



Improving consumer access to mobile services at 3.6 to 3.8 GHz

Consultation

Publication date:

6 October 2016

Closing Date for Responses:

1 December 2016

About this document

This document presents our initial thinking on how we could expand spectrum access for mobile services in the 3.6 – 3.8 GHz band. We consider this band a high priority band for future mobile use, due to the large amount of spectrum available and the interest in this band for the rollout of future 5G services (the fifth generation of mobile connectivity technology, which is currently being developed).

Part of the band is already authorised for electronic communications networks (which includes mobile and fixed communications), where spectrum access is coordinated with other current spectrum users.

In this document, we set out two broad policy options that could allow mobile including 5G use in the rest of the band. In considering the future of this band, we are taking into account the services provided by existing use of fixed links and satellite services to citizen and consumers. We are seeking input from stakeholders that will inform our future policy proposals.

Contents

Section		Page
1	Executive summary	1
2	Introduction	4
3	Our statutory duties	6
4	Current usage	9
5	Harmonisation of the 3.4 to 3.8 GHz band	20
6	Potential for mobile	22
7	Applying our statutory duties	25
8	Coexistence analysis	27
9	Policy options to enable mobile at 3.6 to 3.8 GHz across the UK	30
10	Next steps	35
Annex		Page
1	Responding to this consultation	37
2	Ofcom's consultation principles	39
3	Consultation response cover sheet	40
4	Consultation questions	42
5	Coexistence analysis	43
6	Legal framework	48
7	Glossary	53

Section 1

Executive summary

- 1.1 Consumer use of mobile data, via smartphones, tablets and other devices is growing fast. Total data traffic across networks in recent years has been growing at around 60% a year. We believe that strong growth will continue for some time and is likely to be driven by new products and services made available by future mobile technologies such as 5G¹.
- 1.2 Spectrum is the key enabler of wireless connectivity, including mobile, and we have identified the 3.6 to 3.8 GHz band as a high priority band for future mobile services in our Mobile Data Strategy².
- 1.3 The band is currently used by fixed links and by satellite services for space to Earth reception. Both services provide a range of valuable benefits for UK consumers³. But within all bands used by the fixed service, 3.6 to 3.8 GHz ranks low in terms of intensity of use – there are a total of 35 fixed links in the band, compared to thousands in several other bands. Similarly, while this band is used by five sites under Recognised Spectrum Access for Receive Only Earth Stations (RSA for ROES) and 14 sites under Permanent Earth Station licences (PES licences)⁴, it is lightly used in the UK compared to other satellite bands.
- 1.4 UK Broadband has a UK-wide licence to access 84 MHz of this band, to provide electronic communication services, sharing the band on a first-come-first-served basis with other existing users coordinated through Ofcom.
- 1.5 National regulators across Europe and industry have identified the wider 3.4 to 3.8 GHz band as a potential first 5G band⁵. This band can provide the large bandwidths necessary for new 5G services and is harmonised within Europe. We have identified this band as high priority for consideration for mobile use since 2014⁶. We are

¹ See *Mobile Data Strategy update*, June 2016, <http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/update-strategy-mobile-spectrum.pdf>

² See *Mobile Data Strategy*, May 2014, https://www.ofcom.org.uk/_data/assets/pdf_file/0027/58347/Mobile-Data-Strategy-statement.pdf

³ For more details see *Space spectrum strategy consultation*, March 2016, https://ofcom-build.squiz.co.uk/_data/assets/pdf_file/0022/82228/space_spectrum_strategy_consultation.pdf and *Fixed Wireless Spectrum Strategy call for input*, July 2016, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/84181/fixed-wireless-spectrum-strategy.pdf

⁴ Excludes sites with satellite earth stations used by foreign governments

⁵ See *5G for Europe: An Action Plan*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, September 2016, <https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document>; also *Public consultation on the Draft RSPG Opinion on spectrum related aspects for next-generation wireless systems (5G)*, June 2016, [https://circabc.europa.eu/d/a/workspace/SpacesStore/1a40dd19-c8a8-4ed0-bc9c-6cc5a7755f7d/RSPG16-031Final Opinion 5G for public consultation.pdf](https://circabc.europa.eu/d/a/workspace/SpacesStore/1a40dd19-c8a8-4ed0-bc9c-6cc5a7755f7d/RSPG16-031Final%20Opinion%205G%20for%20public%20consultation.pdf) and *5G Manifesto for timely deployment of 5G in Europe*, July 2016, http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=16579

⁶ See *Mobile Data Strategy*, May 2014, https://www.ofcom.org.uk/_data/assets/pdf_file/0027/58347/Mobile-Data-Strategy-statement.pdf

currently readying an award for 150 MHz in the lower part of the band, 3.4 to 3.6 GHz.

- 1.6 This consultation proposes making the upper part of this band, 3.6 to 3.8 GHz, available for future mobile services including 5G. This would include eventually awarding for mobile use the remaining 116 MHz of the band which is not already in use for electronic communications services. We believe that this will result in more efficient use of the spectrum and greater benefits for UK citizens and consumers. We also believe that making this band available for mobile has the potential to help us fulfil our duties regarding competition and innovation.
- 1.7 Our initial coexistence analysis indicates that large separation distances between mobile and existing users in the 3.6 to 3.8 GHz band would be required to prevent undue interference to existing users. This raises a policy question around how mobile could share the band with existing users. We have identified two policy options:
- a) **Retain** existing users' current authorisation to transmit for fixed links, and authorisation to receive for satellite earth stations registered under grants of Recognised Spectrum Access for Receive Only Earth Stations and under Permanent Earth Station (WT Act) licences receiving within the 3.6 to 3.8 GHz band⁷. Under this option, we would continue to take satellite earth stations with a receiver component in the 3.6 to 3.8 GHz band into account for frequency management purposes.

We would also include in any new mobile licences terms and conditions aimed at preventing undue interference into current licensed fixed links, or satellite earth station receivers in the band that are registered through PES licences or grants of RSA for ROES. Due to the large separation distances, this option would likely deny access to this band to mobile users over large areas across the UK. We would be likely to consider reviewing fees to existing users to reflect this;

- b) **Remove** existing users' authorisation to transmit for fixed links and no longer take satellite earth stations with a receiver component in the 3.6 to 3.8 GHz band into account for frequency management purposes. The effect on current users would be as follows:

Fixed links: we would propose to revoke the Wireless Telegraphy Act licences in the band after serving appropriate notice.

Satellite earth station users operating under a grant of RSA for ROES: we would propose to revoke grants of RSA insofar as they recognise use in the 3.6 to 3.8 GHz band, after appropriate notice is given. After such revocation the satellite users would still be able to receive signals in this band but would have to adjust to an expectation of much lower spectrum quality such that they might suffer interference from mobile use in the same band (depending on the intensity of that mobile use in particular locations as it is rolled out by network operators).

Satellite earth station users operating under a wireless telegraphy licence⁸: we would propose to vary these licences, after appropriate notice is given. This

⁷ Reception of radio signals is generally authorised under licence exemption regulations (The Wireless Telegraphy Apparatus (Receivers) (Exemption) Regulations 1989 (SI 1989/123)).

⁸ Satellite earth stations receiving space-to-Earth transmissions at 3.6 to 3.8 GHz typically use the 5825 to 6725 MHz band for uplink transmissions (existing Wireless Telegraphy Act licences).

would result in removing all frequencies in the 3.6 to 3.8 GHz band from the schedule of “receive frequencies” identified in the licence. However, after such a variation the satellite users would still be able to receive signals in this band⁹ but (as outlined in the preceding paragraph) would have to adjust to an expectation of much lower spectrum quality.

If we were to award mobile licences in the interim period, new mobile licences could include interim terms and conditions aimed at preventing interference into current licensed or recognised receivers in the band until the end of the notice period.

- 1.8 We are also interested in hearing of any other possible solutions, that might allow for mobile use including 5G in the 3.6 to 3.8 GHz band across the UK while maintaining sufficient certainty for at least some existing users to continue to invest and utilise the band. We invite any suggestions stakeholders may have.

Next steps

- 1.9 We plan to bring the 3.6 to 3.8 GHz band (including UK Broadband’s current licence at 3605 to 3689 MHz) under the Mobile Trading Regulations¹⁰, rather than under the Wireless Telegraphy (Spectrum Trading) Regulations 2004¹¹. This is consistent with our main proposal in this document to make the band available for mobile use.
- 1.10 While developing our policies with regards to access to this band by fixed links and satellite earth stations, we will take into account the substance and objectives of this consultation when considering any new applications for use of this band for these existing services. During this period, we will be less likely to grant new PES licences, or grants of RSA for ROES with reception in 3.6 to 3.8 GHz in new sites; and we also intend to only issue temporary fixed links licences in this band (potentially with three years’ duration).
- 1.11 We invite submission of additional evidence to inform the development of our policy proposals.

⁹ Reception of radio signals is generally authorised under licence exemption regulations (The Wireless Telegraphy Apparatus (Receivers) (Exemption) Regulations 1989 (SI 1989/123)).

¹⁰ See *The Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011*, June 2011, <http://www.legislation.gov.uk/uksi/2011/1507/made/data.pdf>

¹¹ See *The Wireless Telegraphy (Spectrum Trading) Regulations 2004*, November 2004, <http://www.legislation.gov.uk/uksi/2004/3154/contents/made>

Section 2

Introduction

- 2.1 As part of our work to secure the optimal use of the electro-magnetic spectrum, and deliver the greatest benefits to citizen and consumers, we have for some time worked towards making more spectrum available to meet the growing demand for mobile data. Our 2014 Mobile Data Strategy¹², which defines our plan to deliver against our objectives, identified the 3.6 to 3.8 GHz band as a high priority band for providing additional spectrum for mobile services.
- 2.2 Our June 2016 update¹³ to the Mobile Data Strategy provided more information on the growth in consumption of mobile data services, and anticipated that this growth will continue in the future as new technologies are introduced to the market. It also confirmed that we continue to consider the 3.6 to 3.8 GHz band as a high priority band for mobile.
- 2.3 A decision of the European Commission in 2008 harmonised the 3.6 to 3.8 GHz band and its adjacent band, 3.4 to 3.6 GHz for electronic communications networks, which includes mobile and fixed broadband. Together the bands are known as 3.4 to 3.8 GHz.
- 2.4 Industry, in partnership with governments around the world, is working on the next generation of mobile technology, known as 5G. This standard is expected to support low latency, highly resilient, and high speed data communications that may deliver new services to consumers, and improved versions of existing services, including the internet of things.
- 2.5 The 3.4 to 3.8 GHz band as a whole represents an attractive opportunity because it is harmonised across Europe for mobile and has sufficiently large bandwidth for 5G. Both national regulators and mobile industry have identified it as a band with potential for early launch of 5G services. Leadership in 5G services and early availability is a priority for many national governments, including the UK government¹⁴, as well as the European Union. It is our goal that spectrum should not hold back the deployment of 5G services.
- 2.6 We are currently working to different timetables in separate parts of the 3.4 to 3.8 GHz band. In the lower part, 3.4 to 3.6 GHz, we are readying an award of spectrum previously used by the Ministry of Defence but released to Ofcom in December 2015, totalling 150 MHz.
- 2.7 This document is concerned with the upper part of the band, 3.6 to 3.8 GHz, which has existing users in the UK that deliver benefits to UK citizens and consumers. This document presents our initial thinking on possible policy options. It sets out the discussion as follows:

¹² See *Mobile Data Strategy*, May 2014,

https://www.ofcom.org.uk/data/assets/pdf_file/0027/58347/Mobile-Data-Strategy-statement.pdf

¹³ See *Mobile Data Strategy update*, June 2016, <http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/update-strategy-mobile-spectrum.pdf>

¹⁴ See *Budget 2016*, March 2016, <https://www.gov.uk/government/publications/budget-2016-documents/budget-2016> section 5.3

- **Section 3** explains our statutory duties when regulating the use of spectrum in the UK;
- **Section 4** describes how the band is currently used by existing services;
- **Section 5** explains the implications of the European harmonising measures regarding the 3.4 to 3.8 GHz band;
- **Section 6** sets out the growing demand for mobile services in the UK, and the potential for the 3.6 to 3.8 GHz band to play an important role in meeting that demand;
- **Section 7** explains how our interpretation of our statutory duties and our understanding of the current and likely future trends regarding the 3.6 to 3.8 GHz band leads us to propose making this band available for mobile services, at a minimum in geographic locations with no existing deployments;
- **Section 8** explains how existing users and potential future mobile networks could co-exist;
- **Section 9** discusses the policy options available to us to enable the use of the band for mobile services;
- **Section 10** presents next steps.

Section 3

Our statutory duties

Legal background

- 3.1 In addressing issues of spectrum management, Ofcom must operate under a legal and regulatory framework, which is set out in more detail at annex 6.
- 3.2 This framework provides Ofcom with duties of furthering the interests of UK citizens and consumers through, among other things, securing the optimal use of radio spectrum and promoting competition. Ofcom must carry out these duties with transparent, objective, reasonable, and non-discriminatory principles.
- 3.3 Our duties derive from both domestic and European legislation, specifically from:
- The Communications Act 2003 (the ‘Communications Act’) and the Wireless Telegraphy Act 2006 (the ‘WT Act’);
 - The European Common Regulatory Framework¹⁵ for electronic communications networks and services, in particular, the Framework Directive and the Authorisation Directive.

Duties under the Communications Act 2003

- 3.4 Section 3 of the Communications Act provides that our principal duty is:
- to further the interests of citizens in relation to communications matters; and
 - to further the interests of consumers in relevant markets, where appropriate, by promoting competition.
- 3.5 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; and the availability throughout the UK of a wide range of electronic communication services.

Duties under the Wireless Telegraphy Act 2006

- 3.6 Section 3 of the Wireless Telegraphy 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 use of the spectrum.
- 3.7 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

¹⁵The Common Regulatory Framework comprises the Framework Directive (Directive 2002/21/EC), the Authorisation Directive (Directive 2002/20/EC), the Access Directive (Directive 2002/19/EC), the Universal Service Directive (Directive 2002/22/EC) and the Directive on privacy and electronic communications (Directive 2002/58/EC), as amended by the Better Regulation Directive (Directive 2009/140/EC).

telegraphy; and the development of innovative services and competition in the provision of electronic communications services.

European Common Regulatory Framework

- 3.8 The European Regulatory Framework creates duties for National Regulatory Authorities in EU Member States (including Ofcom) regarding policy objectives and the principles that must be adhered to when taking steps to achieve those objectives.
- 3.9 In particular, Article 8 of the Framework Directive establishes the objectives (among others) of:
- promoting competition in the provision of electronic communications networks and services by, among other things, ensuring that there is no distortion or restriction in competition in the electronic communications sector, and encouraging efficient use of radio frequencies.
- 3.10 In doing so, Article 8 also stipulates that Ofcom must apply objective, transparent, non-discriminatory, and proportionate regulatory principles. The Article also provides that Ofcom must take the utmost account of the desirability of making regulations technologically neutral.
- 3.11 Article 5 of the Authorisation Directive provides that where it is necessary to grant individual rights of use of radio frequencies, member states must grant such rights through open, transparent and non-discriminatory procedures.
- 3.12 Additionally, Article 7 of the Authorisation Directive provides that where member states decide to limit the number of rights of use to be granted for radio frequencies, they must (amongst other things) give due weight to the need to maximise benefits for users and to facilitate the development of competition.

Impact assessment

- 3.13 Impact assessment provides a valuable way of assessing different options for regulation. They form part of best practice policy-making.
- 3.14 In preparing this document we have considered the citizen and consumer interests in respect to our overall policy objectives. We have also considered the potential impact on service providers; manufacturers and users of devices and applications; and on existing users of the 3.6 to 3.8 GHz band and neighbouring frequencies of making the band available for 5G / mobile services in general.
- 3.15 The band's current characteristics of use make it possible for 5G services to use the band without affecting existing services only across a limited geographic area. Bearing in mind the likely benefits to be derived from making this band available for mobile, we believe there is a case for further considering options to make it available for citizens and consumers across more of the UK.
- 3.16 This document identifies initial policy options that could make the 3.6 to 3.8 GHz band available for 5G / mobile services for citizens and consumers across the UK. We invite stakeholder comments on the options identified, and our analysis of their associated opportunities and risks.
- 3.17 We plan to make proposals based on one of these options. At that point we may undertake a cost benefit analysis, informed by the evidence received in response to

this consultation that would represent a formal impact assessment as defined in section 7 of the Communications Act.

- 3.18 For further information about our approach to impact assessments, see the guidelines on our website¹⁶

Equality impact assessment

- 3.19 Ofcom is separately required by statute to assess the potential impact of all our functions, policies, projects and practices on race, disability and gender equality. Equality Impact Assessments (EIAs) also assist us in making sure that we are meeting our principal duty of furthering the interests of citizens and consumers regardless of their background or identity.
- 3.20 We do not consider that our consideration of the 3.6 to 3.8 GHz band is likely to have a greater impact on any protected groups of stakeholders as compared to its impact on UK citizens and consumers generally.

¹⁶ *Better policy-making: Ofcom's approach to impact assessment*, July 2005, https://www.ofcom.org.uk/consultations-and-statements/category-1/ia_guidelines

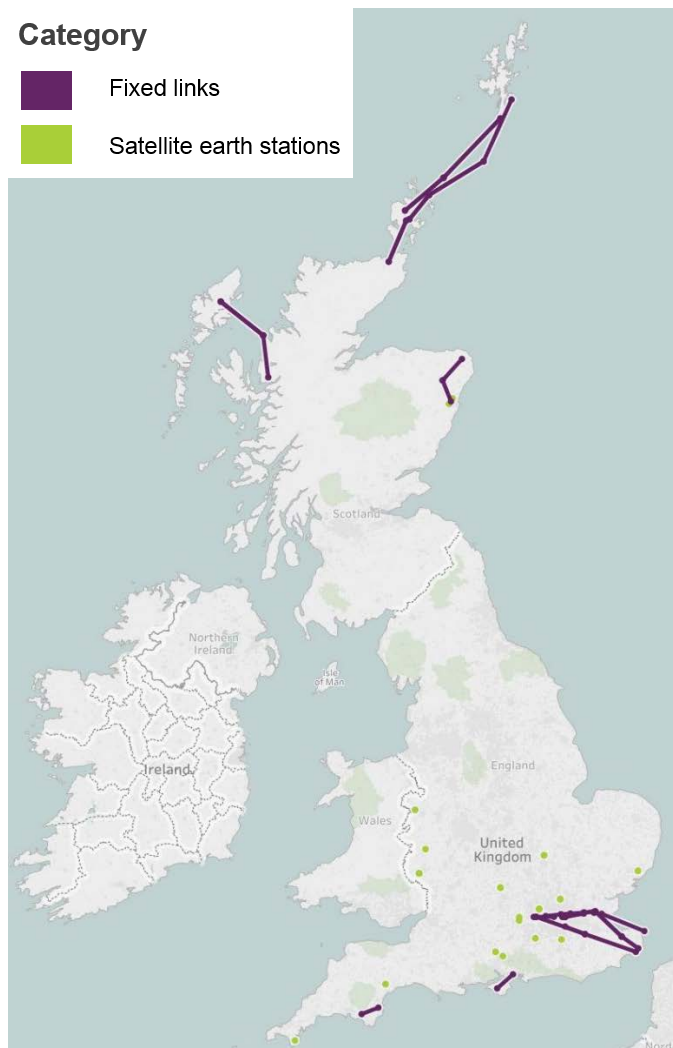
Section 4

Current usage

Introduction

4.1 The 3.6 to 3.8 GHz band is currently used for fixed links, satellite earth stations, and wireless broadband. These services provide a range of valuable benefits for UK citizen and consumers¹⁷, with usage concentrated geographically, as shown in the following diagram:

Figure 1: Geographic distribution of fixed links and satellite earth stations at 3.6 to 3.8 GHz



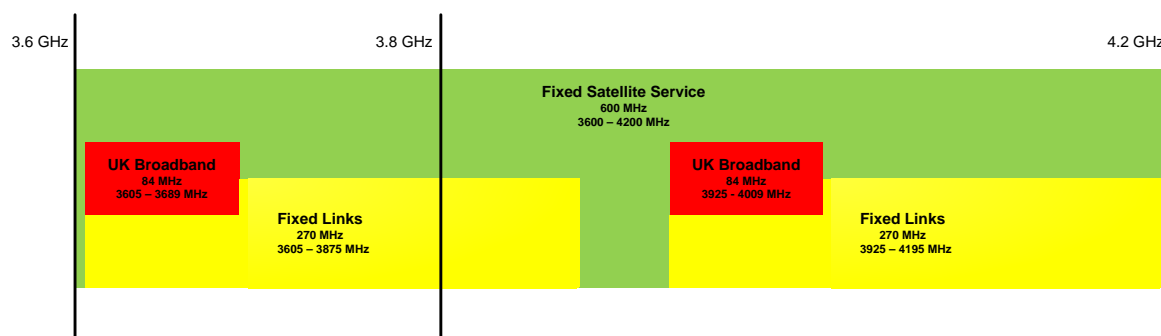
¹⁷ For more details see *Space spectrum strategy consultation*, March 2016, https://ofcom-build.squiz.co.uk/_data/assets/pdf_file/0022/82228/space_spectrum_strategy_consultation.pdf and *Fixed Wireless Spectrum Strategy call for input*, July 2016, https://www.ofcom.org.uk/_data/assets/pdf_file/0022/84181/fixed-wireless-spectrum-strategy.pdf

4.2 In this section, we give further details on how the existing services use the 3.6 to 3.8 GHz band. Further information is available in our interactive data¹⁸, which is being published in tandem with this document. All of the data used in this analysis is publicly available in our Wireless Telegraphy Register¹⁹.

Distribution of frequencies at 3.6 to 3.8 GHz and adjacent bands

4.3 As shown in Figure 2, the 3.6 to 3.8 GHz band is part of a wider band, 3.6 GHz to 4.2 GHz, which is used as a whole by fixed links and satellite earth stations.

Figure 2: Existing services using the 3.6 GHz to 4.2 GHz band



4.4 The duplexed nature of the band means we need to consider the effect of our policies on both the 3.6 to 3.8 GHz band and the 3.8 to 4.2 GHz band. In particular, use of the 3.6 to 3.8 GHz spectrum by fixed links is paired (or duplexed) with spectrum in the upper part of the band (3.8 to 4.2 GHz), and any changes to use in 3.6 to 3.8 GHz spectrum may impact the higher part of the band.

4.5 The 3.8 to 4.2 GHz band is subject to a separate programme of work exploring the potential for enhanced use of this band on a shared basis²⁰.

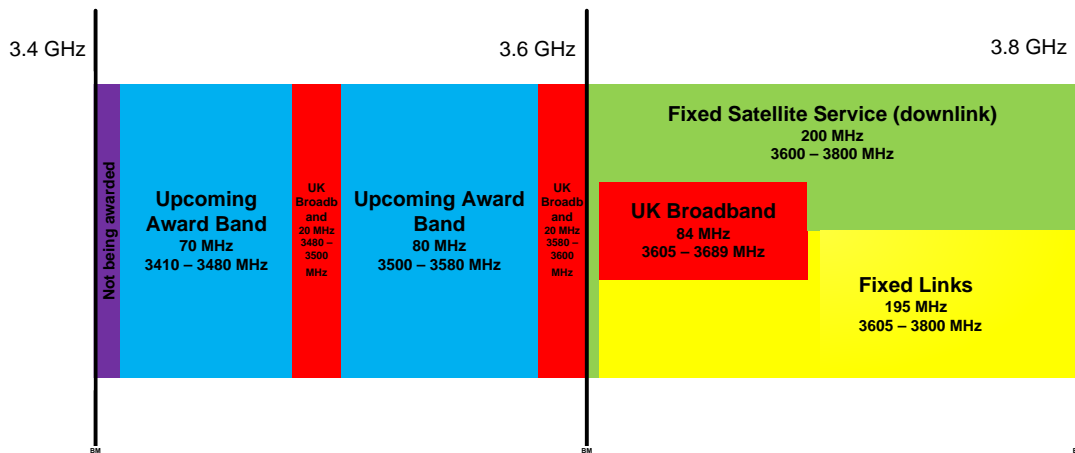
4.6 This band is also part of a wider band, 3.4 to 3.8 GHz, which has been harmonised for electronic communications services. We are currently working to award an additional 150 MHz of spectrum in 3.4 to 3.6 GHz (referred to as the 3.4 GHz band) band as shown in Figure 3.

¹⁸ See <https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz/interactive-data>

¹⁹ See *Wireless Telegraphy Register*, <http://spectruminfo.ofcom.org.uk/spectrumInfo/licences>

²⁰ See *3.8 GHz to 4.2 GHz band: Opportunities for Innovation* <https://www.ofcom.org.uk/consultations-and-statements/category-2/opportunities-for-spectrum-sharing-innovation>

Figure 3: Existing services using the 3.4 to 3.8 GHz band

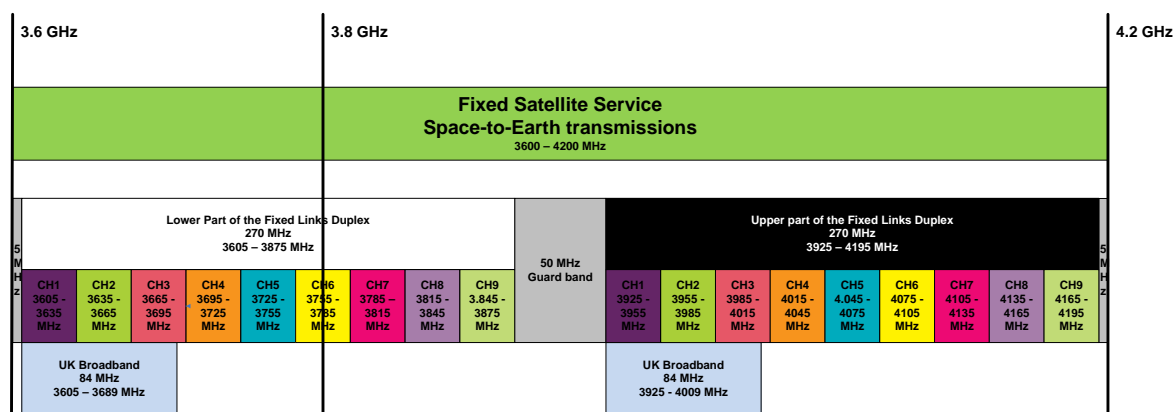


Fixed links

- 4.7 The fixed service refers to services delivered by fixed wireless links used to convey voice or data traffic between specified geographic locations. They are used for a variety of important applications, including backhaul for mobile base stations; distributing TV signals from studios to broadcast transmitter sites; providing direct voice or data connections to end users (leased lines) and connecting nodes within private or corporate communication networks.
- 4.8 In the Ofcom managed point to point fixed link bands, which includes 3.6 to 4.2 GHz, links are assigned and authorised on a first-come-first-served basis (taking into account all existing assignments in the band), subject to coordination and technical frequency assignment criteria²¹. In the 3.6 to 4.2 GHz band there are nine channels on the 30 MHz plan of which six are currently open (Channels 4 – 9 on the 30 MHz plan).

²¹ OfW 446, July 2015 https://www.ofcom.org.uk/data/assets/pdf_file/0013/75100/ofw446.pdf

Figure 4: Bandplan for fixed links at 3.6 to 4.2 GHz

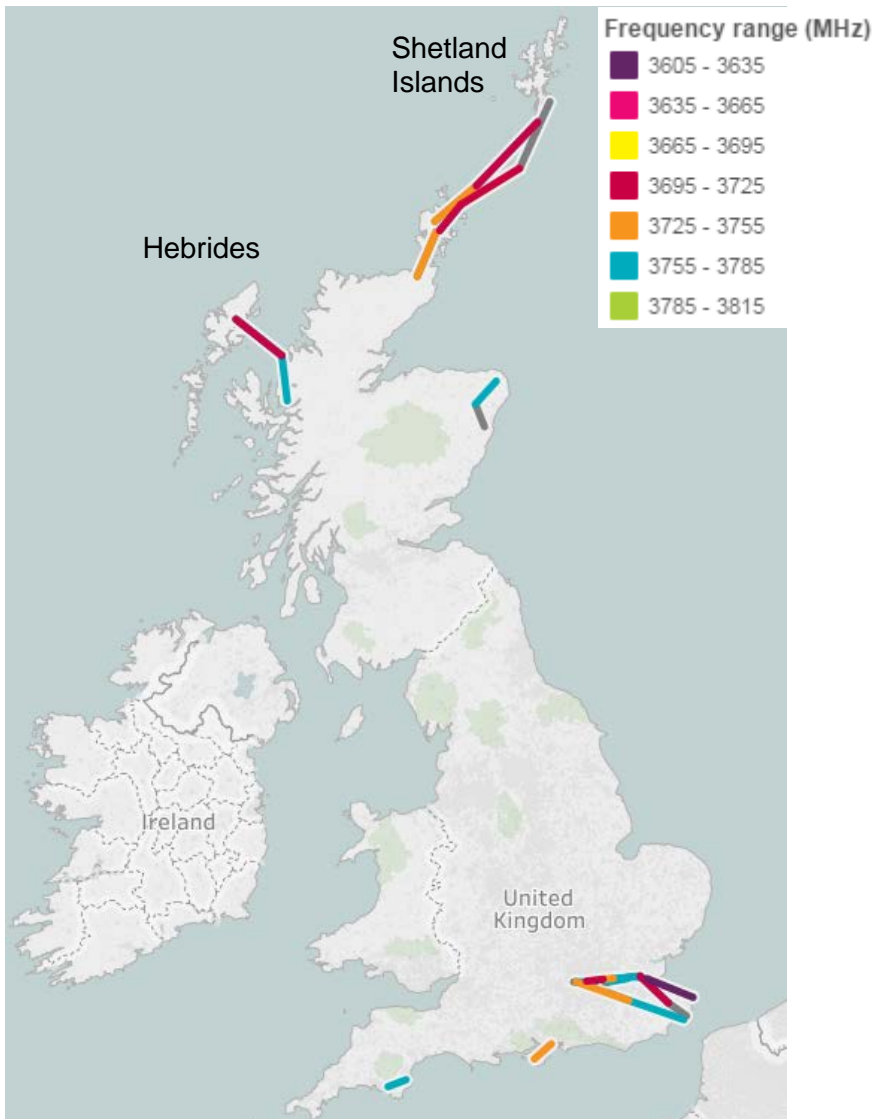


- 4.9 With respect to the 3.6 to 3.8 GHz band, there are currently 35 fixed links operating across the UK²². On the whole, this is significantly lighter use than other fixed links bands, which often have thousands of links.²³
- 4.10 There are currently a number of fixed links in areas of low population density, such as the links near the Hebrides and Shetland islands. Two additional fixed links to the west and north of Aberdeen. And a number of fixed links connecting London and the South East. Figure 5 shows where the fixed links are located.

²² There are 65 fixed links licensed within the 3.6 to 4.2 GHz band across the UK.

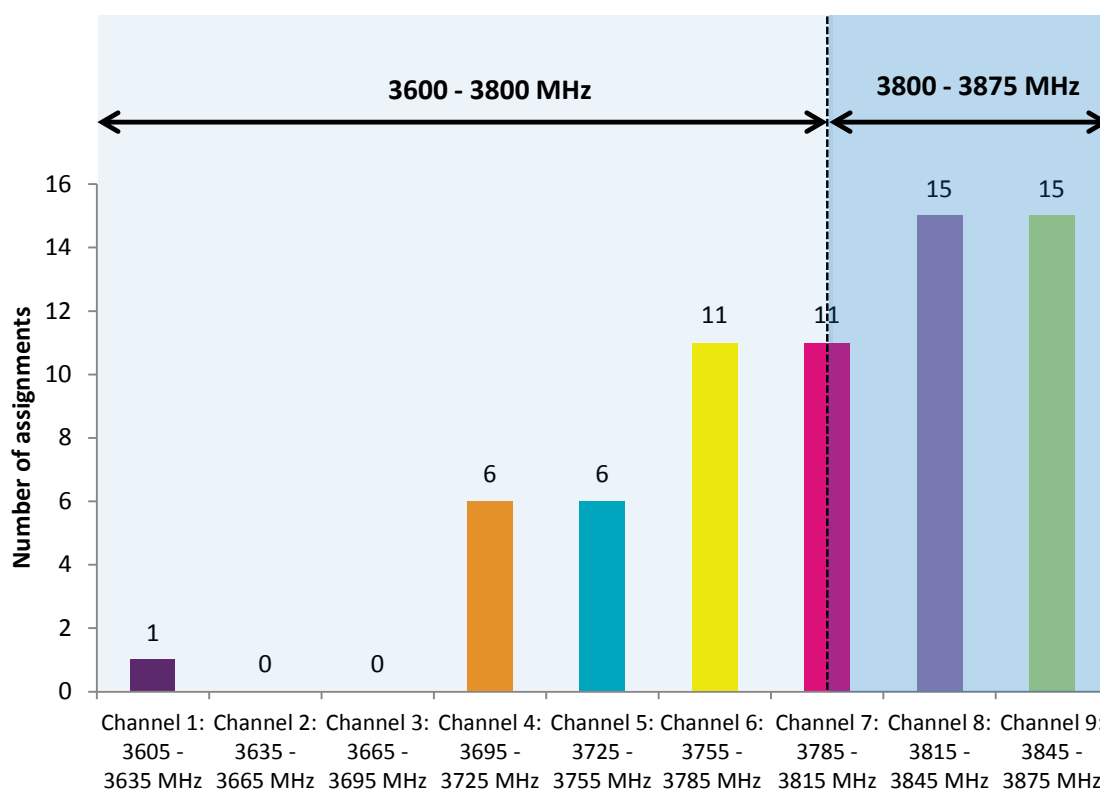
²³ For example, see *Fixed Wireless Spectrum Strategy*, Call for Input, July 2016, https://www.ofcom.org.uk/data/assets/pdf_file/0022/84181/fixed-wireless-spectrum-strategy.pdf page 11.

Figure 5: Geographic distribution of fixed links at 3.6 to 3.8 GHz



4.11 As shown in Figure 6, there is only one fixed link assigned in channels 1-3. There are a further four fixed links channels (Channels 4 – 7), where the lower duplex falls within the 3.6 to 3.8 GHz band, with a total of 34 links; Channels 8 – 9 are unaffected by our proposals.

Figure 6: Frequency spread of Fixed Link assignments (MHz)²⁴



- 4.12 In recent years, and taking into account the increased interest for mobile services in the 3.6 to 3.8 GHz band Ofcom has changed the fixed link assignment process to start from the top of the 3.6 to 4.2 GHz band when making new assignments. This means that there are proportionately fewer fixed links in Channels 4 – 7, which includes the 3.6 to 3.8 GHz band, compared to Channels 8 – 9.
- 4.13 The number of fixed links assignments in this band spiked in 2013 - 2015, but has otherwise been stable over the long term. In April 2015 there were 94 fixed links assignments in the 3.6 to 4.2 GHz band. These dropped to 65 (of which 35 are in 3.6 to 3.8 GHz) in August 2015 and there has been no change since then.
- 4.14 We are also keen to develop a deeper understanding of current usage of fixed services in general across all bands, and we have published a call for inputs asking for more information about the sector in general and about how technologies, supply and demand are likely to develop²⁵.

Fixed Satellite Service

- 4.15 Satellite and space science use of spectrum delivers a diverse range of benefits to UK citizens and consumers. Some of the applications include satellite TV, satellite navigation (“satnav”), broadband connectivity, and communications in emergency and disaster situations²⁶.

²⁴ Data was extracted in August 2016.

²⁵ See *Fixed Wireless Spectrum Strategy*, July 2016, <https://www.ofcom.org.uk/consultations-and-statements/category-1/call-for-inputs-fixed-wireless-spectrum-strategy>

²⁶ For more details, see *Space spectrum strategy consultation*, March 2016, https://ofcom-build.squiz.co.uk/_data/assets/pdf_file/0022/82228/space_spectrum_strategy_consultation.pdf

- 4.16 This is a downlink-only band (space-to-Earth) for the Fixed Satellite Service.
- 4.17 The wider 3.6 to 4.2 GHz band is favoured by the satellite industry in tropical regions because of the relatively low propagation losses and tolerance of high rainfall conditions. In non-tropical countries including the UK, tolerance of tropical rainfall is less critical, as a result the band is relatively lightly used. Typically, the band is used for broadcasting, as well as corporate data communications.
- 4.18 Ofcom provides coordination based on frequency management criteria for satellite earth station receivers through two regulatory products: Permanent Earth Station licences under Wireless Telegraphy Act (PES licences)²⁷; and grants of Recognised Spectrum Access for Receive Only Earth Stations (RSA for ROES). Both of these products are issued on a first-come-first-served basis.
- 4.19 Ofcom ensures that satellite earth stations registered under PES licences and grants of RSA for ROES benefit from benchmark spectrum quality. Spectrum quality here refers to the sum of interference present at the receiver. Ofcom achieves a benchmark by taking into account registered receivers within the 3.6 GHz to 4.2 GHz band when coordinating new deployments between the different users.
- 4.20 In total, there are 14 sites with satellite earth stations operating with PES licences²⁸, receiving in the 3.6 to 3.8 GHz band; and 5 sites with satellite earth stations operating with grants of RSA for ROES (one of which also operates under a PES licence²⁹).
- 4.21 These satellite earth stations receive downlinks from a number of satellites across 36 geostationary orbit locations³⁰ for a range of commercial operators, as well as some government departments. Overall, this is relatively light use compared to some other bands³¹.
- 4.22 The map below shows the geographic distribution of these satellite earth stations. Green dots refer to sites with satellite earth stations operating under grants of RSA for ROES; purple dots refer to sites with satellite earth stations operating under PES licences; and the red dot refers to the site with satellite earth stations that operates under both regulatory products.

²⁷ The receive component of satellite earth stations are authorised under licence exemption regulation (The Wireless Telegraphy Apparatus (Receivers) (Exemption) Regulations 1989 (SI 1989/123)).

²⁸ This excludes the use of the band by foreign governments.

²⁹ Data was extracted in August 2016.

³⁰ This excludes the use of the band by foreign governments.

³¹ See *Space spectrum strategy*, consultation, March 2016, p44-48. https://ofcom-build.squiz.co.uk/_data/assets/pdf_file/0022/82228/space_spectrum_strategy_consultation.pdf

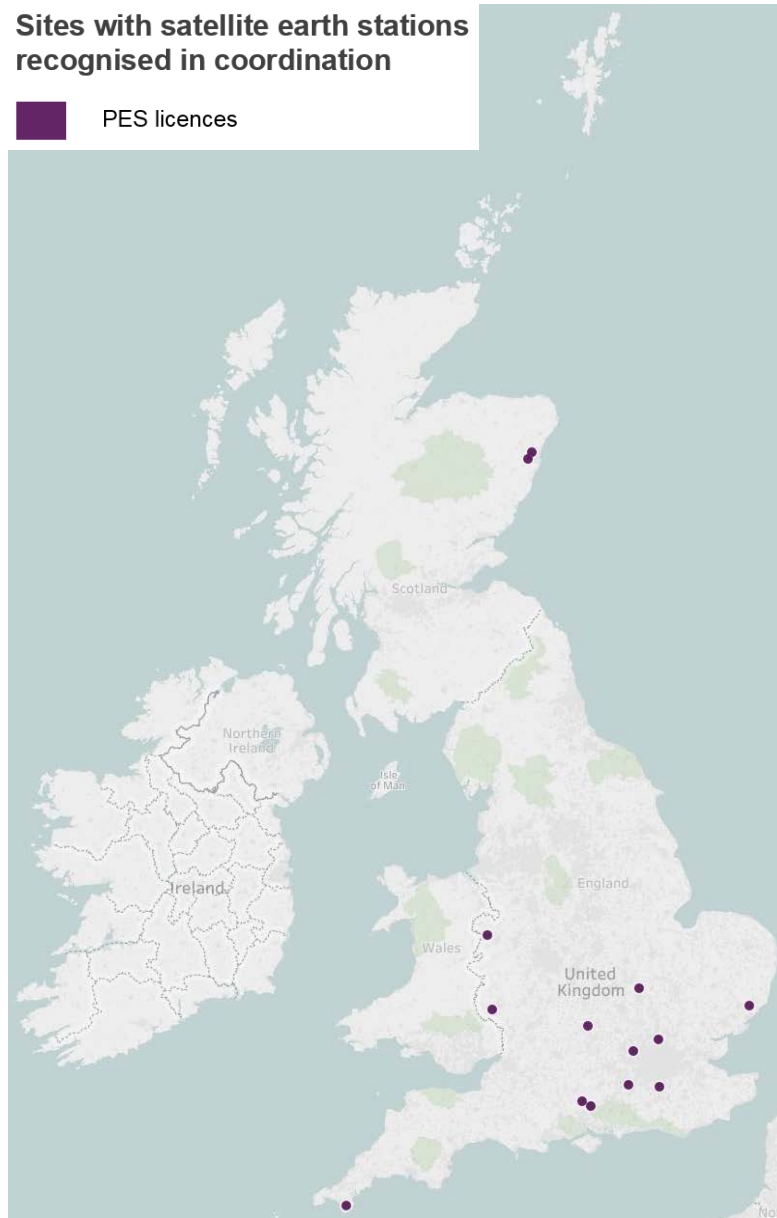
Figure 7: Geographic distribution of sites with satellite earth stations receiving at 3.6 to 3.8 GHz



4.23 The 14 PES licences define the technical parameters for both Earth-to-space and space-to-Earth transmissions including the location of the earth station(s) and orbital location of the satellite(s). These licences include the use of several frequency bands, including space-to-Earth transmissions at 3.6 to 4.2 GHz, which is typically paired with Earth-to-space transmissions at 5.825 to 6.725 GHz.

4.24 In Figure 8 we show the distribution of satellite earth station sites operating under PES licences across the UK. The majority of these sites are located in the South East, although there are also sites located in Cornwall, Shropshire, Herefordshire, and near to Aberdeen.

Figure 8: Geographic distribution of sites with receiving satellite earth stations operating under PES licences



4.25 As mentioned in paragraph 4.20, there are five sites with satellite earth stations operating under grants of RSA for ROES, as shown in Figure 9. Three of these are located near London (two of which are very close to each other to the West of London), two are located in the West Midlands and South West.

Figure 9: Geographic distribution of sites with receiving satellite earth stations operating under RSA for ROES



4.26 Unlike for fixed links, where stakeholders stipulate which spectrum they wish to use when applying for authorisation from Ofcom, satellite earth station operators often have limited and / or indirect control over frequencies that their clients demand access to. It is typical for many frequencies in the 3.6 to 3.8 GHz band to be used at a single satellite earth station and they require benchmark spectrum quality across a greater spread of frequencies within the band than is normal for fixed links.

Fixed Wireless Access

4.27 UK Broadband holds a national spectrum access licence for wireless broadband services for 84 MHz in this band (3605 to 3689 MHz), and another 84 MHz at 3925 to 4009 MHz. When UK Broadband wishes to deploy a base station, it is first required to submit the relevant technical information to Ofcom so that Ofcom can make an

assessment against existing deployments, as set out in the co-ordination guidelines³².

- 4.28 UK Broadband started deploying an LTE network in February 2012 in a Time Division Duplex (TDD) configuration using 2 x 20 MHz in the 3.4 to 3.6 GHz band as well as 20 MHz channels within its 3605 to 3689 MHz holding where these can be coordinated with existing services on a first come first served basis. Its service 'Relish' uses both indoor and outdoor LTE devices to offer commercial services to consumers and businesses in central London, with plans for roll-out in other cities.

Question 1: Do you have any comments on the use of the 3.6 to 3.8 GHz band by existing services?

³² UK Spectrum Co-Ordination: Co-ordination of licensed services in the band 3605 to 3689 MHz paired with 3925 – 4009 MHz January 2008, https://www.ofcom.org.uk/_data/assets/pdf_file/0027/85086/coordination_processes.pdf

Section 5

Harmonisation of the 3.4 to 3.8 GHz band

5.1 This section presents the European decisions that harmonised the 3.4 to 3.8 GHz band for electronic communication services.

European harmonisation decisions at 3.4 GHz to 3.8 GHz

- 5.2 On 21 May 2008, the European Commission adopted Commission Decision 2008/411/EC, which seeks to harmonise the conditions for the availability and efficient use of the 3.4 to 3.8 GHz band for terrestrial systems capable of providing electronic communications services in the EU³³, mainly targeting wireless broadband services for end-users. In relation to the 3.6 to 3.8 GHz band, the decision provides that Member States should designate the band by 21 November 2008, on a non-exclusive basis, for terrestrial electronic communications networks in compliance with the parameters set out in the annex to the decision. These parameters include the deployment of fixed, nomadic, or mobile networks.
- 5.3 The Commission Decision was implemented in the UK by way of the 3400 MHz-3800 MHz Frequency Band (Management) Regulations 2008³⁴, which required Ofcom to exercise its functions under the WTA so as to give effect to the obligations of the United Kingdom under the Commission Decision. Any award of the 3.4 to 3.8 GHz band has to be compliant with the Commission Decision.
- 5.4 Subsequently Decision No 243/2012/EU of the European Parliament and the Council³⁵ required EU Member States to make the band available for electronic communication services by December 2012. These authorisations should be subject to market demand, without prejudice to existing deployments of services, and under conditions that allow consumers easy access to wireless broadband services.
- 5.5 This Commission Decision was amended in May 2014, when the European Commission adopted Commission Implementing Decision 2014/276/EU³⁶, which established technical parameters for Electronic Communication Services that are authorised to use the 3.4 to 3.8 GHz band. EU Member States must make sure that spectrum licences issued for electronic communication services in these bands are aligned with these parameters. For the 3.6 to 3.8 GHz band, these parameters, as articulated in CEPT Report 49³⁷ correspond to TD-LTE spectrum access technology.
- 5.6 The Decision notes that the 3.4 to 3.8 GHz band offers significant potential for deploying dense and high-speed wireless broadband networks to provide innovative electronic communications services to end users. It added that the use of this

³³ Commission Decision 2008/411/EC, May 2008, <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008D0411&from=EN>

³⁴ See S.I. 2008/2794, October 2008, http://www.legislation.gov.uk/ukxi/2008/2794/pdfs/ukxi_20082794_en.pdf

³⁵ Decision 243/2012/EU, March 2012, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:081:0007:0017:EN:PDF>

³⁶ See Commission Decision 2014/276/EU, May 2014, <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014D0276&from=EN>

³⁷ CEPT Report 49, March 2014, <http://www.erodocdb.dk/Docs/doc98/official/pdf/CEPTREP049.PDF>

frequency band for wireless broadband should contribute to the economic and social policy objectives of the Digital Agenda for Europe.

- 5.7 This decision was implemented in UK law by way of Statutory Instrument 2016 No. 495³⁸. This statutory instrument states that Ofcom must designate and make available, on a non-exclusive basis, the 3.4 to 3.8 GHz frequency band for terrestrial electronic communications networks, in compliance with the technical parameters for high power TD-LTE mobile networks.
- 5.8 These technical parameters would allow for TD-LTE based mobile access for small cells or macro cells, as well as fixed wireless access. These parameters are reflected in a separate consultation we are undertaking³⁹ about allowing mobile user terminals to operate in this band without the procurement of individual licences. This consultation on the potential issuance of mobile spectrum access licences at 3.6 to 3.8 GHz has no effect on, and is not affected by, the outcome of our consultation on making the user terminals licence exempt.
- 5.9 5G technology is in an early stage of development and there is not yet clarity regarding technical parameters for its use in the 3.4 to 3.8 GHz band. It is possible that these parameters will not be aligned with those designated in relevant domestic and European legislation. If that turns out to be the case, the future use of the 3.4 to 3.8 GHz band for 5G services in the UK would require a new Statutory Instrument. Additionally, Commission Decision 2008/411/EC may need to be amended to take account of 5G's requirements in order to enable the future use of the band for 5G services across the EU.
- 5.10 Subsequent to Commission Implementing Decision 2014/276/EU, the majority of EU Member States have made or are in the process of making the band available for electronic communication services, including mobile⁴⁰. We have authorised use of the band for electronic communications services in 84 MHz within this band since 1992.

³⁸ See *The 1452-1492 MHz and 3400-3800 MHz Frequency Bands (Management) Regulations 2016*, April 2016, http://www.legislation.gov.uk/uksi/2016/495/pdfs/uksi_20160495_en.pdf

³⁹ See *Notice of proposal to make Wireless Telegraphy Exemption Regulations 2016 User Terminal Exemptions*, July 2016, https://www.ofcom.org.uk/_data/assets/pdf_file/0029/78464/user_terminal_exemption_notice.pdf

⁴⁰ Our current understanding is that nine other EU Member States have assigned parts of this band for electronic communication services, while six are in the process of doing so.

Section 6

Potential for mobile

6.1 In this section, we consider the opportunity created by the potential deployment of mobile services in the 3.6 to 3.8 GHz band including 5G.

Consumer demand for mobile services

6.2 Our Mobile Data Strategy⁴¹, published in 2014, stated that the data carried on mobile networks could increase 25 times in the period to 2030, which is the equivalent of an annual rate of growth of 22 percent. Since publication of the Mobile Data Strategy, the growth in mobile data traffic has been around 60% per annum⁴². We believe strong growth is likely to continue in view of consumers' interest in mobile applications, new innovative services and the rise of a new "digital native" generation who grew up with wireless data.

6.3 Many of these innovations are likely to comprise future 5G services. These services are likely to further drive demand for mobile data.

6.4 In our Mobile Data Strategy Update in June 2016, we projected that exponential growth in mobile data demand may continue for some time. In this document, we also developed three scenarios for potential growth in mobile data consumption to provide an indication of its potential scale in the coming years⁴³.

6.5 The assignment of further spectrum for mobile services in the UK will play an important role in providing for this growth in mobile data demand, as well the use of denser networks and more spectrally efficient technology.

The role of the 3.6 to 3.8 GHz band in future 5G / mobile networks

6.6 The 3.6 to 3.8 GHz band could play an important role in addressing the increasing demand for mobile data services in the medium to long term by being one of the first bands used in Europe (and beyond) for future 5G services.

6.7 The band offers a large amount of contiguous bandwidth and therefore could provide a great deal of capacity for mobile networks in areas where demand for mobile data is geographically concentrated.

6.8 The next generation of mobile technology, 5G, is anticipated to require wide bandwidths, possibly as wide as hundreds of MHz. Bearing in mind the amount of

⁴¹ *Mobile Data Strategy Statement*, May 2014, <https://www.ofcom.org.uk/consultations-and-statements/category-1/mobile-data-strategy> paragraph 4.43.

⁴² Growth rates were 65% (2015-14); 54% (2014-13); 46% (2013-2012); 119% (2012-11). See *Connected Nations Report*, December 2015, <http://stakeholders.ofcom.org.uk/market-data-research/market-data/infrastructure/connected-nations-2015/>

⁴³ See *Mobile Data Strategy update*, June 2016, <http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/update-strategy-mobile-spectrum.pdf> paragraph 3.14

spectrum available in this band, many companies and regulators have identified the 3.4 to 3.8 GHz band's potential for 5G.

- 6.9 For example, the Radio Spectrum Policy Group (RSPG), the group of European National Regulatory Authorities that advises the European Commission on spectrum issues, recently identified the wider 3.4 to 3.8 GHz band as the “primary band suitable for the introduction of 5G use in Europe even before 2020”⁴⁴. The European Commission also identified in its action plan the 3.4 to 3.8 GHz band as having “high potential to become a strategic band for 5G launch in Europe”⁴⁵.
- 6.10 This position is supported by many mobile operators, mobile equipment manufacturers, and industry consortia in their responses to a RSPG consultation⁴⁶. A recent survey conducted by the European Commission targeting the telecom sector and related sectors also found a preference for the 3.4 to 3.8 GHz band as a pioneer band for 5G⁴⁷. Japan is also currently considering use of 3.6 to 4.2 GHz for 5G⁴⁸.
- 6.11 A manifesto signed by many large companies in the mobile industry also identified the potential for 5G in the 3.4 to 3.8 GHz band, when it called for it to be licenced in time and across the EU to enable 5G deployment before 2020, alongside other bands⁴⁹.
- 6.12 In response to our Call for Input on enhanced spectrum sharing in the 3.8 to 4.2 GHz band, stakeholders with an interest in the mobile industry stated that the 3.6 to 3.8 GHz band, as well as the wider 3.4 to 4.2 GHz band, could be used for LTE-Advanced and /or 5G in the medium term⁵⁰. Specifically, BT/EE, Trinity College Dublin, Ericsson, Google, GSA, H2020 Coherent & Fairspectrum, Huawei, Intel, Qualcomm, and the WBA identified the band's potential for 5G.
- 6.13 Many National Regulatory Authorities in Europe have in the past assigned this band for Fixed Wireless Access services. In the USA, the FCC is making parts of this band available on a dynamic shared basis⁵¹.

⁴⁴ See *Public consultation on the Draft RSPG Opinion on spectrum related aspects for next-generation wireless systems (5G)*, June 2016, https://circabc.europa.eu/d/a/workspace/SpacesStore/1a40dd19-c8a8-4ed0-bc9c-6cc5a7755f7d/RSPG16-031Final_Opinion_5G_for_public_consultation.pdf

⁴⁵ See *5G for Europe: An Action Plan*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, September 2016, <https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document>

⁴⁶ See responses to the RSPG consultation at https://circabc.europa.eu/d/a/workspace/SpacesStore/77f82564-135a-402a-b4a5-d4c7996c0f36/Responses_5G.pdf

⁴⁷ See *5G for Europe: An Action Plan*, Staff Working Document, September 2016 <https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document>

⁴⁸ See report by the Ministry of Internal Affairs and Communications on 2020 mobile, July 2016. It is available in Japanese only at http://www.soumu.go.jp/main_content/000430218.pdf.

⁴⁹ *5G Manifesto for timely deployment of 5G in Europe*, July 2016, http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=16579

⁵⁰ See full responses at <https://www.ofcom.org.uk/consultations-and-statements/category-2/opportunities-for-spectrum-sharing-innovation>

⁵¹ The Federal Communications Commission is making the 3550 MHz to 3700 MHz available for small cell mobile broadband services on a shared basis within the Citizen Band Radio Service. For more information, see <https://www.fcc.gov/rulemaking/12-354>

- 6.14 The equipment ecosystem is still developing, but the number of devices capable of accessing the bands for 4G mobile broadband is continuing to grow. According to the Global Mobile Suppliers Association (GSA), there are a total of 82 devices that can use parts of the wider 3.4 to 3.8 GHz band⁵² for TD-LTE. We also understand that many TD-LTE devices designed to operate at 3GPP Band 42 (3.4 GHz to 3.6 GHz) could also operate at 3GPP Band 43 (3.6 to 3.8 GHz) with few additional costs.

Question 2: Do you agree with our identification of a trend towards the use of mobile in the 3.6 to 3.8 GHz band?

⁵² 3GPP Bands 42 and 43. For more information see *Status of the LTE Ecosystem Report*, June 2016, <http://gsacom.com/paper/status-lte-ecosystem-report-5614-lte-devices-announced-455-suppliers/>

Section 7

Applying our statutory duties

- 7.1 This section considers the high level policy implications that flow from a consideration of the characteristics of use for the 3.6 to 3.8 GHz band and likely future trends, in the context of our statutory duties.
- 7.2 As explained in section 3, we have statutory duties related to securing the optimal use of spectrum, furthering the interests of UK citizens and consumers, and promoting competition in access to electronic communication services. In doing so, we must take account of the likely future demand for spectrum, as well as current demand. Our Spectrum Management Strategy⁵³, published in April 2014, identified growing demand for mobile data as a key driver of future demand for spectrum.
- 7.3 As set out in section 4, the number of fixed links and satellite receivers in the band is relatively low and geographically concentrated. For example, satellite earth station usage of this band is limited to 19 sites⁵⁴ with satellite earth stations⁵⁵ while in the Ku Band (10.7 to 12.75 GHz), licence-exempt terminals are used for downlinks at thousands of premises. Fixed link usage is limited to 35 sites, while there are thousands of links in other bands. This indicates that there is scope to further optimise the use of the 3.6 to 3.8 GHz band for the benefit of UK citizens and consumers.
- 7.4 In section 6, we explained that the international trends regarding this band indicates that it has the potential to be an early 5G band. We have shown how the launch of 4G has acted as a catalyst for innovative mobile services, and that we expect the same to be true of 5G. These services are anticipated to require much wider bandwidths than contemporary mobile networks, and should ideally be able to access frequencies where equipment will be made available across many countries so as to allow for affordable access enabled by economies of scale. Therefore, our preliminary view is that making this band available for mobile is likely to be in line with our duties regarding innovation.
- 7.5 We also note that, as explained in section 5, we are obliged by statute to make the 3.6 to 3.8 GHz band available for electronic communication services, and we have already made 84 MHz in this band available for this purpose⁵⁶.
- 7.6 Shortage of spectrum can act as a significant barrier to entry and innovation in the wireless communication market. In general releasing spectrum gives both incumbents and new entrants an opportunity to acquire new spectrum, this could result in increased competition through market entry, including innovative entry with new business models.
- 7.7 This is particularly relevant in a market where consumer demand is growing rapidly, as in the mobile market (see section 6 for more detail). We have also recently reviewed a number of potential bands for future mobile use, and have found the 3.4

⁵³ See *Spectrum Management Strategy*, April 2014, <https://www.ofcom.org.uk/consultations-and-statements/category-1/spectrum-management-strategy>

⁵⁴ Data was extracted in May 2016.

⁵⁵ This excludes the use of the band by foreign governments.

⁵⁶ This spectrum is assigned to UK Broadband.

to 3.8 GHz band is one of the few bands with the characteristics, including bandwidth and international harmonisation, to merit high priority for consideration for mobile⁵⁷. We therefore believe that making this band available for mobile has the potential to help us fulfil our duties to promote competition.

7.8 Taking into account the above, we believe that making the 116 MHz of the band not currently assigned to electronic communications services available for mobile services is consistent with our statutory duties.

7.9 In section 8, we present analysis that found that mobile services and existing fixed links and satellite earth stations can coexist but at large geographic separation distances. The consequence of these large separation distances is that making 5G / mobile services in this band available more widely for citizens and consumers across the UK would require a change in the landscape of current usage. We are currently considering policies to stimulate such a change. We present our initial thinking on this in section 9 and invite comment.

Question 3: Do you agree with our high level proposal to make 116 MHz within the 3.6 to 3.8 GHz band available for mobile and 5G services, bearing in mind our statutory duties and the high level trends we have identified?

UK Broadband

7.10 UK Broadband already provides electronic communications services in this band, and by authorising their current use we complied with the decision on harmonisation in the 3.4 to 3.8 GHz band. We note that UK Broadband has stated that they intend to expand their services, to include future mobile broadband services⁵⁸. As with other services, we will consider reflecting the opportunity cost of mobile use in the fees they pay for their spectrum.

7.11 If we proceed with the proposals in this consultation, we will also consider at the appropriate time the opportunities and risks associated with harmonising UK Broadband's spectrum licence's coordination obligations with the potential obligations associated with potential future mobile network operators in this band. This could effectively mean lifting or changing the coordination requirement from UK Broadband's use of the 3605 to 3689 MHz band.

Question 4: Do you agree with our general approach regarding spectrum currently licensed to UK Broadband?

⁵⁷ See Mobile Data Strategy update, June 2016, <https://www.ofcom.org.uk/consultations-and-statements/category-1/mobile-data-strategy>

⁵⁸ See *Variation of UK Broadband's 3.4 GHz licence*, June 2014
https://www.ofcom.org.uk/_data/assets/pdf_file/0026/55583/condoc.pdf

Section 8

Coexistence analysis

- 8.1 This section provides a summary of our findings on sharing between mobile networks and fixed links / satellite earth stations.
- 8.2 Our analysis is based on two studies. The first is a report we published in June 2015, that we had commissioned from Transfinite to examine prospects for the geographic sharing of spectrum across the whole of the C-band (3.6 to 4.2 GHz)⁵⁹.
- 8.3 We have extended this analysis in a second study that takes into account macro cell mobile deployments rather than small cell only deployments, and the effect of unusual weather conditions that can lead to increased interference, rather than considering only long term interference. The details of the methodology and inputs we used for our internal study are given in annex 5.
- 8.4 For both fixed links and satellite earth stations we found that coexistence with a large scale macro cell deployment could be very challenging. We give more details in the next two subsections.

Coexistence with fixed links

- 8.5 As noted in section 4, there are 35 fixed links across the UK operating in the 3.6 to 3.8 GHz band, of which 18 are situated in the south of England (including London). See Figure 1 in that section for a map of where the links are located.
- 8.6 We tackled the coexistence analysis first by considering an isolated small cell, second by considering the case of aggregate interference from multiple small cells, and finally by extending the results to macro cells. These scenarios set progressively harder tests for coexistence: if coexistence is not possible with a single small cell, it will certainly not be possible with multiple macro cells.
- 8.7 As a starting point for our work, we analysed the interference from a single outdoor small cell to a microwave receiver. When terrain and clutter models are used (in particular with clutter only close to transmitter and receiver), denied pixels could be found up to 50 km in one direction from the fixed link antenna⁶⁰.
- 8.8 Areas of denied pixels could further increase when anomalous propagation conditions are taken into account. While we expect that areas and distance of denied pixels would significantly decrease if even more sophisticated modelling tools and propagation measurements were available, the separation distances would likely still be large. Macro cells would require even larger denied areas, mainly due to the increased transmit power and to the deployment above clutter, that would increase the probability of line-of-sight to a microwave link.

⁵⁹See *Geographic Sharing in C-band Final Report*, June 2015, <https://www.ofcom.org.uk/research-and-data/technology-research/2015-reports/c-band-sharing>

⁶⁰ This is not the same as a continuous denied area 50 km across; we found smaller continuous denied areas surrounded by a larger border of scattered pixels. For example, see figure 5.4 in the [Transfinite report](#).

- 8.9 We found that denied areas decrease if the small cell deployment is optimised. For example, deploying small cells below roof-tops and outside the line of sight of the fixed link receiver, exploiting local clutter and pointing the antennas away from the fixed link receiver in order to minimise interference. However, there could be a significant burden in terms of deployment optimisation at each individual site to prevent undue interference as defined in our interference management criteria. Moreover, this approach would be significantly less effective for macro cells, as macro antennas are usually deployed above rooftops and changing the alignment of the antennas would be insufficient to meet the criteria limits.
- 8.10 From the discussion above, considering that some of the 18 fixed links in the South of England are deployed in very dense populated areas, use of the spectrum could be denied to a large number of mobile users if we were to prevent undue interference to fixed links. We also anticipate that future 5G / mobile networks in rural parts of the UK may use macro cells. Therefore, sharing between mobile networks and the remaining 17 links in the north of the UK would also be challenging.

Coexistence with satellite earth stations

- 8.11 As noted in section 4, there are 19 UK satellite sites in the 3.6 to 3.8 GHz band. We refer to section 4 for maps of where the earth stations are located.
- 8.12 We again tackled the coexistence analysis first by considering an isolated small cell, second by considering the case of aggregate interference from multiple small cells and finally by extending the results to macro cells.
- 8.13 As a starting point for our work, we analysed the interference from a single outdoor small cell to satellite earth stations operating under both PES licences and grants of RSA for ROES. We found that, even under this simple test, some suburban and rural areas (where earth stations are usually deployed) would have access to a lower amount of spectrum, or no spectrum in the proximity of earth stations.
- 8.14 This test revealed fewer issues in densely populated areas as earth stations are in general sufficiently far from these areas as to be able to tolerate a single small cell.
- 8.15 In a similar way as the analysis above for fixed links, we found that denied areas decrease with an optimised small cell deployment. For example, deploying small cells below rooftops and outside the line of sight of the satellite earth station, exploiting local shadowing and pointing the antennas in a way to minimise interference. However, as noted above, there could be a significant burden in terms of deployment optimisation at each individual site to prevent undue interference as defined in our interference management criteria.
- 8.16 We studied the effect of aggregate interference, and found that it becomes increasingly hard to deploy small cells in proximity of earth stations as the density increases.
- 8.17 With macro cells, coexistence between base stations and satellite earth stations becomes much more challenging than with small cells, mainly due to the higher power and above-roof deployment.
- 8.18 We modelled via computer simulations a large scale macro cell deployment in London, and found that several different locations with earth stations (including Chalfont, Bedford, Crawley Court, Crowsley Park and Brookmans Park) would suffer undue interference. For example, we found that for Chalfont undue interference could

occur due to a macro cell up to 150 km away under anomalous propagation conditions.

- 8.19 We found that mitigations techniques (including site shielding, pits and an increased antenna dimension) could be effective for small cells. However, our analysis suggests they may not be sufficient for the case of a large scale macro cell deployment.
- 8.20 We have also identified a satellite earth station site 80 km from Birmingham, which is likely to suffer from interference in the event of a macro cell mobile deployment in Birmingham.
- 8.21 Other satellite earth stations are located away from the largest population centres in the country, but are still likely to constrain deployment in other areas. There are earth stations near Aberdeen, Penzance, Winchester, Exeter, and Felixstowe.
- 8.22 A more detailed summary of our analysis in respect to permanent earth stations can be found in annex 5.

Conclusions

- 8.23 Our analysis suggests that prevention of undue interference into some of the fixed links in the densely populated South of England is likely to be very difficult with both small cell and macro cell deployments. Macro cells deployments in other areas of the UK, such as Exeter and parts of Scotland, would also be likely to cause undue interference to the other fixed links.
- 8.24 Macro cell deployments of mobile services across the UK are likely to cause undue interference to the reception of space-to-Earth transmissions to most or all satellite earth station sites.

Question 5: Do you agree with our assumptions, methodology, and conclusions with regards to potential coexistence between mobile and existing fixed links and satellite earth stations? Please refer to annex 5 for further details.

Section 9

Policy options to enable mobile at 3.6 to 3.8 GHz across the UK

- 9.1 As outlined in section 7, we believe that we should make the 3.6 to 3.8 GHz band available for future mobile services via award, at a minimum at locations where their use does not cause undue interference to existing services.
- 9.2 We also believe that we should consider policies to ensure the benefits delivered by 5G / mobile are available to citizens and consumers across the UK. In this context, we believe that we have two policy options available to us relating to existing deployments in the band:
- a) **Retain** existing users' current authorisation to transmit for fixed links, and authorisation⁶¹ to receive for satellite earth stations registered under grants of RSA for ROES and under PES licences (WT Act) receiving within the 3.6 to 3.8 GHz band.
 - b) **Remove** existing users' authorisation to transmit for fixed links; and no longer take satellite earth stations with a receiver component in the 3.6 to 3.8 GHz band into account for frequency management purposes.
- 9.3 We are also interested in hearing of any other possible solutions, that might allow availability for mobile use including 5G using the 3.6 to 3.8 GHz band across the UK while maintaining sufficient certainty for at least some existing users to continue to invest and utilise the band. We invite any suggestions stakeholders may have.
- 9.4 In this section, we outline these potential policy options and ask for input. Stakeholders' responses to this consultation and specifically to our policy options will be used to inform any subsequent proposals with regard to the future of this band.
- 9.5 In both of the following options, we would award 116 MHz of the band not currently assigned to UK Broadband across the UK. This award would create new mobile licences. As a consequence, additional assignments under the current licensing systems would no longer be available. But as explained in section 4 we note that this band has not seen any significant recent growth for either fixed or satellite services.

Option A - Retain

- 9.6 Under this option, new mobile licences would be subject to terms and conditions aimed at preventing interference to existing licensed fixed links or satellite earth station receivers recognised under PES (WT Act) licences or grants of RSA for ROES.
- 9.7 These conditions would likely follow one of two approaches: either exclusion or restriction zones, which constrain mobile deployment near existing deployments; or

⁶¹ Reception of radio signals is generally authorised under licence exemption regulations (The Wireless Telegraphy Apparatus (Receivers) (Exemption) Regulations 1989 (SI 1989/123)).

“interference budgets” where Ofcom establishes the maximum permitted interference power at the input of the satellite or fixed link receiver⁶².

- 9.8 This option would likely be combined with policies that could eventually allow for more extensive use of mobile resulting from incremental reductions in usage in this band by fixed links and satellite earth stations. For example, we would consider allowing existing users to accept a lower benchmark spectrum quality if they wish to come to a commercial or technical agreement with new users of the band for mobile services. When doing so, we would work within an established framework⁶³, which enables licence variations triggered by licensees. This would allow for more extensive use of the band for mobile, and earlier availability.
- 9.9 Under this option we would be likely to also review fees for existing users taking into account the extent to which mobile deployments would have been denied access to the band. This is in line with our pricing framework⁶⁴.
- 9.10 The principal advantage of this approach is that it would cause less disruption to existing users than option B. However, this option could result in extensive areas of the UK being unavailable for 5G / mobile services at 3.6 to 3.8 GHz, at least by the time of an initial roll-out. This is due to the separation distances likely to be required, and the geographical location of the existing deployments, as explained in section 8.

Option B - Remove

- 9.11 Under this option, if we were to award new mobile licences before the end of an appropriate notice period, these licences would have interim terms and conditions to prevent undue interference into current licensed or recognised sites. At the end of this period, these provisions would no longer apply.
- 9.12 In comparison to option A, this policy could in principle result in mobile being made available in this band across a much broader geographic area and potentially in some cases on a shorter timescale. We explain below how this approach could affect current fixed links and satellite earth stations. In addition, mobile operators might be able to reach commercial deals with existing users to achieve early access to this band, before the appropriate notice period has passed, as is also the case under option A. As explained in section 9.8, this is in line with previous policy.

⁶² We have adopted in latter approach when enabling mobile and digital terrestrial television networks to share the 800 MHz band temporarily while DTT was being cleared; and to protect fixed links at 1492 MHz to 1517 MHz (paired with 1350 MHz to 1375 MHz) from Supplemental Downlink mobile transmissions in the adjacent 1452 MHz to 1492 MHz band. See *Notice of transitional restrictions on Mobile Networks in the 800 MHz band for protection of DTT in channels 61 and 62*, August 2013 https://www.ofcom.org.uk/data/assets/pdf_file/0023/47930/annex_6.pdf and *Variation of the Spectrum Access Licence for 1452-1492MHz and changes for fixed link use in the paired bands 1350-1375 MHz and 1492-1517 MHz*, September 2014, https://www.ofcom.org.uk/data/assets/pdf_file/0022/74461/1.4ghz-consultation.pdf

⁶³ See *A Statement on Spectrum Liberalisation*, January 2005, https://ofcom-build.squiz.co.uk/data/assets/pdf_file/0029/51887/statement.pdf section 1.12, which adopts a proposal set out in *Spectrum Liberalisation*, September 2004, https://www.ofcom.org.uk/data/assets/pdf_file/0023/62429/spec_liberalisation.pdf section 4.22

⁶⁴ See *SRSP: The revised Framework for Spectrum Pricing Our policy and practice of setting AIP spectrum fees*, December 2010, https://ofcom-build.squiz.co.uk/data/assets/pdf_file/0024/42909/srsp-statement.pdf

Effect on existing licenses and RSAs

- i) Fixed links; we would propose to revoke the wireless telegraphy licences in the band after serving appropriate notice.
- ii) Satellite earth station users operating under a grant of RSA for ROES; we would propose to revoke grants of RSA insofar they recognise a specified maximum interference level to be taken into account in the 3.6 to 3.8 GHz band after serving appropriate notice. After such revocation the satellite users would still be able to receive signals in this band. If we were to adopt this policy option, future use of the 3.6 to 3.8 GHz band would be on a licence-exempt basis for receive-only satellite earth stations. However, earth station users would have to adjust to an expectation of much lower spectrum quality such that they might suffer interference from mobile use in the same band (depending on the intensity of that mobile use in particular locations as it is rolled out by network operators).

Ofcom encourages licensees to take account of benchmark spectrum quality which is the level of spectrum quality on which Ofcom's technical planning and coordination processes and criteria are based. In other words, the level of unwanted emissions at the receiver location from neighbours' transmissions. In this case, we would no longer seek to maintain this benchmark spectrum quality (after an appropriate notice period), in other words the risk of interference may be higher.

To effect this policy, we would need to give appropriate notice to holders of grants of RSA for ROES that these grants would either be revoked or varied to remove the authorisation to receive in the 3.6 to 3.8 GHz band. We would also issue a statutory instrument subject to a public consultation⁶⁵ to remove the option to have a grant of RSA for ROES issued in the 3.6 to 3.8 GHz band.

- iii) Satellite earth station users operating under a wireless telegraphy licence; we would propose to vary these, removing any frequencies in the 3.6 to 3.8 GHz band from the licence, after appropriate notice is given. As in case (ii) above, stakeholders would continue to be authorised to receive under licence exemption; they would also no longer be able to rely on a given benchmark spectrum quality.

Potential effect on services provided via fixed links

- 9.13 Our initial view is that stakeholders may be able to use comparable frequencies as an alternative to the 3.6 to 3.8 GHz band in the same locations before an appropriate notice period has passed.

Potential effect on services provided via satellite

- 9.14 Satellite earth station operators may have only a limited or indirect ability to choose which frequencies they receive. This is because they need to connect to a transmitter, often in other continents, via a satellite. The frequencies that they use may be determined by the operators of the transmitting station, or by the satellite operator. The exact commercial agreements, and technical constraints, shared among these parties will vary from case to case. In some cases, the frequencies to

⁶⁵ Such a Statutory Instrument would revoke *The Wireless Telegraphy (Recognised Spectrum Access for Satellite Receive-Only Earth Stations) Regulations 2011*, November 2011, http://www.legislation.gov.uk/ukxi/2011/2763/pdfs/ukxi_20112763_en.pdf

be used may also change from time to time, leading some earth station operators to seek flexibility to access the entire band.

- 9.15 However, unlike fixed link operators, satellite service operators are generally able to provide the same service by using the same frequencies but from a different location or by adopting technical mitigations against undue interference (i.e. shielding). In most cases, the satellites they connect to can be reached from almost anywhere in the UK and sometimes using different frequencies.
- 9.16 Some satellite earth stations, located away from urban centres, might be able to continue receiving in this band without suffering undue interference from future mobile / 5G networks in this band. It would be up to the satellite earth station operator to determine that a particular satellite earth station is sufficiently protected from undue interference, for example by natural or artificial shielding (such as terrain or walls) or by reaching an agreement with the relevant mobile licensees.

Other solutions

- 9.17 Our coexistence analysis, as summarised in section 8, suggests that maintaining benchmark spectrum quality for existing users may prevent the deployment of 5G across much of the UK. However, our analysis does not take into account all additional information that stakeholders have regarding their specific sites.
- 9.18 The likelihood of identifying suitable solutions is likely to vary between fixed links and satellite earth stations, and from site to site. In some locations co-existence may be too challenging but in others it may be possible to find a solution, for natural shielding.
- 9.19 It is also possible that in some locations continued operation of existing services would have minimal impact on availability of 5G services, if technical coordination solutions can be found. We invite suggestions from stakeholders on this matter to help us determine whether a different approach is feasible.

Option comparison

- 9.20 Broadly speaking, policy option A, which minimises the disruption to current users, is likely to result in the least extensive availability of spectrum for 5G / mobile services at 3.6 to 3.8 GHz. By contrast, option B is likely to be the most effective policy to enable spectrum availability for 5G / mobile services in the band, but is also likely to generate the most disruption for current users.
- 9.21 If we decide to make the 116 MHz in this band not already available for electronic communication services available for 5G / mobile, we would take into account evidence received in response to this consultation when considering policy proposals that could enable such an outcome.

Question 6: Do you have a view on any of the two options we identified?

Question 7: Do you have any quantitative evidence on the costs and benefits associated with the options? This include costs for existing users and/or consumers of existing services associated with potential changes, and benefits to UK consumers in gaining access to mobile services in this band.

Question 8: Do you have any other suggestions that would allow widespread 5G availability using the 3.6 to 3.8 GHz band across the UK while allowing certainty for

at least some existing users to continue to provide the benefits currently provided by use of the 3.6 to 3.8 GHz band?

Question 9: Do you have any comments in relation to these proposals?

Section 10

Next steps

Introduction

- 10.1 This section sets out the measures we are taking while seeking evidence to inform future policies to enable the use of the 3.6 to 3.8 GHz band for mobile services.

Mobile trading regulations

- 10.2 This consultation document proposes making the 3.6 to 3.8 GHz band available for 5G / mobile services in the future. As such, we also plan to bring the 3.6 to 3.8 GHz band (including UK Broadband's current licence at 3605 to 3689 MHz) under the Mobile Trading Regulations⁶⁶, rather than under the Wireless Telegraphy (Spectrum Trading) Regulations 2004⁶⁷.
- 10.3 The effect would be to enable Ofcom to conduct an assessment of the impact on competition of any trade before deciding on whether to approve that trade. We will consider this issue in the coming months and welcome any evidence that may feed in to this process.

We will take into account the aims of this consultation when considering further licence applications in this band

- 10.4 While developing our policies with regards to access to this band by fixed links and satellite earth stations, we will take into account the substance and objectives of this consultation when considering any new applications for use of this band for these existing services.

Fixed links

- 10.5 We will continue to accept applications for new point-to-point fixed links licences and technical variations to existing licences in the 3.6 to 4.2 GHz band. In line with our current assignment approach (i.e. channel assignment from the top of the band down), we shall continue to focus assignments, where possible, on Channels 8 and 9 (3815 to 3875 MHz and 4135 to 4195 MHz), taking into account our high level policy goals outlined in this consultation. When considering new applications we will take into account the fact that we are reviewing our policy regarding this band.
- 10.6 The effect of these considerations will be a strong preference to avoid Channels 4 – 7 (3695 to 3815 MHz and 4015 to 4135 MHz)⁶⁸, but we would consider offering a temporary licence (potentially 3 years) in these channels, if such assignment is only possible in these same channels.

⁶⁶ See *The Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011*, June 2011, <http://www.legislation.gov.uk/uksi/2011/1507/made/data.pdf>

⁶⁷ See *The Wireless Telegraphy (Spectrum Trading) Regulations 2004*, November 2004, <http://www.legislation.gov.uk/uksi/2004/3154/contents/made>

⁶⁸ Channels 1 – 3 (3605 to 3695 MHz and to 3925 to 4015 MHz) are currently closed to new applicants.

Satellite earth stations

- 10.7 While we are developing our proposals on future use of the 3.6 to 3.8 GHz band, we will continue to accept applications in respect of new grants of Recognised Spectrum Access for Receive Only Earth Stations (RSA for ROES).
- 10.8 However, when deciding whether or not to grant a new RSA or a variation of an existing RSA, we will take into account (amongst other things) the fact that we are consulting on the possibility of making further spectrum available in this band for 5G / mobile services when considering whether an application meets the three criteria⁶⁹ necessary for a grant of RSA. This includes whether a grant would secure the optimal use of spectrum and the promotion of competition in electronic communications services, having regard to the matters set out in section 3(1) and (2) of the Wireless Telegraphy Act 2006.
- 10.9 We will also continue to accept applications in respect of new Permanent Earth Station licences. However, when deciding whether or not to issue further licences, or to issue variations to existing licences, we would consider our over-riding duty to secure the optimal use of spectrum, and the fact that we are reviewing our policy regarding this band.
- 10.10 The effect of these considerations will be that new assignments will be less likely to be granted at new sites; or at existing sites not already using the 3.6 to 3.8 GHz band. In any case, as outlined in section 4, the use of the band by existing services is relatively stable and we do not often receive applications for new sites.
- 10.11 We intend to provide further clarity for stakeholders regarding existing services' future access to the 3.6 to 3.8 GHz band after having considered the input received in response to this consultation.

⁶⁹ The 2011 Limitation Regulations provide that Ofcom “will make a limited number of grants of RSA” and that it will only grant RSA where, broadly speaking, (i) the apparatus or station is ‘receive-only’, (ii) it operates within the 3.6 GHz to 4.2 GHz band to provide a fixed satellite service, and (iii) the number of grants made is the number which is most likely to secure optimal use and promote competition. See *Wireless Telegraphy (Limitation of Number of Grants of Recognised Spectrum Access for Satellite-Receive Only Earth Stations) Order 2011*, November 2011, <http://www.legislation.gov.uk/ukxi/2011/2757/introduction/made>

Annex 1

Responding to this consultation

How to respond

- A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made **by 5pm on 1 December 2016**.
- A1.2 Ofcom strongly prefers to receive responses using the online web form at <https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz>, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response cover sheet (see annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.
- A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email 3.6-3.8.GHz.mobile@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

Responses may alternatively be posted or faxed to the address below, marked with the title of the consultation.

Alberto Fernandes
Floor 3:126
Spectrum Group
Riverside House
2A Southwark Bridge Road
London
SE1 9HA

- A1.4 Note that we do not need a hard copy in addition to an electronic version. Ofcom will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.
- A1.5 It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at annex 4. It would also help if you can explain why you hold your views and how Ofcom's proposals would impact on you.

Further information

- A1.6 If you want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Alberto Fernandes on 3.6-3.8.GHz.mobile@ofcom.org.uk.

Confidentiality

- A1.7 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt. If you think your

response should be kept confidential, can you please specify what part or whether all of your response should be kept confidential, and specify why. Please also place such parts in a separate annex.

- A1.8 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and will try to respect this. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.
- A1.9 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's approach on intellectual property rights is explained further on its website at <https://www.ofcom.org.uk/about-ofcom/website/terms-of-use>

Next steps

- A1.10 Input from stakeholders will inform any future policy proposals regarding the 3.6 to 3.8 GHz band.
- A1.11 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details, please see: <https://www.ofcom.org.uk/about-ofcom/latest/email-updates>

Ofcom's consultation processes

- A1.12 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information, please see our consultation principles in annex 2.
- A1.13 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.
- A1.14 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Steve Gettings, Secretary to the Corporation, who is Ofcom's consultation champion:
- A1.15 Steve Gettings
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA
- Tel: 020 7981 3601
- Email steve.gettings@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. If we do not have enough time to do this, we will hold an open meeting to explain our proposals shortly after announcing the consultation.

During the consultation

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 We will make the consultation document as short and simple as possible with a summary of no more than two pages. We will try to make it as easy as possible to give us a written response. If the consultation is complicated, we may provide a shortened Plain English Guide for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will consult for up to 10 weeks depending on the potential impact of our proposals.

A2.6 A person within Ofcom will be in charge of making sure we follow our own guidelines and reach out to the largest number of people and organisations interested in the outcome of our decisions. Ofcom's 'Consultation Champion' will also be the main person to contact with views on the way we run our consultations.

A2.7 If we are not able to follow one of these principles, we will explain why.

After the consultation

A2.8 We think it is important for everyone interested in an issue to see the views of others during a consultation. We would usually publish all the responses we have received on our website. In our statement, we will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

- A3.1 In the interests of transparency and good regulatory practice, we will publish all consultation responses in full on our website, www.ofcom.org.uk.
- A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality where appropriate.
- A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore, Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.
- A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at <https://www.ofcom.org.uk/consultations-and-statements/consultation-response-coversheet> .
- A3.5 Please put any parts of your response you consider should be kept confidential in a separate annex to your response and include your reasons why this part of your response should not be published. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your cover sheet only, so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

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

Nothing

Name/contact details/job title

Whole response

Organisation

Part of the response

If there is no separate annex, which parts?

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

DECLARATION

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

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here.

Name

Signed (if hard copy)

Annex 4

Consultation questions

Question 1: Do you have any comments on the use of the 3.6 to 3.8 GHz band by existing services?

Question 2: Do you agree with our identification of a trend towards the use of mobile in the 3.6 to 3.8 GHz band?

Question 3: Do you agree with our high level proposal to make 116 MHz within the 3.6 to 3.8 GHz band available for mobile and 5G services, bearing in mind our statutory duties and the high level trends we have identified?

Question 4: Do you agree with our general approach regarding spectrum currently licensed to UK Broadband?

Question 5: Do you agree with our assumptions, methodology, and conclusions with regards to potential coexistence between mobile and existing fixed links and satellite earth stations? Please refer to annex 5 for further details.

Question 6: Do you have a view on any of the two options we identified?

Question 7: Do you have any quantitative evidence on the costs and benefits associated with the options? This include costs for existing users and/or consumers of existing services associated with potential changes, and benefits to UK consumers in gaining access to mobile services in this band.

Question 8: Do you have any other suggestions that would allow widespread 5G availability using the 3.6 to 3.8 GHz band across the UK while allowing certainty for at least some existing users to continue to provide the benefits currently provided by use of the 3.6 to 3.8 GHz band?

Question 9: Do you have any comments in relation to these proposals?

Annex 5

Coexistence analysis

A5.1 In this appendix we provide a summary of the assumptions and methodology used for our coexistence analysis.

Coexistence with fixed links

A5.2 Ofcom manages the interference environment for fixed microwave links by coordinating additional use of the 3.6 to 3.8 GHz band using the Ofcom technical frequency assignment criteria⁷⁰. Two different thresholds are defined, a long-term one and a short-term one. The long-term threshold is used to manage the interference conditions for the receiver that will occur most of the time, whereas the short-term threshold takes into account an interference signal enhanced for a short period of time by a receiver. Short-term interference usually occurs when hot weather causes anomalous propagation conditions.

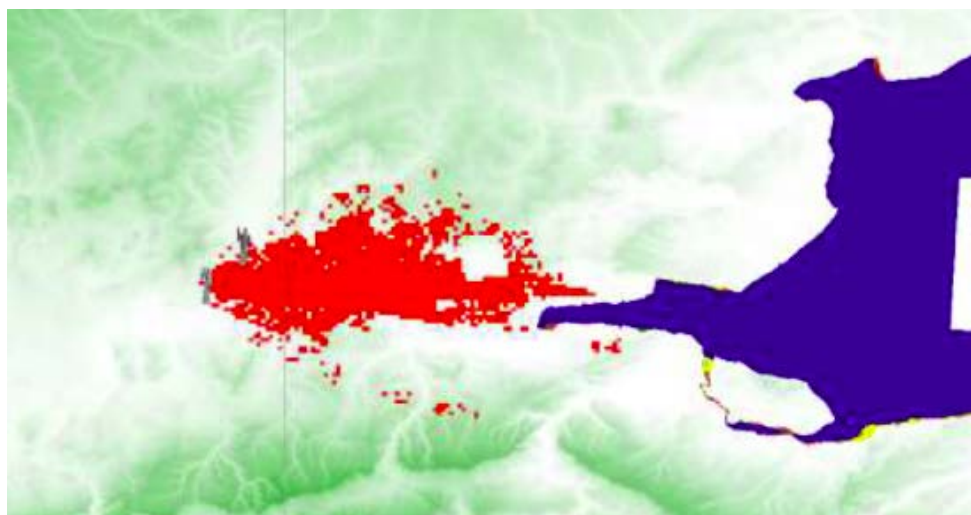
A5.3 When analysing via computer simulations the interference from an outdoor small cell to a microwave receiver, we measured a denied area of hundreds of square kilometres when the long-term threshold is considered. Studies we commissioned from Transfinite⁷¹ found that the size of the denied area for the BT Tower in London is about 500 km² and it extends up to around 50 km east from the fixed link antenna, with a widest dimension of about 30km (see Figure 10).

⁷⁰ See *OfW 446*, July 2015 https://www.ofcom.org.uk/_data/assets/pdf_file/0013/75100/ofw446.pdf

⁷¹ See *Geographic Sharing in C-band*, June 2015,

https://www.ofcom.org.uk/_data/assets/pdf_file/0012/51303/c-band-sharing.pdf Chapter 5.

Figure 10: Area analysis for the BT Tower in London considering long-term threshold.



- A5.4 We extended Transfinite's analysis to account for the short-term threshold, and we found that the area of denied pixels could further increase when anomalous propagation conditions are taken into account.
- A5.5 The denied area reduces significantly for an indoor cell. For the example provided by Transfinite for the BT Tower in London, the size of the denied area is about 27 km².
- A5.6 A high resolution analysis⁷², indicates that small cells can be deployed nearer to fixed links in dense urban areas if base stations are deployed below clutter, outside the line of sight of the 'victim' and there is a significant degree of diffraction loss due to buildings. However, there could be a significant burden in terms of deployment optimisation at each individual site to ensure regulatory compliance with interference management criteria. Moreover, this approach would not be effective for macro cells, as macro antennas are usually deployed above clutter.
- A5.7 In summary, both the Transfinite study and our internal study indicated that coexistence between small cells and fixed links could be very challenging in densely populated areas with a large number of fixed links deployed.
- A5.8 Clearly, coexistence with macro cells would be even more challenging than with small cells.
- A5.9 Considering that some of the fixed links are deployed in very dense populated areas in the South of England, denied zones with the dimensions in the example above could deny use of the spectrum to a large number of mobile users.
- A5.10 The links around the Hebrides and the Shetland islands are much farther away from densely populated areas. There are also two fixed links to the West and North of Aberdeen. These are relatively close to the city, but stand in open fields and their antennas point away from Aberdeen and mostly across fields. The potential for undue interference to these links caused by these mobile networks may be limited by the use of highly directional antennas by the fixed service in general.

⁷² See *Geographic Sharing in C-band*, June 2015,

https://www.ofcom.org.uk/data/assets/pdf_file/0012/51303/c-band-sharing.pdf Chapter 7.

Coexistence with satellite earth stations

- A5.11 Currently, satellite earth stations in this shared band are able to register to have emissions received in the 3.6 to 3.8 GHz band taken into account in Ofcom's coordination process with other services on a first come first served basis. In a similar way as for fixed links, two different interference thresholds are defined, a long-term one and a short-term one. Both thresholds are taken into account when authorising PES (WT Act) licences that include reception at 3.6 to 3.8 GHz, while only long-term interference is taken into account for RSA for ROES in this spectrum.
- A5.12 We assessed the impact of a small cell and macro cell mobile base station deployment to both long-term and short-term thresholds.
- A5.13 A 50m resolutions analysis⁷³ shows that suburban and rural areas (where earth stations are usually deployed) would have access to a lower amount of spectrum, because interference management zones are required in the proximity of earth stations.
- A5.14 A high resolution analysis⁷⁴ (that is able to capture in details site-specific characteristics) shows that there is potential to deploy small cells reasonably close to satellite earth stations on a co-channel basis, provided that adjustments are possible for the location of the base stations and for the antenna orientation. However, as in in the case of fixed links, there could be a significant burden in terms of measurement and deployment optimisation at each individual site to ensure regulatory compliance with interference management criteria.
- A5.15 The effect of aggregate interference between different small cells is also considered. Transfinite indicates that it becomes increasingly hard to deploy small cells in proximity of earth stations as the density increases. However, sharing could be facilitated via using directional antennas with a higher discrimination towards the earth station.
- A5.16 Mitigation techniques at the satellite earth stations could be effective to allow a larger number of small cells to be deployed or to allow deploying small cells closer to earth stations. Mitigation techniques include site shielding or an increased antenna dimension.
- A5.17 We extended the set of scenarios considered in Transfinite's analysis to account for macro cells and short-term interference. We found that coexistence between mobile macro cells and satellite earth stations becomes much more challenging than with small cells.
- A5.18 We considered a large scale macro cell deployment covering greater London within the M25, with antenna heights and relative power levels based on the EC harmonisation recommendations and knowledge of existing mobile networks, a sector antenna pattern modelled as SL 12436A, a down tilt of 2°, 3 sectors per BS and a max licensed EIRP of 61 dBm/MHz

⁷³ See *Geographic Sharing in C-band*, June 2015, https://www.ofcom.org.uk/_data/assets/pdf_file/0012/51303/c-band-sharing.pdf Chapter 5.

⁷⁴ See *Geographic Sharing in C-band*, June 2015, https://www.ofcom.org.uk/_data/assets/pdf_file/0012/51303/c-band-sharing.pdf Chapter 7.

- A5.19 We assessed long term (I/N levels of -10 dB for 20% propagation time) and short term interference (0 dB for 0.005% propagation time) using the ITU-R P.452 propagation model. For the long term interference, we also used the ITU-R P.1812 model, that although intended for use between 30 MHz and 3 GHz, can provide an idea of the effect of clutter along the path profile.
- A5.20 Our results show that a large scale macro cell mobile deployment in London would cause both long-term and short-term undue interference at five locations with earth stations. We summarise the results in the table 2 below. In this example, we studied the effect on three sites with satellite earth stations operating under PES licences, one site operating under a PES licence and a grant of RSA for ROES (Brookmans Park), and one site (Crowsley Park) that operates under grants of RSA for ROES.

Table 3: Undue interference to satellite earth stations from large scale mobile macro cell deployment in London

PES SITE	Model P.452-16						Model P.1812-4			
	Long Term 20 %				Short Term 0.005%		Long Term 20%			
	Worst I/N (dB)	Margin (dB)	Aggr I/N (dB)	Margin (dB)	Worst I/N (dB)	Margin (dB)	Worst I/N (dB)	Margin (dB)	Aggr I/N (dB)	Margin (dB)
Chalfont, with 30dB shielding ⁷⁵	10.45	-20.5	23.9	-34	17.5	-17.5	5.1	-15.1	14	-24
Bedford	-23	13	-8.4	-1.6	17.5	-17.5	-34	24	-13.5	3.5
Crawley Court	-34.7	24.7	-14.8	4.8	13.7	-13.7	-42	32	-20.8	10.8
Crowsley Park	4.18	-14.2	19.5	-29.5			-17.2	7.2	-0.8	-9.2
Brookmans Park	32.4	-42.4	44.5	-54.5	38.6	-38.6	23.4	-33.4	31.6	-41.6

- A5.21 Bearing in mind that the threshold for long-term interference is -10 dB, four of these earth stations can be seen to suffer undue interference from a large scale macro cell mobile deployment in London when model P.452-16 is used whereas only three earth stations appear to suffer undue interference when model P.1812-4.
- A5.22 Considering short term interference, where the interference management criteria is 0 dB for 0.005% propagation time, model P452-16⁷⁶ indicates that all four of the PES licences⁷⁷ considered are liable to suffer undue interference.
- A5.23 Our simulations show that the effect of an aggregate interference on the long-term threshold and of a single interference on the short-term thresholds are both challenging and may not be sufficiently addressed through mitigation techniques.
- A5.24 In particular, the analysis suggests that the distance between satellite earth stations and mobile base stations required to satisfy the short-term threshold constraint could be large. For example, for Chalfont our studies indicate that the distance would need to be in the order of 145 km around Chalfont.

⁷⁵ Regarding Chalfont, local knowledge of the tree line between Chalfont Grove and London, along with previous measurements completed by the Radiocommunications Agency relating to the original 6 GHz application by Kingston TLI, lead us to believe that at least 30 dB of local shielding is available.

⁷⁶ Model P.1812-4 does not take into account short-term interference.

⁷⁷ Reception of satellite emissions at Crowsley Park is authorised through grants of RSA for ROES, which do not take into account short-term interference.

- A5.25 This means that management of the interference environment for satellite earth stations might not only exclude major cities due to the aggregate interference effect, but also exclude deployment in smaller cities due to interference from a single macro cell above the short-term threshold.
- A5.26 We have also identified a satellite earth station site 80 km from Birmingham operating under a PES licence, which is likely to suffer from interference in the event of a macro cell mobile deployment in Birmingham.
- A5.27 Preliminary studies on out-of-band interference are provided in the Transfinite report, however further studies are needed.

Annex 6

Legal framework

- A6.1 In this annex we describe in more detail the general legal and policy framework for spectrum in the UK, as summarised in section 2. The legal framework derives from our duties under both European and domestic legislation, specifically from:
- A6.2 the European Common Regulatory Framework⁷⁸ for electronic communications networks and services, in particular, the Framework Directive and the Authorisation Directive; and
- A6.3 The Communications Act 2003 (the “Communications Act”) and the Wireless Telegraphy Act 2006 (the “WTA”) which transpose the provisions of those directives into national law.
- A6.4 We also discuss Commission Decision 2008/411/EC on the harmonisation of the 3400-3800 MHz frequency band and the regulations implementing that decision.

European Regulatory Framework

- A6.5 Article 8 of the Framework Directive sets out the objectives that national regulatory authorities (NRAs) must take all reasonable steps to achieve. These include:
- i) the promotion of competition in the provision of electronic communications networks and services by, among other things, ensuring that there is no distortion or restriction in competition in the electronic communications sector, and encouraging efficient use of radio frequencies; and
 - ii) contributing to the development of the internal market by, among other things, removing obstacles to the provision of electronic communications networks and services at a European level, and encouraging the interoperability of pan-European services.
- A6.6 In pursuit of these policy objectives, Article 8 requires NRAs to apply objective, transparent, non-discriminatory and proportionate regulatory principles by (amongst other things) ensuring that, in similar circumstances, there is no discrimination in the treatment of undertakings providing electronic communications networks and services; safeguarding competition to the benefit of consumers; and promoting efficient investment and innovation in new and enhanced infrastructures.
- A6.7 Article 8 also requires EU member states to ensure that in carrying out their regulatory tasks, NRAs take the utmost account of the desirability of making regulations technologically neutral.

⁷⁸The Common Regulatory Framework comprises the Framework Directive (Directive 2002/21/EC), the Authorisation Directive (Directive 2002/20/EC), the Access Directive (Directive 2002/19/EC), the Universal Service Directive (Directive 2002/22/EC) and the Directive on privacy and electronic communications (Directive 2002/58/EC), as amended by the Better Regulation Directive (Directive 2009/140/EC).

- A6.8 Article 9 of the Framework Directive requires member states to ensure the effective management of radio frequencies in accordance with (amongst other things) Article 8.
- A6.9 Article 5 of the Authorisation Directive provides that where it is necessary to grant individual rights of use of radio frequencies, member states must grant such rights through open, transparent and non-discriminatory procedures and in accordance with the provisions of Article 9 of the Framework Directive. When granting those rights, member states are required to specify whether they can be transferred by the holder, and if so, under which conditions.
- A6.10 Article 7 of the Authorisation Directive provides that where member states decide to limit the number of rights of use to be granted for radio frequencies, they must (amongst other things) give due weight to the need to maximise benefits for users and to facilitate the development of competition.
- A6.11 The legal duties imposed on the UK by the Framework and Authorisation Directives are transposed into UK law and given effect by the Communications Act and the WTA.

Duties under the Communications Act 2003

- A6.12 Section 3 of the Communications Act 2003 provides that our principal duty is: to further the interests of citizens in relation to communications matters; and to further the interests of consumers in relevant markets, where appropriate, by promoting competition.
- A6.13 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; and the availability throughout the UK of a wide range of electronic communication services.
- A6.14 Section 3(3) provides that, in performing our duties, we must in all cases have regard to the principles of transparency, accountability, proportionality and consistency, as well as ensure that our actions are targeted only at cases in which action is needed.
- A6.15 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 encouraging investment and innovation in relevant markets; and the different needs and interests of everyone who may wish to use the spectrum for wireless telegraphy.
- A6.16 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.
- A6.17 Section 4 requires Ofcom to act in accordance with the six Community requirements, which give effect to the requirements of Article 8 of the Framework Directive.

Duties under the Wireless Telegraphy Act 2006

- A6.18 Section 3 of the WTA 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.

- A6.19 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.

Wireless Telegraphy Licences

- A6.20 The WTA sets out our legal power to grant wireless telegraphy licences. Section 8(1) makes it an offence for any person to establish or use any station for wireless telegraphy or to install or use any apparatus for wireless telegraphy except under and in accordance with a licence granted by us under that section (a wireless telegraphy licence). However, the WTA does not bind the Crown, so Crown bodies, such as government departments and executive agencies, do not need authorisation from Ofcom in order to install or use radio equipment, and there is no basis for Ofcom to license them.
- A6.21 Section 9(1) of the WTA gives us the power to grant wireless telegraphy licences subject to such terms as we think fit. This broad discretion is, however, subject to the rule that we must impose only those terms that we are satisfied are objectively justifiable in relation to the networks and services to which they relate, not unduly discriminatory, and proportionate and transparent as to what they are intended to achieve (see section 9(7)).
- A6.22 In addition, our discretion under section 9 must be interpreted in a way that is consistent with the licence conditions permitted under the Authorisation Directive.

Granting licences

- A6.23 In accordance with section 10 and schedule 1 of the WTA, Ofcom may grant licences in accordance with procedures prescribed in regulations made by Ofcom.
- A6.24 Ofcom has made general regulations in relation to licensing procedures (the Wireless Telegraphy (Licensing Procedures) Regulations 2010⁷⁹). Where Ofcom decides to award licences by auction or 'beauty contest', it makes specific regulations for those purposes, in accordance with section 14 of the WTA in relation to auctions, and Schedule 1 of the WTA in relation to 'beauty contests'.
- A6.25 The Wireless Telegraphy (Licensing Procedures) Regulations make provision for Ofcom to grant licences in relation to particular wireless telegraphy stations or apparatus, where an applicant has provided Ofcom with the requisite information set out in Regulation 5.

Charging fees for wireless telegraphy licences

- A6.26 Section 12 of the WTA permits Ofcom to charge fees for wireless telegraphy licences, subject to certain specified exemptions relating to licences granted in accordance with auction regulations made under section 14 of the WTA.

⁷⁹Made under section 10 and Schedule 1 of the Wireless Telegraphy Act 2010.

A6.27 Under Article 13 of the Authorisation Directive, any fees imposed for rights of use of radio frequencies must reflect the need to ensure the optimal use of the resources. Such fees must be objectively justifiable, transparent, non-discriminatory and proportionate in relation to their intended purpose and take into account the objectives set out in Article 8 of the Framework Directive.

Our approach to applying our duties

A6.28 The duties set out above require us to balance a range of considerations. In doing so, we have a variety of regulatory tools and market mechanisms at our disposal in order to carry out our functions. In general, as set out in our Spectrum Framework Review⁸⁰, we prefer to use market mechanisms to manage the spectrum.

A6.29 We consider that market-based mechanisms, such as trading, liberalisation, administered incentive pricing and auctions are more likely to achieve our statutory objective of securing optimal use of the spectrum than 'command and control' methods based on regulatory and administrative decisions.

A6.30 We have recently consulted on a new Spectrum Management Strategy⁸¹. This proposes a slightly revised position whereby we would rely on market mechanisms where possible and effective, but also take regulatory action where necessary. The consultation proposed that once the conditions required for the use of market mechanisms are in place, they should generally be considered the most effective method of allocating scarce resources to ensure they are used efficiently. The consultation responses are still under consideration.

Commission Decision 2014/276/EU on the harmonisation of the 3.4 GHz to 3.8 GHz frequency band

A6.31 On 21 May 2008, the European Commission adopted Commission 2008/411/EC, which seeks to harmonise the conditions for the availability and efficient use of the 3.4 to 3.8 GHz frequency band for terrestrial systems capable of providing electronic communications services in the EU⁸². In relation to the 3.6 to 3.8 GHz band, the decision provides that member states should designate, by 21 November 2008, the band, on a non-exclusive basis, for terrestrial electronic communications networks in compliance with the parameters set out in the annex to the decision.

A6.32 The Commission Decision was implemented in the UK by way of the 3400-3800 MHz Frequency Band (Management) Regulations 2008⁸³, which required Ofcom to exercise its functions under the WTA so as to give effect to the obligations of the United Kingdom under the Commission Decision. Any award of the 3.4 GHz to 3.8 GHz band has to be compliant with the Commission Decision.

⁸⁰ See *Spectrum Framework Review*, November 2004 <https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2005/spectrum-framework-review/>

⁸¹ See *Spectrum management strategy - Ofcom's approach to and priorities for spectrum management over the next ten years*, October 2013, <https://www.ofcom.org.uk/consultations-and-statements/category-1/spectrum-management-strategy>

⁸² *Commission Decision 2008/411/EC*, May 2008, <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008D0411&from=EN>

⁸³ See *S.I. 2008/2794*, October 2008, http://www.legislation.gov.uk/ukxi/2008/2794/pdfs/ukxi_20082794_en.pdf

- A6.33 This Decision was amended in May 2014, when the European Commission adopted Commission Implementing Decision 2014/276/EU, which established technical parameters for Electronic Communication Services that are authorised to use the 3.4 GHz to 3.8 GHz band. EU Member States must make sure that spectrum licences issued for ECS in these bands are aligned with these parameters. For the 3.6 to 3.8 GHz band, these parameters correspond to TD-LTE spectrum access technology.
- A6.34 This decision was implemented in to UK law by way of Statutory Instrument 2016 No. 495.

Annex 7

Glossary

3GPP	The 3rd Generation Partnership Project (3GPP) is a body that develops standards for mobile technology.
5G	Fifth generation mobile phone standards and technology, which are currently under development. Most consumers currently use a combination of 4G, 3G and 2G services.
DTT	Digital Terrestrial Television - Broadcasting delivered by digital means. In the UK and Europe, DTT transmissions use the DVB-T and DVB-T2 technical standards.
EU	European Union
FCC	Federal Communications Commission, the United States' primary authority for communications laws, regulation and technological innovation
GHz	Gigahertz. 1,000,000,000 (or 10 ⁹) oscillations per second.
LTE	Long-Term Evolution is a standard for communication of high-speed data for mobile phones and data terminals. The term 4G is generally used to refer to mobile broadband services delivered using the next generation of mobile broadband technologies, including Long Term Evolution (LTE) and WiMAX.
MHz	Megahertz - A unit of frequency of one million cycles per second.
PES	Permanent Earth Station. In satellite services, a terrestrial station that transmits signals to and/or receives from a satellite, and has a permanent location.
ROES	Receive Only Earth Station. In satellite services, an earth station which does not transmit, but receives signal from a satellite.
RSA	Recognised Spectrum Access. RSA is a regulatory mechanism that provides formal recognition of receive-only radio stations by allowing Ofcom to take them into account when planning spectrum use and assigning frequencies to other radio users.
RSPG	Radio Spectrum Policy Group. A high level advisory group that assists the European Commission in the development of radio spectrum policy.
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.
TD-LTE	TDD applied to LTE.