A framework for spectrum sharing

Consultation

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About this document

Demand for spectrum is growing significantly and will continue to do so. Spectrum sharing will become increasingly important to serve that demand. By allowing different users to offer more wireless applications, spectrum sharing can bring benefits to citizens and consumers as well as contributing to optimal use of the spectrum.

This document proposes a new framework for our thinking about spectrum sharing, which will offer a model for systematically considering whether frequencies have the potential to be shared. We expect to use this framework when defining new spectrum authorisation and when we seek to identify spectrum to meet new demands.

The proposed framework set out in this consultation:

- identifies potential barriers to sharing;
- introduces a set of regulatory tools and market and technological enablers that have potential to facilitate further sharing; and
- sets out how we will consider sharing on a case by case basis, taking into account the characteristics of both incumbent use, where there is any, and proposed new use.

Ofcom plans to update the framework in the light of comments from stakeholders and may consult again on a more refined framework. We expect to publish this follow-up document by the end of 2015/16.

This consultation closes on 2 October.

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Section 1

Summary

1.1 In our Spectrum Management Strategy we highlighted our intention to consider new opportunities and tools for spectrum sharing to meet growing and competing demand for spectrum. This document sets out our thinking about a new framework for assessing options for spectrum sharing.

1.2 Our framework identifies tools and barriers and how they apply on a case by case basis to identify new spectrum opportunities taking into account the characteristics of use of both incumbent and new users. We expect to use this framework systematically when defining new spectrum authorisation and when we seek to identify spectrum to meet new demands.

1.3 Ofcom's principal spectrum duty is to secure the optimal use of spectrum, and to achieve this, where appropriate, we authorise shared access to spectrum and we will continue to do so. With increasing demand for spectrum, and technology developments that make what previously seemed more complex sharing options possible, we believe it is helpful for us now to set out our views with regards to sharing and the role it will play in the future.

1.4 Some stakeholders may see future spectrum sharing as a threat to their own use. We believe it should be possible to respect the rights of existing licence holders whist increasing sharing. There are already bands where spectrum is shared between two or more uses. We believe that there is significant potential for more, but some of these will need different types of sharing.

1.5 Authorisation of spectrum use in the UK is regulated through the application of the Wireless Telegraphy Act. Licenses issued under this legislation confer and define rights but generally do not provide exclusivity of use. Subject to not causing undue interference, new sharing uses may be allowed access to spectrum otherwise licensed. Of course, giving effect to this general observation in specific cases requires detailed consideration to ensure that those aims are achieved.

Our proposed framework

1.6 This document outlines our intention to consider sharing options systematically when defining new spectrum authorisation, and when we seek to identify spectrum to meet new demands. Our proposed framework is intended to ensure we consider the potential for sharing when we think about any new spectrum authorisations, and to ensure that we are building in the right flexibility, opportunities and incentives. We also expect to be looking at new opportunities in bands that are already allocated and in use where appropriate.

1.7 Our ultimate objective is to ensure the appropriate spectrum is available to meet demand from both new and existing uses and minimise the scope for spectrum to remain underutilised. In particular we want to promote innovation and allow for new services.

1.8 This framework is relevant to any spectrum band and any new demand to use spectrum, but it is not a programme to enforce sharing in every band.

1.9 The framework has three elements that, combined, should help us to identify how and where to consider sharing. These are:

- potential barriers to sharing;
- tools and enablers that could have potential to facilitate or enable further sharing; and
- a set of high level 'characteristics of use' that should help to give a high level picture of what an incumbent or new user needs from spectrum access. Looking at these characteristics on a case by case basis should give an initial insight into whether two types of users might be able to share, and which (if any) tool or combination of tools may be appropriate.

Barriers

1.10 We have set out a number of possible barriers that may potentially limit the extent of current or future sharing, despite the liberalisation of licences and introduction of market tools such as trading or leasing. These barriers fall into four categories:

- availability of information on spectrum use and spectrum demand. Without accurate information on use it is not possible to identify opportunities for sharing or to deduce which other barriers might be playing a role in preventing sharing;
- barriers to sharing through market mechanisms, including transparency, transaction costs, lack of incentives and strategic concerns;
- technological challenges (limits to the ability to manage co-existence between sharers); and
- constraints on flexible spectrum use from our own regulatory approach (terms of authorisation).

Tools and enablers

1.11 We have identified an initial list of existing and potential tools and enablers that could support new opportunities for increased sharing and address the barriers identified. International developments in sharing, including initiatives by other national regulators and work that has been carried out by international organisations have informed our list of tools. A summary of some of the spectrum sharing initiatives that regulators are putting in place can be found in Annex 5.

1.12 In line with our identification of barriers, our proposed tools are categorised into:

- **Increased information** available to Ofcom and/or the market – could include information on actual use (rather than authorisations), in real-time or forward-looking. Also increased information on public sector use, or demand.
- **Market enablers** – how market mechanisms could be developed to overcome some of the barriers to sharing by commercial arrangement;
- **Technology enablers** – ways that technology can enable more intelligent and efficient sharing, e.g. enhancements to geolocation databases, potentially to manage access between opportunistic sharers; sensing; or more frequency agile equipment.

- **Authorisation tools** – the Spectrum Management Strategy noted that we need a combination of market mechanisms and regulatory action to deliver optimal spectrum use. We therefore also look at how we could use authorisation conditions to provide incentives to share or to make sharing technically feasible. This includes, for example, the potential to create new 'tiers' of users (e.g. TWVS), and to consider requirements in licences to provide information.

Characteristics of use

1.13 Finally we outline the high level characteristics of use, for both incumbent and new users, that will need to be taken into account when considering the potential for sharing and the applicable tools in any individual case. It also involves looking at potential scenarios over the life of the services involved and, therefore, accounting for the uncertainties associated with longer timeframes and future market developments.

Purpose of this document

1.14 We are setting out this framework to start a substantive dialogue with stakeholders on how to get the most out of spectrum sharing. Through this, we wish to move to concrete steps to facilitate better, and more, sharing where this supports optimal use of the spectrum. We are seeking views from stakeholders on all elements of our framework:

- whether we are looking at the right barriers, whether there are others that we have missed and whether some are leading to missed opportunities today;
- whether we have identified all the potential tools and enablers to overcome these barriers, and in particular whether stakeholders think there are tools that would work particularly well that we should be prioritising, or conversely if any pose particular risks or challenges; and
- whether the characteristics of use that we have identified as a means for determining which tools could be effective are sensible and sufficient to provide an indication of sharing potential, and if there are views on their relative significance.

Next Steps

1.15 Our proposed aim is to use this framework as a key part of our approach to spectrum authorisation, to be considered whenever we are assessing how to address demand for spectrum from incumbent and/or new users.

1.16 We will update the framework in the light of comments from stakeholders. Subject to the nature of the feedback, we may consult again on a more refined framework. This may include an identification of new bands where sharing could play a role in the optimal use of that spectrum. We expect to publish this follow-up document by the end of 2015/16.

1.17 We are seeking responses to this consultation by 2 October 2015 and we intend to engage with stakeholders on these proposals over the coming months.

Section 2

Introduction

2.1 In our Spectrum Management Strategy, published in April 2014, we highlighted our intention to consider new opportunities and tools for spectrum sharing in order to extend sharing to meet growing and competing demand for spectrum from stakeholders.

2.2 This document sets out our thinking about a new framework for assessing options for spectrum sharing. We are seeking stakeholders' views on all aspects of the framework and in particular on where we should prioritise our effort.

2.3 This section sets out the context for this work and it:

- notes the challenges for the future in meeting spectrum demand and why increased sharing is important;
- outlines the existing types of spectrum sharing and how shared access is authorised;
- identifies recent steps taken on sharing to date;
- sets out our duties in regard to spectrum management;
- outlines the structure of this document.

Challenges in meeting spectrum demand and the role of sharing

2.4 Spectrum is a valuable resource, and securing its optimal use is key to delivering significant benefits for UK citizens and consumers. Demand for mobile and wireless data is predicted to increase significantly in the future. At the same time spectrum requirements for other services are also likely to grow or, at the very least, remain stable. In our strategy we committed to monitor mobile data growth to better understand demand and also to develop a framework to understand demand from other users, for example with our recent *Strategic review of satellite and space science use of spectrum*.[1] These trends point towards a significant increase in competing demand for spectrum bands.

2.5 Users often seek dedicated spectrum, but opportunities to clear spectrum are challenging. Spectrum sharing will become increasingly important as competing spectrum requirements grow.

2.6 It is likely that many, or most, spectrum uses leave some spectrum unused some of the time, or in some locations, or operate in such a way that other uses could be permitted that would not cause harmful interference. Any approach to authorisation that restricts use of spectrum beyond what is required for coexistence in theory risks sterilising otherwise useful spectrum. In many cases the unused spectrum will not be such that there is any credible compatible use for it, but sometimes there will be - or

[1] *Strategic review of satellite and space science use of spectrum*, June 2015 http://stakeholders.ofcom.org.uk/binaries/consultations/space-science-cfi/summary/CFI_SSS_Review.pdf

there could be - a compatible use. Making apparently unattractive spectrum available can sometimes stimulate new uses, with Wi-Fi being by far the best known example. The regime we are putting in place for TV White Spaces is an example of where we are making such spectrum, unused in a particular location, available.

2.7 The Government's Spectrum Strategy is also clear on the need for more sharing.[2] It sets out Government support for increased sharing, and the potential to develop new models of spectrum management based much more on a dynamic access model than an ownership model. There is also a commitment to making information on public sector use of spectrum available to facilitate new use/sharing.

2.8 The tools and enablers covered in this document could, for the most part, be relevant to both market access and public sector spectrum.

Spectrum sharing can take place in a number of ways

2.9 Spectrum is shared when the same spectrum band is accessed by multiple users and/or for different type of uses. There are several types of shared access across several dimensions (frequency, geography and time).

2.10 To understand the different ways in which spectrum is shared, we need to consider the different types of spectrum access.

2.11 As a companion paper to our Spectrum Management Strategy, we provided an overview of how spectrum is accessed in the UK.[3] At an aggregate level, we defined access to spectrum as relating to one of three main categories:

- Market access (authorised by Ofcom and available to the market, although this also includes use by public bodies not subject to Crown immunity, such as local authorities);
- Public sector (accessed using the immunity the Crown has from requiring a licence);[4] and
- Space science (accessed without explicit need for a licence or using Crown immunity, as its use is either receive-only in the UK or is transmissions from outer space).

Market access

2.12 Spectrum accessed for market uses can be authorised by:

[2] Department for Culture Media and Sport, *The UK Spectrum Strategy*, March 2014: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/287994/UK_Spectrum_Strategy_FINAL.pdf

[3] *Spectrum attribution metrics*, December 2013: http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-management-strategy/annexes/Spectrum_attribution_metrics.pdf

[4] "Public sector", in the context of spectrum use, has long been used to mean Government use under Crown immunity. 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. It should be noted that there are other users usually understood to be public sector that use spectrum but do so using commercial licences as they do not have Crown immunity. These uses, such as use by local government, are captured under the market access category.

- Licence exemption, which the UK (under the EU legislative framework) sets as the preferred option for all spectrum access where the use of the spectrum is not likely to (among other things) involve undue interference with wireless telegraphy.[5]

- Licensed access. Where we licence spectrum use, access is provided through two main types of licence:

  - Ofcom Managed access: 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.

  - Block Assigned access: spectrum bands where use is authorised by Ofcom through individual licences granted for a contiguous block of spectrum over a wide geographic area and where technical coordination of use within the block of frequencies is the responsibility of the licensee, e.g. auctioned spectrum.

Types of sharing

2.13 There are different types of sharing:

- Multiple users can share spectrum for a similar type of use, for example Business Radio users sharing with each other; or

- Multiple users can use share spectrum for multiple different uses. An example of this would be fixed links, satellite users and Spectrum Access licensees[6] sharing in the 3.6-3.8 GHz band.

2.14 Sharing can happen between users within a category of spectrum access - market, public sector or space science - such as in the examples above (which concern market access), and public sector spectrum bands are often shared between more than one type of public sector user. Sharing can also happen between categories. For example, PMSE services share with Ministry of Defence services in the bands 2025-2110 MHz and 2200-2290 MHz.

2.15 The types of shared access defined above can be achieved across several dimensions:

- In frequency – with individual licences each with a specific channel, as opposed to concurrent access for several licensees to the same range of frequencies.

- In geography – with licences covering the whole of the UK, or specific geographical areas, or defining the location of transmitting equipment e.g. business radio between users, and between fixed links and satellite uses.

- In time – some licences are indefinite in duration and others have a fixed duration. For example, PMSE access to spectrum is based on geographic and temporal restrictions, with each user authorised in a defined geographical area for a defined period of time. In some ways White Space Device use is similar, using geolocation, though the authorisation can be much more dynamic to reflect changes in use over relatively short periods of time.

[5] See Communications Act, Wireless Telegraphy Act and Authorisation Directive
[6] UK Broadband Limited and UKB Networks Limited

2.16 There is also sharing enabled using technical restrictions, particularly in Licence Exempt bands, where equipment is capable of working around other users (e.g. using polite protocols such as listen before talk in Wi-Fi).

Recent Ofcom activities to promote sharing

2.17 The Spectrum Management Strategy highlighted our intention to work on developing new approaches to sharing in new bands. In our strategy we also highlighted the role sharing will play in the future, in a context of increasing competing demand from new and incumbent uses.

2.18 Ofcom has taken a number of actions in line with this increased emphasis. This includes both strategic and operational activity on sharing:

- In April 2014 we published a Statement setting out the steps that Ofcom intends to take to help spectrum sharing play a complementary role alongside dedicated spectrum bands in meeting the significant growth in demand for mobile and wireless data.[7] This document builds on that Statement and considers the potential for sharing among existing and future spectrum use across all applications and uses.

- We have confirmed our decision to introduce database controlled access in the UHF TV band and we are working to get databases qualified for operation and the licence exemption in place by the end of the year.[8]

- In April 2015, for an initial two year period, we made 3 MHz of additional spectrum available on a national basis in the UHF2 band (450–453 MHz and 464- 467.3 MHz) for short term civil use licences. This was the result of negotiations with the Emergency Services to share spectrum that was not being used, but may be required for operational purposes as a result of the emergency service mobile communications programme (ESMCP).

- The PMSE review is looking to identify new spectrum sharing opportunities for audio PMSE users. We have identified two candidate bands that we believe have good potential for sharing with low power PMSE audio applications and are carrying out coexistence work in these bands in close cooperation with incumbent stakeholders.

- As part of the UHF 1 and 2 review (420-470MHz), the Business Radio team is looking to investigate and implement ways to optimise the assignment criteria and the licensing process to enable more efficient sharing of PMR channels, especially in London and other major conurbations in order to address market demand against spectrum supply.

Our Spectrum Duties

2.19 When making decisions on the conditions of spectrum authorisation Ofcom is required, together with our other general duties, to secure the optimal use for wireless telegraphy of the electro-magnetic spectrum and the availability of a wide

[7] *The future role of spectrum sharing for mobile and wireless data services*, April 2014: http://stakeholders.ofcom.org.uk/consultations/spectrum-sharing/

[8] *Implementing TV White Spaces*, February 2015: http://stakeholders.ofcom.org.uk/consultations/white-space-coexistence/statement

range of electronic communications services. In doing that we have to have regard to a range of factors including:

- the desirability of promoting competition in relevant markets;
- the desirability of encouraging investment and innovation in relevant markets;
- the desirability of encouraging the availability and use of high speed data transfer services throughout the United Kingdom;
- the different needs and interests, so far as the use of the electro-magnetic spectrum for wireless telegraphy is concerned, of all persons who may wish to make use of it;
- the different interests of persons in the different parts of the United Kingdom, of the different ethnic communities within the United Kingdom and of persons living in rural and urban areas.

2.20 The framework we propose in this paper would not change the factors that Ofcom will take into account when considering spectrum authorisation. Neither would it change the weight that Ofcom will apply to those factors. However, we do propose to ensure that explicit consideration is given to the various options for spectrum sharing that might be appropriate in any given case to help us to ensure the optimal use of spectrum.

2.21 Authorisation of spectrum use in the UK is regulated through the application of the Wireless Telegraphy Act. Licenses issued under this legislation confer and define rights but generally do not provide exclusivity of use. For example, Ofcom introduced Ultra-Wide Band use in a range of bands including the 2.1 GHz band some years after the 2000 “3G auction”. Therefore, subject to not causing undue interference, new sharing uses may be allowed access to spectrum otherwise licensed.

Structure of the document

2.22 In section 3 we set out the purpose of the framework and what it does.

2.23 In section 4 we identify potential barriers to sharing.

2.24 In section 5 we provide an initial list of sharing tools and approaches, from those in current use to floating some relatively speculative ideas that would require considerable development that could have potential to enable sharing and may require changes to the legal framework.

2.25 Section 6 highlights that the relevance of each tool will be defined by the characteristics of use of both incumbent use and new uses and therefore how sharing will need to be considered on a case by case basis in order to identify which, if any, tools might be appropriate in any particular circumstance.

2.26 Section 7 outlines our next steps for taking forward this work.

2.27 Finally in Annex 5, we provide a short overview of some of the international initiatives underway examining sharing opportunities and approaches.

Section 3

Purpose of the framework

3.1 With increasing demand for spectrum, and technology developments that make more complex sharing options possible, we believe it is helpful for us now to set out clearly our views with regards to sharing and the role it will play in the future in securing the optimal use of spectrum.

3.2 We already authorise shared access to spectrum and we will continue to do so. Our intention in developing a sharing framework is to ensure that we consider sharing options systematically when defining new spectrum authorisation, and when we seek to identify spectrum to meet new demands.

3.3 Our proposed framework is about changing the way that we think about new spectrum authorisations, and to ensure that we are building in the right flexibility, opportunities and incentives. However, as demand for spectrum continues to increase we will need to look at new opportunities in bands that are already allocated and in use. There is no intention, though, of attempting to restrict those rights that licence holders have, or of disincentivising licence holders from innovation or investment.

3.4 Our objective is to ensure the appropriate spectrum is available to meet demand from both new and existing uses and minimise the scope for spectrum to remain underutilised. In particular we want to promote innovation and allow for new services and new entrants.

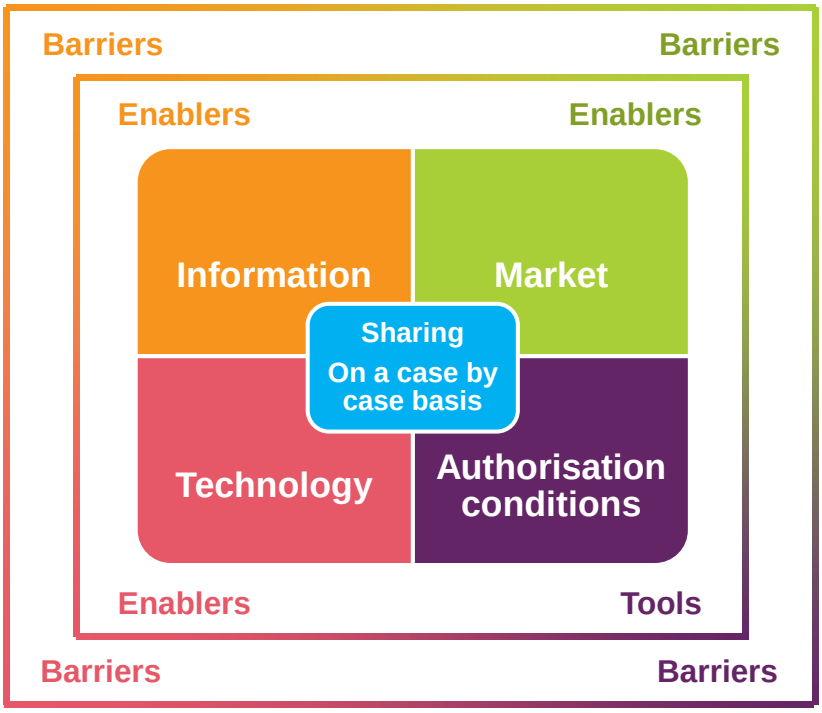
3.5 This framework is relevant to any spectrum band and any new demand to use spectrum, but it is not a programme to enforce sharing in every band.

3.6 The framework has three elements that, combined, should help us to identify how and where to consider sharing. These are:

- potential barriers to sharing;
- tools and enablers that could have potential to facilitate or enable further sharing; and
- a set of high level ‘characteristics of use’ that should help to give a high level picture of what an incumbent or new user needs from spectrum access. Looking at these characteristics on a case by case basis should give an initial insight into whether two types of users might be able to share, and which (if any) tool or combination of tools may be appropriate.

3.7 Figure 1 below shows the relationship between tools and barriers, and that they will be considered on a case by case basis to identify new spectrum opportunities taking into account the characteristics of use of both incumbent and new users.

Figure 1: Illustration of sharing framework



3.8 By consulting on this framework, we both hope to refine our analysis and to build recognition and acceptance among stakeholders that sharing between uses and users is likely to happen across an increasing number of spectrum bands, as demand increases over time.

3.9 Some stakeholders may see future spectrum sharing as a threat to their own use. We believe it should be possible to respect the rights of existing licence holders whist increasing sharing. We want to emphasise that spectrum sharing can also provide opportunities, including for incumbent users whose spectrum demands also continue to grow.

Section 4

Barriers to more and better sharing

4.1 Liberalisation of licences and market tools such as spectrum trading and leasing mean that in many cases it should be possible for sharing of similar services to take place within the market and with a minimum of intervention by Ofcom. Alternatively, Ofcom can intervene to create new sharing opportunities, for example the implementation of TV White Spaces.

There may be barriers that could limit the extent of sharing

4.2 Once a user has a spectrum authorisation they will use it to maximise their private benefit. Incumbents are likely to consider making spectrum available to others only where there is sufficient return (and it is sufficiently easy) for them to make it commercially worthwhile without affecting their options for future use. Where the costs of sharing are too high, because it takes too much effort to organise a transaction, where there is too much perceived risk or where there is strategic value in preventing a potential competitor from using spectrum, it will not happen.

4.3 We have already taken action to liberalise the market and empower stakeholders to get access to spectrum:

- We have been running a programme of spectrum auctions with seven auctions already completed, bringing more spectrum into the market.[9]
- We have sought to remove technical restrictions by liberalising licences, where possible and where there was demand. E.g. adding 4G to EE's 2G/3G 1800 MHz licence.[10]
- We have introduced spectrum trading and leasing for many categories of licences, which is the mechanism by which licensees can share spectrum rights at present, under existing law. We have also created new rights (recognised spectrum access) so that public sector users and/or receive-only services could trade.[11]
- We are implementing our proposals for dynamic use of the White Spaces within the UHF band (TV White Spaces).[12]
- We have been making more information available, in more useful ways, about spectrum authorisations.[13]

[9] http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/
[10] *Decision to vary Everything Everywhere's 1800 MHz spectrum licences to allow use of LTE and WiMax technologies,* August 2012: http://stakeholders.ofcom.org.uk/binaries/consultations/variation-900-1800mhz-lte-wimax/statement/statement.pdf
[11] *Simplifying Spectrum Trading*, June 2011: http://stakeholders.ofcom.org.uk/binaries/consultations/simplify/statement/statement-spectrum-leasing.pdf
[12] http://stakeholders.ofcom.org.uk/spectrum/tv-white-spaces/
[13] http://stakeholders.ofcom.org.uk/spectrum/information/

4.4 The majority of licence classes are now tradeable. As a result, we estimate that 84% of relevant spectrum is tradeable, up from 15% in 2005[14], and there have been a significant number of spectrum trades.[15] However, given the increasing importance of sharing in response to growing demand, we need to know if there are remaining barriers to sharing.

4.5 We set out here a number of barriers that may potentially limit the extent of sharing. These potential barriers fall into four categories:

- availability of information;
- market barriers (transaction costs, lack of incentives, strategic concerns);
- technological challenges (co-existence); and
- authorisation constraints (issues with our own regulatory approach).

4.6 Availability of information is an important part of a well-functioning market. Given its importance, it is discussed separately from other market barriers throughout this document.

4.7 The barriers to sharing and potential tools described in this document may have relevance to both the civil and public sectors. However, there may be additional issues when sharing with the public sector which mean that the application of sharing tools in the public sector would require specific consideration in the light of the spectrum authorisation methods already in place in the band.

Availability of information

A lack of transparency prevents identification of opportunities

4.8 Finding information about what actual use licensees make of a band or how that might evolve over time is typically difficult and costly. The information is not publicly available, so it can be difficult for potential sharers to choose which bands to focus on, leaving potentially many licensees to engage with. This makes it difficult to establish whether there is an opportunity for sharing.

4.9 Ofcom has limited information on demand for spectrum for sharing other than from specific requests. We are trying to address this by carrying out demand studies, but these have limitations, as they are mostly scenario-based.

Market barriers

Transaction costs can be disproportionately high

4.10 Transaction costs can be seen as prohibitive, particularly where the value to an individual potential user is small and it is not possible to have generic terms of use. For example, a national licence holder may be unlikely to see a case for talking to a small prospective provider interested in a limited geographical area. Agreeing a

[14] This excludes sectors for which trading is not relevant, these are: Amateurs and Ships, Aeronautical, PMSE, Police and Fire, licence exempt and Science and Technology.
[15] Ofcom's Transfer Notification Register provides information on licences which have been traded or are in the process of being traded http://spectruminfo.ofcom.org.uk/spectrumInfo/trades

contract would require material efforts for a relatively small commercial gain, and licence holders may be unwilling to devote management time to developing spectrum sharing arrangements, at the expense of focussing on their core business.

There are limited incentives for sharing either in financial or regulatory terms

4.11 Incumbents may, at present, have limited incentives to engage with potential sharers.

4.12 In setting AIP for a spectrum licence, we seek to reflect its opportunity cost, i.e. the market demand for that spectrum. Market mechanisms such as auctions and trading should also lead to prices which reflect market demand for the spectrum concerned.

4.13 Auctions so far have not typically sought to address potential demand for shared use other than through making licences tradable;[16] to date this has not generated new sharing opportunities.

4.14 Some might argue that in the absence of an explicit regulatory requirement on licensees to look favourably on requests to share, comparatively low value sharing opportunities are unlikely to be considered.

Uncertainty about the future may discourage licensees from pursuing sharing arrangements

4.15 In a dynamic sector, there are risks to a licensee in allowing other firms to share the spectrum it uses. One risk is that the arrangement will not allow the licensee sufficient flexibility to adapt its business model in future, e.g. by expanding its network to new locations. Another is that facilitating sharing could allow the market entry of a disruptive rival technology.

Technological challenges

Coexistence with sharers is seen as a risk to an incumbent

4.16 A good understanding of the operational scenarios of both uses is needed in order to assess the realistic risk of interference between systems, and if one system deviates from this then there could be a risk of interference to the incumbent. Assumptions and margins are required in the technical modelling in order to mitigate this risk wherever possible. These margins however can lead to a reduction in the availability for sharing and therefore a fine balance is required between availability and risk of interference. Often the incentives for sharing are not sufficient to offset this risk.

4.17 Disincentives against trading or leasing also include the complexity and costs involved in analysing the interference risks between incumbent and new users and their spectrum neighbours, because this requires a thorough understanding of the concept of operations relating to spectrum use and the corresponding use-cases being protected. Once these cases have been established appropriate technical parameters are required. Often many of these parameters are unknown, especially where they relate to service protection. Whilst they can be estimated, this introduces risk which is usually mitigated by the addition of margin, and this has the effect of

[16] In the UK 4G auction we allowed for the aggregation of bids from low power use, from up to ten bidders, for either 2x10 MHz or 2x20 MHz of 2.6 GHz spectrum. However, we decided not to reserve spectrum for low power use, and in the auction all paired 2.6 GHz spectrum was won by high power users.

reducing the potential for sharing. These margins can be avoided to some extent by gathering measurement data, a task which often requires great skill and effort to complete. Measurements imply additional time and cost which is a further disincentive. See our recent work on White Space Devices and the 2.3 GHz band. The issue arises for each new authorisation and is just as relevant to private parties trying to strike a sharing deal.

Authorisation constraints

The terms of authorisation can limit flexible use of the spectrum

4.18 Our own regulatory approach may constrain flexible use, for example if it is onerous for a licence holder to vary the terms of a licence so it can be used by another type of service. The complexity in most cases is not caused by the variation process itself but the steps needed to understand coexistence issues. Although the need for us to consult in some cases before issuing a licence (as set out in section 8C of the Wireless Telegraphy Act) can cause further delays.

4.19 In the Spectrum Management Strategy coexistence associated with changes in spectrum use was an area of increased emphasis. Our assessment of coexistence issues needs to balance carefully the benefits that could derive from new uses gaining access to spectrum with the need for existing services to operate without suffering harmful interference. If our assessment of coexistence is overly cautious this could limit (or deny) access to spectrum for new users by placing onerous and costly constraints on them, although conversely if our assessment is overly optimistic this could degrade services that are already provided. Our efforts need to be proportionate to the level of risk involved.

Question 1: Do you have any comments on the barriers to increased sharing that we have identified above? Which are the most significant and why? Are there others we should take into account?

Question 2: Have you experienced or are you experiencing the effects of these barriers? If so, in what circumstances and with what impact?

Section 5

Sharing tools and enablers

We are identifying a set of tools and enablers with potential to facilitate sharing

5.1 Having identified barriers in section 4, in this section we introduce an initial list of tools and enablers that have the potential to increase benefits from sharing, by addressing barriers to help meet demand and deliver more efficient use of spectrum.

- By enablers we mean:
  - New types of spectrum information that could enable stakeholders to identify and pursue spectrum sharing opportunities.
  - Market mechanisms that could create incentives for existing and potential users to use spectrum more efficiently, as well as market infrastructure.
  - Technological capabilities that enhance existing forms of spectrum use and/or enable new ways of using spectrum.
- By tools, we mean ways in which Ofcom could potentially authorise the use of spectrum to promote further sharing, or make it more effective.

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

5.3 We are setting out this initial list to stimulate stakeholders' consideration of the ways in which spectrum sharing could be encouraged and delivered and to invite substantive feedback. Some of the tools and enablers identified would require considerably more work to develop and/or sit with others to deliver. The inclusion of a tool in this list does not mean that we think it is necessarily appropriate for use or are advocating its introduction. Rather, we are setting out here a list of potential tools on which we would welcome comments. In particular, we are interested in whether there are tools or enablers that would work particularly well, or conversely would pose particular risks or challenges.

Information

Provision of information on spectrum use

5.4 Consistent with the Spectrum Management Strategy we are providing more and more detailed information on spectrum authorisation.[17] We will continue to develop the information we make available over time.

5.5 Provision of more and better information could help to increase opportunities for sharing. In particular, information in the following areas might be helpful:

[17] http://spectruminfo.ofcom.org.uk/spectrumInfo/

- increased information on public sector spectrum use;
- Information on actual use, not just what is authorised;
    - real-time usage information from licensees on which frequencies are in use in which locations and characteristics of use (e.g. power levels, transmitter heights);
    - forward looking information on use from licensees (could help address insecurity of tenure for opportunistic users) to mitigate the secondary nature of sharers' rights relative to incumbents, whether for opportunistic users or sharers with more notice to quit;
- information on actual interference to manage the interfaces between users better; and
- information on spectrum demand both from existing users and potential users.

5.6 In its Spectrum Strategy, Government indicated that it would develop a single source of information on spectrum managed by the public sector which clearly identifies what frequencies are in use at what geographic locations, and hence what frequencies could be available for shared use. In the long term the aim is to enable any potential user of spectrum to interrogate an up-to-date source of information on spectrum availability, and to identify who is responsible for agreeing terms for use of such spectrum.[18]

5.7 More granular information about actual use and interference could feed into trading systems (see market enablers below), and having more information on spectrum demand would help to prioritise what sort of sharing opportunities are required.

5.8 Detailed information on spectrum use would likely be considered commercially sensitive by users, and this may need to be taken into account when determining the types and amount of information that can be made available. How information is collected, handled, and by whom, would require careful consideration.

Information about spectrum characteristics

5.9 One possibility would be to set out relatively simple information on spectrum that is potentially available for a particular purpose, to help prospective users understand and compare opportunities. This could cover for a given application, for example, international harmonisation, any constraints on geographical and population coverage from incumbent use, interference environment, and a propagation indicator as a proxy for the extent of infrastructure necessary to provide services.

Question 3: Are the categories of information set out in paragraph 5.5 the right ones? Are there any areas here that you think we should prioritise? Are there other types of information that we should be improving?

[18] Department for Culture, Media and Sport, *The UK Spectrum Strategy,* March 2014, pp. 26-27: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/287994/UK_Spectrum_Strategy_FINAL.pdf

Question 4: Do you think the information about spectrum characteristics described in paragraph 5.9 would be useful? What information would need to be included as a minimum to make it useful?

Market enablers

5.10 Market enablers are most likely to be relevant to sharing where spectrum has been assigned as block assigned licences, and where leasing or trading part of these spectrum rights is possible. Some incentives, such as spectrum pricing, may also be applicable to the public sector.

Spectrum trading and leasing

5.11 Many UK spectrum licences can be traded. Trading can facilitate sharing, because in addition to full trades, trades can be partial (i.e. selected frequencies or locations), temporary (i.e. time-limited transfer) or concurrent (i.e. multiple licensees who hold the same rights to the same frequencies and who coordinate between themselves).

5.12 Trading and leasing offers a private route for spectrum rights to flow to higher-value users, and gives the freedom to private parties to explore opportunities and to negotiate spectrum access deals without regulatory involvement. Section 3 set out barriers to trading and leasing, including transaction costs.

5.13 There have been a significant number of spectrum trades over the years. In principle intermediaries or trading platforms could increase market liquidity, but so far such mechanisms have not emerged, and it is not clear that there is a business case for them.

Spectrum pricing

5.14 Where demand for spectrum exceeds supply, spectrum pricing is a valuable complement to other market-based mechanisms to ensure optimal use of spectrum. Spectrum pricing, if prices are set at appropriate levels (i.e. reflecting opportunity cost), gives licensees an incentive to use spectrum efficiently. Ofcom already implements spectrum pricing in the form of AIP. Crown spectrum is also subject to spectrum pricing.

5.15 The potential for sharing could have implications for the opportunity cost of a spectrum licence, and where possible, pricing should take account of demand from potential sharers.

5.16 In order to be able to reflect the opportunity cost of shared use in spectrum pricing, we would need to have appropriate information about that opportunity cost, i.e. about the demand for shared access

Auctions

5.17 Where relevant, we could look for opportunities for bidding in auctions to reflect demand for shared use. There are several options for doing this, including creating specific licences for sharers, additional to those for tier 1 users, and selecting the highest value outcome across all bids; or awarding bidding credits to bidders who commit to accommodating sharers. This would offer prospective sharers an open and transparent opportunity to secure spectrum rights. It would establish sharing clearly at the outset, rather than add it to existing uses sometime into the life of their authorisations.

5.18 There are regulatory failure risks in defining how to accommodate sharing demand, e.g. in defining licences for sharers or in any setting the appropriate level of bidding credits to compensate those willing to accommodate sharers. There is also risk in adding complexity to auctions which may already be relatively complex, making it potentially difficult for bidders to derive and to implement efficient strategies and/or creating potential gaming opportunities.

5.19 A range of auctions could also be used in sharing scenarios, e.g.:

- Market-based enhancements to databases – the existing database pilot for TV white spaces involves first-come-first-serve access for WSDs. This could evolve to prioritise access between prospective sharers, with auctions to resolve conflicting demand. The databases might also support information exchange between existing and prospective sharers to facilitate trades.

- Incentive auctions – an incentive auction is a voluntary, market-based tool to compensate existing spectrum licensees for returning their licences to make spectrum available for new uses. In such an auction, existing spectrum licensees have a choice of whether to relinquish some or all of the spectrum they currently use, new users bid for future use of the spectrum in a standard auction, and existing users receive some form of consideration from the auction proceeds. At present, Ofcom does not have the legal power to hold such an auction.

- Overlay auctions - an overlay auction is one in which the winner of the auction must share the spectrum with the incumbent user and avoid harmful interference taking place. The incumbent users then have the choice whether to relinquish some or all of their rights to the spectrum they currently use in return for a commercially negotiated payment from the new user. A potential use of overlay auction would be to introduce a tiered-access framework, where existing licensees would be in tier 1 and new licensees would be in tier 2, with the right to use the frequencies wherever and whenever it would not create undue risks of interference. Commercial discussions between new and existing licensees may lead to an improvement of tier 2 rights. Another potential use of overlay auctions is where existing licences have an end date. Identifying new licensees earlier, through an overlay auction, may facilitate a better transition from existing to new licensees, with commercial negotiations potentially enabling faster completion.

Question 5: Have we identified the relevant market enablers, or are there others we should take into account? For each one, what is the potential for it to facilitate sharing and what are the downsides? Are there any that you think would be particularly effective or problematic?

Technology enablers

5.20 New developments in technology have the potential to enable more intelligent and efficient ways of sharing spectrum. They can help devices know which frequencies and time slots to use based on a better understanding of other users' use of the same spectrum band close to their location.

5.21 Technological innovation sits primarily with industry. However, Ofcom may have a role in the implementation of innovative spectrum management techniques, as we have done in authorisation of the use of dynamic spectrum access databases in TV white space. Ofcom may also contribute to some standards-setting activities. An example is helping industry to understand the need to define appropriate receiver characteristics to comply with the new Radio Equipment Directive. This activity has

the benefit of formalising receiver protection and therefore facilitates better spectrum sharing as the device performance is more certain.

Protocols for accessing shared spectrum

5.22 There are a number of technical approaches or protocols for accessing shared spectrum in a way that manages or avoids interference.

5.23 A common family of access control methods are termed Carrier Sense Multiple Access (CSMA). This approach - often termed "listen before talk" - is implemented by Wi-Fi equipment, whereby devices with data to send listen for the transmission of other devices on the network. They only transmit if no other devices can be heard.

5.24 This approach can also extend to other technologies, often termed "d*etect and avoid"* or "sensing" (see paragraph 5.30 below). For example, Wi-Fi access points listen for other users of spectrum, such as radar services, and, if found, they switch to another, clear frequency within the band. A variant of this approach sees Wi-Fi access points select frequencies that are less used, or not used at all, by neighbouring access points. Detect and avoid approaches can therefore be used to both protect existing spectrum users and improve the performance of Wi-Fi networks.

5.25 These protocols do not take account of the value to end-users and may reduce quality of service for some or all users where there is heavy demand.

5.26 It is possible that protocols such as this could be used in a way to give effect to tiered access amongst licence exempt users if certain users, or uses, are allowed to be less 'polite' than others. Tiered access is discussed further from paragraph 5.38.

Geolocation database technologies

5.27 Geolocation databases are making it easier for devices to identify spectrum that is available for sharing while protecting the operation of existing services. While the current focus is on the use of databases to manage access to TV white spaces within 470-790 MHz, the fundamental principle is not frequency specific and can extended to a broader range of frequencies.

5.28 Under current plans for TVWS, databases provide information to users about whether and on what frequencies and at what power levels they may transmit to avoid causing harmful interference to incumbent users in and adjacent to the band. Coordination to prevent interference between different white space users is not currently mandated in the UK. However coordination between white space users could be done at the database level and the geolocation database approach could be extended to manage access amongst opportunistic sharers, improving quality of service.

5.29 Where incumbent use is static (e.g. around radio telescopes or military sites), database information could potentially be integrated into devices. A geo-located device could know where it could transmit, removing the need to connect to a database to confirm whether it is possible to transmit. However one of the benefits of geo-location databases is that they can be updated, albeit infrequently so that changes in those static sites could be reflected (e.g. a new of decommissioned radio telescope site or a new systems operating in a different military base).

Sensing

5.30 Sensing describes the ability of devices to listen for other nearby spectrum users and determine whether it is possible to transmit. An advantage of a sensing approach is that a device is able to determine autonomously whether spectrum is available for use without the need to contact a database.

5.31 As part of the Spectrum Sharing consultation in 2013 we asked for views on whether recent developments in technology had made cost effective and accurate spectrum sensing viable. Respondents indicated that barriers to achieving cost effective and accurate sensing remain. But technical research is continuing to address these challenges, and the Statement set out our view that in the longer term we believe spectrum sensing is likely to play a role alongside geolocation databases.

5.32 Sensing may not work for some channels because the occupying service is not amenable to detection by sensing, such as passive services. Beacons signalling that particular channels are in use by protected services or vacant may be an approach that can help to overcome some of the difficulties of sensing. This requires spectrum in which the beacon can operate reliably, which has an opportunity cost, and further equipment costs for the actual beacons and the ability in sharing equipment to receive the beacon signal. This would place a significant responsibility on existing users in managing access, when their incentives may be to minimise sharing.

Automatic reporting of interference

5.33 Automatic reporting on interference between users would serve to provide real-world feedback on technical co-existence. This would enable technical parameters to be optimised, assumptions refined and margins reduced, resulting in more efficient sharing and greater value extracted out of spectrum.

Frequency and band agile equipment

5.34 Equipment that can tune across a wide spectrum range in a more agile way than being engineered to very specific bands could allow greater flexibility in sharing. This could help reduce dependence on band harmonisation to help achieve sufficiently low device price points and increase the pool of frequencies a sharer can build its business on – thus ultimately reducing the risk that its business case is damaged by changes in the incumbent's spectrum. However, we acknowledge that becoming more flexible on frequency bands can introduce extra device complexity to overcome technical limitations, which may have an adverse effect on any business case.

Question 6: Have we identified the relevant technology enablers, or are there others we should take into account? For each one, what is the potential for it to facilitate sharing and what are the downsides? Are there any that you think would be particularly effective or problematic? What, if any, role should Ofcom play in helping to develop them?

Authorisation tools

5.35 Where the market is not delivering optimal use, Ofcom can facilitate shared access through authorisation. Ofcom action may also be required for the implementation of some of the enablers mentioned above.

Information requirements

5.36 In paragraph 5.5 we set out that the provision of more and better information could help to increase opportunities for sharing.

5.37 Obtaining this information may require obligations in licences, where appropriate.

Tiered access

5.38 By tiered access we mean a hierarchy of rights for different categories of user in a given frequency band. For example, this would include the model in place for TV white spaces, with DTT as tier 1, PMSE as tier 2 and white space devices as tier 3. TV licensees take precedence over all users of the band and PMSE licensees fit around TV licensees but take precedence over WSDs. WDSs fit around all other users. Other examples include 3.5GHz in USA, which is discussed further in Annex 5 on international sharing approaches.

5.39 The definition of tiers could cover relative priorities between groups of licensed users, between licensed and licence-exempt users and between groups of licence-exempt users. The benefit of tiered access is that it should create conditions in which existing users can continue to invest and in which new users have some clarity on the opportunity a band offers.

5.40 A tiered approach that applies between licence exempt users could address risks to quality of service through congestion and reduce uncertainty of access for some users. A priority tier or users would have precedence over other types of users or use of different technologies. The desired effect would be to generate more value out of unlicensed use, such that less valuable use would give way to more valuable use. However, the need to identify who should be the 'priority' users means there would be a risk of effectively creating a licensing framework, and negating the low barriers to entry that are the primary attraction of unlicensed spectrum. There would also be a risk of regulatory failure when picking the users or technologies for the top tier.

5.41 Tiered access can be static or dynamic. It needs to combine with other tools and enablers to support each tier in delivering services, and make interference management and application of precedence successful.

5.42 With all tiered access approaches, balancing the impact on the incumbent and the usage constraints on any additional user is a challenge. If access for lower tiers can only be opportunistic, this increases risk to the users in those tiers and may prevent them from developing a viable business model in the spectrum.

5.43 Within the European Union, the concept of multiple uses sharing the same band is being is being explored and trialled under what is known as Licensed Shared Access (LSA) in a number of Member States. LSA was examined by the Radio Spectrum Policy Group (RSPG) in the *RSPG Opinion on Licensed Shared Access.*[19] The UK already facilitates sharing between multiple uses under the WT Act.

5.44 Further information on LSA is included in Annex 5 along with other examples of international activity on sharing.

[19] Radio Spectrum Policy Group, *RSPG Opinion on Licensed Shared Access*, November 2013: https://circabc.europa.eu/d/d/workspace/SpacesStore/3958ecef-c25e-4e4f-8e3b-469d1db6bc07/RSPG13-538_RSPG-Opinion-on-LSA%20.pdf

Question 7: Do you have any comments on the authorisation tools that we have identified above? Are there others we should take into account? For each one, what is the potential for it to facilitate sharing and what are the downsides? Are there any that you think would be particularly effective or problematic?

Section 6

Identifying sharing opportunities: the role of characteristics of use

We will always need to consider sharing opportunities on a case by case basis

6.1 One of the aims of the framework is to ensure that, when we make authorisation decisions, we give users access to the spectrum in a way that meets their needs as well as respecting those of any incumbents in a band.

6.2 In practice each service that uses spectrum has different characteristics and different needs, mainly depending on the business model behind the service on offer. There is no “one size fits all” solution. We will therefore always need to consider any spectrum sharing opportunity on a case by case basis.

6.3 We also recognise that requirements for spectrum exist within a broader context. This includes the availability of relevant competitively priced equipment that will operate within the terms of spectrum authorisation, which is in turn likely to be significantly influenced by international allocation decisions.

6.4 This section looks at the high level characteristics of use that we would expect to take into account when considering the potential for sharing and whether any specific tool or enabler is appropriate to address the relevant barriers, taking account of such characteristics.

We set out a set of high level ‘characteristics of use’ to guide consideration of sharing potential

6.5 Spectrum users’ needs will define sharing opportunities and constraints, determining which tools are likely to support viable business opportunities and what other uses they might be compatible with.

6.6 Implementing sharing is likely to be complex in many cases, and may require resource-intensive technical studies that – as set out in section 4 – can act as a deterrent to sharing. Assessing a potential new sharing opportunity requires identifying at a high level whether there may be a case for pursuing in more detail.

6.7 To do this, we have set out a set of high level characteristics of use – a series of characteristics that we think, when combined, give a high level picture of what an incumbent or potential new user needs from spectrum access. By looking at these characteristics, we think it should be possible to get an initial insight into whether two types of users may be able to share with one another, and whether any tool or combination of tools is likely to deliver what they need.

6.8 The characteristics of use that we have identified are set out in Table 1.

Table 1: High level characteristics of use

Criteria	Characteristics
Time	What are the temporal requirements of the service? Is it always–on, a set time, or unpredictable?
Geography/coverage	Will the service cover the national territory or be restricted to certain areas? Will it be ground-based? Outdoor/indoor? Is the service in a fixed location or mobile? Is its location predictable? Control over end users - does the user know where its end-users are? Can the user control them?
Quality of service	What type of reliability does the service require? Guaranteed availability vs. best efforts
High level technical characteristics	Power and directionality
Economies of scale and harmonisation	How essential are the benefits from international harmonisation? What extent of economies of scale is necessary or desirable (e.g. subset of EU member states, all EU or several world regions)? What is essential to securing sufficient harmonisation?
Capacity requirement	How much capacity needed for each device and for the whole service? Is this a core capacity requirement or for additional capacity, e.g. for occasional overflow?
Density of use	Number of devices in use, i.e. whether a mass market consumer use or a limited number of applications
Evolution of these criteria over the life of an authorisation	How will each of these characteristics evolve over the term of the authorisations involved? What is the best way of approaching the uncertainty over longer timeframes? What is the payback period on the investment?

6.9 We would expect parties interested in sharing spectrum and in engaging with us about their plan to describe these characteristics. The high level assessment of potential opportunities to share they enable will need to be followed by detailed technical studies to confirm it, including the impact on services in adjacent bands.

6.10 In this section we have outlined the various factors that we would expect to take into account when considering shaping a spectrum authorisation to deliver optimal use of spectrum. We invite comments on whether we have identified the right factors, and whether there are other factors that we should expect to take into account. It would also be helpful if stakeholders could indicate which of these factors they consider to be particularly significant and which, if any, they think we should attach less weight to.

Question 8: Are the characteristics of use we have identified sensible and sufficient to provide a high level indication of sharing potential? Are there other factors that we should expect to take into account? Are there any factors that you consider to be particularly significant? Are there any which we should attach less weight to?

Section 7

Next steps

7.1 This document sets out a proposed framework for assessing spectrum requirements and ensuring optimal use of spectrum, with a particular focus on spectrum sharing where appropriate. Our aim is that this framework will form a key part of our approach to spectrum authorisation, and will be considered whenever we are assessing how to address demand for spectrum from incumbent and/or new users.

7.2 We are seeking comments by 2 October 2015.

7.3 To give stakeholders the opportunity to engage with Ofcom on these proposals, we intend to hold a stakeholder event in the autumn, before the close of the consultation period. If you would like to attend the event, please register your interest by emailing Sharing.Framework@ofcom.org.uk.

7.4 We will update the framework in the light of comments from stakeholders and further consideration. We expect to publish a follow-up document by the end of 2015/16.

Annex 1

Responding to this consultation

How to respond

A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made **by 5pm on 2 October 2015**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://stakeholders.ofcom.org.uk/consultations/spectrum-sharing-framework/howtorespond/form, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response cover sheet (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email sharing.framework@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

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

Kirsty Logan
Spectrum Group
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 Note that we do not need a hard copy in addition to an electronic version. Ofcom will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.

A1.6 It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at Annex 4. It would also help if you can explain why you hold your views and how Ofcom's proposals would impact on you.

Further information

A1.7 If you want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Kirsty Logan on 020 7981 3095.

Confidentiality

A1.8 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt. If you think your response should be kept confidential, can you please specify what part or whether

all of your response should be kept confidential, and specify why. Please also place such parts in a separate annex.

A1.9 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and will try to respect this. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.10 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/terms-of-use/

Next steps

A1.11 Following the end of the consultation period, Ofcom intends to publish a follow-up document by the end of 2015/16.

A1.12 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details please see: http://www.ofcom.org.uk/email-updates/

Ofcom's consultation processes

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

A1.14 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

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

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

Tel: 020 7981 3601

Email Graham.Howell@ofcom.org.uk

Annex 2

Ofcom's consultation principles

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

Before the consultation

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

During the consultation

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

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

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

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

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

After the consultation

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

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency and good regulatory practice, we will publish all consultation responses in full on our website, www.ofcom.org.uk.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality where appropriate.

A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at http://stakeholders.ofcom.org.uk/consultations/consultation-response-coversheet/.

A3.5 Please put any parts of your response you consider should be kept confidential in a separate annex to your response and include your reasons why this part of your response should not be published. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your cover sheet only, so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

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

Nothing ☐

Whole response ☐

Part of the response ☐

Name/contact details/job title ☐

Organisation ☐

If there is no separate annex, which parts?

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

DECLARATION

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

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

Name

Signed (if hard copy)

Annex 4

Consultation questions

Question 1: Do you have any comments on the barriers to increased sharing that we have identified above? Which are the most significant and why? Are there others we should take into account?

Question 2: Have you experienced or are you experiencing the effects of these barriers? If so, in what circumstances and with what impact?

Question 3: Are the categories of information set out in paragraph 5.5 the right ones? Are there any areas here that you think we should prioritise? Are there other types of information that we should be improving?

Question 4: Do you think the information about spectrum characteristics described in paragraph 5.9 would be useful? What information would need to be included as a minimum to make it useful?

Question 5: Have we identified the relevant market enablers, or are there others we should take into account? For each one, what is the potential for it to facilitate sharing and what are the downsides? Are there any that you think would be particularly effective or problematic?

Question 6: Have we identified the relevant technology enablers, or are there others we should take into account? For each one, what is the potential for it to facilitate sharing and what are the downsides? Are there any that you think would be particularly effective or problematic? What, if any, role should Ofcom play in helping to develop them?

Question 7: Do you have any comments on the authorisation tools that we have identified above? Are there others we should take into account? For each one, what is the potential for it to facilitate sharing and what are the downsides? Are there any that you think would be particularly effective or problematic?

Question 8: Are the characteristics of use we have identified sensible and sufficient to provide a high level indication of sharing potential? Are there other factors that we should expect to take into account? Are there any factors that you consider to be particularly significant? Are there any which we should attach less weight to?

Annex 5

Spectrum sharing initiatives – international activities

A5.1 This annex notes some of the spectrum sharing initiatives that regulators across the globe are putting in place. It captures only those sharing techniques that go beyond the traditional methods of sharing.

A5.2 We present first the regulatory initiatives in the TV band, and secondly work in other bands carried out nationally or at international organisations (such as the ITU or ECC).

A5.3 This annex represents our current understanding at the time of going to print. Sharing initiatives listed will be subject to change over time. It is not intended to be an exhaustive list.

Table 2: Sharing in the UHF band

Jurisdiction	Summary of activities in the TV band
United States[20]	In Sept 2010 the FCC finalised the rules for use of TVWS. Devices are allowed to operate on a licence exempt basis, provided that they communicate their location to certified database and operate according to the channel list provided by the database. Spectrum sensing can be performed, but is not required Devices must contact database at least once in every 24 hours for new channel list. All devices must report location, FCC ID and technical characteristics. Personal/Portable devices must get new channel list if they move more than 100 m or lose power. In Jan 2011 the FCC designated nine database providers, subject to an approval process. It has so far approved 4 of them for operation: Google, SpectrumBridge, KeyBridge and iConectiv The incentive auction will bring significant changes to TVWS availability. The proposed band reshuffle guarantees that at least one channel will be available for white space devices and wireless microphones, plus additional channels depending on the outcome of the auction.
Canada[21]	Industry Canada (IC) – the Government Department in charge of spectrum management – released in October 2012 its policy decision to enable access to TVWS with the following characteristics: • TVWS devices permitted on a no-protection, no interference basis to licensed users in the band; • Existing users require a license to receive protection from TVWS devices; • No limits on number of database administrators; • Spectrum sensing is allowed but initial implementation of rules will focus on a geo-location database;

[20] Sources: Code of Federal Regulations, Title 47, Chapter I, Subchapter A, Part 15, Subpart H; FCC website; FCC NPRM 15-68
[21] Sources: IC website; IC SMSE-012-12; IC DBS-1;IC RSS-222

	• TVWS devices will require certification. IC expects that TVWS technology will deliver improved, Wi-Fi–like services in rural regions. TVWS devices will initially provide broadband Internet, similar to Wi-Fi, but with expanded coverage that exceeds traditional Wi-Fi. In February 2015 IC published a Specification (RSS-222) describing the technical and operational requirements for WS devices. This Standard broadly follows the US requirements in terms of equipment types and technical characteristics. IC will put in place a process for database and device certification involving a call for applications to become a database provider, a review, evaluation and testing of applicants, the designation of databases and finally certification of devices against a database.
Singapore[22]	Singapore's Infocomm Development Authority (IDA) has approved in November 2014 the rules enabling access to TVWS. Operation of TV WS devices will be on a licence-exempt basis provided that devices comply with the technical requirements specified by the IDA, contact a licensed database to obtain channel availability, and are registered with the IDA following a comprehensive validation process. The device types and requirements are broadly in line with the US model, although Singapore allows for variable EIRP levels (like the UK/ETSI model). The IDA has introduced two High Priority Channels (HPC).These channels can only be activated when there are no common TVWS channels available at a WSD location. The HPC access will be managed by the Geo-location Database and the allocation method (including any fees to be imposed) will be left to the commercial decisions of the Database providers Organisations interested in becoming Database providers must apply for an SBO (Individual) Licence from IDA. There will be no limit set for the number of providers to be licensed. The application must include their vision for TVWS deployment in Singapore and their business plans, in particular the pricing and, terms and conditions of the service.
New Zealand[23]	Radio Spectrum Management, the government department in charge of spectrum in New Zealand, has put in place a temporary arrangement for access to TVWS in New Zealand starting November 2014. This arrangement allows interested parties to obtain licenses for operation of WS devices at channels that will be specified in the licence – operation with a database is not required. Devices must be compliant with either FCC rules or the ETSI standard EN 301 598, with the requirements related to interaction with databases being removed.

[22] Source: IDA REGULATORY FRAMEWORK FOR TV WHITE SPACE OPERATIONS IN THE VHF/UHF BANDS, June 2014
[23] Source: RSM Television White Space devices certification and licensing rules, November 2014

Table 3: Sharing in bands other than the TV band

Sharing initiative	Description
3.5 GHz in US[24]	The FCC is proposing to put in place a sharing arrangement between public and commercial users in the 3550 MHz to 3700 MHz range, in the form of a three-tiered sharing framework enabled by a Spectrum Access System (SAS). Incumbent users represent the highest tier and include Defense, Fixed Satellite Service (FSS) and grandfathered terrestrial wireless operations. The Citizens Broadband Radio Service is introduced in the two tiers below, as Priority Access and General Authorized Access (GAA). Both are authorized in any given location and frequency by an SAS. Priority Access operations are licensed and receive protection from GAA operations. The hybrid framework is intended to select the best licensing approach based on local supply and demand. Where competitive rivalry for spectrum access is low, the GAA tier provides a low-cost entry point to the band, similar to unlicensed access. Where rivalry is high, an auction resolves mutually exclusive applications in specific geographic areas for PALs. The initial proposals from 2012 contained exclusion zones of several hundreds of km required for protection of Naval radars. These zones made the band unusable for commercial purposes in the coastal areas. In April 2015 the FCC released new rules based that reduce the exclusion zones substantially, and in addition propose to progressively turn them into protected zones. This involves the deployment of networks of sensors around radar installations. These networks will inform the SAS when a radar operation is detected.
2.3 GHz in the Netherlands[25]	The Radiocommunications Agency is running a dynamic licensing pilot in the 2300 – 2400 MHz band. Existing users are PMSE (ENG/OB); Government and Radio amateurs. The pilot will start with an online dynamic licensing system for PMSE and if successful move to other services, such mobile broadband, and eventually other bands.
2.3 GHz in France[26]	The Agence Nationale des Fréquences (ANFR) is considering the introduction of sharing in this band. The primary users in this band are telemetry and other defence applications, and the expected secondary use would be the mobile service. The regulatory regime under study at the ANFR is Licensed Shared Access (LSA), followed by an individual authorisation for mobile services providers. The implementation of LSA relies on the concept of a “sharing framework” which is the responsibility of the regulator although its development requires the involvement of all stakeholders. The sharing framework aims to ensure a certain level of guarantee in terms of spectrum access and protection against harmful interference for both the incumbent(s) and LSA licensees, thus allowing them to provide a predictable quality of service. ANFR has conducted compatibility studies and is now running trials to verify the results of the studies, and to assess the performance of dynamic sharing vs. the requirements of defence and the industry.

[24] Source: FCC NPRM 15-47
[25] Source: Presentation from the RA at the EC WS on Spectrum Sharing, 20/3/15
[26] Source: Presentation from the ANFR at the EC WS on Spectrum Sharing, 20/3/15

5350-5470 MHz[27]	The 5350 – 5470 is allocated to earth exploration globally. The bands immediately above and below are allocated to RLAN. This scenario has led to proposals from several organizations (including Ofcom) to consider how RLAN could be allowed in the 5350-5470 MHz as secondary users. These proposals have been present at the ITU (JTG 4-5-6-7 and WP 5A) and ECC CPG/PTD. Several techniques have been identified and studied: Dynamic Frequency Selection, changes in the RLAN channelling arrangements, dedicated sensor networks and geolocation databases. Geo-location databases in particular could be a viable technique for protection of EESS if detailed information on the orbits of the EESS satellites are provided to the database providers. However it is likely that a global regulatory framework is required for this approach to be workable.
17.7-19.7 GHz[28]	This band is used by fixed service microwave as the primary use throughout Europe. A case for sharing with uncoordinated fixed satellite service is being studied in ECC[29] **Error! Hyperlink reference not valid.**and the ANFR in France. Wideband satellite service is currently delivered with a downlink in 19.7-20.2 GHz. This service allows commercial internet access with data rates up to 20 Mbit/s. There is interest from satellite community to combine both bands to provide extra-capacity. This could be enabled if information on fixed service frequency assignments is made available so that satellite users select frequencies that avoid interference from microwave links at their particular location. ECC is considering a geo-location database approach to provide information about fixed links to the FSS users.
5.8 GHz[30]	A geo-location approach is being considered in ECC SE24 / ETSI ITS in support of coexistence in the 5.8 GHz band between road tolling applications and Intelligent Transport Systems embarked in vehicles (to avoid interference from ITS into road tolling applications). A geo-location map that contains locations of the road tolling stations would be implemented in ITS enabled vehicles (ETSI TS 102 792)

[27] Source: Ofcom internal
[28] Source: Presentation from the ANFR and CoRaSat at the EC WS on Spectrum Sharing, 20/3/15
[29] http://www.cept.org/ecc/groups/ecc/wg-fm/fm-44
[30] Source ETSI ITS

Table 4: Sharing approaches (not band specific)

Sharing approach	Description
Licensed Shared Access in the EU	In its Opinion on Licensed Shared Access (LSA) (RSPG13- 538 RSPG Opinion on Licensed Shared Access – November 2013) [31], the RSPG considered how sharing could be implemented in a licensing regime, primarily in those bands where spectrum re-farming opportunities may be limited and where sharing could improve the efficiency of spectrum use. For the purposes of the Opinion spectrum sharing was defined as common usage of the same spectrum resource by more than one user. Sharing can be made with respect to all three domains: frequency, time and place. The objective of an LSA approach as set out in the RSPG Opinion is to grant additional rights of use in specific bands on a shared basis allowing predictable quality of service for all rights holders. However, these arrangements will need sufficient flexibility in order to allow for the incumbent to develop its network and to be able to take into account changes in technology (both the incumbent and new LSA users), in accordance with its spectrum rights of use. LSA could be initiated on a voluntary basis, but it also may be imposed by the regulator in order to ensure efficient spectrum use. Therefore, LSA could be introduced where needed, as a regulatory approach to enable spectrum sharing and is therefore an enabler in environments where the existing regulatory approach may not already facilitate it. RSPG view LSA not as a new licensing regime, but rather a regulatory approach focussed on facilitating a more efficient use of spectrum.

[31] Radio Spectrum Policy Group, *RSPG Opinion on Licensed Shared Access*, November 2013: https://circabc.europa.eu/d/d/workspace/SpacesStore/3958ecef-c25e-4e4f-8e3b-469d1db6bc07/RSPG13-538_RSPG-Opinion-on-LSA%20.pdf

Annex 7

Glossary

4G	Fourth generation mobile phone standards and technology
AIP	Administered incentive pricing. A fee charged to users of the spectrum to encourage them to make economically efficient use of their spectrum.
ECC	Electronic Communications Committee
EIRP	Equivalent Isotropically Radiated Power. This is the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain).
ETSI	European Telecommunications Standards Institute.
EU	European Union
FCC	Federal Communications Commission (US)
Fixed link	A terrestrial based wireless system operating between two or more fixed points
Frequency band	A defined range of frequencies that may be allocated for a particular radio service, or shared between radio services
Geolocation	The capability of a white space device to determine the latitude and longitude coordinates of its antenna and the level of uncertainty in the accuracy of its antenna latitude and longitude coordinates, specified as ±Δx and ±Δy metres respectively, corresponding to a ninety-five per cent confidence level.
ITU	International Telecommunications Union - Part of the United Nations with a membership of 193 countries and over 700 private-sector entities and academic institutions. ITU is headquartered in Geneva, Switzerland.
LTE	Long-Term Evolution is a standard for communication of high-speed data for mobile phones and data terminals. The term 4G is generally used to refer to mobile broadband services delivered using the next generation of mobile broadband technologies, including Long Term Evolution (LTE) and WiMAX
MOD	Ministry of Defence
Ofcom	Independent regulator and competition authority for the UK communications industries

Opportunity cost	The cost of a decision or choice in terms of the benefits which would have been received from the most valuable of the alternatives that was foregone
PMSE	Programme Making and Special Events. A class of radio application that supports a wide range of activities in entertainment, broadcasting, news gathering and community events.
RSPG	Radio Spectrum Policy Group - High-level advisory group that assists the European Commission in the development of radio spectrum policy.
SMS	Spectrum Management Strategy, published by Ofcom on 30 April 2014
UHF	Ultra High Frequency. The ITU (International Telecommunications Union) designation for radio frequencies in the range between 300 MHz and 3 GHz.
Wi-Fi	Commonly used to refer to wireless local area network (WLAN) technology, specifically that conforming to the IEEE 802.11 family of standards. Such systems typically use one or more access points connected to wired Ethernet networks which communicate with wireless network adapters in end devices such as PCs. It was originally developed to allow wireless extension of private LANs but is now also used as a general public access technology via access points known as "hotspots".
WSD	White Space Devices - which make use of transmission frequencies that are nominally allocated to other services but which are unused in the vicinity of the device.
WT Act	Wireless Telegraphy Act 2006