Spectrum attribution metrics

Spectrum management strategy

Companion Paper

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Contents

Section 1

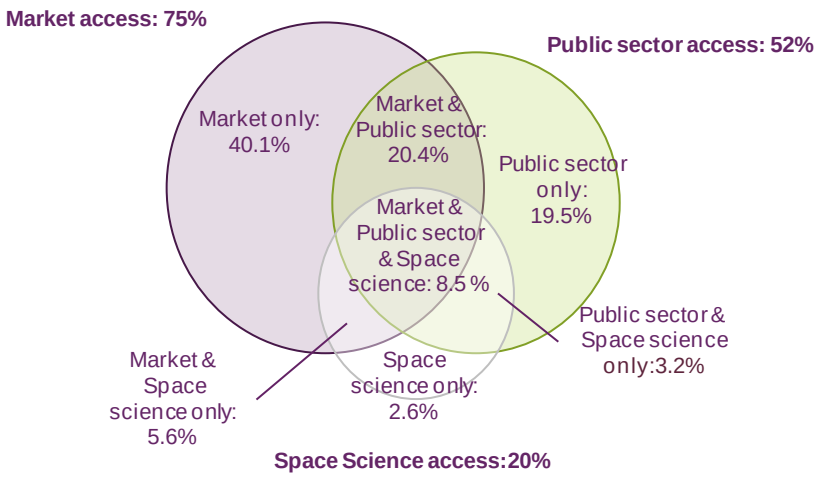
Executive Summary

1.1 This document provides an analysis of the different ways in which spectrum is accessed in UK[1]. The aim is to provide some relatively simple visual representations of spectrum use that are likely to prompt questions and debate amongst us and stakeholders. This is of interest as the way in which access to spectrum is provided impacts the use that can be made of it and, therefore, the value that can be derived from its use.

1.2 A key observation from this analysis, and one that is perhaps not widely appreciated, relates to the extent of spectrum sharing that happens today. 58% of the spectrum bands are accessed in more than one way with the other 42% of the spectrum bands being accessed on an exclusive basis The overall level of sharing builds up to this 58% figure as we consider more detailed levels of disaggregation in the way that spectrum is accessed, as explained below.

1.3 At an aggregate level we have defined access to spectrum as relating to one of three main categories: Market access (authorised by us and available to the market); Public sector (accessed using the immunity the Crown has from requiring a licence) or Space science (accessed without explicit need for a licence, or using Crown immunity[2]). As shown in Figure 1 Market has access to 75%, Public sector access to 52% and Space science has access to 20%[3].

Figure 1: Proportion of total weighted spectrum accessed by Market uses, Public sector uses and Space science uses[4]



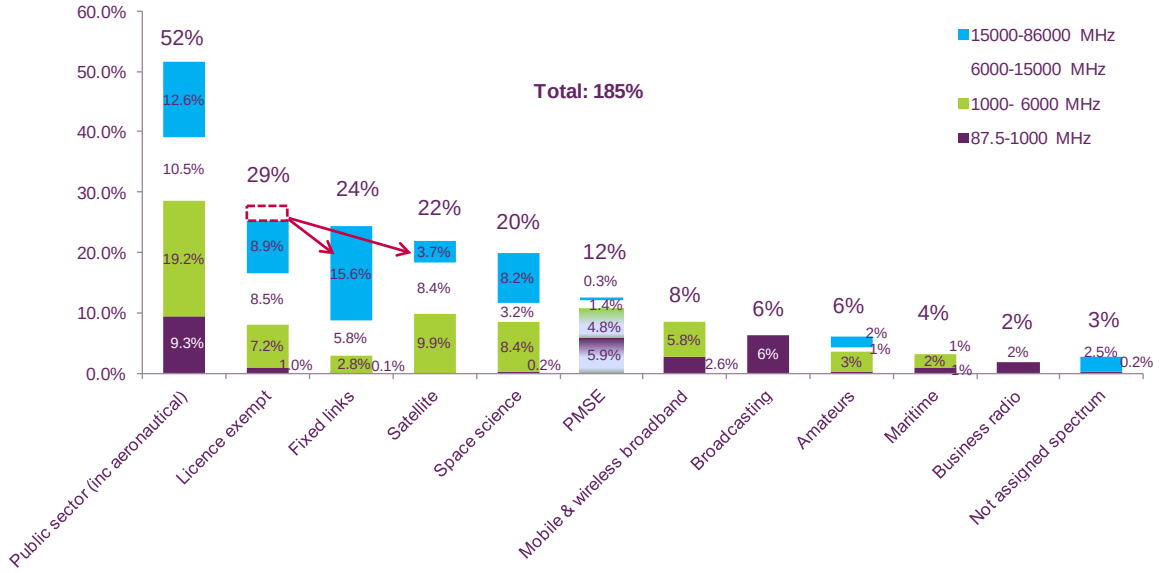
[1] This document updates and provides a greater level of detail of the spectrum attribution metrics that we presented in Section 2 of our consultation document on Spectrum Management Strategy. This has led to some very minor changes to some of the numbers given in the consultation document.
[2] As its use is either receive-only in UK or is transmissions from outer space.
[3] All figures presented refer to "weighted spectrum" which is an adjustment that ensures the analysis is not dominated by access to higher frequencies, which would otherwise be the case. See Section 2 for further details.
[4] Please note the Venn Diagram provided is illustrative and is not to scale

1.4 This figure shows that almost 40% (37.7%) of the spectrum is shared between these three high level categories.

1.5 Further analysis of the data (which is not shown in Figure 1) indicates that, of the 52% of spectrum bands to which public sector users have access, 43% (of this 52%) is managed by Crown bodies themselves[5] and Crown bodies permit access by Market uses to roughly half of this 43% (21% of the 43%).

1.6 This document takes the analysis beyond these three main categories of spectrum access to provide a view of the sector make up of spectrum access as illustrated in Figure 2 below.

Figure 2: Proportion of spectrum available to the sectors and its distribution across the frequency (% total weighted spectrum)



1.7 From this analysis we observe that, leaving aside Public sector access, four sectors each access more than 20% of the spectrum: Licence exempt (29%), fixed links (24%), satellite (22%) and Space science (20%). However, these four sectors have very little (if any) access to the most contested bands under 1 GHz and a significant presence in the above 15GHz bands (this presence being more pronounced for the Licence Exempt, fixed link and Space science sectors than for satellite).

1.8 In contrast, mobile, broadcasting maritime and business radio all have access to less than 10 % of the spectrum, but with most of this being below 6GHz (with terrestrial broadcasting and business radio only accessing spectrum below 1 GHz).[6]

1.9 The licence exempt figure of 29% may appear quite high. We note, however, that only 0.7% of this 29% is accessed on an exclusive basis (in other words, the vast majority of licence exempt access is in bands which it is sharing access to with other Market, Public sector or Space science uses). It is challenging to provide more detailed information on what makes up the 29% because of the wide range of licence exempt applications. However, a significant proportion is accounted for by a few

[5] The remaining access to spectrum enjoyed by Public sector is to spectrum managed by Ofcom and for which there are specific arrangements made for Public sector access

[6] Nb. although Figure 2 indicates that PMSE has access to 12% of the spectrum, this access is highly constrained in both frequency and geography compared to other uses. This figure therefore is a little misleading and overstates the extent of PMSE access to spectrum.

niche applications that have access to very large bandwidths. If we focus on licence exempt uses that relate to mass market, consumer applications then these have access to a around half of the overall licence exempt spectrum (14% of the 29%).

1.10 The percentages in Figure 2 add to more than 100% because of spectrum sharing. We noted above that sharing occurs in 58% of spectrum bands and that almost 40% (of this 58%) relates to sharing at the highest level between the Market, Public sector and Space Science categories. The other 18% (of the 58%) relates to sharing between different sectors *within* the Market access category.

1.11 In the 58% of bands where some form of sharing occurs, it is shared intensely; on average three different sectors share access in these bands (with up to four sectors sharing access in any individual band).

1.12 Turning to the 42% (41.6%) of spectrum bands where access is exclusive, this is comprised of Public sector (19.5%)[7], mobile and wireless broadband (6%), fixed links (6%), satellite (4%), Space science (2.6%), Licence Exempt(0.7%) and 2.8 % of spectrum that is not assigned for use[8].

[7] The Public sector is treated as one access mechanism for the purposes of this analysis; however, in practice, public sector spectrum bands are often shared between more than one type of public sector user (e.g. MOD shares access with other public sector users such as aeronautical and emergency service users).

[8] This includes the bands 870-876 and 915-921 MHz where we plan to exempt use; and also 66-71 GHz, 47.2 to 47.9GHz and 45.5 to 47GHz, which are all extension bands for satellite use but where there is no current authorisations, or use of the band

Section 1

Introduction and background

Introduction

2.1 We published our Spectrum Management Strategy consultation ("our consultation document") on 2nd October setting out proposals for our spectrum management strategy and priorities over the next ten years. In Section 2 of this document we included some high level spectrum attribution metrics to provide context for our strategy[9]. These metrics included:

- The proportion of spectrum that can be accessed by the Market compared to the proportion that can be accessed by the Public sector; and
- A breakdown of the composition of spectrum accessed by the Market between the categories of: Ofcom Managed (i.e. available via standard Ofcom licence products), Block Assigned (e.g. auctioned spectrum) and Licence Exempt uses.

2.2 In our consultation we emphasised that the figures presented were provisional and subject to revision in light of further work which was in hand. We are now in a position to provide a more detailed, and updated, picture of these spectrum metrics. In particular this document provides:

- more granular detail on the components of the spectrum accessed by the Market i.e. the composition of spectrum that is accessed by Ofcom Managed, Block Assigned and Licence Exempt uses;
- more detail on the extent of sharing of spectrum bands between the various methods of accessing spectrum;
- a sector view of access to spectrum; and
- a view of the distribution of the access to frequencies that the sectors enjoy.

2.3 We also provide, in a separate document available on our website, a spectrum map showing the access these sectors have to each individual spectrum band. This provides for the first time a comprehensive view of the access to spectrum in UK that is provided to individual sectors on a band by band basis in a single A3 chart, including Public sector and Licence Exempt use.

2.4 As part of our further work we have reviewed the "Other" category (that was referred to in our consultation document) and are now able to better characterise access to these bands in the analysis we present here. We have also undertaken additional analysis to identify access to bands at a more detailed sub-band level in order to better understand the extent of sharing of spectrum. In doing this we have identified bands that we had previously treated as shared, but which are, in reality, divided into different sub-bands that are accessed by different users. This has resulted in some changes to the provisional figures presented in our consultation document – although

[9] Provided in our Spectrum Management Strategy consultation in Figure 1 (page 3) of the Executive summary, and Figures 3 and 4 (pages 16 and 19). Also described in paragraphs 2.11 – 2.17 of the document which can be found http://stakeholders.ofcom.org.uk/consultations/spectrum-management-strategy/?a=0

the relevant messages about the high level nature of spectrum access remain the same.

2.5 It is not necessary to read this document in order to respond to our consultation on Spectrum Management Strategy. However, if stakeholders wish to do so, the following parts of this document might be of most relevance:

- Paragraphs 4.4 to 4.14 in which we present the results of our analysis at the aggregate level between Market, Public sector, and a new category of Space science access;
- Paragraphs 4.18 to 4.19 in which we present the results of our refined analysis in terms of the components of Market access: Block Assigned, Ofcom Managed and Licence exempt use as well as a new category of unassigned spectrum bands.

Purpose of analysis of spectrum metrics

2.6 The way in which access is provided to spectrum impacts the use that can be made of it and therefore the value that can be derived from its use. In carrying out the analysis behind the various views of spectrum presented in this document we have sought to provide a useful insight into the way that spectrum is authorised and used. Whilst we are not looking to directly represent the value of spectrum in these views, we are trying to provide views that will help us and others to identify areas worth investigating further and will improve our overall understanding of how spectrum is used in UK.

2.7 Although this document takes forward the work on spectrum metrics that was summarised in the consultation, it is designed to be read as a stand-alone document and does not require the reader to be familiar with our consultation document.

2.8 This document is not a formal consultation. However, comments and suggestions from stakeholders are very much welcomed. In particular, we would be interested to hear from stakeholders whether they find the information of interest and whether there is additional information we could consider making available in future.

2.9 We anticipate that over time we will further refine the specific attributions of the individual bands (for example, to consider a further level of granularity in sub-bands, if appropriate, and also, if it is appropriate, to refine our interpretation of the source material in specific bands).

Legal framework

2.10 Since the focus of this document is on the different ways that users can gain the legal right to use spectrum we summarise here the legal framework that we work within and which sets out our powers and duties with respect to the authorisation of spectrum use.

2.11 Ofcom is responsible for authorising the use of all spectrum with the exception of use by Crown bodies. There is no general legal definition of a Crown body but central government departments reporting to ministers such as the Ministry of Defence, Home Office and Department for Transport are generally considered to be Crown bodies.

2.12 The European common regulatory framework for electronic communications,[10] in particular the Framework Directive and the Authorisation Directive, sets the broad framework for how spectrum use should be authorised and managed in UK and aims to harmonise the regulation of electronic communications networks and services throughout the European Union. The UK's responsibilities for spectrum management under these Directives are given effect in UK law through two Acts of Parliament:

- The Communications Act 2003 (the "2003 Act"); and
- The Wireless Telegraphy Act 2006 (the "WT Act").

2.13 These Acts confer on Ofcom specific duties and powers in respect of spectrum (and the other sectors we regulate).

2.14 The 2003 Act and WT Act set out a broad range of duties and powers, as well as a wide range of factors that we need to consider when making decisions on how to exercise our powers. Of particular relevance to the exercise of our spectrum functions, the 2003 Act sets out our principal duty to further the interests of citizens in relation to communications matters and of consumers in relevant markets, where appropriate by promoting competition. It also requires us to secure in the carrying out of our functions the optimal use for wireless telegraphy of the electro-magnetic spectrum. The WT Act also includes specific duties which we must have regard to when carrying out our radio spectrum functions.

Structure of the remainder of the document

2.15 In the remaining sections of the document:

- In Section 3 we describe the broad approach we have taken in developing the spectrum attribution metrics.
- In Section 4 we describe the results of our analysis in terms of the different ways that users gain access to spectrum. This includes a high level view of whether spectrum is accessed by: Market, Public sector or Space science access and the reasons we chose these three high level categories. We then describe the various components of the spectrum accessed by Market uses: Licence exempt use, Block Assigned and Ofcom Managed.
- In Section 5 we provide a sector view of spectrum access and indicate the amount of spectrum that each of the 11 licence sectors have access to. We also provide details of the distribution of frequencies that these sectors have access to. We then describe the extent and complexity of sharing that occurs between the sectors, and we provide a method of expressing the intensity of sharing in terms of a sharing "reuse factor".

2.16 The document also includes three annexes:

- Annex 1 provides a Glossary of the terms used in the document including the definition of the individual spectrum attributes

[10] The Common Regulatory Framework comprises the Framework Directive (Directive 2002/21/EC), the Authorisation Directive (Directive 2002/20/EC), the Access Directive (Directive 2002/19/EC), the Universal Service Directive (Directive 2002/22/EC) and the Directive on privacy and electronic communications (Directive 2002/58/EC), as amended by the Better Regulation Directive (Directive 2009/140/EC), www.ec.europa.eu/information_society/policy/ecomm/doc/140framework.pdf.

- Annex 2 provides more details on the methodology we used to define the attributes and decide which bands should be included in each category; and

- Annex 3 provides further details on the way that Ofcom authorises spectrum use to provide Market access.

Section 3

Approach to Spectrum attribution metrics

Introduction

3.1 The purpose of developing metrics of spectrum attribution is to provide insights into the extent to which spectrum is accessed in different ways and for different types of use. In particular, we are seeking to illustrate:

- who currently has rights to use which spectrum bands (and may therefore be preventing others from using spectrum, whether they are actively using it or not);
- the various mechanisms by which users gain access to spectrum;
- the extent to which different sectors have access to spectrum; and
- the extent of sharing between different types of spectrum access that currently occurs.

3.2 In order to do this we have ascribed a number of attributes to each individual spectrum band such that these attributes identify the above distinctions. Annex 2 provides greater detail of the specific attributes that we use and the methodology we have used to assign these attributes to each specific spectrum band. In practice, we have identified over 500 individual bands and sub-bands for this purpose. In doing this analysis we looked at all spectrum bands between 87.5 MHz and 86 GHz and considered all uses, including those used by Crown bodies.

3.3 Ofcom is responsible for authorising use of spectrum in UK and in this document we present a variety of different views of the types of use we authorise under different authorisation methods. We refer to these, for simplicity, as “use” rather than “authorised use”, for example, “market use”. This does not imply any knowledge on our part of whether or not the spectrum is in practice “used”, or to what extent it might be used.

Sources of information

3.4 We have used four main sources in order to ascribe attributes to each spectrum band:

- the UK Frequency Allocation Table (FAT);
- the UK Plan for Frequency Authorisation (UK PFA);
- the Licence Exemption regulations; and
- the knowledge of our sector specialists.

3.5 The UK FAT[11] is maintained on behalf of the government’s UK Spectrum Strategy Committee and is a key source for this work in several respects. It represents an understanding that specific bands are broadly designated for “military” or “civilian”

[11] UK FAT is available http://stakeholders.ofcom.org.uk/spectrum/information/uk-fat/)

use. [12] It also includes footnotes that designate specific bands for use by other public sector bodies and includes specific reference to the arrangements for using and sharing aeronautical bands co-ordinated by CAA and MoD.[13] The FAT also reflects the international regulatory framework of the International Telecommunications Union (ITU) allocations plan within the Radio Regulations. Although this publication has no prescribed status in law, it is an extremely useful document because it sets out broadly how the different frequency bands are "allocated" to different uses within the UK.

3.6 The UK PFA provides details on the frequencies authorised by Ofcom. It includes a list of all licence types, whether they are available for assignment, the basis on which the licences are or have been assigned, and whether or not they can be traded.

3.7 In a small number of cases, making decisions on the attribution of individual spectrum bands has required a level of subjectivity (there was no obvious "right attribution"). In such cases when making these decisions we were guided by our main objective in presenting these visual presentations. As such the attributions we have made should not be interpreted to change the legal status or rights to use spectrum of any authorisations we have granted. Equally we needed, in a small number of cases, to interpret the FAT and PFA and this analysis is not intended to revise or supersede the information presented in either of these documents.

Frequency range covered

3.8 In our analysis we have looked at the frequency bands between 87.5 MHz and 86 GHz[14]. We decided on this range because it encompasses the most usable and important frequencies available. The lower limit is the beginning of the FM radio bands and the upper limit of 86 GHz is the highest frequency for which Ofcom currently authorise use.[15,16] Frequencies below this range often have more limited utility as the opportunity for reuse of the spectrum is hampered by the extent the spectrum travels, and because these frequencies can support only low data rates (although they are, nevertheless, valuable for certain applications). Frequencies above this have very little use by services other than Space science as equipment has yet to be developed that use these frequencies.

3.9 For some of the metrics given in this paper we segment the overall 87.5 MHz and 86 GHz range into four frequency ranges as follows:

- Below 1GHz as, in general, spectrum bands below 1GHz are the most contested frequency bands for a variety of uses;

[12] In one respect, the UKFAT represents an understanding between Ofcom and Crown users about the nature of access to different specific bands. This is a valuable tool for avoiding the risks of harmful interference that might arise in the absence of coordination between market and public sector users of spectrum (noting that Ofcom has legal powers to authorise spectrum use at any frequencies and that Crown users have legal immunity over use of any spectrum without the need for authorisation from Ofcom).

[13] For example, footnotes using the "UK1" label identify bands allocated for civil use, the "UK2" label is used for MOD, "UK3" for emergency services etc

[14] This is a slight refinement to the analysis presented in our consultation document which only went up to 81 GHz. We have done this in order to include all of the frequencies used by fixed links

[15] Except for receive only uses that are authorised for all bands through licence exemption regulations.

[16] Although uses, including Earth Exploration Space Services, do make use of spectrum above 86GHz

- 1GHz – 6GHz as spectrum below 6GHz is currently considered the most appropriate for applications needing mobility and is becoming increasingly contested;

  6GHz – 15GHz as spectrum above 15 GHz is generally less contested than other bands;

- Above 15GHz.

Weighting factor

3.10 All of the metrics we present in this paper are based on quantitative measures of spectrum access – or, more specifically, quantitative measures of the proportion of total spectrum access for each particular attribute (for example, the proportion of spectrum accessed by Licence Exempt uses). The simplest way to create quantitative measures would be to base them on the raw MHz of bandwidth associated with each type of spectrum access. However, under such an approach the results would be dominated by the higher frequency bands (which have massively greater bandwidths) and would not provide meaningful insights as this is not a fair reflection of the importance of these bands. As with previous work of this nature, we have therefore applied a simple inverse logarithmic weighting factor to adjust for the fact that at higher frequency bands there is inherently more spectrum available on a per MHz basis than at lower frequencies[17].

3.11 However, the use of a simple inverse logarithmic weighting factor can, in itself, distort the results by giving excessive weight to low frequency spectrum (for example, it gives the same weight to 10 MHz of bandwidth at 90 MHz as it gives to 1 MHz of bandwidth at 900 MHz). In the analysis presented here[18], we have therefore employed a hybrid weighting factor that uses:

- A constant weighting factor up to 1 GHz (so that 10 MHz of bandwidth at 100 MHz is given the same weight as 10 MHz of bandwidth at 1 GHz); and

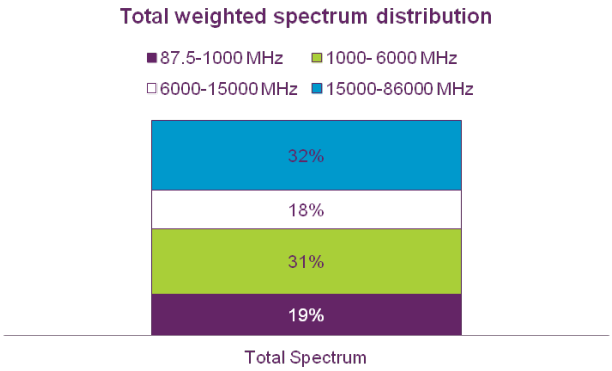
- An inverse logarithmic weighting factor above 1 GHz (so that 10 MHz of bandwidth at 1 GHz is given the same weight as 100 MHz of bandwidth at 10 GHz or 800MHz of bandwidth at 80GHz).

3.12 The weight that this method attaches to each of the four frequency ranges outlined above is shown below in Figure 3.

[17] For example in our Spectrum Framework Review in 2005 http://stakeholders.ofcom.org.uk/consultations/sfr/

[18] For the avoidance of doubt this weighting factor was also used in our Spectrum management strategy consultation document

Figure 3: Proportion of spectrum in each of four ranges of spectrum



3.13 The four frequency ranges have been chosen because of significance attached to the boundaries at 1GHz and 6 GHz as noted above. Accordingly, they do not each represent 25% of the total weighted spectrum (which would have been another way to choose the four ranges). However, the choice of ranges does mean that 50% of the total weight is attached to bands below 6 GHz and 50% is attached to bands above 6 GHz. The choice of weighting factor is discussed further in Annex 2 which shows, amongst other things, the impact of different weighting factors on the proportion of the total spectrum that each of the major frequency bands represent.

Section 4

Spectrum attribution metrics – access methods and authorisation

Introduction

4.1 In this section we present the results of our analysis of the spectrum attribution metrics described in Section 3 and Annex 2. In particular, we provide:

- A high level view of how spectrum is accessed, defined with reference to Market access (where spectrum use is explicitly authorised by Ofcom), access by Public Sector users, and access by Space science uses;
- An analysis of the different components of Market Access, distinguishing first between access through individual licensing or access through Licence Exemption - and then breaking access by licensed users into two broad types which relate to spectrum access via "Block Assigned" licences and spectrum accessed via standard Ofcom licence products;
- A further analysis of the composition within each of the above three main components of Ofcom authorisation (Licence Exempt, Block Assigned and Ofcom Managed).

4.2 Where of particular interest we also provide an indication of the distribution of frequency bands accessed by each of these components.

4.3 In the following discussion all percentages quoted, unless otherwise stated and indicated by *italics,* are percentages of total weighted spectrum. As Market access represents 75% of total weighted spectrum the figures should be expected to add up to 75% and not 100%.

High level view of how spectrum is accessed

4.4 At the highest level spectrum bands can be characterised in terms of the different basis on which users gain access to the use of the spectrum as follows:

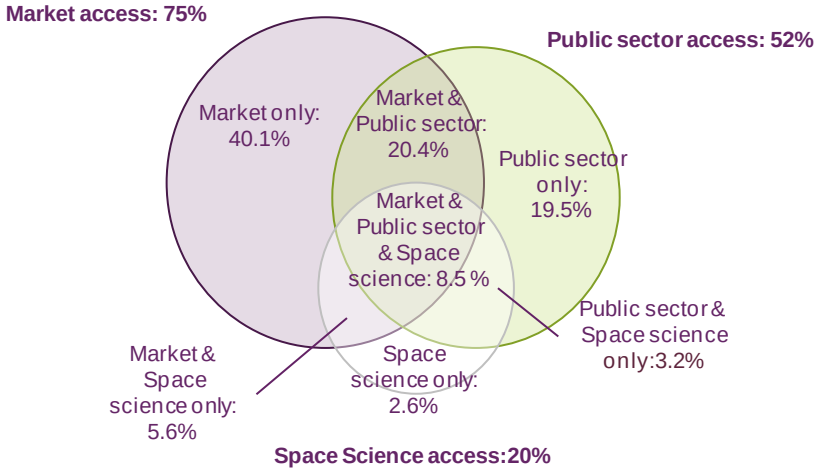
- Market access – spectrum bands where users gain access through Ofcom's explicit authorisation (either a licence granted by us, or the use is explicitly exempted from licensing by us). This comprises two components: all bands managed by Ofcom ("Civil bands"): and bands where the FAT provides specific access for civil uses in bands managed by Crown bodies;
- Public sector access – spectrum bands where users gain access through arrangements under the FAT for use under Crown immunity. This comprises two components: all bands managed by Crown bodies ("Crown spectrum"): and bands where the FAT provides specific access for Crown users in bands managed by Ofcom; and
- Space science access – spectrum bands which are used to research and monitor natural phenomena and where, typically, the way in which the spectrum is

accessed does not need authorisation by Ofcom[19],[20], but neither does it rely on public sector access through the terms of the FAT under Crown immunity. Under the terms of the FAT Space science use includes both bands that are managed by Crown and managed by Ofcom.

4.5 Annex 2 provides further details of our methodology on how we decided to ascribe one or more of these attributes to any particular spectrum band.

4.6 Our analysis, shown in Figure 4 below, shows that Market uses have access to 75% of the total weighted spectrum, whilst the Public sector has access to 52%[21] and Space science has access to 20%[22].

Figure 4: Proportion of total weighted spectrum accessed by Market use, Public sector use and Space science use[23]



4.7 We have introduced a third category, Space science access because of the distinct basis on which it accesses spectrum. Space science use needs to be available globally for it to be of use for most of the research purposes it supports as data is needed from around the globe[24]. This distinguishes it from other uses[25] where the need for global harmonisation is driven primarily by the requirement for the economy of scale this provides. Space science comprises a range of satellite services that are used to investigate natural phenomena and includes Radioastronomy, Earth

[19] Although we takes its use into account in our technical planning
[20] This is unlike access to spectrum by other satellite uses which are authorised either through licensing of the Permanent Earth stations, a VSAT network licence or through licence exemption of the terminal handsets.
[21] This is slightly lower that the figure of 54% quoted in our consultation document
[22] Space science was not presented as a separate category in our consultation document, but rather was a large proportion of spectrum categorised as “Other”
[23] Please note the Venn Diagram provided is illustrative and is not to scale
[24] For some uses of Space science spectrum the need for global harmonisation is because the frequencies used are dictated by the physical properties of the subject under study e.g. Radioastronomy. For other uses it is because the satellites need to be non-geostationary so that they travel across the face of the Earth collecting data from around the globe. For other uses it is that we wish to collaborate with other countries globally to share research data and access to scientific resources in these countries.
[24] Although there are non-geo-stationary satellite constellations that deliver commercial service this is not a pre-requisite to deliver such service
[25] Although there are non-geo-stationary satellite constellations that deliver commercial service this is not a pre-requisite to deliver such service

Exploration and Meteorological satellite and other directly associated radiocommunication services such as Space Research and Space Operations.

4.8 Our analysis includes access to spectrum by Aeronautical uses (which represent 14% of total weighted spectrum) within the Public sector category[26]. This is because our objective in defining the spectrum attribution metrics is to reflect who is authorised to use the spectrum or who is preventing others from using spectrum. For Aeronautical use the decisions on the use of the spectrum, including potential future changes, are highly constrained by the safety requirements of the aeronautical sector and are the responsibility of the specialist aeronautical regulator CAA[27].

4.9 Figure 4 shows that even at this high level of spectrum attribution there is extensive sharing between the different access methods with almost 40% of the total weighted spectrum[28] accessed by two, or by all three, of these high level categories.

4.10 The major contribution to sharing in Figure 4 relates to that between Public sector and Market, where almost a third of total weighted spectrum (29%) is shared. A separate analysis of the nature of this sharing (which is *not* shown in figure 4) indicates that:

- 20% (of the 29%*)* relates to bands managed by Crown bodies (Crown spectrum) but where the UKFAT also provides specific access for Market uses; and
- 9% (of the 29%*)* relates to bands m*a*naged by Ofcom for market access (Civil bands) but where the UKFAT also provides specific access for Crown users.

4.11 In other words, of the 52% of total weighted spectrum to which public sector users have access, 43% (of this 52%) is managed by Crown bodies themselves[29] (i.e. is Crown spectrum) and, of this 43% of spectrum which is managed by Crown bodies, Market users have access to roughly half (21% of the 43%*).*

4.12 Turning to spectrum which is shown as not shared in Figure 4, Space science has exclusive access to only 2.6% of spectrum[30], the Public sector has exclusive access to 19.5% and Market 40.1%. However extensive additional sharing occurs within the Market category between different types of authorised use and within the Public sector category between different public sector users. We discuss sharing between different types of authorised use in the Market category later in this section (and sharing more generally in Section 5).

4.13 We have also analysed the distribution of spectrum made available to the Market and the Public sector across the four frequency ranges noted in section 2. This analysis shows that, in broad terms, they have access to a very similar proportion of spectrum (relative to the total spectrum they access) in each of the four spectrum ranges.

[26] As we previously did in the analysis presented in our consultation document

[27] The situation is further complicated by the extent of co-ordination of spectrum required between civil and military uses, particularly in shared airspace. As such we decided that any attempt to reflect this sharing was somewhat artificial and would distort the overall picture

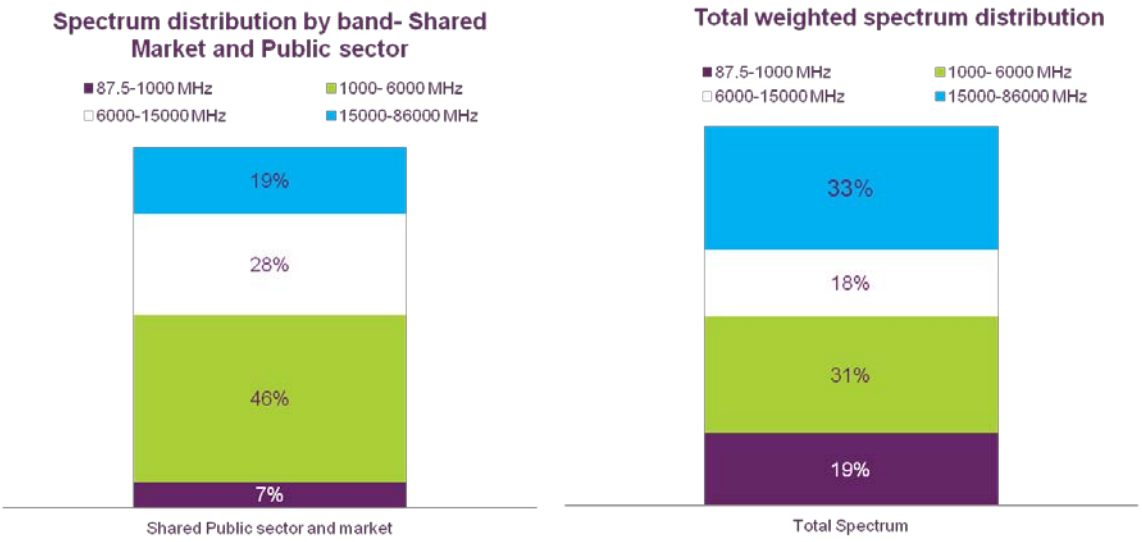
[28] This analysis does not seek to reflect the extent of geographic sharing in a band (i.e. a band is treated as being shared if there is any geographic sharing of frequencies within it)

[29] The remaining access to spectrum enjoyed by Public sector is to spectrum managed by Ofcom and for which there are specific arrangements made for Public sector access under the FAT

[30] This figure has increased from the 2% we quoted of the exclusive access of the “Other” category. This is because our further analysis has identified sub-bands which we had previously believed to include sharing but that in reality do not.

4.14 When we look at the distribution of access to spectrum that is shared between Market and Public sector, as in Figure 5 below, we see that it is least concentrated in the ranges below 1 GHz (which contains only *7%* of this type of spectrum compared with the overall weight of 19% that attaches to the bands below 1GHz).

Figure 5: Distribution of access to spectrum shared by Market and Public sector



Composition of Market Access

Licensed access compared to licence exemption

4.15 We either authorise access to spectrum by licence exemption, where this is possible, or by the grant of an individual licence where it is not (as explained in more detail in Annex 3). In either case, we set out technical conditions with which the users must comply (through licence exemption regulations in the first case and through licence conditions in the second[31]). In general, we licence exempt uses where there is no need to co-ordinate the individual use of spectrum and therefore no need to limit the numbers of users.[32] This tends to be for low power uses where the risk of interference from uncoordinated use is low. For higher power uses we typically need to limit the number of users and so need to authorise spectrum access via a licence.

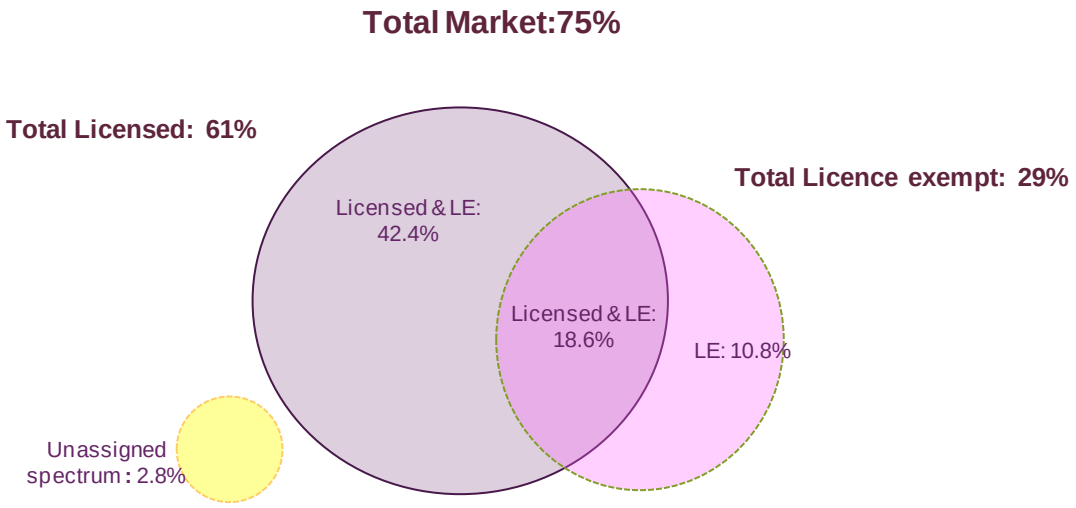
4.16 The percentage of total spectrum that is accessed by each main authorisation approach is illustrated in Figure 7 below: 61% of total spectrum is accessed on a licensed basis, whilst 29% can be accessed by licence exempt uses. Access to spectrum is shared by licensed and licence exempt use in 18.6% of the spectrum.

31 Both of which reference Interface Regulations that are technical regulations which (under the European Directive 98/34/EC) we are required to notify to the Commission in draft form before being adopted in national law. This procedure is aimed at providing transparency and control in order to ensure that there are no unjustified barriers to trade introduced by Member States through these regulations.

32 There are some particular circumstances where we still require users to obtain a "light" licence even through there is no need to co-ordinate the individual use of spectrum and the licence can be obtained on demand without limitation on the numbers that can be issued. These circumstances are explained in Annex 3.

4.17 Figure 6 also shows that there is also a small proportion of spectrum for which there is currently no use authorised (2.8% of total weighted spectrum); this mainly relates to two bands above 45 GHz that are allocated for use by satellite, but for which no authorisations are available (as there are currently no satellites transmitting in these bands) and a band that we are in the process of making available for licence exempt use.[33]

Figure 6: Proportion of total weighted spectrum accessed via licensed use and Licence Exempt Use



Main types of licensed access

4.18 Where we licence spectrum use, access is provided through two main types of licence: Block Assigned or Ofcom Managed. There is a significant distinction between these two modes of spectrum access:

- Ofcom Managed (OM) access is provided by a set of "standard" licence products: this is where we coordinate the individual assignment of frequencies within a band often on a first come first served basis: where we need to undertake technical coordination of individual transmitters before making assignments; where we make narrow channels available on a UK wide (or more limited area) basis; or where devices are low power, but cannot be made licence-exempt, and are available on request under "light licence" products.

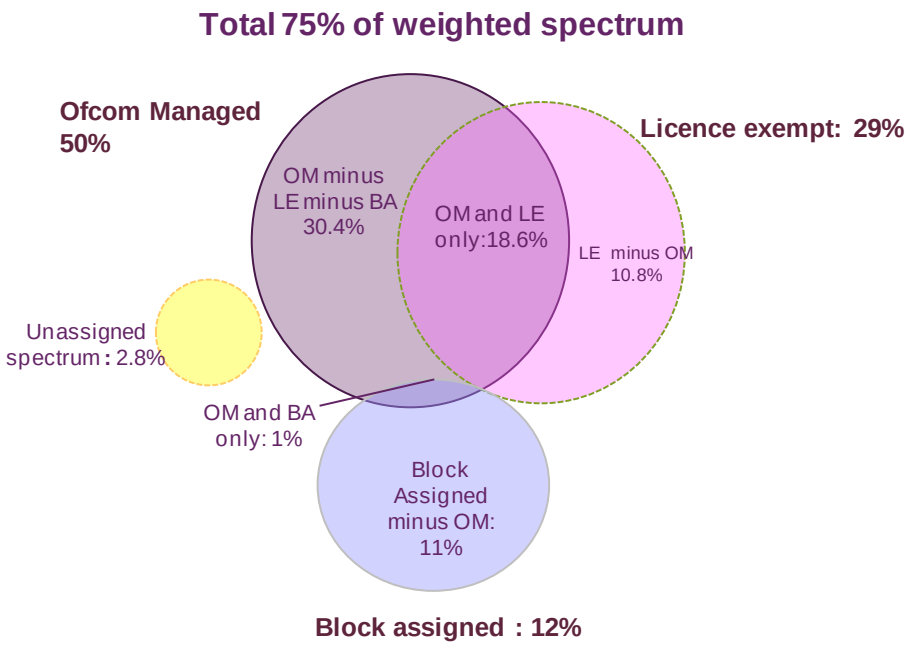
- Block-Assigned access is provided through licences that grant access to a large range of frequencies in one "block" (or two blocks in the case of paired spectrum); many of these block assignments have been awarded via auction to one or more users under licences which give these licensees significant flexibility in the way that they manage the band concerned (almost always they do this for their own use, but they could also provide spectrum access to third parties as a commercial band manager). This category also includes some long standing administrative assignments such as the 900MHz and 1800MHz mobile network licences.

4.19 Figure 7 below shows the same information as in Figure 6, but with the licensed access now split out into these two main licence types. It shows that half of the total

33 This includes to the bands 870-876 and 915-921MHz where we plan to exempt use; and also 66-71 GHz, 47.2 to 47.9GHz, and 45.5 to 47GHz, which are all extension bands for satellite use but where there is no current authorisations, or use of the band

weighted spectrum (50%) can be accessed via standard Ofcom Managed licence products, whereas a little over a tenth of spectrum (12%) is accessed by Block Assigned uses. The nature and level of spectrum sharing is very different as between Ofcom Managed and Block Assigned spectrum. Within the overall Market access category, there is a significant degree of sharing between Ofcom Managed access and Licence exempt access (the 18.6% figure referred to above). This contrasts with access to Block Assigned use where there is little sharing (1% of the 12 %) with the other methods of authorisation[34].

Figure 7: Proportion of total weighted spectrum available for Market uses by each main type of authorisation[35]



4.20 The distinction between Block Assigned and Ofcom Managed licence access is significant in a number of ways. Block Assigned licences are designed to give significant freedom to the licensee to deploy equipment as they see fit and are often used to provide infrastructure services such as mobile access. Our policy is to make these as flexible as we can, including the ability to change use if this can be done within the broad technical conditions of the licence. We also have a general presumption in favour of varying the licence conditions of these licences provided this does not impact adversely on other users, typically adjacent users, (or if these users agree to the change perhaps as part of a commercial deal) and subject to consideration of the potential impact on competition in downstream markets.

4.21 In contrast Ofcom Managed licences are typically more restrictive in terms of how the spectrum can be used or provide more limited access to frequency ranges. This is necessary because we co-ordinate individual assignments between different users in a band shared with a large number of individual users. e.g. for point-to-point links we need to technically co-ordinate hundreds or thousands of individual point-to-point links and ensure that all users can operate effectively.

[34] This relates to a licence held by UKBB in parts of the 3.6 – 4.2 GHz band where it is a condition of its licence to co-ordinate with other Ofcom Managed uses in the band
[35] Note the Venn Diagram provided is illustrative and is not to scale

4.22 Where new access rights are granted in the form of Block Assigned licences these are typically awarded through an auction. These are "one-off" opportunities to acquire these rights from Ofcom, although they can typically be traded in the secondary market. In contrast, access to spectrum through Ofcom Managed licences is available on demand (which is why we refer to them as "standard licence products") although, if only a limited number can be made available, they are typically made available on a first come first served basis.

4.23 Block Assigned licences are more attractive for trading because they are typically higher value (they provide access to far greater amounts of spectrum on a more flexible basis) than Ofcom Managed licence products.

Detail within different types of Market access

4.24 The remainder of this section provides further detail on the make-up of Market access in terms of each of the three types of access authorised by Ofcom (Licence Exempt, Block Assigned and Ofcom Managed).

Access to spectrum by Licence Exempt uses

4.25 The additional analysis presented below sheds light on three further aspects of the access to spectrum by licence exempt use:

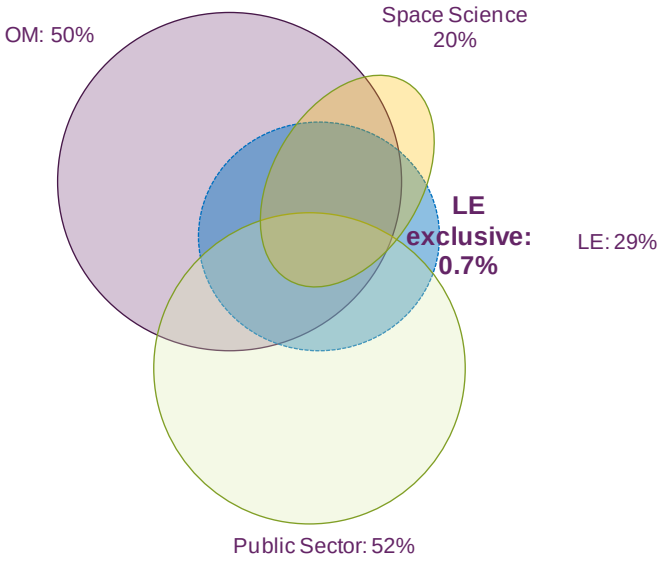
- The very significant extent to which it accesses spectrum on a shared basis with other types of spectrum use (as opposed to having its own exclusive access to bands[36]);
- The distribution of its access between the four different frequency ranges from 87.5MHz to 86GHz, showing that it has proportionately much less access below 1GHz than it has above 1GHz; and
- The different nature of licence exempt uses, based on a broad distinction between mass market consumer applications and more specialist, niche applications.

4.26 We have deliberately not included two specific types of Licence Exempt use from the analysis presented here: receive only use and Ultra-Wideband (UWB) use as both of these uses can access the entire spectrum range and so would obscure the picture.

4.27 In order to convey a picture of the full extent to which licence exempt access shares with other types of spectrum use it is necessary to take account of sharing not only with Licensed uses (as in Figure 7 above) but also with Public sector and Space science uses (noting that licence exempt use is not split out as a separate component of market access in Figure 4 above). This fuller extent of spectrum sharing is illustrated in Figure 8 below. Notably, only a small fraction of spectrum is made available to licence exempt use on an exclusive basis, 0.7% of total weighted spectrum.

[36] Although it should be recognised that different types of Licence Exempt use may also share access to spectrum

Figure 8: Extent of sharing of spectrum by licence exempt uses[37]

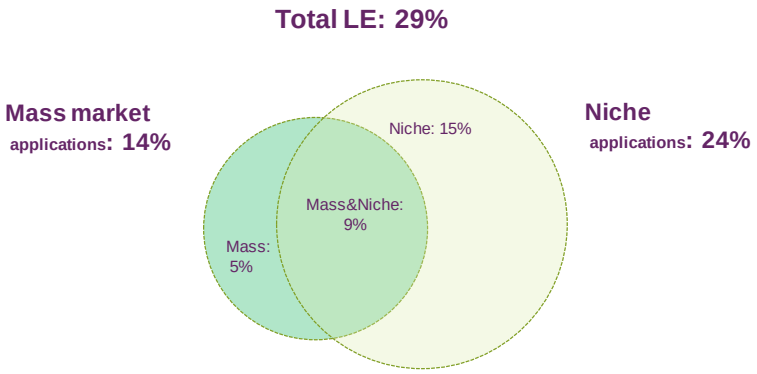


4.28 Licence exempt use includes a huge range of different applications which generate very substantial economic and consumer value. It is challenging to divide this range of applications into different categories in order to understand which applications contribute most to the overall 29% figure. However, we have tried to differentiate between applications for mass market uses such as Wi-Fi, automotive short range radars, short range devices etc and application for niche uses of spectrum such as data buoy telemetry and Railway level crossing radar.

4.29 Further analysis, shown in Figure 9, indicates that niche applications access *82%* of spectrum that is available for Licence Exempt use overall (24% of total spectrum). Mass market applications have access to around half of spectrum that is available for Licence Exempt use overall (14% of total spectrum). There are also two specific niche applications, Tank Level Probing Radar and radar level gauges, that have very similar characteristics to Ultra wideband (UWB) applications but are more constrained in terms of the bands in which they are permitted to operate. If these two applications were to be removed from the analysis, , then access to spectrum by Licence Exempt uses would be significantly less, at 17% rather than 29% of total weighted spectrum. This compares to the share of the total weighted spectrum that is made available for Wi-Fi devices in the 2.4 and 5 GHz bands which together represent only 2% of total weighted spectrum.

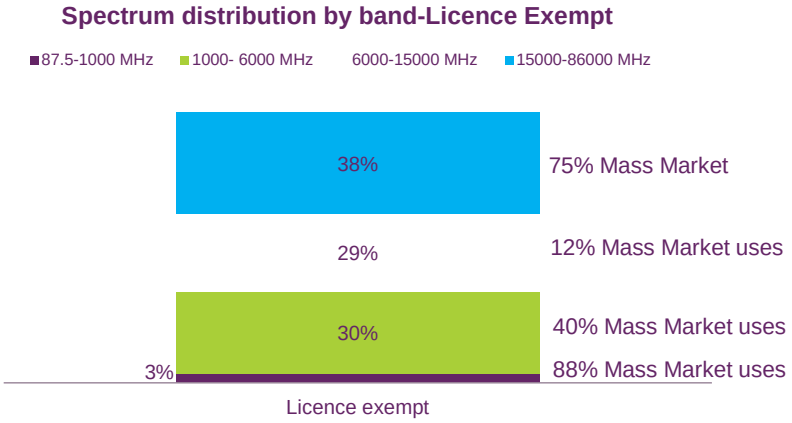
[37] Note the Venn Diagram provided is illustrative and is not to scale

Figure 9: Proportion of spectrum made available for mass market and niche Licence Exempt uses



4.30 Looking into Licence Exempt use from a perspective of the specific frequencies they have access to, Figure 10, below, provides a breakdown by the distribution of frequencies to which it has access. We see that the majority of spectrum available for licence exempt use is above 6 GHz (*67%* of the spectrum made available to licence exempt uses) with only *3%* being below 1GHz.

Figure 10: Distribution of frequency bands for spectrum made available for licence exempt uses and the access provided to mass market applications



4.31 However, unsurprisingly, mass market applications dominate the use of the lower frequencies with *88%* of the spectrum made available for licence exempt use below 1 GHz being for mass market applications. Perhaps more interesting is the extensive use of spectrum by mass market applications above 15GHz, with nearly three quarters (*75%*) of the spectrum available for mass market applications.

Block Assigned access to spectrum

4.32 Figure 7, above showed that 12% of total weighted spectrum is accessed via Block Assigned licences.

4.33 There are currently 16 Block Assigned licences as listed in the table below. The table also shows the sectors to which we have attributed the spectrum bands authorised by these licences, together with the % of total weighted spectrum that the licences represent, for the purposes of the sector analysis in Section 5.

Frequency bands	Sector attribution
412 – 414 MHz paired 422 – 424 MHz	Business radio

GSM-R (876 – 880 MHz paired with 921-925 MHz)	(0.1% of total weighted spectrum)
800 MHz (791-821 MHZ paired with 832-862 MHz)	Mobile& wireless broadband (8.4% of total weighted spectrum)
900 MHz (880 – 915 MHz paired with 925 960 MHz)	
L-band (1452 MHz – 1492 MHz)	
1800 MHz (1710 – 1781.5 MHz paired with 1805 1876.5 MHz)	
Concurrent spectrum access (1781.7 – 1785 MHz paired with 1876.7 – 1880 MHz)	
2100 MHz (1900 – 1920, 1920 – 1980 MHz paired with 2110 – 2170 MHz)	
2600 MHz (2500 – 2570 MHz paired with 2620 – 2690 MHz, 2570-2620 MHz)	
3.5 GHz (3480 – 3500 MHz paired with 3580 – 3600 MHz)	
3.6 GHz (3605 – 3689 MHz paired with 3925 – 4009 MHz)	
10 GHz (10.125 – 10.225 GHz paired with 10.475 – 10.575 GHz)	Fixed links[38] (3.4% of total weighted spectrum)
28 GHz Spectrum Access (27.8285 – 28.445 GHz paired with 28.8365 – 29.4525 GHz)	
32 GHz (31.815 – 33.383 GHz)	
40 GHz (40.5 GHz – 43.5 GHz)	

Access to spectrum by Ofcom Managed licence products

4.34 As noted above, Ofcom Managed licence products have access to half of total weighted spectrum (50%). These licence products can be subdivided by either:

- Licence type, of which there are three broad types (Area Defined licences, Technically Assigned licences and Light licences) as explained in annex 3: or
- The sector that the licence product supports.

4.35 In the next section we discuss our more detailed analysis of the spectrum accessed by the individual Market sectors however that access is provided (i.e. whether through Licence exemption, Block assigned licences or Ofcom Managed licence products). However, it is worth noting here that the majority of access provided to the licensed sectors, with the notable exception of mobile and wireless broadband, is through our Ofcom Managed licence products (80%). In particular, the vast majority of access by the following sectors:

- Fixed links – providing terrestrial point-to-point links between two fixed locations and scanning telemetry
- Satellite – which covers a range of uses delivered over satellites

[38] In the 28 GHz licences there are explicit technical conditions for both terrestrial and satellite services but currently we understand that no licensee has taken advantage of the ability to use satellite services

- Business radio – which covers a range of uses, providing private mobile radio services,
- Maritime radio – which covers a range of maritime uses,[39]
- Programme making and special events (PMSE) – primarily providing time limited access to spectrum, shared with a primary user, for the use by wireless cameras and microphones[40],
- Amateur and Amateur satellite use – which covers a range of uses by amateurs both terrestrially and by satellite, and
- Broadcasting – this covers use of spectrum by terrestrial broadcasting of radio and TV[41].

[39] Including Ship licences
[40] The day-to-day technical co-ordination of assignments is managed on our behalf by JFMG Ltd but we manage the band in terms of deciding the spectrum bands and licence products available for use by PMSE users
[41] Broadcasting licence products are different from the other Ofcom Managed classes, in that they are not available as a "standard" product on first come first served basis, but are administratively assigned by Ofcom. Ofcom does, however, manage all the detailed technical co-ordination work needed to ensure that the coverage obligations of the PSB providers are met and so are considered as Ofcom Managed licence products for the purposes of our discussion and analysis

Section 5

Spectrum attribution metrics - sector view and sharing of spectrum

Introduction

5.1 In this section we analyse the extent to which individual sectors can access spectrum and the degree of sharing that takes place between different sectors and different categories of spectrum access. In particular we describe:

- the sectors we have used for this analysis,
- the extent to which these sectors gain access to spectrum through our Ofcom Managed licence products (as opposed to Block Assigned licences or licence exemption);
- the proportion of spectrum to which each sector has access and the distribution of the frequency bands in which this access occurs; and
- the extent of sharing of spectrum between the sectors: and
- our assessment of the overall level of spectrum sharing.

5.2 In the following discussion all percentages quoted, unless otherwise stated and indicated by *italics,* are percentages of total weighted spectrum.

Sectors

5.3 All of the spectrum bands have been attributed to one (or more) sectors. These sectors are:

- Fixed links
- Satellite
- Business radio
- Maritime radio
- Programme making and special events (PMSE)
- Amateur and Amateur satellite use
- Broadcasting
- Mobile
- Licence exempt use
- Space Science

- Unassigned – a small number of bands mainly above 40 GHz for which we do not currently authorise any use.

5.4 We have not included Aeronautical in the above list of sectors because it is treated as being part of the Public sector category for the purposes of this analysis (for reasons explained in Section 4) and because the analysis in this document does not analyse Public sector access except at the aggregate level. However, we note that the Aeronautical sector has access to 14% of spectrum.

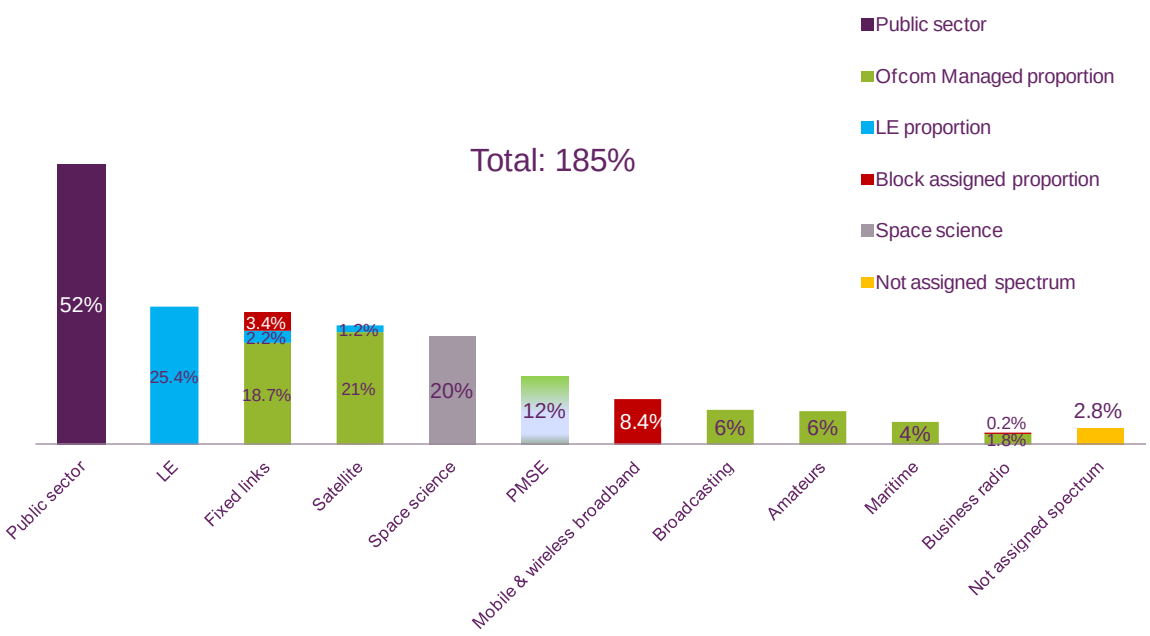
5.5 To identify the spectrum to which individual sectors have access we have:

- Attributed a sector to each of the Ofcom Managed licence products, as indicated in Section 4 and Annex 2;
- Attributed a sector use for each of the Block Assigned licences as described in Section 4; and
- Attributed licence exempt access to a specific sector in a small number of cases where the nature of the licence exempt use makes this appropriate.

Proportion of spectrum available by sector

5.6 Figure 11 shows the proportion of spectrum that is authorised for use by each of the sectors, together with the way this access is made up (in terms of the different methods discussed in the previous section).

Figure 11: Proportion of total weighted spectrum made available to each sector and how it is accessed



5.7 From the figure above it is clear that, aside from Public sector use of spectrum, the sectors that have greatest access to spectrum are licence exempt, fixed links,

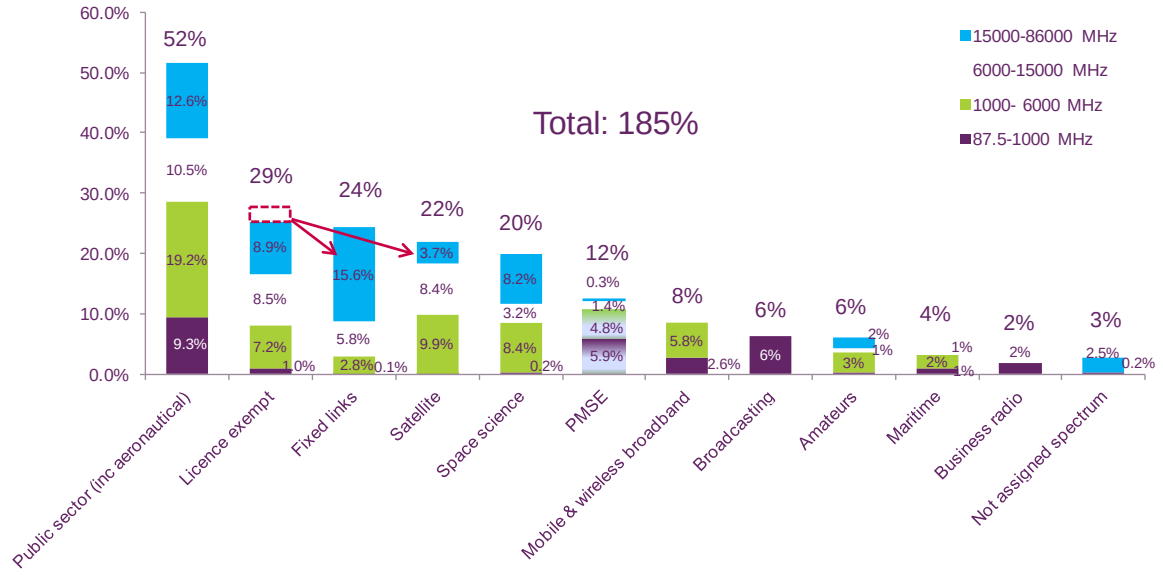
satellite and Space science which all have access to at least a fifth of the spectrum bands.

5.8 For most of the sectors that make up Market access (i.e. excluding Public sector and Space science use) their access to spectrum is obtained primarily through one of our Ofcom Managed standard products, with the notable exception of mobile & wireless broadband which is primarily accessed by Block Assigned Licences.

5.9 We note that the sum of all the columns in Figure 11 and also in Figure 12 comes to 185%. This is because spectrum bands that are accessed by more than one sector are recorded in each of the bars representing the sectors that have access to it. This exposes the extent of sharing of spectrum between the sectors. We discuss sharing in more detail in later sub-sections of this Section.

5.10 A different cut of the analysis shows the distribution of frequency bands to which the individual sectors have access as in Figure 12. So, for example, of the 24% of spectrum to which fixed links have access, 5.8% (of this 24%) is in the frequency range 6-15GHz.

Figure 12: Proportion of total weighted spectrum made available and distribution of spectrum made available to each sector



5.11 From this frequency view we note that, of the sectors which have access to more than 20% of the spectrum, the access for each of Licence Exempt, Space science and fixed links is skewed towards the upper frequencies. For example, two thirds of the spectrum accessed by Space science is above 6GHz and it has virtually no access below 1 GHz. In contrast, the satellite sector, with access to 22% of the total weighted spectrum has nearly half of this access between 1 and 6 GHz.

5.12 The mobile, broadcasting and business radio sectors on the other hand have access to much smaller amounts of spectrum (8%, 6% and 2% respectively). But all of this is below 1 GHz for business radio and broadcasting, and over a third below 1 GHz (*37%*) for mobile and wireless broadband.

5.13 As we discuss in a little more detail below, the access to spectrum that we provide to PMSE is much more restricted in both geographic and frequency than access for

other uses and we have reflected this in the above graph by the hatched shading. The figure of 12% therefore needs to be interpreted in this light.

Sharing of spectrum bands by sectors

Overall level of spectrum sharing

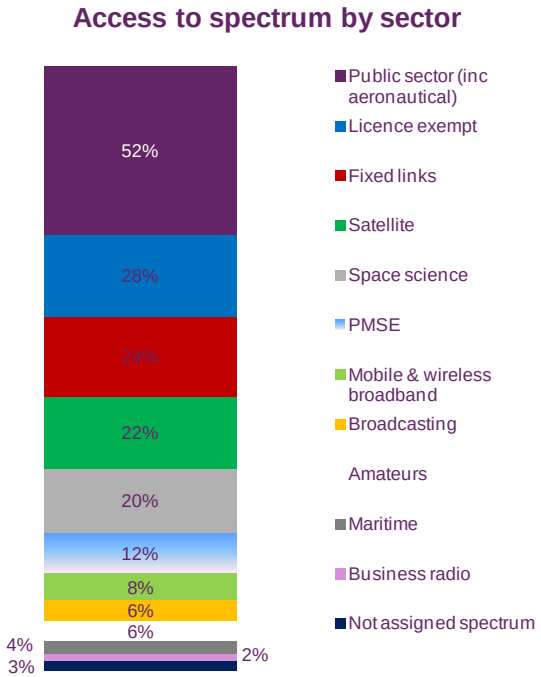
5.14 For the purposes of our analysis of the spectrum attribution metrics we describe spectrum as being shared if a spectrum bands is given two or more spectrum attributes. i.e. it is:

- accessed by two or more of Market, Public sector of Space science uses: and/or
- its use is authorised by us in two or ways: Licence Exempt, Block Assigned licence or Ofcom Managed; and/or
- two or more sectors have access to the band.

5.15 However, this view of sharing does not take into account the sharing of spectrum by individual licensees in any band. We also note that this analysis does not seek to reflect the extent of geographic sharing in a band (i.e. a band is treated as being shared if there is any geographic sharing of frequencies within it).

5.16 As noted above, our sector analysis of spectrum access has shown that the sum of access across all sectors adds to 185%. We refer to this as a "sharing re-use factor" of 1.85 which means that, on average, access to spectrum is shared by two uses. This is illustrated again as a stacked chart in Figure 13 below (which we return to below when considering its breakdown by frequency range).

Figure 13: Proportion of total weighted spectrum accessed by each sector



5.17 In addition we have been able to identify that a significant proportion of spectrum is made available on an exclusive basis (42% of total weighted spectrum).This includes

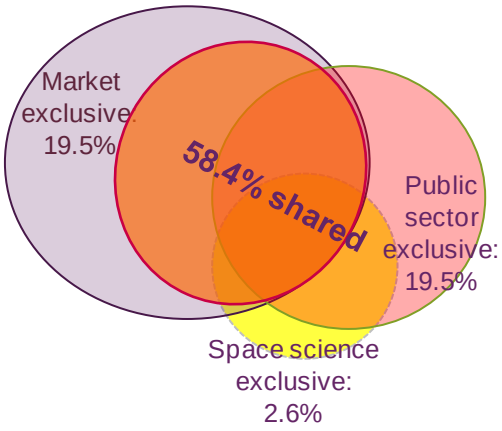
sharing of spectrum within the Market access category between Ofcom Managed, Block Assigned and Licence exempt uses and between two or more Ofcom Managed licence classes as explained in the previous Section.

5.18 The components of this exclusive access to spectrum are:

- Public sector use (19.5%)
- Space science use (2.6%)
- Market uses:
    - Mobile (6%)
    - Fixed links (6%)
    - Satellite (4%)
    - Not assigned spectrum (2.8%)
    - Licence exempt exclusive (0.7%).

5.19 This means that in 58% of spectrum bands there is some level of sharing as illustrative in Figure 14, below.

Figure 14: Extent of sharing in spectrum[42]



5.20 To give an average sharing reuse factor of 1.85 across the total spectrum, but with any level of sharing occurring in only 58% of the total spectrum there must be a reuse factor of 3 in the bands where sharing occurs[43] i.e. where spectrum **is** shared, access to it is shared on average by at least 3 different uses. This points to a contrast between bands that are accessed on an exclusive basis and those which are shared. Looking individually across all the spectrum bands we also note that the greatest level of sharing in any one band is sharing between 4 different access methods.

5.21 Note, however, that we have not tried to analyse the extent of sharing between different types of Public sector users within the Public sector category. If the information were available to do this, the overall level of sharing would be shown to be higher still.

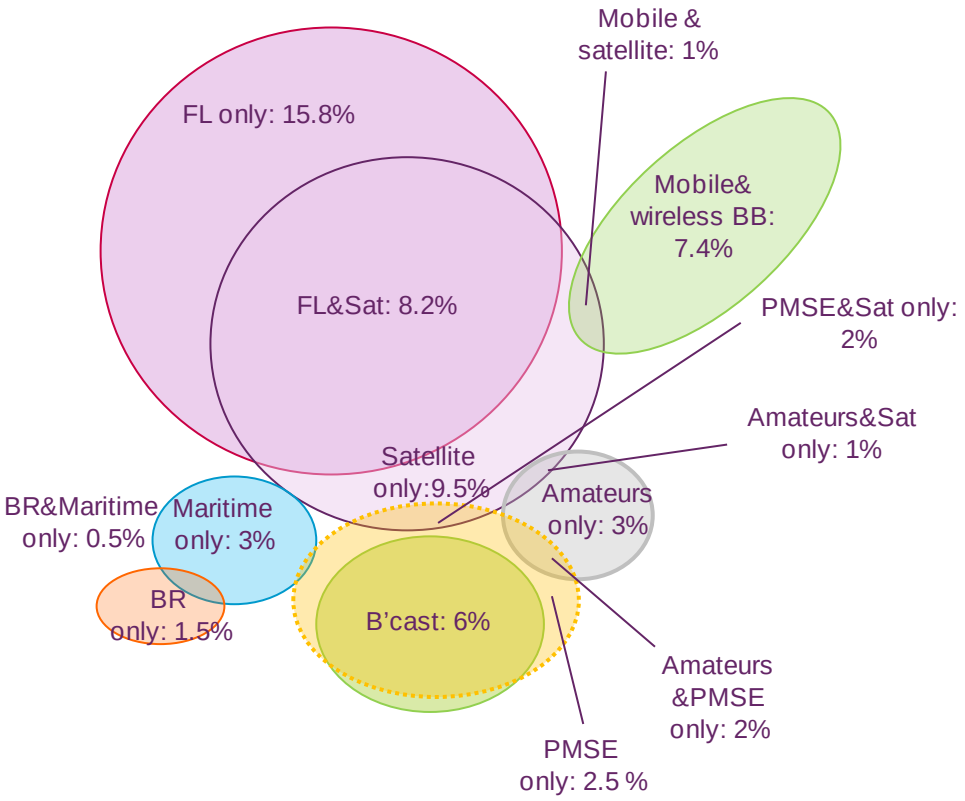
[42] Note the Venn Diagram provided is illustrative and is not to scale
[43] The average of 1.8 occurs in only 58% of the total weighted spectrum and so 1.8/0.58 = 3.1.

Sharing between sectors

5.22 To illustrate better the nature of sharing between sectors we have undertaken some additional analysis of the Ofcom licensed uses on their own as illustrated in Figure 15 below.

5.23 Note that the sharing between sectors in Figure 15 does not represent the full extent of sharing since it is looking only at spectrum accessed via Ofcom licences; as such, it does not take account of sharing with Public sector, Space science and licence exempt use (as this would complicate the view even further).

Figure 15: Proportion of spectrum made available to sectors and the extent of sharing between these sectors[44,45]



5.24 This analysis shows that:

- Fixed links and the satellite sector share a considerable amount of access to spectrum (*30%* and *50%* respectively of the spectrum they have access to);
- Fixed links and satellite access 15.8% and 9.5% of spectrum respectively that they do not share with other sectors but only 6% and 4% on a truly exclusive basis as we said in the previous section. They thus share extensively with Space science and/or Public sector;

[44] This view excludes the additional 1% of spectrum shared in total between: maritime and satellite, PMSE and maritime, PMSE and fixed links, fixed links and amateurs, business radio and fixed links, therefore the total is 49% rather than 50% quoted elsewhere in this document
[45] This view considers Market uses only and therefore does not consider the sharing of these sectors with Public sector and Space Science

- Mobile and wireless broadband have almost exclusive access to spectrum, sharing with other sectors in only 1% of the 8%. However, as we have stated above they have access to only 6% on a truly exclusive basis.

5.25 All of the other sectors which show spectrum which appears to be exclusive e.g. “maritime only”, “Amateur only” share this entire spectrum with either the Public sector, Space science, or Licence Exempt use as they have no exclusive access to spectrum as we discussed previously.

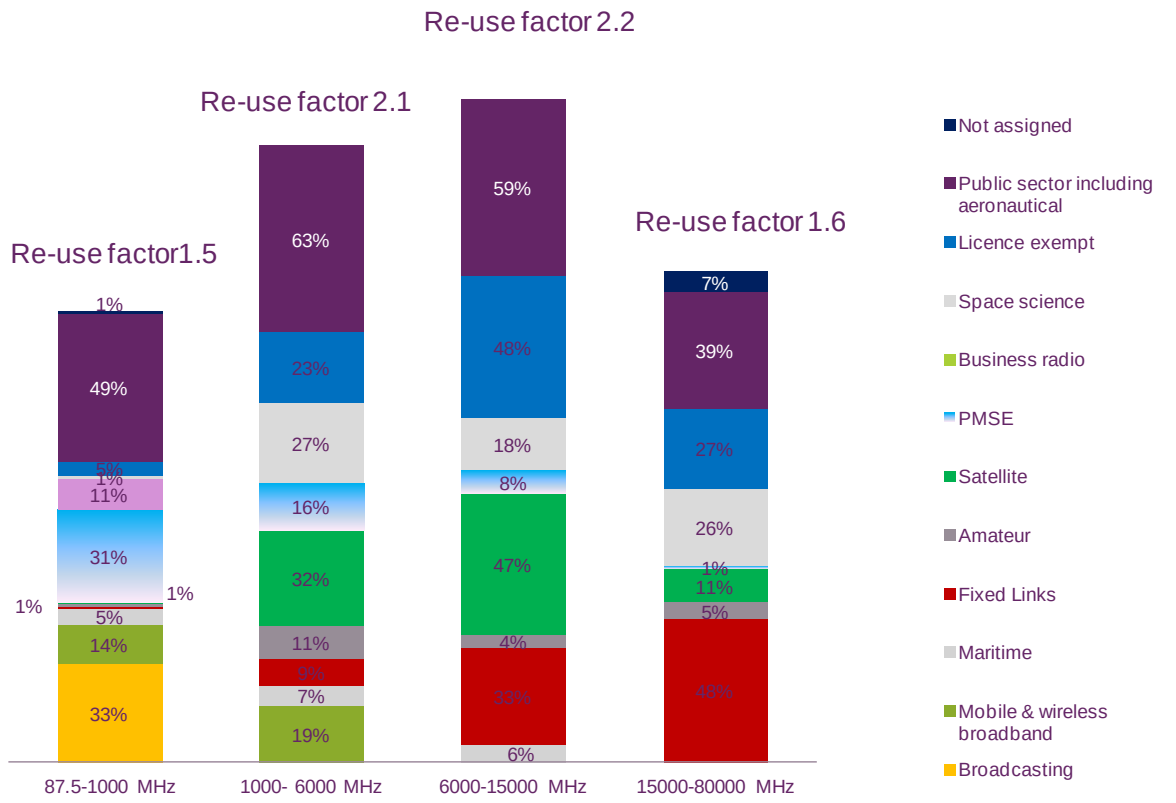
5.26 In the figure above access to spectrum by PMSE is shown with a dotted line to reflect the unusual nature of how PMSE use gains access to spectrum. Access to spectrum for PMSE is typically required, and authorised by us, on a temporary and shared basis. PMSE use is mainly authorised in distinct, relatively small locations for short periods of time (from days to weeks) and we co-ordinate its use around the major user(s) of the band who we permit to use the spectrum permanently. As a result, in bands where PMSE use can be authorised this use is severely restricted in terms of the number of frequencies that they have access to in any specific location. For example where it shares spectrum with terrestrial TV broadcasting PMSE use is only permitted in the “white space” needed to protect TV transmitters from interfering with each other. For this reason we indicate in the diagram above that the spectrum that is notionally shared between PMSE and broadcasting is, in practice, available primarily to broadcasting.

Sharing and sector access across the frequency ranges

5.27 Finally we have analysed access to spectrum by the individual sectors across the four spectrum ranges that we have presented previously to indicate what proportion of the weighted spectrum is available in each of these bands for each sector, this is provided as Figure 16 below.

5.28 From this it is possible to see the extent of sharing in each of the frequency ranges. By adding up the spectrum bands available for each sector in each range we can see how much of the spectrum is made available for more than one use. For example in the range 87.5 MHz – 1 GHz, the sum of spectrum access across all sectors comes 150% of total weighted spectrum in this range; this reflects a sharing reuse factor of 1.5. This compares to the frequency range between 6 and 15 GHz where there is a sharing reuse factor of 2.2. Across the full spectrum range from 87.5MHz to 86GHz, the average sharing reuse factor is 1.85 as noted above.

Figure 16: Proportion of spectrum available for individual sector use in each of the four spectrum ranges



5.29 From this it is interesting to observe that:

- For Space science the distribution of spectrum it has access to is skewed to the higher frequencies with between a fifth and a quarter of spectrum in each range above 1 GHz (between 18% and 27%) and only 1% below 1 GHz;
- Similarly fixed links is skewed to the higher frequencies having access to a third of the spectrum in range 6-15 GHz and almost half of the spectrum above 15 GHz (33% and 48% respectively). In the lower frequencies they have access to less than 10% between 1 – 6GHz and virtually none below 1 GHz;
- For satellite services, access is concentrated between 1 and 6 GHz and 6 and 15 GHz, where they have access to nearly a third and a half of the spectrum respectively (32% and 47%);
- With the notable exception of Public sector and those sectors that only have access to the sub-1 GHz spectrum[46], PMSE has the greatest access to spectrum in this band, although that use is heavily constrained as we have discussed previously.

[46] Broadcasting and business radio

Annex 1

Glossary of terms

A1.1 The following provides a glossary of the main terms used in our analysis of the spectrum attribution metrics.

- *Market access*: all spectrum bands where use is authorised by Ofcom (through a licence or explicit licence exemption[47]).
- *Public sector access:* all spectrum bands used by the public sector with Crown immunity (i.e. without need for authorisation by Ofcom). This category includes all aeronautical uses of spectrum.
- *Space Science use*: all spectrum bands that are allocated to a range of space science uses on a Primary basis in the UK FAT.
- *Ofcom Managed access:* all spectrum bands where use is authorised by our standard licence products and where Ofcom is responsible for the co-ordination of individual assignments in the band. This category includes all terrestrial broadcasting uses of spectrum.
- *Licence exempt access:* all spectrum bands where use is authorised through our licence regulations, which include the technical conditions devices need conform to, but for which no further co-ordination of individual uses is required[48].
- *Block Assigned access:* all spectrum bands where use is authorised by us through individual licences granted for a contiguous block of spectrum over a wide geographic area and where the technical co-ordination of use within the block of frequencies is the responsibility of the licensee.
- *Crown spectrum:* the spectrum bands identified by the FAT as being managed by Crown bodies including MoD, Department for Transport, Home Office.
- *Civil spectrum*: the bands identified by the FAT as under Ofcom management.

[47] Excluding receive-only use which is exempted under a general licence exemption across all bands and is not band specific

[48] Spectrum bands that provide licence exempt access to UWB, handset terminals and receive-only terminals were not included in this category.

Annex 2

Methodology and definitions of the spectrum attributes

Introduction

A2.1 The following annex provides a high level description of the methodology by which we decided the spectrum attributions to give to individual spectrum bands and how we defined the spectrum attributions.

A2.2 It also includes a discussion of the weighting factor used in the analysis.

Types of spectrum attributes

A2.3 In presenting the spectrum attribution metrics we analysed frequency bands between 87.5 MHz and 86 GHz[49]. We decided on these limits because we think that these frequencies are currently the most usable and important frequencies available. The upper limit of 86 GHz is the highest frequency for which we authorise uses[50],[51] and the lower limit is the beginning of the FM radio bands.

A2.4 We defined 3 main types of attributes that we thought of interest and that we analysed in this document, which are defined in more detail later in this Annex:

i) Whether access to the spectrum is provided to:

- Market uses, through Ofcom authorisations, and/or
- Public sector uses through use of Crown rights to use spectrum without authorisation; and/
- Space science uses, which mainly do not require explicit authorisation from Ofcom as the transmitters are in outer space, and/or the use in UK is receive-only.

ii) For Market uses, whether the access to the band is managed by:

- Ofcom - "Ofcom Managed use", and/or
- Licence exemption regulations – "Licence exempt use, and/or
- Licensees of block assigned licences – "Block Assigned use".

iii) What sector makes use of the spectrum:

- Aeronautical

[49] This is a slight change from the data presented in our Spectrum management strategy which went up to 81 GHz

[50] Except for receive only uses that are authorised for all bands through licence exemption regulations.

[51] Although uses, including Earth Exploration Space Services, do make use of spectrum above 86GHz

- Space Science
- Satellite
- Fixed Links
- Business radio
- Maritime
- Amateur
- Mobile and Wireless Broadband
- Licence exempt
- Not used

A2.5 For any specific band it will have at least two of these attributes: Market use, Public sector use or Space science and a sector. It is, however, possible for a band to have many more of these attributes[52] because of the amount of sharing that is possible in these bands:

- Public sector and Market users share the use of some bands;
- different authorisation types share access to bands, such as licence exempt and Ofcom Managed use;
- for different uses to share the use of a band;
- For example, access may be provided both to Public sector and Market uses in a single band (e.g. PMSE and Amateur Market access in MoD managed bands); or be provided to more than one standard Ofcom licence product (e.g. satellite Permanent Earth Stations and Fixed links); and it is usual for licence exempt use to share with other types of access including Public sector or other licensed use.

Definitions of spectrum attributes

A2.6 The definitions for each of the high level spectrum attributes are provided in the previous Annex, Annex 1 as a Glossary.

A2.7 We also defined a set of sectors that we attributed to spectrum bands:

- Public sector - spectrum bands that public sector use under Crown immunity, this included the Aeronautical sector
- Space Science – spectrum bands that are used by Space science uses under a primary allocation in the FAT;
- Satellite – spectrum bands that have a Satellite Fixed, Mobile or Broadcasting use authorised, including the licence exempt uses of MSS. It also includes Global Navigation Space Services;

[52] Although very few bands, if any, have all of these attributes

- Fixed Links – spectrum bands that have fixed links authorised for use. This includes Block Assigned bands where the technical licence conditions imply, in our view, that they are primarily likely to be used for fixed links. This category excludes bands where fixed links are licensed but the band is closed to new link assignments;

- Business radio – spectrum bands where business radio uses are authorised. This category does not include emergency services use (in Public sector use), nor scanning telemetry in UHF bands (in fixed links);

- Maritime – spectrum bands that have maritime uses authorised including ships use;

- Amateur – spectrum bands that have amateur use authorised;

- Broadcasting – spectrum bands that have terrestrial radio or TV broadcasting authorised;

- Mobile and Wireless Broadband – spectrum bands in which mobile or wireless broadband use is authorised. This category is primarily Block Assigned licences where the technical conditions lend themselves, in our view, to mobile or wireless broadband use;

- Programme Making and Special Events (PMSE) – spectrum bands in which PMSE use is authorised;

- Licence exempt – spectrum band in which licence exempt use is authorised, but excludes bands in which licence exempt for MSS handsets are authorised which are included in the satellite sector and bands in which licence exempt use of point-to-point is authorised which are included in the fixed link sector; and

- Not used - this is primarily spectrum bands above 40 GHz that are allocated to satellite services for expansion but for which no authorisation exist.

Assignment of attributes

Sources of information

A2.8 We assigned these attributes to spectrum bands from four main sources of information:

- the UK Frequency Allocation Table (FAT);

- the UK Plan for Frequency Authorisation (UK PFA);

- the licence exemption regulations; and

- the knowledge of our sector specialists.

A2.9 The UK FAT[53] is issued by the National Frequency Planning Group on behalf of the Cabinet Official Committee on UK Spectrum Strategy. The UK FAT details the uses

[53] UK FAT is available http://stakeholders.ofcom.org.uk/spectrum/information/uk-fat/)

to which various frequency bands can be put in the UK (referred to as 'allocations') and the division of responsibilities between a variety of bodies, including Ofcom, MoD and other Crown bodies responsible for planning and managing these bands. This division reflects the understanding that for the purposes of managing and co-ordinating spectrum use between public sector users[54] and users authorised by Ofcom, specific bands are broadly designated for “military” or “civilian” use. The FAT also includes footnotes that designate specific bands for use by other public sector bodies and includes specific reference to the arrangements for using and sharing aeronautical bands co-ordinated by CAA and MoD.

A2.10 This publication has no legal status. However, it is an extremely useful document because it sets out broadly how the radio spectrum use is “allocated” to different bands within the UK. The FAT also reflects the international regulatory framework of the International Telecommunications Union (ITU) allocations plan within the Radio Regulations.

A2.11 The UK PFA[55] provides details on the frequencies authorised by Ofcom. It includes a list of licences available through Ofcom and provides information on how they are allocated and whether or not they can be traded.

Public sector use

A2.12 Public sector use was primarily identified through careful interpretation of the footnotes in the FAT in combination with the judgement of our sector specialist. This category includes spectrum used exclusively by Crown bodies and spectrum managed by Crown bodies (e.g. the MOD and the CAA), but where specific provisions allow Ofcom to manage civil uses within the same band(s). These bands have UK2, UK3 or UK4 allocation provisions associated with them and civil access is allocated typically under a UK4.xx provision.

A2.13 This category also includes cases where bands managed by Ofcom have a UK1 provision associated with them, but also have specific provisions for shared Crown uses. Specific footnotes in the UK FAT are used in these cases often Crown access is often limited to specific radiocommunication services. An example of such a case is where the FAT includes specific reference to MoD radiolocation use in a UK1 band and also includes spectrum bands where the FAT indicates a residual MoD use in a band. It excludes bands where MoD uses are allowed access to a band on a non-interference basis to critical civil services.

A2.14 For the purposes of the analysis presents in this document this category also includes all spectrum bands that are identified for aeronautical uses (as identified in the UK PFA and UK FAT). This is because the objective of the spectrum attribution metrics is to reflect who (or what sector) is authorised to use the spectrum or who is preventing others from using spectrum (where no use is authorised such as in Public sector or Space science use).

A2.15 In the case of aeronautical spectrum the decisions on the use of the spectrum, including potential future changes in use, is highly constrained by the safety requirements of the aeronautical sector which is the responsibility of the specialist aeronautical regulator CAA, which also undertakes the assignment of civil frequencies in the band. The situation is further complicated by the extent of spectrum co-ordination required between the civil and military uses of the spectrum,

[54] Where that use is under Crown immunity
[55] The UK PFA is available http://spectruminfo.ofcom.org.uk/spectrumInfo/ukpfa

particularly in shared airspace. As such we decided that any attempt to reflect this sharing was somewhat artificial and would distort the overall picture.

Market uses

A2.16 Market uses of spectrum were primarily identified through the PFA which provides details of what licence products are authorised in specific frequency ranges. As such it provides a greater level of detail than the FAT about authorised use of spectrum bands and provides more granular detail on frequency bands. For example, it provides details on whether the use authorised is business radio or PMSE whereas the FAT will only indicate that a "mobile use" is allocated.

A2.17 Where the PFA indicates Market uses that are directly related to Space science uses these were excluded from the Market uses category so that our analysis of spectrum sharing does not "double count" the use.

Space science uses

A2.18 Space science use of spectrum was primarily identified using the FAT with careful interpretation by our sector specialists. The main bands that are included in this category are those used by Radio astronomy, Meteorological-satellite services and Earth Exploration Satellite Services (passive, active, uplink and downlink). It also, however, includes bands used by other related radiocommunication services including Space operations and Space Research. Only bands that are identified as Primary services in the UK FAT were included.

A2.19 Space science use was identified as distinct from Market and Public sector uses because for the vast majority of the use made by Space science use they do not require explicit authorisation from Ofcom as they either use transmitters in outer space and/or use receive-only equipment. However, the use of the spectrum by these services prevents or constrains the use of bands for other uses and we take this use into account when we make decisions on future changes of use.

A2.20 There are a small number of spectrum bands where the use by Space Science is authorised. This includes a small number of licensed Permanent Earth Stations and RSA[56] for a small number of receive-only earth stations. For the purposes of this analysis these were included in the Space Science category, but not in the Market use category so as not to "double count" the use.

A2.21 Space science use is primarily funded by public sector bodies[57] which fund the satellites that use the spectrum and as such is similar to the Public sector use of spectrum. However, the spectrum is also used by academic researchers and others with an interest in the subject matter. It is not recognised as public sector spectrum under the terms of the FAT.

A2.22 For Radioastronomy we identified those bands that we continue to provide protection for through RSA below 42 GHz and above this we included all bands that are allocated on a Primary basis. For the avoidance of doubt we included the bands that are international harmonised for passive uses under Radio Regulations footnote 5.340.

[56] Recognised Spectrum Access
[57] Met Office, UK Space Agency and STFC

A2.23 A small number of bands are used for Met Office radars that we included in this category in order to keep all Meteorological uses together.

Ofcom Managed uses

A2.24 Importantly, this category relates to a sub-set of spectrum bands where Ofcom authorises spectrum use and does not relate in any way to the management of bands referred to in the FAT, nor intend to imply any restriction on Ofcom's powers to authorise spectrum. The specific bands that are identified in this category are those where we provide standard licence products that stakeholders can apply for on a first come first served basis and are typically in bands where we co-ordinate the shared use of spectrum by many licensees.

A2.25 The Ofcom Managed uses of spectrum were primarily identified using the PFA, but with careful interpretation. This category includes spectrum that is authorised for the following types of licence products:

- Fixed links: point-to-point, scanning telemetry and self co-ordinated
- Business radio: area defined, technically assigned, simple site, simple UK, suppliers light
- Satellite: Permanent Earth stations, Transportable Earth Stations and satellite networks
- Amateur: foundation licence, intermediate licence, full licence
- Maritime: Maritime Navigational Aids and Radar , Costal Stations Radio (various), Differential Global Positioning System, Maritime Radio (Suppliers and Demonstration), AIS (Automatic Identification Systems) and ships: portable and radio
- Broadcasting: radio and TV transmission
- PMSE: Fixed Site, Link, Low Power, UK wireless microphone annual

A2.26 Broadcasting use of spectrum, while not available as a standard product, nor on a first come first basis was included in this category to reflect the extent of Ofcom's involvement in the planning and management of the band including the individual assignments of spectrum to transmitters.

A2.27 Light licensed products, although they are very similar in nature to licence exempt products are included in this category as they still require some level of co-ordination or impose some additional burdens on licensees compared to licence exempt use and we believe would therefore distorted the picture of licence exempt use.

A2.28 Where a band included one of Ofcom's standard products, but its use was for Space science, such as PES use in the EESS bands used by Universities this was excluded from this category so that its use was not "double counted".

Licence exempt use

A2.29 Licence exempt use of spectrum was primarily identified through the licence exemption regulation, with some interpretation.

A2.30 Spectrum to which access is permitted for Ultra-wideband services were excluded as this provides access to very wide spectrum bands for uses that operate under the radio noise floor as this would distort, in our view, the picture for licence exempt use. We also excluded consideration of all receivers, as they are authorised under an authorisation covering all bands and again this would, in our view, distort the picture.

A2.31 We also excluded bands that were authorised for use by handset terminals as the conditions of the exemption usually require these to be connected to a licensed network so as not to "double count" this use. The only exception to this was in the bands used by Mobile Satellite Services (MSS) which are not authorised by us and thus if we had excluded the licence exempt MSS handsets we would not have reflected MSS use of these bands.

A2.32 We have also analysed the types of Licence exempt use and categorised them into mass market applications and niche applications based on our sector expert's knowledge of the uses authorised under each use and the current state of play in terms of equipment availability.

A2.33 Mass market applications have been defined as where the devices are marketed directly to retail consumers. However, for some applications where equipment is expected to be marketed to consumers but is not currently readily available it has not been included as mass market.

Block Assigned use

A2.34 Block Assigned use of spectrum was identified through the PFA with some interpretation. In Section 4 we provide the full list of Block Assigned licences which we reproduce here for completeness

.**Frequency bands**	**Sector attributed to**
412 – 414 MHz paired 422 – 424 MHz	Business radio
GSM-R (876 – 880 MHz paired with 921-925 MHz)	Business radio
800 MHz (791-821 MHZ paired with 832-862 MHz)	Mobile& wireless broadband
900 MHz (880 – 915 MHz paired with 925 960 MHz)	Mobile& wireless broadband
L-band (1452 MHz – 1492 MHz)	Mobile& wireless broadband
1800 MHz (1710 – 1781.5 MHz paired with 1805 1876.5 MHz)	Mobile& wireless broadband
Concurrent spectrum access (1781.7 – 1785 MHz paired with 1876.7 – 1880 MHz)	Mobile& wireless broadband
2100 MHz (1900 – 1920, 1920 – 1980 MHz paired with 2110 – 2170 MHz)	Mobile& wireless broadband
2600 MHz (2500 – 2570 MHz paired with 2620 – 2690 MHz, 2570-2620 MHz)	Mobile& wireless broadband
3.5 GHz (3480 – 3500 MHz paired with 3580 – 3600 MHz)	Mobile& wireless broadband
3.6 GHz (3605 – 3689 MHz paired with 3925 – 4009 MHz)	Mobile& wireless broadband
10 GHz (10.125 – 10.225 GHz paired with 10.475 – 10.575 GHz)	Fixed links
28 GHz Spectrum Access (27.8285 – 28.445 GHz paired with 28.8365 – 29.4525 GHz)	Fixed links
32 GHz (31.815 – 33.383 GHz)	Fixed links
40 GHz (40.5 GHz – 43.5 GHz)	Fixed links

Weighting factor

A2.35 When presenting information on spectrum use across a wide range of frequency bands, we use a weighting factor to take account of the fact that at higher frequency bands there is inherently more spectrum available on a per MHz basis than at lower frequencies. If we were not to use a weighting factor that adjusts for this effect, the higher bands would dominate any view of spectrum, which would not be a fair reflection of the importance of these bands.

A2.36 In the analysis presented here[58], however, we have employed a slightly revised weighting factor that uses:

- A constant weight between 87.5 MHz and 1 GHz so that 10 MHz of bandwidth at 100 MHz is given the same weight as 10 MHz of bandwidth at 1 GHz; and
- An inverse logarithmic weighting factor above 1 GHz, so that the same weight is given to 10 MHz of bandwidth at 1 GHz as to 100 MHz of bandwidth at 10 GHz[59]. .

A2.37 In the past[60], we have applied the simple inverse logarithmic weighting factor to all spectrum, including that below 1GHz. We have refined our approach because we consider that the simple inverse logarithmic weighting factor would place a disproportionate importance on the lower frequencies (for example, it would give as much weight to 1MHz of bandwidth at 90MHz as to 10MHz of bandwidth at 900MHz).

In deciding how to refine the weighting factor we looked at the impact of different weighting factors on the proportion of the total spectrum that each of the major frequency bands represented. Table 1 below shows the results of this analysis for three different weighting factors:

- unweighted (or, rather, constant weighting factor based on MHz of bandwidth with no adjustment for the frequency at which this is located)
- inverse logarithmic weighting across all frequencies, and
- constant weight to 1 GHz and then inverse logarithmic weighting factor above 1GHz.

[58] For the avoidance of doubt this approach to weighting factor was also used in the provisional analysis presented in our consultation document

[59] These are calibrated so that 10MHz of bandwidth at 1GHz is given the same weight whether using a constant weighting factor (as for spectrum up to 1GHz) or using an inverse logarithmic function (as for spectrum from 1GHz upwards))

[60] For example in our Spectrum Framework Review in 2005 http://stakeholders.ofcom.org.uk/consultations/sfr/

Table 1: Analysis of the impact of different weighting factors on individual bands

Distribution by band	Unweighted (MHz)	Fully Logarithmic	Constant to 1GHz
87.5-1000 MHz	1%	37%	19%
1000- 6000 MHz	6%	24%	31%
6000-15000 MHz	11%	14%	18%
15000-86000 MHZ	82%	25%	33%
<500 MHz	0.4%	24%	7%

A2.38 From Table 1 it is clear that an un-weighted view of spectrum would overstate the importance of spectrum above 15 GHz as this would represent 82% of the total spectrum. Similarly the fully logarithmic weighting factor would result in spectrum below 500 MHz representing 24% of total spectrum which, as noted above, we believe would overstate its importance.

A2.39 It would, of course, be possible to choose a different point at which to cut-over from the constant weighting factor to the inverse logarithmic weighting factor. However, the choice of 1 GHz as this cut-over point seems appropriate in light of the general understanding of the spectrum “sweet-spot”.

Annex 3

Authorisation of Spectrum use by Ofcom

A3.1 This annex provides some additional explanation of the ways in which Ofcom authorises use of spectrum.

A3.2 The different ways in which Ofcom authorises use is illustrated in the first three rows of figure 1 which distinguish between:

- The type (or legal form) of authorisation: we are required to exempt any use of spectrum from requiring a licence if we are satisfied that that use is not likely to involve undue interference (or certain other specified effects). Alternatively we grant a licence to the user.

- Licence type which, at the highest level, can be divided into two broad categories:

    - Ofcom Managed (OM): a set of "standard" licence products of which there are 3 generic classes: Area Defined, Technically Assigned and Light Licence classes (as explained further below) and with different versions of these licence types being tailored to the needs of different sectors / services in different frequency bands..

    - Block-Assigned: licences that provide access to a large range of frequencies in one or more "blocks"; these licences give these licensees significant flexibility in the way that they manage the band concerned

A3.3 The bottom three rows in figure 1 illustrate the differences between the licences in terms of several characteristics as follows:

- Responsibility for coordination between individual transmitter deployments:

    - in the case of Block Assigned licences and Area Defined Ofcom Managed licence products the licensee has responsibility for managing its own deployments within the envelop permitted by the technical conditions of the licence, giving them a high degree of flexibility in how they deploy;

    - in the case of Ofcom Technical Assigned licences the coordination is undertaken by Ofcom as part of the assignment process, prior to granting the licence; and

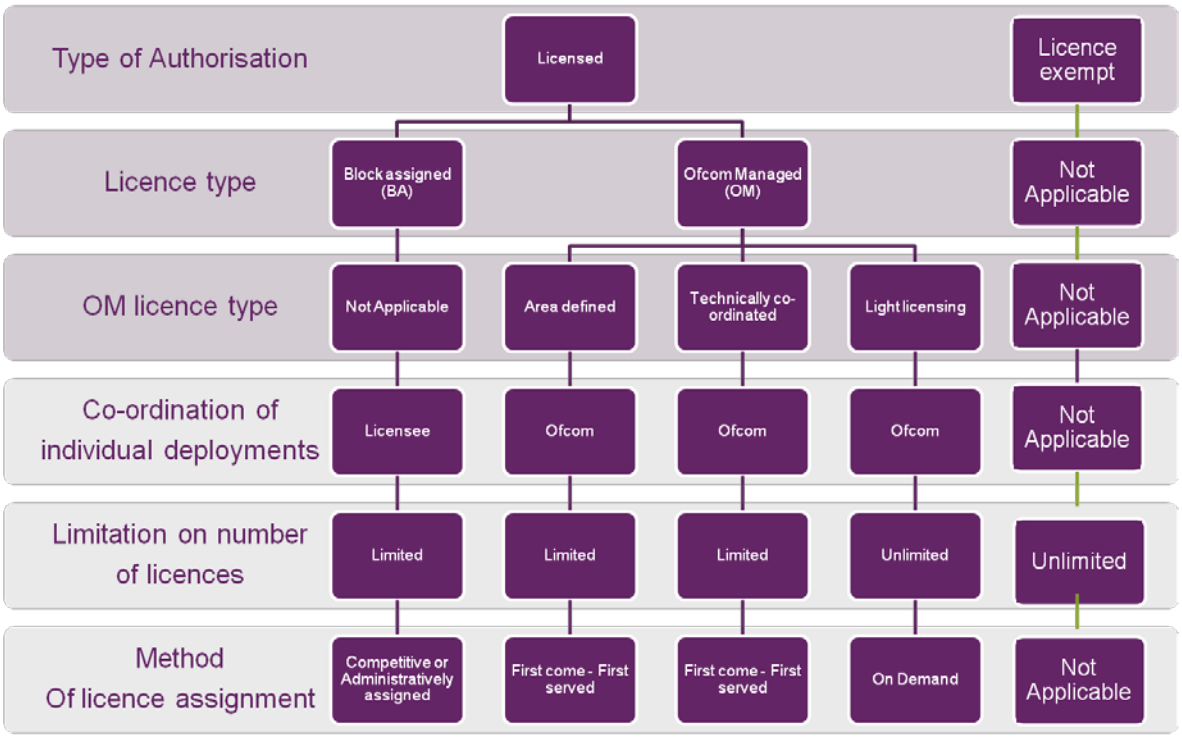
    - in the case of Ofcom Light Licence products – and in the case of licence exempt use - there is no need for central coordination.

- The limitation on the number of licences that can be issued: in the case of Block Assigned, Area Defined and Technically Assigned there is a limit on the number of licensees because of the risk of harmful interference if we do not. In contrast, there is no limitation on the number of light licences because these do not need Ofcom to carry out a technical coordination assessment first (these licences are therefore available on-demand).

- Method of licence assignment: where there is a limit on the number of licences: the main distinction here is that the relevant Ofcom Managed licence products

are open to new applications on an ongoing basis and are, in general, made available on a first come first served basis. In contrast, the Block Assigned licences are made available once, at a specific point in time; if there are more applicants than licences available, then the assignment of these licences takes place following a competitive award process (usually an auction, although there are provisions in the WT Act to allow other comparative selection methods e.g. a "beauty parade"); if there aren't more applicants than licences available, then the licences are awarded administratively.[61]

Figure 1: UK authorisation regime



A3.4 In Section 4 we summarise the significance of the distinction between licensed use and licence exempt use and, in the case of licensed use, between spectrum which is made available for use under Block Assigned licences and spectrum which is made available for use under one of the Ofcom Managed licence products. The remainder of this annex provides some further description of the three generic types of Ofcom Managed licence product.

A3.5 Within Ofcom Managed the products can be broken down into the sectors that they support (see Section 5) and into three types of licence class:

- Area Defined
- Technically Assigned
- Light Licensing

[61] All Block Assigned licences issued since 2000 have been awarded by auction (as opposed to beauty parade) where more than one entity has expressed an interest in the licence

Types of Ofcom Managed licence products

A3.6 We describe each of the three types of Ofcom Managed licence products in the following sub-sections.

Area defined licences

A3.7 Area defined licences are made available to both business radio and maritime users in a number frequency ranges. They permit the use of transmitters at a specific frequency and specific bandwidth, defined according to a channel plan (usually narrowband channels of up to 25 kHz although wider channels might be made available in future in some VHF bands). They are available on either a UK wide basis or within specified sub-UK geography.[62] The technical conditions of these licences have been set using a methodology called Spectrum Usage Rights (SURs) that defines the maximum power flux density that is permitted at the geographical boundary of the licence, rather than maximum power levels (and, in some cases, block edge masks) for the individual transmitters that are included in most other licences.

A3.8 There is no need for Ofcom to carry out technical co-ordination work before making assignments because we pre-define the technical licence conditions to manage interference with neighbours. In this sense, they are available to applicants "off the shelf" on application under a first come first served basis (since only one licence is available at each frequency in each area).

Technically Assigned licences

A3.9 Technically Assigned licences permit the use of spectrum that requires technical co-ordination with other users in the band. These uses can be omni-directional (e.g. for Business Radio or maritime applications in VHF and UHF spectrum) or directional in nature i.e. the power is focused in one direction (e.g. for fixed point to point links or Permanent earth stations). For such uses, it is necessary to undertake detailed technical analysis to understand whether it is possible to grant permission for additional assignments of spectrum without causing harmful interference into existing licensees.

A3.10 Requests for such standard licence products, therefore, require us to undertake this detailed analysis before we can grant additional licences. This analysis, is however, undertaken by an automated planning tool and, only exceptionally, requires manual intervention when it is proving difficult to make a new assignment. In such cases, through more detailed analysis, we are often able to determine that we can grant requests without the risk of harmful interference to others.

A3.11 Non-operational licences are a specific type of technically assigned licence that permits access to spectrum on a temporary basis for testing and development. It is not permitted to use these licences to provide commercial services, although it is possible to use these licences to trial services with consumers and they are issued for a fixed duration of six months for tests and trials and one year for scientific research and development.

A3.12 Often the spectrum we are able to make available for test and development is managed (under the terms of the FAT) by MoD.

[62] Currently defined by 50 km x 50 km squares with adjacent squares being capable of aggregation in order to cover larger areas / regions

Light licensing

A3.13 Light licences typically permit uses that are conceptually very similar to those permitted under a licence exempt regime, in that there is no need to manage the interference between the individual users and, accordingly, no need to limit the number of licences that can be issued.

A3.14 However, there are a number of reasons why we might still licence the use of spectrum under a light licence (rather than licence exempt it) even though there is no need for Ofcom to carry out coordination in order to manage the risk of interference between these users:

- Where spectrum access is not available in all locations UK wide: in general we do not make licence exemption regulations that permit use in some locations but not others as it is not practical to expect users to be aware of these geographical limitations if they are simply buying equipment which is CE marked[63].

- Where the use to be authorised is shared with spectrum managed by the public sector (under the terms of the FAT) and where there are concerns from the primary user of the band, or a user in an adjacent band about the potential impact of any interference, for example, into vital defence or safety of life services. In these cases, the probability of harmful interference may be low but because of the potential impact this could have, maintaining a database of licensed users and their locations will help identify the source of interference in the event that harmful interference is detected. Global Navigation Satellite Service (GNSS) repeaters are an example where we have used a light licence approach for this reason.

- A variant of this approach is the network licence for Very Small Aperture Terminals (VSAT) which permits use of all VSAT below a given power limit, but requires the licensee to clear deployments of VSATs at higher powers with the MOD, CAA (e.g., near airports)

- Where an aspect of spectrum use needs to be linked to the identity of the user, or there is need for additional personal certification of the user and the licence provides the legal vehicle to define and record this information: for example, where users might need to be identified through their transmission and so need an identification code (MMSI in the case of ships, a call sign in the case of radio amateurs – and in the case of amateurs there is also a need for the applicant to demonstrate the necessary qualifications to use the spectrum)

- Where users require proof of authorisation from Ofcom when they travel to other jurisdictions, as in the case of aircraft and ships.

Licence types providing access to different sectors

A3.15 Ofcom Managed licence products provide access to most sectors that use spectrum with the exception of mobile and wireless broadband. The Table below indicates

[63] Note exception for 60GHz LE since there are only 3 small exclusion zones which are remote and where the likelihood of use is very low and, should it ever occur, any associated interference could be detected and dealt with.

which of the above licence types are available for access by each of the sectors that are provided access to spectrum through Ofcom Managed products[64]

Table 2: Availability of different Ofcom Managed licence types by licence class

Ofcom Managed licence classes[65]	Area defined	Technically Assigned	Light
Fixed links	×	✓	✓
Satellite	×	✓	✓
Business radio	✓	✓	✓
Maritime	✓	✓	✓
PMSE	✓	✓	✓
Broadcasting	×	✓	×

[64] See Section 4 of this document for more detail on these licence classes

[65] For the purposes of this analysis Aeronautical use has been categorised as Public sector use although there are Ofcom Managed aeronautical licence products that we grant and manage as well as aeronautical uses for which the individual assignments are managed, and WT Act licences issued, on our behalf by CAA