was in practical terms unable to exercise its spectrum management functions in an efficient manner.
- 4.162 The Authorisation Directive (article 7 in particular), on which Telefónica relies, contains important provisions which are intended to ensure that Member States (in this case acting through Ofcom) allocate spectrum through fair and open processes.
- 4.163 It is appropriate to consider the question of the grant of new rights to use 3600 – 3605 MHz, and hence the application of the Authorisation Directive, in the context of the requested variation as a whole and the purpose of the legislation. We do not consider that the Authorisation Directive requires that Member States must make each and every

¹⁰⁹ Telefónica's response to the June 2018 consultation, paragraphs 3, 16 – 23.

¹¹⁰ Art. 7(3) of the Authorisation Directive.

¹¹¹ Vodafone's response to the June 2018 consultation, pages 4-5.

¹¹² [3<]

frequency available to all interested parties in all cases. That would be too narrow an interpretation of what the legislation is seeking to achieve, and the rights that it is seeking to protect.

- 4.164 There are certainly occasions in which, in order to grant new rights to use frequencies it is appropriate to make such rights available through a process such as an auction, and to allow the market to decide the allocation of the spectrum. We are proposing to use such a process to award rights to use 80 MHz of spectrum in the 700 MHz and 120 MHz of spectrum in the 3.6 – 3.8 GHz bands.
- 4.165 There are however also situations in which in order to ensure that spectrum (which is a scarce and finite state resource) is efficiently managed and used in the interests of citizens and consumers, it is appropriate for Ofcom to make spectrum management decisions which include changes to the frequencies which are licensed for use.
- 4.166 We have considered whether, in this case, the effect of the variation is such that it amounts to a grant of new rights of use of frequencies which should, in light of the matters which the Authorisation Directive seeks to protect and ensure, be made available to any interested party.
- 4.167 The variation at issue here changes UKB's frequency allocation by effectively swapping the 9 MHz at 3680 – 3689 MHz for the 5 MHz at 3600 – 3605 MHz. We consider that there is no material difference between the frequencies that UKB will be moving from and to, in terms of their technical characteristics and usability.¹¹³ As discussed in more detail above at paragraph 4.32, in its current position the 5 MHz block at 3600 – 3605 MHz is likely to be of limited use to MNOs other than H3G for future mobile services including 5G because of the small amount of bandwidth available. Swapping the frequencies as described above increases by 10 MHz the amount of contiguous spectrum which is usable by all that can be made available in the forthcoming 3.6 – 3.8 GHz award, as: (i) the rights to use 9 MHz of spectrum between 3680 – 3689 MHz will become available for open allocation in the award (i.e. 4 MHz more than would otherwise be available for allocation) and (ii) the 9 MHz are situated contiguously with the 111 MHz that Ofcom is clearing for allocation in the award.
- 4.168 We consider that the safeguards that the Authorisation Directive provides will be met (and its purpose achieved) in this instance when we award new rights of use to 3680 – 3689 MHz in the forthcoming award. As set out above, the frequencies that are released as a result of this variation, which we consider in all material respects to be of the same utility as the 5 MHz of frequencies into which we are moving UKB's spectrum block, will be included in that award, and so will be available for all bidders to bid for.

¹¹³ Both 3600 – 3605 MHz and 3680 – 3689 MHz are currently used for satellite earth station reception. We note that there is one site with registered satellite earth stations receiving in 3600 – 3605 MHz, while there are currently 6 sites with registered satellite earth stations receiving in 3680 – 3689 MHz. However, from June 2020, or in one case September 2020, Ofcom will no longer take registered satellite earth stations with a receive component in the 3.6 – 3.8 GHz band into account for frequency management purposes, and so we do not consider that this is a material difference in the usability of the frequencies.

- 4.169 We have separately considered above whether the 5 MHz in question have any other particular importance to other operators (for example with regard to prospects for defragmentation of the wider 3.4 – 3.8GHz band), and are satisfied that they do not.

5. Other considerations

Timing

- 5.1 BT/EE, Telefónica and Vodafone expressed the view that we should at least delay granting the variation. BT/EE considered that we must defer our decision until we have completed the competition assessment and have consulted and decided on the 3.6 – 3.8 GHz auction design.¹¹⁴ Vodafone had a similar view that this variation should be considered together with the broader approach to the allocation in the band.¹¹⁵ In addition, Vodafone suggested that we should not give effect to the variation “until after the point at which it is not possible for Three to legally challenge the detail of the 3.6GHz auction”.¹¹⁶ Telefónica was concerned that if there is disagreement over the terms of the variation, that has the potential to delay the award of the 3.6 – 3.8 GHz. Telefónica also argued that H3G has the incentive to delay the future award so as to prolong its advantage in total 5G spectrum holdings and delay future payments of AIP based on the auction price outcome.¹¹⁷ H3G and UKB, on the contrary, urged us to grant this variation as soon as practicable, so that the identified benefits of the variation can be realised.
- 5.2 We do not consider delaying the implementation to be appropriate. All the MNOs have the ability to launch 5G services and UKB already has 84 MHz of contiguous spectrum, and we consider that granting this variation does not give H3G an unmatched competitive advantage. We remain of the view that this variation is likely to result in benefits for citizens and consumers and we agree with H3G that we do not want to delay those benefits being realised.

Annual Licence Fees

- 5.3 BT/EE, Telefónica and Vodafone said that Ofcom should provide more clarity on UKB's fees before the variation of the licence is agreed. BT/EE noted that H3G plans to use a 100 MHz carrier that will straddle the boundary between bands, so it is not clear why the fee for 3.6 GHz should differ from 3.4 GHz.¹¹⁸ Although Telefónica agreed that 3.6 GHz award receipts will ultimately be the best benchmark for setting fees for these holdings, both it and Vodafone suggested that Ofcom should not wait until the upcoming award to review fees, as the outcome of the 3.4 GHz award gives a good proxy for the lump sum value of 3.6 GHz.¹¹⁹ Both said that revised fees should be payable from the point at which licence variation occurs; in the event that the 3.6 GHz award yields a materially different value, Vodafone states that the applicable annual licence fees could be varied at that time.¹²⁰

¹¹⁴ BT/EE's response to the June 2018 consultation, page 9.

¹¹⁵ Vodafone's response to the June 2018 consultation, page 5.

¹¹⁶ Vodafone's response to the June 2018 consultation, page 10.

¹¹⁷ Telefónica's response to the June 2018 consultation, paragraph 12.

¹¹⁸ BT/EE's response to the June 2018 consultation, page 7.

¹¹⁹ Telefónica's response to the June 2018 consultation, paragraph 81.

¹²⁰ Vodafone's response to the June 2018 consultation, page 10.

- 5.4 According to Telefónica, delaying the imposition of fees commensurate with the value of spectrum is bad policy in that it is discriminatory, delays the introduction of an increased incentive for H3G to consider trading, and strengthens the incentive on H3G to delay the award as this would delay the date when H3G has to pay full fees.
- 5.5 BT/EE said that the basis on which annual licence fees (ALF) will be set should be clarified before the variation because it could affect bidding in the upcoming award. In its view, if Ofcom takes into account 3.6 GHz award receipts to set fees for UKB's existing spectrum assignments, H3G might have incentive to temper its demand for further 3.6 GHz spectrum, thereby potentially affecting the prices paid and amounts of spectrum that other parties may win.¹²¹
- 5.6 In its response, Telefónica also noted that Ofcom has not yet announced how it will introduce ALF to UKB's legacy holdings in the 3.4 GHz band and that it should do so immediately.¹²²
- 5.7 In 2014 UKB's licence at 3.4 GHz was indefinitely extended. In our October 2014 statement on that licence variation, we said that we expected the bids and prices from the 3.4 GHz auction to inform the ALF for UKB's holdings at 3.4 GHz.¹²³
- 5.8 We will be publishing a consultation on the introduction of annual licence fees in the 3.4 GHz band and revised annual licence fees in the 3.6 GHz band next week.

Spectrum trading and leasing

- 5.9 BT/EE noted that the UKB Licence includes provisions for spectrum leasing, but this is not currently available to other licensees in the adjacent 3.4 GHz band.¹²⁴ BT/EE said that Ofcom might consider a more consistent approach across all spectrum access licences in the 3.4 – 3.8 GHz range since they are, or will become once the 3.6 GHz technical conditions are changed, substantially the same in terms of rights and obligations and since they can all be used to deliver the same services. According to BT/EE, leasing arrangements in spectrum suitable for mobile should be subject to the same ex ante scrutiny as trades.
- 5.10 BT/EE suggested that, before concluding on a possible variation of the UKB Licence, Ofcom should make the licence subject to the Mobile Trading Regulations (which allow Ofcom to do a competition assessment before approving a licence trade) and at the same time address the issue of leasing arrangements (which could have a similar effect from a competition standpoint as a trade).

Spectrum trading

¹²¹ BT/EE's response to the June 2018 consultation, page 7 – 8.

¹²² Telefónica's response to the June 2018 consultation, paragraph 80.

¹²³ Ofcom, October 2014. Variation of UK Broadband's 3.4 GHz Licence, Statement.

<https://www.ofcom.org.uk/consultations-and-statements/category-2/uk-broadband-licence>

¹²⁴ BT/EE's response to the June 2018 consultation, pages 8-9.

5.11 In December 2016,¹²⁵ we proposed to add the 3.6 – 3.8 GHz band to the list of frequencies covered under the Mobile Trading Regulations¹²⁶ and, as a consequence, remove the frequency band 3605 – 3689 MHz from the General Trading Regulations.¹²⁷ These changes, if implemented, would have the effect of making the 3.6 – 3.8 band, including 3605 – 3689 MHz, tradable under the Mobile Trading Regulations, including enabling Ofcom to conduct an assessment of the impact on competition of any transfer of frequencies in that band before deciding on whether to approve that transfer. We received six responses, which are available on our website.¹²⁸ Given the lapse of time since our initial consultation, we currently anticipate that we will re-consult on bringing the 3.6 – 3.8 GHz band under the Mobile Trading Regulations in preparation for the future spectrum award, taking account of the comments to our earlier consultation.

Spectrum leasing

5.12 As set out in our current Trading Guidance Notes,¹²⁹ leasing is a streamlined trading process that is being introduced initially for selected licence classes. A licence-holder may grant leases only if the licence contains the necessary terms and conditions. The UKB Licence allows UKB to grant leases, subject to certain conditions set out in the licence.¹³⁰ We have not yet determined the future conditions for 3.6 – 3.8 GHz licences and we plan to consult on the terms and conditions of these licences as part of our wider consultation on the new award. In our Trading Guidance Notes, we said that we were prepared to allow leasing on all tradable Spectrum Access licences, except those covered by the Mobile Trading Regulations (and the 'DECT guard band'), and set out the process for applying for a licence variation for allowing leasing.¹³¹ We also said that we would keep the position under review and look positively at requests to extend leasing more widely if there is market demand.

5.13 We are not proposing to remove the leasing provisions from the UKB Licence because, as explained below, we have no evidence that these would be distortive to competition and/or harmful to consumers.

5.14 These leasing provisions were originally included in the UKB Licence in 2013 and are currently barely used in the lower frequency block. We have sought information from UKB

¹²⁵ Ofcom, December 2016. Proposed changes to spectrum trading regulations, Consultation.

https://www.ofcom.org.uk/_data/assets/pdf_file/0030/96087/STR-changes.pdf

¹²⁶ The Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011.

¹²⁷ The Wireless Telegraphy (Spectrum Trading) Regulations 2012.

¹²⁸ Responses are available at <https://www.ofcom.org.uk/consultations-and-statements/category-3/changes-to-spectrum-trading-regulations>. In summary: (i) BT/EE suggested that we should amend the UKB Licence to remove the spectrum leasing provisions; (ii) UKB said that the proposed changes were premature as Ofcom had not yet decided to make the remaining frequencies in the 3.6 – 3.8 GHz band available for future mobile services through an award; (iii) Vodafone supported the proposed changes; and (iv) some individual respondents suggested that there should be a spectrum cap on spectrum ownership.

¹²⁹ Ofcom Trading Guidance Notes, https://www.ofcom.org.uk/_data/assets/pdf_file/0029/88337/Trading-guidance-notes.pdf

¹³⁰ See paragraph 7 and Schedule 3 of the UKB Licence (annex A2).

¹³¹ Table 4, section 3 of the Ofcom Trading Guidance Notes,

https://www.ofcom.org.uk/_data/assets/pdf_file/0029/88337/Trading-guidance-notes.pdf

about the leasing contracts currently in place for the frequencies within the 3605 – 3689 MHz band and understand that UKB has entered into leases with two entities for this spectrum and that it intends to serve notice imminently in order to terminate these contracts in 2019.¹³² As discussed above, UK Broadband has said in the variation request that will offer a 100 MHz bandwidth 5G service, with its consumers benefitting from “fast 5G fixed wireless access services” from [3<] and “fast 5G mobile services” [3<]. This is unlikely to be compatible with substantial leasing of spectrum. In general, mobile operators have not substantially considered spectrum leasing in the past. In our 2016 review of spectrum sharing,¹³³ we noted that we would consider extending leasing in bands where it is not currently available if there are likely to be net benefits, including sufficient evidence of demand to lease spectrum. To date we do not have evidence of such demand.

5.15 We also note that, if material issues were to arise in the future with regard to these provisions, we could vary them in accordance with the process set out in Schedule 1 of the 2006 Act (paragraphs 6-7), if we considered it appropriate.

3.4 - 3.8 GHz future technical requirements

5.16 As noted at paragraph 4.57, BT/EE made a number of comments relating to both the changes in technical requirements of the UKB Licence, and the technical requirements of 3.4 – 3.8 GHz licences more generally. We have discussed their comments on the changes to technical requirements of the UKB Licence in Section 4.

5.17 BT/EE said that the variation would render the additional band edge requirement above 3605 MHz contained in paragraph 14 of the schedule in other licences in the 3.4 – 3.6 GHz band unnecessary, since this relates to the possible need for reduced out of block emission levels to protect the UKB use above 3605 MHz. BT/EE also said that, in their view, the frame structure will support, but is not optimised for, 5G NR technology capabilities. BT/EE urged Ofcom to facilitate discussion on this issue and explore with existing licensees how these more optimal 5G technical licence conditions can be applied across the whole 3.4 – 3.8 GHz band.

5.18 We agree with BT/EE that the additional band edge requirement above 3605 MHz contained in paragraph 14 of the schedule in the current 3.4 GHz licences will become obsolete as a result of this variation. We note that the draft CEPT “toolbox” report on synchronisation, which is currently under public consultation by ECC¹³⁴, suggests that there may be throughput and latency advantages to using new frame structures which are optimised for 5G NR rather than the frame structures currently in the 3.4 GHz licences which might be more suitable for LTE. This will be discussed in more detail in our consultation on the award of 3.6 – 3.8 GHz spectrum. We anticipate that we will initiate discussions with the MNOs about the appropriate frame structure(s) for 5G in the wider

¹³² H3G response to formal information request, dated 18 October 2018.

¹³³ Ofcom. 2016, *A framework for spectrum sharing*, statement https://www.ofcom.org.uk/data/assets/pdf_file/0028/68239/statement.pdf

¹³⁴ Draft ECC Report 296 National synchronisation regulatory framework options in 3400-3800 MHz: a toolbox for coexistence of MFCNs in synchronised, unsynchronised and semi-synchronised operation in 3400-3800 MHz.

3.4 – 3.8 GHz band in the near future. In any case, in line with our normal processes, we would consider any variation to the 3.4 GHz licences at an appropriate time and at the request of licensees.

6. Conclusions

- 6.1 We have decided to grant the variation, with immediate effect.
- 6.2 We consider that the variation is:
- **Objectively justifiable** as it will enable us to release 4 MHz of spectrum from 3685 – 3689 MHz, as well as to relocate 5 MHz of spectrum from 3680 – 3685 MHz. This variation will increase the amount of contiguous spectrum available in the future award from 111 MHz to 120 MHz.
 - **Non-discriminatory** as we have considered this variation request on the same basis as we would any other variation request, and any participant in the future award will have the opportunity to win the additional usable spectrum that will be available in the award, subject to any competition measures or other relevant award rules we may decide to put in place.
 - **Proportionate** since the changes are the minimum necessary to achieve a more efficient allocation of spectrum in a timely manner, and do not give rise to disproportionate effects.
 - **Transparent** as the changes that we have decided to make are clear on the face of the varied licence, and we have set out our reasoning in this document.
- 6.3 We have today issued UKB with a varied licence, with all the amendments coming into force today. A copy of the varied licence is set out in Annex A2.
- 6.4 As described at paragraph 1.3, UKB requested a transitional period during which they would continue to be authorised to use 3605 – 3689 MHz under their existing technical requirements, whilst also being authorised to deploy 3600 – 3680 MHz under the new technical requirements. They requested that this period end from the later of 1 September 2019 or nine months from the date of the licence being varied. As the licence has been varied effective today, this transitional period will come to an end on 14 September 2019.

A1. Assessment of further comments made in response to the June 2018 consultation

- A1.1 We received five responses to the June 2018 consultation (BT/EE, H3G, Telefónica, Vodafone and Nominet) and published all non-confidential responses on our website.
- A1.2 We have addressed the majority of points made by stakeholders in Section 4. This annex addresses some additional points made by stakeholders in response to the consultation.

Comments recommending revocation of the UKB Licence

- A1.3 Telefónica argued that UKB has limited spectrum rights in the 3.6 – 3.8 GHz band and should not be allowed to retain 80 MHz of spectrum in the band, on the following basis:
- the UKB Licence is not for “exclusive use” but is shared with fixed links and satellite earth stations on a first come first served basis;
 - UKB has only deployed across a modest geographic area;
 - in Telefónica’s view, H3G would realise a “large windfall gain” from the variation as it would “convert 80 MHz of its 84 MHz holdings to exclusive use spectrum for mobile use, while other users must vacate the band”;
 - if more spectrum were handed back for the future award, this would allow operators to bid for more spectrum and would likely result in a more efficient distribution of spectrum; and
 - while the policy approach in the UK has been to permit licence holders of spectrum subsequently designated for mobile use to keep the spectrum and use it for mobile, past examples do not necessarily provide a precedent for this case as the band is shared, rather than having been “awarded by auction for exclusive use of the licensee”.¹³⁵
- A1.4 Telefónica said that Ofcom should have consulted on a “full range of clearance options”, including clearing UKB from the band, or only allowing UKB to retain a proportion of its spectrum, as well as the proposed licence variation. In its view, a “pragmatic approach” would have been for us to “require UKB to surrender 44 MHz of spectrum in return for the licence variation to exclusive use”, on the assumption that “a shared use licence of the type granted to UKB is equivalent to owning a proportion of the spectrum, e.g. about 50% of the spectrum”.¹³⁶ If H3G did not consent to surrender 44 MHz, Telefónica suggested that

¹³⁵ Telefónica’s response to the June 2018 consultation, paragraphs 6 and 70 – 73.

¹³⁶ Telefónica’s response to the June 2018 consultation, paragraph 7. Telefónica considered 44 MHz to be the appropriate volume of spectrum to be returned for the following reasons: (i) this would leave H3G with access to 100 MHz which, in its view, is the largest carrier size and the maximum required for 5G “for the foreseeable future”; (ii) 160 MHz could be sold at auction, sufficient for all four operators to potentially acquire 90 – 100 MHz for 5G; (iii) H3G’s claim that it has a superior business case for more than 100 MHz of spectrum could be market tested in the auction. Telefónica also said that H3G is unlikely to be the most efficient user of any spectrum in excess of 100 MHz, and its intrinsic value for holdings above 100 MHz are therefore likely to be smaller than the value to other operators seeking to increase holdings up to 100 MHz. See Telefónica’s response to the June 2018 consultation, paragraphs 78 and 91.

we should revoke UKB's rights to use the 84 MHz authorised under the UKB Licence (i.e. 3605 – 3689 MHz) on spectrum management grounds by giving 5-years' notice and auction all these frequencies, which would become available for use by the winning bidder(s) once the 5-year notice period has expired.¹³⁷

- A1.5 As we said in paragraph 4.18, any decision to revoke the UKB Licence for reasons related to the management of the radio spectrum would be a separate consideration from this licence variation, given that H3G has not requested the variation that Telefónica is proposing. Nonetheless, we address below the arguments made by Telefónica and set out why we are not minded to revoke the UKB Licence.

The logic for clearance of fixed links does not apply to the UKB Licence

- A1.6 In 2017, Ofcom decided to revoke fixed links licences in the band and vary the licences or grants of satellite earth station users to facilitate the deployment of future mobile services in the 3.6 – 3.8 GHz band across wider areas of the UK. As we set out in our statement, the band is particularly suitable for mobile services including 5G,¹³⁸ and has already been harmonised for mobile and identified as part of the primary band for introducing 5G in Europe by the Radio Spectrum Policy Group (RSPG).

- A1.7 Maintaining the current fixed link and PES licences and grants of RSA in the band would create material constraints on future mobile deployments, including in areas of high demand. Therefore, our view was that the expected benefits of enabling more widespread future mobile services in the band outweigh the costs and impacts for existing satellite earth station and fixed links users.

- A1.8 The UKB Licence does not constrain the rollout of 5G services. The UKB Licence could be used to deliver mobile services (although the requested changes for technical requirements of the licence make it easier to do so) and H3G have confirmed that they plan to roll out 5G services using this spectrum (see paragraph 4.46). We therefore do not think that it is appropriate to revoke this licence based on the precedent of fixed links and satellite earth stations.

Efficient use does not require the revocation of the UKB Licence

- A1.9 As we have noted in section 4, the other MNOs all have 40 MHz or 50 MHz in the 3.4 – 3.6 GHz band. Telefónica, BT/EE and Vodafone have already announced plans to launch a 5G service with their current spectrum holdings.

- A1.10 Moreover, even though we are granting the variation, if another operator values the spectrum more highly than H3G, that operator may be able to obtain the spectrum, by trading with UKB. The UKB Licence is subject to an annual licence fee, and we have said that we will review this fee (pricing is discussed further in 5.3 – 5.8). Spectrum pricing has an important role to play in encouraging the efficient use of spectrum.

¹³⁷ Telefónica's response to the June 2018 consultation, paragraph 77.

¹³⁸ See paragraph 2.18, Improving consumer access to mobile services at 3.6 GHz to 3.8 GHz, Statement, 26 October 2017. https://www.ofcom.org.uk/_data/assets/pdf_file/0019/107371/Consumer-access-3.6-3.8-GHz.pdf

The licence variation itself does not grant greater "exclusivity" to UKB

- A1.11 The UKB Licence does not confer exclusive rights on UKB to use the relevant spectrum and requires it to operate in accordance with any coordination procedure notified by Ofcom. As we set out at paragraph 4.154, we will continue to coordinate UKB deployments with registered users, until fixed links and satellite earth stations have vacated the band or earth stations are no longer taken into account for frequency management purposes.
- A1.12 To the extent that UKB will need to coordinate with fewer spectrum users in future, this is as a result of the decision taken in 2017 to clear the band as described above, rather than a consequence of the licence variation.

Spectrum caps for the forthcoming award

- A1.13 Telefónica argued that Ofcom should not be proposing a licence variation without clarifying Ofcom's views on H3G's potential participation in the 3.6 GHz award. In its view, if the variation is implemented as proposed, H3G would have more spectrum in the core 5G band than any other operator. In these circumstances, it should not be allowed to bid for any more spectrum at 3.4 – 3.8 GHz.
- A1.14 Telefónica requested that Ofcom set a band-specific cap across 3.4 – 3.8 GHz that is not higher than 140 MHz, preferably 120 MHz. In its view, this cap should be introduced alongside the established cap of 37% on usable mobile spectrum. Telefónica argued that a 3.4 – 3.8 GHz band-specific cap is necessary to (i) prevent bidders from exercising strategic value associated with blocking rivals from enhancing their 5G capacity; (ii) promote outcomes in which all four operators are likely to win substantial 5G holdings, and (iii) prevent H3G from threatening to price drive at 3.6 GHz in an attempt to improve its bidding position in other bands (such as 700 MHz).
- A1.15 Granting the variation does not increase the amount of spectrum that is licensed to UKB and H3G in the 3.6 – 3.8 GHz band. We therefore do not think that it is necessary to address the issue of any potential future spectrum cap as part of the assessment of this licence variation. We will consult on proposals for any competition measures that may be required as we prepare for the future award.

Authorisation framework

- A1.16 Nominet encouraged Ofcom to adopt innovative frameworks, such as data-base enabled three-tiered sharing.
- A1.17 The authorisation framework to be adopted in the 3.6 – 3.8 GHz band is not directly relevant to this licence variation. We will consider the future authorisation framework for the band as we prepare for the future award.

Stakeholders' comments on the benefits of contiguity

- A1.18 Below, we summarise the additional reasons why Vodafone and Telefónica argued that granting the variation would give H3G a competitive advantage as a result of the contiguity they would achieve.

Performance of devices

- A1.19 Telefónica argued that devices perform more poorly when using fragmented spectrum because some handset designs might only be able to use 4x4 MIMO for a single component carrier. In Telefónica's view this would imply that an operator with fragmented spectrum will not be able to produce the same speeds for the users even if it has the same amount of spectrum in the band.¹³⁹
- A1.20 We acknowledge that the penalty to peak speeds could be larger than considered above if SU MIMO¹⁴⁰ is only available for a limited number of component carriers when aggregating carriers within a device. However, this penalty might be small if we did not grant the variation to H3G because handsets could use SU MIMO for the 80 MHz carrier with no SU MIMO for the 20 MHz carrier and so will still derive most of the benefit from SU MIMO overall.

Extended mobile device battery life

- A1.21 Telefónica quoted a draft of the ECC 3.4 – 3.8 GHz defragmentation report¹⁴¹ which observes that 5G NR on large bandwidths will “reduce terminal front end complexity and power consumption” compared to LTE using multiple 5 to 20 MHz carrier aggregations to exploit a similar large bandwidth.¹⁴²
- A1.22 It is currently too early to assess the impact of the variation on terminal complexity and power consumption. If we did not grant the variation, then H3G may or may not use carrier aggregation to increase peak speeds as discussed above.

Lower deployment costs

- A1.23 Telefónica said that non-contiguous spectrum assignments in the 3.4 – 3.8 GHz band may require (depending on the frequency separation between carriers) the implementation of several radio units, increasing the costs of network deployment, and for active antenna systems (AAS) in particular. Telefónica said that in some locations, roll-out of active antenna systems on non-contiguous blocks of spectrum may be unfeasible owing to space limitations for the antennas.¹⁴³ Vodafone had a similar view and added that current vendor roadmap suggest that AAS will only support a [∞] frequency span, and that deployments of several AAS may not be possible on some sites due to size and weight constraints.¹⁴⁴
- A1.24 We do not consider that the cost advantage H3G will gain from having one contiguous block of spectrum rather than two separate (but proximate) blocks of spectrum, will be sufficiently material to distort competition. The proximity of H3G's spectrum will not be

¹³⁹ Telefónica response to the June 2018 Consultation, paragraph 45.

¹⁴⁰ Single-user MIMO. This is the version of MIMO which takes advantage of there being more antennas and receive paths in the mobile device.

¹⁴¹ “Guidance on defragmentation of the frequency band 3400-3800 MHz”, ECC Report 287, 26 October 2018, <https://www.ecodocdb.dk/document/7245>

¹⁴² Telefónica response to the June 2018 Consultation, paragraph 41.

¹⁴³ Telefónica response to the June 2018 Consultation, paragraph 45.

¹⁴⁴ Correspondence from Vodafone to Ofcom dated 4 September 2018.

changed significantly by the variation (3460 – 3680 MHz instead of 3460 – 3689 MHz if we did not grant the variation).

A2. Varied licence

Published as a separate document

A3. Glossary

3GPP	The 3rd Generation Partnership Project (3GPP) is a body that develops standards for mobile technology
5G	5G is the term used to describe the next generation of wireless networks beyond 4G LTE mobile networks. 5G is expected to deliver faster data rates and better user experience. Technical standards are still under development and are likely to include both an evolution of existing and new radio technologies.
5G NR	5G NR refers to the new air interface that has been developed by 3GPP for 5G. This defines how 5G base stations and user devices both transmit and receive radio signals using spectrum
CEPT	The European Conference of Postal and Telecommunications Administrations
Communications Act	The Communications Act 2003
DECT guard band	Frequency bands 1781.7 – 1785 MHz paired with 1876.7 – 1880 MHz
EC	European Commission
ECC	Electronic Communications Committee, one of the three business committees of CEPT.
EU	European Union
Fixed wireless access (FWA)	An access service where the connection between the network and the equipment located at the customer premises is provided over the radio access medium
GHz	Gigahertz. A unit of frequency of one billion (10^9) cycles per second
H3G	Hutchison 3G UK, a mobile network operator which trades as Three (or 3) in the UK
IMT-2020	Term used by the International Telecommunications Union to refer to systems generally considered to be 5G.
LTE	Long Term Evolution. Part of the development of 4G mobile systems that started with 2G and 3G networks.
Massive MIMO	Massive MIMO is a high-order MIMO technology typically using a large number of antenna elements at the base station and user terminal. This technology uses spatial multiplexing and beamforming to enhance spectral efficiency and deliver higher throughputs in mobile networks.
MHz	Megahertz. A unit of frequency of one million cycles per second.

Variation of UK Broadband's Spectrum Access Licence for 3.6 GHz spectrum

MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator. An organisation which provides mobile telephony services to its customers but does not have allocation of spectrum or its own wireless network.
Ofcom	The Office of Communications
PES	A satellite Permanent Earth Station
ROES	Receive Only Earth Station. In satellite services, an earth station which does not transmit, but receives signal from a satellite.
RSA	Recognised Spectrum Access. RSA is a regulatory mechanism that provides formal recognition of receive-only radio stations by allowing Ofcom to take them into account when planning spectrum use and assigning frequencies to other radio users.
UKB	UK Broadband. A UK supplier of fixed wireless mobile services, now owned by H3G.
UKB 3.4 – 3.6 GHz Licence	The Spectrum Access Licence authorising UKB to use two non-adjacent blocks of 20 MHz in the 3.4 – 3.6 GHz spectrum band, at 3480 – 3500 MHz and 3580 – 3600 MHz.