Spectrum above 6 GHz for future mobile communications

Call for Input

Publication date: 16 January 2015

Closing Date for Responses: 27 February 2015

About this document

This document asks for stakeholder input on spectrum bands above 6 GHz that might be suitable for future mobile communication services, often referred to as 5G (the 5th generation of mobile services).

The exact nature of 5G is not yet defined, but to lay the foundations for its future introduction we need to understand how it might use spectrum. 5G is likely to provide much faster mobile broadband speeds than the current generation of mobile technology (4G), and the use of large blocks of spectrum is likely to be important to achieve the fastest speeds. Ofcom has already identified possible bands below 6 GHz for future mobile services, including 5G, as part our Mobile Data Strategy, but large blocks of spectrum are difficult to find at lower frequencies. Therefore higher frequency bands, e.g. above 6 GHz, are also likely to be important. However, those bands are already used by a wide range of services that benefit citizens and consumers.

This Call for Input will help us better understand the advantages and disadvantages of different bands above 6 GHz, taking account of other existing and potential users of that spectrum. The information provided will, along with our ongoing work on 5G and demand for other uses of spectrum, inform our strategy on bands above 6 GHz. This includes our input to international discussions on bands above 6 GHz that could be considered at the World Radiocommunications Conference (WRC) in 2019.

Ofcom will publish a summary of the responses to this Call for Input and an update on next steps in Q2 2015.

Contents

Section 1

Introduction

Overview

1.1 The purpose of this Call for Input (CFI) is to gather information from stakeholders on spectrum above 6 GHz that might be suitable for future mobile communication services, often referred to as 5G (the 5th generation of mobile services), whilst taking account of the other existing and potential users of that spectrum. It is one element of our ongoing work to understand the potential implications of 5G technology for future spectrum use. The information gathered will help Ofcom better understand the advantages and disadvantages of potential spectrum options above 6 GHz for 5G. This will inform our strategy and further work on these bands, including our engagement in international discussions which may narrow down the range of frequencies for future study.

1.2 Although this CFI particularly focuses on questions in relation to 5G mobile services, we are, in parallel, initiating work to better understand the potential future demand of other key applications, including those that are large existing users of spectrum above 6 GHz. This work will be part of future publications later in the year. It is also important to consider the future needs of public sector users of these bands, including defence, and we will do further work to better understand their potential future spectrum requirements.

1.3 In the rest of this introduction we set out why it is important to start to consider bands above 6 GHz for 5G services now, outline some of the challenges in doing so and the wider market and regulatory context, both nationally and internationally.

5G and bands above 6 GHz

1.4 As well as enabling consumers to do all the things they do today with mobile devices (such as smartphones and tablets) faster and more reliably, 5G may support new ways of using those mobile devices (eg new applications), and completely new types of mobile devices.

1.5 Although there is no overall consensus yet on what 5G will actually be, a number of players have already set out their aspirations for it. These include support for very high data rate communications, a large number of connected devices, and ultra-low latency and high reliability applications. For example, the 5GIC[1] has stated a 5G vision of 'always having sufficient rate to give the user the impression of infinite capacity' and preliminary figures being discussed within the International Telecommunication Union (ITU) suggest peak data rates in the range from 10 – 50 Gbit/s and latency of 1 millisecond.

1.6 There is significant research and development activity within industry and academia on future technologies for 5G. Coupled with this, there is increasing interest in identifying the frequency bands that will be suitable for its delivery. Ofcom has already started considering a number of bands *below* 6 GHz that might be suitable for future mobile systems, including 5G, as part our Mobile Data Strategy. 5G is likely

[1] 5G Innovation Centre at the University of Surrey

to make use of existing mobile bands, aggregated with new bands. Ofcom's long standing policy is to liberalise all mobile licences so as to remove regulatory barriers to deployment of the latest available mobile technology.[2]

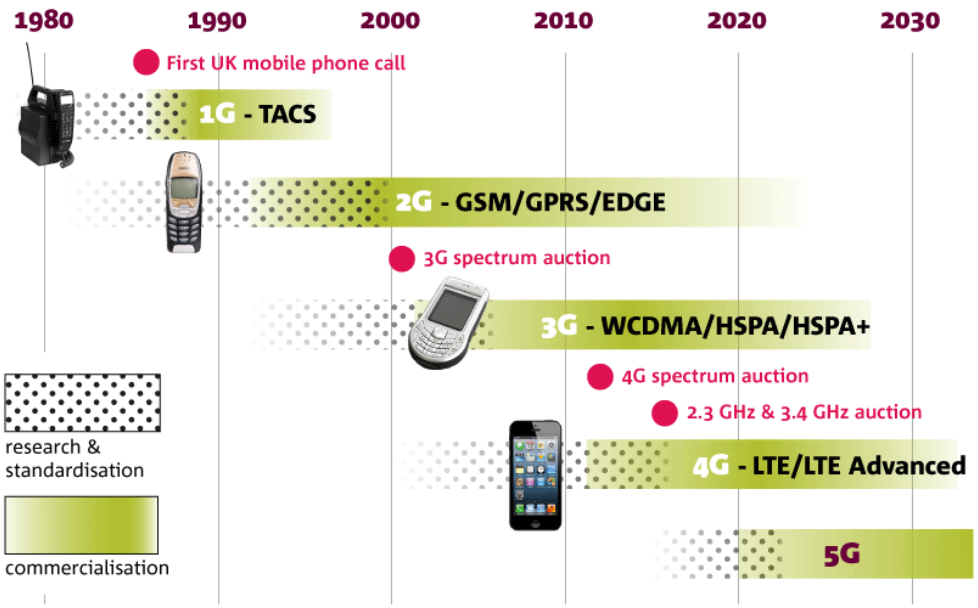
1.7 5G is also expected to benefit from utilising spectrum at much higher frequencies, e.g. *above* 6 GHz. This is because the greater bandwidth that might be available at higher frequencies could support significantly higher speeds and because of technical innovations that enable use of higher frequencies, which to date have not been suitable for achieving good mobile coverage.

1.8 However, it is uncertain which specific bands above 6 GHz might be most suitable for introducing 5G mobile services whilst taking account of other users of that spectrum. Existing uses include satellite communications, fixed wireless links, defence and science applications. Therefore, this document seeks to gather information to better understand and prioritise the areas for further study, rather than the detailed issues for specific bands.

Why now?

1.9 4G mobile services (based on LTE technology) were launched in the UK in 2012 and take-up of these services is growing rapidly alongside continued use of 3G and 2G services. The precise timing for launch of future 5G services is currently uncertain, but the first release of the global standard for the new technology could be completed by the end of 2018[3] and commercial deployments could follow from around 2020.[4]

Figure 1: Evolution of mobile communications over time



[2] For example see Statement on the Requests for Variation of 900 MHz, 1800 MHz and 2100 MHz Mobile Licences http://stakeholders.ofcom.org.uk/binaries/consultations/variation-900-1800-2100/statement/statement.pdf

[3] For example see http://www.ngmn.org/nc/news/newssingle3/article/ngmn-shares-executive-version-of-the-5g-white-paper-with-the-industry-1186.html

[4] Some of the earliest announced deployments are 5G trials in 2018 in South Korea and Korean and Japanese plans for 5G networks by 2020.

1.10 In addition to standardisation of 5G technology, the other key element on which commercial deployment will depend is the identification of suitable regional, and ideally globally, harmonised spectrum allocations. Over the last few years, as part of preparation for WRC-15 (specifically agenda item 1.1), there have been considerable international efforts to consider potential future bands for mobile broadband use below 6 GHz. Global identification of allocations in the Radio Regulations (for IMT[5]), as a result of a WRC, is an important first step in supporting global adoption of a technology. However, it generally does not prescribe spectrum use at a national level, as that remains under the jurisdiction of each individual country, and is therefore not always necessary for regional harmonisation (e.g. with the EU).

1.11 As the potential benefit of spectrum above 6 GHz for 5G has started to emerge, there has been some support for a new agenda item for WRC-19 on bands above 6 GHz, in order to facilitate introduction of 5G systems in the early 2020s.

1.12 However, a future WRC agenda item looking at every band above 6 GHz is likely to be too broad for ITU-R study groups and a future WRC to manage. If the scope is too wide there is a risk that no decision will be agreed, but closing down too many options too early may miss opportunities. Hence, in the lead up to the WRC-15 it is desirable to narrow down the range of bands under consideration to a more manageable level.

1.13 As part of our consultation on WRC-15 we asked stakeholders about potential future agenda items including the scope of a future agenda item on bands above 6 GHz for IMT and we recently published an update on our preparations for the conference.[6] We continue to support a future agenda item for IMT in bands above 6 GHz, but recognise that further work is required to try to narrow the scope of the Agenda Item. The further evidence we receive in response to this CFI, along with other complementary work outlined below, will inform our thinking on the scope of that future agenda item.

Challenges in identifying spectrum above 6 GHz for 5G

1.14 As noted above spectrum at higher frequencies is already used for a range of important services. For example, 40% of the weighted spectrum between 6 and 100 GHz is authorised for use by Fixed Links, and 23% for Satellite services.[7]

1.15 Many of these users responded to our consultation on WRC-15 to highlight the concerns they had relating to a future agenda item on bands above 6 GHz. Although there was strong support from the mobile sector for such an agenda item, the concerns raised included:

- Satellite operators looked to bands above 30/31 GHz, thereby avoiding the Ku and Ka bands which are established and widely used by the satellite community. They also argued that it is very premature to consider a new IMT agenda item so

[5] International Mobile Telecommunications (IMT) is the ITU term that encompasses all harmonised mobile broadband technologies (e.g. 3G, 4G and future 5G technologies)

[6] See http://stakeholders.ofcom.org.uk/consultations/wrc15/update-jan-15

[7] Spectrum bands above 1 GHz have been weighted so that 10 MHz at 1 GHz have the same weight as 100 MHz at 10 GHz. This is consistent with our approach outlined in the Spectrum Management Strategy: http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-management-strategy/summary/spectrum_management_strategy.pdf

soon after AI 1.1, and expressed their concern that mobile growth predictions have been significantly over estimated.

- The Ministry of Defence (MOD) indicated opposition to an IMT identification in certain bands between 40-95 GHz due to their specific satellite requirements.

1.16 In considering which bands above 6 GHz might be suitable for 5G technologies, it is important that we appropriately take into account any impact this might have on existing uses, including the extent to which sharing of spectrum will be possible.

1.17 Greater clarity on the potential technical requirements for 5G technologies above 6 GHz and their ability to share with other users will therefore be important. To help inform our view of this, we have commissioned a high level technical review of these questions, in addition to seeking stakeholders' input through this CFI. The future demands of other spectrum users will also influence the potential for sharing, and our parallel work to understand potential future demand from other existing and potential applications in bands above 6 GHz will help inform this.

1.18 We think that there are two important points flowing from this:

- First, the huge efforts being made into research and development of 5G technologies need to recognise real life constraints on spectrum availability – that is the wide range of existing uses. We think it would be wise for research and development efforts to consider how 5G technologies can work effectively alongside other users, for example by investigating innovative ways of sharing and minimising co-existence issues, rather than solely on developing higher performance mobile systems. This will make it more likely that suitable spectrum can be identified, enabling consumers to benefit from existing uses whilst enabling new 5G mobile services.

- Second, it is possible that new regulatory models for access to spectrum may enable more efficient use and sharing with existing users. As we have previously stated in our Spectrum Management Strategy[8], we will place growing emphasis on exploring new forms of spectrum sharing and extending this to new bands. We are therefore very open to considering innovations in spectrum management which could support deployment of 5G, including sharing with incumbent users. We expect to consult further on potential sharing methods and opportunities more generally later in the year.

Wider context

1.19 Although Ofcom (and the UK more generally) is taking a keen interest in the development of 5G and potential use of spectrum above 6 GHz, the 5G debate is a very active global one in which the UK is but one voice. This CFI does not stand alone but is part of a much broader debate nationally and internationally in many fora on the vision for 5G, its benefits, its technical characteristics and, most relevant to this CFI, its spectrum requirements. **Annex 6** provides an overview of activities considering potential 5G spectrum above 6 GHz, including UK, European and global activities, and initiatives by other regulators and equipment manufacturers.

[8] See http://stakeholders.ofcom.org.uk/consultations/spectrum-management-strategy/

1.20 In addition, Ofcom already has several initiatives which are relevant, or potentially relevant, to 5G and/or bands above 6 GHz:

- **Strategy.** Our Mobile Data Strategy[9] sets out our priorities for looking at the potential future spectrum options below 6 GHz for mobile services.
- **Technology.** We have commissioned a study on the technical suitability of potential bands above 6 GHz for future 5G mobile services. We will also be holding a stakeholder event in March 2015 which will look at the spectrum implications of technology developments, particularly 5G technologies[10].
- **Spectrum information.** We are continuing to increase the quality and quantity of information on spectrum use. Most recently we extended the Wireless Telegraphy Register[11], to include more detailed technical information on spectrum use.
- **Spectrum demand.** We are continuing work on mobile data demand (as part of our mobile data strategy) and are initiating work to look at the longer term demand for spectrum for other key civil sectors, including those that have significant current use in bands above 6 GHz (satellite, space science and fixed links).
- **Sharing.** We published a statement on the future role of spectrum sharing for mobile and wireless data services in April 2014[12] and we are planning further work to explore new forms of sharing and how this might be extended to new bands.

1.21 Ofcom's current work on other bands suitable for mobile broadband use (but not currently being considered for 5G) includes planned releases of spectrum at 700 MHz[13], 2.3 GHz and 3.4 GHz[14] and a proposal to vary the licence for the 1452-1492 MHz band to make it suitable for 4G Supplemental Downlink (SDL) services.[15]

Rest of this document

1.22 **Section 2** outlines some of the technical issues relevant to 5G use of bands above 6 GHz and asks what the implication of 5G technology might be for use of those bands, for example in terms of frequency and bandwidth.

1.23 **Section 3** provides a high level overview of bands above 6 GHz and outlines one way of filtering this very wide range down to a smaller number of bands, for which summary information on current use is provided in **Annex 5**. It asks stakeholders about alternative criteria for narrowing down the range potential bands and views on specific bands.

1.24 **Section 4** sets out our next steps following this Call for Input.

[9] See http://stakeholders.ofcom.org.uk/consultations/mobile-data-strategy/

[10] See http://stakeholders.ofcom.org.uk/spectrum/spectrum-events/

[11] See http://spectruminfo.ofcom.org.uk/spectrumInfo/licences

[12] See http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-sharing/statement/spectrum_sharing.pdf

[13] See http://stakeholders.ofcom.org.uk/consultations/700MHz/

[14] See http://stakeholders.ofcom.org.uk/consultations/2.3-3.4-ghz-auction-design/

[15] See http://stakeholders.ofcom.org.uk/binaries/consultations/licence-variation-1.4ghz/summary/1.4ghz-consultation.pdf

Section 2

Technology developments and spectrum implications

2.1 As noted in section 1, although there is no overall consensus on what 5G will actually be, it is widely accepted that at least one element of 5G will require the use of spectrum bands at much higher frequencies than those that current mobile broadband technologies can make use of, i.e. bands above 6 GHz.

2.2 This section considers what the implication of 5G technology might be for spectrum use above 6 GHz. We have, in parallel, commissioned a technical study to start to consider these questions in more detail and we welcome stakeholder feedback on these questions directly to this CFI and/or via that technical study.

Why are bands above 6 GHz needed?

2.3 There is a direct correlation between the bandwidth of a signal and the achievable data rate. Hence to achieve significantly increased data rates for mobile broadband, such as the preliminary figures currently being discussed (10–50 Gbit/s), much higher bandwidths are expected to be needed, for example, bandwidths of 1 GHz are being discussed within the ITU-R. If 1 GHz is required per operator then several GHz of spectrum may be needed in total. Bands above 6 GHz, where there are larger contiguous frequency blocks and spectrum is less fragmented, present a more realistic opportunity to meet these requirements than bands below 6 GHz.

2.4 Multiple lower frequency, narrow bandwidth channels aggregated together could, in principle, be an alternative to using contiguous spectrum above 6 GHz. However, there are likely to be technical constraints, which in practice limit the number of channels that can be aggregated efficiently in a mobile device.

Question 1: Are there practical ways of achieving the very high performance that use of wide channels above 6 GHz could offer, for example using carrier aggregation of lower frequency bands?

Using bands above 6 GHz for mobile broadband systems

2.5 Mobile broadband systems are more complex at higher frequencies, particularly in terms of the radio frequency (RF) front end, antenna design, and the need to combat higher propagation losses. The power output of amplifiers and oscillator stability are particularly challenging. Increased propagation losses at higher frequencies may mean that the range of a cell could be 200 meters or less.

2.6 We expect that existing lower frequency bands will continue to be needed for wide area coverage and that the higher bands will provide increased performance and capacity at specific locations. Therefore mobile devices will need to operate over a wide range of frequency bands, i.e. both below and above 6 GHz.

2.7 Advanced antenna techniques such as Multiple Input Multiple Output (MIMO) are commonly deployed by current 3G, 4G and Wi-Fi networks. Recent advances have seen the emergence of more sophisticated multiple antenna techniques such as beam-forming based on ‘massive MIMO’ systems. These systems may allow the

exploitation of higher frequency bands so far unused by current mobile broadband technologies by overcoming some of the associated propagation constraints. These systems require a very large number of antennas (many 10s or even 100s) and thus are only practical at relatively high frequencies where antennas and antenna separation is relatively small. Massive MIMO can provide benefits such as higher gain and beam steering arrays.

2.8 Greater use of small cells may also support the use of higher frequencies. Demand in a mobile network can be highly localised with traffic hotspots developing in predictable locations. It can be more efficient and cheaper to cover these areas with small (micro and pico) cells than by a traditional large (macro) base station. While small cells can be deployed in any frequency band, the lower power and coverage requirements of small cells mean that they can take advantage of higher frequencies that are otherwise challenging to use for the provision of more ubiquitous coverage from macro sites.

2.9 In addition to the above points, there continues to be research in the use of higher bands including developments in semiconductor and antenna technologies. Further advances in technology may therefore provide effective solutions to the challenges of using bands above 6 GHz.

Question 2: What recent or emerging advances in technology may provide effective solutions to the challenges in higher frequency bands? For example can increased propagation losses be mitigated by using the high gains available with massive MIMO?

Question 3: Are there any fundamental/inherent frequency constraints of the 5G technologies currently being investigated with regard to:

a) minimum contiguous bandwidth per operator? Will the spectrum for multiple operators need to be contiguous (ie a single band) or could multiple operators be supported through multiple bands?

b) frequency range over which the technologies are expected to be able to operate, for example due to propagation, availability of electronic components, antenna designs and costs of deployment? For example, is 10-30 GHz better or worse than 30-50 GHz and why?

Spectrum Sharing

2.10 We expect to see an increase in shared access to spectrum amongst different uses as the opportunities to access clear spectrum (particularly on a nationwide basis) become ever more challenging, and as technical and regulatory developments, such as dynamic shared access, enable more efficient re-use of spectrum.

2.11 In addition, above 6 GHz, sharing of the spectrum may become easier due to the limited range of the systems and this could be further improved by the use of advanced antenna techniques with greater directionality.

Question 4: Will 5G systems in higher frequency bands be deployed, and hence need access to spectrum, on a nationwide basis or will they be limited to smaller coverage areas? And if so, what sort of geographic areas will be targeted?

Question 5:
a) To what extent will 5G systems in higher frequency bands need dedicated spectrum on a geographical and/or time basis or can they share?

b) If they can share, what other types of services are they likely to be most compatible with?

c) What technical characteristics and mitigation techniques of 5G technologies could facilitate sharing and compatibility with existing services?

d) Could spectrum channels be technically shared between operators?

Spectrum requirements for wireless backhaul

2.12 The spectrum requirements for wireless backhaul from the 5G systems at higher frequencies also need to be considered. The requirements for wireless backhaul are expected to increase considerably due the higher data rates and very low latency being discussed for 5G as well as higher density of networks. The technologies for higher spectrum efficiency for 5G could also be applicable for wireless backhaul. It is also possible to envisage flexible solutions where the spectrum resources are shared between the mobile access and wireless backhaul elements.

Question 6:
a) Given the capacity and latency targets currently being discussed for 5G how do you anticipate backhaul will be provided to radio base stations? Are flexible solutions available where the spectrum can be shared between mobile access and wireless backhaul?

b) What, if any, spectrum will be required? What channel sizes will be needed? Will the bands used be similar to those currently used for wireless backhaul?

Section 3

Overview of bands above 6 GHz

3.1 This section outlines one way – based on bandwidth and a current allocation in the Radio Regulations to the mobile service – of filtering the spectrum above 6 GHz down to a smaller number of frequency ranges. It sets out the list of frequency ranges that results from that filtering and asks stakeholders about alternative and additional criteria for narrowing down the range of potential bands, as well as views on specific bands.

3.2 A high-level overview of allocations and uses in the bands that result from our illustrative filtering can be found in Annex 5.

Identifying spectrum for future mobile broadband services

3.3 The process of identifying potential mobile broadband spectrum above 6 GHz is at a much earlier stage than for bands below 6 GHz. As a starting point, given the very large amount of spectrum potentially under consideration, it may be helpful to identify some basic criteria to reduce the range of frequencies for analysis. We do not think such criteria should be applied rigidly, so as to absolutely rule out options, but only as a means of focusing efforts where they are more likely to be fruitful.

3.4 Two factors that we think are likely to be relevant are international harmonisation and availability of sufficient bandwidth. We have conducted some initial filtering of the spectrum between 6 and 100 GHz in order to highlight spectrum ranges that meet the following criteria:

- an existing global primary allocation to the mobile service in the Radio Regulations[16]; and
- contiguous bandwidth of at least 1 GHz.

3.5 Our initial focus is on bands that are already allocated internationally to the mobile service. The objective of a future WRC agenda item would be to harmonise these for mobile broadband applications, for example by identifying them for IMT in the Radio Regulations. Only bands that are internationally harmonised are likely to be economically viable for the delivery of mass market mobile data services. As we are looking at a long term strategy, the fact that a band is not yet allocated internationally to the mobile service is not necessarily a constraint. This is because there may be opportunities over the coming years to build international consensus over allocating additional bands. However, harmonising bands with an existing mobile allocation for mobile broadband applications is likely to be easier than for bands where a mobile allocation does not yet exist.

3.6 The bandwidth criterion is based on the expectation, outlined in the previous section, that higher bandwidths are expected to be needed to achieve significantly increased

[16] For the allocation of frequencies the ITU divides the world into three Regions, broadly summarised as Europe, Africa and the Middle East (Region 1), North and South America (Region 2) and Asia Pacific (Region 3). The Radio Regulations state whether services have a primary or secondary allocation. Stations of a secondary service shall not cause harmful interference to stations of primary services, and cannot claim protection from harmful interference from stations of a primary service. For the purposes of this document, we use 'global primary allocation' to signify where there is a primary allocation to the mobile service in all three Regions.

data rates. It has been suggested that bandwidths may need to be as large as 1 GHz, potentially per operator. We invite comments on whether a 1 GHz minimum bandwidth is an appropriate criterion for our initial filter of bands or whether a wider or narrower bandwidth would be more appropriate. For example, if 1 GHz is needed per operator, and the spectrum for each operator needs to be contiguous, then a much wider contiguous bandwidth would be required.

3.7 Our analysis currently extends to 100 GHz, but we have the ability to look higher in response to international developments or the responses to this Call for Input.

Question 7: Should we expand the scope of bands being reviewed beyond the 6-100 GHz range?

Question 8: Do you agree that it is likely to be necessary for bands to have an existing allocation to the mobile service? Does this need to be a primary allocation?

Question 9: Do you agree with the criteria we have used for our initial filter of bands, and are there other criteria that could also be used?

Frequency ranges that result from initial filtering

3.8 The spectrum ranges that result from applying the initial criteria (an existing primary global allocation to the mobile service and a contiguous bandwidth of at least 1 GHz) comprise approximately 60.8 GHz of spectrum. These ranges cut across civil and military spectrum for completeness and consistency. We have not had discussions with Government, including the Ministry of Defence, about spectrum reserved for Government use, but we intend to as part of this process.

3.9 The frequency ranges that result from applying the initial criteria are:

- 5925-8500 MHz
- 10.5-11.7 GHz (excl. 10.68-10.7 GHz[17])
- 14.4-15.35 GHz[18]
- 17.8-19.7 GHz
- 21.2-23.6 GHz
- 25.25-29.5 GHz
- 36-40.5 GHz
- 42.5-52.6 GHz (excl. 50.2-50.4 GHz[19])
- 55.78-76 GHz

[17] All emissions are prohibited in this band by the Radio Regulations. Footnote 5.340 in the ITU Table of Frequency Allocations and the UKFAT

[18] This range comprises 950 MHz of spectrum.

[19] See Footnote 17

- 81-86 GHz
- 92-100 GHz

Information about the filtered frequency ranges

3.10 Annex 5 provides high level information for the above frequency ranges on:

- **Allocations:** primary and secondary UK allocations as set in the UK Frequency Allocation Table (UKFAT)[20]
- **Ofcom authorised uses:** uses requiring Ofcom authorisation through licensing or licence exemption in the UK. Information on different types of spectrum authorisations and licences is available in the UK Plan for Frequency Authorisation (UKPFA)[21]
- **Other uses not requiring Ofcom authorisation:** this category includes military use of spectrum, where users gain access through arrangements under the FAT for use under Crown immunity, and space science access where, typically, the way in which the spectrum is accessed does not need authorisation by Ofcom, but neither does it rely on public sector access through the terms of the FAT under Crown immunity.
- **Licences/Assignments:** when applicable we provide information with regards to the detailed numbers of licences and assignments in a given band and for a given licenced use. This information is only available for uses that are authorised and managed by Ofcom. Where spectrum has been awarded by auction we do not hold detailed information, but the spectrum might well be extensively used.

3.11 The purpose of the information is to give an initial view of the type and extent of current use, so that stakeholders examining spectrum options for 5G can begin to take these into account. For illustration:

- Information on the 18 GHz band (17.7-19.7 GHz) indicates that it currently has the highest number of individual fixed links compared with other available bands managed and assigned by Ofcom, with 7,805 licenses currently on issue. This is also a band for satellite uses (Ka band) with 745 Permanent Earth Station frequency assignments in the spectrum 17.7-19.7 GHz.[22]
- The 10.5-11.7 GHz range shows that it cuts across the bands used by satellite space–to-Earth at 10.7-12.75 GHz (Ku band). This band also includes licence exempt direct to home (DTH) satellite TV receivers where a large number of satellite TV receivers exist.

3.12 In addition, Table 1 below provides a summary of the services that 5G may have to share with/coexist alongside across the spectrum range under review. It provides an overview of the total spectrum identified by our criteria, approximately 60.8 GHz, against a number of other uses in those bands; including Ofcom authorised (e.g. satellite and fixed links) and not authorised (space science and military) uses.

[20] http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-information/UKFAT_2013.pdf

[21] http://spectruminfo.ofcom.org.uk/spectrumInfo/ukpfa

[22] As at November 2014

3.13 For example, in the 20-40 GHz range, 10.65 GHz have been highlighted by our filtering exercise. Of these, 7.35 GHz (70%) are authorised for use by fixed links applications, indicating that it will be important to understand the extent to which 5G connectivity to end user devices can share with fixed links, not least because many of these links will be used for mobile backhaul.

Table 1: Summary of use / allocation of bands resulting from initial filter

	6-20 GHz		20-40 GHz		40-100 GHz		Total	
	GHz	% of filtered bands	GHz	% of filtered bands	GHz	% of filtered bands	GHz	% of filtered bands
Spectrum identified by initial filter	6.71		10.65		43.42		60.78	
Fixed Links authorised use in filtered bands	4.01	60%	7.35	70%	15.42	36%	26.78	44%
Satellite authorised use in filtered bands	4.25	64%	2.00	18%	0	0%	6.25	10%
Space science primary allocations in filtered bands	0.81	12%	3.80	35%	15.96	37%	20.57	34%
Bands reserved for military use (UK2) in filtered bands[23]	1.16	17%	2.50	23%	3.50	8%	7.16	12%

3.14 Additional information is available from the spectrum information pages on the Ofcom website. If you are interested in a band that is not covered by our analysis, Annex 5 explains how and where you can gather relevant information.

Bands being considered by other organisations

3.15 As noted earlier in this Call for Input, many organisations are also considering which spectrum bands might be suitable for future mobile systems. Annex 6 gives an overview of the major developments in this area, and lists the following bands as having being publicly mentioned:

- The EU project **METIS** (Mobile and Wireless Communications Enablers for the Twenty-Twenty Information Society) has also identified a series of potential bands and assigned priorities for further investigation (see paragraph 3.18 below and Annex 6).

[23] Reserved exclusively for military use, except where access for civil use has been agreed MOD. These bands have the footnote UK2 in the UKFAT. The MOD is responsible for military frequency assignments in these bands.

- The United States Federal Communications Commission (**FCC)** published a Notice of Inquiry (NOI) in October 2014, which considered a number of spectrum bands above 24 GHz (see paragraph 3.19 below and Annex 6 for more details).

- **Researchers in the US** (including New York University and University of Texas) are undertaking work in a range of bands including 28 GHz, 39 GHz and 73 GHz.

- **South Korea** has made proposals to ITU WP5D covering the bands 13.4-14 GHz, 18.1–18.6 GHz and 28-29 GHz. The Korean Electronics and Telecommunications Research Institute (ETRI) has developed a 500 MHz channel sounder for the 28 GHz band to investigate propagation at these frequencies.

- The following **companies** have mentioned specific bands:

    - **Intel** says that it is considering a range of bands ranging from below 30 GHz to above 60 GHz. They are also exploring the possibility of mobile access in the 39 GHz band and Wi-Fi-like "WiGig" operations in the 60 GHz band, as well as concepts around the 28 GHz band.

    - **Samsung** have been carrying out preliminary technical and feasibility studies in 28 GHz and 39 GHz.

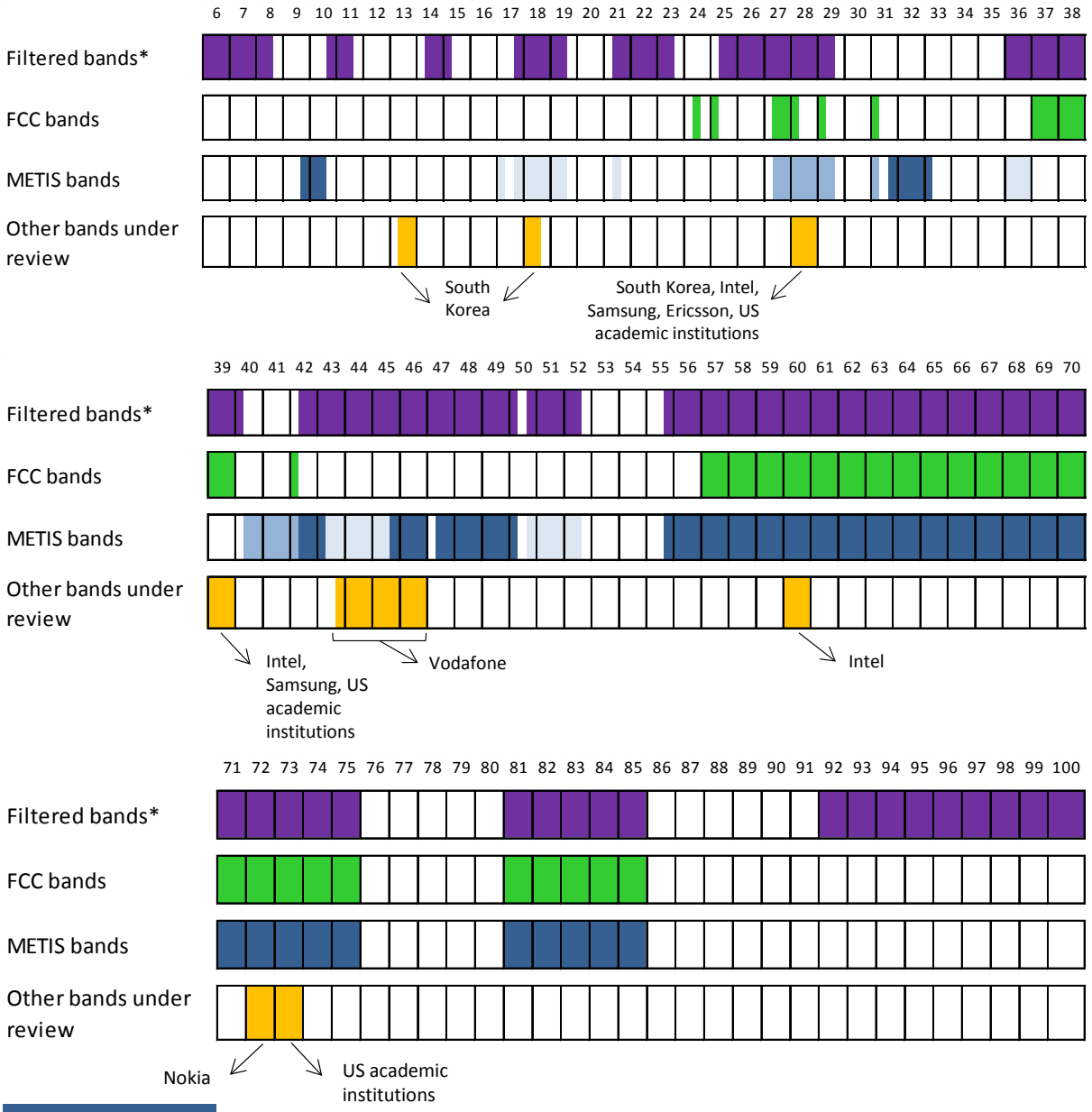
    - **Vodafone** has suggested that Ofcom consider the potential of 43.5-47 GHz.

    - **Nokia** has conducted ray-tracing computer simulations to demonstrate that mobile service would be feasible at 72 GHz.

    - **Ericsson** has demonstrated the ability to establish reliable wireless links at 28 GHz. They also note that 5G will potentially require additional spectrum in the 10, 15 and 30 GHz bands.

3.16 Figure 2 summarises the information above on bands identified by others as having potential for 5G use. It also shows how these bands compare with those that result from applying the initial filter discussed above.

Figure 2: Summary of bands identified as having potential for 5G



Frequency blocks are approximate

* Filtered on the basis of an existing global primary allocation to the mobile service in the Radio Regulations and contiguous bandwidth of at least 1 GHz.

3.17 Figure 2 shows that the majority of bands identified by other organisations fall within our filtered spectrum ranges. However there are a number of exceptions, including some bands identified by METIS and the FCC. The reasons for these exceptions are outlined below. A further exception is the 13.4-14 GHz band proposed by South Korea to ITU WP5D, as it does not have a mobile allocation. However we welcome any stakeholder responses about this band, or any others, in response to this Call for Input.

METIS

3.18 This EU project has also identified a series of potential bands and assigned priorities for further investigation. Annex 6 contains the list of all frequency bands identified by the EU METIS project and the priority assigned to them. The spectrum ranges that we have identified include the majority of these METIS bands, with the following exceptions:

- 9.9-10.6 GHz: These bands are not included in our filtered ranges because there is no international Mobile allocation in 9.9-10 GHz and 10.45-10.5 GHz. 10-10.45 GHz is only a secondary allocation in Region 2. Our analysis does cover 10.5-10.6 GHz.
- 17.1-17.3 GHz: These bands have no international mobile allocation.
- 17.7-19.7: Our illustrative range begins at 17.8 GHz, as there is only a secondary allocation to mobile in Region 2 in 17.7-17.8 GHz.
- 31-31.3 GHz: While this band has a mobile allocation, it did not satisfy the 1 GHz minimum bandwidth requirement.
- 31.8-33.4 GHz: These bands have no international mobile allocation.
- 40.5-42.5 GHz: These bands have only a secondary allocation to mobile.

FCC Notice of Inquiry (NOI) on bands above 24 GHz

3.19 The FCC NOI, published in October 2014, focused on spectrum bands above 24 GHz.[24] The full list of the FCC's proposed bands can be found in Annex 6. The spectrum ranges we highlight in this document include the majority of these bands; where we have not considered bands proposed by the FCC, this was because they do not have an allocation to the mobile service and/or they fall below our 1 GHz bandwidth threshold. These exceptions are detailed below.

- 24.25-24.45 GHz: This band not have a primary allocation to Mobile in all three Regions of the ITU, it only has a mobile allocation in ITU Region 3 (Asia Pacific region).
- 25.05-25.25 GHz: This band only has a mobile allocation in Region 3 (Asia Pacific region. In Region 1 the band is allocated to Fixed and Fixed-Satellite (Earth to space) and in Region 2 to Fixed-Satellite (Earth to space) only.

[24] FCC Use of Spectrum Bands Above 24 GHz For Mobile Radio Services http://www.fcc.gov/document/noi-examine-use-bands-above-24-ghz-mobile-broadband

- 31-31.3 GHz: While this band does have a primary allocation to the mobile service, it has a bandwidth of 300 MHz. The band is allocated to the Fixed and Mobile services on a primary basis, and secondary allocations to Standard Frequency and Time Signal-Satellite (space to Earth), Space Research.

- 42-42.5 GHz: This band has only a secondary allocation to Mobile globally. The other, primary, allocations in the band are Fixed, Fixed-Satellite (space to Earth), Broadcasting and Broadcasting-Satellite.

Other factors relevant to future use of bands above 6 GHz

3.20 Information about current use is a helpful starting point as lightly used bands may, if everything else were equal, be less challenging to introduce new 5G services into than more heavily used bands. However, there is a range of other important considerations relevant to the future use of bands above 6 GHz. These include:

- **Future demand and strategy for other sectors use of spectrum.** For example, our strategy for video PMSE applications is that the PMSE allocation at 7 GHz (7.110 to 7.250 GHz and 7.300 to 7.425 GHz) is the preferred resource for future PMSE access for video link applications.[25] Similarly we are initiating work to better understand the potential future demand of other sectors that use spectrum above 6 GHz.

- **Ability to share**. As discussed in section 2 we are interested in understanding the technical potential for 5G services to share with existing uses above 6 GHz. For example the ability to share with fixed wireless links used for backhaul from mobile base stations could be particularly relevant, given that a significant proportion of bandwidth above 6GHz is used for fixed wireless links (and many of these are used for backhaul).

- **International position.** Any 5G band above 6 GHz will clearly need wide international support. As discussed in Section 1 and Annex 6 the UK is but one voice in part of a much broader European and global debate on 5G spectrum, and UK use may or may not align with the pattern of use of in other countries. Satellite and space science use of spectrum is important in this regard as services are provided on a regional or global basis.

3.21 Ofcom will continue to work to understand all the above areas, including taking account of the feedback from this Call for Input.

Question 10: Of the spectrum bands/ranges mentioned in this section, are there any that should be prioritised for further investigation?

Question 11: Are there any bands/ranges not mentioned in this section that should be prioritised for further investigation? If so, please provide details, including why they are of particular interest.

Questions 12: Are there any particular bands/ranges that would not be suitable for use by future mobile services? If so, please provide details.

[25] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/statement/Statement_on_camera_strategy.pdf

Question 13: What additional information, beyond that given in Annex 5 would be useful to allow stakeholders to develop their own thinking around spectrum options?

Question 14: What are the most important criteria for prioritising bands going forward?

Section 4

Next steps

4.1 Following the close of this Call for Input we expect to publish a summary of responses and an update in Q2 2015. The update will also draw on the related work we are undertaking (discussed in section 1), including technical research and the technology event which we are planning to hold in March 2015, and our ongoing work on the future demands of other sectors that use spectrum above 6 GHz.

4.2 The output of the Call for Input and related work will also help inform our contribution to forthcoming international discussions, including the relevant European preparatory meetings for WRC-15 at which the scope of a future WRC-19 agenda item on bands above 6 GHz will be considered. The output will also help to inform the positions we take at WRC-15 itself and in any other European or international discussions addressing future requirements for 5G.

4.3 Looking further ahead we will consider if and when it would be appropriate to publish a strategy consultation on bands above 6 GHz (similar to our Mobile Data Strategy that looked at bands below 6 GHz), that consider the issues for specific potential bands in more detail. Such a consultation is more likely to be after WRC-15, when the scope of any future agenda on bands above 6 GHz item is clearer.

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 27 February 2014**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://stakeholders.ofcom.org.uk/consultations/above-6ghz/howtorespond/form, 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 justin.moore@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

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

Justin Moore
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

Fax: 020 7981 3333

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 Justin Moore at justin.moore@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 a summary of responses and updated in Q2 2015.

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

Tel: 020 7981 3601

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: Are there practical ways of achieving the very high performance that use of wide channels above 6 GHz could offer, for example using carrier aggregation of lower frequency bands?

Question 2: What recent or emerging advances in technology may provide effective solutions to the challenges in higher frequency bands? For example can increased propagation losses be mitigated by using the high gains available with massive MIMO?

Question 3: Are there any fundamental/inherent frequency constraints of the 5G technologies currently being investigated with regard to:

a) minimum contiguous bandwidth per operator? Will the spectrum for multiple operators need to be contiguous (i.e. a single band) or could multiple operators be supported through multiple bands?

b) frequency range over which the technologies are expected to be able to operate, for example due to propagation, availability of electronic components, antenna designs and costs of deployment? For example, is 10-30 GHz better or worse than 30-50 GHz and why?

Question 4: Will 5G systems in higher frequency bands be deployed, and hence need access to spectrum, on a nationwide basis or will they be limited to smaller coverage areas? And if so, what sort of geographic areas will be targeted?

Question 5:
a) To what extent will 5G systems in higher frequency bands need dedicated spectrum on a geographical and/or time basis or can they share?

b) If they can share, what other types of services are they likely to be most compatible with?

c) What technical characteristics and mitigation techniques of 5G technologies could facilitate sharing and compatibility with existing services?

d) Could spectrum channels be technically shared between operators?

Question 6:
a) Given the capacity and latency targets currently being discussed for 5G how do you anticipate backhaul will be provided to radio base stations? Are flexible solutions available where the spectrum can be shared between mobile access and wireless backhaul?

b) What, if any, spectrum will be required? What channel sizes will be needed? Will the bands used be similar to those currently used for wireless backhaul?

Question 7: Should we expand the scope of bands being reviewed beyond the 6-100 GHz range?

Question 8: Do you agree that it is likely to be necessary for bands to have an existing allocation to the mobile service? Does this need to be a primary allocation?

Question 9: Do you agree with the criteria we have used for our initial filter of bands, and are there other criteria that could also be used?

Question 10: Of the spectrum bands/ranges mentioned in this section, are there any that should be prioritised for further investigation?

Question 11: Are there any bands/ranges not mentioned in this section that should be prioritised for further investigation? If so, please provide details, including why they are of particular interest.

Questions 12: Are there any particular bands/ranges that would not be suitable for use by future mobile services? If so, please provide details.

Question 13: What additional information, beyond that given in Annex 5 would be useful to allow stakeholders to develop their own thinking around spectrum options?

Question 14: What are the most important criteria for prioritising bands going forward?

Annex 5

Information on bands above 6 GHz

A5.1 This annex provides high-level information on the allocations and current use, as of November 2014 except where stated otherwise, of the frequency ranges identified in Section 3:

- 5925-8500 MHz
- 10.5-11.7 GHz (excl. 10.68-10.7 GHz)
- 14.4-15.35 GHz
- 17.8-19.7 GHz
- 21.2-23.6 GHz
- 25.25-29.5 GHz
- 36-40.5 GHz
- 42.5-52.6 GHz (excl. 50.2-50.4 GHz)
- 55.78-76 GHz
- 81-86 GHz
- 92-100 GHz

A5.2 It also provides an overview of the spectrum information resources available on the Ofcom website, to assist stakeholders in their own research on spectrum bands.

Spectrum information resources

A5.3 High-level spectrum information about our filtered bands is presented in this annex for ease of reference. However, the majority is gathered from the various spectrum information resources available on the Ofcom website. These resources can be used to derive broadly comparable information about bands that are not covered in this document.

- The UK Frequency Allocation Table (UKFAT)[26] details allocations in the UK and identifies responsibilities for the management of frequency bands or services, showing whether they are managed by Ofcom, the Ministry of Defence, or another Government department or Agency. The UKFAT also shows the internationally agreed spectrum allocations of the International Telecommunications Union.

[26] http://stakeholders.ofcom.org.uk/spectrum/information/uk-fat/

- The Interactive Spectrum Map[27] is an easy way to browse and search how different spectrum bands are used in the United Kingdom, by sector and by product/application. This map covers spectrum from 8.3 kHz to 275 GHz.

- The UK Plan for Frequency Authorisation (UKPFA)[28] provides information on which frequencies are available for assignment by Ofcom, for what purposes the different frequencies have been allocated and whether these can be traded.

- The Wireless Telegraphy Act Register (WTR)[29] provides information about who is licensed to operate services in specific frequencies or geographical areas. It provides information such as contact name and address details, class of licence, band(s) of frequencies and geographic areas of operation. In some cases we also provide transmission parameters including power and antenna characteristics.

- The Transfer Notification Register (TNR)[30] provides information on licences which have been traded or are the process of being traded. The publication of trading information will enable interested parties to find out about the number of transactions that have taken place and details of the spectrum that is being or has been traded

A5.4 The website also provides a link to the ECO Frequency Information System (EFIS)[31], an on-line tool provided by The European Communications Office (ECO) which enables users to search and compare spectrum allocations, frequencies assigned for applications and technical radio interface information across European Countries. It also provides links to European spectrum decisions, recommendations, reports and equipment standards.

List of spectrum ranges

A5.5 For each of the spectrum ranges presented here, we have provided:

- Bandwidth.

- The status of the allocation to the mobile service. This details whether the bands within the range are allocated to the mobile service in all three regions in the ITU Table of Frequency Allocations, and whether there is also an allocation to the mobile service in the UKFAT.

- Allocations in the UK. This is taken from the UKFAT. Primary services are printed in capitals; secondary services are printed in lower case. In some cases, there may be an allocation to a service in a band but no authorised product.

[27] http://www.ofcom.org.uk/static/spectrum/map.html

[28] http://spectruminfo.ofcom.org.uk/spectrumInfo/ukpfa

[29] http://spectruminfo.ofcom.org.uk/spectrumInfo/licences

[30] http://spectruminfo.ofcom.org.uk/spectrumInfo/trades

[31] http://www.efis.dk/

- An excerpt from Ofcom's Interactive Spectrum Map. The map reflects information from the UKPFA for spectrum we authorise, and from the UKFAT for spectrum which is not authorised by Ofcom (i.e. spectrum that is used by Government). It does not show how the bands are allocated to the various radiocommunication services; allocations to services are shown in the UK FAT. It should be noted that the order in which the services appear vertically in the spectrum map does not signify priority of one service over another, and is for ease of presentation only.

- Access to spectrum, including licences[32] and assignments[33] for Ofcom authorised products. This replicates the information, on use, behind the spectrum map, with additional information on uses that are managed by Ofcom to give an impression of the extent of use. It is important to note that licence numbers only tell one part of the way a band is used; they do not provide context about the actual services utilising the band, the bandwidth being used or the geography of use. If more specific information for a band is required, more details may be found in the spectrum information resources listed above, particularly the WTR.

- Management of the bands. Footnotes in the UKFAT describe which bodies are responsible for planning and managing spectrum bands, including making frequency assignments to individual users or installations at particular locations. Of particular relevance are:

    - UK1: Except by special agreement having the approval of the NFPG[34] this frequency band, or the allocation to this radio service, is reserved exclusively for CIVIL use.

    - UK2: Except by special agreement having the approval of the NFPG this frequency band, or the allocation to this radio service, is reserved exclusively for MILITARY use.

    - In all bands not allocated exclusively for civil or military use, and thus not annotated UK1 or UK2, civil and military services to be operated in accordance with the Allocation to Services in the UKFAT and have equal rights of access to the bands, and where appropriate assignments for such services shall be made by joint planning among the Departments/Agencies concerned.

[32] A licence is a formal authorisation under the Wireless Telegraphy Act for a customer to use radio equipment under certain restrictions.

[33] An assignment is authorisation given by licensing authority for a radio station to use a specific radio frequency or channel under specified conditions.

[34] National Frequency Planning Group

5925-8500 MHz

A5.6 **Bandwidth:** 2575 MHz

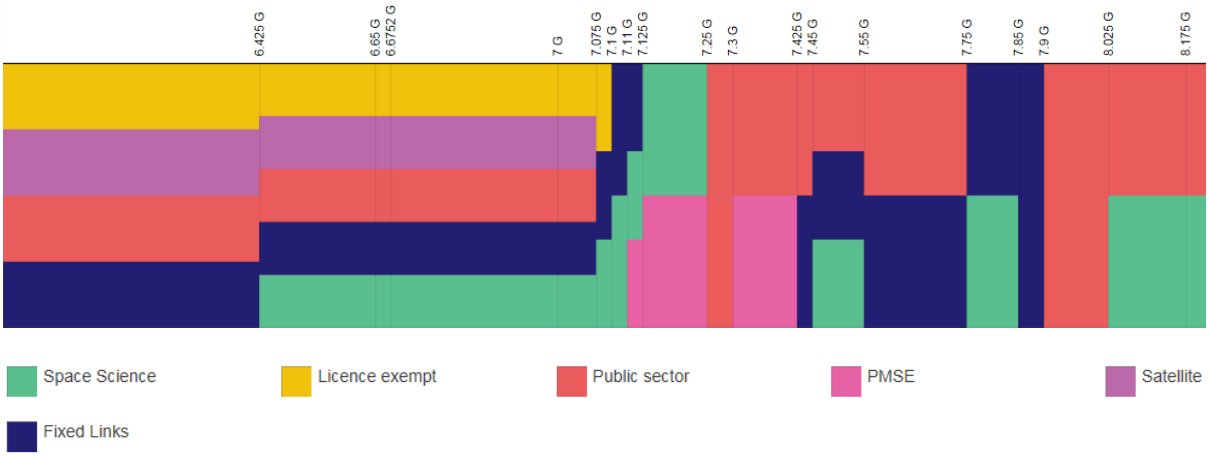
A5.7 **Status of mobile allocation:** Primary global allocation to the mobile service. Primary UK allocation to the mobile service, except for the following frequencies: 7250-7300, 7925-8025, 8215-8500.

A5.8 **Allocations in the UK:**

Frequency range	**Allocations in the UK**
5925-6700 MHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE
6700-7075 MHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE
7075-7145 MHz	FIXED, MOBILE
7145-7235 MHz	FIXED, MOBILE, SPACE RESEARCH (Earth to space)
7235-7250 MHz	FIXED, MOBILE
7250-7300 MHz	FIXED-SATELLITE (space to Earth), MOBILE-SATELLITE (space to Earth)
7300-7450 MHz	FIXED, FIXED-SATELLITE (space to Earth), MOBILE except aeronautical mobile
7450-7550 MHz	FIXED, FIXED-SATELLITE (space to Earth), MOBILE except aeronautical mobile, METEOROLOGICAL-SATELLITE
7550-7750 MHz	FIXED, FIXED-SATELLITE (space to Earth), MOBILE except aeronautical mobile
7750-7900 MHz	FIXED, METEOROLOGICAL-SATELLITE (space to Earth), MOBILE except aeronautical mobile
7900-7975 MHz	FIXED, FIXED-SATELLITE (Earth to space), LAND MOBILE, MOBILE-SATELLITE (Earth to space)
7975-8025 MHz	FIXED-SATELLITE (Earth to space), MOBILE-SATELLITE (Earth to space)
8025-8175 MHz	EARTH EXPLORATION-SATELLITE (space to Earth), FIXED, FIXED-SATELLITE (Earth to space), MOBILE, MOBILE-SATELLITE (Earth to space)
8175-8215 MHz	FIXED, FIXED-SATELLITE (Earth to space), METEROLOGICAL-SATELLITE (Earth to space), MOBILE-SATELLITE (Earth to space), MOBILE
8215-8400 MHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE-SATELLITE (Earth to space)
8400-8500 MHz	FIXED, SPACE RESEARCH (space to Earth)

A5.9 **Overview of services in the UK:**

Spectrum Map excerpt, range of 5925–8215 MHz



A5.10 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Licence Exempt	4.5-7 GHz 5.15-7.1 GHz	Radio Determination Tank Level Probing Radar (TLPR) Radar Level Gauges
Satellite Services	5.725-7.075 GHz 5.925-7.075 GHz	Satellite (Earth Station)(Non-Fixed Satellite Service) – 0 licences Satellite (Earth Station)(Non-Geostationary) – 0 licences Satellite (Permanent Earth Station) - 159 PES links, 964 PES frequency assignments[35] (Nov 2014) Satellite (Transportable Earth Station) – 0 frequency requests in 2014
Public Sector	5.85-7.075 GHz; 7.25-7.3 GHz; 7.3-7.75 GHz; 7.9-8.4 GHz 8.34-8.36 GHz; 8.4-8.46 GHz	Military Business Radio (Police and Fire)
Fixed Links	5.925-6.425 GHz 6.425-7.125 GHz 7.425-7.9 GHz	Point to Point Fixed Links - 375 licences (Nov 14) Point to Point Fixed Links - 620 licences (Nov 14) Point to Point Fixed Links - 1113 licences (Nov 14)
Space Science	6.425-7.25 GHz 6.65-6.6752 GHz 7.45-7.55 GHz	Met Office Radio Astronomy Met Office

[35] A link equals a unique Earth Station to Satellite link. A link may contain one or more frequency assignments

	7.75-7.85 GHz 8.025-8.175 GHz 8.175-8.4 GHz 8.4-8.5 GHz	Met Office RSA[36] for receive-only earth stations (ROES) Earth Exploration Satellite Service Met Office Radio Astronomy
PMSE	7.11-7.25 GHz 7.3-7.425 GHz 8.46-8.5 GHz	354 assignments in 2014 78 assignments in 2014 1 assignment in 2014 In October 2014 Ofcom published the Strategy for video PMSE applications, outlining that PMSE allocation at 7 GHz is the preferred resource for future PMSE access for video link applications.[37]

A5.11 **Management of the bands:** 5925-7250 MHz, 7300-7900 MHz and 8400-8500 MHz are UK1. 7250-7300 MHz and 7900-8400 MHz are UK2. In 7300-7450 MHz, 7450-7550 MHz and 7550-7750 MHz the Department/Agency responsible for planning frequency assignments for the Fixed-Satellite service is the MoD.

[36] Recognised Spectrum Access. A method of recognising the use of radio spectrum by an operator which is not covered by a Wireless Telegraphy Act licence or licence exemption.

[37] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/statement/Statement_on_camera_strategy.pdf

10.5-11.7 GHz (excl. 10.68-10.7 GHz)

A5.12 **Bandwidth:** 1180 MHz

A5.13 **Status of mobile allocation:** Primary UK and global allocation to the mobile service, except 10.68-10.7 GHz.

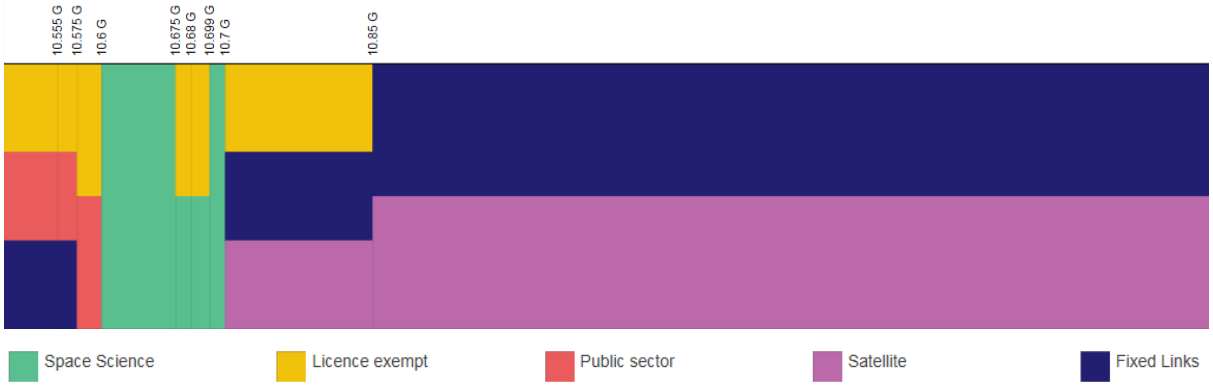
The 10.68-10.7 GHz band has a global primary allocation to the Earth Exploration-Satellite (passive), Radio Astronomy and Space Research (passive) services. All emissions are prohibited in this band by the Radio Regulations. [38]

A5.14 **Allocations in the UK:**

Frequency range	Allocations in the UK
10.5-10.55 GHz	FIXED, MOBILE, Radiolocation
10.55-10.6 GHz	FIXED, MOBILE except aeronautical mobile, Radiolocation
10.6-10.68 GHz	EARTH EXPLORATION-SATELLITE (passive), FIXED, MOBILE except aeronautical mobile, RADIO ASTRONOMY, SPACE RESEARCH (passive), Radiolocation
10.68-10.7 GHz	EARTH EXPLORATION-SATELLITE (passive), RADIO ASTRONOMY, SPACE RESEARCH (passive), Radiolocation
10.7-11.7 GHz	FIXED, FIXED-SATELLITE (space to Earth) (Earth to space), MOBILE except aeronautical mobile

A5.15 **Overview of services in the UK:**

Spectrum Map excerpt, range of 10.5-11.7 GHz



A5.16 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Licence Exempt	8.5-10.6 GHz	Radar Level Gauges Radio Determination TLPR

[38] Footnote 5.340 in the ITU Table of Frequency Allocations and the UKFAT

	10.575-10.6 GHz	Radio Determination
	10.675-10.699	Radio Determination Short Range Indoor Data Links
	10.7-10.85	Radar Level Gauges
Public Sector	10.225-10.6 GHz	Military
Fixed Links	10.475-10.555 GHz	Spectrum Access: Mobile Broadband Network Limited (Downlink)
	10.555-10.575	Spectrum Access: Digiweb (Downlink)
	10.7-11.7	Point to Point Fixed Links - 22 licences (Nov 14). Band is closed to new applications.
Space Science	10.6-10.68	Earth Exploration Satellite Service (passive) Met Office Space Research Service (passive)
	10.68-10.7	Earth Exploration Satellite Service (passive) Met Office Recognised Spectrum Access (Radio Astronomy) Space Research Service (passive)
Satellite Services	10.7-11.7 GHz	Land Mobile-Satellite Service Stations – licence exempt
	10.7-12.75	Satellite (Earth Station)(Non-Geostationary) – 0 licences Satellite(Permanent Earth Station) – 355 links, 3,252 frequency assignments (Nov 14)

A5.17 **Management of the bands:** UK1

14.4-15.35 GHz

A5.18 **Bandwidth:** 950 MHz

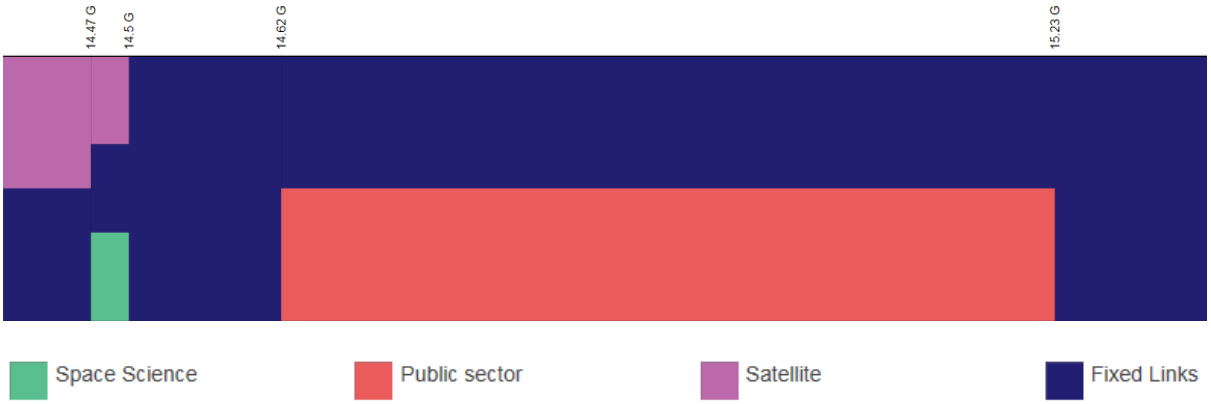
A5.19 **Status of mobile allocation:** Primary UK and global allocation to the mobile service

A5.20 **Allocations in the UK:**

Frequency range	Allocations in the UK
14.4-14.47 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE except aeronautical mobile, Mobile-Satellite (Earth to space), Space Research (space to Earth)
14.47-14.5 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE except aeronautical mobile, Mobile-Satellite (Earth to space), Radio Astronomy
14.5-14.62 GHz	FIXED, MOBILE, Space Research
14.62-15.23 GHz	FIXED, MOBILE
15.23-15.35 GHz	FIXED, MOBILE

A5.21 **Overview of services in the UK:**

Spectrum Map excerpt, range of 14.4-15.35 GHz



A5.22 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Satellite	13.75-14.5 GHz	Satellite (Earth Station)(Non-Geostationary) – 0 licences Satellite(Permanent Earth Station) – 412 PES links, 3183 PES frequency assignments (Nov 14)
	13.78-14.5 GHz	Satellite (Transportable Earth Station) – 289,739

		frequency requests in 2014
Fixed Links	14.25-14.5 GHz 14.5-15.35 GHz	Point to Point Fixed Links – 187 licences (Nov 14). Band is closed to new applications. Point to Point Fixed Links – 2546 licences (Nov 14)
Space Science	14.47-14.5 GHz	Radio Astronomy
Public Sector	14.62-15.23 GHz	Military

A5.23 **Management of the bands:** UK1, except 14.62-15.23 GHz which is UK2.

17.8-19.7 GHz

A5.24 **Bandwidth:** 1900 MHz

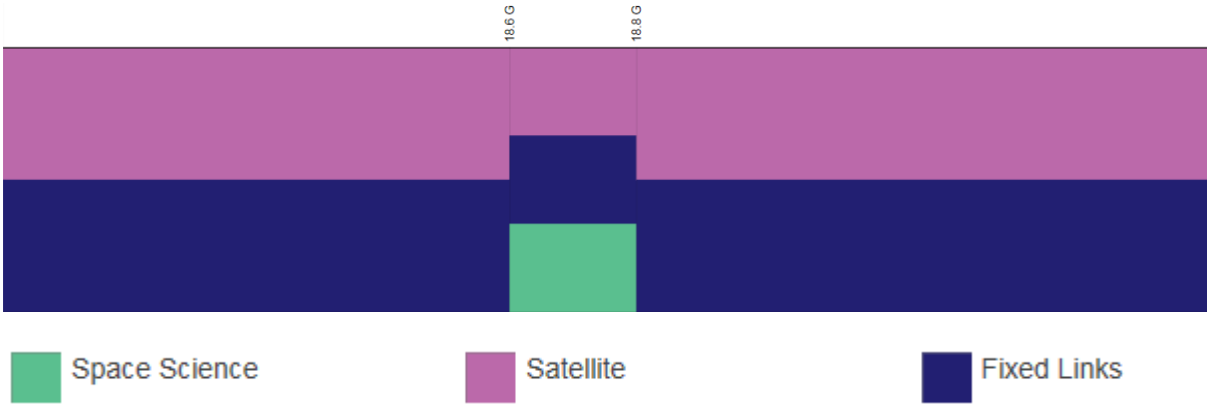
A5.25 **Status of mobile allocation:** Primary global allocation to the mobile service.[39] No primary allocation to the mobile service in the UK.

A5.26 **Allocations in the UK:**

Frequency range	Allocations in the UK
17.7-18.1 GHz	FIXED, FIXED-SATELLITE (Earth to space) (space to Earth)
18.1-18.4 GHz	FIXED, FIXED-SATELLITE (Earth to space) (space to Earth)
18.4-18.6 GHz	FIXED, FIXED-SATELLITE (space to Earth)
18.6-18.8 GHz	EARTH EXPLORATION-SATELLITE (passive), FIXED, FIXED-SATELLITE (space to Earth), Space Research (passive)
18.8-19.3 GHz	FIXED, FIXED-SATELLITE (space to Earth)
19.3-19.7 GHz	FIXED, FIXED-SATELLITE (Earth to space) (space to Earth)

A5.27 **Overview of services in the UK:**

Spectrum Map excerpt, range of 17.8-19.7 GHz



A5.28 Access to spectrum, including licences and assignments for Ofcom authorised products:

Sector	Frequency range	Use and licences/assignments
Satellite	17.3-20.2 GHz	Satellite (Permanent Earth Station) – 17.3-17.7 GHz 24 links, 178 frequency assignments; 17.7-19.7 GHz 32 links, 745 frequency assignments (Nov 14)
Fixed Links	17.7-19.7 GHz	Point to Point Fixed Links – 7805 licences (Nov 14)
Space Science	18.6-18.8 GHz	Earth Exploration Satellite Service (passive) Space Research Service (passive)

A5.29 **Management of the bands:** UK1

[39] 17.7-17.8 GHz has a primary allocation to the mobile service in ITU Regions 1 and 3, but only a secondary allocation in Region 2.

21.2-23.6 GHz

A5.30 **Bandwidth:** 2400 MHz

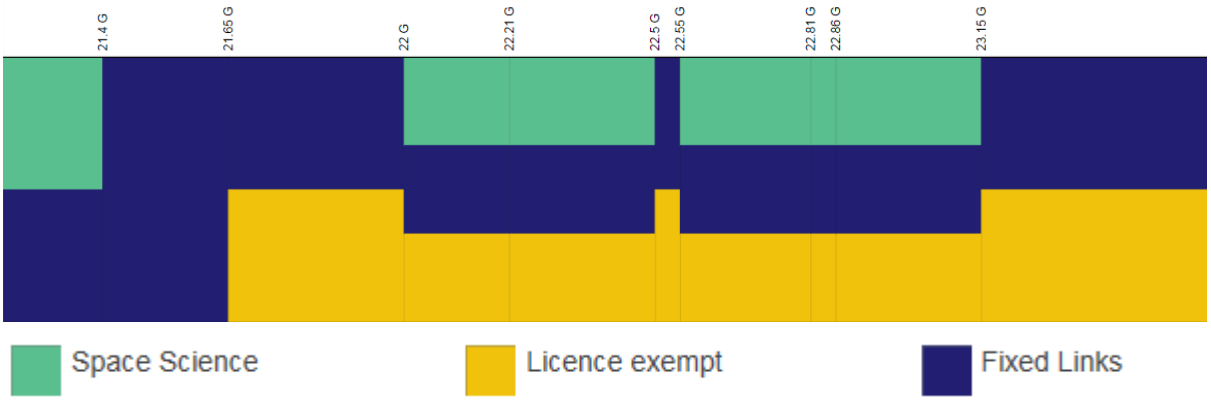
A5.31 **Status of mobile allocation:** Primary UK and global allocation to the mobile service

A5.32 **Allocations in the UK:**

Frequency range	Allocations in the UK
21.2-21.4 GHz	EARTH EXPLORATION-SATELLITE (passive), FIXED, MOBILE, SPACE RESEARCH (passive)
21.4-22 GHz	BROADCASTING-SATELLITE, FIXED, MOBILE
22-22.21 GHz	FIXED, MOBILE except aeronautical mobile, RADIO ASTRONOMY, SPACE RESEARCH
22.21-22.5 GHz	EARTH EXPLORATION-SATELLITE (passive), FIXED, MOBILE except aeronautical mobile, RADIO ASTRONOMY, SPACE RESEARCH (passive)
22.5-22.55 GHz	FIXED, MOBILE
22.55-23.15 GHz	FIXED, MOBILE, RADIO ASTRONOMY, SPACE RESEARCH (passive)
23.15-23.55 GHz	FIXED, INTER-SATELLITE, MOBILE except aeronautical mobile, Radio Astronomy
23.55-23.6 GHz	FIXED, MOBILE

A5.33 **Overview of services in the UK:**

Spectrum map excerpt, range of 21.2-23.6 GHz



A5.34 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Space Science	21.2-21.4 GHz	Earth Exploration Satellite Service (passive) Space Research Service (passive)

	22-22.21 GHz	Recognised Spectrum Access (Radio Astronomy)
	22.21-22.5 GHz	Earth Exploration Satellite Service (passive) Recognised Spectrum Access (Radio Astronomy) Space Research Service (passive)
	22.55-23.15 GHz	Space Research Service (passive)
	22.81-22.86 GHz	Recognised Spectrum Access (Radio Astronomy)
Fixed Links	21.2-22 GHz	Point to Point Fixed Links – 1763 licences (Nov 14). Band is closed to new applications.
	22-23.6 GHz	Point to Point Fixed Links – 2063 licences (Nov 14)
Licence Exempt	21.65-26.65 GHz	Automotive Short Range Radar (SRR)

A5.35 **Management of the bands:** UK1

25.25-29.5 GHz

A5.36 **Bandwidth:** 4250 MHz

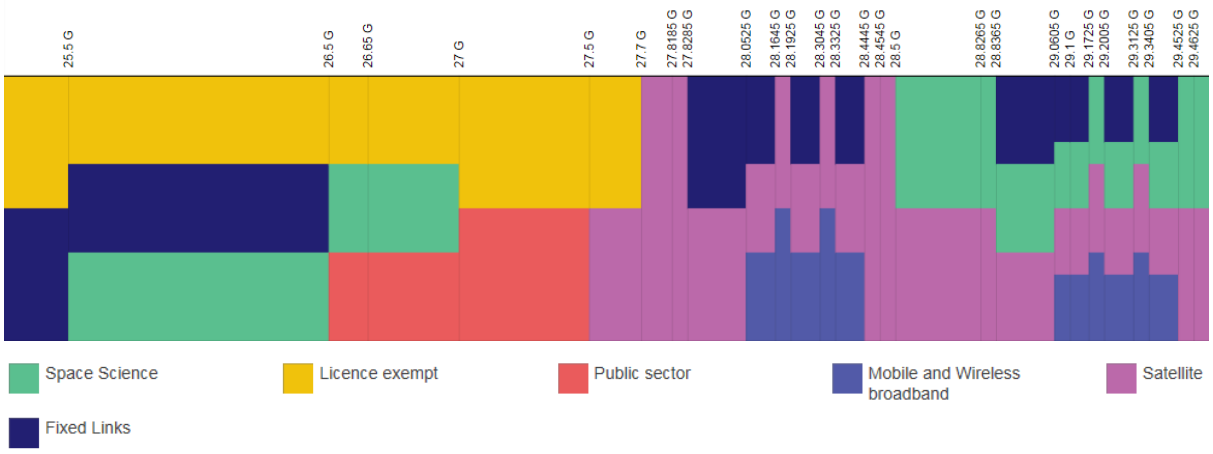
A5.37 **Status of mobile allocation:** Primary UK and global allocation to the mobile service

A5.38 **Allocations in the UK:**

Frequency range	Allocations in the UK
25.25-25.5 GHz	FIXED, MOBILE, INTER-SATELLITE
25.5-26.5 GHz	EARTH EXPLORATION-SATELLITE (space to Earth), FIXED, MOBILE, INTER-SATELLITE, SPACE RESEARCH (space to Earth), Standard Frequency and Time Signal-Satellite (Earth to space)
26.5-27 GHz	EARTH EXPLORATION-SATELLITE (space to Earth), FIXED, MOBILE, INTER-SATELLITE, SPACE RESEARCH (space to Earth), Standard Frequency and Time Signal-Satellite (Earth to space)
27-27.5 GHz	FIXED, MOBILE, INTER-SATELLITE
27.5-28.5 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE
28.5-29.1 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE, Earth Exploration-Satellite (Earth to space)
29.1-29.5 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE, Earth Exploration-Satellite (Earth to space)

A5.39 **Overview of services in the UK:**

Spectrum map excerpt, range of 25.25-29.5 GHz



A5.40 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Licence Exempt	21.65-26.65 GHz	Automotive Short Range Radar

	24.05-27 GHz	Tank Level Probing Radar (TLPR)
	24.25-26.65 GHz	Automotive Short Range Radar (SRR)
	24.3-27.7 GHz	Radar Level Gauges
Fixed Links	24.5-26.5 GHz	Point to Point Fixed Links – 2867 licences (Nov 14)
	27.8285-28.0525 GHz	Spectrum Access: Arqiva (uplink) Spectrum Access: Vodafone (uplink)
	28.0525-28.1645	Spectrum Access: Telefonica (uplink)
	28.1925-28.3045 GHz	FWA Urban Wimax (uplink) Spectrum Access: Telefonica (uplink) Spectrum Access: UK Broadband (uplink)
	28.3325-28.4445 GHz	Spectrum Access: UK Broadband (uplink)
	28.8365-29.0605 GHz	Spectrum Access: Arqiva (downlink)
	29.0605-29.1725 GHz	Spectrum Access: Telefonica (downlink) Spectrum Access: Vodafone (downlink)
	29.2005-29.3135 GHz	FWA Urban Wimax (Downlink) Spectrum Access: Telefonica (downlink) Spectrum Access: UK Broadband (downlink) Spectrum Access: Vodafone (downlink)
	29.3405-29.4525 GHz	Spectrum Access: UK Broadband (downlink)
Space Science	25.5-26.5 GHz	Earth Exploration Satellite Service
	25.5-27 GHz	Standard Frequency and Time Signal Satellite
	26.5-27 GHz; 28.5-29.1 GHz; 29.1-29.5 GHz	Earth Exploration Satellite Service
Public Sector	26.5-27.5 GHz	Military
Satellite Services	27.5-27.8185 GHz	Earth Stations on Mobile Platforms (ESOMPs) HDFSS – licence exempt Satellite (Earth Station)(Non-Fixed Satellite Service) – 0 licences Satellite (Earth Station)(Non-Geostationary) – 0 licences Satellite (Permanent Earth Station) – 12 licences, 240 frequency assignments across the frequencies 27.5-30 GHz (Ka band) (Nov 14) Satellite (Transportable Earth Station) – 15,016 frequency requests across the frequencies 27.5-30 GHz (Ka band) in 2014
	27.8185-28.4545	Satellite (Earth Station)(Permanent Earth Station)

	GHz 28.4545-28.8265 GHz 28.8265-29.4625 GHz 29.4625-29.5 GHz 29.4625-30 GHz	 Earth Stations on Mobile Platforms (ESOMPs) HDFSS – licence exempt Satellite (Earth Station)(Non-Fixed Satellite Service) – 0 licences Satellite (Earth Station)(Non-Geostationary) – 0 licences Satellite (Permanent Earth Station) Satellite (Transportable Earth Station) Satellite (Permanent Earth Station) Satellite (Earth Station)(Non-Fixed Satellite Service) – 0 licences Earth Stations on Mobile Platforms (ESOMPs) HDFSS – licence exempt Satellite (Earth Station)(Non-Geostationary) – 0 licences Satellite (Permanent Earth Station) Satellite (Transportable Earth Station)
Mobile and Wireless Broadband	28.0525-28.4445 GHz; 29.1925-28.3045 GHz 29.0605-29.4525 GHz 29.2005-29.3125 GHz	Broadband Fixed Wireless Access (28 GHz – Guernsey) Broadband Fixed Wireless Access (28 GHz – Isle of Man) Broadband Fixed Wireless Access (28 GHz – Jersey) FWA Chorus Communications (uplink) Broadband Fixed Wireless Access (28 GHz – Guernsey) Broadband Fixed Wireless Access (28 GHz – Isle of Man) Broadband Fixed Wireless Access (28 GHz – Jersey) FWA Chorus Communications (downlink)

A5.41 **Management of the bands:** UK2, except 26.5-27.5 GHz which is UK2.

36-40.5 GHz

A5.42 **Bandwidth:** 4500 MHz

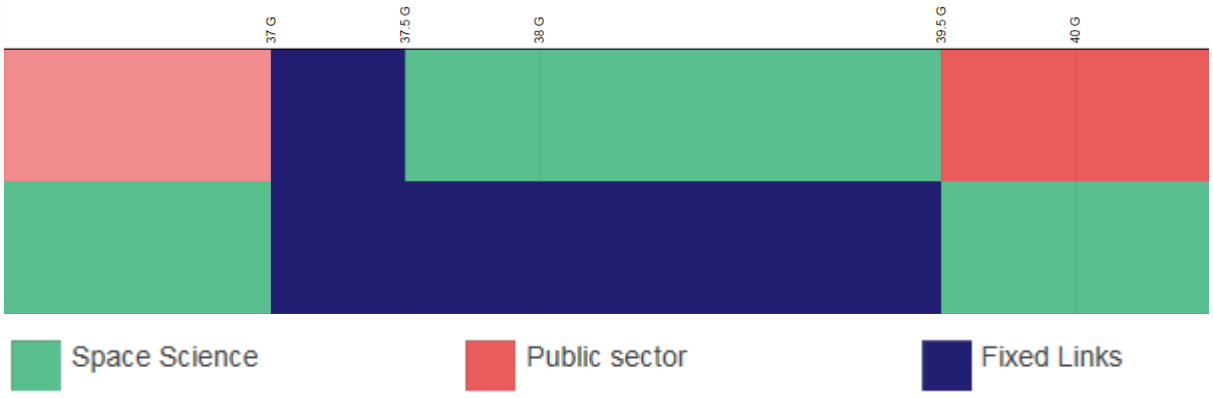
A5.43 **Status of mobile allocation:** Primary UK and global allocation to the mobile service

A5.44 **Allocations in the UK:**

Frequency range	Allocations in the UK
36-37 GHz	EARTH EXPLORATION-SATELLITE (passive), FIXED, MOBILE, SPACE RESEARCH (passive)
37-37.5 GHz	FIXED, MOBILE except aeronautical mobile, SPACE RESEARCH (space to Earth)
37.5-38 GHz	FIXED, FIXED-SATELLITE (space to Earth), MOBILE except aeronautical mobile, SPACE RESEARCH (space to Earth), Earth Exploration-Satellite (space to Earth)
38-39.5 GHz	FIXED, FIXED-SATELLITE (space to Earth), MOBILE, Earth Exploration-Satellite (space to Earth)
39.5-40 GHz	FIXED, FIXED-SATELLITE (space to Earth), MOBILE, MOBILE-SATELLITE (space to Earth), Earth Exploration-Satellite (space to Earth)
40-40.5 GHz	FIXED, FIXED-SATELLITE (space to Earth), MOBILE, MOBILE-SATELLITE (space to Earth), SPACE RESEARCH (Earth to space), Earth Exploration-Satellite (space to Earth)

A5.45 **Overview of services in the UK:**

Spectrum map except, range of 36-40.5 GHz



A5.46 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Public Sector	36-37 GHz; 39.5-40.5 GHz	Military
Space Science	36-37 GHz	Earth Exploration Satellite Service (passive) Space Research Service (passive)

	37.5-38 GHz; 38-39.5 GHz; 39.5-40 GHz; 40-40.5 GHz	Earth Exploration Satellite Service
Fixed Links	37-39.5 GHz	Point to Point Fixed Links – 6490 licences (Nov 14)

A5.47 **Management of the bands:** 36-37 GHz and 39.5-40.5 GHz are UK2. 37-39.5 GHz is UK1.

42.5-52.6 GHz (excl. 50.2-50.4 GHz)

A5.48 **Bandwidth:** 9900 MHz

A5.49 **Status of mobile allocation:**

- Primary UK allocation to the mobile service, ex. 47-47.2 GHz and 50.4-51.4 GHz
- Primary global allocation to the mobile service, ex. 47-47.2 GHz and 50.2-50.4 GHz

The 50.2-50.4 GHz band has a global primary allocation to the Earth Exploration-Satellite (passive) and Space Research (passive) services. All emissions are prohibited in this band by the Radio Regulations. [40]

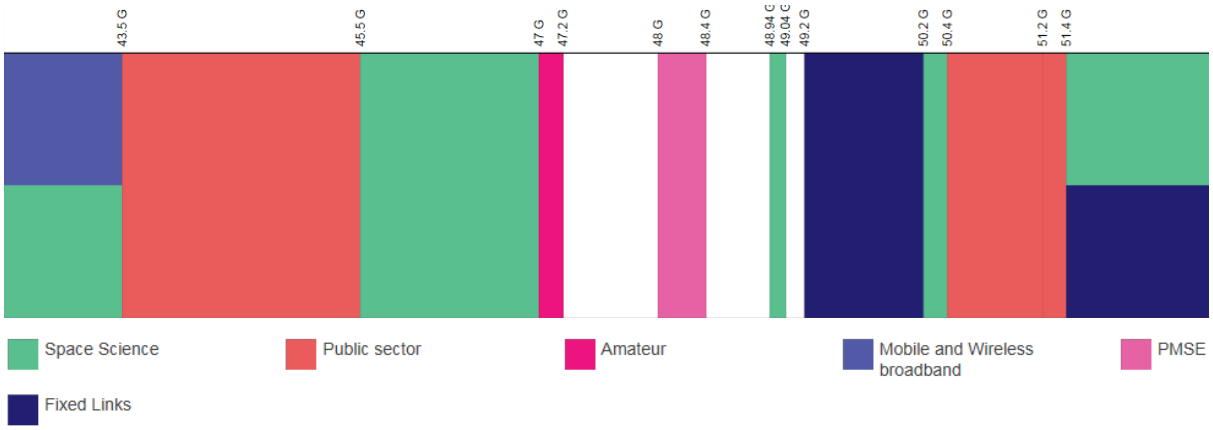
A5.50 **Allocations in the UK:**

Frequency range	Allocations in the UK
42.5-43.5 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE except aeronautical mobile, RADIO ASTRONOMY
43.5-45.5 GHz	MOBILE, MOBILE SATELLITE
45.5-47 GHz	MOBILE, MOBILE-SATELLITE, RADIONAVIGATION, RADIONAVIGATION-SATELLITE
47-47.2 GHz	AMATEUR, AMATEUR-SATELLITE
47.2-47.5 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE
47.5-47.9 GHz	FIXED, FIXED-SATELLITE (Earth to space) (space to Earth), MOBILE
47.9-48.2 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE
48.2-48.54 GHz	FIXED, FIXED-SATELLITE (Earth to space) (space to Earth), MOBILE
48.54-49.44 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE
49.44-50.2 GHz	FIXED, FIXED-SATELLITE (Earth to space) (space to Earth), MOBILE
50.2-50.4 GHz	EARTH EXPLORATION-SATELLITE (passive), FIXED, MOBILE, SPACE RESEARCH
50.4-51.4 GHz	FIXED, FIXED-SATELLITE (Earth to space), Mobile-Satellite (Earth to space)
51.4-52.6 GHz	FIXED, MOBILE

[40] Footnote 5.340 in the ITU Table of Frequency Allocations and the UKFAT

A5.51 **Overview of services in the UK:**

Spectrum map excerpt, range of 42.5-52.6 GHz



A5.52 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Mobile and Wireless Broadband	42.5-43.5 GHz	Spectrum Access: UK Broadband (downlink)
Space Science	42.5-43.5 GHz 45.5-47 GHz 48.94-49.04 GHz 50.2-50.4 GHz 51.4-54.25 GHz	Recognised Spectrum Access (Radio Astronomy) Radio Navigation Satellite Service Recognised Spectrum Access (Radio Astronomy) Earth Exploration Satellite Service (passive) Radio Astronomy
Public Sector	43.5-45.5 GHz; 50.4-51.2 GHz 51.2-51.4 GHz	Military Business Radio (Police and Fire)
Amateur	47-47.2 GHz	Amateur Radio Full Licence Amateur Radio Intermediate Licence
PMSE	48-48.4 GHz	0 assignments in 2014
Fixed Links	49.2-50.2 GHz 51.4-52.6 GHz	Point to Point Fixed Links – 31 licences (Nov 14). Band closed to new applications. Point to Point Fixed Links – 0 licences.

A5.53 **Management of the bands:** UK1,except 43.5-45.5 GHz and 50.4-51.4 GHz which are UK2.

55.78-76 GHz

A5.54 **Bandwidth:** 20220 MHz

A5.55 **Status of mobile allocation:** Primary UK and global allocation to the mobile service

A5.56 **Allocations in the UK:**

Frequency range	Allocations in the UK
55.78-56.9 GHz	EARTH-EXPLORATION SATELLITE (passive), FIXED, INTER-SATELLITE, MOBILE except aeronautical, SPACE RESEARCH (passive)
56.9-57 GHz	EARTH-EXPLORATION SATELLITE (passive), FIXED, INTER-SATELLITE, MOBILE except aeronautical, SPACE RESEARCH (passive)
57-58.2 GHz	EARTH-EXPLORATION SATELLITE (passive), FIXED, INTER-SATELLITE, MOBILE except aeronautical, SPACE RESEARCH (passive)
58.2-59 GHz	EARTH-EXPLORATION SATELLITE (passive), FIXED, MOBILE, SPACE RESEARCH (passive)
59-59.3 GHz	EARTH-EXPLORATION SATELLITE (passive), FIXED, INTER-SATELLITE, MOBILE, RADIOLOCATION, SPACE RESEARCH (passive)
59.3-64 GHz	FIXED, INTER-SATELLITE, MOBILE, RADIOLOCATION
64-65 GHz	FIXED, INTER-SATELLITE, MOBILE except aeronautical mobile
65-66 GHz	EARTH-EXPLORATION SATELLITE, FIXED, INTER-SATELLITE, MOBILE except aeronautical mobile, SPACE RESEARCH
66-71 GHz	INTER-SATELLITE, MOBILE, MOBILE-SATELLITE, RADIONAVIGATION, RADIONAVIGATION-SATELLITE
71-74 GHz	FIXED, FIXED-SATELLITE (space to Earth), MOBILE, MOBILE-SATELLITE (space to Earth)
74-75.5 GHz	BROADCASTING, BROADCASTING-SATELLITE, FIXED, FIXED-SATELLITE (space to Earth), MOBILE, Space Research (space to Earth)
75.5-76 GHz	BROADCASTING, BROADCASTING-SATELLITE, FIXED, FIXED-SATELLITE (space to Earth), MOBILE, Amateur, Amateur Satellite, Space Research (space to Earth)

A5.57 **Overview of services in the UK:**

Spectrum map except, range of 55.78-76 GHz

A5.58 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Space Science	55.78-56.9 GHz; 56.9-57 GHz; 57-58.2 GHz	Earth Exploration Satellite Service (passive) Space Research Service (passive)
	58.2-59 GHz	Earth Exploration Satellite Service (passive) Radio Astronomy Space Research Service (passive)
	59-59.3 GHz	Earth Exploration Satellite Service (passive) Space Research Service (passive)
	64-65 GHz	Radio Astronomy
	65-66 GHz	Earth Exploration Satellite Service
	66-71 GHz	Radio Navigation Satellite Service
Fixed Links	55.78-57 GHz	Point to Point Fixed Links – 0 licences
	57-64 GHz	Fixed Wireless Systems (57.1-63.9 GHz) – licences exempt
	64-66 GHz	Self Co-ordinated links – 0 licences
	71.125-75.875 GHz	Point to Point Fixed Links (Ofcom coordinated and Self Coordinated links) – most point to point fixed links using 71.125-75.875 GHz are paired with 81.125-85.875 GHz. There are 1673 links across both bands (Nov 14)
Licence Exempt	57-64 GHz	Non-Specific Short Range Devices Tank Level Probing Radar (TLPR)
	57-66 GHz	Wideband Data Transmission Devices
	61-61.5 GHz	Non-Specific Short Range Device

	63-64 GHz 75-85 GHz	Transport and Traffic Telematics TLPR
Public Sector	59-64 GHz; 71-74 GHz	Military
Amateur	75.5-81 GHz	Amateur Radio Full Licence Amateur Radio Intermediate Licence

A5.59 **Management of the bands:** UK1 for 55.78-59 GHz, 64-71 GHz and 74-76 GHz. In 59-59.3 GHz and 59.3-64 GHz, the Departments/Agencies responsible for planning frequency assignments are Ofcom for the Fixed and Mobile services, and the MoD for the Radiolocation service. In 71-74 GHz, Ofcom for the Fixed and Mobile services, and the MoD for the Fixed-Satellite and Mobile-Satellite services.

81-86 GHz

A5.60 **Bandwidth:** 5000 MHz

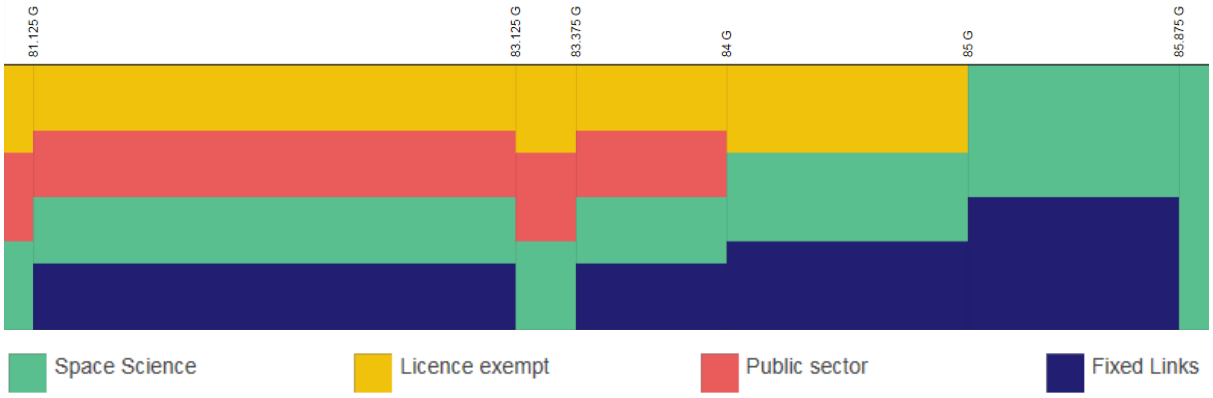
A5.61 **Status of mobile allocation:** Primary UK and global allocation to the mobile service

A5.62 **Allocations in the UK:**

Frequency range	Allocations in the UK
81-84 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE, MOBILE-SATELLITE (Earth to space), RADIOASTRONOMY, Space Research (space to Earth)
84-86 GHz	FIXED, FIXED-SATELLITE (Earth to space), MOBILE, RADIOASTRONOMY

A5.63 **Overview of services in the UK:**

Spectrum map excerpt, range of 81-86 GHz



A5.64 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Licence Exempt	75-85 GHz	Tank Level Probing Radar (TLPR)
Public Sector	79-84 GHz	Military
Space Science	79-86 GHz	Radio Astronomy
Fixed Links	81.125-85.875 GHz	Point-to-Point Fixed Links (Ofcom coordinated and Self-Coordinated links) - most point to point fixed links using 81.125-85.875 GHz are paired with 71.125-75.875 GHz. There are 1673 links across both bands (Nov 14)

A5.65 **Management of the bands:** 81-84 GHz Ofcom for the Fixed and Mobile services, MoD for the Fixed-Satellite and Mobile-Satellite services. 84-86 GHz UK1.

92-100 GHz

A5.66 **Bandwidth:** 8000 MHz

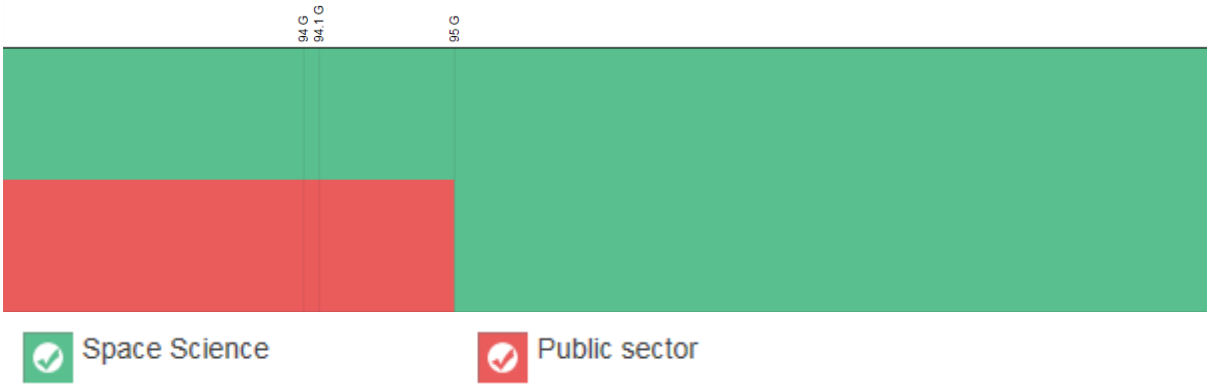
A5.67 **Status of mobile allocation:** Primary UK and global allocation to the mobile service, except 94-94.1 GHz.

A5.68 **Allocations in the UK:**

Frequency range	Allocations in the UK
92-94 GHz	FIXED, MOBILE, RADIOASTRONOMY, RADIOLOCATION
94-94.1 GHz	EARTH EXPLORATION-SATELLITE (active), RADIOLOCATION, SPACE RESEARCH (active), Radioastronomy
94.1-95 GHz	FIXED, MOBILE, RADIOASTRONOMY, RADIOLOCATION
95-100 GHz	MOBILE, MOBILE-SATELLITE, RADIONAVIGATION, RADIONAVIGATION-SATELLITE, RADIOASTRONOMY, Radiolocation

A5.69 **Overview of services in the UK:**

Spectrum map excerpt, range of 92-100 GHz



A5.70 **Access to spectrum, including licences and assignments for Ofcom authorised products:**

Sector	Frequency range	Use and licences/assignments
Space Science	92-94 GHz	Radio Astronomy
	94-94.1 GHz	Earth Exploration Satellite Service (active) Radio Astronomy Space Research Service (Active)
	94.1-116.25 GHz	Radio Astronomy
	95-100 GHz	Radio Navigation Satellite Service
Public Sector	92-95 GHz	Military

A5.71 **Management of the bands:** UK1. 92-95 GHz MoD for the Radiolocation service.

Annex 6

Overview of activities on bands above 6 GHz for 5G

Introduction

A6.1 This annex provides a summary of many current activities on bands above 6 GHz for 5G. It covers initiatives at the national and international level as well as work led by equipment manufacturers, but does not aim to provide an exhaustive list of all 5G related activities.

UK initiatives

A6.2 The **5G Innovation Centre** based in the **University of Surrey** is developing a test bed for 5G technologies. One of its priorities will be the development of intelligent systems that work together to give the impression of unlimited data capacity. A new system is being built up with the support of Huawei, BT and Vodafone but a suitable band has not yet been selected. Many other UK universities have embarked on 5G studies, including **Bristol** and **Kings College London,** and EPSRC has asked UK universities to establish a research cooperation mechanism (CommNet 2) which is expected to be launched early in 2015.

A6.3 The Government has announced an investment partnership with Germany on new technologies including a 5G research programme between the **University of Surrey, the University of Dresden** and **Kings College London**. This follows an earlier UK agreement with Taiwan collaborating on 5G and other technologies under the management of the UK Science and Innovation Network (SIN).

A6.4 The **UK Spectrum Policy Forum** is considering the spectrum needs for future mobile services, including 5G, as part of its 'Cluster 1' work.

Regional initiatives

Europe

A6.5 The **European Telecommunications Standards Institute (ETSI)** is providing advice to two initiatives, **5GNOW** and **METIS** (Mobile and Wireless Communications Enablers for the Twenty-Twenty Information Society).

A6.6 The **METIS** project[41] has identified the following potential bands and assigned priorities for further investigation. These have been based primarily on their current allocation status (e.g. whether they have a primary mobile allocation), the available bandwidth, and the extent of incumbent use. Their current view is that there is little spectrum available under 30 GHz, and that above 30 GHz there are a number of possible candidates notably between 40-90 GHz.

[41] METIS Documents D5.1 and D5.3:

https://www.metis2020.com/documents/deliverables/?doing_wp_cron=1417448765.0715610980987548828125

Table 2: List of METIS candidate bands for 5G services above 6 GHz

Candidate frequency bands (GHz)	Incumbent use (Europe)	Priority
9.9 – 10.6	Fixed / Amateur (police radars migrating to higher bands)	Medium-High
17.1 - 17.3	Military Radars / SRDs	Low
17.7 – 19.7	Fixed Links / Satellite	Low
21.2 – 21.4	PMSE (temporary fixed links)	Low
27.5 – 29.5	Fixed links / Satellite	Medium
31 – 31.3	Fixed links (limited use)	Medium
31.8 – 33.4	Fixed links	High
36 - 37	Passive services	Low
40.5 – 42.5	Fixed links (including future high density networks)	Medium
42.5 – 43.5	Little use currently	High
43.5 – 45.5	Military satellite uplinks	Low
45.5 - 47	Little use currently	High
47.2 – 50.2	Little use currently	High
50.4 – 52.6	Limited fixed link use	Medium – Low
55.78 - 57	Earth exploration satellites (limited use)	High
57 – 66	Fixed links (licensed and exempt)	High
66 – 71	No known use currently	High
71 – 76	Fixed links	High
81 - 86	Fixed links	High

A6.7 The **European Conference of Postal and Telecommunications Administrations (CEPT)**, the European Commission's **Radio Spectrum Policy Group (RSPG)** and the **5G Public-Private Partnership Association (5GPPP)** are also undertaking work on this area, although they have not yet announced specific bands.

A6.8 The European Union has formed a joint research partnership with South Korea to focus on 5G mobile broadband technology. The aim is that **Europe's 5G Infrastructure Association**, which includes telecoms companies Alcatel-Lucent, Deutsche Telekom, Telefonica and Orange, will work directly with South Korea's 5G Forum (see below) to research 5G issues including potential candidate bands.

USA

A6.9 At this stage there is little that has been published by regulators on which bands may be preferred for 5G services above 6 GHz. A notable exception to this is the USA's **Federal Communications Commission (FCC)**. In October 2014 they issued a Notice of Inquiry (NOI)[42] which discusses a number of bands above 24 GHz which could be suitable for 5G services. The bands covered by the FCC's NOI are listed in Table 3 below.

A6.10 The FCC's Notice states that since most of the candidate bands above 24 GHz are already shared - and will probably remain that way - it will be important to determine

[42] FCC Use of Spectrum Bands Above 24 GHz For Mobile Radio Services http://www.fcc.gov/document/noi-examine-use-bands-above-24-ghz-mobile-broadband

whether or not those services are compatible with advanced mobile service in the mmW bands.

Table 3: FCC list of potential bands for 5G services above 6 GHz

Candidate frequency bands (GHz)	Current allocation / incumbent use (USA)
24 GHz Bands (24.25-24.45 GHz and 25.05-25.25 GHz)	• There is no mobile allocation in either of the 24 GHz band segments. The FCC found that it would be premature to allow mobile operations in the 24 GHz bands, but it has reserved the discretion to revisit that issue (if it is presented with technical information demonstrating that such operations would be technically feasible without generating interference).
LMDS Band (27.5-28.35 GHz, 29.1-29.25 GHz, and 31-31.3 GHz)	• LMDS occupies portions of two spectrum bands that the Commission has allocated on a co-primary basis for Fixed and Mobile services. • There are no primary federal allocations in the LMDS band. • The 27.5-28.35 GHz band segment includes a co-primary Fixed-Satellite Service (FSS) Earth-to-space allocation which is secondary to LMDS in that band. • For the 29.1-29.25 GHz band segment has co-primary status for Mobile-Satellite Service (MSS) feeder links and LMDS. • The 31-31.3 GHz band segment has co-primary allocations for terrestrial Fixed and Mobile services, with a secondary federal and non-federal allocation for space-to-Earth standard frequency and time signal operations
39 GHz Band (38.6-40 GHz)	• This band has a co-primary allocation for fixed and mobile services. • There are no allocations in the 38.6-39.5 GHz band. There are allocations for FSS (space-to-Earth) and MSS (space-to-Earth) services in the 39.5-40 GHz band.(Federal government earth stations in the MSS in the 39.5-40 GHz band are prohibited from claiming protection from non-Federal stations in the fixed and mobile services in this band, but are *not* required to protect non-federal fixed and mobile services in the band) • At present, Federal satellite services in the 39.5-40 GHz band are limited to military systems. • Non-Federal government FSS (space-to-Earth) is co-primary throughout the entire 39 GHz band.
37/42 GHz Bands (37.0-38.6 GHz and 42.0-42.5 GHz)	• There are co-primary allocations for terrestrial mobile service in these bands, but the FCC has not yet adopted service rules to authorize such services. All operations in the 42-42.5 GHz band are required to take all practicable steps to protect radio astronomy observations in the 42.5-43.5 GHz band from interference • There is a co-primary FSS (space-to-Earth) allocation for the 37.5-38.6 GHz band segment, and Broadcasting and Broadcasting-Satellite Service (BSS) allocations for the 42-42.5 GHz band segment. • The Commission has proposed eliminating the BSS allocations in the 42-42.5 GHz band and adding a FSS (space-to-Earth) allocation in order to protect adjacent channel radio astronomy in the 42.5-43.5 GHz band
60 GHz Bands (57-64 GHz and 64-71 GHz)	• There are no licensed operations in any of these bands. • Unlicensed operation within the 57-64 GHz band is permitted. • The 65-71 GHz band is authorized for satellite links. There are currently no active satellite licenses in that band. There is also a series of allocations for Federal and non-Federal Fixed, Radiolocation, Radio navigation-Satellite and

	other satellite • International and domestic rules also indicate that any use of the 66-71 GHz band by the land mobile service is subject to not causing interference to, and accepting interference from, the space radiocommunication services in this band.
70/80 GHz Bands (71-76 GHz, 81-86 GHz)	• There are co-primary mobile allocations in all three bands, subject to the requirement that non-Federal operations may not cause harmful interference to, nor claim protection from, Federal Fixed Satellite Service operations located at 28 military bases. • The 71-74 GHz band segment also has co-primary allocations for Federal and non-Federal Fixed, FSS, Mobile, and MSS (space-to-Earth) operations. • The 74-76 GHz band segment has co-primary allocations for Federal and non-Federal government Fixed, FSS (space-to-Earth), Mobile, and Space Research Service operations. • Operators in the 80 GHz bands must also avoid interfering with 18 radio astronomy observatories. • The 81-86 GHz band has co-primary allocations for Federal and non-Federal government Fixed, FSS (Earth-to-space), and Mobile, and within that band the 81-84 GHz band segment also has a Federal and non-Federal government allocation for MSS (Earth-to-space)

A6.11 Research is also being undertaken by a number of US academic institutions, including the **Polytechnic Institute of New York University**, **Virginia Polytechnic Institute** and **State University (Virginia Tech**). For example, research at the Polytechnic Institute of New York University includes 3D measurements and models at 28 GHz and 73 GHz. Defence linked research is being undertaken by the Polytechnic Institute of New York University and the University of Texas to explore potential uses at 39 GHz (also see 'Samsung' below).

Asia

A6.12 The **South Korean government** has announced that it would spend approximately £1 billion to deploy 5G services partly under its 5G Forum Program and the national regulator recently launched the Mobile Gwanggaeto Plan 2.0, which seeks to identify a further 1190 MHz of mobile spectrum by 2023. This currently includes at least 500 MHz in bands above 6 GHz which may be suitable for 5G. The government's plan is to start testing a nationwide 5G network in 2018, with commercial services scheduled for 2020.

A6.13 South Korea has also made proposals to ITU WP5D covering the bands 13.4 – 14 GHz, 18.1 – 18.6 GHz and 27 -29 GHz. Their aim is to achieve 1 Gbps per user and 100 Gbps per cell for 5G deploying the 500 MHz channel bandwidth noted above.

A6.14 On the academic front the **Korean Electronics and Telecommunications Research Institute (ETRI)** has developed a 500 MHz channel sounder for the 28 GHz band to investigate propagation at these frequencies.

A6.15 The **Chinese government** initiated the IMT2020 (5G) Promotion group in April 2013 which aims to organize research organizations and enterprises to promote 5G research and standards. Other 5G initiatives include the China Ministry of Science and Technology's National "863" Project in 5G. No recommended bands have been published at this stage by either organisation.

A6.16 The **Japanese government** is looking to have commercial 5G services in operation in time for the Tokyo Olympics and Paralympics in 2020. Japan's 2020 and Beyond program is also examining a range of bands but with no priority or preferences band yet listed. .

A6.17 **Taiwan's government** is reported to have plans to access funds from its recent 4G spectrum-license auction to fund 5G developments. The three-year budget plan allocates approximately £320 million to the initiative. As of yet no favoured bands have been noted.

Global organisations

A6.18 The International Telecoms Union Radiocommunications Committee (ITU-R) is currently producing a report under its **ITU-R WP5D** working group regarding the technical feasibility of 5G in the bands above 6 GHz.[43] The report is due to be finalised in Summer 2015.

A6.19 The ITU-R's working group's draft report notes that there may be opportunities to consider bands already allocated to the mobile service in the ranges from 6-100 GHz. Contributors to the current evaluation process have also suggested a wide variety of bands from 6.425 GHz to 50 GHz, 71-76 GHz and 81-86 GHz.

A6.20 Other international organisations including the **Next Generation Mobile Networks** (NGMN) Alliance and the **Wireless World Research Forum** (WWRF) have carried out early work on this issue but have not yet formally mapped out recommended bands. NGMN currently estimates that 500-1000 MHz of spectrum located above 6 GHz may be required to support very high data rates and shorter-range connectivity.

Equipment Manufacturers

A6.21 Several companies are investing substantial resources in the development of advanced mobile service technologies, including Intel, Alcatel-Lucent, Ericsson, Huawei, InterDigital, Nokia, Qualcomm, and Samsung. The following publicly announced examples illustrate some of main developments. Several companies are investing substantial resources in the development of advanced mobile service technologies, including Intel, Alcatel-Lucent, Ericsson, Huawei, InterDigital, Nokia, Qualcomm, and Samsung. The following publicly announced examples illustrate some of main developments.

A6.22 A major joint partnership is being managed by the Japanese carrier **NTT Docomo**. It is working with six mobile companies on its test run of 5G technologies across a range of frequencies, including above 6GHz. The current group trail group consists of Alcatel-Lucent, Ericsson, Fujitsu, NEC, Nokia, and Samsung, with NTT Docomo running experiments with each of the companies in parallel.

A6.23 **Nokia** has conducted ray-tracing computer simulations to demonstrate that mobile service would be feasible at 72 GHz. Their trials with Docomo are focused on millimetre wave technology and 'beam forming' at the 70 GHz spectrum band.

[43] Draft new Report ITU-R M.[IMT.ABOVE 6 GHz], http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx

A6.24 **Samsung** is focusing attention on two particular bands, 28 GHz and 39 GHz. Field trials are being conducted with New York University and the University of Texas to analyse the 39 GHz band (see above). Samsung will also be testing its technology with Docomo in the 28 GHz band, examining the potential of super-wideband hybrid beam forming and beam tracking.

A6.25 **Ericsson** has demonstrated the ability to establish reliable wireless links at 28 GHz by combining multiple reflected signals. Ericsson's trials with NTT DoCoMo and SK Telecom are expected to focus on the potential of the 15 GHz band exploring new antenna technologies supporting 'Massive MIMO'. They note that 5G will potentially require additional spectrum in the 10, 15 and 30 GHz bands.

A6.26 **Intel** is exploring the possibility of developing chipsets capable of supporting mobile access in the 39 GHz band and Wi-Fi-like "WiGig" operations in the 60 GHz band. It is also looking at concepts around the 28 GHz band.

A6.27 **China Mobile** is focussing on maximising the potential for multiple frequencies between the 6GHz and 20 GHz bands. In their view this will provide some utility, while avoiding fragmented, discontinuous spectrum below 6 GHz.

A6.28 **Huawei** is participating in a variety of 5G partnerships including the EU's 5GPPP (5G Public-Private Partnership) and the IMT2020 Promotion group. It announced that it has achieved a 115 Gbps transmission speed over the air with a 5G wireless technology prototype using equipment operating between the 70 and -90 GHz bands.

Annex 7

Glossary

4G	Fourth generation mobile phone standards and technology
5G	Fifth generation mobile phone standards and technology
5GIC	5G Innovation Centre. The research centre at the University of Surrey that will conduct research into the next generation of mobile communication technology
CEPT	The European Conference of Postal and Telecommunications Administrations
CFI	Call for Input
ETRI	The Korean Electronics and Telecommunications Research institute
ETSI	European Telecommunications Standards Institute.
EU	European Union
FAT	See UKFAT
FS	Fixed Service
FSS	Fixed Satellite Service
GHz	Gigahertz. A unit of frequency of one billion oscillations per second.
GNSS	Global navigation satellite systems
GPS	The Global Positioning System is a space-based satellite navigation system
IMT	International Mobile Telecommunications. The ITU term that encompasses 3G, 4G and 5G wireless broadband systems
IoT	Internet of things. Refers to the interconnection (wirelessly) of uniquely identifiable embedded computing-like devices within the existing Internet infrastructure.
ITU	International Telecommunications Union - Part of the United Nations with a membership of 193 countries and over 700 private-sector entities and academic institutions. ITU is headquartered in Geneva, Switzerland.
ITU-R	International Telecommunications Union Radiocommunication

	Sector
LTE	Long-Term Evolution is a standard for communication of high-speed data for mobile phones and data terminals. The term 4G is generally used to refer to mobile broadband services delivered using the next generation of mobile broadband technologies, including Long Term Evolution (LTE) and WiMAX
METIS	An EU projec on Mobile and Wireless Communications Enablers for the Twenty-Twenty Information Society
MHz	Megahertz. A unit of frequency of one million cycles per second.
MIMO	Multiple Input Multiple Output. The use of multiple antennas at both the transmitter and receiver to improve communication performance.
MOD	Ministry of Defence
NFPG	National Frequency Planning Group
NOI	Notice of Inquiry
PMSE	Programme-making and special events. A class of radio application that support a wide range of activities in entertainment, broadcasting, news gathering and community events.
PES	Permanent Earth Station
PSSR	Public Sector Spectrum Release
RF	Radio frequency
ROES	Receive-only earth station. A satellite earth station which receives radio signals but does not transmit.
RSA	Recognised spectrum access. A method of recognising the use of radio spectrum by an operator which is not covered by a Wireless Telegraphy Act licence or licence exemption.
RSPG	Radio Spectrum Policy Group - High-level advisory group that assists the European Commission in the development of radio spectrum policy.
SDL	Supplemental down link. Used for enhancing downlink capacity in mobile networks.

SRD	Short range device is a general term, applied to various radio devices designed to operate usually on a license exempt basis, over short range and at low power levels, for example alarms, radio microphones, radio local area networks and anti-theft devices.
TNR	Transfer notification register. Ofcom's online register which provides information on licences which have been traded or are in the process of being traded.
UK1	Except by special agreement having the approval of the NFPG (National Frequency Planning Group) this frequency band, or the allocation to this radio service, is reserved exclusively for civil use
UK2	Except by special agreement having the approval of the NFPG this frequency band, or the allocation to this radio service, is reserved exclusively for military use
UKFAT	UK Frequency Allocation Table. Details spectrum allocations in the UK and identifies responsibilities for the management of frequency bands or services
UKPFA	UK Plan for Frequency Authorisation. Provides information on which frequencies are available for assignment by Ofcom, for what purposes the different frequencies have been allocated and whether these can be traded.
Wi-Fi	Commonly used to refer to wireless local area network (WLAN) technology, specifically that conforming to the IEEE 802.11 family of standards.
WRC	World Radiocommunication Conference. The WRC reviews and revises the Radio Regulations, They are held every two to three years.
WTR	Wireless Telegraphy Register. Ofcom's online register which provides information about individual licences.