3.8 GHz to 4.2 GHz band: Opportunities for Innovation

Call for Input

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About this document

This Call for Input (CFI) introduces the 3.8 GHz to 4.2 GHz band as a candidate band for enhanced spectrum sharing, for potential new innovative applications, and seeks feedback and input from stakeholders.

The document is being published alongside the Spectrum Sharing Framework[1], which sets out an approach to systematically review opportunities for spectrum sharing.

We apply the spectrum sharing framework throughout this document to consider the opportunities that this band could offer to enable enhanced spectrum sharing.

Our preliminary analysis indicates that the band is suitable for more intensive sharing, while taking into account incumbent services.

To assist stakeholders in their understanding of how the band is currently used we have also made available, in conjunction with this CFI, the incumbent users characteristics of use in an online interactive tool[2].

[1] http://stakeholders.ofcom.org.uk/consultations/spectrum-sharing-framework/statement/
[2] http://stakeholders.ofcom.org.uk/consultations/opportunities-for-spectrum-sharing-innovation/interactive-data/

Contents

Section 1

Introduction

Purpose

1.1 The purpose of this Call for Input (CFI) is to build upon the Spectrum Sharing Framework[3], by introducing a first candidate band that we plan to consider for more intense sharing. This document is the beginning of a conversation with stakeholders and highlights our intention to promote increased shared access in the 3.8 GHz to 4.2 GHz band as we believe this band poses a good opportunity and potential for more intensive usage by innovative applications / services, while taking in to account incumbent services.

1.2 Respondents to our consultations on the Spectrum Management Strategy[4] and the Spectrum Sharing Framework highlighted the demand for shared spectrum for high capacity applications. Respondents also added that access could be facilitated by the introduction of an advanced sharing framework. Further, the incumbents' characteristics of use in this band are geographically defined at fixed locations, relatively stable and known by Ofcom as we centrally manage the coordination between the existing services in the band. We believe such characteristics are important to define the potential for new services to share the spectrum. Therefore, we believe the band comprises a good balance of these necessary properties and an opportunity for innovative applications wishing to access spectrum on a shared basis.

1.3 This is the first band where we apply the Spectrum Sharing Framework by identifying the characteristics of use of its incumbents. Through this CFI, we are seeking stakeholders' feedback on the characteristics of use of potential new applications that could share the band. We also ask what types of barriers stakeholders identify to greater sharing in the band, and what types of tools could be applied to address these.

1.4 This initiative is focussed on UK innovation and is based on the band's specific characteristics of existing use in the UK.

Sharing is important

1.5 In our Spectrum Management Strategy, published in April 2014, we highlighted the important role of sharing in addressing increasing demand for spectrum access and identified sharing as an area of increased emphasis to ensure the ongoing optimal use of spectrum.

1.6 We further highlighted our commitment to exploring new opportunities for increased shared access to spectrum in our Spectrum Sharing Framework Statement, published in parallel to this Call for Input, where we indicate our intention to understand the opportunity and impact of more intensive sharing in the 3.8 GHz to 4.2 GHz band, with a particular interest in new innovative services.

[3] http://stakeholders.ofcom.org.uk/consultations/spectrum-sharing-framework/statement/
[4] http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-management-strategy/statement/statement.pdf

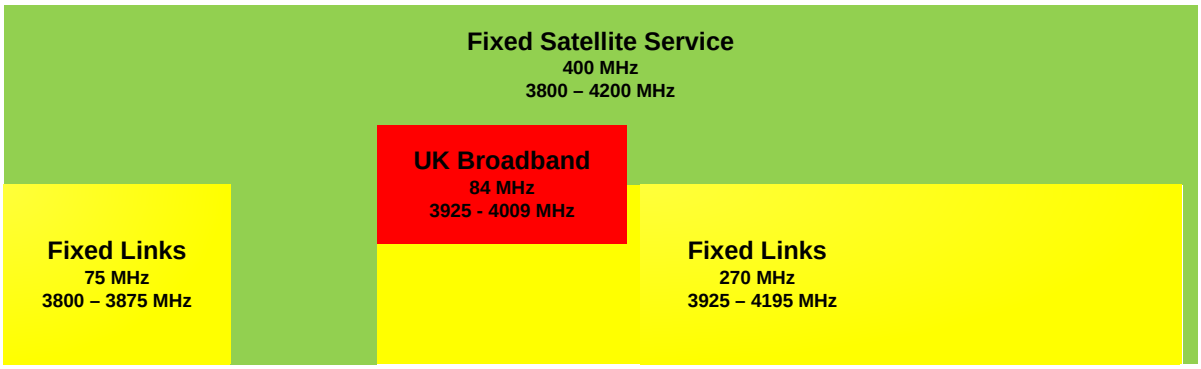
1.7 In the sharing framework we also acknowledge that when we are evaluating whether it is possible to create a new sharing opportunity, we will always need to consider what the relative merits of that opportunity might be. Where there is potential benefit to new sharing we will need to consider the associated changes carefully, taking account of the benefits that incumbent services deliver to citizens and consumers. This includes incumbents' incentives to innovate and invest.

Applying the Spectrum Sharing Framework

1.8 In line with the Spectrum Sharing Framework, in order to understand the opportunity for increased shared access, we analyse the bands' users and their characteristics of use.

1.9 The 3.8 GHz to 4.2 GHz band is already accessed in the UK by Fixed Links, Fixed Satellite Services, and UK Broadband as per Figure 1. There are currently 28 sites with satellite earth stations and 65 fixed links assignments across multiple channels in this band[5]. This usage is concentrated in particular geographic areas and at particular frequencies within the band. UK Broadband has a UK-wide licence that includes 84 MHz of spectrum at 3925 MHz to 4009 MHz. All incumbents' deployments in the 3.8 GHz to 4.2 GHz band, including UK Broadband's deployments in the 3925 MHz to 4009 MHz range, are coordinated by Ofcom on a first-come-first-served basis.

Figure 1: Frequency allocations in the 3.8 GHz to 4.2 GHz band.



1.10 Given the characteristics of use of incumbent Fixed and Fixed Satellite Services, as set out in Section 2, we believe the 3.8 GHz to 4.2 GHz band has the potential to be accessed on a more intense shared basis by innovative applications with different requirements. In particular, some innovative applications might be able to use the spectrum on an opportunistic basis while other applications might, for example, require a defined quality of service but within a discrete area. Our preliminary view is that we could develop geographic licences, which could enable the delivery of a defined quality of service, in spectrum currently not assigned on a geographic basis[6] and separated from fixed links and satellite earth stations. We also believe at this point that it may be possible to consider facilitating opportunistic spectrum access across the band without causing undue interference to existing licences.

[5] Ofcom licensing data as of January 2016
[6] UK Broadband holds a geographic licence for the 3925 MHz to 4009 MHz range, assigned on a UK-wide basis.

1.11 Having identified tools and enablers for spectrum sharing in the Spectrum Sharing Framework, our intention is therefore to further consider developing regulatory tools that could enable additional access to the 3.8 GHz to 4.2 GHz band. We believe a multi-tier authorisation approach could be one way to provide an opportunity to cater for the diverse requirements of the potential new and existing users.

Rest of this document

1.12 **Section 2** provides a more detailed analysis of the rationale for considering this band as a potential candidate band for enhanced sharing. It also provides an overview of how the 3.8 GHz to 4.2 GHz band is currently used to assist stakeholders with an interest in making use of this shared band to understand the level and nature of the existing usage of the band. The information presented focusses on the usage of the spectrum by the Fixed and Fixed Satellite Services, where Ofcom carries out detailed co-ordination and issues individual licences or in the case of receive only earth stations, grants of recognised spectrum access (RSA for ROES). In addition to the fixed links and satellite earth stations, UK Broadband also has access to an 84 MHz block of spectrum within this band (3925 MHz to 4009 MHz) under a nationwide spectrum access licence. Details of the UK Broadband licence can be found on Ofcom's website[7]. The section also refers to the Characteristics of Use identified in the Spectrum Sharing Framework where appropriate, and provides additional information about, channelization, interdependencies with adjacent bands, and the international context.

1.13 **Section 3** introduces potential regulatory approaches and highlights tools that could potentially facilitate more intense spectrum sharing in the 3.8 GHz to 4.2 GHz band, as identified in the Spectrum Sharing Framework. Our preliminary view is that this could be enabled through opportunistic and geographically defined spectrum access approaches. We believe there is scope to incorporate these approaches in to a tiered authorisation approach to spectrum access.

[7] http://licensing.ofcom.org.uk/binaries/spectrum/mobile-wireless-broadband/cellular/licences/SA_3.6_LICENCE_-_UK_Broadband_0823615_05-04-13.pdf

Section 2

The 3.8 GHz to 4.2 GHz band

Why this band

2.1 In the Spectrum Management Strategy, many stakeholders supported in general terms the potential for increased spectrum sharing. We also received feedback advocating considering more intense spectrum sharing within the 3.6 GHz to 4.2 GHz band (also referred to as 'C-Band'), specifically highlighting the potential of the 3.8 GHz to 4.2 GHz sub band as a good opportunity given its characteristics. We agree that the band has good potential for considering increased use and sharing.

2.2 Following the Spectrum Sharing Framework consultation, issued in July 2015, we understand that some stakeholders may be interested in high-capacity applications that would require larger amounts of spectrum, more likely to be available above 1 GHz[8]. In addition a confidential respondent identified the 3.6 GHz to 4.2 GHz band as a potential candidate band for dynamic shared access.

2.3 We have analysed the characteristics of use of incumbents, focusing on Fixed Satellite and Fixed Services, where Ofcom carries out detailed co-ordination and issues individual licences or in the case of receive only earth stations, grants of recognised spectrum access (RSA for ROES). This is a first step to help stakeholders in understanding the opportunity for enhanced sharing. We believe the band is uniquely apt for more intensive spectrum sharing that takes account of the use of the current licence holders against potential new uses. This is supported by the following reasons:

- Incumbent usage of the band by the Fixed and Fixed Satellite Services tends to be concentrated in discrete geographic areas
- Historical data shows that the incumbent Fixed and Fixed Satellite Services in the band appear to have had relatively stable usage requirements
- Specific frequencies / channels within the band are used at specific locations, leaving opportunities for alternative use on these frequencies potentially across multiple locations.
- Ofcom holds information regarding specific deployments in the band because it carries out the technical co-ordination between the three existing services assignments in the band
- There are no current harmonisation measures within Europe for this band.

2.4 In this section we analyse in detail why we believe the band has potential for increased sharing, and we start using the sharing framework as a guide to support stakeholders in defining the opportunity. This analysis begins by explaining how the band's usage by fixed links and satellite earth stations is segmented by geography

[8] We also identified that some stakeholders may be interested in applications that require more limited infrastructure and achieve relatively wide-area coverage, and therefore operate at lower frequency spectrum, which is likely to be available in smaller channels.

and frequency range in turn. It then combines both of these aspects to illustrate a more detailed picture of how intensively the spectrum is being used by incumbent Fixed and Fixed Satellite Services.

Incumbent services and their characteristics

2.5 There are currently three types of application already accessing the 3.8 GHz to 4.2 GHz band[9]:

- **Fixed Satellite Service (FSS).** Ofcom authorises access for these applications through licences for assignments to permanent earth stations (PES) and grants of recognised spectrum access for receive only earth stations (RSA for ROES) on a first-come-first served basis. The 400 MHz block forms part of a wider 3.6 GHz to 4.2 GHz block that is used for space-to-Earth transmissions. Access is authorised to a licensee depending on the outcome of Ofcom coordination[10] with other services. Typically, this band is used for TV contribution, as well as terrestrial networks backhaul, legacy telephone, and carrier applications.

- **Fixed Service (FS).** Ofcom authorises point to point fixed links on a first-come-first-served basis, subject to Ofcom coordination and Ofcom technical frequency assignment criteria[11]. These links use the 3800 MHz to 3875 MHz and 3925 MHz to 4195 MHz ranges within the 3.8 GHz to 4.2 GHz band which is part of the wider 3.6 GHz to 4.2 GHz fixed link harmonised duplexed channel plan[12]. Fixed links in this band are used for a range of infrastructure and backhaul applications including applications that benefit from the low latency properties of point to point fixed wireless links.

- **Mobile / Wireless Access Applications.** UK Broadband holds a UK-wide spectrum access licence[13] in the 3925 MHz to 4009 MHz band with individual assignments coordinated by Ofcom on a first-come-first-served basis with both Fixed and Fixed Satellite Services. When UK Broadband wishes to request a new assignment in this spectrum, it submits technical information to Ofcom which is then assessed against incumbent deployments using Ofcom's technical co-ordination tool as given in the coordination guidelines[14].

2.6 Our analysis is based on licensing data that Ofcom holds on Fixed and Fixed Satellite Services' use of spectrum as of January 2016. This analysis does not include UK Broadband's use of the 3925 MHz to 4009 MHz range. Data on fixed links

[9] All licences granted by Ofcom are not exclusive. If a key public policy objective could only be met through use of this spectrum, and the licensees were unwilling or unable to meet this objective, but other users could, Ofcom reserves the right to grant additional licences for the use of some or all of these frequencies, with appropriate safeguards to manage the risk of interference.
[10] This is a process by which Ofcom checks the potential for interference with other existing services that could arise from a new deployment.
[11] OfW 446 http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/tfac/ofw446.pdf
[12] CEPT/ERC/REC 12-08 E Annex A Part 2
[13] http://licensing.ofcom.org.uk/binaries/spectrum/mobile-wireless-broadband/cellular/licences/SA_3.6_LICENCE_-_UK_Broadband_0823615_05-04-13.pdf
[14] UK Spectrum Co-Ordination: Co-ordination of licensed services in the band 3605 to 3689 MHz paired with 3925 – 4009 MHz http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/coordination-documents/coordination_processes.pdf

and satellite earth station deployments is also available in searchable form in the Wireless Telegraphy Act Register[15], and has been released in open-data format[16] alongside the Spectrum Sharing Framework Statement.

2.7 Our analysis focusses on the characteristics of use of the Fixed and Fixed Satellite Services, as identified in the Spectrum Sharing Framework. The following table illustrates from a high level perspective how these services use the band with reference to these characteristics of use.

Table 1: Incumbents' characteristics of use

	Fixed Satellite Service 3.8 GHz to 4.2 GHz	Fixed Service 3.8 GHz to 4.2 GHz
Time	Satellite earth stations generally receive radio signals from satellites on a continuous basis.	Fixed links generally transmit and receive radio signals on a continuous basis.
Geography/ coverage	Satellite earth stations are distributed widely across the UK, particularly in rural areas.	Fixed links tend to be concentrated around and between specific locations / routes with particular use in the south and around London.
Quality of service	Satellite earth stations require high levels of availability.	Fixed links require high levels of availability.
Capacity Requirement	These can be variable depending on the specific applications.	These can be variable depending on the specific applications.
Density of use	As of January 2016, a total of 28 sites with satellite earth stations[17].	As of January 2016 a total of 65 Fixed links.
Evolution of these criteria	Fixed Satellite Services have had stable characteristics of use in recent years, and there are no indications that this will change.	The number of fixed links grew sharply in late 2013, but has since been stable. Other characteristics of use are generally stable.

2.8 The technical characteristics of use regarding the Fixed and Fixed Satellite Services, specifically the applications' azimuth, antenna height, and power levels, are published in an interactive format alongside this Call for Input[18]. Stakeholders can use this tool to discover how these technical characteristics of use apply to each frequency range. In addition to the above, the Spectrum Sharing Framework also introduces "economies of scale and harmonisation" as a relevant characteristic of use for potential new users only.

[15] http://spectruminfo.ofcom.org.uk/spectrumInfo/licences
[16] http://stakeholders.ofcom.org.uk/spectrum/information/spectrum-info-FAQ/wireless-telegraphy-register/. This data will be updated quarterly.
[17] This excludes satellite links licensed to foreign governments.
[18] http://stakeholders.ofcom.org.uk/consultations/opportunities-for-spectrum-sharing-innovation/interactive-data/

2.9 UK Broadband's spectrum access licence covers wireless access applications on a nationwide basis. Details of this licence are available on Ofcom's website[19].

2.10 Our aim in analysing the characteristics of use is to provide an informed view on the existing services to support stakeholders in identifying the opportunities for more shared usage.

Current use of spectrum by Fixed Links and Fixed Satellite Services

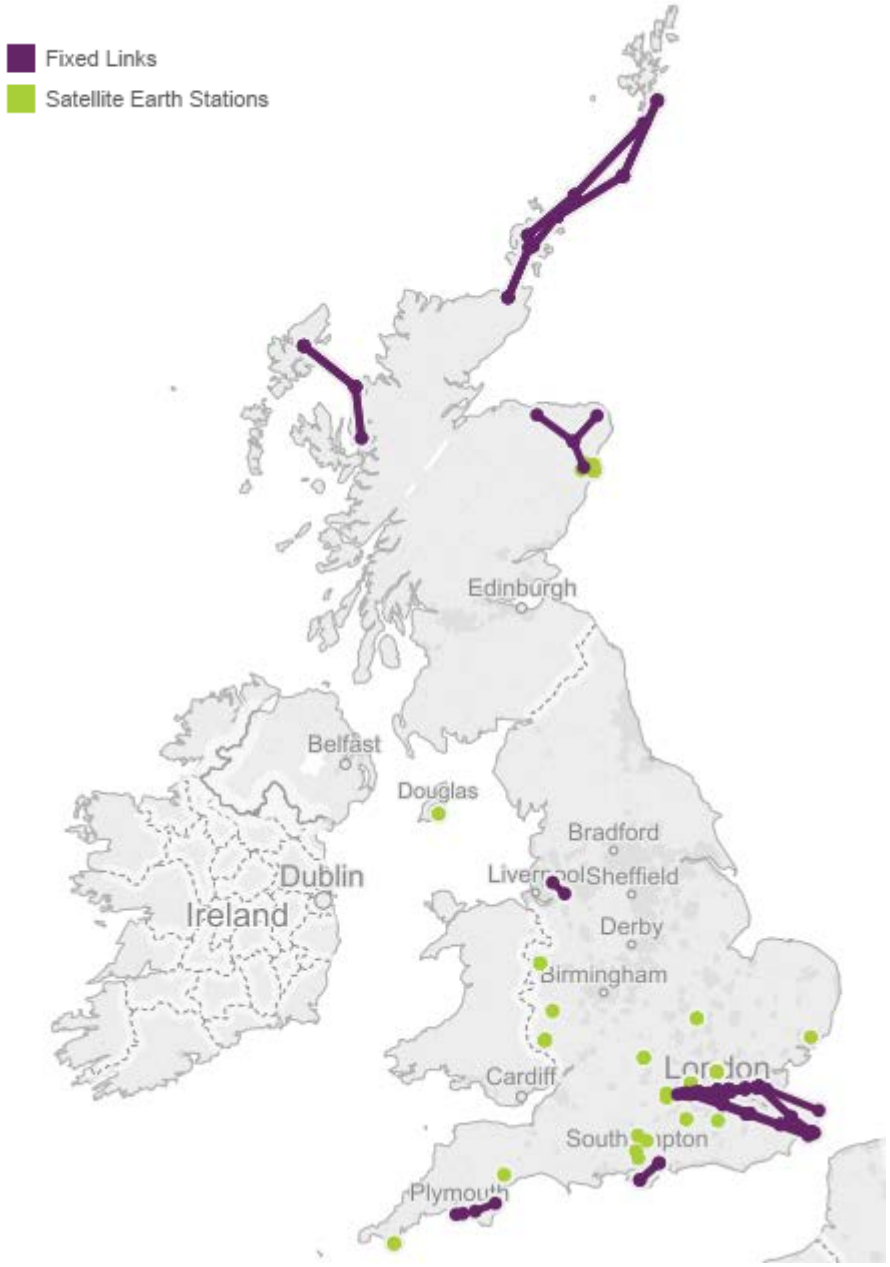
2.11 Information has been identified in our Spectrum Sharing Framework as both a critical enabler and tool for spectrum sharing.

2.12 Building on the characteristics of use, this section provides further information about how the fixed links and fixed satellite services use the band considering, use by channel and by geography[20].

2.13 As of January 2016, there are 28 sites with satellite earth stations in the UK, accounting for 201 separate links between the earth stations and the relevant satellites[21] (52 satellites). There are also 65 fixed links assignments authorised in the band, as of January 2016. Here we refer to any fixed link assignment that falls within the band[22], including those in which only one part of the duplex is within the band, and those in which both the upper and lower duplex are within the band. Figure 2 below provides an overview of the distribution of fixed link and satellite earth station locations in the UK.

[19] http://licensing.ofcom.org.uk/binaries/spectrum/mobile-wireless-broadband/cellular/licences/SA_3.6_LICENCE_-_UK_Broadband_0823615_05-04-13.pdf
[20] This data does not include any analysis of the use of the band by UK Broadband
[21] This excludes satellite links licensed to foreign governments.
[22] A fixed links assignment refers to a 2 x 30 MHz channel that is licensed to serve a link on a particular geographic path between two fixed points. As explained in Section 3, the Fixed Links' channelling arrangements in this band mean that for some of these assignments only the upper duplex channel falls in the 3.8 GHz to 4.2 GHz band, whereas for other assignments both the upper and lower duplex fall inside the band.

Figure 2: Incumbent geographic distribution of fixed links and satellite earth stations in the 3.8 GHz to 4.2 GHz band



2.14 Incumbent use of the band by the Fixed and Fixed Satellite Services has been relatively stable, as shown by our analysis of historical figures for both fixed links and satellite earth stations. This is illustrated in Table 2 for fixed links and Table 3 for satellite earth stations. With regards to fixed links we have provided information going back to 2010, whilst for satellite earth stations we have analysed the last two years' worth of data. We have also published alongside this CFI, an interactive analysis including the technical characteristics of use for incumbents[23]; specifically, we provide technical information concerning the applications' azimuth, antenna

[23] http://stakeholders.ofcom.org.uk/consultations/opportunities-for-spectrum-sharing-innovation/interactive-data/

height, and power levels by frequency range where appropriate. This information can also be downloaded in open format for re-use[24].

Table 2: Historical fixed links usage of 3.8 GHz to 4.2 GHz band

	Dec 2010	Jun 2011	Dec 2011	Jun 2012	Dec 2012	Jun 2013	Dec 2013	Jun 2014	Dec 2014	Jun 2015	Dec 2015
Fixed links assignments[25]	42	41	33	31	31	31	86	88	91	94	65

Table 3: Historical satellite earth station usage of 3.8 GHz to 4.2 GHz band[26]

	December 2014	June 2015	December 2015
Satellite earth station links[27]	200	201	201

2.15 As illustrated in Figure 2, usage of this band varies by location and is relatively concentrated. Usage is further segmented when considering different channels within the band.

2.16 We have identified 12 distinct frequency ranges within the 3.8 GHz to 4.2 GHz band, which we use to analyse the intensity of the band's usage. In Figure 3 we provide an overview of the band's structure along with the associated Fixed Service channels.

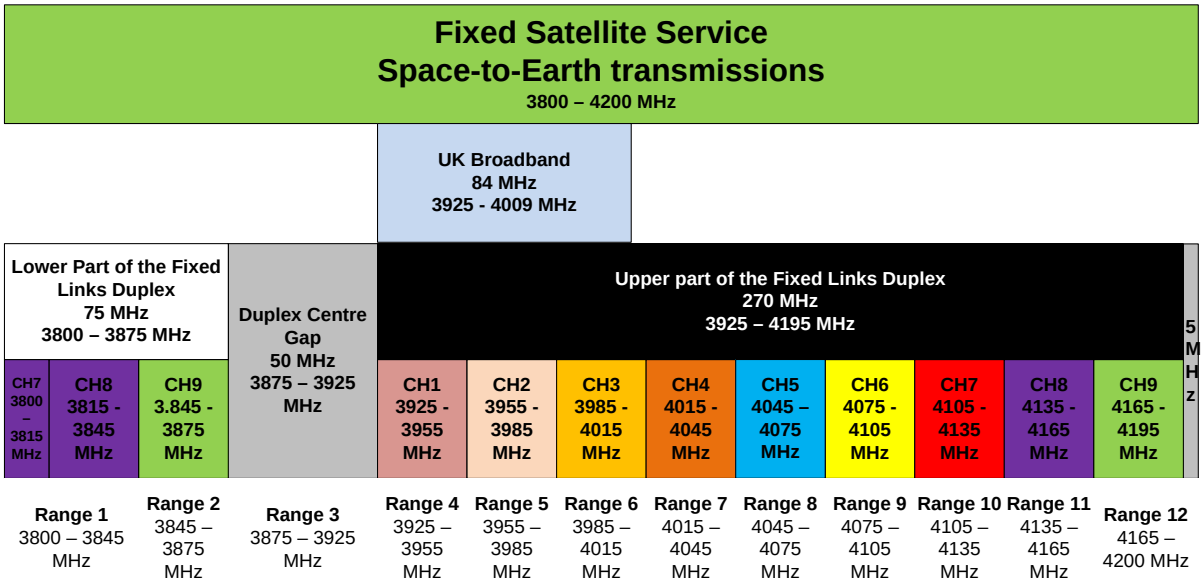
[24] http://stakeholders.ofcom.org.uk/spectrum/information/spectrum-info-FAQ/wireless-telegraphy-register/

[25] This refers to the assignment of a 2 x 30 MHz channel for a single bi-directional fixed link path.

[26] This excludes satellite links licensed to foreign governments.

[27] This refers to a unique path between a satellite and an earth station. Each earth station will have one or more links authorised to it, depending on the number of satellites it receives signals from. Several spectrum assignments can be licensed to each link.

Figure 3: Channelling arrangements in the 3.8 GHz to 4.2 GHz band

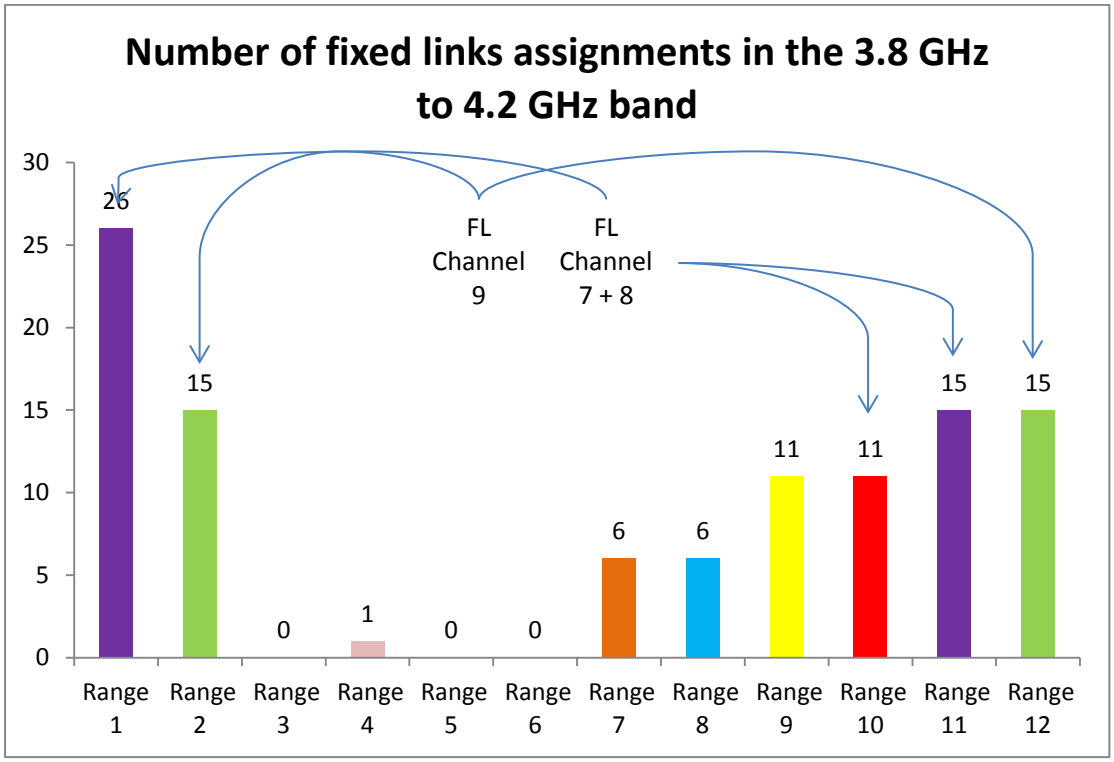


2.17 Our ranges are based on the Fixed Links' channelling arrangements, in which there are nine 2 x 30 MHz duplex channels. Both the upper and lower duplexes of channels 7, 8, and 9 fall inside the 3.8 GHz to 4.2 GHz sub band while only the upper duplex falls in the 3.8 GHz to 4.2 GHz band for channels 1 to 6. Please note that the lower duplex assignments for channels 7 and 8 are contained within range 1 while their upper duplex assignments are spread across ranges 10 and 11. Effectively, this means that the fixed links assignments for range 1 equals the assignments in both ranges 10 and 11.

2.18 As explained in Section 2.5, the Fixed Satellites Service's uses the band to receive space-to-Earth transmissions between 3.6 GHz and 4.2 GHz; the Fixed Service uses the band as part of a 2 x 270 MHz duplex arrangement between 3605 MHz and 4195 MHz; and UK Broadband's 3925 MHz to 4009 MHz assignment is paired with another 84 MHz assignment at 3605 MHz to 3689 MHz.

2.19 In Figure 4 we analyse the number of fixed links assignments against the ranges we have identified.

Figure 4: Intensity of Fixed Links usage of the 3.8 GHz to 4.2 GHz band

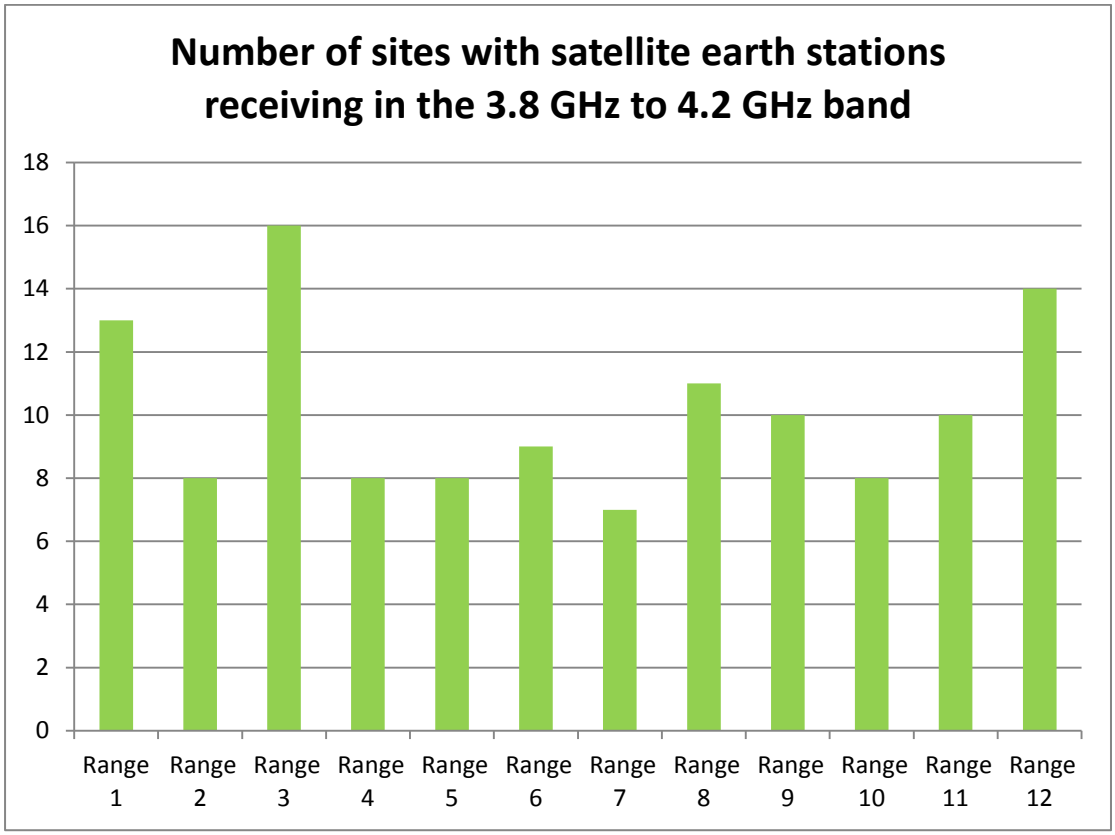


2.20 This graph demonstrates that frequencies at the upper and lower parts of the 3.8 GHz to 4.2 GHz band are used at a relatively greater intensity. For example, there are 41 fixed links assignments that use the 75 MHz across ranges 1 and 2 (3800 MHz to 3875 MHz) yet there are only 35 fixed links assignments that use the 260 MHz across ranges 3 to 10 (3875 MHz to 4135 MHz). This is partly driven by the fact that fixed links observe a centre gap in Range 3 and that Ranges 4, 5, and 6 are prioritised for UK Broadband.

2.21 The channel arrangements in this band mean that some fixed links assignments are marked twice on this diagram due to the bi-directional duplexed nature of the links. Specifically, links using Channel 7 fall in both Range 1 and 10; links in Channel 8 fall in Ranges 1 and 11; and links using Channel 9 fall in Ranges 2 and 12. Fixed links assignments using channels 1 – 6 fall in Ranges 4 – 9.

2.22 In Figure 5, we analyse the use of the band by the Fixed Satellite service.

Figure 5: Intensity of Fixed Satellite usage of the 3.8 GHz to 4.2 GHz band[28][29]



2.23 It should be noted that the above graph refers to sites with satellite earth stations where the centre frequency of a particular assignment to the Fixed Satellite Service is within a particular range. In cases where an assignment has a wide bandwidth, several ranges may be used / overlapped at a given site.

2.24 The graph shows that there are only a handful of sites operating throughout the UK where satellite earth stations receive with their centre frequency in a particular range. Unlike fixed links applications, each frequency range that we have identified is used at a similar number of sites with satellites earth stations.

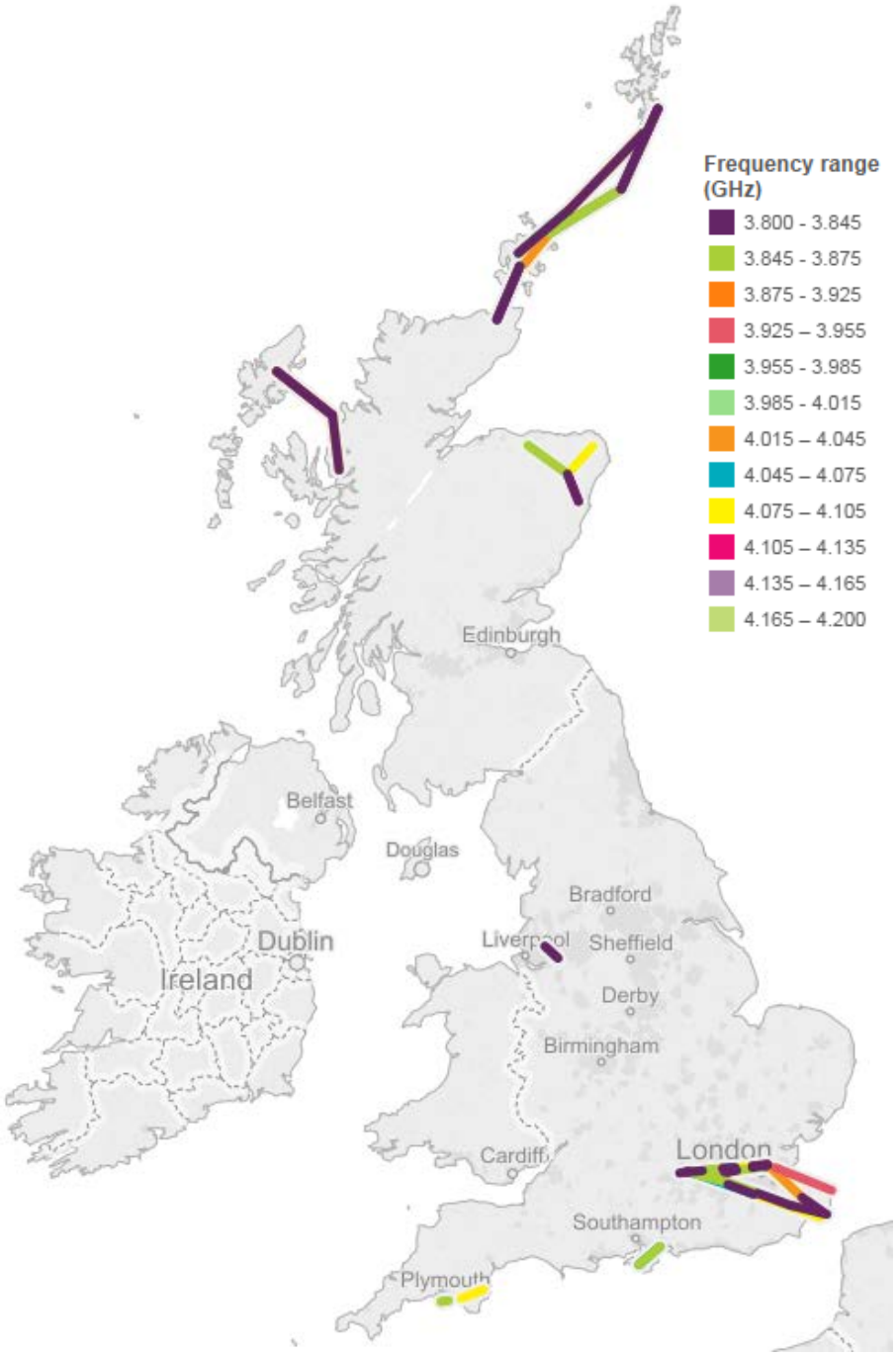
2.25 In the above section, we have analysed spectrum use by frequency range and by geography separately. We have found that some frequency ranges have very few fixed links assignments and that all frequency ranges are only used by a handful of sites with satellite earth stations. This indicates that there may be a potential opportunity for more intensive spectrum usage in some parts of the band.

2.26 Building on this analysis, we now consider both channel and geography simultaneously. Figure 6 provides an overview of the different fixed links assignment by both geography and by channel. Further information and the ability to analyse use

[28] Please note that the majority of sites with satellite earth stations will receive on frequencies spanning several of the spectrum ranges we have identified.
[29] This excludes satellite links licensed to foreign governments.

on a channel by channel basis is provided in the interactive visualisation tool published alongside this document[30].

Figure 6: Fixed links assignments by frequency and geography (3.8 GHz to 4.2 GHz)



2.27 The map above illustrates that the majority of fixed links applications in the UK are concentrated within particular frequency ranges and at particular geographic

[30] http://stakeholders.ofcom.org.uk/consultations/opportunities-for-spectrum-sharing-innovation/interactive-data/

locations. It shows that there are no fixed links at all in Wales, the Midlands, and Northern England. Further, aside in a couple of frequency ranges, there is no fixed links usage in South West England.

2.28 Only a portion of the sites with satellite earth stations are likely to be using any particular frequency range. To illustrate this, Figure 7 shows the geographic usage of the 4015 MHz to 4045 MHz band, which we refer to throughout this document as Range 7, by both fixed links and satellite earth stations. Additional information with regards to the individual ranges used in the different locations is provided in the interactive tool[31]. Stakeholders can also download additional information in an open-data format.

[31] http://stakeholders.ofcom.org.uk/consultations/opportunities-for-spectrum-sharing-innovation/interactive-data/

Figure 7: Incumbent geographic use of 4015 MHz to 4045 MHz range[32]

2.29 The map above illustrates that the spectrum is not being used in Wales, Northern England, Northern Ireland, the South West, and the majority of Scotland.

2.30 Our initial analysis of the band indicates that there may be an opportunity, depending on the type of potential new demand and its characteristics, for enhanced sharing. We are therefore strongly minded to progress with the aim of enabling a new framework within this band for innovative uses while taking into account the incumbent users.

[32] This excludes satellite links licensed to foreign governments.

Wider 3.6 GHz to 4.2 GHz band context

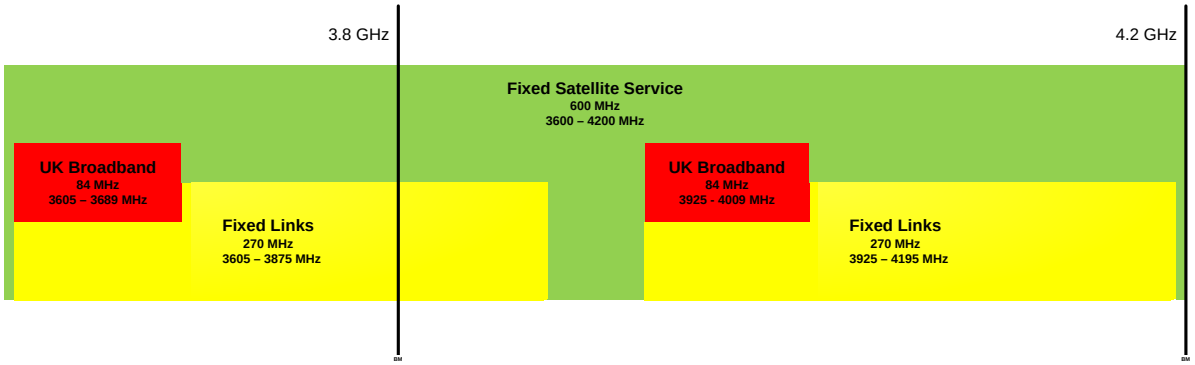
2.31 The 3.6 GHz to 4.2 GHz band is allocated in the Radio Regulations in Region 1 (which includes the UK) to the Fixed Satellite (space-to-Earth), and Fixed Services on a primary basis, and to the Mobile Service on a secondary basis. There is no EU harmonisation legislation governing the 3.8 GHz to 4.2 GHz band.

2.32 The 3.6 GHz to 3.8 GHz band is already harmonised for mobile services in Europe[33] and has been identified in our Mobile Data Strategy[34] as a *high* priority band for mobile usage. We intend to publish a separate consultation document and statement on this in the coming months. The 3.8 GHz to 4.2 GHz band was also identified in our Mobile Data Strategy as a *medium-high* priority band for mobile. Although this band may be of future interest for mass-market mobile services, for the foreseeable future its prospects for international harmonisation appear to be low.

2.33 Incumbent users of this band are subject to their own channelling arrangements. For Fixed Satellite Service applications, the wider 3.6 GHz to 4.2 GHz band is used for downlink communications, often paired with the 5825 MHz to 6725 MHz range for uplink communications. For the Fixed Service, duplex channels in the 3.8 GHz to 4.2 GHz band overlap with the adjacent 3.6 GHz to 3.8 GHz band. This means that changes to the fixed links (bi-directional links) in the lower part of the band will impact the upper part of the band and vice versa.

2.34 Figure 8 provides an overview of the wider 3.6 GHz to 4.2 GHz band.

Figure 8: High level 3.6 GHz to 4.2 GHz bandplan



2.35 This section has analysed the characteristics of use of the Fixed and Fixed Satellite Services in the 3.8 GHz to 4.2 GHz band. It shows that the number of locations where a particular spectrum range is in use by those services varies significantly across the 3.8 GHz to 4.2 GHz band. In some areas spectrum is used intensively by those services, but in others it is not and we believe the band therefore offers scope for some enhanced spectrum sharing, taking into account the incumbents' use.

Question 1: Given the nature of the incumbents and their use of the spectrum, what new types of applications do you foresee could access this spectrum on a shared

[33] ECC Decision (07)02 establishes harmonised frequency arrangements for mobile/fixed communications; CEPT Report 049 establishes technical conditions for spectrum harmonisation for terrestrial wireless systems; and Commission Decisions 2008/411/EC and 2014/276/EU harmonise the band for terrestrial electronic communications networks.

[34] http://stakeholders.ofcom.org.uk/consultations/mobile-data-strategy/statement

basis? Please provide details on the potential applications and their characteristics of use as identified in the spectrum sharing framework.

Question 2: Based on information provided in this Section, can you identify any barriers to enhanced sharing in the 3.8 GHz to 4.2 GHz band? Please use the Spectrum Sharing Framework, which identifies four types of barriers to spectrum sharing: lack of information; market barriers; technology barriers; and authorisation barriers.

Section 3

Enabling enhanced spectrum sharing in the 3.8 GHz to 4.2 GHz band

3.1 In our Spectrum Sharing Framework, we have set out an initial list of tools and enablers that have the potential to increase benefits from sharing. By enablers we mean: new types of spectrum information; market mechanisms (including overlay auctions); and technological capabilities. When we refer to authorisation tools we mean ways in which Ofcom could potentially authorise the use of spectrum to promote further sharing, or make it more effective.

3.2 These tools and enablers could be applied in combination, to create new sharing models. Some of the licence conditions or market enablers might require technological solutions (either extant or yet to be developed).

3.3 In this section we focus on potential regulatory tools that could be considered and that may enable new users to access the band on a shared basis.

Authorisation tools

3.4 New technologies have the potential to enable the development of new authorisation models that allow for greater flexibility. In order to support new and innovative uses of the spectrum, it may be necessary to develop new regulatory tools including new types of spectrum access. To better inform our understanding of potential future uses of the band, we wish to find out from stakeholders what the requirements of these new applications and uses may be in order to consider what potential regulatory and authorisation tools could best enable additional sharing in the band.

3.5 We have identified two possible types of spectrum access that could be considered and combined into a tiered authorisation approach that may be appropriate for potential sharers in the 3.8 GHz to 4.2 GHz band. We are also interested in any other potential type of spectrum access that stakeholders may identify as appropriate for potential sharers.

3.5.1 Geographic licences

As we identified in the Spectrum Sharing Framework, one dimension of shared access is to allow the same spectrum to be used simultaneously in different locations. A geographic licence could allow an interested entity to acquire spectrum usage rights for a defined area. Effectively, these would be comparable to a nationwide spectrum licence, but only applicable to a discrete geographical area along with a set of defined technical conditions. It is also possible to design licences that grant a certain amount of spectrum to be made available to a licensee for a defined geographic area. Such a regulatory tool would need to be carefully designed in order to ensure that usage furthers our statutory duty to optimise the use of spectrum, and cannot be used to preclude other stakeholders' access to spectrum. The design and complexity of such a tool would also need to be considered carefully particularly with respect to implementation and the cost of the implementation.

3.5.2 Opportunistic spectrum access

New technology enablers, such as geolocation databases, allow secondary[35] devices to be able to determine whether or not a particular frequency is available and determine that its use will not cause undue interference to incumbent users. These are appropriate in environments where a primary spectrum user operates within a defined frequency range and where detailed usage characteristics are known. In the 3.8 GHz to 4.2 GHz band, this is also relevant for spectrum assigned to UK Broadband (3925 MHz to 4009 MHz) and / or for any stakeholder that may potentially acquire a geographic licence as described above. In some cases, this could also be appropriate for managing the interference environment to the Fixed Satellite Services in the 3.8 – 4.2 GHz band, although it is noted that detailed usage information would be required for receive-only terminals. When the primary user is not using the spectrum, for example, the opportunistic device can transmit on this frequency until such a time that a primary[36] user wishes to use the spectrum. In December 2015, Ofcom authorised manually configured devices to access TV White Spaces in this way[37]. We believe there could be scope to build on this decision, and to apply this type of regulatory tool to frequencies that can support high capacity data transmission over a short area, such as the 3.8 GHz to 4.2 GHz band. Another approach could be to make opportunistic spectrum access equipment operating in this band licence exempt, which could facilitate mass market adoption of products that access spectrum in this way.

A Tiered authorisation approach to sharing in the 3.8 GHz to 4.2 GHz band

3.6 We are committed to enable greater sharing, and so that both geographically defined access and opportunistic access approaches to spectrum management can be used simultaneously. We believe there is potential, among other options for enhancing sharing in the 3.8 GHz to 4.2 GHz band, to enable a multi-tiered authorisation approach to shared access.

3.7 Our preliminary view is that such a model could combine three different types of spectrum access:

3.7.1 **Tier 1 / Existing Licence Classes** would comprise the bands' incumbent services. Tier 1 licence holders' spectrum access rights would fall within a given range of frequencies and geographic areas not accessed by the other tiers. Fixed and fixed satellite licences would continue to be available on a first-come-first-served basis, subject to Ofcom's established coordination procedures, and UK Broadband would continue to access spectrum according to the coordination mechanism in which it avoids causing undue interference to the Fixed and Fixed Satellite services.

3.7.2 **Tier 2 / New Geographic Licence Layer** would comprise geographic licences, as described in Section 3.3.1. Once a geographic licence has

[35] In secondary spectrum access, an entity can access spectrum when a primary user is not using it. Secondary users can not cause harmful interference nor claim protection from primary users.
[36] An entity can be said to have primary access to spectrum when it holds (or shares) the first chance to use a given frequency at a given time or place. Primary users are protected from undue interference from secondary users.
[37] http://stakeholders.ofcom.org.uk/spectrum/tv-white-spaces/consultations-statements/tvws-regulations-2015/

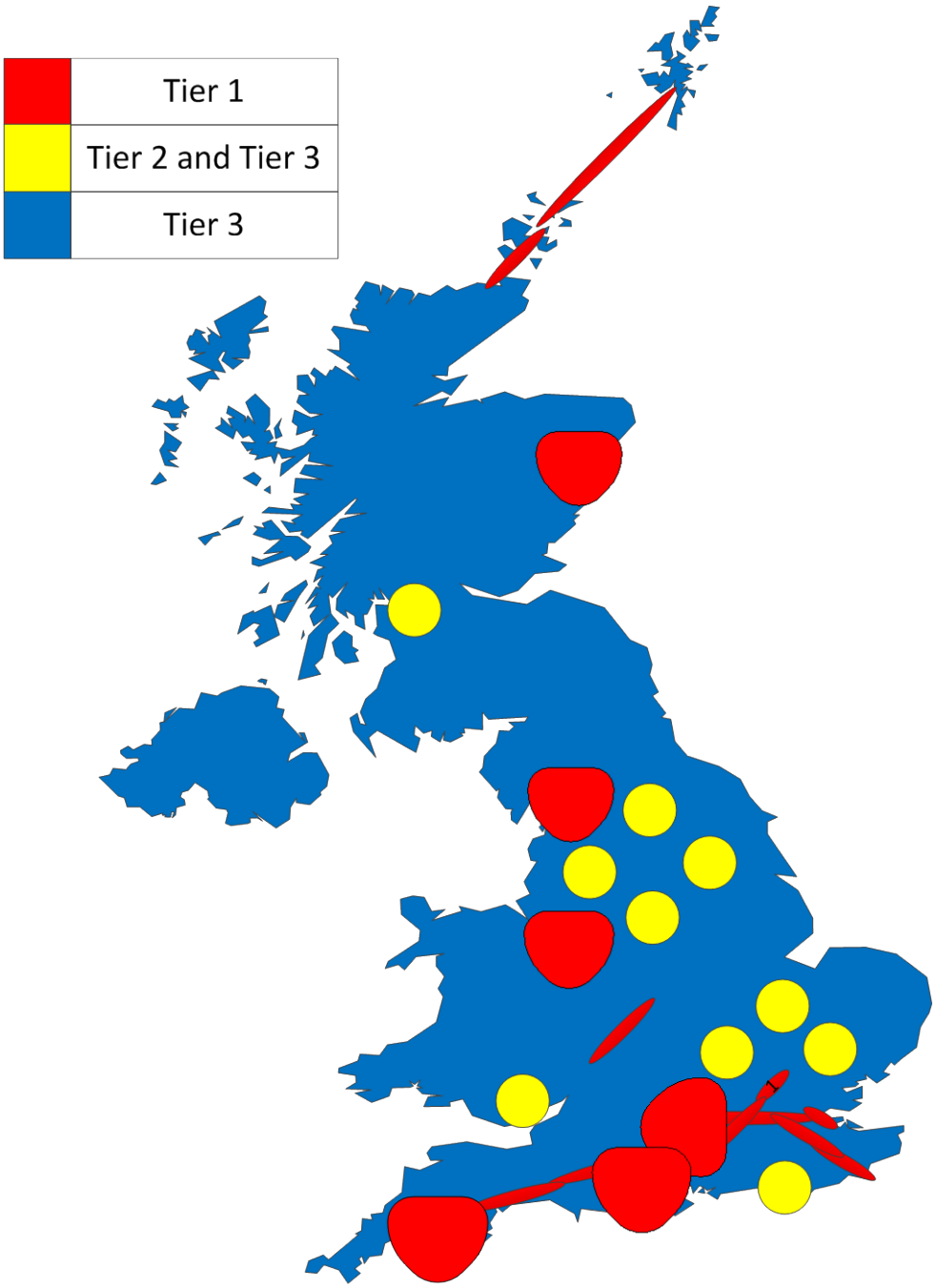
been acquired, future Tier 1 licences would need to be coordinated around these licences[38].

3.7.3 **Tier 3 / New Opportunistic Access Layer** would comprise a rules-based opportunistic access mechanism to the spectrum in a given geographic area. Stakeholders operating in this Tier would need to not cause undue interference to both Tier 1 and Tier 2 Licenses on a dynamic basis, possibly through a geolocation database or other technology enabler, and would not be able to claim protection from any other Tier, or from each other.

3.8 The following figure provides a high level illustration of how these tiers could be used on a geographic basis in a potential tiered authorisation approach to spectrum sharing. The distribution of geographic licences is likely to be dependent on market demand. The map in Figure 9 is purely for demonstrative purposes, and the areas highlighted for Tier 1 usage is not intended to reflect actual incumbent usage of the band.

[38] Our preliminary view is that this tier may not be available where a geographic licence has already been issued to an incumbent.

Figure 9: Illustrative distribution of different types of spectrum access for a given frequency



3.9 Alternative regulatory tools may also be identified by stakeholders for enhanced spectrum access on a shared basis in the 3.8 GHz to 4.2 GHz band.

Question 3: Do you agree with our initial assessment of a potential application of a tiered authorisation approach in this band?

- *If yes, please provide as much detailed information as possible of how you consider any tiered authorisation approach may enable greater spectrum sharing and how it could be implemented in practice.*
- *If no, please describe the spectrum access method that you consider may best meet any requirements you have to access spectrum in the 3.8 GHz to*

4.2 GHz band. Please give specific details of how you would envisage this working in practice, where appropriate with reference to the tools and enablers identified in the Spectrum Sharing Framework.

3.10 One additional option to provide certainty for stakeholders interested in Tier 2 access that could be considered for a new multi-tiered authorisation approach to spectrum access for the band would be to freeze further growth of Fixed and Fixed Satellite services' Tier 1 applications. However, our preliminary view is that if we proceed with a multi-tiered authorisation approach then we should also continue to allow Tier 1 licensees to grow their businesses in this band, and on the continued basis of first-come-first-served coordination mechanisms that these licences are currently subject to. This of course may indirectly limit the amount of spectrum available to them, depending on the popularity of geographic licences that have been issued.

Question 4: Should a potential future tiered authorisation approach to spectrum access in the 3.8 GHz to 4.2 GHz band accommodate changes from incumbent services of the spectrum? I.e. should new licences or variations to existing fixed link and satellite earth station licences be allowed to continue on a first-come-first-served co-ordinated basis?

3.11 We are at the very first steps in our thinking of how to enable enhanced sharing in this band. If there is interest from stakeholders, we would need to subsequently consider how to develop and issue geographic licences, and how to authorise opportunistic spectrum access. We would have to consider how to deliver a shared access solution in line with the characteristics of use of existing incumbents. We also recognise that this may well involve increased sharing complexity along with the associated implementation aspects that would need to be thoroughly considered.

3.12 In line with the Spectrum Sharing Framework if we do proceed with proposals to share this band in a new way, we would take account of the incremental impact of the new sharing opportunity on incumbents, and the benefits that incumbent services deliver to citizens and consumers. Also if we consider that sharing in this case would risk imposing changes to the incumbents' characteristics of use, and therefore generate any material new costs, we would also take these costs in to account. These costs would be weighed against the relative merits of any potential new sharing opportunity in the 3.8 GHz to 4.2 GHz band.

3.13 We also appreciate that it would be necessary at any subsequent stage to consider the appropriate way to meet the costs of developing any potential multi-tier authorisation approach to spectrum access.

Section 4

Next Steps

4.1 We see this Call for Input as the beginning of a conversation with industry regarding enhanced shared access to spectrum and with an initial focus on the 3.8 GHz to 4.2 GHz band, potentially through a multi-tiered authorisation approach to spectrum access.

4.2 To ensure shared access in the band, to enable coordination, and to better define the appropriate regulatory tools, and their combination, we need to understand the characteristics of the potential users.

4.3 Stakeholders have until 9 June 2016 to respond to this Call for Input. We will review the information and views provided by stakeholders and use this to inform any proposals that we may put to stakeholders in a formal consultation.

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 9th June, 2016**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://stakeholders.ofcom.org.uk/consultations/opportunities-for-spectrum-sharing-innovation/howtorespond/ , 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 3.8-4.2GHz.Sharing@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

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

Toby Youell
Spectrum Group
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 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.

A1.6 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

A1.7 If you want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Toby Youell on 3.8-4.2GHz.Sharing@ofcom.org.uk.

Confidentiality

A1.8 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.

A1.9 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.

A1.10 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 http://www.ofcom.org.uk/terms-of-use/

Next steps

A1.11 Following the end of the consultation period, Ofcom intends to publish an update on our findings in summer 2016.

A1.12 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: http://www.ofcom.org.uk/email-updates/

Ofcom's consultation processes

A1.13 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.14 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.

A1.15 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Graham Howell, Secretary to the Corporation, who is Ofcom's consultation champion:

Graham Howell
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA

Email Graham.Howell@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 http://stakeholders.ofcom.org.uk/consultations/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 ☐

Whole response ☐

Part of the response ☐

Name/contact details/job title ☐

Organisation ☐

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: Given the nature of the incumbents and their use of the spectrum, what new types of applications do you foresee could access this spectrum on a shared basis? Please provide details on the potential applications and their characteristics of use as identified in the spectrum sharing framework.

Question 2: Based on information provided in this Section, can you identify any barriers to enhanced sharing in the 3.8 GHz to 4.2 GHz band? Please use the Spectrum Sharing Framework, which identifies four types of barriers to spectrum sharing: lack of information; market barriers; technology barriers; and authorisation barriers.

Question 3: Do you agree with our initial assessment of a potential application of a tiered authorisation approach in this band?
If yes, please provide as much detailed information as possible of how you consider any tiered authorisation approach may enable greater spectrum sharing and how it could be implemented in practice.
If no, please describe the spectrum access method that you consider may best meet any requirements you have to access spectrum in the 3.8 GHz to 4.2 GHz band. Please give specific details of how you would envisage this working in practice, where appropriate with reference to the tools and enablers identified in the Spectrum Sharing Framework.

Question 4: Should a potential future tiered authorisation approach to spectrum access in the 3.8 GHz to 4.2 GHz band accommodate changes from incumbent services of the spectrum? I.e. should new licences or variations to existing fixed link and satellite earth station licences be allowed to continue on a first-come-first-served co-ordinated basis?