Improving consumer access to mobile services at 3.6GHz to 3.8GHz

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STATEMENT:

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About this document

This document confirms Ofcom's intended approach to expanding spectrum access for future mobile services in the 3.6GHz to 3.8GHz band in order to enable citizens and consumers across the UK to benefit from future mobile services including 5G.

We will now commence the statutory process to propose (i) revocation of fixed links licences in the 3.6GHz to 3.8GHz band and (ii) variation of licences and grants of Recognised Spectrum Access (RSA) for satellite earth stations such that Ofcom would no longer take registered satellite earth stations with a receive component in the band into account for frequency management purposes.

Affected licensees and grantholders will have a further opportunity to make representations before we take final decisions on individual licences and grants of RSA.

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1. Executive summary

1.1 In July 2017 we published a Statement and Consultation on improving consumer access to mobile services at 3.6GHz to 3.8GHz (the "July 2017 document").[1] In this we set out our decision to make the 3.6GHz to 3.8GHz band available for mobile use as soon as practicable, and award the remaining 116 MHz in the band for future mobile services.[2]

1.2 We also consulted on our assessment of possible options towards existing registered satellite earth station and fixed link users of the 3.6GHz to 3.8GHz band. We considered two primary options, as well as alternative approaches proposed by stakeholders:

a) **Option A**: to retain existing authorisations for fixed links and satellite earth stations; or

b) **Option B**: to remove current authorisations for fixed links and no longer take registered satellite earth stations with a receive component in the 3.6GHz to 3.8GHz band into account for frequency management purposes.[3]

1.3 To facilitate deploying future mobile services including 5G in the band across the UK, we explained that our preferred approach was option B. We consulted on this proposed approach and also wrote to affected licensees and grantholders to draw the consultation to their attention and explain how, if ultimately adopted, this would affect their licence(s)/grant(s) in the band.

1.4 This statement confirms our intention, having taken into account stakeholders' responses, to follow our proposed approach.

1.5 In accordance with the provisions of the Wireless Telegraphy Act 2006, we will now write to individual licensees and grantholders to propose to revoke or vary their licence(s)/grant(s) as follows:

a) We will propose to revoke current authorisations for fixed links in the 3.6GHz to 3.8GHz band, with a notice period of 5 years; and

b) We will propose to vary existing authorisations for receiving satellite earth stations operating under Permanent Earth Station (PES) licences and grants of Recognised Spectrum Access for Receive Only Earth Stations (RSA for ROES)[4] such that, with effect from 1 June 2020, we would no longer take registered satellite earth stations with a receive component in this band into account for frequency management purposes.

1.6 Affected licensees and grantholders will each have a further opportunity to make representations on our proposals before we reach final decisions in relation to individual licences and grants of RSA in the band. In taking final decisions we will take into account

[1] Ofcom, *Improving consumer access to mobile services at 3.6GHz to 3.8GHz: Statement and Consultation*, July 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0017/103355/3-6-3-8ghz-statement.pdf.
[2] 84 MHz of the 3.6GHz to 3.8GHz band is already authorised for electronic communications services.
[3] These options were previously set out in Ofcom, *Improving consumer access to mobile services at 3.6GHz to 3.8GHz: Consultation*, October 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0035/91997/3-6-3-8ghz-consultation.pdf)
[4] Hereafter referred to as "grants of RSA".

any further information provided on the specific circumstances of each licensee/grantholder.

1.7 We expect to publish a short update in early 2018.

1.8 We intend to deliver the award of the remaining 116 MHz being made available in the 3.6GHz to 3.8GHz band in 2019. We will consult in 2018 to prepare for this award.

2. Introduction

The role of Ofcom

2.1 Ofcom is responsible for managing the radio spectrum. Ofcom's principal duty is to further the interests of citizens and consumers, where appropriate by promoting competition. We are also required, amongst other things, to secure the optimal use for wireless telegraphy of the electro-magnetic spectrum.

2.2 Our direction and spectrum priorities were set out in our 10-year Spectrum Management Strategy in 2014,[5] in which we identified addressing future mobile data demands as a priority, recognising the importance of improving mobile coverage and availability of new mobile services. This work underpinned our Mobile Data Strategy[6] which identified the 3.6GHz to 3.8GHz band as a high priority band for providing additional mobile services.

Legal framework

2.3 The relevant legal framework was set out in our consultation *Improving consumer access to mobile services at 3.6GHz to 3.8GHz* (the "October 2016 consultation")[7] and the subsequent July 2017 document. The full detail is not repeated here. However, we highlight the following aspects:

Principal duties under the Communications Act 2003

2.4 Our principal duties under Section 3 of the Communications Act 2003 ("the Communications Act") are:

a) to further the interests of citizens in relation to communications matters; and

b) to further the interests of consumers in relevant markets, where appropriate, by promoting competition.

2.5 In carrying out our functions, Section 3(2) provides that we are required, amongst other things, to secure the optimal use for wireless telegraphy of the electromagnetic spectrum; the availability throughout the UK of a wide range of electronic communication services; and the availability throughout the UK of a wide range of television and radio services which (taken as a whole) are both of high quality and calculated to appeal to a variety of tastes and interests.

2.6 Section 3(4) requires us, in carrying out our functions, to have regard to certain factors as appear relevant in the circumstances, including the desirability of promoting the fulfilment

[5] Ofcom, *Spectrum management strategy: Ofcom's approach to and priorities for spectrum management over the next ten years*, April 2014, https://www.ofcom.org.uk/consultations-and-statements/category-1/spectrum-management-strategy
[6] Ofcom, *Mobile Data Strategy: Update on our strategy for mobile spectrum*, June 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0033/79584/update-strategy-mobile-spectrum.pdf
[7] Ofcom, *Improving consumer access to mobile services at 3.6GHz to 3.8GHz: Consultation*, October 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0035/91997/3-6-3-8ghz-consultation.pdf

of the purposes of public service television broadcasting in the United Kingdom; the desirability of encouraging investment and innovation in relevant markets; and the desirability of encouraging the availability and use of high speed data transfer services throughout the UK.

2.7 In performing our duty under Section 3 of furthering the interests of consumers, we must have regard, in particular, to the interests of those consumers in respect of choice, price, quality of service and value for money.

2.8 Section 4 requires Ofcom to act in accordance with the six Community requirements, which give effect to the requirements of the Article 8 of the Framework Directive.

Duties under the Wireless Telegraphy Act 2006

2.9 Section 3 of the Wireless Telegraphy Act 2006 ("the WT Act") imposes a number of further duties relating to spectrum management. Amongst other things, in carrying out our spectrum functions, we are required to have regard to the extent to which the spectrum is available for use; and to the demand, both current and future, for the use of the spectrum.

2.10 In carrying out those duties, Section 3(2) requires us to have regard to (amongst other things) the desirability of promoting the efficient management and use of the spectrum; the economic and other benefits that may arise from the use of wireless telegraphy; and the development of innovative services and competition in the provision of electronic communications services.

European Commission decisions relevant to the 3.6GHz to 3.8GHz band

2.11 On 21 May 2008, the European Commission adopted Decision 2008/411/EC ("the EC Decision") which sought to harmonise the conditions for the availability and efficient use of the 3.4GHz to 3.8GHz frequency band for terrestrial systems capable of providing electronic communications services in the EU. In relation to the 3.6GHz to 3.8GHz band, the Decision provided that Member States should designate, by 1 January 2012, the band on a non-exclusive basis for terrestrial communications networks in compliance with the technical parameters set out in the annex to the decision.

2.12 On 2 May 2014, the European Commission adopted Decision 2014/276/EU12, which amended Commission Decision 2008/411/EC, primarily in relation to the technical conditions in compliance with which the band should be made available.[8]

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

The October 2016 consultation

2.13 In the October 2016 consultation[9] we proposed making the spectrum in the 3.6GHz to 3.8GHz band not already assigned for electronic communications services (116 MHz of the 200 MHz) available for future mobile services including 5G.

2.14 Alongside the October 2016 consultation, we published technical analysis showing that coexistence between mobile and existing users of the band would be challenging under current coordination criteria.[10] We therefore set out two policy options on how we could approach coexistence:

- **Option A: retain** existing users' current authorisations under the WT Act to (i) transmit for fixed links, and (ii) receive for satellite earth stations registered under grants of RSA and PES licences within the 3.6GHz to 3.8GHz band – which would mean that future mobile services could only be permitted where these would not be expected to create interference which would degrade benchmark spectrum quality for existing registered users;[11] and
- **Option B: remove** existing users' authorisations under the WT Act to transmit for fixed links and no longer take registered satellite earth stations with a receiver component in the 3.6GHz to 3.8GHz band into account for frequency management purposes – which would allow future mobile roll-out across the UK.

The July 2017 Statement and Consultation

2.15 Having considered responses to the October 2016 consultation and other information provided by stakeholders, in July 2017 we published a statement setting out our decision to make the 3.6GHz to 3.8GHz band available for mobile services (the "July 2017 document").[12]

2.16 This document also set out for consultation our proposed approach to existing authorisations in the band.

Decision to make the 3.6GHz to 3.8GHz band available for future mobile services

2.17 The July 2017 document set out our decision, in accordance with the legal framework set out above including the EC Decision, to make the 3.6GHz to 3.8GHz band available for

[9] Ofcom, *Improving consumer access to mobile services at 3.6GHz to 3.8GHz: Consultation*, October 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0035/91997/3-6-3-8ghz-consultation.pdf
[10] See section 8 and annex 5 of the October 2016 consultation.
[11] In this document we use the term "registered users" to denote satellite earth station receiver components which appear in Schedule 2 of a PES licence or Schedule 1 of a grant of RSA for ROES registered with frequencies in the range 3.6GHz to 3.8GHz; and, where relevant, authorised licensed fixed links in this range.
[12] Ofcom, *Improving consumer access to mobile services at 3.6GHz to 3.8GHz: Statement and Consultation*, July 2017 https://www.ofcom.org.uk/__data/assets/pdf_file/0017/103355/3-6-3-8ghz-statement.pdf.

mobile use as soon as practicable, and to award the remaining 116 MHz in the band for future mobile services.[13]

2.18 We explained that we expected that making the 3.6GHz to 3.8GHz band available for mobile would support meeting increasing consumer demand for mobile data, as well as delivering new and improved mobile services, including future 5G services.[14] We noted that this band is particularly suitable for future mobile services including 5G because:

a) the large bandwidth can support higher data rates and provide increased capacity to support large numbers of connected devices, and enable higher speeds to concurrently connected devices;

b) it can support mobile services including 5G across wide areas, as it can be deployed using macrocells over existing grids; and

c) it 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),[15] with potential for devices to become available as early as 2019-20, and economies of scale for these.

2.19 We therefore concluded that making the band available for mobile would result in greater benefits for UK citizens and consumers, ensure optimal use of the spectrum, and give effect to our duties regarding the promotion of competition and innovation.

2.20 We also noted that the benefits resulting from our decision would be greater the sooner the spectrum can be used for mobile services, and if the spectrum is made available for mobile services in as many areas across the UK as possible.

2.21 As a result of this decision to make the band available for mobile, we closed the band to new applications for fixed link licences, PES licences and grants of RSA for satellite earth stations with a receive component in the 3.6GHz to 3.8GHz band. We also said that we did not expect to approve any variations to existing PES licences or grants of RSA which would add additional frequencies (including associated emissions) within the band.

Proposal to remove fixed link and satellite earth station authorisations in the 3.6GHz to 3.8GHz band

2.22 In the July 2017 document we also consulted on our proposed approach to existing users of the 3.6GHz to 3.8GHz band. The July 2017 document explained that, in order to facilitate deploying future mobile services including 5G in the band across the UK, we proposed to follow option B outlined in the October 2016 consultation - to remove current authorisations for fixed links and no longer take registered satellite earth stations with a

[13] See section 5 of the July 2017 document.
[14] 5G is the next generation of mobile technologies and is being designed to provide greater capacity for wireless networks, offer greater reliability, and deliver extremely fast data speeds, enabling innovative new services across different industry sectors. See further paragraphs 5.21-5.27 of the July 2017 document.
[15] The RSPG is a high-level advisory group that assists the European Commission in the development of radio spectrum policy and is chaired by one of the Member States. The RSPG Opinion which identified the 3.4GHz to 3.8GHz band as the primary band for 5G services in Europe is discussed in paragraph 5.41 of the July 2017 document.

receive component in the 3.6GHz to 3.8GHz band into account for frequency management purposes.

2.23 Key aspects which we considered in reaching this provisional conclusion were:

- current usage of the 3.6GHz to 3.8GHz band;
- coexistence analysis; and
- assessment of costs and benefits of policy options towards existing authorisations.

Current usage of the 3.6GHz to 3.8GHz band

2.24 In the July 2017 document we explained how frequencies in the 3.6GHz to 3.8GHz band are used for fixed links, fixed satellite services (to receive space-to-Earth transmissions) and wireless broadband (provided by UK Broadband).[16] Presently, fixed links, wireless broadband and fixed satellite services share the band on a first come, first served basis, subject to our coordination and technical frequency assignment criteria.[17] Under these criteria, proposed new transmitters are not permitted to use the band if they are expected to undermine benchmark spectrum quality for existing registered users. [18]

2.25 There are currently 26 fixed links in the 3.6GHz to 3.8GHz band, two of which will expire on 28 November 2019. These links are used to convey voice or data traffic wirelessly between specified geographic locations. They support a variety of applications, including connections to broadcasting sites, mobile backhaul, and high frequency trading.

2.26 Satellite earth stations use the 3.6GHz to 3.8GHz band for satellite downlink from geostationary satellites for a number of services, including broadcasting contribution and distribution from overseas, and data communications. The 3.6GHz to 3.8GHz band is part of the wider C-band (3.6GHz to 4.2GHz) which is favoured by the satellite industry in tropical regions because of its relatively low propagation losses and tolerance of high rainfall conditions. The relatively low frequency also allows a single satellite to provide coverage across large portions of the globe.

2.27 The 'receive' components of satellite earth stations are authorised under licence exemption regulations.[19] Ofcom also coordinates the band based on frequency

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[16] Ofcom, *Improving consumer access to mobile services at 3.6GHz to 3.8GHz: Statement and Consultation*, July 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0017/103355/3-6-3-8ghz-statement.pdf

[17] Ofcom, *OfW 446,* October 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0017/92204/ofw446.pdf; and the principles of Ofcom, *OfW 188*, January 2008, https://www.ofcom.org.uk/__data/assets/pdf_file/0027/85086/coordination_processes.pdf.

[18] We have closed the frequency range 3.6GHz to 3.8GHz (channels 1-7) to new applications for fixed link licences. We have also closed the band to new applications for PES licences and grants of RSA for ROES for satellite earth stations with a receiver component in the 3.6GHz to 3.8GHz band using these frequencies. In addition, the July 2017 document set out that we do not expect to approve any variations to existing PES licences or grants of RSA for ROES which would add additional frequencies (including associated emissions) within the 3.6GHz to 3.8GHz band. However, satellite earth station operators may receive on a licence exempt basis. Non-operational licences for testing and development purposes will continue to be available in the period before an award.

[19] *The Wireless Telegraphy Apparatus (Receivers) (Exemption) Regulations 1989 (SI1989/123),* January 1989, http://www.legislation.gov.uk/uksi/1989/123/contents/made (accessed 17/10/2017)

management criteria to provide benchmark spectrum quality for satellite earth station receivers registered for specific frequencies through two regulatory products:

a) Permanent Earth Station (PES) licences under the WT Act, under which we also authorise transmission at given frequencies; and

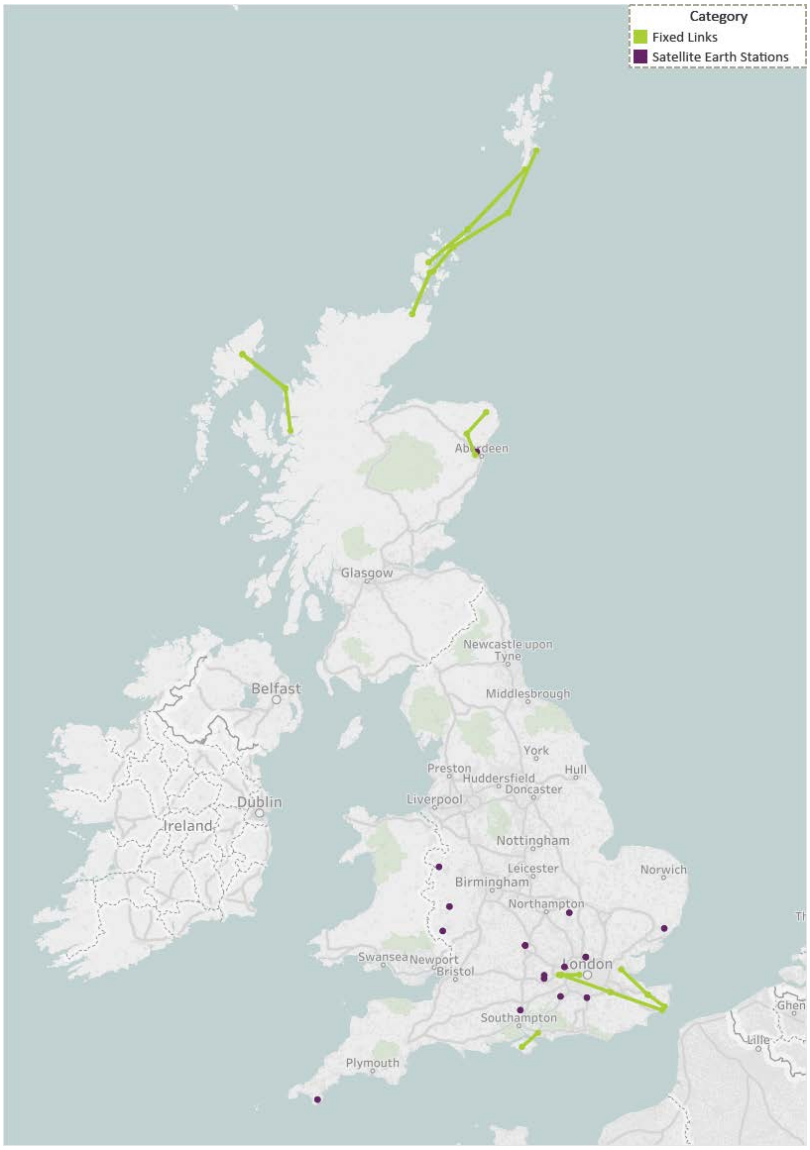
b) Grants of Recognised Spectrum Access for Receive Only Earth Stations (RSA for ROES).[20]

2.28 There are currently 12 sites with satellite earth stations registered with a receive component in the 3.6GHz to 3.8GHz band under PES licences, and 4 sites with satellite earth stations registered with a receive component in this band under grants of RSA for ROES (one of which is also registered under a PES licence).[21] This is one fewer site registered under a grant of RSA than at the time of the July Statement and Consultation.

2.29 The location of registered fixed link and satellite earth station users of the 3.6GHz to 3.8GHz band is shown in Figure 1 below.

[20] Hereafter referred to as "grants of RSA".
[21] The figures for registered satellite earth stations in this document exclude [✂].

Figure 1: Geographic distribution of fixed links and registered satellite earth stations receiving at 3.6GHz to 3.8GHz[22]



2.30 An 84 MHz block within the 3.6GHz to 3.8GHz band is already used for electronic communications services (which includes mobile and fixed communications). It is currently licensed to UK Broadband, which provides wireless broadband services using an LTE network in and around London, Reading, Wiltshire and various parts of the UK across its spectrum holdings, including 2 x 20 MHz within the 3.4GHz to 3.6GHz band, and the 3605MHz to 3689MHz frequency range. UK Broadband is now a wholly owned subsidiary of H3G.

[22] This map does not show the two fixed links licences which expire in November 2019, which are located in Kent and Essex, or [✂].

Coexistence analysis

2.31 In setting out our proposed approach we took account of our updated coexistence analysis which showed that it would be very challenging for mobile and existing registered users to coexist without extensive restrictions on mobile deployments.[23] Stakeholders had confirmed this assessment in response to the October 2016 consultation and in subsequent discussions.

2.32 Our coexistence analysis modelled a realistic simulated future UK-wide 5G macrocell network deployment, and simulated the interference expected from this model network into existing registered users of the band. The simulations identified the mobile base station sectors[24] which would be likely to undermine benchmark spectrum quality for existing registered satellite earth station or fixed link band users, using our current coordination criteria. We also identified sectors which would be expected to contribute to degradation of spectrum quality below the current benchmark owing to the combined effect of multiple sectors (aggregate interference).

2.33 This modelling enabled us to consider the likely scale of restrictions on future mobile deployment including 5G which could be needed to maintain the current benchmark spectrum quality for registered users. Whilst the degree of interference varied by registered user site according to a range of factors, our analysis suggested that under our current coordination approach around one quarter of mobile base station sectors across the UK could undermine benchmark spectrum quality for existing registered band users. Given the location of registered band users, these sectors are particularly concentrated in the south of England,[25] where around two fifths of sectors could be affected. This figure rose to over half of sectors in Greater London.[26]

Assessment of costs and benefits of policy options towards existing authorisations

2.34 Our coexistence analysis led us to conclude that maintaining existing authorisations (i.e. option A) would significantly constrain mobile deployment across large parts of the UK including some densely populated areas such as Greater London, where we would expect there to be particularly strong demand for new mobile services including 5G. Whilst the impact would vary by region, we concluded that nationwide deployment of future mobile services including 5G could not coexist with the coordination approach and current benchmark spectrum quality provided to registered users of the band.

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[23] See section 6 of the July 2017 document for a detailed explanation of the coexistence analysis.
[24] Cellular network provides coverage of an area by dividing it into cells; sectorisation involves dividing each cell spatially into sectors. Sectorisation is achieved by having a directional antenna at the base station that focusses transmissions into the sector of interest. Usually each cell is divided into one, three or six sectors. See Tse, D. and Viswanath, P., 2005. *Fundamentals of Wireless Communication.* Cambridge: Cambridge University Press.
[25] Where "the south of England" is defined as the European Parliament constituencies "Eastern", "London", "South East" and "South West".
[26] "Greater London" is defined as the European Parliament constituency "London".

2.35 As a result we considered that, by enabling more citizens and consumers to access future mobile services provided using the band and supporting the delivery of innovative mobile services to wider areas across the UK, option B would deliver the greatest benefits from making the band available for mobile services.

2.36 Separately, we set out our view that most, if not all, of the benefits currently delivered by services in this band could continue to be achieved using alternative frequencies and technologies. We also noted that, under option B, some satellite earth stations might be able to continue to receive using this band on a licence exempt basis.[27] As a result we considered that the benefits of enabling more widespread future mobile services including 5G to be made available to citizens and consumers across the UK would outweigh the costs and disruption to existing registered users of doing so.

Provisional conclusion and consultation on proposed approach

2.37 We therefore provisionally concluded that option B would result in greater net benefits to citizens and consumers than maintaining existing authorisations and that adopting this approach would be in accordance with our statutory duties.[28] In the consultation we sought views on this proposed approach and our assessment of the likely costs and benefits.

2.38 As well as consulting generally on this proposed approach we wrote to affected licensees and grantholders to draw the consultation to their attention and to explain how, if we ultimately adopted our proposed approach, this would affect their licence(s)/grant(s). We invited comments from these stakeholders as part of the consultation process.

Responses to the consultation

2.39 We received 19 responses to the July 2017 document and also had bilateral contact with a number of registered band users regarding the proposals set out in the consultation. [29] We consider the main themes from responses and wider engagement in sections 3-5. Additional detail on stakeholder responses is provided in annex 1.

Structure of this document

2.40 The rest of this document is structured as follows:

a) **Section 3** summarises the information and views received during the consultation and sets out our intention, taking account of these, to follow our proposed approach as set out in the July 2017 document.

[27] See paragraph 6.28 and sections 7-8 of the July 2017 document.
[28] Section 7 of the July 2017 document set out our assessment of the costs and benefits of our proposed approach to existing authorisations, including consideration of relevant stakeholder comments made in response to the October 2016 consultation.
[29] This includes an email from Goonhilly Earth Station dated 1 September 2017 offering comments on our proposed approach to which we refer in this document.

b) **Section 4** explains the next steps we will take to expand spectrum access for mobile services in this band, through commencing the statutory process to propose (i) revocation of fixed links licences which authorise transmission using frequencies in the 3.6GHz to 3.8GHz band; and (ii) variation of current authorisations for satellite earth stations such that we would no longer take registered satellite earth stations with a receive component in the 3.6GHz to 3.8GHz band into account for frequency management purposes. This section also addresses other issues relevant to existing registered users of the band.

c) **Section 5** addresses issues raised in the consultation which do not directly concern current registered fixed link and satellite earth station users of the band, and sets out future steps towards a future spectrum award, planned for 2019.

d) **Annex 1** contains a summary of stakeholder responses to the consultation, and Ofcom's response.

e) **Annex 2** contains a glossary.

3. Our intended approach to fixed links and satellite earth stations

3.1 In this section, we consider the responses we received to the July 2017 document and set out our intended approach to existing registered fixed links and satellite earth stations in the 3.6GHz to 3.8GHz band, taking account of the information provided by stakeholders.

Our proposal

3.2 As a result of our decision to make the remaining 116 MHz in the 3.6GHz to 3.8GHz band available for mobile services, we set out for consultation our proposed approach to existing authorisations in the band.

3.3 We proposed to adopt option B from the October 2016 consultation to remove fixed links and satellite earth station authorisations in the 3.6GHz to 3.8GHz band, as follows:

- Revocation of current authorisations for fixed links with a notice period of 5 years, but we stated that we would aim for these operations to migrate to alternative frequencies by 1 June 2020 where possible; and
- Variation of existing authorisations for receiving satellite earth stations operating under PES licences and grants of RSA such that, after an appropriate period of notice, we would no longer take registered satellite earth stations with a receive component in this band into account for frequency management purposes. We proposed that these variations would take effect by 1 June 2020.

Consultation responses

3.4 In general, mobile stakeholders (including companies which operate satellite earth stations as well as mobile-related activities) supported our proposed removal of existing authorisations for fixed links and satellite earth station users, whereas stakeholders focused on the satellite sector urged a different approach to the band.

Costs and benefits of proposed approach

3.5 Respondents offered a range of views on the costs and benefits of our proposed approach. Most comments focused on our assessment of the expected benefits resulting from the rollout of this spectrum on a nationwide basis, and the potential impacts of our proposed approach on existing users of the band. We consider stakeholder comments on notice periods and funding separately in section 4.

Benefits of enabling wider rollout of future mobile services

3.6 In setting out our decision to make the remaining 116 MHz of spectrum in the 3.6GHz to 3.8GHz band available for future mobile services in the July 2017 document, we explained that this had the potential to deliver significant benefits for UK citizens and consumers by

providing additional capacity to enable mobile networks to meet increasing consumer demand for mobile data, as well as delivering new and improved mobile services including 5G.[30] We noted that the expected benefits resulting from this decision would be greatest the sooner the spectrum can be used for mobile services, once a device ecosystem is available,[31] and if the spectrum is made available in as many areas as possible across the UK.

3.7 As set out in section 2 above, in setting out our proposed approach to existing authorisations (i.e. option B), we took into account technical analysis which showed that under current coordination arrangements there would be large parts of the UK where mobile roll out would be significantly constrained, including in some densely-populated areas where we would expect there to be the highest demand for mobile data services.[32] We also took into account our assessment that most, if not all, of the benefits currently delivered by services in this band could continue to be achieved using alternative frequencies and technologies.

3.8 We therefore considered that, by removing these constraints and enabling wider rollout of future mobile services including 5G using the 3.6GHz to 3.8GHz spectrum, our proposed approach would result in greater benefits for citizens and consumers than maintaining existing authorisations.[33] We also considered this would achieve optimal use of the spectrum.

3.9 In response to the consultation, a number of mobile stakeholders argued that it was essential for this spectrum to be made available for mobile services in as many areas as possible and as soon as possible, noting the significant constraints which would remain if we did not pursue our proposed approach. On this basis, they strongly supported our proposed approach. Some other respondents also supported the strategic aim of making this spectrum available for mobile 5G use.

3.10 However, some stakeholders questioned whether there was proven demand for future mobile services in the band. Whilst our July 2017 decision to make the band available for mobile reflected our assessment that we expected widespread demand, which informed our proposed approach to remove existing authorisations, some stakeholders suggested this might not be the case and hence option B would be disproportionate. A number of respondents, including several satellite stakeholders, also questioned the likely geographic extent of future provision of mobile services using this spectrum. For example, the University of Surrey 5G Innovation Centre (5GIC) suggested that future 5G services in this band would be expected to be deployed using dense small cell networks, which would be focused on urban areas and indoors, with potentially only around 10% of the UK landmass being covered. It also suggested that it would not be efficient for macro and micro cells to be used in the same band.

[30] See paragraphs 5.55-5.61 of the July 2017 document.
[31] We expect that mobile devices which can use the 3.6GHz to 3.8GHz band could potentially be available as early as 2019-20. See paragraphs 5.46-5.49 of the July 2017 document.
[32] See section 6 of the July 2017 document.
[33] See paragraphs 6.22-6.27 and 7.74-7.80 of the July 2017 document.

Ofcom's response

3.11 To a large extent, views provided on the likely demand for future mobile services using this spectrum repeated arguments put forward in response to the October 2016 consultation. We took account of these views both in reaching our decision to make the band available for mobile, and when determining our proposed approach to existing users in the July 2017 document.[34] As we set out in Section 5 of the July 2017 document, our assessment is that this spectrum is particularly suitable for meeting the increasing demand for mobile data and delivering future mobile services including 5G, noting its properties and expected device availability. We also note the arguments put forward by mobile stakeholders in support of early and widespread spectrum availability.

3.12 We have considered carefully the University of Surrey 5GIC's description of the 3.6GHz to 3.8GHz band as a small cell band. 5G technologies remain under development, and are likely to include both an evolution of existing technologies and new radio technologies.

3.13 A Qualcomm study[35] based on computer simulations indicates that spectrum at around 4GHz can be expected to achieve a similar range (with better throughput performance) as spectrum at 2GHz, when Massive-MIMO is deployed for the 4GHz network. In other words, when beamforming gains can be exploited by using a large number of antenna elements, base stations at around 4GHz can be deployed at existing sites associated with networks at around 2GHz. These results are consistent with those published by Nokia,[36] which has concluded that MIMO-beamforming can allow 3.5GHz base stations to be deployed on existing base stations sites using 1.8GHz or 2.1GHz.

3.14 Given this technological capability, the likely cost and reduced complexity compared to small cell deployments, and evidence provided by MNOs and vendors we consider it is reasonable to expect that MNOs would look to deploy this spectrum on their existing grid of macrocells. This is consistent with the responses received from the GSA to the July 2017 document and BT/EE and Vodafone to the October 2016 consultation [✂].[37] However, we recognise that there is some uncertainty and that future licensees may choose to use small cells or other technologies in some areas, including in addition to macrocells. We also note that shared use of macro and micro cells within one band is already possible within the 4G standard.[38]

3.15 Mobile stakeholders have clearly indicated that they wish to have the possibility of deploying mobile using this spectrum on a UK wide basis, in response to increasing demand for mobile data. Whilst 5G technologies remain under development there is a range of potential future 5G applications that could use this band, and we consider it

[34] See section 5 of the July 2017 document.
[35] Qualcomm, "Leading the world to 5G" presentation, Feb. 2016, https://www.qualcomm.com/media/documents/files/qualcomm-5g-vision-presentation.pdf (accessed 17/10/2017)
[36] Nokia, "Beamforming for 4.9G/5G networks" white paper, https://resources.ext.nokia.com/asset/201377 (accessed 19/10/2017)
[37] [✂]
[38] See e.g. Chapter 14, E. Dahlman, S. Parkvall and J. Skold, *4G, LTE-Advanced Pro and The Road to 5G*, Academic Press, 2016.

important to ensure that constraints on spectrum availability are not a barrier to these being deployed across the country.

3.16 Overall, the consultation responses have not altered our view that demand for future mobile services including 5G using this spectrum can be expected on a nationwide basis, and that it is reasonable to expect that MNOs would look to deploy using macrocells. As a result, it is appropriate to assess the potential benefits of mobile use of this band, together with options relating to current band users, based on this scenario. Furthermore, it remains our view that enabling nationwide deployment is likely to deliver significant benefits which would not be delivered if we were to maintain the current coordination mechanisms to provide benchmark spectrum quality for registered users.[39]

Impact of our proposal on satellite earth stations

3.17 In the July 2017 document, we noted that Ofcom's 2017 Space Spectrum strategy[40] had not identified the 3.6GHz to 3.8GHz band (as part of the wider C-band including 3.8GHz to 4.2GHz) as a key growth band for the UK satellite sector, nor any specific area of demand reliant upon 3.6GHz to 3.8GHz.

3.18 We recognised that our proposed approach to existing authorisations for receiving satellite earth stations operating under PES licences and grants of RSA would have some impact on the existing services delivered using the 3.6GHz to 3.8GHz band. In particular, we noted that satellite earth stations currently operating under a PES licence or grant of RSA would, over time, have to adjust to an expectation of lower spectrum quality in this band. However, we considered that it should be feasible for most, if not all, of the services currently delivered using the band to continue to be delivered.

3.19 We noted a number of possible options which these operators would have:

a) we considered that operators located away from densely populated areas might be able to continue operating in the 3.6GHz to 3.8GHz band on a licence exempt basis, although we noted that the extent to which each site would be able to do so would depend on the level of interference from mobile, which would be determined by a range of factors;

b) many services could be migrated to other frequencies, including using higher C-band frequencies at 3.8GHz to 4.2GHz; and

c) operators could use alternative sites or technologies in other cases.[41]

3.20 We explained that under our proposed approach registered users would in many cases need to make operational changes to continue the delivery of services currently using the band. We noted that associated costs would vary according to decisions taken by each

[39] See paragraphs 6.26-6.27 of the July 2017 document.
[40] Ofcom, *Space Spectrum: Statement*, January 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0030/96735/Statement-Space-Spectrum.pdf
[41] See paragraphs 7.44-7.49 of the July 2017 document.

operator, and identified a range of potential costs which some of the registered fixed link and satellite earth station operators and their clients might incur including engineering and equipment costs, relocation, contract-related costs and loss of business.[42]

3.21 We separately noted that under our proposed approach we would explore applying localised restrictions in future mobile licences, where these would not have a material impact on mobile deployment, to facilitate continued operation of satellite services in the band where possible.[43]

3.22 Some respondents disagreed with our analysis of the likely future demand for C-band satellite services and the benefits of the UK space industry continuing to have access to benchmark spectrum quality in 3.6GHz to 3.8GHz, relative to the benefits of future mobile services using the band. Speedcast said that market trends in the region only pointed to signs of growth in C-band, although they did not link this specifically to 3.6GHz to 3.8GHz. The UK Space Agency said there was no evidence that use is decreasing or that this spectrum is no longer required. It said operators continue to make filings in the band and there are new satellite services emerging. Goonhilly Earth Station described the market for C-band satellite services as continuing and still growing.

3.23 Satellite respondents also offered differing views on the feasibility and cost of the options we identified for services currently provided using satellite reception in this band.

3.24 Several satellite earth station operators cast doubt on whether they would be able to continue receiving using this band on a licence exempt basis in the longer term, including Speedcast which noted that technical adaptations to protect reception at 3.8GHz to 4.2GHz could rule this out. Goonhilly Earth Station argued that losing access to the 3.6GHz to 3.8GHz band would have a significant detrimental effect on their business. However, Vodafone suggested that some satellite earth stations could likely enjoy continued *de facto* protection from interference for a period beyond any formal notice periods to vary their licence(s)/grant(s), given the relative geographic locations of satellite earth stations and early 5G deployments in this band. The GSA also thought licence exempt operations could be a viable option for some satellite earth stations.

3.25 A number of satellite earth station operator responses indicated that in principle many services could be delivered using 3.8GHz to 4.2GHz. Most satellite respondents also noted Ofcom's consideration of scope for future sharing of the 3.8GHz to 4.2GHz band, and called for security of tenure for satellite operations using these frequencies.

3.26 One operator, Speedcast, responded that migration of services to other frequencies was unlikely to be possible in every case, highlighting concerns around the availability of alternative frequencies, and noted the potential for stranded infrastructure. ESOA/GVF and Intelsat raised similar concerns. Speedcast also said that the use of alternative technologies would not be universally feasible.

[42] See paragraphs 7.50-7.53 of the July 2017 document.
[43] See paragraphs 8.19-8.21 of the July 2017 document.

3.27 Stakeholders identified a number of potential types of costs which corresponded to the broad categories which we identified in the July 2017 document; within these respondents pointed to some specific examples including replacing low noise block downconverters (LNBs) and satellite dual illumination.[44] Speedcast also highlighted the potential for foregone customer revenues, and argued that option B would create millions of pounds in costs for registered satellite earth station users from mitigations and stranded investment, although it noted that it would be "extremely difficult" to quantify the likely costs at this stage. Nonetheless, Speedcast thought that Ofcom had not sufficiently considered the magnitude of the impact and associated costs that option B would impose on existing licensees.

3.28 The BBC noted BBC Monitoring's requirement for ongoing access to the 3.6GHz to 3.8GHz band and stated that Ofcom's proposed approach would remove the flexibility required for BBC Monitoring to receive sources wherever they are broadcast in the C-band. The BBC stated that it would not be possible for BBC Monitoring to operate on a licence exempt basis as this would not ensure continuity of service for BBC newsgathering and its external clients. [✂]

3.29 The Ministry of Defence (MOD) noted the potential for impacts on a small number of MOD locations.

Ofcom's response

3.30 We recognise that there is likely to be continued demand for UK satellite earth stations to provide some services using C-band reception given its particular characteristics, and that our proposed approach would reduce the range of available C-band frequencies for reception for some sites. We also recognise that it is possible that alternative frequencies might not be suitable or available in every case. However, it is our understanding that there is available C-band satellite capacity above 3.8GHz and we note that several satellite earth station operators confirmed that frequency migration was feasible.[45]

3.31 Nonetheless, our overall assessment of the importance of C-band for future UK satellite sector growth remains consistent with our Space Spectrum strategy. This identified potential growth areas for satellite applications, particularly satellite broadband and earth observation, but highlighted the Ka-band, Ku-band and X-band as important bands to support this. It did not identify the 3.6GHz to 3.8GHz frequencies as a key growth band.

3.32 We have noted the range of views on the feasibility of licence exempt operations in the 3.6GHz to 3.8GHz band in the medium and longer term. As we indicated in our July 2017 document,[46] removing current coordination mechanisms does not preclude satellite earth stations from entering into commercial agreements with the eventual new licensees. Our proposal to explore restriction zones could also facilitate ongoing reception using this

[44] See paragraphs 7.50-7.52 of the July 2017 document.
[45] We address the wider issues raised by respondents in relation to the future availability of 3.8GHz to 4.2GHz in paragraphs 3.47 to 3.49 below.
[46] See paragraph 7.50 of the July 2017 document.

band, in particular at sites in more remote areas (see further paragraphs 4.25 to 4.32 below).

3.33 Our proposal to adopt option B, and the assessment set out in the July document, took account of evidence stakeholders provided in response to the October 2016 consultation and subsequent meetings. We do not agree with Speedcast's comments concerning our consideration of the magnitude of the impact and associated costs which option B might impose on existing licensees and grantholders. Whilst Speedcast argued that option B would create millions of pounds in costs for registered satellite earth station users from mitigation and stranded investment they did not explain the basis on which these numbers have been calculated. As we set out in the July 2017 document, we do not consider it feasible to estimate the total costs that would be incurred as these would vary according to decisions taken by the operators at each site, and we note that Speedcast acknowledged that it would be "extremely difficult" to quantify the likely costs at this stage. We have also noted that other satellite stakeholders, including operators of other registered sites in this band, have noted the types of costs that could be involved in mitigations but have not indicated costs of this magnitude. Overall, therefore, the consultation responses confirmed our analysis of the types of potential costs and did not materially change our assessment of the likely scale of costs individual operators might incur.

3.34 We recognise that the impact on each satellite earth station site may be different, reflecting the different locations, services and equipment specifications of the registered satellite earth station users of the band, and may justify a different approach to individual licensees/grantholders. The operators of eleven of the fifteen registered satellite earth station sites for this band submitted responses to the consultation.[47] Within this, the responses from the operators of six sites (Arqiva, BT/EE and Vodafone) supported our proposed approach. However Speedcast (which operates two registered satellite earth station sites using this band) and Goonhilly Earth Station argued against our proposed approach and the BBC made representations regarding the potential impact on its monitoring operations.

3.35 We have considered whether, in light of the further information provided by these stakeholders, it would be appropriate to adopt a different approach to their existing licences/grants. However, we do not consider that these stakeholders' representations provided sufficient evidence on the potential impacts of our proposed approach on their operations to demonstrate that it would be appropriate to do so (see also paragraphs 4.14 to 4.18 below).

3.36 With regard to MOD sites, we stated in the July 2017 document that we would work with the MOD to identify appropriate restrictions for future licences to ensure that Defence capabilities are not unduly affected.

[47] This figure includes the email received from Goonhilly Earth Station dated 1 September 2017.

Impact on fixed links users

3.37 In the July 2017 document we set out our assessment that the services currently delivered using fixed links in the band could be delivered using other frequencies or technologies.[48] We explained that, if we ultimately adopted option B, we would propose to revoke relevant fixed links on five years' notice in line with the minimum required notice under the terms of the licences. However we also noted that we would aim for these fixed links operations to migrate to alternative frequencies or technologies by June 2020 where possible.

3.38 We received one consultation response from a licensed fixed link operator currently using this band. Arqiva highlighted its concerns over the impact of Ofcom's proposals in relation to its use of fixed links in this band to provide the backhaul for free to view digital terrestrial television (DTT) to the Outer Hebrides, Orkney, Shetland and the Isle of Wight. It was concerned that Ofcom had made no commitment to find alternative spectrum for its fixed links in the 3.6GHz to 3.8GHz band and argued that there was not a clear alternative means to deliver the services currently provided using these fixed links which would be commercially viable. Arqiva therefore considered that, in the absence of public funding to support moving the links, a revocation of the licences with five years' notice might be inconsistent with Ofcom's statutory duties to ensure the provision of a wide range of television services throughout the UK, as well as its obligations under the recent BBC Agreement[49] and wider public policy objectives. Arqiva also noted that it was difficult to quantify costs at this stage.

3.39 BT/EE and techUK noted their support for Ofcom's proposal to revoke fixed links licences in the band and urged us to consider means to accelerate fixed link users leaving the band, ideally by 2020. techUK noted that it thought alternative spectrum should be identified for these licensees.

Ofcom's response

3.40 We remain of the view, as set out in the July 2017 document, that the services currently using fixed links in the 3.6GHz to 3.8GHz band could in principle use other frequencies or technologies. This has been confirmed by the fixed links licensees with whom we have spoken.

3.41 Fixed link licences are assigned on a first come first served basis, in line with our published policies. There are a number of alternative bands which may be suitable for fixed links currently using the 3.6GHz to 3.8GHz band, including lower and upper 6GHz, 7.5GHz and 13GHz. In line with usual practice we will engage with individual licensees to explore which alternative spectrum is suitable and available on a case by case basis, taking account of each user's business needs and systems. Beyond this, there is also scope for alternative technologies to deliver services.

[48] See paragraph 7.43 of the July 2017 document.
[49] BBC Royal Charter and Agreement, https://www.gov.uk/government/publications/bbc-charter-and-framework-agreement (accessed 17/10/2017)

3.42 Arqiva was the only existing fixed links user which objected to our proposed approach, arguing that, given the locations of its fixed links and the services they are used to provide, there was a case for adopting a different approach in relation to its licences.

3.43 In relation to the points raised by Arqiva, we recognise the importance of free to view TV, which provides cultural and social benefits to UK audiences. It helps to deliver key policy objectives and enables public service broadcasting to reach a wide audience. As part of our assessment, we have taken account of our general duties under the Communications Act, which include ensuring a wide range of TV and radio services are available throughout the UK. These services, taken as a whole, must be of a high quality and calculated to appeal to a variety of tastes and interests. We have also taken account of our other duties regarding the delivery of television services and public service broadcasting, as relevant.[50] [51]

3.44 We do not consider that our intended approach is in conflict with these duties. We remain of the view that the services currently using these fixed links could be delivered using other solutions.

3.45 Arqiva stated that replacing its fixed links to the Outer Hebrides, Orkney, Shetland and the Isle of Wight with other technologies was unlikely to be a credible option, and that there would be complications with moving its links to alternative frequencies/locations. However, Arqiva did not provide any further evidence to demonstrate that it would be unviable to deliver the services currently provided using these links via alternative means.

3.46 We are therefore not satisfied, based on the information provided by Arqiva, that it is appropriate to adopt a different approach in relation to the relevant Arqiva licences. We also remain of the view that option B is reasonable for the other fixed link licences using the band. [✂]

3.8GHz to 4.2GHz

Future band access

3.47 As set out in paragraph 3.25 above, a number of satellite sector respondents called for greater certainty on the future use of 3.8GHz to 4.2GHz as a necessary condition for migrating services to these frequencies.

Ofcom's response

3.48 We have noted satellite earth station requests for greater clarity on the future outlook for the 3.8GHz to 4.2GHz band, following Ofcom's 2016 Call for Input[52] and the UK

[50] For example, under section 3(4)(a) of the Communications Act, Ofcom is required to have regard, as relevant, to the desirability of promoting the fulfilment of the purposes of public service broadcasting in the UK. Ofcom also has specific responsibilities for the regulation of DTT that go further than our responsibilities for other television platforms, reflecting the role that DTT has in making public service broadcasting available to all.

[51] We do not agree with Arqiva that the BBC Agreement imposes additional duties on us to consider the BBC's delivery of PSB services and related issues in undertaking our wider functions, including our spectrum management functions.

[52] Ofcom, *3.8 GHz to 4.2 GHz band: Opportunities for Innovation: Call for Input*, April 2016, https://www.ofcom.org.uk/consultations-and-statements/category-2/opportunities-for-spectrum-sharing-innovation

Government's 5G Strategy.[53] In the July 2017 document we recognised that there was likely to be continued demand for UK satellite earth stations to provide services using C-band, given its particular characteristics. We also said that we were minded to develop proposals to facilitate shared access between existing and future users in 3.8GHz to 4.2GHz based on geographically defined authorisations, including further consideration of database solutions for dynamic spectrum access.

3.49 We plan to bring forward a consultation on enabling further sharing in the 3.8GHz to 4.2GHz band in 2018, with a view to enabling innovative uses. Our preliminary view, as indicated in our 2016 Call for Input and subject to further consultation, is that in any future framework all existing and new users of the band (including variations to existing satellite earth station PES licences and grants of RSA and new satellite earth station sites) would be authorised on the basis of first-come first-served coordination mechanisms, as is the case in the band now. Under this approach existing PES licences and grants of RSA would remain in place. We will continue to engage with stakeholders as we develop proposals for consultation.

Coexistence

3.50 In the July 2017 document we noted that there were potential adjacent band coexistence issues between new mobile use in the 3.6GHz to 3.8GHz band and operations in the adjacent 3.8GHz to 4.2GHz band, although we expected the impact of this to be much less than the impact of interference arising in band. We considered that the additional coexistence impacts with operations in the 3.8GHz to 4.2GHz band under our proposed approach (i.e. option B) would be limited compared to the additional benefits which this approach would deliver through enabling wider mobile roll-out at 3.6GHz to 3.8GHz.

3.51 Several respondents set out concerns about adjacent band coexistence issues. The BBC said that it strongly disagreed with Ofcom's approach, arguing that the July 2017 document provided no clarity on adjacent band coexistence impacts, and encouraged Ofcom to consult on this issue. Intelsat thought that mobile services in 3.6GHz to 3.8GHz could overwhelm the ability of earth stations to receive low-power satellite transmissions anywhere in the band, causing intermodulation effects and other interference issues. A number of respondents provided information on potential technical mitigations and associated costs.

Ofcom's response

3.52 We recognise that there is some risk of adjacent band coexistence issues between new services in the 3.6GHz to 3.8GHz band and existing satellite and fixed link assignments above 3.8GHz.

3.53 For the purposes of assessing the costs and benefits of our proposed approach to existing authorisations within the 3.6GHz to 3.8GHz band (i.e. option B) we are concerned with any

[53] DCMS and HM Treasury, *Next Generation Mobile Technologies: A 5G strategy for the UK*, March 2017, https://www.gov.uk/government/publications/next-generation-mobile-technologies-a-5gstrategy-for-the-uk (accessed 19/10/2017)

additional impacts on users above 3.8GHz arising from this approach, as compared to possible alternative approaches to these authorisations.

3.54 As set out in the July 2017 document, the expected interference impact on users above 3.8GHz are likely to be greater under option B given that we expect this to allow more widespread mobile deployment in the 3.6GHz to 3.8GHz band. However, the analysis we have undertaken to date shows that any potential impacts are likely to be limited.

3.55 In particular, our initial analysis shows that the potential interference risks are likely to be limited to small areas around earth stations or along the path of fixed links operating above 3.8GHz, and that there are a range of methods that can be used to mitigate these risks. The potential impacts identified are dominated by the adjacent channel selectivity performance of the satellite and fixed link receivers, i.e. where these receivers 'listen' to signals below 3.8GHz. This means that receivers with good selectivity performance will be less susceptible to interference and, where needed and feasible, additional filtering at the receiver will be an effective mitigation for managing the adjacent band coexistence risk. Filtering at the receiver would also help to mitigate any impacts related to blocking.

3.56 We therefore remain of the view that any additional coexistence impacts under option B to operations in the 3.8GHz to 4.2GHz band will be minimal compared to the additional benefits which this option would deliver.

3.57 We are continuing our analysis of adjacent band coexistence issues as part of preparing for an award of this spectrum and plan to consult on our findings in 2018.

Overall considerations on options A and B

3.58 Speedcast argued that a better approach would be to adopt a policy closer to the option A set out in the October 2016 consultation which could allow satellite earth station operators to retain current benchmark spectrum quality and expand this to new operations but without the associated fee review we had suggested under this option. ESOA/GVF and Intelsat called for an option in the middle of option A and B, whereby satellite earth stations and fixed links in suburban or rural areas would be afforded protection, while incumbents in cities and urban areas would have their protection assessed on a case by case basis.

3.59 The UK Space Agency opposed option B in general while the MOD advocated the continuation of current grants of RSA.

3.60 The University of Surrey 5GIC supported the proposed approach for urban areas but believed that more efficient use of the spectrum could be achieved by taking a more flexible approach in rural areas. Landways Management made a similar point, arguing that a licensing approach based on smaller geographical units could lead to a more efficient solution which allowed existing users to remain in the band.

Ofcom's response

3.61 The July 2017 document set out our reasoning for considering that our proposed approach (option B) would deliver greater benefits for consumers and citizens compared with option

A. Specifically, option B would provide additional capacity for mobile data services, including future 5G services, across the UK. In contrast, under option A, the anticipated benefits would not be available or would be constrained in many areas, including both densely populated areas such as Greater London where there is likely to be the highest demand and also in a number of rural and suburban areas. This option would be expected to constrain the UK's ability to realise the very significant potential economic and wider benefits of new and improved mobile services, including future 5G services.[54]

3.62 In the July 2017 document we recognised that a number of services and associated benefits are currently delivered by existing users of the band, but concluded that most, if not all, of the benefits delivered could be delivered using alternative frequencies, locations or technologies, albeit with additional costs in some cases, or potentially through licence exempt reception. We also noted that some costs to existing users would be likely to apply even if we maintained existing authorisations, given that under option A we would be likely to review fees to take account of the extent to which mobile deployment would have been denied access to the band, and that some users had suggested they would not be able and/or willing to pay revised fees and would therefore cease using the band. Speedcast's proposal that we adopt option A without a fee review would be inconsistent with our framework for spectrum pricing.[55]

3.63 With regard to suggestions that option B should not be applied to licensees and grantholders in suburban or rural areas given arguments put forward about the likelihood of mobile rollout in these areas, we remain of the view that demand for future mobile services including 5G using this spectrum can be expected across the country (see paragraphs 3.11 to 3.16 above). Furthermore, our previous analysis found that maintaining current coordination mechanisms for all satellite earth stations situated in rural locations could create a significant constraint on mobile roll-out, including in more densely-populated areas.[56] We therefore do not consider that this would deliver the greatest benefits from the band.

3.64 However, as we indicated in our July 2017 document,[57] removing current coordination mechanisms does not preclude satellite earth stations from receiving on a licence exempt basis or entering into commercial agreements with the eventual new licensees. Our proposal to examine restriction zones could also facilitate ongoing reception using this band, in particular at sites in more remote areas (see further paragraphs 4.25 to 4.32 below).

[54] Our full reasoning was set out in paragraphs 7.75-7.85 of the July 2017 document. We also addressed the anticipated benefits in section 5 of the July 2017 document.
[55] Ofcom, *SRSP: The revised Framework for Spectrum Pricing: Our policy and practice of setting AIP spectrum fees: Statement*, December 2010, https://www.ofcom.org.uk/__data/assets/pdf_file/0024/42909/srsp-statement.pdf
[56] See section 6 and paragraph 7.65 of the July 2017 document.
[57] See paragraph 7.50 of the July 2017 document.

Compatibility of proposed approach with the EC Decision

3.65 Intelsat, ESOA/GVF and the UK Space Agency argued that Ofcom's proposed approach (i.e. option B) would be inconsistent with the requirements and/or spirit of the EC Decision. These stakeholders considered that the proposal to remove existing users' authorisations would be contrary to the requirement that Member States should designate and subsequently make available the 3.4GHz to 3.8GHz frequency band for terrestrial electronic communications networks on a "non-exclusive basis" and "without prejudice to the protection and continued operation of other existing uses" in the band.

Ofcom's response

3.66 As set out in section 2 above, the EC Decision originally provided that Member States should designate, by 1 January 2012, the 3.4GHz to 3.8GHz band on a non-exclusive basis for terrestrial communications networks. The Decision was amended in 2014, primarily in relation to the technical conditions in compliance with which the band should be made available. The amended Decision was implemented in UK law by way of Statutory Instrument 2016 No. 495.

3.67 Ofcom has already designated the 3.6GHz to 3.8GHz band for electronic communications services, on a non-exclusive basis, and has also made 84 MHz in this band available for this purpose (licensed to UK Broadband). In July 2017 we decided to make the remaining 116 MHz in the band available for mobile services.

3.68 The EC Decision neither precludes nor obliges clearance of the existing licensees in the 3.6GHz to 3.8GHz band. This is left as a matter for Member State discretion. Having carefully considered all of the evidence provided to us, in this document we are exercising our discretion by setting out our intention to facilitate widespread availability of future mobile services including 5G using this spectrum by following option B, subject to completing the statutory process for revocation/variation of relevant licences and grants of RSA for fixed links and satellite earth station users in the band.

3.69 This is in accordance with the terms and conditions of those licences/grants, and falls within Ofcom's general licensing functions. We therefore consider that the exercise of our discretion in this way is consistent with the EC Decision. In reaching this conclusion we have taken into account that the objective of the EC Decision is to promote the wider availability of wireless broadband services, including mobile services, throughout the EU.[58]

Impact Assessment

3.70 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy-making. This is reflected in Section 7 of the Communications Act, which means that generally, we have to carry out impact assessments where our proposals would be likely to

[58] As noted in section 2 above, this band has also been identified by the RSPG as part of the primary band for 5G services in Europe with the possibility to put Europe at the forefront of 5G deployment.

have a significant impact on businesses or the general public, or when there is a major change in our activities.

3.71 In the July 2017 document, we explained that we believed it would be appropriate to remove current authorisations for fixed links and no longer take registered satellite earth stations with a receive component in the 3.6GHz to 3.8GHz band into account for frequency management purposes, following appropriate notice periods. Section 7 of the July 2017 document set out our provisional assessment of the likely benefits to be derived from doing so and the potential impact on affected stakeholders, in particular existing users of the band. In the consultation we sought stakeholder comments on our proposed approach and our assessment of the likely costs and benefits of this approach.

3.72 We have taken into consideration all stakeholder responses in concluding on our intended approach, as set out below.

Equality Impact Assessment

3.73 Ofcom is also required to assess the potential impact of all its functions, policies, projects and practices on the equality of individuals to whom those policies will apply. An equality impact assessment (EIA) assists Ofcom in making sure that it is meeting its principal duty of furthering the interests of citizens and consumers regardless of their background or identity.

3.74 We remain of the view set out in the July 2017 document that our proposals for the 3.6GHz to 3.8GHz band are not likely to have a greater impact on any protected groups of stakeholders, including (among others) groups protected by Northern Irish equality legislation, as compared to their impact on UK citizens and consumers generally.

Conclusion

3.75 We have considered the information provided in consultation responses, and through bilateral engagement with stakeholders where relevant, on our proposed approach to existing authorisations in the 3.6GHz to 3.8GHz band. Overall, they do not alter our assessment, set out at paragraphs 7.74 to 7.85 of the July 2017 document, that the net benefits to citizens and consumers will be greatest under option B and that this will deliver optimal use of spectrum.

3.76 Our assessment remains that there will be significant demand for using this band for future mobile services and that future mobile services including 5G using this spectrum can be expected across the country. Maintaining the current fixed link and PES licences and grants of RSA in the band would create material constraints to future mobile deployments, including in areas of high demand. We recognise that our proposed approach to existing authorisations will result in some costs and impacts for existing satellite earth station and fixed links users, however the additional information provided by stakeholders has not changed our overall view that the expected benefits of enabling more widespread future mobile services in the band outweigh these costs and impacts.

3.77 Accordingly, we intend to adopt the proposed approach outlined in the consultation (i.e. option B), and will now commence the statutory process to propose:

- revocation of current authorisations for fixed links; and
- variation of existing authorisations for receiving satellite earth stations operating under PES licences and grants of RSA for ROES such that we would no longer take registered satellite earth stations with a receive component in this band into account for frequency management purposes.[59]

3.78 We have taken note of information provided on potential impacts on specific operators as part of the consultation process in concluding on our intended approach. As explained further in section 4, we will consider any further representations from individual licensees and grantholders before taking final decisions on individual licences and grants.

3.79 We set out the next steps we will take to implement our intended approach in section 4.

[59] [✂]

4. Implementation of our intended approach to fixed links and satellite earth stations

4.1 In section 8 of the July 2017 document we explained our proposed implementation approach towards existing licences and grants in the 3.6GHz to 3.8GHz band if we adopted option B following consultation. We also wrote to licensees and grantholders with more details on how this would affect their licences/grants and invited comments.

4.2 In this section we consider the main issues stakeholders raised and set out the next steps we will take as a result of our intention to follow option B.

Ofcom's powers to vary and revoke licences and grants of RSA granted under the WT Act

4.3 Schedules 1 and 2 of the WT Act set out the process which Ofcom must follow where it proposes to vary or revoke a wireless telegraphy licence or grant of RSA. In summary, Ofcom is required to take the following steps:[60]

- notify the licensee/grantholder of the reasons for the proposed revocation or variation;
- specify a period of at least one month in which the licensee/grantholder may make representations about the proposal; and
- decide whether or not to vary the licence/grant within one month of the end of that period.[61]

4.4 Ofcom may only revoke or vary a wireless telegraphy licence or grant of RSA where the proposed revocation or variation is objectively justifiable.

Consultation responses regarding the proposed implementation approach

Proposed notice periods for revocations/variations

4.5 In our July 2017 document, we explained that, should we ultimately adopt our proposed approach (i.e. option B), we would propose to:

a) remove current authorisations for fixed links with a notice period of 5 years, whilst aiming for these operations to migrate to alternative frequencies by 1 June 2020 where possible; and

b) vary existing authorisations for receiving satellite earth stations operating under PES licences and grants of RSA such that, after an appropriate period of notice, we would

[60] See Schedule 1, paragraph 7 of the WT Act in relation to the revocation or variation of a wireless telegraphy licence, and Schedule 2, paragraph 6 of the WT Act in relation to the revocation or modification of a grant of RSA.
[61] Where a proposal to vary or revoke a wireless telegraphy licence or grant of RSA is made with the consent of the licensee/grantholder, Ofcom is not required to follow the above process.

no longer take registered satellite earth stations with a receive component in this band into account for frequency management purposes. We proposed that these variations would take effect by 1 June 2020.

4.6 We explained that we considered that this would provide a reasonable and appropriate period for licensees and grantholders to make any necessary adjustments to their operations. We also considered that this represented a suitable balance between minimizing disruptions for satellite earth station operators and ensuring the benefits of making this band available for future mobile services could be realized as soon as practicable, having regard to the potential mitigations we had identified.[62]

4.7 Most comments focused on the proposed period for varying satellite earth station authorisations. The operators of eleven of the fifteen registered satellite earth station sites for this band submitted responses to the consultation. Within this, the operators of six sites (Arqiva, BT/EE and Vodafone) confirmed that the potential mitigations and proposed 1 June 2020 notice period were feasible. Vodafone agreed that the proposed notice period was justified but called on Ofcom to explicitly set out its reasoning.

4.8 By contrast, Speedcast, the UK Space Agency, Intelsat and ESOA/GVF argued that longer time periods would be appropriate, given satellite equipment investment cycles and the complexity and costs involved. Speedcast (which operates two registered satellite earth station sites) noted that its contracts typically carry lengthy terms, and that there would be many contracts in 2020 that would need to be renegotiated or broken prematurely. The MOD described a minimum of a five-year notice period as a realistic compromise. The BBC (which operates two sites) suggested that given its operations the proposed changes to its grant were closer to a revocation and hence would merit a five-year notice period. [✂]

4.9 Only Arqiva specifically commented on the proposed five year notice period for fixed links, commenting that it was unclear whether this was sufficient because Ofcom had given no guarantees of alternative replacement frequencies. A small number of other respondents called for Ofcom to take steps to support fixed links leaving the band more quickly.

Ofcom's response

4.10 As set out above, Ofcom has a general power to revoke a WT Act licence or grant of RSA, or to vary its terms, provisions or limitations, provided that any proposed variation or revocation is objectively justifiable.

4.11 The terms and conditions of all relevant fixed links licences, PES licences and grants of RSA contain restrictions on the circumstances in which Ofcom may revoke. In each case Ofcom may revoke the licence/grant for spectrum management purposes on five years' notice served on the licensee/grantholder. The terms and conditions of the licences/grants do not, however, contain any restrictions on the circumstances in which Ofcom may vary the terms of the licence/grant (including a minimum notice period).

[62] See paragraph 8.8 of the July 2017 document.

4.12 The notice periods contemplated in the July 2017 document reflected these provisions and our view that the proposed periods would be reasonable and proportionate, in particular in light of expected timeframes for affected licensees to make any necessary adjustments to their operations and the expected timing for availability of mobile devices in this band. This followed discussions with all registered band users earlier in the year.

4.13 We recognise that the individual circumstances of each licensee might justify a different notice period. We considered information provided by all registered users on their operations in the band in proposing the above notice periods in the July 2017 document.

4.14 In the consultation responses, the licensees which operate six of the fifteen registered satellite earth station sites supported our proposal including the notice period we proposed for satellite earth stations in the July 2017 document (1 June 2020). However, Speedcast and the BBC (which each operate two registered sites) put forward arguments that this period was not, or might not be, sufficient given the specific nature of their operations.[63]

4.15 Arqiva argued that our proposed five-year notice period might not be appropriate given the circumstances of its operations in the Outer Hebrides, Orkney, Shetland and the Isle of Wight.

4.16 We have considered whether, in light of the further information provided by Speedcast, the BBC and Arqiva, a longer notice period would be appropriate for these licensees/grantholders. However, we do not consider that the information provided by these stakeholders provided sufficient evidence to demonstrate that it would be appropriate to do so (see also paragraphs 3.34 to 3.35 and 3.43 to 3.46 above).

4.17 We therefore remain of the view that is appropriate to propose:

a) the revocation of relevant fixed links licences following a period of five years' notice; and

b) the variation of relevant PES licences and grants of RSA such that we would no longer take registered receiving earth stations into account for frequency management purposes with effect from 1 June 2020.

4.18 As set out in section 4 we will consider any further representations by individually affected licensees/grantholders before concluding on the appropriate notice period in each case.

4.19 With respect to stakeholder suggestions that we should look to accelerate fixed link users leaving the band, we note that in the July 2017 document set out that we would aim for these fixed links operations to migrate to alternative frequencies by 1 June 2020 where possible. This remains our aim. [✂] As set out in paragraph 3.41 we will engage with individual licensees to explore which alternative spectrum is suitable and available on a case by case basis, taking account of each user's business needs and systems.

[63] Intelsat, ESOA, the MOD and UKSA whilst not current registered users of the band, also considered this period too short.

Funding

4.20 In the July 2017 document we noted that a number of stakeholders had argued that existing users should be compensated for any impacts on them as a result of our proposal to make the band available for mobile. However we said that we did not see a case for funding being made available, given that we were proposing reasonable notice periods in accordance with the terms of the respective licences/grants.

4.21 A number of respondents argued that compensation should be provided towards costs borne by existing registered band users, should option B be adopted. Arqiva argued that Government funding provided for changes in spectrum use of other frequency bands created a relevant precedent for this band, and pointed to the funded clearance of DTT and PMSE from the 700MHz and 800MHz bands, radio astronomy from the 800MHz band and civil aviation radar from 2.6GHz. Arqiva suggested that our assessment that there was not a case for funding meant that seemingly preferential treatment had been provided to users in other bands. Speedcast also pointed to previous examples where compensation had been offered to negatively impacted incumbents, including in relation to 800MHz coexistence and the 700MHz clearance programme. Several respondents suggested that compensation could be provided by future mobile users of the band. BT/EE and techUK suggested funding should be considered to accelerate clearance of fixed links from the band.

Ofcom's response

4.22 We have considered the responses which suggested compensation should be provided to some or all registered users of the band.

4.23 We do not agree that this is the case.[64] As acknowledged by Arqiva, funding decisions are taken on a case by case basis taking into account the specific circumstances. In most of the previous cases to which Arqiva and Speedcast refer, funding was offered where changes to spectrum access resulted in licensees incurring costs which were additional to those otherwise implied by reasonable notice given by Ofcom, or where they had a reasonable expectation to continue using the spectrum based on inferences drawn from regulatory statements.[65]

4.24 We do not consider that this is the case in relation to changes of access to the 3.6GHz to 3.8GHz band given we are proposing reasonable periods of notice in accordance with the terms and conditions of the relevant licences/grants (see above).[66]

[64] Under section 1 of the WT Act Ofcom may only make a grant of funding to any person with the consent of the Treasury and where the making of the grant is likely to promote (a) the efficient use in the UK of the electromagnetic spectrum for wireless telegraphy; or (b) the efficient management of that use.

[65] We note that different considerations applied in relation to 800MHz coexistence where Government decided that new licensees should provide funding to deal with the specific risk of interference impacts and disruption to DTT consumers across the UK.

[66] In the case of fixed link users we note that [✂]. As set out in paragraph 3.41 we will engage with individual licensees to explore which alternative spectrum is suitable and available on a case by case basis, taking account of each user's business needs and systems.

Potential mobile restriction zones around satellite earth stations

4.25 In the July 2017 document we noted that satellite earth stations could continue to operate in the band on a licence exempt basis following the end of notice periods, although in practice their ability to continue to receive without service-impacting interference could vary. We said that we would explore applying localised restrictions in future licences to facilitate continuing operation of satellite services in the 3.6GHz to 3.8GHz band, where these would not have a material impact on mobile deployment. Such conditions would apply beyond notice periods relating to current licences/grants and would place technical restrictions on a mobile network operator deploying base stations in the immediate vicinity of satellite earth station sites.[67]

4.26 We received a range of responses to our proposal. Not all satellite respondents specifically responded to this aspect of our proposed approach, while several of those that did believed that these zones should not be constrained by the requirement to not have a material impact on mobile. The UK Space Agency proposed concentrating satellite teleports in to a limited number of key sites which would be fully protected from mobile interference. Goonhilly Earth Station suggested establishing a "special spectrum zone" around their site on Cornwall's Lizard Peninsula to preserve existing satellite spectrum frequencies. The BBC welcomed Ofcom's examination of restriction zones, but said that this would not be a feasible long term solution for BBC Monitoring's operations in the band. Nevertheless, they appreciated the opportunity to explore whether there is potential for ongoing reception of a limited number of key sources post mobile rollout as a result of restriction zones.

4.27 Mobile stakeholders on the other hand cautioned about potential impacts and proposed that any zones should be small, and perhaps only a temporary transitional measure. Telefónica said it was very concerned about any proposals to apply restrictions on future mobile services in the 3.6GHz to 3.8GHz band, and suggested that any uncertainty created by such restrictions would in itself constitute a material impact. H3G thought that Ofcom should only implement localised restrictions as an absolute last resort and only for a short period of time.

Ofcom's response

4.28 We have considered the range of views put forward on restriction zones. Whilst we have noted the comments received in the consultation on the scope for satellite earth stations to continue to receive on a licence exempt basis, it remains our assessment that some sites may be able to continue to operate on a licence exempt basis beyond the applicable notice periods,[68] and that our proposal for restriction zones might facilitate this.

4.29 We have not proposed implementing more wide-ranging exclusion zones in which restrictions on mobile activity would be applied to provide benchmark spectrum quality for satellite earth stations. This is because our coexistence analysis found that maintaining

[67] See paragraphs 8.19-8.21 of the July 2017 document.
[68] See paragraphs 8.16 to 8.19 in the July 2017 document.

benchmark spectrum quality for some satellite earth stations based in rural locations could result in material constraints on mobile over wide areas, particularly for sites operating under a PES licence.

4.30 We continue to think that our proposal to explore applying localised restrictions in future licences, where these would not have a material impact on mobile deployment, could facilitate continuing operation of satellite services in the band. As some registered satellite earth stations have not yet offered views on this proposal we plan to continue to engage with stakeholders to explore this proposal further in the coming months.

4.31 Under the proposal which we set out in the July 2017 document,[69] a restriction zone would place technical restrictions on a mobile network operator deploying base stations in the immediate vicinity of satellite earth station sites. For example, this might require MNOs to take steps to mitigate interference when deploying base station sectors in the direct line of sight of a receiving dish within a specified area or to reduce transmit power. We said that in general we would expect any such arrangements to apply to relatively small areas, such as within a radius of 1-3km. However, we said we would consider larger areas if these would not have a material impact on mobile deployment.

4.32 We remain of the view that we should apply the following considerations when developing this proposal:

- our objective to ensure consumers right across the UK can benefit from new mobile services including 5G;
- that any constraints to mobile deployment should be kept to a minimum, and should not prevent MNOs from offering mobile services in the area affected;
- that any proposals should take account of local site and topology characteristics; and
- ensuring MNOs are able to meet demand across the UK by deploying mobile services using this spectrum on existing macrocells.

Our approach to implementation

Ofcom will now consult with affected licensees and grantholders

4.33 We will now commence the statutory process for proposing revocation of the relevant fixed links licences and variation of the relevant PES licences and grants of RSA for ROES in the 3.6GHz to 3.8GHz band in accordance with the provisions of the WT Act, in line with the timeframes we proposed in the July 2017 document.[70]

4.34 Licensees will have a period of one month within which to make representations on our proposals for their licence(s) or grant(s) of RSA. We will take into account any new evidence provided through individual representations before reaching a final decision in relation to individual licences and grants. We will also issue formal requests for information where we consider this necessary.

[69] See paragraphs 8.19 to 8.21 in the July 2017 document.
[70] [✂]

4.35 Given our intention to follow option B, having carefully considered all the evidence provided to us, we expect that any representations from licensees/grantholders will be primarily relevant to our consideration of the terms on which to revoke/vary that stakeholder's licence(s) or grant(s) of RSA. However, should any new evidence be put forward to suggest that revocation or variation of an individual licence or grant of RSA is not justifiable in the circumstances we will also take this account.

4.36 We will write to affected licensees/grantholders within one month of the deadline for their representations to confirm our final decision for their licence(s)/grant(s).

4.37 We will publish a short update in early 2018.

Transitional arrangements

4.38 We would continue to maintain appropriate protections for registered band users whose licence(s) or grant(s) of RSA are revoked or varied (as applicable) until the relevant notice period had lapsed.

Fees

4.39 Given our intention to revoke fixed links licences and to vary PES licences and grants of RSA in the 3.6GHz to 3.8GHz band, we do not currently intend to review the fees paid by these users.[71]

Policy on new licence applications and licence/grant variations in the 3.6GHz to 3.8GHz band

4.40 In the July 2017 document Ofcom said it did not expect to agree to any variations to existing licences or grants where these would increase the interference protections provided, and that the band was now closed to new applications for PES licences and grants of RSA for ROES. Vodafone suggested that Ofcom should permit existing licensees and grantholders to vary their licences on a temporary basis and argued that not doing so was inconsistent with the approach taken to the 700MHz clearance, where Ofcom issued licences to operate interim DTT multiplexes until such a time that the spectrum was unavailable. Arqiva and the UK Space Agency questioned the rationale for refusing new licence applications for downlink protection in the 3.6GHz to 3.8GHz band before June 2020.

Ofcom's response

4.41 We do not anticipate that this policy is likely to create operational challenges for satellite earth station operators. Satellite earth stations are authorised to receive new emissions on a licence exempt basis. Following our decision to close the band to new applications for

[71] In the event that our final decision on any licence or grant is to adopt a different approach to that set out above (for example by allowing an extended notice period), we may consider reviewing the fees paid by the licensee/grantholder in question, in line with our pricing framework.

fixed link licences, interference risks are constrained to new UK Broadband deployments at 3605MHz to 3689MHz, which must take account of any existing registered satellite earth station receive components in this band. In contrast, licensees seeking to use the 700MHz band in the interim period needed authorisation to transmit and could not have operated without this.

5. The future award and other issues raised in the consultation

5.1 Stakeholders raised a number of wider issues in response to the July 2017 document. We consider these briefly below.

UK Broadband

5.2 BT/EE asked Ofcom to be more specific regarding its intentions for how UK Broadband's frequency assignments would be handled in the award. Telefónica said it would be important to consult with stakeholders on any proposals related to the UK Broadband licence. [✂] commented on the use of UK Broadband frequency assignments [✂].

Ofcom's response

5.3 We are considering issues relating to the UK Broadband licence at 3605MHz to 3689MHz, and will consult in preparation for the future award. We do not propose to [✂], which we do not think would deliver optimal spectrum use.

Future award

Timing and design

5.4 A number of stakeholders offered comments on the future award. BT/EE and techUK suggested that there should be a combined award of the 3.4GHz to 3.6GHz and 3.6GHz to 3.8GHz bands.[72] [✂] disagreed and said the two bands should be kept distinct [✂].

5.5 Some respondents (Surrey University 5GIC, UKWISPA, Landways Management and a confidential respondent [✂]) proposed that to optimise spectrum efficiency the future award should be designed to support alternative use cases to national mobile deployment, including rural licences to support Fixed Wireless Access, a second 'opportunistic use' tier and [✂]. ESOA/GVF and Intelsat queried whether the spectrum would be licensed on an exclusive basis for 5G.

Ofcom's response

5.6 Ofcom made a decision in July 2017 to auction the 2.3GHz and 3.4GHz to 3.6GHz bands together.[73] That decision is currently the subject of judicial review proceedings by BT/EE and H3G. Subject to the outcome of those proceedings, Ofcom intends to proceed with that award as soon as possible.

[72] [✂]

[73] Ofcom, *Award of the 2.3 and 3.4GHz spectrum bands: Competition issues and Auction Regulations: Statement*, July 2017, 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

5.7 We remain minded to deliver an award of the remaining 116 MHz being made available in the 3.6GHz to 3.8GHz band in 2019.

5.8 The design of the future award for this band will be a matter for a future consultation. We plan to consult on the policy objectives for the award and to assess how best to further consumers' interests through the promotion of competition and, where opportunities exist, innovation. We will take account of the responses received to this consultation when we undertake this work.

5.9 No licences issued by Ofcom are exclusive, and we have discretion to authorise use of any spectrum frequencies, for any purpose, in line with our statutory duties.

Fixed wireless access

5.10 UKWISPA said that the EC Decision specifically asks for the band to be used for fixed, nomadic, or mobile networks and that Ofcom had ignored the fixed requirement. It said the 3.4GHz to 3.6GHz and 3.6GHz to 3.8GHz bands are ideal for Fixed Wireless Access (FWA) and called on Ofcom to enable this use for FWA provision of broadband in rural areas.

Ofcom's response

5.11 We recognise that the European harmonised technical standards for this band[74] allow for FWA use, and UKB already offers FWA services within this band. When considering the potential future users of the band, we consider that overall the greatest benefits are likely to be delivered by ensuring that future mobile services including 5G can be deployed in many areas across the UK. However, as set out in paragraph 5.8 the design of the future award relating to this band will be a matter for a future consultation.

5.12 We have also said that we see greater potential for shared access in the adjacent 3.8GHz to 4.2GHz band and plan to consult on proposals for this in 2018, as set out in paragraph 3.49 above.

Further technical analysis

5.13 We will take forward work to determine the technical conditions for the future licences to be made available in the award. This will include details of any conditions required to manage the risk of interference between new systems, existing mobile networks or any specific locations that we determine need to be protected, including details of coordination relating to current licensees and grantholders during notice periods.

5.14 We will consult on the proposed technical conditions for future licences.

5.15 As set out in section 3, we will publish an update and consultation on coexistence with operations at 3.8GHz to 4.2GHz in 2018.

[74] In accordance with the EC Decision Ofcom is required to award future licences for the 3.6 to 3.8 GHz band in compliance with the technical parameters set out in the Annex to the EC Decision.

Other technical conditions

5.16 We will work with the MOD to identify appropriate restrictions for future licences to ensure that Defence capabilities are not unduly affected.

5.17 We will work with neighbouring National Regulatory Authorities to identify any future coordination requirements.

Other implementation steps

5.18 As we set out in the July 2017 document, as a consequence of the decisions taken in that document we also intend to:

- bring the 3.6GHz to 3.8GHz band under the Mobile Trading Regulations prior to a future spectrum award. We published a separate consultation on proposals to the band under the Mobile Trading Regulations in December 2016[75] and will publish a statement;
- consult on a draft statutory instrument to remove the option to have a grant of RSA for ROES issued in the 3.6GHz to 3.8GHz band; and
- update the UK Frequency Allocation Table and Technical Frequency Assignment Criteria to reflect the future use of the band.

[75] Ofcom, *Proposed changes to spectrum trading regulations: Statutory notices of proposals to make regulations under section 122 of the Wireless Telegraphy Act 2006: consultation*, December 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0030/96087/STR-changes.pdf

A1. Summary of stakeholder responses

A1.1 This annex summarises the 19 submissions we received from stakeholders in response to our July 2017 Statement and Consultation (the "July 2017 document"), together with our response to their submissions. A small number of respondents included confidential material, which we have taken into account. All non-confidential responses are published on our website.

A1.2 In this annex, we first give a high-level overview of the consultation responses, followed by a summary of specific comments made by stakeholders and our responses to these.

High level summary of responses

A1.3 Most respondents with an interest in satellite use, including ESOA/GVF, Intelsat, Speedcast and the UK Space Agency, were opposed to our proposed approach (option B in the July 2017 document). The Met Office however were supportive of our proposals provided that at least some capacity within the remaining C band (3.8GHz to 4.2GHz) is maintained. TechUK generally supported our proposed approach but noted that some of its satellite-focused members believed that it is important to protect existing satellite earth stations, particularly large gateway sites. The BBC did not explicitly disagree with the proposed approach but noted specific concerns around potential impacts on its BBC Monitoring operation. The Ministry of Defence (MOD) thought that fixed links posed the greatest barrier to 5G roll-out in key demand areas, and that removing satellite services in the band seemed disproportionate.

A1.4 Mobile respondents including H3G, Telefónica and the GSA, and respondents with an interest in both satellite and mobile use, including BT/EE and Vodafone, supported our proposed approach. Intel also supported our proposed approach. Arqiva, which has interests across satellite, fixed links and mobile, broadly supported the overarching aim of releasing spectrum for mobile 5G use, but expressed concerns relating to fixed links timescales, availability of alternatives and funding for mitigations.

A1.5 UK WISPA, representing a group of wireless internet service providers, did not comment on the proposed approach to existing authorisations in the band but said that it disagreed with auctioning the 3.4GHz to 3.8GHz bands nationally. The University of Surrey 5G Innovation Centre (Surrey 5GIC) agreed in principle with Ofcom's proposed approach to existing authorisations in the band but also thought that a national licensing approach would be inefficient. Landways Management Limited, a provider of digital infrastructure solutions, agreed with our proposed approach but thought that adoption of a geographically non-uniform approach could mean the relocation of existing users could be deferred for many years. [✂]

A1.6 Several respondents with interests in satellite and fixed links thought that we had underestimated the costs and/or impacts of our proposed approach. However we did not receive any substantive new evidence on specific costs and benefits. Some of the satellite

respondents questioned the estimation of the benefits of mobile use. We discuss specific comments made by respondents in the detailed summary of responses below.

Detailed summary of responses

A1.7 In the table below we present the specific comments made by stakeholders in their submissions. Comments are grouped to reflect the main themes raised by respondents.

Compatibility of option B with the EC Decision ESOA and GVF, Intelsat and the UK Space Agency argued that option B is inconsistent with the requirements and/or spirit of the EC Decision that this spectrum be made available for mobile on a non-exclusive basis and "without prejudice to the protection and continued operation of other existing users in this band". ESOA/GVF also argued that option B is incompatible with the technical parameters stipulated by the ECC.	We respond to these comments in paragraphs 3.65 to 3.69. We consider that our intended approach is consistent with the EC Decision. We note that ECC Reports are advisory and provide shared information for national administrations to consider; they do not contain binding requirements.
Demand for future mobile services and likely deployment patterns The GSA said that 5G would need to be delivered broadly across the whole country and that the 3.4GHz to 3.8GHz band would play a key role in this. It noted its agreement with statements provided by the mobile operators during the previous consultation that macro layer coverage would be a clear priority for mobile operators to support wider, faster and cost effective roll out. Telefónica thought that UK wide licensing of the 3.6GHz to 3.8GHz band, without restrictions on mobile network operators' deployment, would ensure a homogeneous deployment of 5G services. It noted that it provides coverage nationally and that areas of interest for the usage of the 3.6GHz to 3.8GHz band would be UK wide. BT/EE, H3G and Vodafone also supported Ofcom's proposed approach. The University of Surrey 5GIC said that 5G in the 3.4GHz to 3.8GHz band would be urban dense small cell networks, which might only cover around 10% of the UK geography. It predicted that there would likely remain many pockets in urban and suburban areas with no dense small cell coverage. It asserted that it is not efficient to mix macrocells and microcells in the	We address responses relating to demand for mobile services in the 3.6GHz to 3.8GHz band in paragraphs 3.6 to 3.16. In the annex to the July 2017 document we noted that stakeholder responses to the October 2016 consultation indicated that there were likely to be very large benefits to be gained by making the band available for mobile. However, we noted that it was difficult to make a full quantitative evaluation as the evidence provided to us was often based on different methodologies and assumptions, and cannot be considered comparable.[76] Given the clear demand for future mobile use of the spectrum, we do not see a case

[76] See annex 6, pages 79-80 of the July 2017 document.

same spectrum band, and 3.4GHz to 3.6GHz should be used for macrocells and 3.6GHz to 3.8GHz for microcells. UKWISPA called on Ofcom to review its assumption that mobile operators will use this band to deploy in rural areas using existing cell sites and argued that this spectrum would be unlikely to be deployed over more than 7% of the land mass of the UK. Goonhilly Earth Station argued that that it was unlikely that MNOs would deploy at 3.6GHz to 3.8GHz in rural areas. Intelsat and ESOA/GVF said that studies attempting to quantify the economic value of making C-band available for terrestrial mobile services tended to be based on methodological flaws, which result in significantly exaggerated economic benefits. They questioned the viability of the business case for the terrestrial use of the band. The UK Space Agency said it would be sensible to await the outcome of the adjacent 3.4GHz to 3.6GHz auctions before making any irreversible decisions around the need for mobile to displace satellite use in the 3.6GHz to 3.8GHz band. The MOD suggested that the results of the auction of 3.4GHz to 3.6GHz could be used to determine the right approach to changes of access for the 3.6GHz to 3.8GHz and 3.8GHz to 4.2GHz bands.	for deferring confirming our approach to the band.
Impacts of option B on holders of PES licences and grants of RSA *Specific comments on costs:* Arqiva said that it was difficult to assess with any great precision what costs would be involved in migrating existing services until there was a firm steer as to what the alternative spectrum would be. Speedcast said that the costs are extremely difficult to determine at this point in the process. Speedcast also commented that it did not believe that Ofcom had sufficiently considered the magnitude of the impact and associated costs of option B on existing licensees. Vodafone thought that with a suitable transition period, the costs of migration of existing users should not be significant in comparison to the benefits of making the band available for mobile usage. Telefónica agreed that the benefits of enabling more widespread future mobile services in the band outweigh the costs.	We present our assessment of the impacts on existing satellite users of the band in paragraphs 3.30 to 3.36. We recognise that, as noted in the July 2017 document (paragraph 7.50), our intended approach to existing authorisations could result in the need for retuning or other adaptations to equipment in the UK and overseas, potentially also affecting uplink operations in cases of fixed frequency pairings. We also recognised that affected users might need to adjust other aspects of their operations. We did not receive any substantive evidence demonstrating that the scale of

Challenges of migrating to new frequencies: The BBC responded that Ofcom's decision would have a material impact on BBC Monitoring operations and remove the flexibility required to receive sources wherever they are broadcast between 3.6GHz to 3.8GHz. It said it would not be possible for BBC Monitoring to operate on a licence exempt basis, as this could not ensure continuity of services for both the BBC's own news gathering and for BBC Monitoring's external clients. Intelsat and ESOA/GVF said that migration away from the 3.6GHz to 3.8GHz band to the 3.8GHz to 4.2GHz band might not always be possible in practice. Intelsat cited the need to renegotiate long-term commercial arrangements, limited space in the upper part of C-band and no certainty that alternative capacity would be identified as barriers to migration. ESOA/GVF added that "equivalent" capacity is not necessarily available in higher bands or might only be available on a different satellite and that changing the downlink frequency of a UK earth station means changing the uplink frequency of all remote stations. It said these changes could take a long time to complete and could be very expensive as customers would require "dual illumination". Speedcast thought that migration to other frequencies would not be possible in every case because frequencies may not be available and this would impact its customers which require broadband connectivity to locations that terrestrial services cannot reach. It said this would also result in stranded infrastructure that is unusable, and require renegotiation of long-term commercial arrangements with satellite operators. It said compression of the C-band would increase congestion and further limit operational flexibility. It also said that this process would be far more costly and complicated than the July 2017 document suggested. Goonhilly Earth Station suggested that removing its PES licence in the 3.6GHz to 3.8GHz band would have a significant detrimental impact on its business. *Other issues:* Speedcast noted that the use of alternative technologies would not be universally feasible, and said that other satellite bands would not provide a viable answer. Intelsat and ESOA/GVF said that gateway earth stations no longer being able to access the 3.6GHz to 3.8GHz band in the	these adjustments would be greater than we originally expected. We will take into account any further representations from affected licensees/grantholders regarding their individual circumstances when we take final decisions on proposed variations of PES licences and grants of RSA. While we recognise that our proposed approach could have an impact on some gateway earth stations due to these no longer being able to monitor or diagnose communication traffic issues in the 3.6GHz to 3.8GHz band, we do not consider that this specific issue would necessarily prevent gateway earth stations in the UK from providing commercial services. In the July 2017 document we noted that there may be a very small number of satellites accessed by registered stakeholders in the UK which do not have a tracking beacon using frequencies above 3.8GHz, which might result in some satellite earth stations needing to adopt alternative tracking mechanisms for these satellites.

UK would effectively preclude them from monitoring and diagnosing communications traffic issues and that this would have an immediate impact on service providers' day-to-day operations and make it difficult to effectively provide commercial services in this band throughout the region. Intelsat, ESOA/GVF and Speedcast all noted that, in general, C-band satellite systems have fixed frequency pairings, meaning that the loss of 3.6GHz to 3.8GHz to satellites could result in the loss of C-band uplink in the 6GHz band. Speedcast added that this would have knock-on impacts on satellite and earth station licences issued by dozens of nations. In relation to implementing alternative tracking mechanisms for satellites which do not have a tracking beacon using frequencies above 3.8GHz, ESOA/GVF said this might require entirely new equipment and ways of operation, and said Ofcom should allow sufficient time, and arrange compensation for, these upgrades.	
International impacts of proposals on satellite use Intelsat and ESOA/GVF commented that the proposals set a concerning precedent by removing current authorisations for incumbent services. They said Ofcom's strategy is unprecedented in terms of the potential disruption for existing users of the band and that such actions if taken on a regional or international basis would undermine global harmonisation. The UK Space Agency suggested that the choice of option B as proposed could discourage future investment in the UK and that some industry may leave the UK. It also said option B would have a significant negative impact on the government's ambition for the UK space sector to capture 10% of the global market by 2030.	We note that it is for national administrations to take spectrum decisions based on national circumstances (subject to relevant European and ITU obligations). As we set out in paragraph 3.31, we have not identified 3.6GHz to 3.8GHz as a key growth band for the satellite sector in the UK. The Government has set out its assessment of the potential benefits of 5G services to the UK economy in its 5G Strategy.[77]
Proposed alternative implementation approaches for satellite earth stations Intelsat suggested that we should facilitate coexistence between incumbent satellite users and new services. It said satellite earth stations and fixed links in suburban or rural areas should be afforded protection, while incumbent users in cities	We discuss proposed alternative approaches in paragraphs 3.58 to 3.64.

[77] DCMS and HM Treasury, *Next Generation Mobile Technologies: A 5G strategy for the UK*, March 2017, https://www.gov.uk/government/publications/next-generation-mobile-technologies-a-5gstrategy-for-the-uk (accessed 19/10/2017)

and urban areas would need their protection assessed on a case-by-case basis. ESOA/GVF made a similar point, saying that conditions could be included in mobile licences to protect earth stations and fixed links in areas of low mobile demand. Speedcast proposed a modified version of option A that (i) enables continued licensed access to the 3.6GHz to 3.8GHz band by FSS earth stations to the maximum extent feasible, without any increase in spectrum fees; (ii) allocates the costs of spectrum sharing or incumbent relocation (where necessary) to new entrants; and (iii) enables future earth station deployment in the 3.6GHz to 3.8GHz band on a licensed, first-in-time basis. techUK said that some of its satellite-focussed members believe that it is important to protect existing satellite earth stations, particularly large gateway sites operating in the band, from undue interference given the importance of the traffic that is carried and the benefits that satellite connectivity provides. The UK Space Agency proposed concentrating satellite teleports in a limited number of key sites which would be fully protected from mobile interference. Goonhilly Earth Station argued in favour of a "special spectrum zone" around its Cornwall site to allow space sector users to continue to use the same frequencies in at least one part of the UK.	
Additional points regarding satellite use ESOA/GVF argued that option B goes against Ofcom's statutory duty to protect incumbent operators and the benefits they provide for citizens and consumers. The UK Space Agency highlighted that earth stations in the 3.6GHz to 3.8GHz band are currently operating within a primary FSS allocation. Intelsat and ESOA/GVF asked Ofcom to provide clarification on grandfathering of earth stations, including whether additional grandfathered sites would be allowed to renew existing licensing and whether licensees could deploy further antennas within the grandfathered site. The MOD noted that there are a small number of MOD locations using the 3.6GHz to 3.8GHz band, including Bude in Cornwall, that would require protection.	We consider that our intended approach to existing authorisations for fixed links and satellite earth stations in the 3.6GHz to 3.8GHz band is consistent with our statutory duties, for the reasons set out in section 3. We have taken into account the benefits provided to citizens and consumers by incumbent services in this band and consider that in most cases, if not all, these benefits could be maintained. The Radio Regulations do not constrain our national spectrum management decisions in this

	case. The UKFAT reflects Ofcom policy, and as outlined in section 5 it will be updated following the publication of this statement. Our intended approach does not include any provision for grandfathering of satellite earth stations. We discuss our approach to interim licence variations in paragraphs 4.40 and 4.41. As we noted at paragraph 9.13 of the July 2017 document, we will work with the MOD to identify appropriate restrictions for future mobile licences to ensure that Defence capabilities are not unduly affected.
Impact of fixed links clearance on Freeview backhaul services Arqiva said that the proposal to clear fixed links appeared to be leaving the issue of ongoing DTT backhaul provision in the Outer Hebrides, Orkney, Shetland and the Isle of Wight to the judgement of the market. It said this was in potential conflict with Ofcom's statutory duties relating to the provision of TV services as well as wider obligations and policy objectives.	We discuss this issue in paragraphs 3.40 to 3.46.
Replacement spectrum for fixed links Arqiva and techUK said that Ofcom should identify alternative spectrum for fixed link users. Arqiva said that Ofcom had made a weaker commitment to find alternative spectrum for fixed links than it had done for satellite, which could move to the 3.8GHz to 4.2GHz band, and than it had done in other previous cases such as for DTT and PMSE moving from the 700MHz band. It suggested that other technologies were unlikely to be a credible option. It said it was committed to engaging with Ofcom to find a solution but that this work needed to be underpinned by the same assurances given to other sectors.	There are a number of alternative bands which may be suitable for fixed links including lower and upper 6GHz, 7.5GHz and 13GHz. In the July 2017 document we noted that alternative frequencies or technologies could be used. We will engage with individual licensees to explore which alternative spectrum is suitable and available on a case by case basis.

Future spectrum access in the 3.8GHz to 4.2GHz band Several respondents including Arqiva, the BBC, BT/EE, Intelsat, MOD and techUK, called on Ofcom to provide more assurances on future satellite use of the 3.8GHz to 4.2GHz band. The GSA on the other hand suggested that access to the 3.8GHz to 4.2GHz band for 5G would bring significant benefits to UK citizens and consumers. Arqiva said that there was no commitment within Ofcom's proposed approach to support a long-term satellite allocation in the 3.8GHz to 4.2GHz band, calling into question whether the satellite sector can migrate to this band with sufficient long-term confidence. The BBC noted the decision on 3.6GHz to 3.8GHz was being made ahead of recommendations about the future use of the 3.8GHz to 4.2GHz band for 5G and thought this introduced significant regulatory uncertainty about the future of satellite services in this band. It noted the need to understand how the whole of C-band would be used in the future to properly consider the costs and benefits of any mitigation options. It urged Ofcom to provide clarity as soon as possible. BT/EE thought it was important that Ofcom provided assurances to satellite network operators about the continued availability of the adjacent 3.8GHz to 4.2GHz band to support migration from the 3.6GHz to 3.8GHz band and to give confidence to make further new investments in satellite systems. Intelsat asked Ofcom to confirm that the 3.8GHz to 4.2GHz band would not be the subject of future measures. It was concerned about the potential opening of the C-band to geographical sharing and said it needed regulatory certainty for future investment. The MOD said that a period of secure tenure should be provided for satellite services in 3.8GHz to 4.2GHz, especially those being affected by the change in 3.6GHz to 3.8GHz. techUK said that if protection of satellite earth station reception in the 3.6GHz to 3.8GHz band ceased, it was important for Ofcom to clarify and confirm future availability of the 3.8GHz to 4.2GHz band for satellite use, including suitable adjacent band protection.	We address respondents' comments around future access to the 3.8GHz to 4.2GHz band in paragraphs 3.48 and 3.49.

The GSA thought it would be beneficial to account for future scenarios in the 3.8GHz to 4.2GHz range. It suggested earth stations could be migrated to alternative sites in remote areas with low population density or could be migrated to frequencies outside the 3.4GHz to 4.2GHz range.	
Coexistence and other impacts in relation to the 3.8GHz to 4.2GHz band The BBC said it strongly disagreed with Ofcom's current approach to coexistence between new services in 3.6GHz to 3.8GHz and operations above 3.8GHz noting that the July 2017 document offered no clarity on the coexistence impacts. It noted concerns about excessive out-of-band emissions or desensitisation of receivers by high levels of signal in adjacent channels. BT/EE thought that it was a pragmatic proposal to include some restrictions in mobile licences to protect satellite use in the 3.8GHz to 4.2GHz band if necessary but that these should be should be carefully determined and should not preclude mobile use to any significant extent. Intelsat and ESOA/GVF said we had not addressed concerns on impacts to earth stations in 3.8GHz to 4.2GHz band. They said 5G transmissions anywhere in the C-band downlink could cause interference to satellite operations because these could overwhelm the ability of the earth station to receive low-power satellite transmissions anywhere in the band, cause intermodulation effects, and create other interference issues. Speedcast said that option B meant that in many cases it may be necessary to replace low noise block downconverters (LNBs) for all C-band use and this would have highly significant costs that should be addressed by Ofcom.	We discuss issues relating to adjacent band coexistence in paragraphs 3.52 to 3.57. As noted there, our initial analysis shows that any interference impacts are dominated by the adjacent channel selectivity performance of the satellite (or fixed link) receivers, i.e. where these receivers 'listen' to signals below 3.8GHz. In the July 2017 document we noted that there may be equipment related costs such as purchasing and installing new equipment suitable for use with different frequencies (see paragraph 7.50). This could include the costs of purchasing and installing filters or new LNBs where these are needed. It is our understanding that costs could vary depending on the specific circumstances of individual deployments, including the specific configuration of equipment. In many cases, it may be possible to retrofit a filter to the satellite earth station prior to a low noise amplifier (LNA) rather than replace an LNB downconverter.

Reasonableness of proposed notice periods Arqiva supported the proposal to remove downlink protection from its existing satellite C-Band licences within the proposed timescale of June 2020 but suggested that Ofcom should specify that protections will be removed at the same time as the 700MHz and 3.6GHz to 3.8GHz bands are made available, so that protections for satellite services are extended in the event that there is any delay in securing availability in either of these bands. It said that it was unclear whether the proposed five years notice for fixed links was sufficient because Ofcom had given no guarantees of alternative replacement frequencies. BT/EE agreed with the proposed notice period while noting that there were some complexities it had to resolve to meet the 2020 date. It also noted agreement with proposed revocation of existing fixed links licences and urged Ofcom to proactively work with the licensees to facilitate migration of the links to new frequencies by 1 June 2020. H3G agreed with our proposal to serve notice on fixed links and satellite earth stations but was concerned about risks to the proposed timelines, noting that the satellite community could be expected to oppose Ofcom's proposal. Vodafone agreed that the June 2020 date was appropriate but thought that Ofcom should explicitly set out its justification for this date. It also noted that the transition period would also comprise the time during which satellite earth stations could likely have *de facto* protection, given the relative geographic locations of satellite earth stations and early 5G deployments in the band. The BBC, ESOA/GVF, Intelsat, MOD, Speedcast and the UK Space Agency all thought that the proposed June 2020 notice period for satellite earth stations was too short: The BBC said that the proposed variation period was considerably shorter than it had been anticipating. It noted that BBC Monitoring had invested on the basis of an annually renewable grant with a five-year revocation period, that around 75% of their use was in 3.6GHz to 3.8GHz and therefore this change was closer to a licence revocation than a licence variation.	We discuss proposed notice periods in paragraphs 4.5 to 4.19. With regard to Arqiva's point that we should specify that protections will be in place until the band is made available, we have explained that we plan to award the spectrum in 2019. As we set out in paragraph 4.38, we would continue to maintain appropriate protections for registered band users whose licence(s) or grant(s) of RSA are revoked or varied (as applicable) until the relevant notice period had lapsed. Satellite earth station users will also continue to be able to receive on a licence exempt basis after PES licences and grants of RSA are varied. We will take into account any further representations from affected licensees/grantholders before taking final decisions on the appropriate notice period in each case.

The MOD thought that a minimum five years' notice would be a more realistic compromise. The UK Space Agency and Speedcast both argued at least 15 years' notice would be needed. The UK Space Agency said that satellite re-investment cycles are typically 20 years and noted issues with long-term lease agreements, limited freedom to change frequency and no guarantee of spare capacity. Speedcast said that the relocation of large earth stations could not be completed by mid-2020. It said such a short time period upsets settled expectations on which licensees have invested substantial capital. It noted that the useful life of the affected facilities exceeds the remaining term of Speedcast's UK earth station licences. It further noted that its contracts typically carry lengthy terms, and that there would be many contracts in 2020 that would need to be renegotiated or broken prematurely.	
Funding Intelsat, ESOA/GVF and Speedcast argued that compensation should be offered for the costs that earth station operations will have to incur. techUK said that support to facilitate migration of earth station assignments from 3.6GHz to 3.8GHz should be explored, and BT/EE said that Ofcom should consider whether compensation could accelerate the migration of existing satellite services in the band. Both Intelsat and ESOA/GVF argued there were strong reasons for compensation saying that migration was costly or even not possible, that it would require extensive renegotiations between service providers and satellite operators and lack of guarantees regarding future of the 3.8GHz to 4.2GHz band added to the uncertainty. Speedcast said it should be for new entrants to compensate the incumbents, and that relevant costs might include transponder lease and customer service contract termination costs, foregone customer revenues, migration to new spectrum or new locations, interference mitigation and equipment replacement costs, and migration to new technologies. The UK Space Agency said that the approach to mitigation costs was not consistent because incumbent services would have to completely fund any mitigation, while mitigation approaches involving sharing had been rejected 'on the basis of increased costs to the mobile sector'.	We respond to calls for funding in paragraphs 4.22 to 4.24. As we explain in more detail in section 4, we consider that we are proposing reasonable notice periods to licensees/grantholders in line with the terms of licences/grants and we therefore do not see a case for providing funding. As we set out in section 3, it is our assessment that the net benefits to consumers and citizens will be greatest under option B compared to option A and other approaches put forward, and that this will deliver optimal use of spectrum. We took account of costs and other impacts as part of our assessment. Ofcom works closely with Government on issues of shared interest and has updated DCMS orally on issues raised by

Arqiva was in favour of funding for fixed links, and said that the 700MHz clearance programmes should be expanded to capture all 5G clearances. They suggested it would be a "potentially perverse" position whereby government is funding 5G related clearance in one band (700MHz) and not in another (3.6GHz to 3.8GHz). techUK said that Ofcom should work with Government to provide appropriate support for fixed links, particularly if this were to enable clearance ideally before 2020. BT/EE supported providing some compensation to fixed links licensees if this could further accelerate clearance of the few remaining links by 2020 and thought that Ofcom should urgently pursue this with Government. Both Arqiva and Speedcast noted past examples where clearances have been funded, including DTT and PMSE from the 700MHz and 800MHz bands, radio astronomy use from 606MHz to 614MHz and civil aviation radar from the 2.6GHz band, saying that these set precedents for funding migration costs.	stakeholders in response to the July 2017 document, including with respect to mitigation costs, and our initial assessment of these issues.
Future award timing and approach BT/EE supported a combined 3.4GHz to 3.6GHz and 3.6GHz to 3.8GHz (and possibly 700MHz) auction, and said the case for this had become compelling given the delays to the award of the 3.4GHz to 3.6GHz spectrum. It noted that 3GPP is standardising 5G at present and is specifying channel bandwidths of up to 100 MHz for equipment in bands below 6GHz, and said that a joint award would maximise the opportunity for large contiguous assignments. techUK suggested bringing forward the 3.6GHz to 3.8GHz auction to be run in parallel with the 3.4GHz to 3.6GHz auction, which it argued would allow for decreased costs for all parties, and increasing the certainty of outcomes.[78] [✂] disagreed and said the two bands should be kept distinct [✂].	We respond to comments on the approach to the future award in paragraphs 5.6 to 5.9.
Alternative use cases Landways Management, UKWISPA and the Surrey 5GIC offered support for an alternative licensing approach.	We respond to suggested alternative uses of the spectrum in section 5.

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Landways Management thought that optimum benefit would be delivered by adopting a non-uniform licensing approach that allocated spectrum on as small a granularity as is practically possible (considering for example buildings, developments and postcode sectors as units of allocation). UKWISPA disagreed with auctioning the 3.4GHz to 3.8GHz bands nationally. It argued that the spectrum is ideal for Fixed Wireless Access and that Ofcom had ignored the new WISP (Wireless Internet Service Provider) need for this band and the public good by helping rural broadband delivery. The Surrey 5GIC said that given its assessment of future 5G deployment scenarios Ofcom should enable a second layer of spectrum exploitation that allows "opportunistic use", including indoor use, to be maximised over the entire 3.4GHz to 3.8GHz band on a non-interference basis. [✂]	
Issues related to the UK Broadband licence BT/EE asked Ofcom to be more specific in terms of its intentions with regard to how UK Broadband's frequency assignments would be handled in the award. Telefónica said it would be important to consult with stakeholders on any proposals related to the UK Broadband licence. [✂] commented on the use of UK Broadband frequency assignments [✂].	We respond to comments on the UK Broadband licence in paragraph 5.3.
Variations and new licence applications in the interim period Arqiva, Vodafone and the UK Space Agency disagreed with Ofcom's proposed approach to not allow further licensing or variation of incumbent applications in the intervening period before removal of protections. Arqiva questioned the rationale for not allowing new licence applications for satellite downlink protection and said it appeared to serve no purpose. Vodafone disagreed with Ofcom's approach and said there was no reason why an operator of an existing earth station should be prevented from deploying new links in the band if they accept that this protection is temporary and will not be there post-2020. It said it may make sense to use such links on a transitionary basis as part of migrating use from the band. It said the approach was spectrally inefficient and had been	Our policy on closing the band to new authorisations is set out in paragraph 2.21. We discuss stakeholder comments on our policy on variations to existing PES licences and grants of RSA in the intervening period before removal of protections in paragraphs 4.40 to 4.41. Satellite earth stations will continue to be authorised to receive on a licence exempt basis. With regard to Vodafone's proposal for discounting fees

implemented unilaterally without consultation. It suggested this approach meant there may be a case for fees for incumbent users of the band to be subject to a discount when compared to the current AIP rates. The UK Space Agency said it was disappointed that no further applications for PES or RSA were being accepted and that this eliminated the potential for any future growth of the UK space sector within this spectrum and was not compatible with government policy to grow the space sector.	for existing registered users, we outline in paragraph 4.39 that we do not currently intend to review the fees paid by these users.
Proposal for localised restriction zones The BBC welcomed Ofcom's examination of potential future mobile restriction zones around satellite earth stations. The UK Space Agency said that they were keen to investigate how this approach might be realised, but that it should not be constrained by the requirement to "not have a material impact" on mobile deployments. Goonhilly Earth Station argued in favour of a "special spectrum zone" around its Cornwall site to allow space sector users to continue to use the same frequencies in at least one part of the UK. Stakeholders with an interest in mobile had reservations about restriction zones. The GSA said they would support further technical analysis on the possibility to apply localised restrictions in future mobile licences around a limited number of Earth stations in remote areas, provided that any constraint to mobile deployment should be kept to a minimum. Telefónica said that any uncertainty created by such restrictions would constitute material impact and urged Ofcom to carefully consider the implications of such restrictions. It thought that any restrictions could prevent the widespread deployment of mobile services, impact upon competition, devalue the spectrum and result in a loss of benefits to consumers and citizens in the UK. H3G said localised restrictions should only be implemented as a last resort and only for a short period of time, and should be subject to regular review by Ofcom to determine their continued suitability.	We discuss comments on restriction zones in paragraphs 4.25 to 4.32.

Vodafone thought that any zones should be coordination rather than exclusion zones, and if mitigation measures were not possible without compromising mobile service, the mobile licensee should not be prevented from deploying. They suggested that zones of the order of 1-3km represented a reasonable compromise. They added that these should be on a temporary basis only, and expire five years from the point at which Ofcom confirms its policy. BT/EE thought that restrictions in mobile licences should be carefully determined to give reasonable protection in immediate vicinity of satellite sites without prejudicing mobile use to any material extent, if necessary to protect satellite use in the adjacent 3.8-4.2GHz band. It suggested that the distance from the earth station sites for which restrictions in mobile licences could be appropriate should be small (e.g. c.1km)	
Infrastructure competition rules The Surrey 5GIC said Ofcom should ease the infrastructure competition rules for the band 3.4GHz to 3.8GHz to facilitate voluntary spectrum pooling and small cell (RAN) sharing.	The primary framework for considering the impact of RAN sharing or network sharing agreements is UK or EU competition law.[79] In our Digital Communications Review in 2016, we indicated we were sympathetic to network sharing arrangements that can reduce the cost of coverage, especially in rural areas (though we would look closely at their impacts on competition and consumers).[80]

[79] See paragraph 5.45 of Ofcom, *Consultation on assessment of future mobile competition and proposals for the award of 800MHz and 2.6GHz spectrum and related issues. Annex 6: Competition Assessment*, March 2011, https://www.ofcom.org.uk/__data/assets/pdf_file/0023/47930/annex_6.pdf

[80] See paragraph 4.58 of Ofcom, *Making communications work for everyone. Initial conclusions from the Strategic Review of Digital Communications*, February 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0016/50416/dcr-statement.pdf

A2. Glossary

3GPP	The 3rd Generation Partnership Project (3GPP), a body that develops standards for mobile technology
5G	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.
BBC Monitoring	A division of the BBC which monitors and reports on mass media worldwide. Reporting produced by the service is used as open-source intelligence by the Government and commercial customers.
BT/EE	A UK mobile network operator
CEPT	The European Conference of Postal and Telecommunications Administrations
Communications Act	The Communications Act 2003
EC	European Commission
ECC	Electronic Communications Committee, one of the three business committees of the CEPT.
ESOA	EMEA Satellite Operators' Association
EU	European Union
FSS	Fixed Satellite Service
FWA	Fixed Wireless Access
GHz	Gigahertz, a unit of frequency of one billion (10^9) cycles per second
GVF	Global VSAT Forum
H3G	Hutchison 3G UK a mobile network operator which trades as Three (or 3) in the UK
ITU	International Telecommunications Union, an agency of the United Nations with a membership of 193 countries and over 700 private sector entities and academic institutions. ITU's headquarters are in Geneva, Switzerland.
LNA	Low Noise Amplifier, an electronic amplifier that amplifies a very low-power signal without significantly degrading its signal-to-noise ratio.
LNB	Low Noise Block downconverter, a combined low noise amplifier and intermediate frequency downconverter, normally used with smaller antennas or VSAT terminals.
LTE	Long Term Evolution, part of the development of 4G mobile systems that started with 2G and 3G networks.
MHz	Megahertz, a unit of frequency of one million cycles per second.
MNO	Mobile Network Operator
MTR	Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011

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, 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.
RSPG	Radio Spectrum Policy Group, a European advisory body on spectrum issues.
TDD	Time Division Duplex, a technology that deals with traffic asymmetry where the uplink is separated from downlink by the allocation of different time slots in the same frequency band in unpaired spectrum.
TD-LTE	Time Division Long Term Evolution, sometimes referred to as Long Term Evolution Time-Division Duplex.
WT Act	The Wireless Telegraphy Act 2006
UK Broadband	A UK supplier of fixed wireless mobile services trading as Relish, now owned by H3G
UKFAT	UK Frequency Allocation Table