5G spectrum access at 26 GHz and update on bands above 30 GHz

Call for Input

Publication date: 28 July 2017

Closing Date for Responses: 22 September 2017

About this document

This Call for Inputs (CFI) seeks information from stakeholders that will inform our ongoing programme of work to make spectrum in the 26 GHz band available for 5G wireless networks. It also sets out our current thinking on which other bands we will prioritise for 5G.

5G is the next generation of wireless network technology and is being designed to deliver more data, to more devices and more consistently than previous technologies.

The 26 GHz band covers the 3.25 GHz of spectrum between 24.25 GHz and 27.5 GHz and is being prioritised across Europe as the first high frequency band for 5G. This high frequency spectrum (known as 'mmWave spectrum'), offers very high data capacity and speeds but with a limited range.

5G networks are being designed to be more flexible than previous generations of mobile networks and will be configurable to provide bespoke services to different types of customer. They will also have the capability to be deployed as enhancements to existing mobile networks or as a standalone, localised network. We expect these new features to fuel innovation, create new markets and, potentially, increase the number of organisations wishing to access spectrum.

The limited range of operation in the mmWave spectrum, combined with new technologies being developed for 5G, could facilitate greater geographic reuse of spectrum and thereby allow more operators to deploy networks than has been previously possible.

The document is aimed at gathering input from stakeholders on all aspects related to making the 26 GHz band available for 5G. We are seeking views from stakeholders who have an interest in deploying networks, from equipment manufacturers planning to build chip sets and network equipment and we also welcome views more generally on authorisation options stakeholders consider best meet their deployment needs and service offering.

The document also sets out our current thinking on which other bands we will prioritise for 5G, and confirms our intention to start working on making available spectrum in the 66-71 GHz band.

Contents

Section 1

Introduction

1.1 5G is the next generation of wireless network technology and is being designed to deliver more data, to more devices, more consistently than previous technologies. As well as meeting the growing demand from consumers for mobile data, 5G is being designed to serve the needs of different industries and enterprises, enabling improved operational efficiency and new ways of working.

The role of spectrum in enabling 5G

1.2 One of the key enablers for 5G is the availability of suitable radio spectrum. The diverse set of services and applications 5G is being designed to deliver will require access to different spectrum bands with different characteristics:

- Spectrum at lower frequencies, such as the 700 MHz band, to enable coverage to wider areas;
- Spectrum at mid-range frequencies with large bandwidths, such as the 3.4 to 3.8 GHz band, to provide the necessary capacity to support a very high number of connected devices and to enable higher speeds to concurrently connected devices; and
- Spectrum at high frequencies above 24 GHz with very large bandwidths, providing ultra-high capacity and supporting services requiring very low latency.

1.3 This CFI relates to the spectrum at high frequencies, often referred to as millimetre wave (mmWave), specifically the 3.25 GHz of spectrum in the 26 GHz band (24.25 – 27.5 GHz).[1] This band has been identified as a 'pioneer' band for 5G across Europe. We also provide an update on other mmWave bands being considered internationally for 5G (e.g. under for WRC-19 agenda item 1.13) and highlight those that we believe have the greatest potential for global harmonisation and therefore should be the focus of further study.

Identification of the 26 GHz band for 5G

1.4 In February 2017, we published our *Update on 5G spectrum in the UK* (the February 5G Update).[2] Amongst other things, this document provided an overview of the international process which led to the identification of 26 GHz as the pioneer mmWave band for 5G in Europe.

1.5 We have worked closely with national spectrum regulators across Europe, through the Radio Spectrum Policy Group (RSPG)[3] to develop an opinion on spectrum bands

[1] Strictly speaking, mmWave is the band of spectrum between 30 GHz and 300 GHz – wavelengths at these frequencies are between 1mm and 1cm long. The term is commonly used refer to frequencies above 24 GHz and this is how we use it here

[2] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf

[3] The Radio Spectrum Policy Group is a high level advisory group that assists the European Commission in the development of radio spectrum policy and is chaired by one of the Member States. The RSPG 'Work Programme for 2016 and Beyond' was adopted in February 2016 and included a

for 5G. The opinion, which was consulted upon and formalised in 2016, identified a strategic roadmap for 5G in Europe.[4] In particular the roadmap identified spectrum at 24.25 – 27.5 GHz as the "pioneer" mmWave band.

1.6 Following on from the RSPG's opinion, the Radio Spectrum Committee (RSC) agreed a European Commission mandate to CEPT to develop harmonised technical conditions for spectrum in the 26 GHz band in support of the introduction of 5G in the European Union.[5]

1.7 We expect the ITU will formally identify the 26 GHz band as a global band for IMT2020 (the ITU terminology for 5G) during the next World Radio Conference in 2019 (WRC-19).

1.8 In the February 5G Update, we set out our view that the 26 GHz band offers the most credible possibility to establish, ahead of the WRC-19, a global band for 5G. We committed to facilitating access to the 26 GHz band for 5G services in the UK, and confirmed that we would consult on making all or part of the band available for 5G services and consider the most appropriate authorisation approach for this band to support innovation and competition.

Purpose of this CFI

1.9 The purpose of this CFI is to seek stakeholders' input on making the 26 GHz band available for 5G deployment in the UK. We are looking for inputs across the following areas:

- The likely demand, with regards to locations, services, channel bandwidth and deployment models to use 5G technologies at 26 GHz.
- The timelines for 5G equipment that will operate across the 26 GHz band and the technology features that may be relevant to how we authorise spectrum.
- The range of spectrum authorisation options that may be relevant in response to the specific market demand at 26 GHz and whether different authorisation types are required to meet the needs of different deployment models and services.
- Options for existing users of the band to allow the introduction of 5G.

1.10 As well as feeding into our proposals for making this spectrum available for 5G wireless systems, responses to this CFI, in conjunction with ongoing coexistence studies, will allow us to assess the implications for existing spectrum users.

1.11 The technology developments brought by 5G in mmWave bands have the potential to open new opportunities and enable innovative services and business models. 5G at mmWave is expected not only to deliver high capacity in high demand areas to meet increasing consumer demand for mobile broadband, but also to enable potential new players and alternative deployment solutions beyond the traditional

work item for spectrum related aspects for Next Generation Wireless systems (5G) http://rspg-spectrum.eu/wpcontent/uploads/2013/05/RSPG16-007_rev_sept_2016.pdf

[4] Opinion on spectrum related aspects for next-generation wireless systrems (5G) http://rspg-spectrum.eu/wp-content/uploads/2013/05/RPSG16-032-Opinion_5G.pdf

[5] The Radio Spectrum Committee is an EU legislative committee. It debates and votes upon both Mandates for technical work to CEPT and European Commission harmonisation decisions.

MNOs model. We are therefore keen, with this CFI, to reach all stakeholders who have an interest in using spectrum at mmWave.

1.12 We expect to consult on our proposed approach to make the 26 GHz band available later in the year.

1.13 In parallel with this CFI, we are minded to commence the process to develop the necessary regulation to facilitate 5G in the 66-71 GHz band, taking into account the current developments in the adjacent lower band (57-66 GHz) which is currently under review as part of our Fixed Wireless spectrum strategy work.

Roadmap for bands for 5G

1.14 This CFI focuses on the use of 5G in high frequency 'mmWave' bands. This is part of our programme of work to ensure spectrum is not an inhibitor of 5G rollout and includes our work to make other bands available for 5G (see Figure 1), these include:

- 3.4-3.6 GHz: On 11 July, we published our statement on the 2.3 / 3.4 GHz auction, setting out the competition measures for the award and an indicative timeline. We expect the auction to start later in 2017.[6]

- 3.6-3.8 GHz: We have today published a further document on the 3.6-3.8 GHz band confirming our intention to make the band available for mobile as soon as practicable, and setting out our proposed approach.[7]

1.15 We have initiated a process to make spectrum in the 700 MHz band available and expect to conduct an award in 2019.

1.16 Whilst 26 GHz remains our highest priority band, in our 5G Update we also committed to defining a UK roadmap for all bands being considered for 5G under WRC-19 agenda item 1.13.[8] In order to achieve progress at the conference, we consider that between now and then, attention needs to be focused on a smaller number of bands in order to increase the likelihood of agreeing globally harmonised ranges that will support the development of a global device ecosystem.

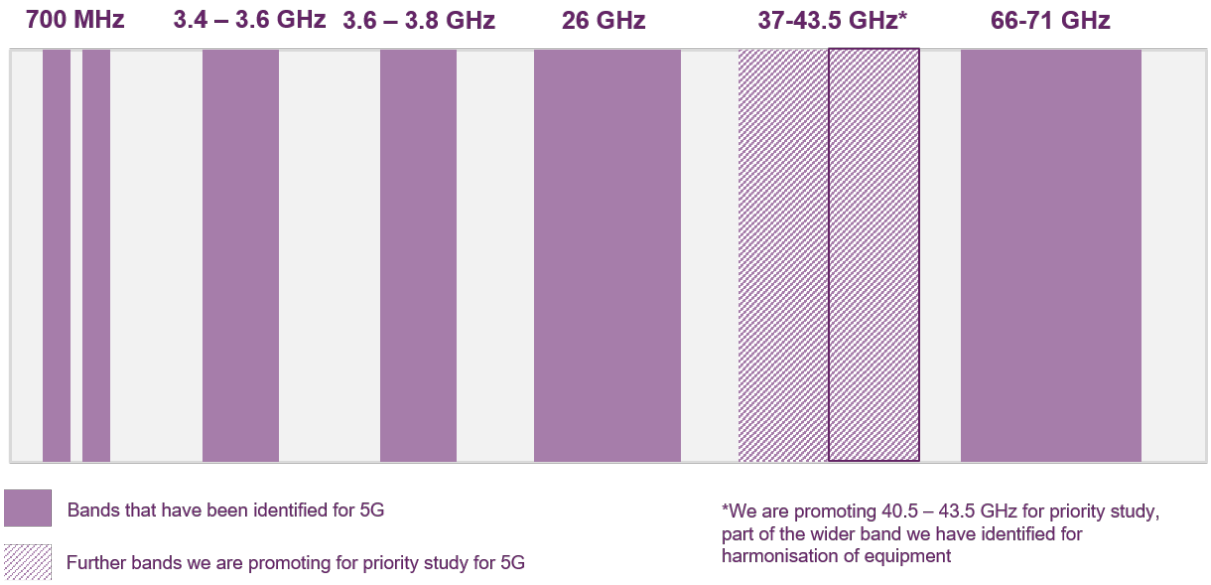
1.17 Based on our prioritisation exercise, we intend to promote 66-71 GHz and 40.5-43.5 GHz (as part of the wider 37-43.5 GHz band) as priority bands for study for 5G services. We set out our rationale for this in section 7. We will continue to consider other bands in preparation for the conference.

1.18 We consider that the frequency range 37-43.5 GHz has strong potential to become a 5G band for harmonisation of equipment. The benefit of identifying a wider frequency range is that we can select frequencies across the range that suit UK utilisation whilst also enabling global economies of scale. We can then make spectrum for 5G available when and where required.

[6] https://www.ofcom.org.uk/about-ofcom/latest/features-and-news/ofcom-sets-rules-for-mobile-spectrum-auction
[7] https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz
[8] The full list of bands being studied, as specified in Resolution 238 (WRC-15) is: 24.25-27.5 GHz, 31.8-33.4 GHz, 37-40.5 GHz, 40.5-42.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47-47.2 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81- 86 GHz

1.19 As mentioned in paragraph 1.14 above, we are minded to commence work on 66-71 GHz.

Figure 1 – UK Roadmap for bands for 5G



Enabling 5G testing and trials

1.20 We recognise that the timely availability of spectrum is a critical component for developing new technologies such as 5G.

1.21 In order to facilitate innovation and ensure that spectrum is not an inhibitor to the development of 5G technologies, we can make spectrum available to enable testing, development, research or demonstration of radio equipment, when requested.

1.22 We have granted a number of non-operational licences to support 5G trials at mmWave frequencies and have an established licencing process in place to support applicants seeking frequencies for trials

1.23 Further details on these licence products. and how to apply can be found on the Ofcom website. [9]

Structure of this document

1.24 Section 2 of this document provides an overview of the key features of 5G in mmWave bands and explains their relevance to spectrum release and authorisation. We also seek views on equipment availability and so this section is of particular relevance to 5G equipment manufacturers.

1.25 Section 3 and Annex 1 provide an overview of the 26 GHz band and its existing use. This section is of particular relevance to existing spectrum users in the 26 GHz band.

1.26 Section 4 provides examples of some of the services and business models mmWave 5G could support and sets out the information we would like to gather from stakeholders to inform our policy development. We seek the view of any stakeholders

[9] https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences

with an interest in deploying mmWave 5G or those who wish to use the services these 5G networks can deliver.

1.27 Section 5 provides examples of different approaches to authorising spectrum that may be relevant to the 26 GHz band.

1.28 Section 6 sets out how we plan to use the results of this CFI.

1.29 Section 7 sets out our latest thinking on further mmWave bands that are being considered for 5G.

Section 2

5G technology and equipment availability

2.1 This section summarises the ongoing activities to develop the new 5G technology standards and introduces some of the key features of 5G at mmWave spectrum that are likely to drive innovation in services and deployment opportunities, and enable greater geographic reuse of spectrum.

2.2 We also seek views from equipment and chipset manufacturers on when they expect to have products that support the 26 GHz band.

5G standard development

2.3 5G is the next generation of mobile technologies. The high-level requirements for 5G have been defined by the ITU in its 'IMT 2020' specification.[10]

2.4 The 3GPP (3rd Generation Partnership Project), an industry driven standardisation body, is currently developing standards for 5G to reflect the ITU requirements. A key component of the standards is a new radio interface (known as 5G New Radio 'NR') which will support a wide range of frequency bands, including frequencies at 3.4 to 3.8 GHz and mmWave frequencies. 5G NR will deliver very high speeds and capacity, and very low latency.

2.5 The development of the first release (Rel. 15) of 5G NR is being phased by 3GPP. The first phase specification will be completed in December 2017 and will define a 'non-standalone' NR solution that must be operated in conjunction with an existing LTE (4G) carrier and a 4G core network. By June 2018 the specification for a 'standalone' version of NR, which is not reliant on an existing 4G network, will be completed, allowing self-contained 5G networks to be built.

2.6 We note that, although 5G NR will support a large number of bands, network and equipment availability will be phased. There is still some uncertainty about tuning ranges and exact planned timelines for equipment availability. Therefore, we are seeking further information from stakeholders on this

5G in mmWave spectrum

2.7 5G will be the first terrestrial mobile technology to operate in high frequency, mmWave spectrum. A key advantage of mmWave over the lower frequency bands currently used for mobile is the large amounts of bandwidth available. Higher bandwidth increases cell capacity and supports higher speeds, and also allows the use of transmission techniques that reduce network latency, thereby improving network responsiveness.

2.8 Performance at mmWave is further enhanced by technologies such as 'beam forming' that use arrays of small antenna to concentrate the signal from the mast toward end users.

[10] http://www.itu.int/en/mediacentre/Pages/2017-PR04.aspx

mmWave propagation

2.9 While mmWave bands offer much higher bandwidths, they are subject to much higher signal losses due to obstacles such as walls, buildings, trees and terrain when compared to the lower frequency bands currently used for mobile networks.

2.10 As such, mmWave 5G cell sites deployed to service mobile handsets in built up areas will typically have a shorter range than traditional mobile macro sites[11] and are therefore often referred to as 'small cells'. It is likely that 26 GHz cells will typically have a radius ranging from 50 meters to a few hundred meters.[12]

2.11 To maximise performance, small cells will preferably be mounted in locations that have clear line-of-sight to end users, such as on street furniture and on the side of buildings. In some cases, users could be reached by exploiting reflected signals. However, it is not fully understood the extent to which mmWave will be able to work in non line-of-sight conditions in practical deployments.

2.12 Due to the higher losses in penetrating through walls, it will be more difficult to provide indoor coverage from outdoor base stations. On the other hand, indoor/outdoor isolation could allow, in some cases, for better geographic reuse of spectrum.

2.13 The limited reach of mmWave radio signals, particularly when deployed indoors, raise the possibility for greater geographic re-use of spectrum.

3GPP is studying enablers for a range of authorisation options

2.14 3GPP has agreed a new study item to start in Q3 2017 to investigate NR-based operations in licence-exempt spectrum.[13] The aim of this study item is to provide protocol and signaling enablers to facilitate new sharing paradigms. These studies are in their initial stages and their scope and outcomes are uncertain. One source[14] discusses coordinated sharing and uncoordinated sharing (for licence-exempt operations), targeting in particular, deployments with a medium traffic load. Timelines for these studies and subsequent specifications are uncertain, however, we note that similar technologies have recently been developed for LTE (4G) networks which have enabled LTE deployments in spectrum with different types of authorisation, including licence exempt spectrum.

Potential for new services and new market entrants

2.15 The increased capacity, speed and responsiveness of mmWave 5G technologies are expected to drive innovation in services and create new markets. The ability to build standalone networks with 5G small cells and technologies to support different authorisation options raises the possibility of new entrants deploying 5G networks in addition to the existing mobile network operators.

---

[11] Mobile operators can already choose to deploy 'small cells' by reducing transmission power and mast heights, for example to densify their networks in high demand area. However, mmWave small cells are inherently small due to the nature of radio propagation at high frequencies.
[12] https://insight.nokia.com/new-spectrum-5g-one-step-closer-mmwaves
[13] http://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_76/Docs/RP-171496.zip
[14] Qualcomm, "New 3GPP effort on NR in unlicensed spectrum expands 5G to new areas", May 4 2017. https://www.qualcomm.com/documents/5g-spectrum-sharing

2.16 This potential shift in demand for spectrum is discussed further in section 4.

Call for input

2.17 We welcome input from the vendor community on their product roadmaps relevant to the 26 GHz band:

Question 2.1: What are your planned timelines for commercial availability of network equipment and devices for the 26 GHz band? When will equipment for testing and trials be available? Please specify the specific mmWave tuning ranges supported and their timing.

Question 2.2: Given the 3GPP studies into NR-based operations in licence-exempt spectrum, when (if ever) do you expect to support licence exempt operation and/or coordinated sharing in the 26 GHz band in your products?

Question 2.3: When do you expect to support standalone New Radio in the 26 GHz band in your products?

2.18 The current use of the spectrum, and the extent to which 5G services can coexist with these users, are also important factors when considering when different parts of the band can be made available for 5G and are discussed in the next section.

Section 3

The 26 GHz band

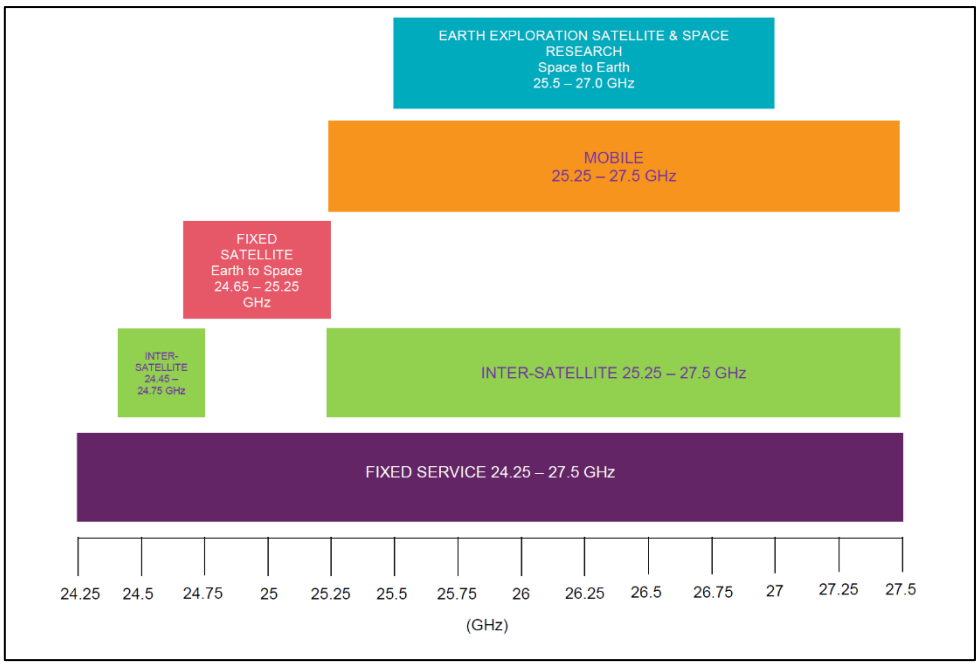
3.1 The 26 GHz band is 3.25 GHz of spectrum between 26.25 GHz and 27.5 GHz. As set out in our 5G update on spectrum, we are currently undertaking a programme of work to make the whole of the 26 GHz band available for 5G on a progressive basis, with an initial focus on the upper 1 GHz of the band, given its light use. Due to the characteristics of spectrum at 26 GHz, we believe that a progressive approach to meet demand, when and where it arises, is likely to ensure optimal use of spectrum. This is in line with the approach set by the RSPG in its recent key messages on 5G.[15]

3.2 This section sets out at a high level what the band currently looks like from both an international and national perspective along with an overview of the international technical studies that are currently underway. We seek stakeholders' views on options that could be considered for existing users to enable the introduction of 5G across the band.

International ITU allocations

3.3 At the international level the 26GHz band has a number of different service allocations across the full frequency range. A high-level diagram showing the different primary service allocations (for ITU-R Region 1) and how they relate to each other is shown below (Fig. 2).

Figure 2 - ITU Region 1 High level Band Structure / Primary Service Allocations (24.25 – 27.5 GHz)[16]



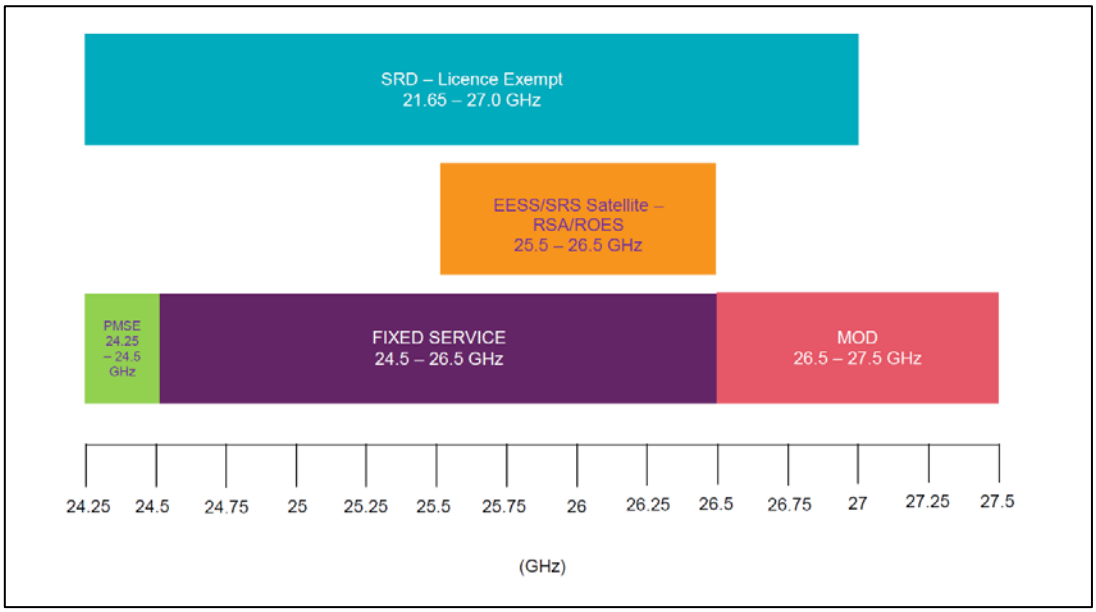
[15] https://circabc.europa.eu/sd/a/d7d08273-0cab-4462-8839-25b009b5900e/RSPG17-029-43rd_Chairs_report.pdf

[16] Article 5 of the Radio Regulations (2016) http://search.itu.int/history/HistoryDigitalCollectionDocLibrary/1.43.48.en.101.pdf

High level current UK use

3.4 From the UK authorisation perspective, the band is used by and is currently available for fixed links, Satellite receiver Earth stations, Programme Making and Special Event stations (PMSE), Short Range Devices (SRDs) and for military uses by the Ministry of Defence (MoD). Figure 3 below shows where, in frequency terms, these authorisations are currently available.

Figure 3 - UK Authorisations / Grants of RSA for ROES / Permissions for Use



3.5 The band can be broadly divided into two main parts and, in total, offers 3.25 GHz of future bandwidth potential for 5G systems:

- the ‘upper 26 GHz band’ (26.5 – 27.5 GHz) currently used by the MoD and
- the ‘lower 26 GHz band’ (24.25 – 26.5 GHz) that is managed and assigned by Ofcom.

Upper 1 GHz of 26 GHz band (26.5 – 27.5 GHz)

3.6 The MoD currently grants permissions for defence use of frequencies in the upper 1 GHz of the 26 GHz band. However, the MoD have confirmed that the band is extremely lightly used and is therefore available for deployment of 5G.

Lower 2.25 GHz of 26 GHz band (24.25 – 26.5 GHz)

3.7 The lower 2.25 GHz of the band is managed by Ofcom. There are a number of applications that are or can be currently authorised to use the band in the UK. These are Fixed Links, Satellite Receiver Earth stations, Programme Making and Special Events (PMSE) applications, and Short Range Devices (SRDs). Below we set out a high level overview of each of these uses.

Fixed Links

3.8 These are point to point wireless links that carry a mixture of low, medium to high capacity data traffic between specific geographic locations. They are individually assigned and licensed on a first come first served basis (FCFS) and used for a variety of applications such as; backhaul for mobile network operators, fixed networks, utilities, emergency service traffic, TV broadcast distribution, and by several other private and public entities. Within the lower 26 GHz band fixed links are the main use of the band with around 2,800 licences currently on issue across the whole of the UK. Annex 5 contains a map showing the geographic distribution of these links in the UK.

Earth Exploration Satellite Service Earth Stations

3.9 Satellite Earth stations in this band are used for receiving Earth observation data, for example satellite imagery and climate data, from Earth exploration satellite systems. The UK currently has one satellite Earth station (receive only) located in Harwell with a grant of Recognised Spectrum Access (RSA). Annex 5 contains a map showing the location of this satellite Earth station. Our space spectrum strategy[17] indicated that we expect that only a small number of Earth stations may be needed to realise the benefits from the EESS data as once downlinked to Earth, the data can be distributed to users using terrestrial (e.g. fibre) networks.

3.10 Grants of RSA for receive only Earth stations are currently available in the UK across 1 GHz of bandwidth in the 25.5 – 26.5 GHz band. These are issued primarily to provide a specified maximum interference level at the Earth station receiver, not to be exceeded, which is then taken into account with respect to any future assignments in the band. There are no current plans to extend, in frequency terms, the 26 GHz RSA product further within the UK.

Programme Making and Special Events (PMSE)

3.11 PMSE is allocated to part of the 24.25 to 25 GHz band. Typical applications are temporary point to point and portable video links. The band is lightly used.

Short Range Devices (SRDs)

3.12 A number of licence exempt uses are possible on a non-protected basis as detailed in IR2030[18] along with the European Commission Decisions related to the harmonised use of 21.65-26.65 GHz for automotive radars, also known as short range radars or SRR. While the long term home for these SRRs is 79 GHz, due to delays in the 79 GHz SRR technology development and associated implementation, the European Commission issued an amending Decision[19] in July 2011 that extended the use of the upper part of the 24 GHz band for SRR from the original date of 30 June 2013 to 1 January 2018. The amending Decision also extended by a further 4 years (until 1 January 2022) the possibility of mounting 24 GHz SRR equipment in cars where type approval was granted before 1 January 2018.

---

[18] https://www.ofcom.org.uk/spectrum/radio-spectrum-and-the-law/licence-exempt-radio-use/licence-exempt-devices/short-range-devices-information

[19] European Commission Implementing Decision 2011/485/EU: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:198:0071:0072:EN:PDF

Technical studies

3.13 As outlined above, the lower 26 GHz band is currently used by a number of services. As part of the work to harmonise the band for 5G ahead of the ITU World Radio Conference in 2019 we are contributing to a number of national and international technical co-existence studies to understand the impact on existing users and any technical and regulatory measures, including the option of progressively clearing the band, in time, geography and with regards to bandwidth required to facilitate 5G.

Call for inputs

3.14 We welcome views from existing users of the 26 GHz band regarding the current use of the spectrum in different parts of the UK and options that could be considered to enable the introduction of 5G services.

Question 3.1: Are there any other aspects related to the existing use of 26 GHz not covered in this CFI that you believe need to be considered?

Question 3.2: What options for the existing services in the 26 GHz band do you believe need to be considered to allow for the introduction of new 5G services? Please give as detailed a response as possible along with all relevant information and explain how you would see any potential option you provide working in practice.

Question 3.3: Should a moratorium be placed on issuing new licences in the 26 GHz band for existing services? E.g.to ensure that the 26 GHz band is not unnecessarily encumbered prior to the development of a new authorisation / licensing approach for 5G services?

3.15 The existing use of the band and the options available for introducing 5G will have implication for where and when 5G can be introduced using different parts of the band. Responses to the questions set out about will be considered as we develop policy options.

3.16 The demand from stakeholders to deploy 5G in the 26 GHz band is also relevant to where and when we make spectrum in the band available for 5G and is discussed in the next section.

Section 4

Understanding spectrum demand

4.1 5G at mmWave is expected not only to deliver high capacity in high demand areas to meet increasing consumers demand for mobile broadband, but could enable new services and applications for citizens and consumers, opening up new business models and new opportunities not only for existing operators, but also for new entrants.

4.2 This section provides an overview of the potential new services and deployment solutions, to meet a potentially very diverse set of market requirements and deliver increased benefits to consumers and citizen.

4.3 We have also set out the types of information that we would like to gather to assess the nature of spectrum demand resulting from market and technology developments.

Understanding spectrum needs at 26 GHz

4.4 5G technologies deployed at 26 GHz will provide very high capacity, lower latency and higher reliability than previous mobile technologies. In addition to supporting the growth of mobile broadband, these new features could enable a wide range of new services and use cases in the commercial/industrial and public sectors.

4.5 The new market opportunities enabled by 5G, combined with the ability to deploy standalone networks could enable numerous different players to deploy their own networks tailored to their individual needs, supported by the equipment vendor and systems integration industries.

4.6 This diversity of 5G services and deployment models will have implication for spectrum demand. Demand for spectrum will likely vary by location, bandwidth and quality of service requirements.

4.7 We have a duty to ensure the optimal use of spectrum, as well as have regard to encouraging investment, innovation and competition. To achieve these goals it is important that we gather evidence of demand from those who have an interest in using the spectrum, including information on target areas for deployments and capacity and quality requirements. This is particularly important for the 26 GHz band given it is the first mmWave band that we will be making available for 5G and so could result in a wave of new service innovation and network deployment models.

4.8 The following subsections provide examples of some of the services and deployment models that could be facilitated by mmWave 5G. It is not intended to be exhaustive, but to highlight the wide range of ways in which 5G technologies can be used at mmWave and the implications in terms of access to spectrum.

High demand for Mobile Broadband in high traffic areas

4.9 Given the increasing use of smart phones to access the internet we expect that one of the primary use cases for 5G will be to increase the network capacity of existing mobile networks in areas of high demand ‘hotspots’, such as railway stations and stadia.

4.10 Initial technical studies indicate that 5G small cells deployed in mobile networks will have a typical coverage range of between 50m and 200m when serving mobile handsets. As a result, in larger hotspot areas such as a city centre, multiple 5G small cells may need to be deployed to give contiguous coverage and configured to allow hand over between cells to provide consistent performance for users on the move.

4.11 Over time we would expect the number of data hotspots to increase as average data consumption per user increases. As such, we'd expect that mobile network operators will need to be able to add additional small cells over time.

4.12 The extent to which operators may need to build areas of contiguous coverage with 5G small cells is a relevant consideration for choosing a spectrum authorisation approach. An operator will likely seek certainty that they can place cells in locations that avoid coverage gaps between cells, achieve reliable handover and quality of service and add additional sites in the future.

Neutral Hosts

4.13 It is likely that some locations will be data hotspots for all the mobile networks and each operator will wish to increase its network capacity using 5G small cells.

4.14 Identifying and securing access to sufficient individual cell sites, provision of power and connecting to backhaul may raise practical, planning and commercial challenges to this approach. A model where a network operator installs and operates small cells and provides wholesale access to other operators or service providers could be envisaged as an alternative.

4.15 In such a model, the 'neutral[20] host' may wish to secure access to spectrum rather than relying on the spectrum held by another operator. For example, if it wished to provide access to service providers that do not have access to spectrum. A neutral host is likely to require more spectrum than any of its individual upstream customers, but less than the sum of individual requirements due to statistical multiplexing gains. As such, a neutral host model could result in more efficient use of spectrum.

4.16 If there is demand to operate a neutral host model then this will need to be considered in the context of how we make spectrum available i.e. enable hosts to secure access to large bandwidths. We may also need to consider the implications for competition, particularly if the spectrum requirements of each neutral host meant that there was insufficient competition between hosts in the provision of wholesale services.

4.17 If this model were adopted by a 'non-neutral' host, for example an operator that wished to offer its own retail service as well hosting other service providers may also raise competition concerns, particularly if service providers did not have alternative options. In such a situation, it may be necessary to consider imposing access obligations.

[20] The operator is 'neutral' in the sense that it only provides wholesale services to other providers and does not operate a competing retail service.

Enterprise and Industrial

4.18 The 5G technology standards are being designed to support application that require very low latency, high reliability and the ability to connect large numbers of devices to the network.

4.19 These features make the technology suitable for enabling automation of factories, depos and warehouses. For example, controlling robotic high speed stock pickers in a warehouse or proactively monitoring the health of equipment to allow preventative maintenance to be undertaken.

4.20 5G technologies may also be used to improve the reliability and control of communications in offices, hospitals and similar sites. For example, very low latency and reliability could find application in trading environments and the high speed and low latency could allow medical staff to reliably access and intuitively manipulate detailed 3D imagery on mobile devices using tactile internet technologies.

4.21 The existing mobile network operators may seek to serve the specialist requirement of enterprise and industrial customers using 'network slicing'[21] and the same infrastructure that is used to provide voice and mobile data to consumers. In some cases additional or dedicated cells may be required to meet capacity and quality requirements.

4.22 The needs of enterprise and industrial customers might also be met by new entrants. Equipment vendors and systems integrators may seek to serve this sector directly using bespoke 5G networks deployed on the customers site. The 5G standards are being developed to support a 'standalone' mode which could allow mmWave small cells to be deployed and provide connectivity within a specific site or area, operating as a self-contained network, independent of any existing mobile network. Such an approach would require access to radio spectrum.

4.23 These types of bespoke 'on site' services are likely to require the installation of dedicated 5G small cells within the relevant buildings and factories.

Fixed Wireless Access

4.24 In addition to serving mobile devices, some operators are planning to use mmWave 5G to broadband access to fixed locations – so called Fixed Wireless Access ('FWA'). Given the high attenuation experienced by mmWave radio when passing through walls, it's expected that in most FWA networks external antenna would be attached to the outside of the target premises and the data traffic is distributed internally over Ethernet or Wi-Fi. This approach improves the radio link, thereby increasing the speed, reliability, coverage and capacity of the network.

4.25 While 5G deployments to address mobile broadband hotspots are expected to be focussed on city centres and other area of high footfall, FWA networks might be targeted at more rural locations where existing copper based broadband is not

[21] Network Slicing is a feature of 5G that allows network operators to provide dedicated virtual networks to different customers over the wireless and core network. Specific services could have a dedicated portion of the network allocated to them, allowing a tailored quality of experience.

meeting consumer needs and the cost of deploying fibre based solutions is not commercially viable.

4.26 The customer premises equipment in a FWA deployment is likely to be mains powered and its operation unconstrained by the battery management considerations associated with a mobile handset. Consequently, network operators may have the opportunity to increase the range and capacity of the serving cells using higher transmission powers and taller masts than those used for serving mobile terminals.

4.27 If operators deploying mmWave technology to offer FWA do require different technical parameters to those offering mobile services (for example, if taller masts or higher power transmission are required to optimise coverage), then there are likely to be implications for how spectrum is authorised because the nature of inter-cell interference will differ.

Wireless Backhaul

4.28 In the examples provided above, mmWave spectrum is used to provide connectivity between 5G small cells and handsets and other devices.

4.29 The nature of the 5G technology may also make it suitable for connecting the 5G small cells back to the core network, either using more conventional point to point microwave links from cells to aggregation points or, possibly, point to multipoint and mesh type networks using the 5G small cells as the nodes. 3GPP has initiated a study to investigate the use of mmWave spectrum for both access and backhaul.

4.30 As with FWA, if network operators do wish to use 26 GHz to provide backhaul as well as radio access, different technical parameters may be required and this could have implication for how spectrum is allocated and authorised.

Road and Rail

4.31 Consumers increasingly expect to be well connected when travelling by road and rail, whether to work more efficiently or to consume information and entertainment services. In addition, with the development of autonomous vehicles and the opportunities for ‘smart’ road networks, connectivity requirements to, and between, vehicles are increasing.

4.32 Given the limited range of small cells and the high attenuation of mmWave signals when passing through glass and steel, it is not clear whether 26 GHz spectrum will play a role in providing connectivity direct to handsets in cars and trains, but could be suitable for connectivity to roof mounted antenna. The service could then be redistributed within the vehicle.

Alternative spectrum and carrier aggregation

4.33 As outlined in section 2, the combination of the mmWave spectrum and the new features being developed for the 5G standards could lead to innovation in service and deployment models. However, some of these new opportunities may not be unique to the 26 GHz band, and alternative spectrum could be suitable.

4.34 It’s expected that some operators will deploy 26 GHz small cells in conjunction with other bands. Carrier Aggregation and other techniques can be used to increase capacity and/or increase reliability of connections. The potential to use carrier

aggregation could reduce the need to rely solely on securing a contiguous block of the 26 GHz band to meet capacity requirement.

4.35 While there is likely to be uncertainty in exact deployment plans, we are interested in hearing stakeholder views on what characteristics of the 26 GHz band make it particularly suited to their needs.

Call for input

4.36 The examples above illustrate the range of possible uses and deployment models of 5G at 26 GHz, but are not intended to be exhaustive. We welcome feedback from any stakeholders who are interested in using spectrum in this band, irrespective of service offering. The information we gather on demand for spectrum will inform our choice of authorisation approaches.

4.37 While we recognise that the exact performance of mmWave 5G technologies and operator plans for deployments are subject to significant uncertainty, the questions below sets out the types of information we would like to gather from stakeholders to inform our policy development.

Question 4.1: What service would be delivered and to which consumers and/or organisations?

Question 4.2: Where in the UK would the 26 GHz spectrum be used to deliver services? For example, will deployments be focussed on:
a) Areas of existing high mobile broadband demand?
b) Rural areas?
c) Rail and road corridors?
d) Specific types of enterprise or industrial sites?
e) Indoors or outdoors?
f) Specific nations or regions of the UK?

Question 4.3: Where 5G cells are deployed, are they expected to be individual cells or as clusters of cells required to give wider areas of contiguous coverage? What would be the area of a typical contiguous coverage cell cluster?

Question 4.4: What capacity and bandwidth (i.e Channel Bandwidth in MHz) would be required at each cell to meet initial capacity requirements? How will this change over time?

Question 4.5: What quality of service is required? How sensitive is the service being offered to variations in radio interference from other operator's 5G cells and other spectrum users?

Question 4.6: Will end users be fixed or mobile?

Question 4.7: What are the characteristics of 5G at 26 GHz which make this band particularly suited to the service you plan to deploy? What other spectrum bands could be used as an alternative, or in preference to, the 26 GHz band? To what extent could carrier aggregation and other techniques reduce your reliance on 26 GHz?

4.38 In addition to the specific questions set out above, we welcome any other information stakeholders wish to submit relating to the future use of the 26 GHz band.

4.39 Feedback from stakeholders on likely demand to deploy 5G in the 26 GHz, in conjunction with information on technology availability and capability (section 2) and the current use of the spectrum (section 3) will inform our policy options for authorising spectrum in the band. A discussion on the potential authorisation options we could consider is provided in the next section.

Section 5

Spectrum Authorisation

5.1 Given the different characteristics of mmWave spectrum, and the potentially different services and deployment models that could be enabled by access to spectrum at 26 GHz, the traditional authorisation approach of national licences each with dedicated spectrum is unlikely to deliver optimal use of spectrum and meet the requirements of a diverse set of users.

5.2 This section provides an overview of some of the high level approaches we are considering for authorising spectrum at 26 GHz. We seek stakeholder views on the different authorisation approaches and how these could meet their deployment needs.

Authorisation approaches and objectives

5.3 Ofcom has a number of duties that we take into consideration when deciding how to make spectrum available, these include the duties to secure and have regard to:

- the optimal use for wireless telegraphy of the electro-magnetic spectrum;
- the availability throughout the United Kingdom of a wide range of electronic communications services;
- the desirability of promoting competition in relevant markets;
- the desirability of encouraging investment and innovation in relevant markets;
- the desirability of encouraging the availability and use of high speed data transfer services throughout the United Kingdom;

5.4 When making spectrum available we take into consideration all our relevant duties.

5.5 As outlined in previous sections, the 5G technology is being designed to enable the development of new use cases and business models. Consequently, new players, beyond the existing mobile network operators are likely to need access to spectrum to meet their specific requirements. For example, there could be demand from a large number of operators, each wanting to deploy a small number of 5G small cells to serve enterprise and industrial customers in different parts of the UK. This would represent a significant change in the demand profile seen in previous mobile spectrum releases and may warrant a change in our approach to spectrum authorisation.

5.6 The Wireless Telegraphy Act entitles Ofcom to use a wide range of licensing approaches to authorise spectrum use in different bands and for different applications.[22] Below we provide an overview of three common approaches and highlight their relative strengths and weaknesses in meeting the needs of different services and network deployment models.

22

Licence Exempt (shared, uncoordinated)

5.7 Where there is evidence that 5G small cells can be deployed in an uncoordinated manner without unacceptable degradation of QoS Ofcom will consider allowing licence exempt operation. Licence exemption would allow anyone to deploy 5G small cells (subject to them meeting technical parameters set out by Ofcom) without having to hold a spectrum licence or coordinate with neighbouring operators. The low barriers to entry associated with licence exemption can encourage high levels of competition and innovation.

5.8 The inherent characteristics of mmWave propagation and the potential development in 3GPP of protocols and mechanisms to reduce interference between 5G NR cells (as a part of the on-going 3GPP study item on licence-exempt operations for NR), as described in section 2, may make 5G small cells more suitable for licence exempt operation than current generation mobile technologies. Indoor deployments and use cases which do not require guaranteed quality of service may be particularly suited to a licence exempt approach, due to the reduced risk of inter cell interference and tolerance of services to periodic degradations in performance.

5.9 While 3GPP will study solutions that allow 5G cells from different operators to coexist, it is currently unclear whether 5G standards will be developed to allow uncoordinated 5G NR deployment alongside existing, non-5G, spectrum users or in a way that would allow new devices, that do not use the 3GPP standards, to also operate in the band. The ability to coexist with non 5G users may have implications for the introduction of 5G NR in the lower 26 GHz band.

Shared, coordinated deployments

5.10 Uncoordinated deployment of small cells, as would be the case in a licence exempt regime, risks a ‘tragedy of the commons’ situation in which operators are unable to deliver the required capacity and QoS due to excessive spectrum congestion and interference. The risk is increased when the number of unique channels available within the band is small.

5.11 A spectrum authorisation regime in which the deployment of each new 5G cell is coordinated with existing cells (and other spectrum users) is a commonly used approach to address the risks associated with licence exemption. Requests to use spectrum are typically considered on a first come, first served basis and are only approved if the deployment of the new cell will not unacceptably impact the performance of an existing cell.

5.12 This approach is well suited to encouraging innovation and competition as there are no theoretic limits to the number of operators that can participate.

5.13 There are a variety of approaches to running the coordination process. For example:

- For some fixed links bands, Ofcom maintains a database of existing links and issues licences for new links once we are satisfied that they will not adversely impact existing users.

- In the DECT guard band, twelve licences have been awarded to allow use of the band and these licensees are required to work together to coordinate deployments.

5.14 Technology developments and costs reduction in geo-location technologies, spectrum sensing techniques and on-line databases are enabling more dynamic and flexible spectrum authorisation. Currently these are mostly used to allow new services to share with incumbent spectrum users (known as 'tiered sharing'), as is the case for TV White Space devices.[23] However, they could theoretically be used to coordinate deployment of 5G cells by different operators.

5.15 Having a database of all cell locations would also allow Ofcom to monitor density of deployments in different parts of the UK, allowing us to plan future spectrum release or assess whether licence exempt approaches can be considered.

5.16 If there is demand to build mmWave 5G cells with very different deployment and technical characteristics, then coordination may become more complicated. For example, it's likely that indoor only deployments, outdoor deployments for mobile and outdoor deployments for FWA will require different separation distances between cells to manage interference and would need to be factored into the coordination process. It may also be appropriate to vary spectrum access charges to reflect the opportunity cost of the spectrum used by the different deployment scenarios.

5.17 The optimum solution for coordination will depend on the nature of demand e.g. how many players wish to use spectrum, the diversity of technical parameters for different service and deployments types, their capacity and quality of service requirements and the complexity of analysis required to coordinate deployments. While automated and dynamic systems are likely to optimise spectrum use and reduce delays in authorisation, their benefits may be negated by higher costs and longer development timelines when compared to simpler solutions. Responses to section 4 of this CFI are relevant to this consideration.

Area Defined Licences

5.18 A first come, first served licensing approach can result in reduced investment certainty for an operator and sub-optimal use of spectrum. For example, an operator wishing to deploy a small cell network across a city centre to provide contiguous high capacity coverage and reliable intercell handover may be prevented from doing so due to fragmented, ad-hoc deployments by other operators.

5.19 Such an operator may prefer an area defined licence which allows them to deploy cells wherever they choose within a defined geographic area and fully manage their inter-cell interference (and hence quality of service). Within their defined area the operator does not need to coordinate with any other operator. This has been our preferred approach for releasing mobile spectrum to date, awarding UK wide licences via auctions.

5.20 Whilst this approach provides investment certainty for the small number of operators holding licences it risks reducing innovation and competition and can result in under-utilisation of spectrum. For example, there may be parts of the UK or certain market segments that the licence holder chooses not to serve and spectrum remains fallow despite there being demand from other operators to use the spectrum.

5.21 Area Defined Licence, awarded via auction, are most appropriate in locations where demand for spectrum is likely to exceed supply. For 5G small cell deployments these locations are likely to be limited to city centres, railway stations and other areas of demand from the public. It may therefore be appropriate to define the licenced areas

[23] https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2015/tvws-statement

based on existing high mobile broadband demand (as a proxy of areas of very high demand in the future) or areas of expected future growth rather than across the entirety of the UK. These areas could be aggregated to form auction lots e.g. all UK city centres grouped together.

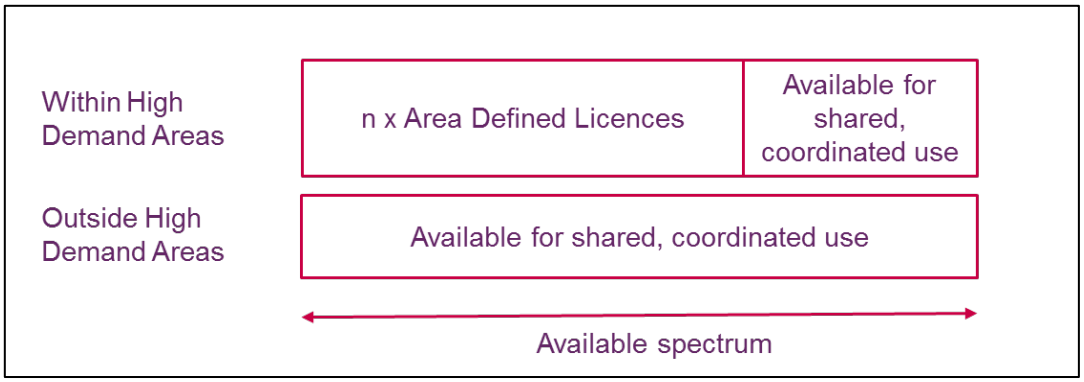
5.22 However, there are risks with Ofcom pre-defining areas of expected high 5G demand. Overestimating the size of the areas could result in underutilisation of spectrum or reduced competition, whilst underestimating (or not anticipating the emergence of new hotspots) could result in sub-optimal investment or degraded quality of service due to fragmentation of networks.

5.23 An alternative way to ensure spectrum does not sit fallow, but avoid the risks of poorly defined licence areas, would be to issue UK wide area licences and then assess whether there are areas of unmet demand after a pre-defined period e.g. 5 years. Where unmet demand is identified, additional operators could be authorised to use the spectrum.

Hybrid authorisation approaches

5.24 It is unlikely that all stakeholders' needs can be met, nor benefits for consumers maximised, with a single licencing approach. A pragmatic option could be to allocate a small number of area defined licences in areas of high demand for part of the 26 GHz band, with the remainder available for individual, coordinated deployment. Outside of the defined licence areas, all the spectrum would be available for coordinated deployments. Such an approach would encourage innovation and competition while giving an option for a small number of operators to secure investment certainty and guaranteed quality of service in high demand areas. See figure 4.

Figure 4 - Example hybrid authorisation approach



5.25 Under this approach, the optimal split of spectrum between area defined licences and coordinated deployment (within the High Demand Areas) would be dependent on demand for each licence type and the value that can be delivered to consumers. Responses to section 4 of this CFI will provide a useful evidence base for assessing this.

5.26 Given the risks and uncertainty associated with licence exemption, it would be prudent not to allow it in the 26 GHz initially but review the situation in the future when there is more certainty over the capabilities of the 5G equipment to coexist with other spectrum users and there is evidence of real world cell deployments densities and quality of service requirements. It should be noted that there is a possibility to

consider making the 66 GHz– 71 GHz band available for licence exempt 5G deployments (see section 7).

Channel bandwidth

5.27 Responses to the CFI (see question 4.4) will also provide evidence that will inform our assessment of the minimum viable channel bandwidths for 5G small cells. Higher channel bandwidth increase the peak speed and capacity of a 5G cell and hence its commercial viability. However, higher channel bandwidths reduce the number of operators that can deploy cells in the same area.

Progressive Release

5.28 To ensure UK consumers and citizens can benefit from 5G services as early as possible we will consider authorising access to the 26 GHz band progressively. For example, releasing of the upper 1 GHz of spectrum to support 5G deployment across the UK in the 2019/2020 timeframe and then the remainder of the band as soon as practicable.

5.29 In releasing the upper 1 GHz we would need to balance the innovation and competition benefits of providing access to numerous providers with the risk of over fragmenting the spectrum to the point where deployments are no longer commercially viable.

5.30 A progressive release of the upper and lower bands also introduces the risk of increased fragmentation of spectrum holding for individual operators who secure spectrum in both sub bands. It is currently unclear whether this would lead to inefficient use of spectrum or whether technologies will be developed to allow aggregation of these non-contiguous blocks.

Call for input

5.31 We welcome stakeholder views on:

Question 5.1: Should Ofcom consider licencing options other than the 3 examples set out above (licence exempt, shared coordinated and area defined) for the 26 GHz band? If so, what other options do you consider should be included?

Question 5.2: What methodologies could be used to pre-define 'high demand areas' for area defined licences?

Question 5.3: What mechanism could be used to coordinate cell deployments by different operators in shared spectrum?

Question 5.4: What methodologies could be used for determining the proportion of spectrum to allocate using area defined licences and coordinated deployment?

Question 5.5: Do you agree that the 26 GHz band should be released progressively? What risks do you envisage with such an approach and how can these be best mitigated?

5.32 In addition to the specific questions set out above, we welcome stakeholder views on any other aspects of spectrum authorisation in the 26 GHz band.

5.33 The next section sets out how we intend to use the responses to this CFI and our plans to consult on firm proposals to prepare the band for the introduction of 5G and authorise its use.

Section 6

Next Steps for 26 GHz

6.1 This call for input closes on 22 September 2017. We welcome input from all interested stakeholders. In addition to written responses, we are happy to meet with stakeholders on a bi-lateral basis to discuss this CFI.

6.2 Stakeholders interested in gaining access to spectrum in the 26 GHz for test and development purposed can apply now for a non-operational licence.[24] Given the limited use of the 26.5 – 27.5 GHz sub-band we expect to be able to issue non-operational licences for these frequencies without delay.

6.3 Responses to the CFI, along with emerging findings from coexistence studies and international developments will inform our development of policy options for releasing and authorising spectrum in the 26 GHz. We plan to consult on these later in the year.

[24] https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences

Section 7

Roadmap for further bands for 5G

7.1 As discussed in this CFI, we are already undertaking work to make 26 GHz available for 5G; it remains our highest priority band going into WRC-19 because we consider that it offers the greatest potential for global harmonisation at mmWave frequencies.

7.2 In our 5G update published in February, we committed to defining a UK roadmap for all bands being considered for 5G under for WRC-19 agenda item 1.13. In order to achieve progress at WRC-19, we consider that between now and the conference, attention needs to be focused on a smaller number of bands in order to increase the likelihood of agreeing globally harmonised ranges that will support the development of a global device ecosystem.

7.3 This section sets out our rationale for promoting 66-71 GHz as another priority band for study for 5G, and our view for that a tuning range covering the frequency range 37-43.5 GHz has strong potential to become a 5G band for harmonisation of equipment. We consider that 40.5 to 43.5 GHz should be identified as a priority band for study.

Bands identified for discussion at WRC-19 for 5G

7.4 A range of different mmWave frequency bands above 24 GHz are being studied in the ITU-R for potential use by 5G technology. This work will culminate at WRC-19 where (under Agenda item 1.13 of the conference) it is expected that a number of these bands will be selected and as a result these bands will be identified in the Radio Regulations for IMT.

7.5 The full list of bands being studied, as specified in Resolution 238 (WRC-15), is: 24.25-27.5 GHz, 31.8-33.4 GHz, 37-40.5 GHz, 40.5-42.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47-47.2 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81- 86

Further bands identified for 5G by the RSPG

7.6 In the first opinion on 5G, the RSPG identified three bands for 5G in Europe: 700 MHz; 3.4-3.8 GHz; and 26 GHz as the “pioneer” mmWave band. Further to these bands, the RSPG also highlighted 32 GHz (31.8 to 33.4 GHz) and 40 GHz (40.5 to 43.5 GHz) as promising bands for 5G.

7.7 The view of the RSPG is that 32 GHz could be made available relatively easily by many European administrations, taking into account the existing fixed deployment in this band. The first opinion also highlighted that 40 GHz is a viable option for 5G.

7.8 In addition to the 26 GHz band, CEPT has also confirmed that the 32 GHz and 40 GHz should be prioritised for study for WRC-19.

Our prioritisation of bands is based on several factors

7.9 In defining our roadmap, we have taken into consideration the following factors:

- Current use of the band in the UK, including: whether the band is actually being used; if there is the potential to share with incumbent uses or alternatively if the incumbent uses can be easily moved.

- International views, specifically, is there sufficient international support to create scale and influence with equipment manufacturers, and particularly in key international markets (e.g. US, China, Europe)?

- Industry views, including R&D focus, and whether equipment is likely to be available in these frequency ranges.

- Adjacent bands, and whether these are likely to impose a constraint on use. For example, passive bands may require significant protection (e.g. guard bands and/or tight out-of-band emission requirements).

- Availability of an existing technology ecosystem that could make adding support for 5G easier. For example, the 66-71 GHz band is adjacent to the 60 GHz band where existing multi-gigabit devices are available.

- The needs of other sectors and spectrum users, particularly where the band is identified as a growth band for another service, or the band has a physical characteristic a particular service requires.

- Whether the band already has an allocation for mobile in the Radio Regulations.

7.10 Based on consideration of the above factors, we believe that the bands with significant potential are 66-71 GHz, and bands around 40 GHz (37-43.5 GHz). We detail our rationale for this prioritisation in the following sections.

7.11 We consider that 66-71 GHz should be a priority band for study under WRC-19 Agenda Item 1.13, and has the potential to be made available on a licence-exempt basis in the UK. It has the potential for global harmonisation for 5G as it is currently very lightly used in many countries and is immediately adjacent to spectrum used for multi-gigabit licence-exempt applications.

7.12 We plan to promote 37–43.5 GHz as a globally harmonised tuning range for 5G, with the sub-band of 40.5-43.5 GHz being best suited for 5G use in the UK and Europe. The benefit of identifying a wider tuning range that can be harmonised globally is that equipment manufacturers and vendors can serve the global market with the same products, thus maximising economies of scale, while allowing different administrations/regions the ability to identify the most appropriate frequencies within the range to be used for 5G. As highlighted by the first RSPG opinion on 5G[25], it is likely that Europe will focus on the top part of the range (40.5-43.5 GHz).

7.13 Our view is that 32 GHz is a promising band for 5G in Europe, but because of the potential for global equipment harmonisation around 40 GHz, we consider 40 GHz is a higher priority. With harmonisation of equipment across the whole 37-43.5 GHz band administrations would have the flexibility to make available the sub-bands that best meet their own needs. This degree of flexibility would not be achievable at 32 GHz, where only 1.6 GHz of bandwidth is available and further restrictions of what frequencies are usable may be required to protect the adjacent passive band.

7.14 This roadmap is a snap shot of our current assessment of the bands. We will also continue to work with other European countries as part of the RSPG and in CEPT and contribute to international studies in the run up to WRC-19.

[25] http://rspg-spectrum.eu/wp-content/uploads/2013/05/RPSG16-032-Opinion_5G.pdf

66 to 71 GHz band: a priority band for 5G

7.15 Based on our prioritisation exercise, we intend to promote 66-71 GHz as a priority for international study for 5G services.

7.16 66-71 GHz is part of the wider 66-76 GHz frequency range being studied for WRC-19 under Agenda Item 1.13. In the UK, 71 – 76 GHz is part of the 70/80GHz fixed links band. This band is being targeted by MNOs to meet the macro cell and small cell backhaul capacity requirements in urban areas in the short/medium term. The 70/80 GHz band is currently the fastest growing fixed link band in the UK. We have therefore taken the view that we should focus on promoting the 66-71 GHz portion of the band for 5G in the UK, rather than the wider 66-76 GHz frequency range, due to the strategic importance of the 70/80 GHz band for mobile backhaul.

7.17 The 66-71 GHz band was initially identified as a priority band for 5G in the March 2015 Quotient report we commissioned as part of our initial assessment of 5G bands.[26] In our April 2015 Statement 2015 'Update on bands above 6GHz' we included the band in our list of "preliminary bands identified" for 5G.[27]

7.18 Building on this initial assessment exercise, we consider 66-71 GHz should be promoted internationally as a priority band for study for 5G for the following reasons:

- The band has no incumbent use in the UK. 66-71 GHz has allocations to the radionavigation and to the radionavigation-satellite services, our current understanding is that these are either not in use or not expected to be a major coexistence issue. The band is also allocated to inter-satellite and the mobile-satellite service, where similar conclusions apply.

- There is existing international support for the band: The US has already made available 7 GHz of unlicensed spectrum available at 64 – 71 GHz and Canada is currently consulting on making the same frequency range available.[28]

- A recent CEPT questionnaire also found there was no reported use in other CEPT countries, increasing the possibility that other European administrations could also make the band available, creating further scale.[29]

- Its proximity to the 57-66 GHz band, which is being made available in many countries for licence-exempt use by multi gigabit applications, indicates that 5G equipment could potentially be available in this band relatively early by building on the existing multi-gigabit ecosystem.

- The band already has a primary allocation for mobile in the Radio Regulations.

7.19 Therefore, our view is that this band has good potential to be globally harmonised for 5G and that it could be made available in the UK, as well as in many other countries

[26] https://www.ofcom.org.uk/__data/assets/pdf_file/0014/31910/qa-report.pdf
[27] Laying the foundations for next generation mobile services: update on bands above 6GHz, https://www.ofcom.org.uk/__data/assets/pdf_file/0028/57196/5g_cfi_update_and_next_steps.pdf
[28] http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11298.html
[29] Summary of responses to questionnaire on bands for AI1.13 http://www.cept.org/files/4549/ECC%20PT1(16)133%20Annex%2031rev1%20Results%20of%20A1_13%20questionnaire.docx

worldwide, relatively easily as it is free from incumbents, and could potentially benefit from early availability of equipment.

7.20 The UK recently proposed that CPG endorses the proposal to include 66-71 GHz as a priority band for study under WRC-19 AI 1.13, and include relevant text into the CEPT brief. The CEPT position was subsequently amended to indicate that 66-71 GHz is also a focus for CEPT studies.

Authorising access at 66 to 71 GHz

7.21 In the February 5G Update, we said that we could consider the most appropriate authorisation approach for each band we identified for 5G. Our current assessment is that 66-71 GHz should be considered further to be made available on a licence exempt basis.

7.22 As we discuss in the February 5G Update, 5G will enable new use cases and business models, and consequently demand for spectrum is likely to come from a variety of players. We consider that licence exemption has the potential to promote innovation and competition, by enabling new players to enter the market.

7.23 The lack of incumbent use of the band removes any need to manage the deployment of 5G cells to avoid radio interference. In addition, current technologies in the adjacent 57-66 GHz band already incorporate techniques to avoid interference. This is one of the main reasons why a licence-exempt approach may be suitable for 5G deployment in this band.

7.24 As described in section 5, licence exemption does not give an operator full control over the quality of service they can deliver and this can vary depending on the activities of other operators. Degradation in quality of services can be mitigated in a variety of ways, including limiting transmission power, restricting deployment to indoor or requiring the use of particular ‘polite’ protocols.

7.25 We therefore plan to start work, in parallel with this CFI, to consider further the necessary regulation to facilitate 5G in the 66-71 GHz band, taking into account the current developments in the adjacent lower band (57-66 GHz) which is currently under review as part of our Fixed Wireless spectrum strategy work.

37 to 43.5 GHz: global harmonisation across a wider range to enable the development of device ecosystem

7.26 We also consider that 37 - 43.5 GHz has the potential to become a globally harmonised band for 5G equipment and for this reason, 40.5 – 43.5 GHz, identified by the RSPG as a promising band for 5G in Europe, should become a priority band for study. The 37 to 43.5 GHz range covers three frequency bands being studied under WRC-19 Agenda Item 1.13: 37 to 40.5 GHz, 40.5 to 42.5 GHz and 42.5 to 43.5 GHz.

7.27 Historically, economies of scale have often rested on precise and inflexible harmonisation conditions. Ongoing technology developments mean that equipment will support bands over a wider tuning range, which could meet the specific requirements of different regions/countries whilst enabling global economies of scale.

7.28 This means that within each range identified, individual countries could make only a sub-set of the frequencies available, depending on their own needs and individual

circumstances, and manufacturers could build a single device that covers the entire tuning range. As demand develops, countries could make additional spectrum within the range available.

7.29 There is already significant international support across the 37 - 43.5 GHz range, increasing the potential for equipment economies of scale.

- China is currently consulting on making the extended 37 – 42.5 GHz frequency range available.[30]

- In the US 37 – 40.5 GHz is available for 5G[31] and Canada is currently consulting on also making it available.[32]

- In its first opinion on 5G, the RSPG identified 40.5 – 43.5 GHz as a "promising" band for 5G.[33] We are recommending RSPG to consider the full 37-43.5 GHz band for harmonisation so that manufacturers can develop equipment covering the whole range and know that it can be sold and used worldwide. We note that 37 – 40.5 GHz band was not included in the European Common Position into WRC-15 or the RSPG Opinion, and in a questionnaire last year there was little support from European administrations, so it is likely that many European administrations will focus on making frequencies in the upper part of the band available.

International Allocations

7.30 At the international level the 37 – 43.5 GHz band has a number of different service allocations across the full frequency range.

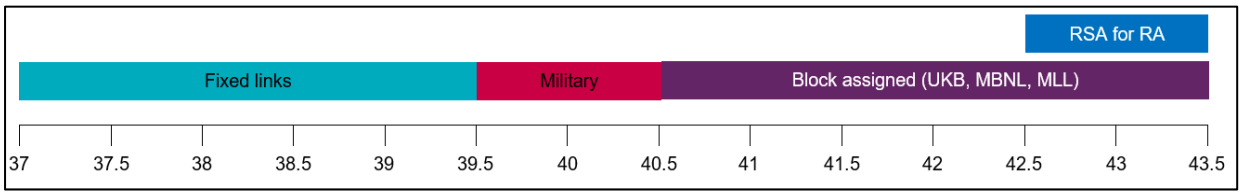
- **37 – 39.5 GHz**: 37-37.5 GHz has a primary allocation to fixed, mobile and space research (space to Earth). The rest of the range has primary allocations to fixed, mobile, and fixed-satellite (space to Earth), and a secondary allocation to earth exploration-satellite (space to Earth). It also has additional allocations to space research (space to Earth) on a primary basis in 37.5-38 GHz; mobile-satellite (space to Earth) on a primary basis in 39.5-40.5 GHz; and Earth exploration-satellite (Earth to space) and space research (Earth to space) on a primary basis in 40-40.5 GHz

- **40.5-43.5 GHz:** The frequencies 40.5-42.5 GHz are allocated on a primary basis to the fixed, fixed-satellite (space to Earth), broadcasting and broadcasting-satellite services. There is a secondary allocation to mobile. ITU-R Region 2 (the Americas) also has a secondary allocation to mobile-satellite in 40.5-41 GHz. 42.5-43.5 GHz is allocated to fixed, fixed satellite (Earth to space), mobile and radio astronomy on a primary basis.

[30] http://miit.gov.cn/n1146285/n1146352/n3054355/n3057735/n3057748/c5676741/content.html
[31] https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-89A1.pdf
[32] http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11298.html
[33] http://rspg-spectrum.eu/wp-content/uploads/2013/05/RPSG16-032-Opinion_5G.pdf

UK utilisation of 37 – 43.5 GHz

Figure 5 - UK Authorisations at 37 – 43.5 GHz / Grants of RSA for RA at 42.5-43.5 GHz



7.31 In the UK, there are a number of different authorisations across the 37 – 43.5 GHz range:

- 37.5-43.5 GHz has an international allocation to the fixed-satellite service, although our current regulations for Recognised Spectrum Access do not cover the 37.5-42.5 GHz band and we do not currently licence satellite Earth stations in the 42.5-43.5 GHz band. This band has been identified by the satellite community as being an important growth band for future feeder links and gateways. In our Space Spectrum Strategy we said that we are supportive of efforts to study ways in which 5G deployment in this band could effectively share (probably on a geographic basis) the spectrum with satellite feeder links.[34]

- 37-39.5 GHz is used for point to point links. There are currently just under 6,000 fixed links in this band, assigned on a link by link basis and managed by Ofcom. These links predominantly serve as backhaul for existing mobile networks in the UK.

- Responsibility for granting permissions to use the frequencies in 39.5 – 40.5 GHz for military users currently rests with the MoD.

- 40.5 – 43.5 GHz is block assigned on a technology/service neutral basis to three operators (UK Broadband Limited, MLL 40 GHz Limited, Mobile Broadband Network Limited as Agent of Everything Everywhere and Hutchison 3G UK Limited). This spectrum was auctioned in 2008. 40.5-43.5 GHz was designated in Europe for terrestrial MWS (Multimedia Wireless System), and was recently re-designated also for the fixed service.

- There is currently only one RSA Radio Astronomy site in this band, issued to STFC and located in Cambridge. This operates within the auctioned spectrum, with a 50km exclusion zone. While the band is still open to applications, the risk of increased Radio Astronomy use of the band is low, as our regulations only allow applications from 6 existing sites.

7.32 The benefit of identifying the wider 37-43.5 GHz frequency range is that we can select frequencies across the range that suit UK utilisation. We will seek to make spectrum for 5G available when and even where necessary, in line with demand.

[34] https://www.ofcom.org.uk/__data/assets/pdf_file/0030/96735/Statement-Space-Spectrum.pdf (specifically, see paragraph 3.52)

Next steps

7.33 We are engaged in the ongoing RSPG work on spectrum related aspects for next-generation wireless systems. As part of this we will promote the benefits of focusing on 40-43.5.5 GHz and 66-71 GHz.

7.34 We also continue to be engaged in the CEPT and ITU-R process to prepare positions on frequency bands for WRC-19 Agenda item 1.13. We will be focusing our engagement on the 24.25-27.5 GHz, 37-43.5 GHz and 66-71 GHz frequency bands.

7.35 We will start the process to consider the necessary regulation to facilitate 5G services in the 66-71 GHz band as part of our Fixed Wireless spectrum strategy work, taking into account the current developments in the adjacent lower band (57-66 GHz).

Annex 1

Responding to this call for inputs

How to respond

A2.1 Ofcom would like to receive views and comments on the issues raised in this document **by 5pm on 22 September 2017**.

A2.2 You can download a response form from https://www.ofcom.org.uk/consultations-and-statements/category-2/5g-access-at-26-ghz. You can return this by email or post to the address provided in the response form. We also provide a cover sheet https://www.ofcom.org.uk/consultations-and-statements/consultation-response-coversheet) for responses sent by post; please fill this in, as it helps us to maintain your confidentiality, and speeds up our work You do not need to do this if you respond using the form.

A2.3 If your response is a large file, or has supporting charts, tables or other data, please email it to Imogen.Buxton@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet.

A2.4 Responses may alternatively be posted to the address below, marked with the title of the consultation.

Imogen Buxton
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A2.5 If you would like to submit your response in an alternative format (e.g.a video or audio file), please contact Imogen Buxton on 020 7981 3239, or email Imogen.Buxton@ofcom.org.uk.

A2.6 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt if your response is submitted via the online web form, but not otherwise.

A2.7 You do not have to answer all the questions in the consultation if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A2.8 It would be helpful if your response could include direct answers to the questions asked in the consultation document. The questions are listed at Annex 3. It would also help if you could explain why you hold your views, and what you think the effect of Ofcom's proposals would be.

A2.9 If you want to discuss the issues and questions raised in this consultation, please contact Imogen Buxton on 020 7981 3239, or by email to Imogen.Buxton@ofcom.org.uk

Confidentiality

A2.10 Calls for inputs are more effective if we publish the responses before the consultation period closes. In particular, this can help people and organisations with

limited resources or familiarity with the issues to respond in a more informed way. So, in the interests of transparency and good regulatory practice, and because we believe it is important that everyone who is interested in an issue can see other respondents' views, we usually publish all responses on our website, www.ofcom.org.uk, as soon as we receive them.

A2.11 If you think your response should be kept confidential, please specify which part(s) this applies to, and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we don't have to edit your response.

A2.12 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A2.13 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further at https://www.ofcom.org.uk/about-ofcom/website/terms-of-use.

Next steps

A2.14 Following the end of the period for inputs, Ofcom plans to publish a consultation later this year.

A2.15 If you wish, you can register to receive mail updates alerting you to new Ofcom publications; for more details please see https://www.ofcom.org.uk/about-ofcom/latest/email-updates

Ofcom's consultation processes

A2.16 Ofcom aims to make responding to a call for inputs as easy as possible. For more information, please see our consultation principles in Annex 2.

A2.17 If you have any comments or suggestions on how we manage our consultations, please call our consultation helpdesk on 020 7981 3003 or email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact Steve Gettings, Ofcom's consultation champion:

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

Ofcom has seven principles that it follows for every public written consultation:

Before the consultation

A3.1 Wherever possible, we will hold informal talks with people and organisations before announcing a big consultation, to find out whether we are thinking along the right lines. 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

A3.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A3.3 We will make the consultation or call for inputs 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 for people to give us a written response. If the consultation is complicated, we may provide a short Plain English / Cymraeg Clir guide, to help smaller organisations or individuals who would not otherwise be able to spare the time to share their views.

A3.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A3.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and aim to reach the largest possible number of people and organisations who may be interested in the outcome of our decisions. Ofcom's Consultation Champion is the main person to contact if you have views on the way we run our consultations.

A3.6 If we are not able to follow any of these seven principles, we will explain why.

After the consultation

A3.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish all the responses on our website as soon as we receive them. After the consultation we will make our decisions and publish a statement explaining what we are going to do, and why, showing how respondents' views helped to shape these decisions.

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 3

CFI questions

Sub heading

7.36 To note, question number are aligned to relevant sections, as such there is no question 1.

Question 2.1: What are your planned timelines for commercial availability of network equipment and devices for the 26 GHz band? When will equipment for testing and trials be available? Please specify the specific mmWave tuning ranges supported and their timing.

Question 2.2: Given the 3GPP studies into NR-based operations in licence-exempt spectrum, when (if ever) do you expect to support licence exempt operation and/or coordinated sharing in the 26 GHz band in your products?

Question 2.3: When do you expect to support standalone New Radio in the 26 GHz band in your products?

Question 3.1: Are there any other aspects related to the existing use of 26 GHz not covered in this CFI that you believe need to be considered?

Question 3.2: What options for the existing services in the 26 GHz band do you believe need to be considered to allow for the introduction of new 5G services? Please give as detailed a response as possible along with all relevant information and explain how you would see any potential option you provide working in practice.

Question 3.3: Should a moratorium be placed on issuing new licences in the 26 GHz band for existing services? E.g.to ensure that the 26 GHz band is not unnecessarily encumbered prior to the development of a new authorisation / licensing approach for 5G services?

Question 4.1: What service would be delivered and to which consumer and/or organisations?

Question 4.2: Where in the UK would the 26 GHz spectrum be used to deliver services? For example, will deployments be focussed on:
a) Areas of existing high mobile broadband demand?
b) Rural areas?
c) Rail and road corridors?
d) Specific types of enterprise or industrial sites?
e) Indoors or outdoors?
f) Specific nations or regions of the UK?

Question 4.3: Where 5G cells are deployed, are they expected to be individual cells or as clusters of cells required to give wider areas of contiguous coverage? What would be the area of a typical contiguous coverage cell cluster?

Question 4.4: What capacity and bandwidth (i.e Channel Bandwidth in MHz) would be required at each cell to meet initial capacity requirements? How will this change over time?

Question 4.5: What quality of service is required? How sensitive is the service being offered to variations in radio interference from other operator's 5G cells and other spectrum users?

Question 4.6: Will end users be fixed or mobile?

Question 4.7: What are the characteristics of 5G at 26 GHz which make this band particularly suited to the service you plan to deploy? What other spectrum bands could be used as an alternative, or in preference to, the 26 GHz band? To what extent could carrier aggregation and other techniques reduce your reliance on 26 GHz?

Question 5.1: Should Ofcom consider licencing options other than the 3 examples set out above (licence exempt, shared coordinated and area defined) for the 26 GHz band? If so, what other options do you consider should be included?

Question 5.2: What methodologies could be used to pre-define 'high demand areas' for area defined licences?

Question 5.3: What mechanism could be used to coordinate cell deployments by different operators in shared spectrum?

Question 5.4: What methodologies could be used for determining the proportion of spectrum to allocate using area defined licences and coordinated deployment?

Question 5.5: Do you agree that the 26 GHz band should be released progressively? What risks do you envisage with such an approach and how can these be best mitigated?

Annex 4

Maps of existing users within the 26 GHz band

Figure 6 – 24.5 GHz to 26.5 GHz Fixed links in the UK (June 2017)

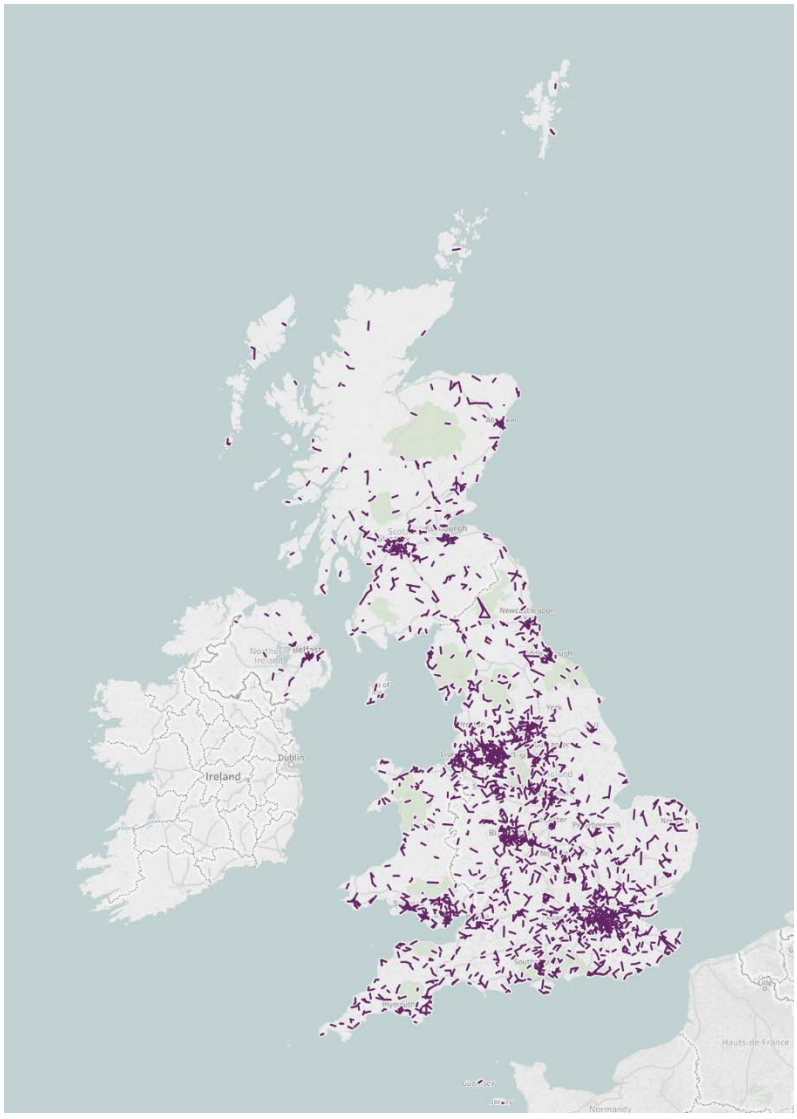


Figure 7 - Satellite Earth station in the UK (June 2017)