Supporting innovation in the 100-200 GHz range

Proposals to increase access to Extremely High Frequency (EHF) spectrum

CONSULTATION:

Publication Date: 17 January 2020

Closing Date for Responses: 20 March 2020

Contents

Section

Annex

1. Overview

1.1 As advances in technology enable the use of increasingly high spectrum frequencies, there is now potential for a new range of innovative services and applications to make use of spectrum above 100 GHz. This spectrum offers large bandwidths and different propagation properties to lower frequency bands. Although these technologies are at an early developmental stage, there is a range of envisaged use cases including health screening applications, non-invasive quality assurance in the pharmaceutical and manufacturing industries and high-speed data links.

1.2 Frequency bands above 100 GHz are lightly used, primarily for space-related applications such as Earth Exploration-Satellite Services (EESS) which collect data on changes to the Earth's atmosphere and weather conditions. There is presently little terrestrial use.

1.3 We are proposing to enable greater access to Extremely High Frequency (EHF) spectrum in the 100-200 GHz frequency range. Given its potential to support a range of new wireless services we are also proposing to make this spectrum available on a flexible service neutral basis. There is growing international interest in using these frequencies, including the recent decision of the Federal Communications Commission to make several bands in this range available in the USA. By increasing access to this spectrum, UK innovators could benefit from international research collaboration, as well as economies of scale as new internationally compatible devices are likely to emerge. We believe these proposals would help position the UK at the forefront of developing new services to use this spectrum and in doing so help deliver benefits to people and businesses.

What we are proposing – in brief

Innovative technology using Extremely High Frequency (EHF) spectrum in the 100-200 GHz bands has the potential to develop a range of new services and applications.

To help foster this innovation, we are proposing to enable simple, flexible access to over 18 GHz of radio spectrum across three bands (116-122 GHz, 174.8-182 GHz and 185-190 GHz). We propose that this spectrum could be accessed using:

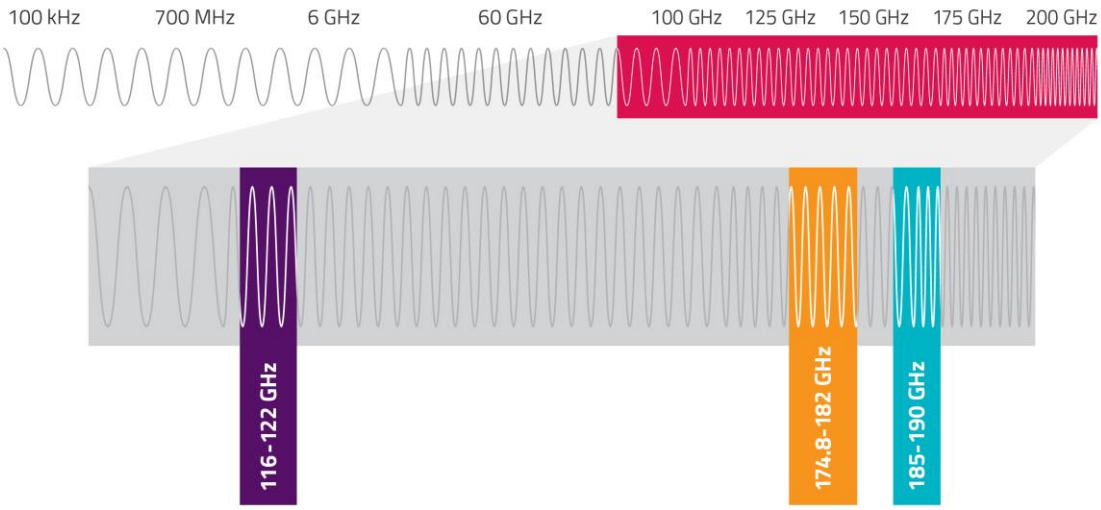
- Lower power licence-exempt devices; or
- Increased power devices under a new 'Spectrum Access: EHF frequencies' licence on an uncoordinated shared basis.

To protect Earth Exploration-Satellite Services from the risk of undue interference, these devices would be authorised subject to certain technical conditions.

Our proposals

1.4 The proposals set out in this document would enable access to over 18 GHz of additional spectrum across three bands: (i) 116-122 GHz; (ii) 174.8 – 182 GHz; and (iii) 185-190 GHz.

Figure 1.1: Spectrum in the 100-200 GHz range



1.5 Enabling simple access to more spectrum above 100 GHz, including large contiguous blocks, should support UK-based innovators to fully explore the potential for using these frequencies, including to launch higher capacity or increased power services. It would allow companies to trial innovative new services, which they could then launch commercially, without needing to worry about access to spectrum being a barrier.

1.6 Devices would be authorised subject to certain technical conditions designed to protect EESS from undue interference. On the basis of our technical analysis, we consider the likelihood of undue interference being caused by new spectrum users to EESS to be very low. There are a number of reasons for this:

a) First, our proposed technical limits would constrain the amount of interference new users can cause;

b) Many of the proposed new use cases are for indoor use; the relatively high building penetration losses at these frequencies would reduce the potential for interference caused by indoor devices;

c) We anticipate that any outdoor high capacity data link services would use highly directive narrow beam antennas to compensate for the high propagation and atmospheric losses, which would reduce the signals radiated into space;

d) The large amount of spectrum we are proposing to make available would also help reduce the likelihood of interference from multiple devices at any given frequency.

Licence exemption for lower power use

1.7 We propose to allow both indoor and outdoor use of lower power devices in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz frequency bands without the need to hold a wireless telegraphy licence (i.e. on a licence exempt basis), subject to the following conditions:

a) indoor licence-exempt use would be permitted up to a maximum equivalent isotropically radiated power (EIRP) of 40 dBm in all three bands;

b) outdoor licence-exempt use would be permitted up to a maximum EIRP of 20 dBm in the 116-122 GHz and 174.8-182 GHz bands, and 40 dBm in the 185-190 GHz band. Additional constraints would be placed on the terrestrial device antennas to minimise their emissions in the direction of EESS.

Licensing regime for increased power use

1.8 We also propose to authorise the indoor and outdoor use of increased power devices (up to 55 dBm EIRP) in each of these three bands, subject to the requirement to hold a spectrum licence (i.e. the "Spectrum Access: Extremely High Frequencies" licence). This licence would impose additional technical restrictions to minimise emissions in the direction of EESS when the licensed devices are used outdoors, both in terms of antenna directivity and the elevation angle of the installed devices.

1.9 Under our proposals, a "Spectrum Access: Extremely High Frequencies" licence would authorise use of a given band across the UK, permitting multiple devices to be deployed by each licensee. We do not propose to coordinate licensees' use of the spectrum in these bands, meaning that new deployments would not be required to take account of existing terrestrial users. This would maximise flexibility for licensees and reflects the very low risk of interference between users given the large amount of available spectrum, the higher reduction in signal level with propagation distance and the likelihood that increased power use such as data links would use highly directive antennas with narrow beams in these bands.

1.10 The licence would have an indefinite duration, subject to a three-year notice period for revocation for spectrum management reasons and would require payment of a licence fee of £75 every five years. Licensees would be required to keep records of the location and antenna main beam elevation angle of radio equipment.

Other future uses of frequencies above 100 GHz

1.11 We recognise that there is interest in making further EHF bands above 100 GHz available. We will continue to explore opportunities to provide flexible access to additional frequency bands above 100 GHz on a technology and service neutral basis. We would welcome stakeholder views on this and the specific bands we should consider, identifying the types of services and innovation this might support and the benefits which might be realised.

Next steps

1.12 We aim to publish our decisions on these proposals in summer 2020. If we decide to proceed with our proposals, we plan to put the new authorisation framework in place before the end of 2020.

2. Introduction

2.1 This document presents proposals to enable greater access to frequencies in the range 100-200 GHz. Whilst these frequencies have been lightly used to date, technological developments are enabling innovation into a range of new services and devices using these frequencies.

2.2 At present, terrestrial users have limited opportunities to access this spectrum. The proposals in this document would increase the amount of spectrum available in the 100-200 GHz frequency range. Enabling simple access to a materially greater amount of spectrum above 100 GHz, including large contiguous blocks, should support UK-based innovators to more fully explore the potential of these frequencies, including for higher capacity or increased power services. Where trials are successful, innovators would be able to move to commercialise applications and devices without spectrum access being a barrier.

2.3 There is growing international activity around innovation using these bands of spectrum, including the recent decision of the Federal Communications Commission to make several bands in this range available in the USA. This context should enable UK innovators to benefit from international research collaboration, and increases the likelihood of economies of scale being realised from the development of new internationally compatible devices.

Legal framework

2.4 Ofcom is responsible for authorising use of the radio spectrum. We permit the use of the radio spectrum either by granting wireless telegraphy licences under the Wireless Telegraphy Act 2006 (the "WT Act") or by making regulations exempting the use of particular equipment from the requirement to hold such a licence. It is unlawful and an offence to install or use wireless telegraphy apparatus without holding a licence granted by Ofcom, unless the use of such equipment is exempted. In annex 5, we set out in more detail the relevant legal framework, which we have taken into account in making the proposals set out in this document. This annex should be treated as part of this document.

Impact Assessment

2.5 This document represents an impact assessment as defined in Section 7 of the Communications Act 2003. Impact assessments provide a valuable way of assessing different options for regulation. They form part of best practice policy making.

2.6 In developing our proposals, we have considered their impact on citizens and consumers, service providers, manufacturers and users of devices and applications, and on existing users of the relevant frequencies, including adjacent bands.

2.7 Ofcom is an evidence-based organisation and welcomes responses to this consultation. Any comments about our assessment of the impact of our proposals should be sent to us

by the closing date for this consultation. We will consider all comments before deciding whether to implement our proposals. For further information about our approach to impact assessments, see the guidelines 'Better policy making: Ofcom's approach to impact assessments' on our website.[1]

Equality Impact Assessment

2.8 Ofcom is separately required by statute to assess the potential impact of all our functions, policies, projects and practices on the following equality groups: age, disability, gender, gender reassignment, pregnancy and maternity, race, religion or belief, and sexual orientation. Equality Impact Assessments (EIAs) also assist us in making sure that we are meeting our principal duty of furthering the interests of citizens and consumers regardless of their background or identity. We consider that our proposals would not be detrimental to any of these equality groups.

2.9 We have not carried out separate EIAs in relation to the additional equality groups in Northern Ireland: religious belief, political opinion and dependants. This is because we anticipate that our proposals will not have a differential impact in Northern Ireland compared to consumers in general. We welcome any stakeholder views on this assessment.

Notification under the Technical Standards Directive

2.10 In accordance with the Radio Equipment Directive and the Technical Standards Directive, we will shortly notify our proposed changes to the current interface requirements for short-range devices (IR 2030) and proposed new interface requirements for licensed devices (IR 2106) to the European Commission.

Structure of document

2.11 The remainder of this document is set out as follows:

- **Section 3** discusses current use of spectrum in the 100-200 GHz range and identifies three bands for which we propose to introduce new authorisation approaches to enable innovative products and services.
- **Section 4** sets out our proposals for allowing the use of lower power devices in the 116-122 GHz, 174.8 – 182 GHz and 185-190 GHz bands under a licence exemption regime.
- **Section 5** sets out our proposals for allowing the use of increased power devices in the same bands under a licensing framework.
- **Section 6** sets out our next steps.

[1] An overview and link to the guidelines can be found on our Policies and guidelines webpage.

3. Increasing access to 100-200 GHz spectrum would support the development of new and innovative services

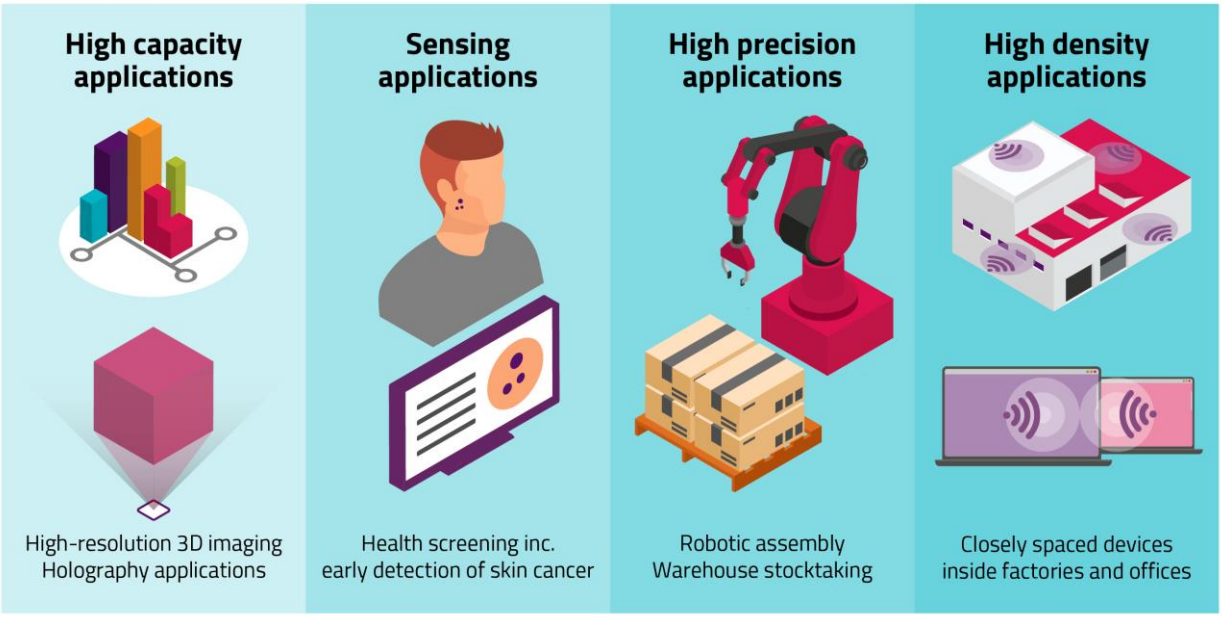
Introduction

3.1 Spectrum in the frequency range 100-200 GHz is currently lightly used in the UK. Advances in technology will enable these frequencies to be used for new types of innovative devices and services. The development and availability of these new devices and services could deliver significant benefits and support wider growth in the UK economy.

3.2 In this section we examine current use and how this spectrum might be used in the future. We identify three bands of Extremely High Frequency (EHF)[2] spectrum in the frequency range 100-200 GHz (the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands) for which we propose to introduce new authorisation approaches to enable the development of new and innovative services and products in the UK.

Advances in technology will enable the use of higher frequencies to deliver new types of innovative services

Figure 3.1: Potential uses of 100-200 GHz spectrum



[2] Extremely High Frequencies (EHF) cover the frequency range 30 to 300 GHz.

3.3 The use of EHF frequencies above 100 GHz to provide new services for consumer and industry applications is becoming an increasingly practical proposition as a consequence of developments in microchip technologies that allow their operation in this frequency range. New services and technologies using these frequencies have the potential to deliver new mass market services by the end of the decade.

3.4 EHF bands above 100 GHz have a number of properties which are different to lower frequencies:

a) Short propagation distances.[3] Signals in these bands also experience high building losses, absorption by physical objects and are more adversely impacted by weather such as rain and snow compared with lower frequency bands.

b) Small wavelengths. These enable small form factor devices with integral antennas capable of providing high directivity and narrow beams. These narrow beams reduce the likelihood of interference between different uncoordinated users as beam-to-beam alignment between different services is much less likely to occur than when wider beams are used. This makes them suited to enabling terrestrial users to coexist without co-ordination.

c) Very large contiguous bandwidths available. In our proposed bands, there are contiguous bandwidths of between 5 GHz and 7.2 GHz available, which enables high capacity use.

3.5 These technical characteristics make them well suited to a wide range of applications including:

a) **High capacity applications.** Frequency bands above 100 GHz offer higher bandwidths and hence more capacity than lower frequency spectrum. This means that this spectrum can facilitate new extremely high data-rate communications and applications. These might include future high-resolution 3D imaging and holography applications.

b) **Sensing applications.** Bands above 100 GHz propagate through physical objects in different ways to lower frequency bands. This makes them suited to detecting, for example, defects within some types of manufactured products, including pharmaceuticals, which cannot be detected in other frequency bands. It also makes them well suited to enabling more effective health screening, including the early detection of skin cancer.

c) **High precision positioning applications.** The high level of signal reflections from objects in these bands, coupled with the large bandwidths available, make the bands well suited to being used for high precision positioning applications. These might include supporting the robotic assembly of high precision products, the precise storage

[3] Propagation distances of up to several metres are feasible for lower power devices, and greater (up to around a kilometre) for reliable directional links with increased power.

and stocktaking of products in warehouses, and detecting outdoor small movements in building structures.

d) **High density applications.** The properties of bands above 100 GHz mean they could be used by closely spaced devices and systems enabling higher density of use, for example inside factories and offices where there are larger numbers of wirelessly connected devices and systems. The bands could also be used for very high-speed, short-range connections in dense applications, such as between microchips and circuit boards. This is possible owing to the easier interference management characteristics of these bands.

3.6 There is increasing activity and research into the development of new technologies and applications using bands above 100 GHz.[4] A widespread availability of new devices and services is expected within a ten-year timeframe.[5]

There is growing international interest in using 100-200 GHz

International spectrum access decisions

3.7 In recent years spectrum above 100 GHz has been made available for terrestrial use in the European Union, USA and Japan.

3.8 In the UK, short-range devices (SRDs)[6] have been authorised to make licence-exempt use of the 122-123 GHz and 244-246 GHz bands up to 100 mW EIRP (20 dBm EIRP) since 2012.[7] The same frequencies have been harmonised for SRDs at European level by Decision 2013/752/EU, which amended Decision 2006/771/EC (the "SRD Decision").

3.9 Following a 2008 trial in which Japanese incumbent NTT used a 120 GHz ultrahigh-speed wireless link to provide live TV coverage of the Beijing Olympics, the Japanese Ministry of Internal Affairs and Communications revised its radio frequency allocations in 2014 to enable use of an 18 GHz band at 116-134 GHz by broadcast auxiliary services on a non-interference, non-protected basis.

3.10 In the USA, the Federal Communications Commission (FCC) adopted new rules in March 2019 to encourage the development of new communications technologies and expedite the deployment of new services in the spectrum above 95 GHz, making 21.2 GHz of spectrum available for use by unlicensed devices across four spectrum bands (116-123 GHz; 174.8-182 GHz; 185-190 GHz and 244-246 GHz).

---

[4] For example, Imperial College London's Centre for Terahertz Science and Engineering and the Terahertz Applications Group of the University of Cambridge.
[5] The mmWave Coalition's comments to the US National Telecommunication and Information Administration on Spectrum Strategy highlight a demand in the near future for spectrum above 100 GHz for communications and other applications.
[6] Short-range devices are usually mass-produced devices that are used in numerous applications like alarm systems, door openers, medical implants, radio frequency identification, intelligent transport systems or local communication equipment such as Wi-Fi routers.
[7] The UK changes were introduced following proposals made by the European Conference of Postal and Telecommunications Administrations (CEPT) in Report 38.

3.11 In these bands the FCC now permits devices to operate on an unlicensed basis with a maximum EIRP of 40 dBm (average) and 43 dBm (peak), measured in the service bandwidth. It also permits outdoor fixed point-to-point devices to operate with a higher maximum EIRP of 82 dBm (average) and 85 dBm (peak), also measured in the service bandwidth, subject to a requirement that devices use antennas with a minimum gain of 51 dBi, with a 2 dB reduction in the maximum permissible EIRP for each dB the antenna gain falls below 51 dBi.

3.12 In addition, the FCC has created a new category of experimental licences for use of frequencies between 95 GHz and 3 THz, to provide more flexibility in innovation activity over this wider frequency range.

International work is considering potential future use of bands above 100 GHz

3.13 At International Telecommunication Union level, the 2019 World Radio Conference (WRC) agreed further work to develop recommendations on sharing and adjacent-band compatibility between passive and active services above 71 GHz, including the 116-122.25 GHz and 174.8-191.8 GHz bands, noting that past technological developments have led to viable communications systems operating at increasingly higher frequencies, and that this could be expected to continue in bands above 71 GHz.[8] It was also agreed to undertake work to consider new allocations for the radiolocation service in the frequency band 231.5-275 GHz, and new identification for radiolocation service applications of frequency bands in the range 275-700 GHz to enable decisions to be taken at the 2027 WRC.

3.14 At European level, the European Conference of Postal and Telecommunications Administrations (CEPT) has undertaken work considering both future fixed wireless requirements and future spectrum requirements for ultra-wide band radio determination applications.

3.15 The CEPT working group SE24 on short-range devices is currently examining radiodetermination applications in the frequency band 116-260 GHz. This follows ETSI Technical Report 103 498 on the technical characteristics for SRD equipment using Ultra Wide Band technology (UWB) and radiodetermination application within the frequency range 120 GHz to 260 GHz. The SE24 work may lead to recommendations to amend the SRD Decision to harmonise various spectrum bands for radiodetermination devices.

3.16 In 2018, CEPT developed two recommendations and a report[9] on radio frequency channel / block arrangements for fixed wireless systems in a number of bands already allocated to the fixed service above 100 GHz. These are 92-94 GHz, 94.1-100 GHz, 102-109.5 GHz and 111.8 – 114.25 GHz (often referred to as the “W Band”) and 130-134 GHz, 141-148.5 GHz, 151.5-164 GHz and 167-174.8 GHz (often referred to as the “D Band”). Following the publication of the recommendations and report in 2018, ETSI has also initiated discussions

[8] See Resolution 731: Consideration of sharing and adjacent-band compatibility between passive and active services above 71 GHz

[9] ECC Recommendation (18)01; ECC Recommendation (18)02; and ECC Report 282.

regarding equipment technical standards for a number of these bands and the work was included as part of CEPT's 5G roadmap regarding their potential suitability for 5G backhaul.

3.17 ETSI has also considered use cases of millimetre wave transmission and potential transport applications.

100-200 GHz spectrum is currently lightly used in the UK

3.18 The spectrum above 100 GHz is internationally allocated to a variety of services. These include both active and passive allocations. The passive services allocated to bands above 100 GHz include Radio Astronomy, Space research and Earth Exploration-Satellite Services (EESS). Active services allocated include fixed and mobile services, fixed and mobile satellite services, active EESS, inter-satellite services, radiolocation and radio navigation services, Industrial, Scientific and Medical (ISM) uses[10] and amateur use.

Earth Exploration-Satellite Services (passive)

3.19 The predominant use of spectrum bands above 100 GHz in the UK is by passive EESS, which observe the characteristics of the Earth and its natural phenomena from sensors onboard satellites. The measurements made by these satellites in a given band are typically combined with those made in other bands to provide information on atmospheric humidity and temperature and for cloud and ice sounding. The instruments currently used in the bands under consideration include EUMETSAT's Microwave Imager, which provides all-weather surface imagery, and NASA's Advanced Technology Microwave Sounder, which provides temperature and moisture profiles that help to track storms, among other purposes.[11] All allocations to EESS in the 100-200 GHz range are primary allocations, meaning that they share the spectrum on equal conditions with other primary services, and that they must be protected from undue interference caused by secondary services.

3.20 Frequencies in the 100-200 GHz range allocated to passive EESS in the UK are:

- 100-102 GHz;
- 109.5-111.8 GHz;
- 114.25-122.25 GHz;
- 130-134 GHz;
- 148.5-151.5 GHz;
- 155.5-158.5 GHz;
- 164-167 GHz; and
- 174.8-191.8 GHz.[12]

[10] Under the Radio Regulations, the 122-123 GHz band is designated internationally for Industrial, Scientific and Medical (ISM) applications. ISM devices include industrial microwave ovens, medical diathermy machines and magnetic resonance equipment.
[11] See the tab "Stakeholder input: space and science services" in our Space Spectrum Strategy interactive data.
[12] Some of the contiguous frequencies listed here are broken down into separate bands with different specifications in the UK Frequency Allocation Table. For example, the 114.25-116 GHz, 182-185 GHz and 190-191.8 GHz bands are designated as 'no emission bands' by the ITU to protect sensitive EESS sensors with primary allocation in these bands.

Other space uses

3.21 There are other space services allocated in the UK to bands in the 100-200 GHz range which either do not use the bands covered by our proposals or are unlikely to be at risk of undue interference from terrestrial users. These are Radio Astronomy (passive), EESS (active), Inter-Satellite (active) and Space research (passive).

3.22 Active EESS use artificially-generated radiation, emitted by a satellite or ground-based instrument, and received by the same instrument or another receiver. This radiation interacts with the Earth's surface or atmosphere; meteorological and other information can be derived from the measurements. Active applications are relatively less sensitive to interference compared with passive sensors. We are not aware of any active EESS in the specific bands covered by our proposals.

3.23 To the best of our knowledge, there are no Radio Astronomy observatories using frequencies above 100 GHz in the UK, nor any planned use for this purpose. Spectrum in this range, however, is used overseas for Radio Astronomy purposes, including at NOEMA in the French Alps, the IRAM telescope in Spain and ALMA in Chile.

3.24 Inter-Satellite and Space research activities operate in space and do not point at the Earth. As a result, they are unlikely to be at risk of undue interference from terrestrial users.

Amateur radio allocations

3.25 There are primary amateur allocations in the 134-136 GHz band, and secondary allocations in the 122.25-123 GHz and 136-141 GHz bands. We understand that these bands are used by a limited number of radio amateurs, for experimental purposes.

Fixed wireless services

3.26 There are also fixed service allocations in the Radio Regulations for several bands above 100 GHz. Whilst these are not currently used, we expect future licensed use of bands above 100 GHz for fixed wireless links (radio communications between fixed terrestrial points, often used for mobile network backhaul).

3.27 Our 2018 Review of spectrum by fixed wireless services found that future demand for fixed wireless links, particularly for mobile backhaul and future 5G networks, was expected to include more short, high capacity connections, for use by smaller mobile cells and last mile fixed wireless access broadband services. This in turn has led to significant industry focus on and collaboration to develop plans for a number of the higher bands above 92 GHz to meet these high capacity requirements, in complement to the lower bands; particularly two new bands (92-114.5 GHz and 130-174.8 GHz) where there are existing Fixed Service allocations in the Radio Regulations.

3.28 In the UK, we have noted this interest as part of our fixed wireless services review and have indicated that we would consider these bands further as part of our future programme of work.

Short range devices

3.29 In line with the SRD Decision, in the UK short range devices are allowed to operate on a licence-exempt basis in the 122-123 GHz and 244-246 GHz bands, subject to certain power limits (maximum EIRP of 100 mW, equivalent to 20 dBm).[13]

Innovation and Trial licences

3.30 Access to spectrum above 100 GHz for innovation or research purposes is currently possible through Ofcom's Innovation and Trial licences.

3.31 Innovation and Trial licensing supports the research, development and trialling of innovative uses of the radio spectrum in the UK. There are two classes of licence available for any frequency within the radio spectrum, including above and below 100 GHz, subject to coordination and availability: (i) Innovation and Research licences (used for research, development and testing purposes) and (ii) Demonstration and Trial licences (used for demonstrating and trialling new equipment).

3.32 These licences permit the use of radio spectrum for innovative purposes for a time limited period of up to 12 months, for a fee of £50 per location. Under the terms of the licences, Ofcom permits testing and development of wireless telegraphy (radio) equipment; scientific research and experimentation; and trials and demonstrations of radio apparatus, applications and technologies. Deployment of commercial or operational services is not permitted. Equipment must not cause undue interference to any other authorised services and no protection is given from undue interference received from other authorised services. Full details of the proposed equipment, usage and location must be provided to Ofcom, with notification of any changes, as set out in the Innovation and Trial licensing guidance notes.

3.33 To date, demand for Innovation and Trial licences for frequencies above 100 GHz has been modest. However, we expect demand for access to these frequencies to grow considerably in the coming years, given the research, technological developments and international changes outlined in this section. In particular, we anticipate future spectrum demand for the deployment of commercial services, which is not permitted through Innovation and Trial licences.

Enabling more access to spectrum in the frequency range 100-200 GHz would enable new and innovative services

3.34 As described above, technological developments and new service innovation are expected to drive growing demand for access to bands above 100 GHz. At present, there are limited opportunities for innovators to access this spectrum in the UK, in particular for larger quantities of spectrum or at increased power beyond a trial and innovation phase.

[13] See regulation 5 of The Wireless Telegraphy (Exemption and Amendment) Regulations 2010 (S.I. 2010/2512), which refers to the Interface Requirements 2030.

3.35 We have considered whether it would be appropriate to introduce new authorisation approaches to additional bands above 100 GHz, to enable simpler and more flexible access to more spectrum by a wider range of devices and uses. In particular, we have considered how this could incentivise innovation and longer-term investment and enable wider and earlier commercialisation than might be the case under the Innovation and Trial licence framework, given that at present new users can only access a relatively small amount of spectrum above 100 GHz beyond the trial and development phase (and only for up to 100 mW EIRP / 20 dBm). These new authorisation approaches could also potentially allow simpler, more flexible use of spectrum during the trial and development phase.

3.36 We have also considered the potential for any proposed new use of these bands to affect EESS, or other potential future users of these bands.[14] Based on our technical assessment, which takes into account the technical characteristics of 100-200 GHz spectrum and those of different services, we are satisfied that coexistence between users can be appropriately managed, protecting the operation of different services, subject to the technical requirements set out later in this document.[15]

We are proposing to enable access to more than 18 GHz of spectrum across three EHF bands

3.37 There remains uncertainty over the future evolution of devices and applications in bands above 100 GHz, and the spectrum needs of different applications. Given this uncertainty, we have considered a range of different frequency bands for future use by new services.

3.38 In line with the principle of technology neutrality, we are proposing to make more spectrum available in a way which would facilitate a wide range of potential uses, as opposed to limiting its use to specific defined applications and their technical parameters.

3.39 As a first step, we have identified three EHF bands which we consider most suitable for coexistence with existing allocations and for internationally compatible devices which might emerge in the future. These are:

- 116-122 GHz;
- 174.8-182 GHz; and
- 185-190 GHz.

3.40 These bands share a number of characteristics which are relevant to their future use by new services.

3.41 First, the **physical properties of these bands** are particularly suited to shared use between existing and new users. In these bands, propagation losses and the absorption of the signals by physical objects are higher compared with lower frequency bands, which reduces the likelihood of interference between different spectrum users. In addition, as a consequence of the short signal wavelengths, 100-200 GHz bands can use small sized

[14] We have also considered the potential for our proposals to affect users of adjacent bands, as set out in paragraph 4.25.
[15] These include Inter-Satellite services and Space research which both operate in space and are unlikely to be at risk of interference from terrestrial use, in particular given our proposed technical conditions as set out in sections 4 and 5.

antennas, with relatively high directivity and narrow beams. This means that most devices are likely to have some directivity and narrow beams, which also reduces the risk of interference, as set out in paragraph 3.4.

3.42 Second, **there is limited current use of these bands in the UK.** Under the Radio Regulations, the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands are allocated for primary use to Earth Exploration-Satellite Services, Inter-Satellite and Space research (passive). Of these categories, we are only aware of EESS use which would need to be considered for the purposes of avoiding undue in-band interference from terrestrial users, based on current use and the sensitivity of passive EESS sensors.

3.43 Third, **there is good potential for internationally compatible devices to be developed for these bands.** Our proposed bands have been made available on an unlicensed basis in the US; and the 116-134 GHz band is also available for terrestrial use by broadcast auxiliary services in Japan. Opening up similar bands in the UK has the potential to provide international economies of scale for research and development into the future use of frequencies above 100 GHz and into the development and manufacture of future receiver and transmitter equipment, which is likely to drive future demand for access to this spectrum.

3.44 Furthermore, opening up access to these bands would offer access to three spectrum blocks offering at least 5 GHz of contiguous spectrum, which would help support the development of wide bandwidth devices and applications.

3.45 We set out our proposals to open up access to these bands in sections 4 and 5.

Other future uses of frequencies above 100 GHz

3.46 We recognise that there is interest in making further EHF bands available. As highlighted in paragraph 3.27, we are considering the 92-114.5 GHz and 130-178.5 GHz bands as part of our work programme. We will also continue to explore opportunities to provide flexible access to additional frequency bands above 100 GHz on a technology and service neutral basis. We would welcome stakeholder views on this and the specific bands we should consider, identifying the types of services and innovation this might support and the benefits which might be realised.

Question 1: Do you have any comments on our analysis of the current use of spectrum bands in the frequency range 100-200 GHz, or the potential future use of these frequencies? Do you have any comments on current or future use of the specific bands 116-122 GHz, 174.8-182 GHz and 185-190 GHz?

Question 2: Are there any further bands above 100 GHz which you think Ofcom should consider making available on a technology and service neutral basis? Which benefits might be realised from enabling access to further bands?

4. Proposals to authorise further use of EHF spectrum on a licence-exempt basis

Introduction

4.1 In this section we set out proposals to authorise use of more than 18 GHz of EHF spectrum in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands on a licence-exempt basis.

Proposals to authorise use on a licence-exempt basis

4.2 At present, low power (up to 20 dBm EIRP) use of non-specific short-range devices is authorised above 100 GHz on a non-exclusive, licence-exempt basis in the 122-123 GHz and 244-246 GHz bands.[16] As described in paragraph 3.4, the properties of spectrum above 100 GHz make it well suited to shared access by multiple terrestrial users, as the risk of causing or receiving undue interference is lower than for frequency bands below 100 GHz.

4.3 Under sections 8(4) and 8(5) of the WT Act, we must make regulations to exempt stations and apparatus from the requirement to be licensed if their establishment, installation or use is not likely to:

- involve undue interference with wireless telegraphy;
- have an adverse effect on technical quality of service;
- lead to inefficient use of the part of the electromagnetic spectrum available for wireless telegraphy;
- endanger safety of life;
- prejudice the promotion of social, regional or territorial cohesion; or
- prejudice the promotion of cultural and linguistic diversity and media pluralism.

4.4 Allowing spectrum use on a licence-exempt basis offers a number of potential benefits. It allows the simplest, most flexible access to the spectrum, without regulatory and administrative burdens or financial cost for innovators, future vendors or future users of devices. In the case of the proposed bands, it could also be consistent with the approach implemented by the FCC in the US. However, licence exemption presents some potential disadvantages compared with a licence-based authorisation approach: (i) it offers less certainty that undue interference will not be encountered; and (ii) ensuring compliance with the relevant technical requirements may be more challenging as regulators generally hold less information about who is operating under a licence-exemption regime. It can also be more challenging to change the authorisation approach to a band where devices are authorised to operate on a licence-exempt basis.

[16] This exemption regime for short range devices including bands below 100 GHz is set out in regulation 5 of The Wireless Telegraphy (Exemption and Amendment) Regulations 2010 (SI 2010/2512, as subsequently amended), which refer to the Interface Requirements 2030 (see p.24).

Summary of coexistence analysis

Coexistence with EESS

4.5 We have undertaken coexistence analysis to assess whether authorising devices to use these frequencies on a licence-exempt basis might cause undue interference to passive EESS in the band. In this analysis, we took account of a number of factors including each band's propagation characteristics, relevant EESS sensor characteristics and existing international standards and analysis such as ECC Report 190. A summary of our coexistence analysis is set out at annex 6.

4.6 According to our analysis, devices operating at up to 20 dBm EIRP – and in one band 40 dBm – with restrictions to minimise emissions towards EESS would be unlikely to cause undue interference to EESS. This would remain the case even in the event of large numbers of devices.

4.7 Many of the proposed new cases for using these frequencies would take place indoors. Given the properties of these bands, in particular the high attenuation of signals as they propagate from indoors to outdoors, we consider that equipment could be authorised to operate in all bands on a licence-exempt basis indoors up to 40 dBm. We also consider that for indoor use, no additional technical restrictions on emissions would be required to protect EESS, which would enable greater flexibility.[17]

Coexistence with other terrestrial users

4.8 In a licence-exempt environment, terrestrial users have no guarantee of interference-free operation. This could, in principle, result in 'tragedy of the commons' in which it becomes less attractive to users to operate owing to the perception or concern of potential interference risks.

4.9 We do not think this is likely in these bands, even where spectrum access is not coordinated, given the large amount of available spectrum and its properties such as higher atmospheric absorption losses leading to short propagation distances and increased absorption of the signals by physical objects including high building losses. Furthermore, the likely use of high directivity with narrow beams would reduce the risk of interference occurring between users.

4.10 Additionally, future devices may be designed to have the potential to detect when other devices are using the same frequencies and to use this information to move to a channel with a lower level of use by other devices and applications.

[17] In line with the definition of "indoor" set out in the Wireless Telegraphy (Mobile Repeater) Exemption Regulations 2018, in this document "indoor" means inside premises which have a ceiling or a roof; and except for any doors, windows or passageways, are wholly enclosed.

Assessment of suitability of a licence-exemption approach

4.11 Taking account of the case for enabling more access to these frequencies, and the findings of our coexistence analysis, we consider that it would be consistent with our duties to authorise devices to operate in these bands on a licence-exempt basis, subject to appropriate technical restrictions to avoid causing undue interference to EESS.

4.12 We expect that these proposals would support innovation and the development and availability of new products and services, for the reasons set out in paragraph 4.4.

4.13 We have also considered whether making more spectrum available on a licence-exempt basis above 100 GHz might not lead to the most efficient use of the spectrum in the future. In our view, this is unlikely to be the case as the short range and high capacity of this spectrum mean that it can be shared by a wide range of different services, in particular at lower power levels.

4.14 We recognise that there could also be demand for services that operate at increased powers compared with the power limits we have identified for licence-exempt use. We consider this further in section 5.

Proposals for licence-exempt use

4.15 To support a wide range of innovation, and in line with the principle of technological neutrality, we have sought to identify flexible provisions for future access to the spectrum, including proposing that the new exemption regime would be available to any potential short-range devices which can operate in the relevant bands (i.e. for "non-specific SRDs", as opposed to specific uses only).

4.16 We have considered the findings of our coexistence analysis[18] to determine appropriate technical restrictions including maximum power levels to enable licence exempt use in these spectrum bands. Our proposals are summarised in Table 4.1 below.

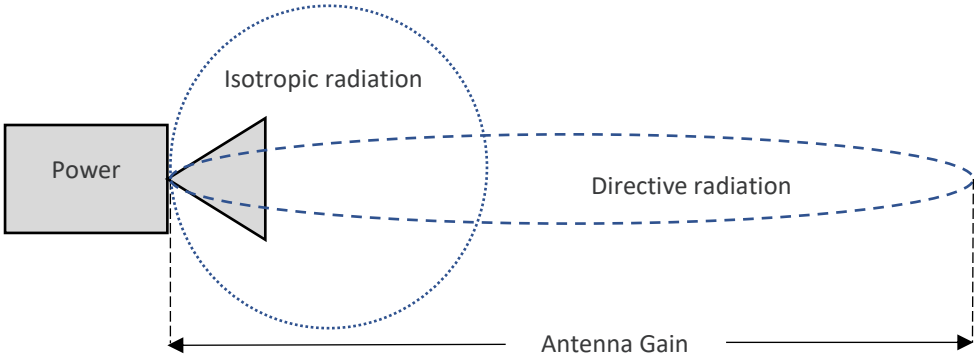
Table 4.1: Proposals for licence-exempt use

Power limits (*max EIRP in dBm*) and emissions restrictions on outdoor use			
USE	**116-122 GHz**	**174.8-182 GHz**	**185-190 GHz**
Indoor	40	40	40
Outdoor	20	20	40
For outdoor use, EIRP at angles (degrees°) relative to main beam in elevation shall not exceed:			
	13 at > 10° 1 at > 40° -3 at > 60°	13 at > 10° 1 at > 40° -3 at > 60°	25 at > 10° 14 at > 40° 10 at > 60°

[18] See annex 6.

4.17 In our analysis, we modelled a range of potential EIRP levels for new terrestrial devices to assess the interference they might cause to EESS. These devices were modelled by considering the use of both isotropic radiators and more directive narrow beam antennas as illustrated in Figure 4.1. below.

Figure 4.1: Illustration of relationship between EIRP, input power to antenna and its directivity



EIRP (dBm)= Power (dBm) + Antenna Gain(dBi)

4.18 The device antenna characteristics considered covered the potentially diverse range of services that may use these bands. For example, some applications may require low EIRPs (isotropic radiators with no antenna directivity) for short-range communications whilst others may require higher EIRPs to support high capacity longer range connections.

4.19 Given that some devices in these bands may use integrated antenna systems which are not separable from their transmitters, our proposed technical conditions are specified in terms of the EIRP radiated by the device. We consider that this approach would make it easier for equipment providers to design their equipment to meet the required technical conditions and would also make it easier to make compliance checks on the equipment.

Licence-exempt indoor use

4.20 As set out at paragraph 4.7, for indoor use, we propose to allow a maximum EIRP levels of 40 dBm in all the relevant bands.

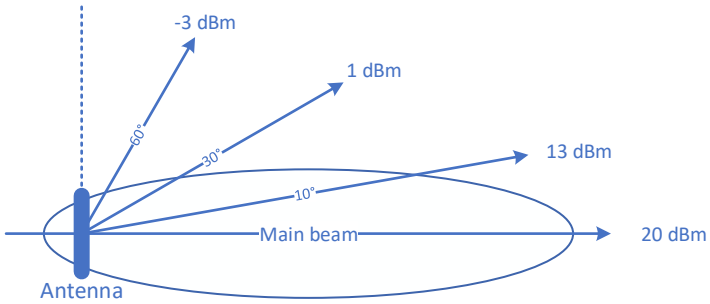
Licence-exempt outdoor use

4.21 For outdoor use, we are proposing to allow a maximum EIRP level of 20 dBm for the 116-122 GHz and 174.8-182 GHz bands and 40 dBm for the 185-190 GHz band. These EIRP levels take account of the variations in band specific propagation characteristics, EESS sensor use and sensor protection criteria, as well as the potential number of simultaneous licence exempt devices and their characteristics.

4.22 Furthermore, as detailed in Table 4.1, for outdoor use we also propose to limit the amount of signal radiation towards EESS by placing limits on the EIRP at increased elevation angles relative to the main beam. Figure 4.2 illustrates how these additional restrictions would apply to any device operating in the 116-122 GHz or 174.8-182 GHz bands. Given our

analysis, our provisional conclusion is that licence exempt use within these EIRP limits would not be expected to adversely affect EESS use.

Figure 4.2: Illustration of proposed EIRP limits at different elevation angles relative to the main beam in the 116-122 GHz and 174.8-182 GHz bands



4.23 We consider that our proposal to restrict emissions with respect to different elevation angles would not be overly restrictive for licence-exempt users and would allow use for different terrestrial applications. For example, these elevation requirements might be met by some services using directional antennas, such as outdoor point to point data links requiring operation at 20 or 40 dBm EIRP. In contrast, shorter range lower capacity applications might meet the requirements as a result of operating at a reduced EIRP with less directive antennas.

Technical provisions applying to all proposed bands – airborne use and out of band emissions

4.24 As an additional safeguard against undue interference to EESS, and potentially Radio Astronomy sites in France and Spain, we propose that airborne use would not be permitted.

4.25 We have also considered whether any additional measures would be needed to protect EESS operating in adjacent bands, including the "no emission bands" at 114.25-116 GHz, 182-185 GHz and 190-191.8 GHz. In principle, the protections provided for co-channel use are likely to protect EESS users in adjacent bands. Nonetheless, we propose to require that any out of band emissions should only be spurious emissions, with out of band emission limits of -10 dBm/MHz in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands (see annex 7). This aligns with standard EN 305 550 (for devices using 122-123 GHz under the existing licence exemption provisions up to 100 mW/20 dBm EIRP) and is equivalent to the standards prescribed by the FCC. We consider these restrictions to be appropriate as they would provide additional protection to the 114.25-116 GHz, 182-185 GHz and 190-191.8 GHz "no emission bands". The out of band emission provisions should also help to maintain the sharing environment for other adjacent bands, including the licence-exempt use of short-range devices in the 122-123 GHz band.

Summary and implementation approach

4.26 We consider that the proposals set out in this section should help foster innovation to deliver new services and technologies to benefit UK people and businesses, without undermining the benefits provided by the operations of EESS in and near these bands.

4.27 To support innovation across different sectors and consistent with the principle of technological neutrality, our proposals would enable licence-exempt access for non-specific short-range devices rather than being focused on specific technologies. We consider that there would be a good prospect of creating future international economies of scale for equipment in these bands, given the alignment of bands and technical conditions for indoor use with those made available in the USA.

4.28 Compared to current allocations, more spectrum would be made available on a flexible basis and would be available from the trial phase through to products being commercially available to people and businesses.

4.29 For the reasons set out in this section, our provisional assessment is that these proposals are:

- **objectively justified** in that they are likely to help meet increased future demand for access to this spectrum for use by innovative services and products, noting the propagation characteristics, international developments and wide bandwidths available in the relevant bands;
- **not unduly discriminatory** against particular persons or against a particular description of persons in that they would apply to all users of devices using these frequency bands (and, indirectly, to all manufacturers and sellers);
- **proportionate** to what they are intended to achieve, in that the proposed technical restrictions would ensure that new users of the bands would not be likely to cause undue interference to EESS; and
- **transparent** in relation to what they are intended to achieve, in that they are clearly described and explained in this consultation document, and any technical restrictions applying to the proposed exemption regime would be clearly set out in regulations.

Next steps and implementation

4.30 We recognise that there is uncertainty on future demand for services using this spectrum, and what the services and applications developed will be. We will keep developments under review and may propose further changes in future.

4.31 The draft proposed amendments to IR 2030 are set out in annex 7.

4.32 If we decide to proceed with the proposals following consultation, we would consult on implementing regulations later in 2020. We would aim to complete consultation and implementation of the new provisions before the end of 2020.

Question 3: Do you have any comments on the approach we have used to assess the potential effect of our proposals on EESS? [Our full technical analysis is set out at annex 6.]

Question 4: Do you have any comments on our proposals to authorise devices to operate on a licence-exempt basis in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands?

5. Proposal to authorise further use of EHF spectrum under a new licence

Introduction

5.1 In section 4 we set out proposals to authorise use of three new bands above 100 GHz on a licence-exempt basis, subject to certain technical conditions. We also recognised there could be demand for devices to operate at increased power levels over longer distances using more directive antenna systems, such as for data transmission.

5.2 In this section, we examine the potential demand for access to these frequencies above above the 20 and 40 dBm levels and discuss the initial findings of our coexistence analysis. In summary, whilst it would be possible for new terrestrial devices operating above these levels to coexist with EESS, this would require additional specifications regarding device emissions and installation to prevent undue interference when devices are used outdoors.

5.3 Given these additional requirements, the increased power levels and uncertainty over future use of these bands we do not consider that it would be appropriate to authorize licence-exempt use for these cases. We therefore propose to introduce a new licensing regime to enable innovators to secure access to spectrum in the 100-200 GHz range at increased power levels without causing undue interference to EESS.

We expect potential future devices and applications to be developed requiring power levels beyond those covered by our proposals for new licence exemptions

5.4 In section 3 we noted that there is potential for a range of future devices and applications which might use spectrum above 100 GHz. Some of these applications will only require lower powers, for example for shorter range lower capacity use. Others will require increased levels of power to provide higher capacity data transmission links over larger distances or to, for example, improve the accuracy of radar distancing systems.

5.5 Many of these increased power applications are also likely to benefit from large blocks of contiguous spectrum. These larger blocks will allow the delivery of high capacity connections over longer distances using more robust modulation and error correction schemes, whose use requires access to more spectrum.

5.6 In sections 3 and 4 we have set out the broad innovation case for increasing the amount of spectrum in the 100-200 GHz range that can be accessed for terrestrial use, and how this corresponds to our duties. Likewise, we consider that enabling easier, cheaper and more flexible access to spectrum above 100 GHz throughout the product development stage for increased power uses would help ensure the future availability of a wider future range of services for people and businesses.

Coexistence with other users is possible, subject to technical and installation requirements

5.7 We have undertaken coexistence analysis to consider whether increased power use of these frequencies could operate without causing undue interference to EESS or terrestrial users. A summary of our coexistence analysis is at annex 6.

Sharing with Earth-Exploration Satellite Services (EESS) is possible, subject to technical and installation requirements

5.8 Our coexistence analysis has identified that large numbers of devices could operate at increased powers in the proposal bands without causing undue interference to EESS, provided that additional technical restrictions are applied for outdoor use. These would minimise emissions in the direction of EESS, both in terms of antenna directivity and the elevation angle of the installed devices.

5.9 More specifically, on the basis of our technical analysis, we consider that an EIRP up to 55 dBm could be permitted whilst avoiding undue interference to EESS, when used indoors or when these additional restrictions are met. We have limited the maximum EIRP in our analysis to 55 dBm. This aligns with the conclusions of our 2018 Review of spectrum used by fixed wireless services, which found there was limited need by high capacity data services for EIRP levels above 55 dBm.

The interference environment enables sharing with other terrestrial users

5.10 We have also considered whether there would be a need for co-ordination with other new terrestrial users of the spectrum, to avoid a potential "tragedy of the commons" scenario in which no users would wish to operate owing to a perception or concern of potential interference risks.

5.11 We do not think additional co-ordination steps would be needed to prevent this scenario from occurring. There are several reasons for this, linked to the large amount of available spectrum and its properties:

a) The **large amount of spectrum available** reduces the likelihood that multiple devices would be operating in the same locations in the same frequencies. If needed, future devices might also be designed to have the potential to detect when other devices are using the same frequencies and to use this information to move to a channel with a lower level use by other devices and applications.

b) The **higher absorption losses, building losses and short propagation distances** in the 100-200 GHz bands compared to lower frequency spectrum bands would reduce the levels of interference from other devices and applications.

c) Given the **small wavelength of bands above 100 GHz**, relatively small antennas are likely to have more directivity and narrower beams than in lower frequency bands, and our proposed technical conditions for enabling increased power use could also only be

met using directive antennas. The narrower beams associated with these directive antennas reduce the likelihood that the antenna beams used by different services would exactly align, making it much less likely that interference would occur between different users compared with when lower directivity wider beam antennas are used.

Proposed approach to authorisation

We propose to introduce a new spectrum access licence to enable increased power use of these bands

5.12 We propose to introduce a new licence to enable increased power use of these bands. This approach takes account of the both:

a) the potential demand for and benefits of enabling increased power use of these bands; and

b) the technical specifications we would require for power limits, including specific requirements for outdoor use to minimise emissions in the direction of EESS, and on the installation elevation angle of devices.

5.13 We consider a licensing regime to be more appropriate than licence-exempt use because:

a) the risk of causing undue interference to EESS or other terrestrial users increases with increased power levels; and

b) the technical requirements that we are proposing to prevent causing undue interference to EESS at increased power levels would require an appropriate compliance regime for not only the technical device standards but also an elevation requirement for how they are installed.

5.14 We consider that a licensing regime would provide a higher degree of confidence in compliance with the technical requirements including the installation requirement for two reasons:

a) Under a licensing regime, the elevation installation requirements would be a clear condition of spectrum access as set out in the relevant licence documentation, and each licensee would be required to be able to demonstrate compliance;[19] and

b) In the event of suspected non-compliance, enforcement would be considerably more straightforward under a licensing regime (compared to a licence-exempt regime) as Ofcom would hold records of authorised users, enabling easier identification of potential sources of undue interference from authorised user non-compliance.

5.15 We also consider that in the case of increased power uses a licensing approach would be more appropriate than a licence-exempt regime given the uncertainty about which future devices and applications will make use of these frequencies, and the greater risk of

[19] In our proposals we propose that each licensee would be required to compile and maintain accurate written records of the antenna main beam elevation angle, measured in degrees, when using equipment outdoors. See annex 9 Draft licence, Schedule 1 condition 4.

interference owing to the increased power level. A licence-based authorisation would also provide more flexibility to make changes to how we authorise the use of these bands in future.

We consider that a flexible licence approach would best support innovation

5.16 Ofcom uses a range of licensing models to authorise access to different spectrum bands. When considering the most appropriate approach for our proposals, we have taken account of the following factors:

a) Potential level of demand – demand is likely to be low at first but grow over time;

b) The benefits of facilitating easy, flexible, inexpensive spectrum access – to make it simple for innovators to access the spectrum with a minimum of administration, cost and delay, and change where/how they deploy as their plans evolve;

c) The low likelihood that new users would encounter interference from other users, given the large amount of spectrum available, propagation characteristics of these bands and likely device properties. In the event of interference, there is a high degree of likelihood that the user could find alternative available spectrum;

d) The likelihood that in most cases new users would not require a very high degree of protection from interference, at least in the near-medium term as new devices and applications are developed. We note that in the US access to these (and higher) power levels is authorized on an unlicensed basis.

5.17 Taking account of these factors, we do not consider that it would be proportionate to propose a fully coordinated licence product (in which Ofcom only authorises spectrum use where we have determined this would not be expected to undermine spectrum quality for existing authorised users) or 'self coordinated' product such as the fixed links licences in the 70-80 GHz band. These licences offer a very high degree of operational certainty around interference risks but require careful coordination of users based on location and device specifications, so can be less suited to the earlier stages of innovation where an approach offering more flexibility and requiring less administration is more likely to be beneficial, for example as testing moves from one site or set of technical parameters to multiple locations or alternative specifications.

5.18 Given the likely demand levels in the near term, large amount of spectrum available, propagation characteristics of these bands and anticipated device properties, we think it is unlikely that a new user would be unable to find frequencies where they could operate without encountering undue interference. Potential licensees could consult Ofcom's Spectrum Information Portal to establish the number of licences allocated in each band, and where the licensee is based (although this would not necessarily indicate the locations of spectrum usage).

5.19 We therefore propose a spectrum access licence which would permit shared access to the spectrum in a given band nationwide. Coordination would not be provided to prevent users causing interference to each other, but we consider that the operational risks associated with this would be very low.

Proposed licence conditions

Proposed technical conditions

5.20 Our proposals are intended to protect EESS from undue interference. In the case of indoor use, we consider that equipment could be authorised to operate in all bands indoors up to 55 dBm under a licensing regime, without additional technical restrictions, given the properties of these bands. For outdoor use, we are proposing additional technical conditions to protect EESS. These take account of the specific properties of each band such as the configuration of EESS sensors, which is important to determining the extent to emissions towards the EESS sensors should be suppressed. [20] In addition, the likely use of directional narrow beam antennas would be expected to limit emissions in the direction of the EESS sensors, providing the devices are installed such that the antennas are pointing towards other terrestrial devices[21] and the emissions are restricted towards EESS as a result.

5.21 We propose to limit the amount of signal radiation towards EESS by placing limits on the EIRP at increased elevation angles relative to the main beam when devices are used outdoors. Given that some devices may use integrated antenna systems which are not separable from their transmitters, our proposed technical licence conditions are specified in terms of the EIRP radiated by the device.

5.22 We also propose a technical requirement for outdoor use regarding the installation elevation angle of the device. Whilst we could have specified different angles for the different bands to reflect their different propagation characteristics and use of different EESS sensors, we propose to simplify the technical requirements, and hence future compliance and enforcement, by applying a common elevation angle requirement of 20°, based on the most sensitive EESS sensor configurations in the 174.8-182 GHz and 185-190 GHz bands.

5.23 Our proposals for a new licensing approach are summarised in Table 5.1, with an illustration of elevation angle requirement on outdoor fixed device installation in Figure 5.1.

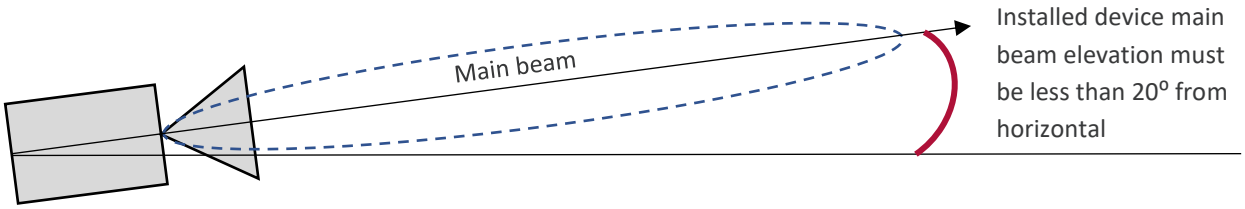
[20] See annex 6.

[21] It is expected that most outdoor terrestrial applications will operate with devices radiating in horizontal plane and the main antenna beams for the transmitter and receivers will most likely need to have near perfect alignment.

Table 5.1: Proposals for licence technical requirements

Power limits (*max EIRP in dBm*) and emissions restrictions for outdoor use		
116-122 GHz	**174.8-182 GHz**	**185-190 GHz**
55	55	55
For outdoor use, EIRP (dBm) at angles (degrees°) relative to main beam in elevation shall not exceed		
13 at > 10° 1 at > 40° -3 at > 60°	13 at > 10° 1 at > 40° -3 at > 60°	25 at > 10° 14 at > 40° 10 at > 60°
Main beam elevation angle of licensed devices shall not exceed 20 degrees above horizontal when devices are used outdoors.		

Figure 5.1: Illustration of device installation elevation angle restriction



5.24 Given our proposed approach to licence exemption, as set out in section 4, our proposed licence would enable additional:

- Outdoor spectrum uses at 20-55 dBm EIRP in the 116-122 GHz and 174.8-182 GHz bands; and 40-55 dBm EIRP in the 185-190 GHz band; and
- Indoor use at 40-55 dBm EIRP.

Technical provisions applying to all proposed bands

Frequency bands

5.25 Each licence would authorise the licensee to use the 116-122 GHz band, the 174.8-182 GHz band or the 185-190 GHz band. Licensees would be able to use any part of their selected band. There would be no limit to the number of devices which a licensee could deploy in the band, subject to compliance with the technical provisions.[22]

Indoor, outdoor and airborne use

5.26 Subject to the technical conditions specified in Table 5.1, both indoor and outdoor use would be permitted by the licence.

[22] If we subsequently identify further EHF bands for which a similar licensing regime would be appropriate, we may make them available as part of this licence, following consultation.

5.27 As an additional safeguard against undue interference to EESS, and potentially Radio Astronomy sites in France and Spain, we propose that airborne use would not be permitted.

Out of band emission limits

5.28 We have also considered whether any additional measures would be needed to protect EESS operating in adjacent bands, including the "no emission bands" at 114.25-116 GHz, 182-185 GHz and 190-191.8 GHz. In principle, the protections provided for co-channel use are likely to protect EESS users in adjacent bands.

5.29 Nonetheless, we propose that the licence would require that any out of band emissions should only be spurious emissions, with out of band emission limits of -10 dBm/MHz in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands (see annex 8). This aligns with standard EN 305 550 (for devices using 122-123 GHz under the existing licence exemption provisions up to 100 mW/20 dBm EIRP) and is equivalent to the standards prescribed by the FCC. We consider these restrictions to be appropriate as they would provide additional protection to the 114.25-116 GHz, 182-185 GHz and 190-191.8 GHz "no emission bands". The out of band emission provisions should also help to maintain the sharing environment for other adjacent bands, including the licence-exempt use of short range devices in the 122-123 GHz band.

Non-technical provisions applying to all relevant bands

5.30 In this section, we set out the non-technical licence conditions that we propose to include in the licences to be issued. The licence conditions are similar to the standard licence terms and conditions that Ofcom includes in all of its licences.

5.31 Licences issued by Ofcom are not exclusive, and we have discretion to authorise use of these or any other frequencies, for other purposes, in line with our statutory duties.

Frequency

5.32 Licensees would be authorised to use the selected frequency band. Any frequency or bandwidth may be used within the band, subject to the technical conditions of the licence.

5.33 Licence variation would be permitted for the licensee to move to a different band covered by the same licensing product.

Geographical boundaries

5.34 The licence would allow use of equipment within the United Kingdom and terrestrial seas. The proposed authorisation would also extend to the Channel Islands and the Isle of Man, subject to further discussions with the relevant authorities.

Duration of the licence

5.35 Similar to existing licence terms and conditions, we propose that the licence would be for an indefinite duration with a payment interval of 5 years. The licence would also permit Ofcom to give 3 years' notice to revoke the licence for spectrum management purposes.

5.36 While spectrum licences generally require Ofcom to give a 5 years' notice for revocation for spectrum management reasons, we consider that a three-year notice period would be appropriate in this case due to the uncertainty surrounding future uses of the bands and the anticipated fast pace of innovation in these frequency ranges. A three-year notice period would enable us to respond promptly in the event that developments in innovation change our assessment of the most appropriate way to authorise access to these bands.

Spectrum trading

5.37 We are proposing that, subject to certain conditions to be set out in legislation,[23] the licensee would be able to transfer their spectrum rights and obligations in the following ways:

- outright total transfer of all rights to another party; or
- concurrent transfer of all rights so two or more parties jointly hold the licence.

5.38 Partial transfers would not be possible.

Access and inspection

5.39 In accordance with our standard conditions, the licence would include a condition that reserves to Ofcom the right to access and inspect the licensee's radio equipment. This is so we could check the licensee's compliance with the terms of its licence, should we decide that it is appropriate to do so.

Modification, restriction and closedown

5.40 The licence would include a condition that reserves to Ofcom the right to require the licensee to modify, restrict or close down the use of its radio equipment, should we have reasonable grounds to believe that the licensee has breached the terms of its licence, or we consider this necessary in the event of a national or local state of emergency being declared. This is a standard clause in most WT Act licences issued by Ofcom.

Provision of information to facilitate optimal spectrum use

5.41 In line with our duty to manage the spectrum efficiently, the licence would include standard conditions to require licensees to provide us, on request, with general information regarding their equipment and use of frequencies, or the rollout of their network. Provision of this information could help identify actual spectrum usage and

[23] If, following consultation, we decide to implement the proposals set out in this document, we would consult on amending The Wireless Telegraphy (Spectrum Trading) Regulations 2012 (S.I. 2187/2012, as subsequently amended) to authorise the transfer of the rights and obligations deriving from the proposed new licences.

facilitate authorisation of frequencies for other purposes where we consider this appropriate in line with our statutory duties.

Determination of fees

5.42 We propose that the new licence would be subject to a fee, payable every 5 years, which would be cost-based. In line with our framework for setting cost-based fees, we would set these fees to reflect our spectrum management costs applicable to these licence products.

5.43 As this would be a new licence, we do not have actual cost data for the licence to base our fee calculation on. We also do not know what the likely take-up of the new licence would be, and therefore how many licences we would issue.

5.44 We have considered carrying out a detailed bottom-up estimation of costs. However, this would be a complex exercise and because specific fixed and common costs typically make up a significant proportion of the total costs, the resulting estimates would be highly sensitive to the assumption on the likely number of licences issued, which is highly uncertain. Given these limitations, we consider that this would not be proportionate or appropriate outside the context of a wider, comprehensive fee review.

5.45 Instead, we propose to use the actual per-licence costs associated with a similar licence product. We have looked at our existing licence products and we believe that the Business Radio light licensing products (comprising the Simple Site, Simple UK and Suppliers Light licences) are the closest to the licensing regime that we are proposing. This is due to the fact that, like our proposed licence, they entail a degree of flexibility for the licensee without the need for full coordination and are available for use on a national basis. Given these similarities, we would propose to use the costs associated with the Business Radio light licences to determine what our 'Spectrum Access: EHF' licence fee should be. As the fee for the Business Radio light licensing products, which is £75 every five years, has been determined on a cost recovery basis, we think it represents a suitable basis for determining a cost-based fee for the new licence product.

Analysis of considerations relevant for fee setting

5.46 In line with the approach set out in the 2010 SRSP: The revised Framework for Spectrum Pricing statement and our framework for setting cost-based fees, we have considered the policy and sectoral considerations relevant for the setting of fees for these new licence products, namely:

- the practicalities of implementation, such as our implementation costs, and whether the cost of collecting fees would form a material (and/or disproportionate) part of the overall fee before resetting/introducing new fees;
- our spectrum management duties, for example, whether the benefits of the use – to society overall or in promoting innovation[24] – justify an adjustment to fees (i.e. where

[24] As set out in the SRSP, where the benefits of the use to society overall are greater than our costs and no other funding is available to users to support their spectrum use, we may consider it appropriate to provide a concession to licensees.

charging fees that fully reflect our spectrum management costs would risk damaging the delivery of these objectives); and
- our wider duties, for example, whether any particular group of citizens or consumers would be unfairly and adversely affected by fee levels that reflected our spectrum management costs, or if charging a fee risked damaging the delivery of a wider public policy agenda within the communications sector.

5.47 Our initial view is that:

- we do not anticipate that the practicalities of implementation or the cost of collecting fees would form a material part of the overall proposed fee;
- we are not aware of any particular group of citizens or consumers who would be unfairly and adversely affected by fee levels that reflected our costs, as per our equality impact assessment;
- we do not anticipate any significant risks to the delivery of the benefits of future uses of this spectrum as a result of setting the fees to fully reflect our spectrum management costs; and
- we consider that the average cost of similar products that we have used for our analysis is sufficiently low not to impede innovation in these bands.

5.48 On this basis, for the new licence we propose a fee of **£75 payable every 5 years**. We have not identified any need to phase in the introduction of fees, given that this is a new licence.

Summary and implementation approach

5.49 We consider that the proposals set out in this section should help foster innovation to deliver new services and technologies to benefit UK people and businesses, without undermining the benefits provided by the operations of EESS in and near these bands. By enabling increased power use, these proposals would help support a wider range of potential innovative services.

5.50 Compared to doing nothing, more spectrum would be made available on a more flexible and cheaper basis and would be available from the trial phase through to products being commercially available to people and businesses. The proposed licensing approach would provide greater assurance of compliance - and ability to enforce technical requirements in case of undue interference to EESS being caused by non-compliance – but without the administrative and operational constraints which can be associated with a more coordinated licensing approach.

5.51 For the reasons set out in this section, our provisional assessment is that these proposals are:

- **objectively justified** in that we have identified likely increased future demand for access to this spectrum for use by innovative services and products at increased powers compared with those permitted under our proposed licence exemption regime. The proposed licence would permit increased power use under conditions that would continue to ensure protection for EESS;

- **not unduly discriminatory** against particular persons or against a particular description of persons in that they would apply to all users of devices licensed to these frequency bands (and, indirectly, to all manufacturers and sellers), and our proposals are unlikely to increase the risk of undue interference to incumbent users;
- **proportionate** to what they are intended to achieve, in that the proposed technical and non-technical licence conditions would ensure that new users of the bands would not be likely to cause undue interference to incumbent users or unnecessary administrative burdens to new users; and
- **transparent** in relation to what they are intended to achieve, in that they are clearly described and explained in this consultation document, and any technical restrictions applying to the proposed licensing regime would be clearly set out in the relevant licences.

5.52 We recognise that there is uncertainty on future demand for services using this spectrum, and what the services and applications developed will be. We will keep developments under review and may propose further changes to how we are proposing to authorise the use of these bands in future.

5.53 The draft proposed new Interface Requirements are set out at annex 8.

5.54 The draft proposed new licence is set out at annex 9.

5.55 If we decide to proceed with the proposals following consultation, we would consult on implementing regulations later in 2020. We would aim to complete consultation and implementation of the new provisions by the end of 2020.

Question 5: Do you have any comments on our proposal to create a 'Spectrum Access: EHF' licence to authorise increased power use in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands?

6. Next steps

6.1 In this consultation we have set out our analysis of current use of spectrum in the 100-200 GHz range, and the potential future demand for access to this spectrum for new services and applications. We are proposing to introduce new provisions to access this spectrum at 116-122 GHz, 174.8-182 GHz and 185-190 GHz comprising:

- a new licence exemption regime for lower power use; and
- a new licensing regime for increased power use (up to 55 dBm EIRP).

6.2 The draft amendments and proposed new Interface Requirements supporting our proposals are set out in annex 7 and annex 8 respectively.

6.3 The draft proposed new licence is set out in annex 9.

6.4 This consultation seeks comments on our analysis and proposals. The consultation closes on 20 March 2020.

6.5 If we decide to proceed with the proposals following consultation, we would consult on implementing regulations later in 2020. We would aim to complete consultation and implementation of the new provisions before the end of 2020.

A1. Responding to this consultation

How to respond

A1.1 Ofcom would like to receive views and comments on the issues raised in this document, by 5pm on 20 March 2020.

A1.2 You can download a response form from https://www.ofcom.org.uk/consultations-and-statements/category-2/supporting-innovation-100-200-ghz. You can return this by email or post to the address provided in the response form.

A1.3 If your response is a large file, or has supporting charts, tables or other data, please email it to EHFSpectrumAccess@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet.

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

Spectrum Policy and Analysis
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 We welcome responses in formats other than print, for example an audio recording or a British Sign Language video. To respond in BSL:

- Send us a recording of you signing your response. This should be no longer than 5 minutes. Suitable file formats are DVDs, wmv or QuickTime files. Or
- Upload a video of you signing your response directly to YouTube (or another hosting site) and send us the link.

A1.6 We will publish a transcript of any audio or video responses we receive (unless your response is confidential)

A1.7 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt if your response is submitted via the online web form, but not otherwise.

A1.8 You do not have to answer all the questions in the consultation if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A1.9 It would be helpful if your response could include direct answers to the questions asked in the consultation document. The questions are listed at annex 4. It would also help if you could explain why you hold your views, and what you think the effect of Ofcom's proposals would be.

A1.10 If you want to discuss the issues and questions raised in this consultation, please contact Jessica Foster on 020 7981 3278, or by email to EHFSpectrumAccess@ofcom.org.uk.

Confidentiality

A1.11 Consultations are more effective if we publish the responses before the consultation period closes. In particular, this can help people and organisations with limited resources or familiarity with the issues to respond in a more informed way. So, in the interests of transparency and good regulatory practice, and because we believe it is important that everyone who is interested in an issue can see other respondents' views, we usually publish all responses on the Ofcom website as soon as we receive them.

A1.12 If you think your response should be kept confidential, please specify which part(s) this applies to and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we don't have to edit your response.

A1.13 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.14 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further in our Terms of Use.

Next steps

A1.15 Following this consultation period, Ofcom plans to publish a statement in 2020.

A1.16 If you wish, you can register to receive mail updates alerting you to new Ofcom publications.

Ofcom's consultation processes

A1.17 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in annex 2.

A1.18 If you have any comments or suggestions on how we manage our consultations, please email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

A1.19 If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact the corporation secretary:

Corporation Secretary
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA
Email: corporationsecretary@ofcom.org.uk

A2. Ofcom's consultation principles

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

Before the consultation

A2.1 Wherever possible, we will hold informal talks with people and organisations before announcing a big consultation, to find out whether we are thinking along the right lines. If we do not have enough time to do this, we will hold an open meeting to explain our proposals, shortly after announcing the consultation.

During the consultation

A2.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A2.3 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 for people to give us a written response. If the consultation is complicated, we may provide a short Plain English / Cymraeg Clir guide, to help smaller organisations or individuals who would not otherwise be able to spare the time to share their views.

A2.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A2.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and aim to reach the largest possible number of people and organisations who may be interested in the outcome of our decisions. Ofcom's Consultation Champion is the main person to contact if you have views on the way we run our consultations.

A2.6 If we are not able to follow any of these seven principles, we will explain why.

After the consultation

A2.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish all the responses on our website as soon as we receive them. After the consultation we will make our decisions and publish a statement explaining what we are going to do, and why, showing how respondents' views helped to shape these decisions.

A3. Consultation coversheet

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 ☐

Name/contact details/job title ☐

Whole response ☐

Organisation ☐

Part of the response ☐

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)

A4. Consultation questions

A4.1 This annex lists the questions we are consulting on.

Question 1: Do you have any comments on our analysis of the current use of spectrum bands in the frequency range 100-200 GHz, or the potential future use of these frequencies? Do you have any comments on current or future use of the specific bands 116-122 GHz, 174.8-182 GHz and 185-190 GHz?

Question 2: Are there any further bands above 100 GHz which you think Ofcom should consider making available on a technology and service neutral basis? Which benefits might be realised from enabling access to further bands?

Question 3: Do you have any comments on the approach we have used to assess the potential effect of our proposals on EESS? [Our full technical analysis is set out at annex 6.]

Question 4: Do you have any comments on our proposals to authorise devices to operate on a licence-exempt basis in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands?

Question 5: Do you have any comments on our proposal to create a 'Spectrum Access: EHF' licence to authorise increased power use in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands?

A5. Legal framework

A5.1 Our statutory duties derive from both European and domestic legislation, specifically from:

a) the Common Regulatory Framework[25] for electronic communications networks and services, in particular, the Framework Directive and the Authorisation Directive;

b) any relevant Decisions of the European Commission which bind the UK as to the use of the spectrum to be awarded; and

c) the Communications Act 2003 (the "2003 Act") and the Wireless Telegraphy Act 2006 (the "WT Act"), which transpose the provisions of the directives referred to above into national law.

d) Ofcom's general duties.

A5.2 Ofcom's statutory powers and duties in relation to spectrum management are set out primarily in the 2003 Act and the WT Act. Amongst our functions are the making available of frequencies for use for particular purposes and the granting of rights of use of spectrum through wireless telegraphy licences and licence exemptions.

Duties under the 2003 Act

A5.3 Our principal duties under the 2003 Act, when carrying out our functions and exercising our powers, are to further the interests of citizens and consumers, where appropriate by promoting competition. In doing so, we are also required (among other things) to secure the optimal use of spectrum and the availability throughout the United Kingdom of a wide range of electronic communications services.

A5.4 We must also have regard to: (i) the desirability of promoting competition in relevant markets; (ii) the desirability of encouraging investment and innovation in relevant markets; (iii) 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; and (iv) 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 in urban areas.

A5.5 In performing our duties, we are required under section 3(3) of the 2003 Act to have regard in all cases to the principles under which regulatory activities should be transparent, accountable, proportionate, consistent and targeted only at cases in which action is needed.

[25] The Common Regulatory Framework comprises the Framework Directive (Directive 2002/21/EC), the Authorisation Directive (Directive 2002/20/EC), the Access Directive (Directive 2002/19/EC), the Universal Service Directive (Directive 2002/22/EC) and the Directive on privacy and electronic communications (Directive 2002/58/EC), as amended by the Better Regulation Directive (Directive 2009/140/EC). We note that the Common Regulatory Framework has been replaced by the European Electronic Communications Code (the "Code"). The Code was published in the Official Journal of the EU on 17 December 2018, and Member States have until 21 December 2020 to implement the provisions in domestic law.

A5.6 Section 4 of the 2003 Act requires Ofcom to act in accordance with the six Community requirements, which give effect to the requirements of Article 8 of the Framework Directive.[26]

Duties under the WT Act

A5.7 Additionally, in carrying out our spectrum functions we have a duty under section 3 of the WT Act to have regard in particular to: (i) the extent to which the spectrum is available for use, or further use, for wireless telegraphy; (ii) the demand for use of that spectrum for wireless telegraphy; and (iii) the demand that is likely to arise in future for such use.

A5.8 We also have a duty to have regard to the desirability of promoting: (i) the efficient management and use of the spectrum for wireless telegraphy; (ii) the economic and other benefits that may arise from the use of wireless telegraphy; (iii) the development of innovative services; and (iv) competition in the provision of electronic communications services.

The licence-exemption regime

A5.9 Under sections 8(3) - 8(3B) of the WT Act, Ofcom may make regulations exempting from the licensing requirements under section 8(1) the establishment, installation or use of wireless telegraphy stations or wireless telegraphy apparatus of such classes or description as may be specified in the regulations, either absolutely or subject to such terms, provisions and limitations as may be specified.

A5.10 Under sections 8(4) and 8(5) of the WT Act, we must make regulations to exempt stations and apparatus from the requirement to be licensed if their establishment, installation or use is not likely to:

a) involve undue interference with wireless telegraphy;

b) have an adverse effect on technical quality of service;

c) lead to inefficient use of the part of the electromagnetic spectrum available for wireless telegraphy;

d) endanger safety of life;

e) prejudice the promotion of social, regional or territorial cohesion; or

f) prejudice the promotion of cultural and linguistic diversity and media pluralism.

[26] In summary, the Community requirements are requirements: a) to promote competition in communications markets; b) to ensure that Ofcom contributes to the development of the European internal market; c) to promote the interests of all European Union citizens; d) to act in a manner which, so far as practicable, is technology neutral; e) to encourage, to the extent Ofcom considers it appropriate, the provision of network access and service interoperability for the purposes of securing efficiency and sustainable competition in communications markets and the maximum benefit for the customers of communications network and services providers; and f) to encourage such compliance with certain international standards as is necessary for facilitating service interoperability and securing freedom of choice for the customers of communications providers.

A5.11 In accordance with the requirements of section 8(3B) of the WT Act, the terms, provisions and limitations specified in the regulations must be:

a) objectively justifiable in relation to the wireless telegraphy stations or wireless telegraphy apparatus to which they relate;

b) not such as to discriminate unduly against particular persons or against a particular description of persons;

c) proportionate to what they are intended to achieve; and

d) transparent in relation to what they are intended to achieve.

The licensing regime

A5.12 Ofcom is responsible for authorising civil use of the radio spectrum and achieves this by granting wireless telegraphy licences under the WT Act. Under section 8(1) of the WT Act, it is unlawful to establish or use a wireless telegraphy station or install or use wireless telegraphy apparatus except under and in accordance with a wireless telegraphy licence.

Licence conditions

A5.13 Article 6 of the Authorisation Directive provides that rights of use for radio frequencies may be subject only to the conditions listed in the Annex to the directive. Part B of the Annex, which sets out conditions which may be attached to such rights of use, includes an obligation to provide a service or to use a type of technology for which the rights of use for the frequency has been granted, including, where appropriate, coverage and quality requirements, as well as conditions relating to the effective and efficient use of frequencies. Section 9(1A) of the WT Act confirms that the terms, provisions and limitations of a licence for the use of spectrum for the provision of an electronic communications network or service must fall within Part B of the Annex to the Authorisation Directive.

A5.14 The terms, provisions and limitations of a spectrum licence must not duplicate the obligations already imposed on the licensee by the general conditions set by Ofcom under section 45 of the 2003 Act (WT Act, section 9(6)).

A5.15 Under section 9(7) of the WT Act, Ofcom may only impose terms, provisions and limitations which are:

a) objectively justified in relation to the network and services to which they relate;

b) not unduly discriminatory;

c) proportionate to what they are intended to achieve; and

d) transparent in relation to what they are intended to achieve.

Spectrum fees

A5.16 Under section 12 of the WT Act Ofcom may prescribe in regulations the sums payable in respect of wireless telegraphy licences other than those awarded by auction. When doing

so, section 122(7) of the WT Act enables Ofcom to make different provisions for different cases and to make incidental provisions. This power enables us to recover the cost of administering and managing WT Act licences. However, section 13 of the WT Act permits us to recover sums greater than those we incur in performing our spectrum management functions, to reflect a range of spectrum management objectives. In particular, in order to provide incentives - Administered Incentive Pricing ("AIP") - to licensees to use their spectrum more efficiently. This power goes to discharging a range of duties under section 3 of the WT Act which require us to efficiently manage the radio spectrum.

Spectrum trading

A5.17 Whilst a licensee cannot assign its licence to another party, spectrum trading is a process that allows the holders of certain wireless telegraphy licences granted by us under section 8 of the WT Act to transfer the licence rights and obligations to another person. Such a transfer involves the notification to Ofcom and the grant by us of a new licence to the transferee.

A5.18 Ofcom has the power under section 30 of the WT Act to make regulations to authorise the transfer to another person by the holder of a wireless telegraphy licence of rights and obligations arising by virtue of such a licence. When doing so, section 122(7) of the WT Act enables us to make different provisions for different cases and to make incidental provisions.

A5.19 Under section 30(4) and (5) of the WT Act, transfers that fail to comply with such regulations (or with certain conditions in licences) will be void. Under section 30(6) of the WT Act, a transfer is void if it fails to comply with a direction given by Ofcom in exercise of a power conferred by such regulations.

The Wireless Telegraphy Act register

A5.20 Section 31 of the WT Act permits Ofcom to make regulations to establish and maintain relevant information in a register. Ofcom has made the Register Regulations and established the Wireless Telegraphy Act Register, which provides information about who is licensed to operate services in specific frequencies or geographical areas.

A5.21 The register provides basic information about licensees such as names, contact details, class of licence, the band(s) of frequencies and, where appropriate, the geographical area of operation. It does not provide precise details about individual transmitters due to security concerns. The register supports the spectrum transfer process by providing basic information about allocated spectrum to the market.

The international context

ITU Regulations

A5.22 The spectrum above 100 GHz is mainly used by the scientific community: Radio-Astronomy, Space research and Earth Exploration-Satellite Services. Other spectrum uses which are permitted in certain bands above 100 GHz include short range devices.

A5.23 Radio Regulations governing the international use of spectrum are determined by the ITU at WRC conferences. According to the Radio Regulations, the 116-122 GHz, 174.8-182 GHz and 185-190 GHz bands are allocated for primary use to Earth Exploration-Satellite (passive), Inter-Satellite and Space research (passive).

The EU Decision on short range devices

A5.24 The European Commission Decision 2006/771/EC, as subsequently amended, harmonises the technical conditions for use of radio spectrum, including certain bands above 100 GHz (122-123 GHz and 244-246 GHz), for a wide variety of short-range devices. The conditions set out in that Decision establish a harmonised sharing environment which allows short-range devices to share the use of spectrum with each other on a non-exclusive basis, regardless of the purpose of such use. Member States may allow the use of the relevant frequency bands under less restrictive conditions or for short-range devices which are not part of the harmonised category, provided that the appropriate sharing environment in the harmonised bands is not compromised.

A5.25 Decision 2006/771/EC has been implemented in the UK through the exemption regime for short range devices set out in regulation 5 of The Wireless Telegraphy (Exemption and Amendment) Regulations 2010,[27] which refer to the Interface Requirements 2030.

Implementing our policy proposals

A5.26 If, following consultation, we decide to proceed with our policy proposals, we will need to implement them by adopting any associated interface requirements and by making new regulations by statutory instruments.

A5.27 In accordance with the Radio Equipment Directive and the Technical Standards Directive, we will shortly notify our proposed changes to the current interface requirements for short-range devices (IR 2030) and proposed new interface requirements for licensed devices (IR 2106) to the European Commission. The Commission and Member States will have three months in which to comment on the draft technical standards before they may be adopted. The decision as to whether to make the proposed regulations would be subject to taking into account any comments or opinion we receive from the Commission or Member States, as well as the responses to our consultation.[28]

A5.28 Before making any regulations, we are also required by section 122(4) of the WT Act to give statutory notice of our proposal to do so to. Under section 122(5), such notice must state that we propose to make the regulations in question, set out their general effect, specify an address from which a copy of the proposed regulations or order may be obtained, and specify a time period of at least one month during which any representations with respect to the proposal must be made to us.

[27] S.I. 2010/2512, as amended by S.I. 2011/3035, S.I. 2013/1253, S.I. 2014/1484, S.I. 2017/746, S.I. 2018/263 and S.I. 2018/1140.
[28] We note that Ofcom is separately consulting on further changes to the IR 2030. See the Notice of Ofcom's proposals for changes to the licence exemption for Wireless Telegraphy Devices (11 December 2019).

A6. Coexistence analysis with Earth Exploration-Satellite Services (passive)

Introduction

A6.1 This annex describes our assessment of the potential interference caused by future terrestrial devices operating under our proposals to Earth Exploration-Satellite Services (EESS). It also describes our proposed approach for ensuring that potential interference from these devices does not affect the operation of EESS.

A6.2 An assessment of the potential interference caused by short-range devices (SRDs) to EESS (passive) in the 122-122.25 GHz band has previously been provided in the ECC Report 190. This considered a future scenario in which geographic clusters of devices are deployed, operating continuously at their maximum permitted power. Whilst this will most likely represent a worst-case interference scenario, we have adopted a similar modelling approach for assessing the potential for interference to be caused by new devices operating in the three proposed bands. This approach provides a high degree of surety that the new devices operating in these bands would not affect the future operation of EESS.

A6.3 We also note that our proposals involve making significantly more spectrum available (over 18 GHz) for use by terrestrial devices. This makes it less likely that devices will operate on the same frequencies. This wider distribution in the frequencies used by devices reduces their likely combined effect in the frequency bands used by EESS. In our analysis we have not taken this potential reduction in interference into account, leading to a potential overestimate of the potential interference they might cause to EESS.

A6.4 We have extended the analysis in the ECC Report 190 to account for the different coverage footprints and sensitivities of the EESS sensors used in each of the proposed frequency bands. We have also included the effect of terrestrial devices using directive narrower beam antenna systems. These narrower beams reduce the signals radiated upwards into space and hence the potential interference they cause to EESS.

A6.5 The ECC Report 190 assumed that the attenuation caused to signals propagating from devices sited inside buildings to outdoors is likely to be greater than 60 dB in the 122 GHz band. Based on this, it was concluded in this report that devices operating indoors were unlikely to be a source of interference to EESS. Similar levels of loss would be expected 116-122 GHz and as the signal attenuation caused by buildings generally increases with frequency and its level is likely to be at least that in the newly proposed bands as in the 122 GHz band.

A relatively cautious set of modelling assumptions have been used to assess the effects of interference

A6.6 The EESS technical parameters used in our analysis are set out in Recommendation ITU-R RS.1861[29] and the protection criteria for the EESS sensors in Recommendation ITU-R RS.2017.[30] These parameters are summarised in Table A6.3

A6.7 For the 116-122 GHz band, we have included the effect of potential interference to the new EUMETSAT sensor described in ECC Report 190.

A6.8 The interfering signals from terrestrial devices are not received with the same intensity all of the time by the EESS sensors due to their changing orbital positions. In our analysis no reduction was made to the estimated levels of interference caused by terrestrial devices to account for this, leading to a potential overestimate of the interference caused to EESS. In addition, we have also only considered the reduction in EESS sensor antenna gain with elevation angle and not azimuth angle. In practice, the EESS antenna will be constantly moving and this angle will vary in time. This, again, is likely to have led to some degree of overestimate of the potential level interference that might be caused to EESS.

A6.9 The following assumptions were used relating to the deployed terrestrial devices in our analysis:

a) **Device power** - All devices were modelled as operating at their maximum permitted power level. In practice, it is likely that not all applications will require operation at maximum permitted power and this assumption is likely to lead to an overestimate of interference they will cause.

b) **Device activity factor** - All devices were modelled as operating on a continuous basis (i.e. a 100% duty cycle). This increases the joint effect of interference from different devices at any given time. For example, the cumulative interference provided by five devices operating with a 20% duty cycle[31] would be broadly equivalent to single device operating on a continuous basis. The ECC Report 190 also recognized that practical devices are likely to operate with a duty cycle below 50%. Hence, our assumption that all devices will operate on a continuous basis will most likely overestimate the potential interference caused to EESS.

[29] Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz.
[30] Performance and interference criteria for satellite passive remote sensing.
[31] A 20% duty cycle was assumed by the FCC in their interference analysis. See FCC 19-19.

c) **Device bandwidth** - We have used a minimum transmission bandwidth for the terrestrial devices of 100 MHz. In practice many applications may use larger bandwidths than this, for example to support higher capacity connections.[32] These wider transmission bandwidths reduce the effect of interference to EESS. No adjustment for this was made in our analysis, leading to a potential overestimate of the actual interference caused to EESS.

d) **Frequency of operation** - The propagation losses specific to the three proposed frequency bands were used in our analysis. The lowest propagation losses in each band were considered which, again, represents a worst-case interference scenario.

e) **Device directivity** - We have included the effect of the gain and directivity of the antennas used by devices. This directivity, coupled with the transmitter and receiver beams aligning horizontally for terrestrial use, further reduces the emission of unwanted signals from the devices towards the EESS.

A6.10 Based on the device assumptions above, we sought to identify through our analysis the technical parameters for new terrestrial devices that would provide at least the same level of interference protection for EESS as that identified in the ECC Report 190. Whilst our analysis, for the reasons described above, has most likely overestimated the actual protection required, this approach provides a high degree of surety that EESS will not be affected by our proposals.

Modelling approach

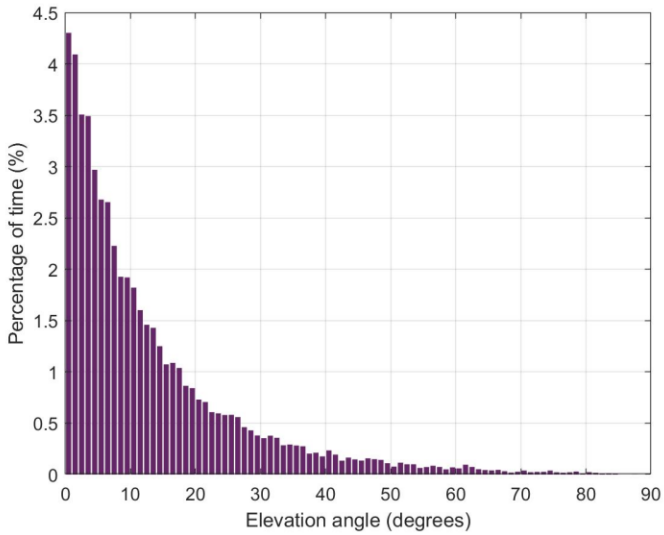
A6.11 The orbits associated with the different EESS were modelled to provide the distribution of elevation angles from potential future terrestrial devices operating in the UK to the sensors on the EESS. These are shown in Figure A6.1. In this distribution, a zero-degree elevation angle is taken to be tangential to the Earth.

A6.12 At a zero-degree angle, the potential interference path from the terrestrial devices to the EESS sensors is the longest and these paths have the greatest atmospheric attenuation. Hence, the potential interference caused by terrestrial devices is the lowest over these paths. Signals travelling along these paths will also be further reduced by terrain and clutter. These additional reductions were not taken into account in our analysis as this interference path geometry is not the limiting case.

A6.13 At an elevation angle of 90 degrees the interference path is at its shortest and has the lowest level of atmospheric attenuation. This path provides the highest level of potential interference to EESS but, as Figure A6.1 shows, these paths to the EESS occur for only a small percentage of time. No adjustment was made for this in our analysis.

[32] The ECC Report 190 also noted that transmission bandwidths are likely to be larger than 500 MHz.

Figure A6.1: Distribution of elevation angles



A6.14 The interference path between the terrestrial devices and the EESS sensor receiver was modelled to obtain the power received at the EESS receiver taking into account the propagation losses, terrestrial device transmit power, antenna gain and pointing, and the pointing of the EESS antenna.

$$P_{received} = P_{terrestrial} + G_{terrestrial} - L_{propagation} + G_{EESS}$$

Where:

$P_{received}$ is the power received at the EESS sensor;

$P_{terrestrial}$ is the power transmitted by the terrestrial device;

$G_{terrestrial}$ is the antenna gain of the terrestrial device in the direction of the EESS sensor;

$L_{propagation}$ is the propagation loss between the terrestrial device and the EESS sensor;

G_{EESS} is the antenna gain of the EESS sensor in the direction of the terrestrial device.

Power transmitted by the terrestrial device

A6.15 A range of different input power levels and antenna gains, and hence Effective Isotropic Radiated Powers (EIRPs), were modelled for the terrestrial devices to assess their impact on the potential interference caused to EESS.

Antenna gain of the terrestrial device in the direction of the EESS sensor

A6.16 Two different types of terrestrial device antennas were considered:

a) Isotropic radiators where the EIRP is the same in all directions; and

b) More directive, narrower beam antennas where the EIRP is higher in the direction of the main beam and lower at angular offsets from the main beam.

A6.17 The directional antenna pattern was modelled using Recommendation ITU-R F.1245.[33] The proposed new frequency bands do not fall within the range of this model but after comparison with a selection of directional antenna patterns operating at frequencies above 90 GHz, we considered that it was appropriate to use this model in our analysis.

A6.18 To assess the average interference from a typical device, an average antenna pattern was created to account for the variation in azimuth and elevation pointing. This was derived to represent an equal probability of any of the pointing angle combinations of azimuth and elevation of the device. Interference assessments were made over the full range of elevation angle paths to the satellites (0 to 90 degrees). For this:

- The device antenna main beam elevation pointing angle was assumed to lie in the range -20 to 20 degrees.
- The relative angle between the main beam of the terrestrial device and the elevation angle at 0 degrees azimuth was calculated over 0 to 359 degree range in azimuth.
- The device antenna gain at each relative angle was found using the antenna models described above and the values for each elevation angle were averaged and used in the assessment.

A6.19 This gives an antenna pattern which accounts for the terrestrial device antenna orientation relative to the EESS. It is appropriate for the assessment of interference from multiple devices but will overestimate the likely interference caused by a specific device.

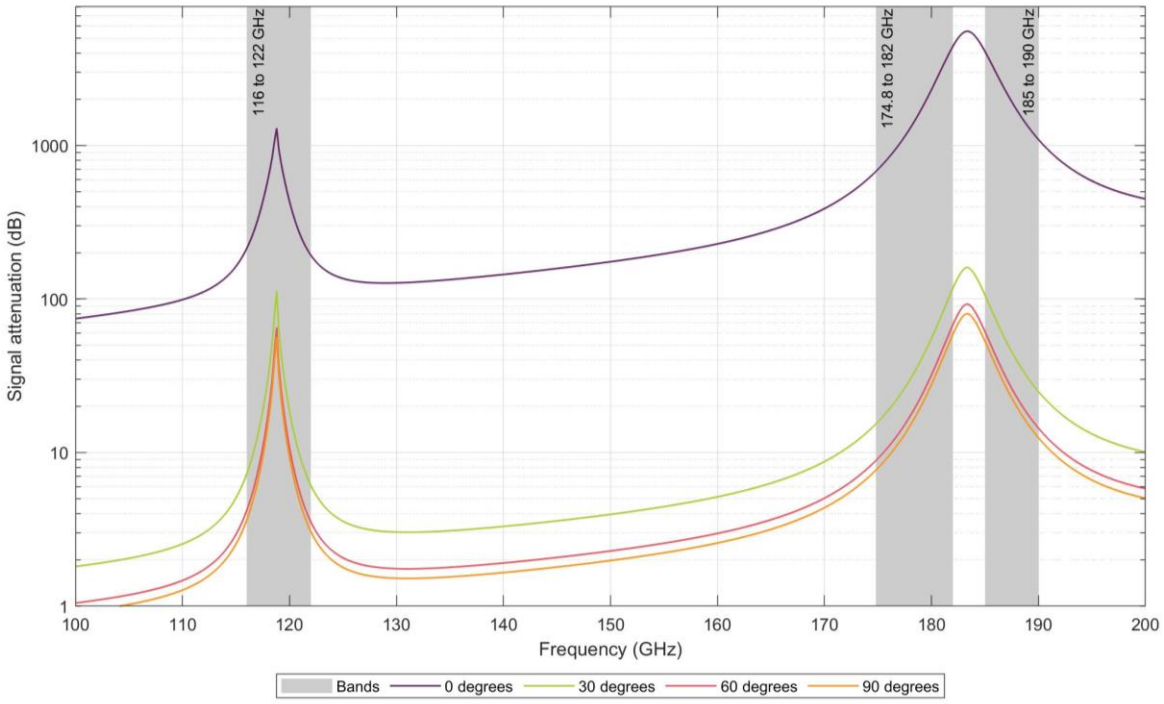
Propagation loss between the terrestrial device and the EESS sensor

A6.20 As radiowaves pass through the atmosphere they interact with the gas molecules. These interactions generally attenuate the signals. This attenuation is largest closer to the resonant frequencies of the gas molecules. The most relevant gases in our proposed frequency bands are oxygen and water vapour. Oxygen has a resonant frequency at around 119 GHz, whilst water vapour has resonances at 120 GHz and 183 GHz.

A6.21 The atmosphere is highly variable in both time and with altitude. Atmospheric pressure and temperature affect the magnitude of the signal attenuation. Altitude variation is modelled by splitting the atmosphere into sections. By estimating the temperature and pressure in each section and the distance travelled by radio waves through it, the loss due to the interaction with gases can be assessed. The losses from each section are then summed to find the total propagation loss. The losses due to interaction with gas molecules vary with frequency and elevation angle, as shown in Figure A6.2. This variation plays an important part in our assessment of potential interference to EESS and was modelled for elevation angles between 0 and 90 degrees.

[33] Mathematical model of average and related radiation patterns for point-to-point fixed wireless system antennas for use in interference assessment in the frequency range from 1 GHz to 86 GHz.

Figure A6.2: Signal attenuation due to gases for varying elevation angles



A6.22 To derive the aggregate interference value, the propagation losses were determined using Recommendation ITU-R P.525[34] for free-space loss (L_{fs}) and Recommendation ITU-R P.676[35] for attenuation by atmospheric gases (L_{ga}) (with the mean annual global reference atmosphere taken from ITU-R P.835[36]).

$$L_{propagation} = L_{fs} + L_{ga}$$

Where:

$L_{propagation}$ is the propagation loss between the terrestrial device and the EESS sensor;

L_{fs} is the free-space loss between the terrestrial device and the EESS sensor; and

L_{ga} is the loss due to atmospheric gases between the terrestrial device and the EESS sensor?

Antenna gain of the EESS sensor in the direction of the terrestrial device

A6.23 The EESS antenna gain was calculated using Recommendation ITU-R RS.1813-1.[37] The proposed bands under consideration do not fall within the range of this model but after

[34] Calculation of free-space attenuation.
[35] Attenuation by atmospheric gases. Annex 1 for Slant path attenuation, this section remains unchanged in ITU-R P.676-12 (updated August 2019).
[36] Reference Standard Atmospheres.
[37] Reference antenna pattern for passive sensors operating in the Earth exploration-satellite service (passive) to be used in compatibility analyses in the frequency range 1.4-100 GHz.

comparison with Figure 12 in Recommendation ITU-R RS.1861, we considered it was an appropriate model to use for this analysis.

A6.24 To determine the EESS antenna gain, the difference between its off-nadir angle and the angle of arrival at the sensor was used. This off-axis reduction in EESS antenna gain only accounts for changes in elevation angle, and no adjustment was made to account for the potential further reduction in gain provided by offsets in azimuth angle.

Interference margin

A6.25 An interference margin was obtained for each elevation angle by comparing the power received and the sensor protection limits. The protection limits were scaled to a minimum bandwidth of 100 MHz.

$$I_{margin} = I_{max} + 10log\left(\frac{100}{BW_{ref}}\right) - P_{received}$$

Where:

I_{max} is the maximum interference level from the sensor protection criteria (see Table A6.3);

BW_{ref} is the reference bandwidth from the sensor protection criteria (see Table A6.3);

$P_{received}$ is the power level received at the sensor.

A6.26 The calculated interference margin provides an indication of the number of terrestrial devices that can operate simultaneously without exceeding the maximum interference level defined in Recommendation ITU-R RS.2017.

Setting the technical device specifications

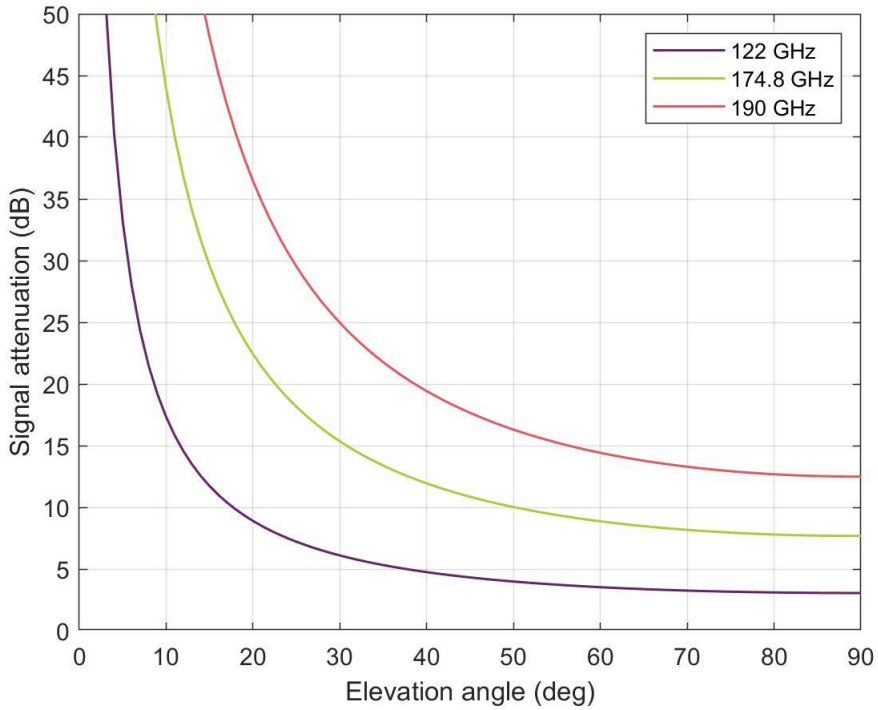
A6.27 In setting the technical specifications, we have considered the two main factors which influence the interference margin:

a) The variation in the signal attenuation due to interaction with gases. In the 116-122 GHz band there is an Oxygen absorption line at 118.75 GHz which leads to high attenuation in the middle of the band but lower attenuation towards the edges of the band. The 174.8-182 GHz and 185-190 GHz bands are on the lower and upper slopes of the water vapour peak at 183.3 GHz. Comparing the lowest losses in each band at elevation angles between 20 and 40 degrees, there is an increase of at least 10 dB in losses per band due to gases. 174.8-182 GHz has at least 10 dB greater loss than 116-122 GHz and there is a further increase in loss of at least 10 dB in the 185-190 GHz band. This is illustrated in Figure A6.3.

b) The antenna pointing of the EESS sensors. The configuration of the EESS sensors vary between the bands. The EUMETSAT sensor in 116-122 GHz has a smaller off-nadir pointing angle than the sensors in the 174.8-182 GHz and 185-190 GHz bands which are the same in both bands.

A6.28 When assessing the potential risk of interference for each band we found that the configuration of the EUMETSAT sensor in the 116-122 GHz band required the same level of protection as the EESS sensors in 174.8-182 GHz after taking into consideration the difference in attenuation due to gases. The EESS sensor configurations in the 174.8-182 GHz and 185-190 GHz bands are the same, so the difference in gaseous attenuation between the bands enabled the setting of higher maximum EIRP levels in the upper band.

Figure A6.3: Comparison of signal attenuation due to gases

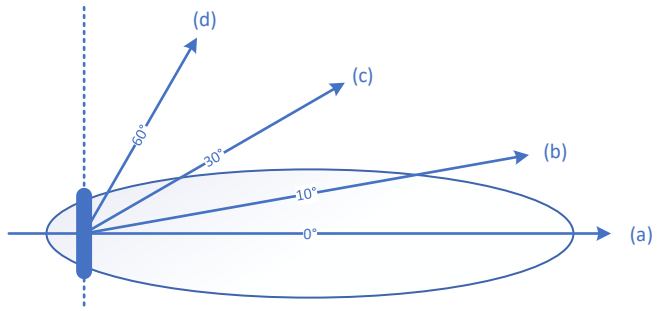


A6.29 For licence-exempt use outdoors, we are proposing maximum permitted device EIRP levels specified at angles of 0, 10, 40 and 60 degrees from the direction of its main beam in Table A6.1. These angles are shown as (a) to (d) in Figure A6.4. We are proposing lower limits for higher elevation angles given their greater potential effect on the EESS. It is expected that most outdoor terrestrial applications will operate with device antenna pointing horizontally. However, in developing these proposed EIRP limits, we have also included scenarios where their beams are tilted upwards with and elevation angle of up to 20 degrees. We believe that this is a reasonable assumption given the likely practical deployment of devices for terrestrial use where the main antenna beams for the transmitter and receiver devices will most likely need to align horizontally.

Table A6.1: Licence exemption EIRP limits

Power limits (*max EIRP in dBm*) and emissions restrictions on outdoor use			
USE	**116-122 GHz**	**174.8-182 GHz**	**185-190 GHz**
Indoor	40	40	40
Outdoor	20(a)	20 (a)	40 (a)
For outdoor use, EIRP at angles (degrees°) relative to main beam in elevation shall not exceed			
	13 at > 10° (b) 1 at > 40°(c) -3 at > 60°(d)	13 at > 10° (b) 1 at > 40°(c) -3 at > 60°(d)	25 at > 10°(b) 14 at > 40°(c) 10 at > 60°(d)

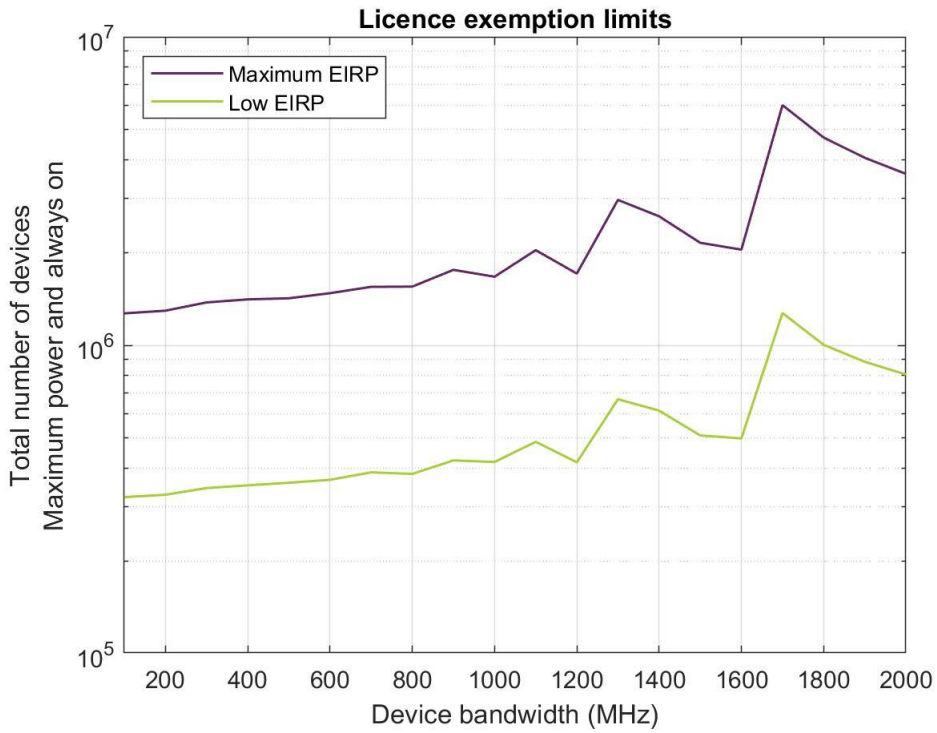
Figure A6.4. EIRP variation relative to the antenna main beam



A6.30 In ECC Report 190 it was estimated that the maximum number of devices that are likely to be visible to the EESS at any one time is 2100 in 250 MHz. If we scale this assumption for the total amount of spectrum in the newly proposed bands, this would be equivalent to a much higher 150,000 devices. This reflects the wider distribution of devices across a wider frequency range.

A6.31 The EIRP limits set out in table A6.1 would ensure that the emissions from over 300,000 outdoor licence exempt devices visible to the satellite at the same time and operating continuously would not exceed the maximum interference levels from Recommendation ITU-R RS.2017. The number of devices that could operate at maximum EIRP using directive antennas at the same time across the newly proposed bands is higher and exceeds one million devices (see Figure A6.5). This figure also shows that for less directive antennas (operating at with a lower permitted EIRP) more than 300,000 devices could be supported. The number of devices also rises significantly as the device bandwidth increases.

Figure A6.5: Permitted number of devices operating continuously outdoors under licence exempt operation which are visible to the satellite at any one time



A6.32 For indoor use, we have considered that a higher proportion of devices may operate indoors than outdoors. The ECC Report 190 estimates that 95% of devices will operate indoors. Taking into account the high propagation losses from devices sited indoors to outdoors in these frequency bands, we do not believe that devices operating indoors will affect EESS. Given this, we are proposing a 40 dBm EIRP limit across all of the proposed bands with no additional angular emission constraints.

A6.33 We recognise that longer range high capacity applications may require higher levels of EIRP. An EIRP limit of 55 dBm was established for high capacity longer range applications in the 57 to 71 GHz bands as part of our 2018 Review of spectrum used by fixed wireless services.

A6.34 We are also proposing to allow operation of devices in the proposal bands above 100 GHz with EIRP levels up to 55 dBm. We are proposing that the use of these higher EIRPs would only be permitted under a licensing regime. For outdoor use, this would also require the use of directive antennas and an additional constraint on their installation. The installation constraint would require the maximum elevation angle of the main beam of the installed equipment to be less than 20 degrees. This would provide additional protection to EESS by reducing the signals radiated into space.

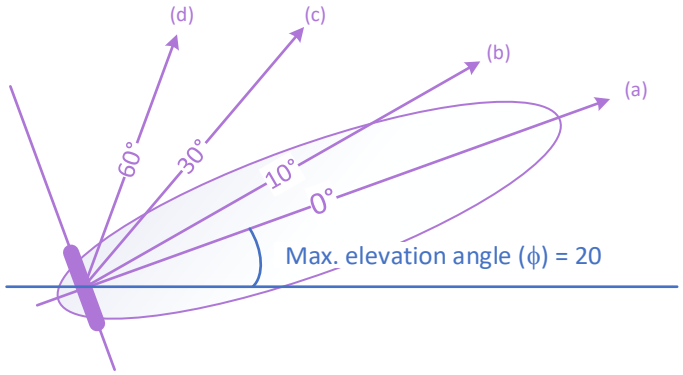
A6.35 For simplicity, we are proposing to impose the same EIRP limits relative to the antenna main beam as for lower power licence exempt devices. These are detailed in table A6.2 below. The maximum permitted device EIRP levels are specified at angles of 0, 10, 40 and

60 degrees from the direction of its main beam for outdoor installations. Figure A6.6 shows the additional proposed constraint on the installed device in elevation of 20 degrees. Taking into account the high propagation losses from devices sited indoors to outdoors in these frequency bands, we do not believe that devices operating indoors will affect EESS. Given this, we are proposing a 55 dBm EIRP limit across all of the proposed bands with no additional angular emission constraints.

Table A6.2: Licensing EIRP limits

Power limits (*max EIRP in dBm*) and emissions restrictions for outdoor use		
116-122 GHz	**174.8-182 GHz**	**185-190 GHz**
55(a)	55 (a)	55 (a)
For outdoor use, EIRP at angles (degrees°) relative to main beam in elevation shall not exceed		
13 at > 10° (b) 1 at > 40°(c) -3 at > 60°(d)	13 at > 10° (b) 1 at > 40°(c) -3 at > 60°(d)	25 at > 10° (b) 14 at > 40°(c) 10 at > 60°(d)
Main beam elevation angle (ϕ) shall not exceed 20 degrees above horizontal when devices are used outdoors.		

Figure A6.6. EIRP variation relative to the antenna main beam including antenna elevation angle



Summary

A6.36 Our proposals are intended to protect EESS from undue interference. For outdoor use, we are proposing to impose maximum EIRP limits which restrict radiated levels for the devices at different elevation angles. We are proposing to set lower limits for higher elevation angles relative to the main beam given their greater potential effect on the EESS.

A6.37 We believe that these technical restrictions will provide a high degree of surety that EESS would not be affected by our proposals, because as detailed above they were developed based on a number of potentially conservative assumptions including:

a) All devices operate continuously at full power. This is unlikely to occur in practice.

b) All devices assumed to operate with narrow bandwidths. Many devices are likely to use larger bandwidths to support higher capacity applications.

c) The lowest propagation losses and hence highest levels of interference were assumed for each band. It is likely that devices will spread across parts of bands with higher propagation losses and hence less interference.

d) An equal probability of device antenna elevation pointing was assumed across the range ±20 degrees. In practice, the majority of the devices are likely to have an installed elevation angle of close to zero degrees.

Table A6.3: EESS sensor parameters[38]

Sensor ID	M1	EU	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Frequency range (GHz)	114.25-122.25		174.8-191.8						
Sensor type	Limb	Conical scan	Conical scan	Cross-track scan	Limb	Mechanical nadir scan	Conical scan	Nadir scan	Nadir scan
Orbit parameters									
Altitude (km)	705	800-850	828	705	705	824	835	867	822
Inclination (°)	98.2	98.7	98.7	98.2	98.2	98.7	98.85	20	89.7
Eccentricity	0.0015	0	0	0	0	0	0	0	0.001
Repeat period (days)	16	9	17	16	16	9	N/A	7	29
Sensor antenna parameters									
Maximum beam gain (dBi)	60	55	54	45	60	43.9	60	49	44.8
-3 dB beamwidth (°)	0.19 x **0.245**	0.35	0.39	1.1	0.19 x **0.245**	1.1	0.2	0.66	1.1
Off nadir pointing angle (°)	**64.2**	45.2	46.8	±48.95	**64.2**	±52.725	55.4	42	49.4
Sensor protection criteria									
Reference bandwidth (MHz)	10	200	200	200	10	200	200	200	200
Maximum interference level (dBW)	-189	-163	-163	-163	-189	-163	-163	-163	-163
Percentage of area or time	1	0.01	0.01	0.01	1	0.01	0.01	0.01	0.01

[38] Values in bold highlight assumptions used in the analysis. Where two values are specified the bolded number has been used in the calculation of EESS antenna gain. When the incidence angle at the Earth has not been provided in the specification, the angle has been deduced from the sensor description.

permissible interference level may be exceeded (%)									

A7. Draft IR 2030 amendment

We are proposing the addition of six new rows to Interface Requirements 2030 (IR 2030). The technical parameters set out in IR 2030 would form part of the requirements with which individuals must comply when operating in the 116-122 GHz, 174.8-182 GHz and 185-190 GHz frequencies. All other requirements set out in IR 2030 would remain the same. The current version of IR 2030 can be found on our website.

Table 3.1: Minimum requirements for the use of Short Range Devices

	Normative Part								Informative Part
Interface / Notification number / Date	**Application**	**Comments to application**	**Frequency band**	**Comments to frequency band**	**Maximum transmit power / Power spectral density / Field strength**	**Comments to Maximum transmit power / Power spectral density / Field strength**	**Channelling**	**Channel access and occupation rules**	**Reference**
New notification	Non-specific short-range devices	Equipment shall not be used airborne	116 – 122 GHz		20 dBm e.i.r.p. EIRP at angles relative to main beam in elevation shall not exceed: 13 dBm at >10 degrees 1 dBm at >40 degrees -3 dBm at >60 degrees	Out of band emissions must be limited to -10 dBm/MHz			

Table 3.1: Minimum requirements for the use of Short Range Devices

	Normative Part								Informative Part
Interface / Notification number / Date	**Application**	**Comments to application**	**Frequency band**	**Comments to frequency band**	**Maximum transmit power / Power spectral density / Field strength**	**Comments to Maximum transmit power / Power spectral density / Field strength**	**Channelling**	**Channel access and occupation rules**	**Reference**
New notification	Non-specific short-range devices	Equipment is restricted to indoor[39] use only.	116 – 122 GHz		40 dBm e.i.r.p.	Out of band emissions must be limited to -10 dBm/MHz			

[39] "Indoor" means inside premises which (i) have a ceiling or a roof; and (ii) except for any doors, windows or passageways, are wholly enclosed.

Table 3.1: Minimum requirements for the use of Short Range Devices

	Normative Part								Informative Part
Interface / Notification number / Date	**Application**	**Comments to application**	**Frequency band**	**Comments to frequency band**	**Maximum transmit power / Power spectral density / Field strength**	**Comments to Maximum transmit power / Power spectral density / Field strength**	**Channelling**	**Channel access and occupation rules**	**Reference**
New notification	Non-specific short-range devices	Equipment shall not be used airborne	178.4 – 182 GHz		20 mW e.i.r.p. EIRP at angles relative to main beam in elevation shall not exceed: 13 dBm at >10 degrees 1 dBm at >40 degrees -3 dBm at >60 degrees	Out of band emissions must be limited to -10 dBm/MHz			
New notification	Non-specific short-range devices	Equipment is restricted to indoor[40] use only.	178.4 – 182 GHz		40 dBm e.i.r.p.	Out of band emissions must be limited to -10 dBm/MHz			

[40] "Indoor" means inside premises which (i) have a ceiling or a roof; and (ii) except for any doors, windows or passageways, are wholly enclosed.

Table 3.1: Minimum requirements for the use of Short Range Devices

	Normative Part								Informative Part
Interface / Notification number / Date	**Application**	**Comments to application**	**Frequency band**	**Comments to frequency band**	**Maximum transmit power / Power spectral density / Field strength**	**Comments to Maximum transmit power / Power spectral density / Field strength**	**Channelling**	**Channel access and occupation rules**	**Reference**
New notification	Non-specific short-range devices	Equipment shall not be used airborne	185 – 190 GHz		40 dBm e.i.r.p. EIRP at angles relative to main beam in elevation shall not exceed: 25 dBm at >10 degrees 14 dBm at >40 degrees 10 dBm at >60 degrees	Out of band emissions must be limited to -10 dBm/MHz			
New notification	Non-specific short-range devices	Equipment is restricted to indoor[41] use only.	185 – 190 GHz		40 dBm e.i.r.p.	Out of band emissions must be limited to -10 dBm/MHz			

[41] "Indoor" means inside premises which (i) have a ceiling or a roof; and (ii) except for any doors, windows or passageways, are wholly enclosed.

A8. Draft tables for new UK Interface Requirement 2106

Table 3.1: Minimum requirements for the use of: ECS equipment operating in the 116-122 GHz and 174.8-182 GHz bands

Mandatory (1 – 10)	
1. Radiocommunication Service	Fixed or Mobile Service
2. Application	Electronic communications services
3. Frequency band(s)	116-122 GHz and 174.8-182 GHz
4. Channelling	N/A
5. Occupied bandwidth	N/A
6. Direction / Separation	N/A
7. Maximum Transmit Power / Power Density	55 dBm EIRP For outdoor installations, EIRP at angles relative to main beam in elevation shall not exceed: • 13 dBm at >10 degrees • 1 dBm at >40 degrees • -3 dBm at >60 degrees For outdoor installations, the main beam elevation angle shall not exceed 20 degrees above horizontal Out of band emissions must be limited to -10 dBm/MHz
8. Channel access and occupation rules	N/A
9. Authorisation regime	A licence is required. Radio equipment is not permitted to be used airborne.
10. Additional essential requirements	None
Informative (11-13)	
11. Frequency Planning	-
12. Planned changes	-
13. Reference	-
14. Notification	

15.	Remarks	-

Table 3.2: Minimum requirements for the use of: ECS equipment operating in the 185-190 GHz band

Mandatory (1 – 10)		
1.	Radiocommunication Service	Fixed or Mobile Service
2.	Application	Electronic communications services
3.	Frequency band(s)	185-190 GHz
4.	Channelling	N/A
5.	Occupied bandwidth	N/A
6.	Direction / Separation	N/A
7.	Maximum Transmit Power / Power Density	55 dBm EIRP For outdoor installations, EIRP at angles relative to main beam in elevation shall not exceed: • 25 dBm at >10 degrees • 14 dBm at >40 degrees • 10 dBm at >60 degrees For outdoor installations, the main beam elevation angle shall not exceed 20 degrees above horizontal Out of band emissions must be limited to -10 dBm/MHz
8.	Channel access and occupation rules	N/A
9.	Authorisation regime	A licence is required. Radio equipment is not permitted to be used airborne.
10.	Additional essential requirements	None
Informative (11-13)		
11.	Frequency Planning	-
12.	Planned changes	-
13.	Reference	-
14.	Notification	
15.	Remarks	-

A9. Draft licence

Wireless Telegraphy Act 2006

Spectrum Access EHF

Sector/Class/Product:	xxxxxx – Spectrum Access EHF
Licence number:	
Licensee:	
Company registration:	
Licensee address:	
Email:	
Date of issue:	xx xxxx 202x
Valid from:	xx xxxx 202x
Payment interval:	5 year

1. The Office of Communications (Ofcom) grants this wireless telegraphy licence ("the Licence") to [LICENSEE] to establish, install and use wireless telegraphy stations and/or wireless telegraphy apparatus as described in the schedules to this Licence (together "the Radio Equipment") subject to the terms set out below.

Licence Term

2. This Licence shall continue in force until revoked by Ofcom or surrendered by the Licensee or, if it is a Short Term Licence, when it reaches its expiration date.

Licence Revocation

3. Pursuant to schedule 1 paragraph 8 of the Wireless Telegraphy Act 2006 ("the Act"), Ofcom may not revoke this Licence under schedule 1 paragraph 6 of the Act except:

   (a) at the request, or with the consent, of the Licensee;
   (b) if there has been a breach of any of the terms of this Licence;
   (c) in accordance with schedule 1 paragraph 8(5) of the Act;
   (d) if it appears to Ofcom to be necessary or expedient to revoke the Licence for the purpose of complying with a direction by the Secretary of State given to Ofcom under section 5 of the Act or section 5 of the Communications Act 2003;
   (e) for reasons related to the management of the radio spectrum provided that in such a case the power to revoke may only be exercised after at least three years notice is given in writing.

4. Ofcom may only revoke this Licence by notification in writing to the Licensee and in accordance with schedule 1 paragraphs 6, 6A and 7 of the Act.

Licence variation

5. Ofcom may only vary this Licence by notification in writing to the Licensee and in accordance with schedule 1 paragraphs 6, 6A and 7 of the Act.

Transfer

6. This Licence may not be transferred. The transfer of rights and obligations arising by virtue of this Licence may however be authorised in accordance with regulations made by Ofcom under powers conferred by section 30 of the Act[42].

Changes to Licensee details

7. The Licensee shall give prior notice to Ofcom in writing of any proposed changes to the Licensee's name, email address and/or address as recorded in this Licence.

Fees

8. The Licensee shall pay to Ofcom the relevant fee(s) as provided in section 12 of the Act and the regulations made thereunder on or before the fee payment date shown above, or on or before such dates as are notified in writing to the Licensee.

9. If the Licence is surrendered, revoked or varied, no refund, whether in whole or in part, of any amount which is due under the terms of this Licence, payable in accordance with any regulations made by Ofcom under sections 12 and 13(2) of the Act will be made, except at the absolute discretion of Ofcom.

Radio Equipment Use

10. The Licensee shall ensure that the Radio Equipment is established, installed and used only in accordance with the provisions specified in the schedules to this Licence. Any proposal to amend any detail specified in any of the schedules to this Licence must be agreed with Ofcom in advance and implemented only after this Licence has been varied or reissued accordingly.

11. The Licensee shall ensure that the Radio Equipment is operated in compliance with the terms of this Licence and is used only by persons who have been authorised in writing by the Licensee to do so and that such persons are made aware of, and of the requirement to comply with, the terms of this Licence.

Access and Inspection

12. The Licensee shall permit any person authorised by Ofcom:

    (a) to have access to the Radio Equipment; and

    (b) to inspect this Licence and to inspect, examine and test the Radio Equipment,

    at any and all reasonable times or, when in the opinion of that person an urgent situation exists, at any time, to ensure the Radio Equipment is being used in accordance with the terms of this Licence.

Modification, Restriction and Closedown

[42] See Ofcom's website for the latest position on spectrum trading and the types of trade which are permitted.

13. Any person authorised by Ofcom may require the Radio Equipment or any part thereof, to be modified or restricted in use, or temporarily or permanently closed down immediately if in the opinion of the person authorised by Ofcom:

(a) a breach of this Licence has occurred; and/or

(b) the use of the Radio Equipment is, or may be, causing or contributing to undue interference to the use of other authorised radio equipment.

14. Ofcom may require any of the Radio Equipment to be modified or restricted in use, or temporarily closed down either immediately or on the expiry of such period as may be specified in the event of a national or local state of emergency being declared. Ofcom may only exercise this power after a written notice has been served on the Licensee or a general notice applicable to holders of a named class of licence has been published.

Geographical Boundaries

15. Subject to the requirements of any coordination procedures notified to the Licensee pursuant to Schedule 1 to this Licence, the Licensee is authorised to establish, install and use the Radio Equipment in the United Kingdom, United Kingdom territorial sea (measured in accordance with section 1 of the Territorial Sea Act 1987), *the Channel Islands and the Isle of Man*.[43]

Interpretation

16. In this Licence:

(a) the establishment, installation and use of the Radio Equipment shall be interpreted as establishment and use of wireless telegraphy stations and installation and use of wireless telegraphy apparatus for wireless telegraphy as specified in section 8(1) of the Act;

(b) the expression "interference" shall have the meaning given by section 115 of the Act;

(c) the expressions "wireless telegraphy station" and "wireless telegraphy apparatus" shall have the meanings given by section 117 of the Act;

(d) the schedule(s) form part of this Licence together with any subsequent schedule(s) which Ofcom may issue as a variation to this Licence; and

(e) the Interpretation Act 1978 shall apply to the Licence as it applies to an Act of Parliament.

Issued by the Office of Communications (Ofcom)

[43] Subject to confirmation from the Island authorities.

Spectrum Access EHF
SCHEDULE 1 TO LICENCE: xxxxxx

Description of Radio Equipment

1. References in this schedule(s) to the Radio Equipment are references to any wireless telegraphy station or wireless telegraphy apparatus that is established, installed and/or used under this schedule(s).

Interface Requirements for the Radio Equipment

2. Use of the Radio Equipment shall be in accordance with the following Interface Requirement:

   IR 2106 Spectrum Access EHF

Special conditions relating to the Radio Equipment

3. Radio Equipment is not permitted to be used airborne.

4. During the period that this Licence remains in force, unless consent has otherwise been given by Ofcom, the Licensee shall compile and maintain accurate written records of the following details relating to the Radio Equipment:

   I. postal address (including post code); or
   II. National Grid Reference (to 1m resolution); and
   III. Antenna main beam elevation angle measured in degrees for outdoor installations.

5. The Licensee shall submit to Ofcom in such manner and within such period as specified by Ofcom, such other information in relation to the Radio Equipment, or any wireless telegraphy station or wireless telegraphy apparatus which the Licensee is planning to use, as Ofcom may from time to time request. Such information may include, but is not limited to, information in relation to the radio frequency, transmitted power and date of first use for wireless telegraphy stations or wireless telegraphy apparatus to be established, installed or used within such timeframe and in such areas as Ofcom may reasonably request.

Coordination at frequency and geographical boundaries

6. The Licensee shall ensure that the Radio Equipment is operated in compliance with such coordination procedures as may be notified to the Licensee by Ofcom from time to time.

Interpretation of terms in this schedule

7. In this schedule:

   a) "IR" means a United Kingdom Radio Interface Requirement notified by Ofcom in accordance with Article 8 of Directive 2014/53/EU of the European Parliament

and of the Council on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment (known as the Radio Equipment Directive).

Spectrum Access EHF
SCHEDULE 2 TO LICENCE NUMBER: xxxxxx

1. When operating, the Licensee must transmit and receive within the limits set out below.

[The licence will authorise use in one of the following bands]

Permitted Frequency Band	**Maximum power levels**	**For outdoor installations, EIRP at angles relative to main beam in elevation shall not exceed**	**Antenna pointing restriction for outdoor installations**
116-122 GHz	55 dBm max EIRP	13 dBm at >10 degrees 1 dBm at >40 degrees -3 dBm at >60 degrees	Main beam elevation angle shall not exceed 20 degrees above horizontal.

Permitted Frequency Band	**Maximum power levels**	**For outdoor installations, EIRP at angles relative to main beam in elevation shall not exceed**	**Antenna pointing restriction for outdoor installations**
174.8-182 GHz	55 dBm max EIRP	13 dBm at >10 degrees 1 dBm at >40 degrees -3 dBm at >60 degrees	Main beam elevation angle shall not exceed 20 degrees above horizontal.

Permitted Frequency Band	**Maximum power levels**	**For outdoor installations, EIRP at angles relative to main beam in elevation shall not exceed**	**Antenna pointing restriction for outdoor installations**
185-190 GHz	55 dBm max EIRP	25 dBm at >10 degrees 14 dBm at >40 degrees 10 dBm at >60 degrees	Main beam elevation angle shall not exceed 20 degrees above horizontal.

Interpretation of terms in this schedule

2. In this schedule:

   a) “dBm” means the power level in decibels (logarithmic scale) referenced against 1milliwatt (i.e. a value of 0 dBm is 1 milliwatt); and

   b) “EIRP” means the 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), measured during the “on” part of the transmission.

A10. Glossary

Activity factor The percentage of time that a signal is present in a communications channel, in either direction, during a specified time interval.

Antenna gain Directivity of an antenna, measured in dBi. An antenna with no directivity, or a 0 dBi gain, is described as isotropic.

Azimuth Rotation of the whole antenna around a vertical axis.

CEPT The European Conference of Postal and Telecommunications Administrations.

ECC Electronic Communications Committee – one of the three business committees of the European Conference of Postal and Telecommunications.

EESS Earth Exploration-Satellite Services – a satellite application for collecting data on changes to the Earth's atmosphere and weather conditions.

EHF Extremely High Frequency – frequencies between 30 and 300 GHz.

EIRP Equivalent Isotropically Radiated Power. This is the product of the power supplied to the antenna and the absolute antenna gain in a given direction.

Elevation With reference to an antenna, elevation is the angle between the main beam pointing direction and the local horizontal plane.

ETSI European Telecommunications Standards Institute.

EUMETSAT The European Organisation for the Exploitation of Meteorological Satellites – an intergovernmental organisation with an objective to establish, maintain and exploit European systems of operational meteorological satellites.

FCC Federal Communications Commission.

GHz Gigahertz – 1,000,000,000 (or 10^9) oscillations per second.

Indoor Inside premises which have a ceiling or a roof; and except for any doors, windows or passageways, are wholly enclosed. This definition is set out in the Wireless Telegraphy (Mobile Repeater) Exemption Regulations 2018.

IR Interface Requirement – the UK Interface Requirements contain the requirements for the licensing and use of specified devices in specified frequency bands. They are notified by Ofcom in accordance with Article 8 of Directive 2014/53/EU of the European Parliament and of the Council on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment.

ISM Industrial, Scientific and Medical applications (of radio frequency energy) – operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications. This definition is set out in the Radio Regulations.

Isotropic radiator A frequency source radiating the same intensity of radiation in all directions, such as an antenna with a 0 dBi gain.

ITU International Telecommunications Union – a specialised agency of the United Nations for information and communication technologies, consisting of 193 Member States and over 700 private-sector entities and academic institutions, headquartered in Geneva.

NTT Nippon Telegraph and Telephone Corporation – incumbent Japanese telecommunications operator.

Radio Regulations International regulations governing the use of radio spectrum and satellite orbits. Together with the Telecommunications Regulations and the Constitution and Convention of the ITU, they form an intergovernmental treaty to which ITU Member States are bound.

Spurious emissions Emissions on a frequency or frequencies outside the assigned channel, the level of which may be reduced without affecting the corresponding transmission of information.

SRD Short range device. Short-range devices are usually mass-produced devices that are used in numerous applications like alarm systems, door openers, medical implants, radio frequency identification, intelligent transport systems or local communication equipment such as Wi-Fi routers.

WRC World Radio Conference – event organised by the ITU every four years to review and, as necessary, revise the Radio Regulations.

WT Act Wireless Telegraphy Act 2006.