Review of spectrum used by fixed wireless services

Our decisions to enable future uses of fixed wireless links

STATEMENT:

Publication Date: 5 July 2018

About this document

This document sets out our decisions and forward plan for spectrum used by fixed wireless links for the next 5 years following extensive engagement and consultation with stakeholders. This sector already delivers a range of important benefits and this plan sets out our approach to continue to support growth in this sector and our priorities to facilitate future uses of fixed wireless links.

We are taking immediate steps to make changes to the regulatory regime in the 57-66 GHz range as well as making new spectrum available at 66-71 GHz.

Contents

Section

Annex

1. Executive Summary

Introduction

1.1 This document sets out Ofcom's decisions and forward 5-year plan for the spectrum used by fixed wireless links. This follows extensive engagement and consultation with stakeholders.

1.2 The fixed wireless sector already delivers a range of important benefits and our overall approach is to continue to support growth in this sector and facilitate future uses of fixed wireless links.

1.3 Fixed wireless links provide connectivity using the radio spectrum between fixed locations on the earth. Their use complements other transmission media, such as fibre, particularly where fibre is not available or cost effective or due to certain favourable properties of wireless connectivity e.g. reduced latency. A range of applications use fixed wireless links including:

- backhaul provision for mobile network base stations;
- distributing TV signals from studios to broadcast transmitter sites;
- connecting nodes within private or corporate communication networks including internet service provision;
- monitoring and control networks to enable the safe and secure supply of water, electricity and gas in the UK;
- emergency services communications backhaul; and
- provision of fixed wireless broadband for last mile connectivity commonly known as fixed wireless access.

1.4 In the UK, the radio spectrum used to deploy fixed wireless links consists of a number of different bands, currently ranging from 1.3 GHz to 86 GHz. The choice of frequency band is dependent on various factors including propagation range, resilience to rain and availability of spectrum. In most cases the bands are also harmonised across Europe and shared with other services.

Our Findings

1.5 We consulted with stakeholders on our assessment[1] of how the use of fixed wireless links was likely to evolve over the next 5-10 years. Our assessment was based on:

- **The evolving uses of fixed wireless links:** including the views of the different users of the spectrum, from major MNOs to smaller SMEs, on how their uses will change, such as the evolving requirements to deliver higher capacity connectivity. A key message received on this was the greater focus now being placed on the higher millimeter

[1] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/108594/Fixed-Wireless-Spectrum-Strategy.pdf

wave bands above 92 GHz to deliver very high capacity traffic, such as backhaul for the next generation of mobile services.

- **Technological developments:** how technology will evolve to enable new ways of using fixed wireless links in the future. Of specific and immediate interest in the stakeholder feedback was the spectrum at 60 GHz, where technology advances are facilitating new use case opportunities and driving change.
- **International developments:** taking into account the international work to identify new spectrum, for very high capacity fixed wireless links, particularly in the higher bands above 92 GHz.
- **The changing requirements of competing uses of the spectrum**; for example, spectrum that is currently used by fixed wireless links being considered for other uses such as mobile services;
- **Changes within specific sectors using fixed wireless links:** Our findings also include a number of specific considerations of future spectrum requirements in response to the following developments:

- The impact of 5G in terms of the densification of mobile networks and the need for much higher capacity mobile backhaul, which we expect will continue to be the main future driver for fixed wireless links in the UK.
- The impact of increasing fibre connectivity which we consider will remain the first choice for the majority of use cases where cost effective and available.
- Increasing capacity requirements to provide better broadband where fixed network operators, including wireless internet service providers, use fixed wireless links to provide broadband backhaul and fixed wireless access solutions.
- Changes in the way electricity distribution in the UK is being managed from a centralised to a more distributed electricity generation model along with the evolution towards the "Smart Grid". We will monitor the associated potential impact for connectivity requirements using fixed wireless links;
- New uses of fixed wireless links by the financial sector, where the most direct paths and lowest possible latency circuits are required.

1.6 On the basis of our analysis, and consultation responses we have developed a forward plan, which has been divided into three main frequency ranges with the following key findings:

- **Bands below 20 GHz:** bands below 20 GHz will continue to be required by users requiring longer links for both rural and suburban areas as well as for applications that require increased capacity over longer routes or where low latency (compared to fibre) is a key design objective.
- **Bands between 20-45 GHz:** Mobile backhaul connectivity is the primary use in this frequency range. With fibre penetration in urban areas, we expect the very high capacity uses in the future to focus on bands above 60 GHz as mobile backhaul connectivity requirements move towards the edges of the network. For all other uses of fixed wireless links, we expect a continued dependency on bands up to 38 GHz. We

also expect that with greater use of block assigned[2] bands within this range, that enough spectrum will remain for future uses, including where 26 GHz is made available for future mobile uses.

- **Bands above 45 GHz:** Over the next 5 years we expect greater focus and take up in the 60/65 GHz bands as well as continued growth in 70/80 GHz. There is also a strong interest in complementing these bands with higher capacity spectrum above 92 GHz.

Our decisions and planned forward work programme

We have decided to implement our findings as follows:

1.7 In order to enable new technologies and facilitate new use cases in the 60 GHz band, we are taking immediate steps to enable licence exempt access to 14 GHz of spectrum by making changes to the regulatory regime in the 57-66 GHz range as well as making new spectrum available at 66-71 GHz. 66-71GHz spectrum can support new 5G use cases for mobile/portable equipment.

1.8 We have also set out our decisions for each band that was considered by this review including where appropriate the specific action we are taking.

1.9 As well as the implementation activities discussed above, our work plan includes areas we will keep under review to address key issues that impact the fixed wireless sector. These are:

- To further consider alternative spectrum for low capacity uses;
- To further consider very high capacity backhaul and access requirements in new spectrum above 90 GHz;
- To consider new potential uses of fixed wireless links within the HF bands;
- To review spectrum that could be considered for alternative uses and
- To continue to keep our licence products and services under review to ensure the spectrum is being used in the most optimal way.

1.10 An indication of timing of these work areas is given in figure 1

[2] Block assigned bands referred to in this review are bands that were made available through auction on a technology neutral basis and licensees have chosen to utilise these blocks for fixed wireless links

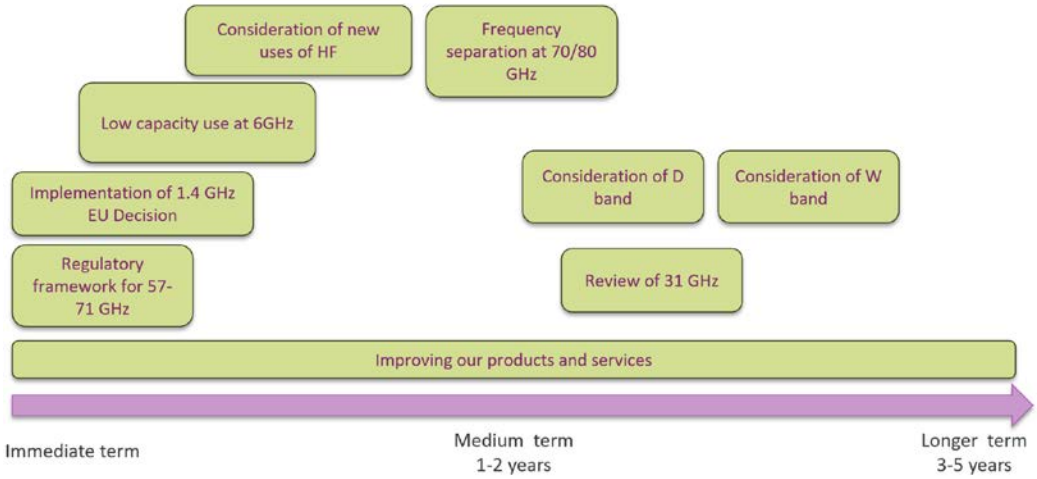

Figure 1: Forward work programme

1.11 In addition, we will focus our policy efforts on continuing to enable growth in the fixed wireless services sector taking into account the changes in spectrum use and requirements by other services. We will do this by providing access to spectrum in ways that enables uses that provide the most benefits to citizens and consumers. This will include the appropriate international frameworks and negotiating at an international level to achieve our objectives. We will also continue to monitor developments in this sector to understand where we may need to take further action in the future.

2. Introduction

2.1 This document sets out Ofcom's plans for the spectrum used by fixed wireless links for the next 5 years. Our decisions follow extensive engagement and consultation with stakeholders. This sector already delivers a range of important benefits and our plan reflects our priorities to support future uses of fixed wireless links.

Fixed Wireless Links

2.2 In the context of this review a fixed wireless link is defined as the provision of wireless connectivity between specified fixed points located on the earth. In general, fixed wireless links are used to provide some form of backhaul or access connectivity. Backhaul fixed wireless links are used to transport aggregated communication signals; for example, between base stations or network access points and the core network. Access fixed wireless links are generally used to provide communications between network access points and fixed end-user termination points – this referred to as fixed wireless access (FWA).

2.3 Both backhaul and access links can have different connection topologies as indicated below:

- **Point to point (P-P)** where wireless connectivity is provided between two specified fixed points;
- **Point to multipoint (P-MP)** where wireless connectivity is provided between a single specified fixed point and more than one other fixed points;
- **Multipoint (MP or Mesh)** where wireless connectivity is provided through full or partial connection between multiple fixed points.

Point to multipoint or mesh can generically be referred to as Multipoint.

2.4 A range of applications use fixed wireless links including:

- backhaul provision for mobile network base stations;
- distributing TV signals from studios to broadcast transmitter sites;
- connecting nodes within private or corporate communication networks including internet service provision;
- monitoring and control networks to enable the safe and secure supply of water, electricity and gas in the UK;
- emergency services communications backhaul; and
- provision of fixed wireless broadband for last mile connectivity commonly known as fixed wireless access.

2.5 We have gathered evidence to understand how these uses are likely to change over the next 5 years in order to develop our approach for each band. We also set out areas of focus as part of our forward programme of work.

Background and objectives

2.6 Spectrum is a vital component to enable wireless communication and effective management of it is one of Ofcom's key duties. In order for us to ensure optimal use of the radio spectrum, it is important for an up to date and thorough understanding of the trends influencing spectrum use, particularly given the increasing and competing demands for spectrum from different sectors. In reaching our decisions, we specifically sought to understand the changing needs of the fixed wireless services sector to meet future connectivity requirements. A key aspect of this was to understand the disparate uses of fixed wireless links and how demand for these would evolve over the next 5-10 years. Our considerations and decisions have also taken into account any international developments as required.

2.7 Our high-level goal is to ensure that spectrum is not a barrier to making communications work for everyone. Our objective in developing our forward work plan was therefore to ensure timely availability of the right mix of spectrum for the fixed wireless sector and with the right authorisation approaches to meet future requirements.

2.8 We published a consultation[3] on our proposed approach in December 2017. Our proposals were informed by earlier stakeholder engagement and a Call for Input[4] which included our analysis of spectrum use and key trends in the fixed wireless sector.

2.9 Having considered responses to our consultation and following a stakeholder engagement exercise, this statement sets out our plan for each band and our resulting programme of work including:

- regulatory changes at 57-66 GHz;
- extending these changes to 71 GHz and;
- starting the process to make the 1.4 GHz band available for future mobile services.

Our decisions and forward work plan will cover a period of 5 years as the evidence we have gathered provides a clearer understanding of changes in the nearer term rather than the longer term of 10 years originally envisaged. A summary of the responses we received and our response to points not covered in the main body of the document is contained in Annex 1.

Our statutory duties

2.10 Our approach has taken regard to Ofcom's key spectrum management principles, which are set out in legislation and summarised below.

2.11 Section 3(1) of the Communications Act 2003 (the "Act") provides that our principal duties in carrying out our functions are:

- to further the interests of citizens in relation to communication matters; and

[3] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/108594/Fixed-Wireless-Spectrum-Strategy.pdf
[4] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/84181/fixed-wireless-spectrum-strategy.pdf

- to further the interest of consumers in relevant markets, where appropriate, by promoting competition.

2.12 Ofcom is required to secure the optimal use of spectrum. In carrying out our spectrum management duties, Ofcom must have particular regard to the different needs and interests of all persons who wish to make use of spectrum.

2.13 Ofcom must also have regard to the principles under which regulatory activities should be transparent, accountable, proportionate and consistent and targeted only at cases in which action is needed.

2.14 In carrying out our radio spectrum functions, we must have particular regard to:

- availability of spectrum for use, or further use, for wireless telegraphy; and
- current and likely future demand for the use of the spectrum for wireless telegraphy.

2.15 And to the desirability of promoting:

- efficient management and use of the spectrum available for wireless telegraphy;
- economic and other benefits arising from the use of wireless telegraphy;
- development of innovative services; and competition in the provision of electronic communications services.

Other relevant work

2.16 Our decisions, and the programme of work resulting from our review, are consistent with other areas of Ofcom work including:

5G Programme

2.17 5G is the next generation of mobile technology. It is expected to deliver faster and better mobile broadband, and to enable more revolutionary uses in sectors such as manufacturing, transport and healthcare. Our programme of work to make spectrum available for 5G is driven by our objectives to ensure that spectrum is made available in the most appropriate and timely way to enable investments, innovation and competition in the development of 5G services to benefit consumers and businesses. In March 2018 we published 'Enabling 5G in the UK' which sets out the actions we are taking to facilitate 5G roll out in the UK, including our spectrum pipeline.[5] In this document:

- We recognised the importance of backhaul to enable 5G rollout and high capacity backhaul in particular;
- We confirmed our intention to start work on making available spectrum in the 66-71 GHz band.
- We highlighted that we see great potential for interested parties to use our innovation and trial licenses to test innovative 5G applications at 26 GHz, where potential business models may not yet have been explored.

[5] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/111883/enabling-5g-uk.pdf

3.6-3.8 GHz:

2.18 On 2 February 2018 we published an Update[6] outlining our decisions to issue notices to revoke all existing fixed wireless link licences in the band, with an effective date of 23 December 2022. We also set out that we would aim for existing fixed wireless links to migrate to alternative frequencies or technologies by June 2020 where possible.

2.19 This followed our 28 July 2017 statement and consultation which set out our decision to make the 3.6-3.8 GHz band available for mobile services as soon as practicable, closed the band to new fixed wireless links and consulted on our proposed approach towards existing fixed links authorisations and registered satellite earth station users.[7]

2.20 We intend to deliver the award of 3.6-3.8 GHz spectrum in 2019. We will consult later this year to prepare for this award.

Potential for increased sharing at 3.8-4.2 GHz

2.21 As indicated in our discussion document on enabling 5G in the UK, in 2016 we identified 3.8-4.2 GHz as a band with the potential for increased sharing, while taking into account existing users.

2.22 Following responses to this Call for Input we published a short update in August 2016, confirming the potential of this band for further shared access given the geographically defined location of existing users.

2.23 In our July 2017 statement and consultation on the use of the 3.6-3.8 GHz band for mobile services we noted that there was likely to be continued demand from existing users (receiving satellite Earth Stations and fixed wireless links) in the 3.8–4.2 GHz band. We also stated that the band has potential for increased shared access, enabling additional users in the band, and that we were minded to develop proposals to facilitate this.

2.24 In our 5G discussion document we consider that this band could be used by a range of different players. We believe we could extend shared access to broadband wireless systems, building on the current coordination arrangements for shared use already in place in the lower part of band and we plan to publish a consultation on this band towards the end of 2018.

This publication

2.25 This document is set out as follows:

- **Section 3** gives an overview of the key messages received to our consultation and our response to these (Detailed responses are given in Annex 1).

---

[6] https://www.ofcom.org.uk/__data/assets/pdf_file/0018/110718/3.6GHz-3.8GHz-update-timing-spectrum-availability.pdf
[7] https://www.ofcom.org.uk/__data/assets/pdf_file/0017/103355/3-6-3-8ghz-statement.pdf The subsequent 26 October 2017 statement confirmed our intended approach to existing authorised fixed links in the band, and that we would commence the statutory process to propose revocation of these fixed links licences https://www.ofcom.org.uk/__data/assets/pdf_file/0019/107371/Consumer-access-3.6-3.8-GHz.pdf

- **Section 4** sets out our decisions including areas on which we are taking immediate action as well as our forward programme of work.

3. Responses to the Consultation

Developments in the fixed wireless link market

3.1 Fixed wireless links are used to provide wireless connectivity for a wide range of uses across a number of different spectrum bands, currently from 1.4 GHz to 86 GHz within the UK. In December 2017 we consulted on our proposals and action plan for fixed wireless links in light of various developments including:

i) **Future fixed wireless links will be required to carry very high capacity traffic** (such as backhaul for 5G) – A greater focus is now being placed on the higher millimetre wave bands above 92 GHz to deliver this capacity (n x 10Gbps). In order to start this discussion, we explored new potential changes due to 5G and spectrum being collectively considered by the fixed service industry above 92 GHz at W band (92-114.5 GHz) and D band (130-174.8 GHz).

ii) **Changing technological developments has meant that alternative topologies to point to point connections are now possible in higher bands** – whilst point to multipoint configurations can already be deployed in several bands[8], we consulted on making some specific regulatory and technical changes at 57-66 GHz to enable new use cases that deploy point to multipoint or meshed fixed wireless links. In addition, we sought views on the use cases and technical conditions in the adjacent 66–71 GHz band given that this band could also be used by the same or similar technologies and be part of the same ecosystem as 57-66 GHz.

We also sought views on new technological developments to support capacity enhancement.

iii) **Many bands used for fixed wireless links are being considered for alternative uses** – this may require existing fixed wireless links to be moved out of current bands if future sharing is unlikely to be possible. e.g. there are around 10 bands currently being considered for alternative uses as part of international 5G discussions. Specifically, the 1492-1517 MHz band is now subject to a EU wide mandatory harmonising decision for downlink-only mobile[9] services. Our consultation therefore proposed to consider future possibilities for future low capacity uses in alternative spectrum at 1350-1375 MHz or at 6 GHz where channel plans have been developed by CEPT.

3.2 In addition, our consultation summarised our findings on the likely changes expected based on the variety of end user types that depend on fixed wireless links and we sought views on these as well as on our proposals for each band.

[8] 5.4 GHz, 5.8 GHz, 10 GHz, 28 GHz, 32 GHz and 40 GHz bands

[9] Also referred to as mobile fixed communication network supplementary downlink (MCFN-SDL) or simply SDL. The mode of operation is limited to base station transmission.

3.3 We received 27 responses to the consultation covering a range of stakeholders including manufacturers and operators. A high-level summary of the key issues raised is provided in the remainder of this section. A detailed summary of issues raised with our response is given in Annex 1

Structure of the remainder of the section

3.4 In our consultation, we sought views where we had identified areas potentially requiring regulatory changes to reflect developments in demand, and areas where further information would be required to inform our programme of work. In the remainder of this section we provide our response to stakeholder views on the following areas:

- Key drivers that underpin the development of our proposals for each band;
- Regulatory framework at 57-66 GHz band, including consideration of the adjacent 66-71 GHz band;
- Future low capacity[10] alternatives for the 1492-1517 MHz band;
- Making the bands 52 GHz and 55 GHz available under alternative authorisation approaches;
- Authorisation approaches for new spectrum above 92 GHz at 92-114.5 GHz (W) and 130-174.8 GHz (D) bands;
- New capacity enhancing techniques;
- Views on our band by band decisions and on authorisation approaches.

Key Drivers for future uses of fixed wireless links

3.5 Most[11] responses agreed that Ofcom had identified the key drivers likely to have a significant impact on spectrum demand for fixed wireless links and the relevant implications for bands below 20 GHz, between 20 GHz and 45 GHz and above 45 GHz. Specifically, our findings, as detailed in our consultation, indicated the following key demand drivers likely to impact the future needs of fixed wireless links:

- Increasing demand for mobile services including 5G;
- Increasing capacity demand for broadband provision particularly for last mile connectivity and in rural areas;
- Potential changes in electricity distribution and future utility networks;
- Impact of changes in delivery of the public safety network in Great Britain;
- International interest in potential use of High Altitude Platform Stations (HAPS) to deliver broadband and backhaul connectivity in underserved areas and for emergency and disaster recovery;
- Financial sector uses of fixed wireless links with demand remaining on specific paths.

3.6 Additional items raised by respondents included:

[10] This reference in to those fixed wireless links that use specific channel sizes between 25 kHz to 3.5 MHz
[11] CBNL, CCS, Horsebridge Network Systems, Huawei, Lattice Semiconductor, Nokia AMNS XHAUL, Optimity, Ruckus Wireless, SIAE Microelecttronica, Siklu Communications, techUK, Telefónica, Vodafone

- Blu Wireless indicated the need to consider trackside to train applications at 60 GHz;
- Horsebridge Network Systems indicated that autonomous vehicles were currently being trialled and spectrum for intelligent transport systems at 5 GHz should be maintained in any plans going forward;
- Siklu and Optimity responded that the trend for public networks including council network requirements such as public Wi-Fi and CCTV which would require the use of fixed wireless links should also be noted;
- Facebook indicated the need to preserve a role for HAPS within the 5G ecosystem and for emergency communications particularly in the 26 GHz and 37-40 GHz bands;
- Intelsat and techUK highlighted their views to enable Fixed Satellite Service operators to use the entire 14-14.5 GHz band for uncoordinated satellite Earth station applications by providing access to the closed fixed wireless link band, 14.25-14.5 GHz, and removing the remaining fixed wireless links;
- The UK Wireless Industry Service Providers Association (UKWISPA) indicated that wireless internet service providers would like access to the 3.4-3.8 GHz spectrum for delivering Fixed Wireless Access (FWA) broadband services in rural areas;

Ofcom's response

3.7 We note the agreement of most respondents indicating that we had identified the key drivers likely to have a significant impact on the future uses of fixed wireless links and we have therefore not broadened the scope of our considerations to account for any additional drivers

3.8 For the additional items raised we consider each of these in turn below:

- Regarding the need to consider trackside to train applications at 60 GHz, Ofcom is currently considering the spectrum options for supporting trackside to train applications and is planning to shortly publish its advice to DCMS on the spectrum aspects of trackside connectivity solutions.
- On trials for autonomous vehicles, no supporting information was provided on demand for additional spectrum for fixed wireless links in the backhaul context. We however plan to monitor these developments along with the general impact of new use cases and their associated requirements for fixed wireless backhaul.
- For council CCTV and further Wi-Fi provision we consider that the range of spectrum bands available for fixed wireless links over the next 5 years adequately meets the requirements to facilitate both CCTV and Wi-Fi backhaul.
- Regarding developments at an international level to pursue HAPS based technologies (within the Fixed Service) to facilitate uses including broadband connectivity in underserved areas, we recognise that this is an interesting area of development which is also currently being discussed in preparation for the forthcoming World Radio Conference (WRC) 2019[12]. We also recognise HAPS could play a role within the 5G ecosystem, particularly in the backhaul context to complement and extend

[12] WRC-19 (28 October – 22 November 2019).

connectivity in areas where other technologies may not to be available or suitable. In terms of HAPS use within the UK, our understanding is that these developments are mainly focussed on underserved areas of the world at this stage and may evolve to other areas in the future. We are interested in understanding more about the spectrum demand for HAPS in terms of both how much and where this may be needed. Therefore, we are actively engaged in these discussions with a view to considering how HAPS based solutions could be addressed in the Radio Regulations at the international level. This would provide options for future national considerations, as and when required, including in the UK. For the specific bands under consideration for HAPS as part of WRC Resolution 160 (WRC-15), our priority for the 26 GHz band is global harmonisation for 5G/IMT.

- Closed bands such as the 14.25 – 14.5 GHz band for fixed wireless links were not included in the development of this review as such bands are no longer accessible to new fixed wireless links. However, regarding the indicated requirement for additional spectrum to the already available 14-14.25 GHz band for uncoordinated satellite earth stations, as specified in our Space Spectrum Strategy, we will keep this under review. In particular if more evidence about the potential benefits and costs of any additional spectrum requirement for this specific use by satellite applications becomes available, noting that there are other sectors that may also benefit from the use of the 14.25-14.5 GHz band.
- We consider the need for spectrum access for FWA an important method of connectivity provision and our findings have indicated how future connectivity needs are changing specifically in the higher frequency bands for multipoint topologies. To enable these changing needs, we proposed in our consultation to change the way in which we make spectrum available at 60/65 GHz to facilitate multipoint access.
- We have completed the process of awarding 3.4-3.6 GHz and plan to award spectrum in the 3.6-3.8 GHz band in 2019. We plan to consult on our proposals for this award later in 2018.

Regulatory changes at 57-71 GHz to enable new use cases

3.9 In our consultation, we considered the need to review the technical framework in 57-66 GHz (V band) as a high priority work item and made specific proposals to facilitate new use cases.

3.10 We highlighted that the future demand for fixed wireless links was expected to move further towards the edge of networks to facilitate dense small cell backhaul and last mile fixed wireless access connectivity and that this was expected to require very high capacity links at millimetre wave frequencies.

Changes to the authorisation regime in the 64–66 GHz band

3.11 In our consultation document, we considered that it would be appropriate to introduce a common set of technical conditions and a common authorisation approach across the 57–

66 GHz band to facilitate all intended outdoor use cases. The proposal was also aimed at enabling a more streamlined and simplified approach for V band.

3.12 To achieve this, we set out our provisional view and proposals to change the current self-coordinated light licensing authorisation approach, for fixed point to point use, in the 64-66 GHz band to a licence exempt approach. We considered that this would enable a single authorisation approach across the entire 57-66 GHz band to facilitate fixed outdoor use.

3.13 Most respondents strongly agreed with our proposal and our impact assessment that this change would not materially impact the overall interference environment for licence exempt devices and would have minimal impact on existing uses. They also agreed that the proposed approach would provide a more streamlined regulatory approach across the 57–66 GHz band.

Ofcom's response

3.14 In light of the responses, we have decided to implement our proposal to change the authorisation approach in the 64 – 66 GHz band from a self-coordinated light licensing approach to licence exempt one.

Changes to the technical conditions in the 57 – 66 GHz band for fixed outdoor installation

3.15 In order to facilitate new outdoor use cases enabled by innovation in antenna technology operating at millimetre wave frequencies, we consulted on making some small changes to the existing technical conditions.

Operation at EIRP[13] ≤ 40 dBm

3.16 We consulted on relaxing the existing fixed wireless technical conditions in the 57 – 64 GHz to facilitate new outdoor use cases i.e. point to multipoint/mesh multigigabit equipment. Specifically, we proposed to relax the existing minimum antenna gain requirement of 30 dBi to 20 dBi and to remove the maximum transmit output power limitation for equipment operating at EIRP ≤ 40 dBm.

3.17 The majority of respondents[14] who answered this question agreed with our proposal. Blu Wireless and Lattice Semiconductor proposed further relaxation to the minimum antenna gain requirement of 15 dBi to enable practical implementation of 3D phased array antennas with vertical and horizontal steering for short range outdoor links from street level to high rise buildings. Cambridge Broadband Networks Limited (CBNL) expressed that a value of 20 dBi would still be high when accounting for losses in antenna systems and proposed a minimum antenna gain of 18 dBi.

[13] Equivalent Isotropic Radiated Power
[14] Horsebridge, Huawei, IEEE802 LAN/MAN Standards Committee, Intel, Optimity, Siklu, SSE, Vodafone, Wi-Fi Alliance, WISPA

3.18 Most respondents also indicated that the main interference mitigation will be achieved through the intelligent self-organising capability of the equipment i.e. built-in interference awareness to adapt to the changing interference environment by changing transmit and receive frequencies and beam direction to achieve the required signal quality.

Ofcom's response

3.19 The primary objective of our proposal was to facilitate new use cases and ensure that users of equipment installed outdoor can operate with a low probability of interference under a licence exempt approach.

3.20 Based on further discussion with a number of stakeholders including RFIC[15] front end/equipment manufacturers, we consider that while specifying a minimum antenna gain ensures that there is antenna directivity, which would help to manage the interference environment, this is not the main interference mitigation parameter.

3.21 We agree with the consultation respondents that the main interference mitigation techniques will come from the equipment's intelligent self-organising capability. Other techniques that could improve robustness to interference include using a different channel/sub-channel and deploying different transmit and receiver filtering techniques. These factors differentiate the performance of equipment by different vendors who could deploy the same RF front end.

3.22 Equipment currently being designed to operate at this range typically utilises phased array antenna technology which would have some form of directivity. The beamwidth of the antenna mainbeam and therefore antenna gain depends on the number of antenna elements deployed which we understand is a trade-off between cost and use cases. The antenna beamwidth of the mainbeam is also affected by other factors such as antenna sidelobe suppression techniques deployed.

3.23 Our view, taking into account the consultation responses and further stakeholder feedback, is that for operation at this EIRP, specifying a fixed minimum antenna gain requirement is not necessary to manage the interference environment given that the generation of equipment currently being developed / manufactured is expected to have built-in intelligent self-organising capabilities. Having a specific minimum antenna gain parameter may also reduce the flexibility in the design of phased array antennas.

3.24 Studies are also currently being conducted in CEPT[16] which to date have considered compatibility based on P-P/P-MP equipment operating at EIRP of 40 dBm with various values of antenna gain starting from 13 dBi. We have proposed that CEPT in its review and development of less restrictive technical conditions in the 60 GHz band do not specify a minimum antenna gain requirement for equipment operating at EIRP ≤ 40 dBm.

[15] Radio frequency integrated circuit

[16] CEPT is reviewing the regulatory framework in the 57-71 GHz band with the aim to establish less restrictive technical conditions that would facilitate outdoor use cases, particularly small cell backhauling and fixed wireless access. See https://eccwp.cept.org/WI_Detail.aspx?wiid=563

3.25 Taking into account the feedback we have received and noting the desire by a number of stakeholders to include some form of minimum antenna gain to provide increased certainty on the interference environment that equipment is operating in, we have instead decided to incorporate a more relaxed maximum transmit output power requirement to better facilitate equipment utilising phased array antenna technologies. The specification of a maximum transmit output power implicitly requires an antenna gain as a function of the EIRP.

3.26 Therefore, we have decided to specify a maximum transmit output power[17] of 27 dBm, which also aligns with the limit set by the FCC. We consider that alignment with FCC regulation will also be a step towards achieving global harmonisation and promote global economies of scale for equipment. The introduction of this measure means that in practice for operation at an EIRP of 40dBm an antenna gain of 13 dBi will be required.

Higher power operation

3.27 In relation to technical conditions for operation above 40 dBm EIRP, responses mainly fell into the following areas and are summarised in Figure 2 below;

a) respondents[18] who agreed with Ofcom's proposal (maintaining existing fixed wireless systems technical conditions in the 57 – 64 GHz band intended for high gain point to point fixed wireless system). SSE also suggested that Class 4 antenna[19] should be mandated in higher power operation;

b) respondents[20] who proposed further relaxation to align with the FCC technical conditions[21]. Huawei Technologies (Huawei) suggested to cap the maximum EIRP at 55 dBm as higher gain phased array antennas are likely to be technically challenging and impractical to implement. Respondents felt that aligning with FCC would enable vendors to create a single global product which will deliver economies of scale and

c) respondents proposing further relaxation to the FCC conditions to enable scalability of phased array antenna solutions with size (i.e. combining multiple antenna arrays as a means to increase EIRP) to facilitate different use cases. Lattice Semiconductor proposed that for each 1 dB EIRP increase above 40 dBm, the antenna gain increases by 1 dBi starting from 15 dBi while Blu Wireless proposed a similar relationship but with the antenna gain starting from 20 dBi.

[17] This refers to the total conducted power delivered to the antenna port/ports.
[18] CBNL, IEEE802 LAN/MAN Standards Committee, Intel, Optimity, Siklu, SSE, Vodafone, Wi-Fi Alliance, WISPA
[19] Antenna performance is defined in ETSI EN 302 217-2.
[20] CCS, Facebook, Huawei, Ruckus, Telefonica
[21] FCC requires the antenna gain to increase by 1 dB with every 2 dB increase in EIRP when operating at EIRP above 40 dBm up to a maximum EIRP of 82 dBm.

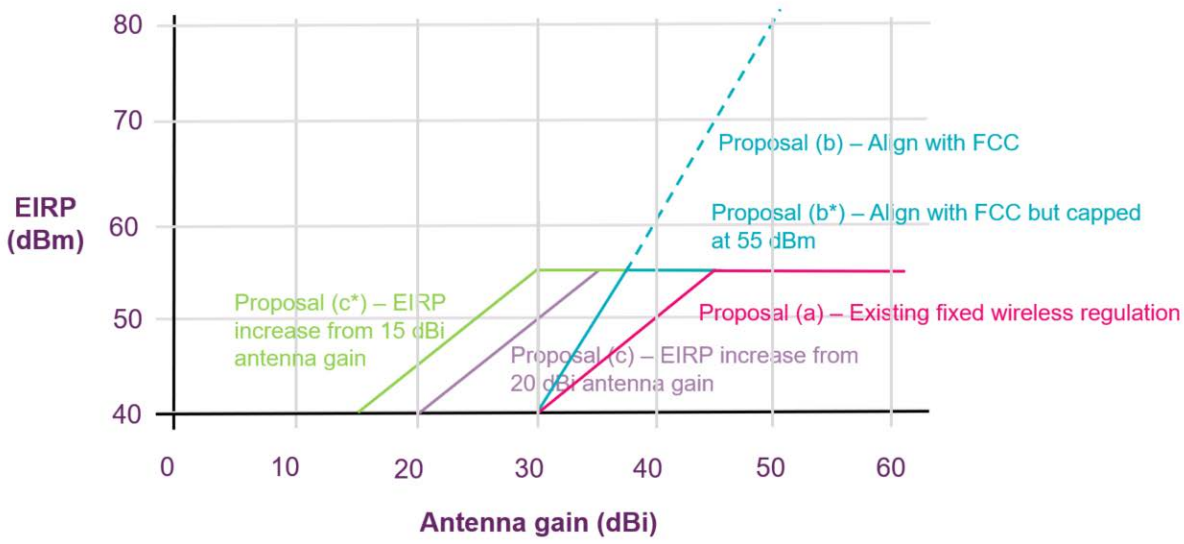

Figure 2: Summary of proposals for EIRP above 40 dBm

3.28 We also sought views on whether there were likely to be fixed outdoor installation use cases that would require operation at EIRP levels above 55 dBm. Most respondents[22] indicated that there are no envisaged use cases above 55 dBm EIRP either due to availability of alternative bands for such use cases or higher gain antennas being unfeasible for practical cost-effective implementation in this band.

3.29 Facebook, Blu Wireless and Cambridge Communications Systems (CCS) suggested that higher EIRP could deliver longer range operation including for longer range access and backhaul applications. Blu Wireless also indicated V2X[23] and trackside to train as specific use cases for increased EIRP levels above 55 dBm.

Ofcom's response

3.30 In relation to technical conditions for operation above 40 dBm, we consider that there is merit in considering a possible further relaxation in the 30 dBi minimum antenna gain requirement specified in the existing fixed wireless technical conditions in the 57 – 64 GHz band to facilitate equipment deploying antenna beamforming technology.

3.31 Currently most multigigabit equipment employing phased array antenna technology typically operate at EIRP of up to 40 dBm. Our understanding is that phased array antenna implementation of equipment operating at EIRP levels above 40 dBm includes consideration of cascading existing phased array antenna designs to achieve the higher gain.

3.32 With the antenna cascading approach, as antenna gain increases, although the antenna main beam becomes narrower, the antenna side lobe level increases proportionally, therefore potentially increasing risk of interference. Compatibility studies conducted in

[22] BT/EE, CBNL, Horsebridge, Intel, Lattice, Optimity, Ruckus, Siklu, SSE, techUK, Wi-Fi Alliance, WISPA
[23] Vehicle to everything

CEPT to date have been based on multigigabit equipment transmitting at 40 dBm EIRP. The risk of interference depends on the use cases and density of use.

3.33 We consider that further work is required to understand how the antenna technology is likely to develop and the impact of increased side lobes arising from higher gain using different phased array implementations to understand the extent to which regulation could be further relaxed, including beyond the limits specified by the FCC for higher power operation, as shown in Proposal (c) and (c*) in Figure 2.

3.34 We are of the view that this analysis is best done as part of the ongoing CEPT work to ensure a consistent European approach before we make any further changes to the national regulations. Therefore, we will keep this under review and in the meantime, in line with our consultation proposals, retain the current technical conditions (minimum antenna gain of 30 dBi and maximum transmit output power of 10 dBm) for the 57 - 64 GHz band for higher power operation until work is completed in CEPT.

3.35 We will also retain the maximum EIRP level of up to 55 dBm given there is limited evidence to suggest the need to increase EIRP levels to above 55 dBm.

Summary of technical conditions for fixed outdoor installation in the 57 – 66 GHz band

3.36 Based on the responses received and our analysis discussed above, we have decided to make some minor changes to our original proposal for the technical conditions for fixed outdoor installations as summarised in Table 1.

Table 1: Summary of technical conditions for fixed outdoor installation in the 57 – 66 GHz band

Transmit EIRP	Decision	Note
≤ 40 dBm	Maximum transmit output power of 27 dBm	The maximum transmit output power has replaced our consultation proposal of a minimum antenna gain of 20 dBi. This change will enable greater flexibility while at the same time ensure that for higher power operation, directional antennas are employed to assist with interference mitigation.
40 dBm < EIRP ≤ 55 dBm	Minimum antenna gain of 30 dBi Maximum transmit output power of 10 dBm	We will retain the existing technical conditions as proposed in the consultation document and review upon completion of the work in CEPT.

Potential use of the 66 – 71 GHz band

3.37 In our consultation, we also sought views on whether the use cases and the technical conditions for both fixed and mobile use in the 66 – 71 GHz band would be similar to the lower 57 – 66 GHz band given equipment could potentially be available in this band relatively early by building on the existing multigigabit equipment ecosystem.

3.38 We also identified 66 - 71 GHz as a potential band for 5G licence exempt use in our publication "Enabling 5G in the UK[24]". This band has been identified in the RSPG second opinion on 5G[25] as a European priority in terms of studies for second stage millimetre wave 5G bands. Millimetre wave spectrum which, to date, has not been used to deliver mobile services, is likely to be used to support new 5G applications, in particular those that require high capacity and very low latency by both MNOs and other players. The band is also being considered under WRC-19 Agenda item 1.13 for an IMT identification in the Radio Regulations[26].

3.39 Most respondents[27] agreed that the technical conditions in the 57 – 66 GHz band could be extended to the 66 – 71 GHz band. In addition, a number of respondents[28] indicated that the band was suitable to be made available on a licence exempt basis and will be important for 5G[29].

3.40 Siklu recommended leaving a small guard band between the 66 – 71 GHz band and 70/80 GHz band (E band) to account for the different licensing schemes and adjacent band compatibility.

3.41 Huawei and Nokia AMNS XHAUL felt it was premature to authorise the 66 – 71 GHz band indicating that the lower 57 – 66 GHz band had not been fully exploited yet.

3.42 Further, Intel, Wi-Fi Alliance and IEEE802 LAN/MAN Standards Committee indicated their preference not to seek IMT identification in the 66-71 GHz band in the Radio Regulations as this, in their view, would hinder the technologies currently accessing the 57 – 66 GHz band from accessing the 66 – 71 GHz band.

Ofcom's response

3.43 Given that there are currently no users in the 66 – 71 GHz band and noting that equipment is already being developed to operate across the entire 57 – 71 GHz band, we have decided to make available the 66 – 71 GHz band at the same time and under the same technical conditions and authorisation approach as the 57 – 66 GHz band for both fixed and mobile use cases.

[24] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/111883/enabling-5g-uk.pdf
[25] http://rspg-spectrum.eu/wp-content/uploads/2013/05/RPSG16-032-Opinion_5G.pdf
[26] https://www.itu.int/pub/R-REG
[27] BT/EE, CCS, Facebook, Intel, Lattice, Optimity, Ruckus, Siklu, TechUK, Telefonica, Vodafone, Wi-Fi Alliance and WISPA.
[28] BT/EE, Facebook, Intel, Ruckus, TechUK, Vodafone, Wi-Fi Alliance
[29] CCS, Huawei, IEEE802 LAN/MAN Standards Committee, Intel, TechUK, Wi-Fi Alliance

3.44 We consider that making available additional contiguous spectrum on a licence exempt basis and with the same technical conditions will secure the optimal use of radio spectrum, facilitate innovation, lower the entry barrier and enable UK citizens and consumers to enjoy the benefits provided by multigigabit applications and 5G as soon as possible. This will also provide regulatory certainty to equipment vendors to invest in product development and promote further innovation.

3.45 In relation to the upper band edge and the adjacency with the 71 - 76 GHz band, fixed outdoor equipment operating at an EIRP above 40 dBm under existing technical conditions (minimum antenna gain of 30 dBi) could have similar characteristics as fixed wireless systems deployed in the 70/80 GHz band i.e. utilising narrow beam high gain antenna. We further noted that the transmit and receive characteristics for fixed wireless equipment specified in ETSI Harmonised Standard EN 302-217-2[30] are similar at frequency bands above 57 GHz band. This would imply that the adjacent band compatibility for fixed wireless systems deploying high gain antenna operating above 57 GHz would be similar.

3.46 In our Statement[31] outlining Ofcom's decision on the future management approach for the 70/80 GHz band, we introduced a 250 MHz frequency separation between the Ofcom coordinated spectrum and the self-coordinated spectrum as a practical measure to avoid interference between the two approaches and minimise adjacent channel interference, noting that this should be reviewed over time with a view to and where practicable reducing its size in the future.

3.47 Therefore, as a precautionary measure and subject to further technical evidence, we will adopt a similar approach to the one we introduced in the 70/80 GHz band i.e. we will introduce a 250 MHz frequency separation between the 57 – 71 GHz band (managed under licence exempt approach) and the Ofcom managed 70/80 GHz band. As there is already a 125 MHz frequency separation above 71 GHz, we will introduce an additional 125 MHz immediately below 71 GHz to create a total of 250 MHz frequency separation, consistent with the approach taken in E band. From a practical point of view, we believe this approach will not impact on the equipment development opportunities within the new combined 57 – 71 GHz band given the recommended international channel arrangements[32] for multigigabit wireless systems. The frequency separation is illustrated in Figure 3 below.

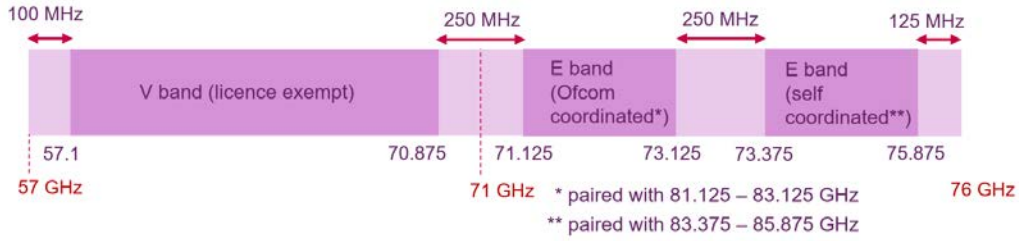

Figure 3: Frequency separation below 71 GHz

[30] http://www.etsi.org/deliver/etsi_en/302200_302299/30221702/03.01.01_60/en_30221702v030101p.pdf
[31] https://www.ofcom.org.uk/__data/assets/pdf_file/0011/50240/statement.pdf
[32] https://www.itu.int/rec/R-REC-M.2003-2-201801-I/en

3.48 In relation to fixed and mobile equipment operating at EIRP up to 40 dBm, we consider that there is no need for a frequency separation below 71 GHz. The fixed outdoor use cases in the 57 - 71 GHz band at this EIRP are likely to be short range street level deployments compared to 70/80 GHz band (roof top deployment). Therefore, we consider that there is likely to be a very low probability of co-located links within line of sight of each other which minimises the risk of adjacent channel interference.

3.49 In relation to responses on IMT identification in the 66 – 71 GHz band, we note that while this view was expressed as part of the consultation responses it is a separate item that is being dealt with as part of the WRC-19 preparation. Our current view supports an option to identify the band with an IMT identification footnote within the Radio Regulations at WRC-19 and highlighting its use by self-provided, technology neutral applications (for instance in a WRC Resolution), though our final position going into the WRC has yet to be finalised.

Future low capacity[33] alternatives for the 1492-1517 MHz band

3.50 The 1492-1517 MHz band has been harmonised for downlink-only mobile use in the EU under mandatory harmonisation measures. This current fixed wireless link band is paired with 1350-1375 MHz and is used for low capacity fixed wireless links. Our consultation sought views on future requirements for low capacity fixed wireless links and whether we should consider, based on stakeholder indications, TDD use at 1350-1375 MHz which would remain after the 1492-1517 MHz was made available for mobile use. We also proposed to consider possible future low capacity uses at 6 GHz based on FDD channel arrangements developed in CEPT. We specifically noted the use of low capacity fixed wireless links by the utility and public safety sector.

3.51 Responses from utility[34] and some non-utility[35] stakeholders supported the future need for spectrum for low capacity fixed wireless links. Our proposals to consider the lower sub-band of the 1.4 GHz band (1350-1375 MHz) received positive views from the Joint Radio Company (JRC) which represents the UK utility industry, although SSE (also from this sector) indicated that TDD considerations at 1.4 GHz could limit tele-protection systems which would require low latency which may not be possible with a TDD solution. Western Power Distribution's response indicated that they no longer use the 1.4 GHz band. The consideration of low capacity systems in the gaps between the 6 GHz band plans was also supported by JRC to be explored further. SAF Tehnika asked Ofcom to consider the wider 1350-1400 MHz to enable FDD solutions as they highlighted it would be possible to redesign current 1.4 GHz equipment to follow an FDD arrangement within this band.

3.52 SSE cite that the propagation characteristics of this the 1.4 GHz both in relation to resilience, rain fading and diffracted path working as useful in resolving links to remote and obstructed locations. With predicted growth in "Smart Grid" connectivity needs, SSE

[33] This reference in to those fixed wireless links that use specific channel sizes between 25 kHz to 3.5 MHz
[34] JRC, SSE, SAF Tehnika
[35] CCS, Rukus Wireless, UK WISPA

indicated that this band would have been of significant value in resolving remote and small site connectivity at the network edge.

3.53 Respondents that see an overall drive towards the need for high capacity fixed wireless links (delivered through the use of higher millimetre wave fixed wireless link bands) proposed the migration of existing links out of the 1492-1517 MHz to support EU harmonisation measures to make the band MHz available for downlink-only mobile services. Intel Corporation (Intel) cautioned the relocation of existing users in 1492-1517 MHz to 6 GHz in that they did not want to jeopardise the initiatives currently underway to study RLANs feasibility in 5925-6425 MHz. Vodafone commented that if incumbent usage were to continue, then the relevant Annual Licence Fee should reflect the opportunity cost of alternative applications being unable to use the band.

3.54 In addition, UKWISPA highlighted that they would like to see the band made available for wireless internet service providers and the British Entertainment Industry Radio Group (BEIRG) requested 1350-1400 MHz to be made available for programme making and special events (PMSE) in light of the 700 MHz clearance.

Ofcom's response

3.55 Although the responses from the utility sector were supportive of potential TDD use in the 1350-1375 MHz band, no further evidence was provided to indicate such solutions are available, or likely to be made available. Therefore, at this stage we consider it would be premature for Ofcom to take a decision to focus on making a low capacity TDD spectrum available. We however consider that there remains merit in gathering further evidence as part of our forward work programme resulting from this review.

3.56 On the proposed request to consider the wider 1350-1400 MHz band for a potential future FDD solution for low capacity fixed wireless links, our view is it is unlikely to be a feasible future solution. This is because the 1375-1400 MHz is used by the Ministry of Defence. Regarding the potential future requirements for PMSE, this is outside the scope of this review however, given the uncertain availability in both the short and long term, we do not see this band as currently viable for allocation to PMSE use.

3.57 We consider that it remains important to carefully consider future low capacity options and given that there remains some support to explore options for an FDD solution at 6 GHz, we will continue to consider this from an implementation perspective as a possibility for future low capacity systems. To enable this, CEPT has already developed and adopted channel plan recommendations for 6 GHz and therefore this band could hold potential as a future possible solution for low capacity fixed wireless links.

3.58 In relation to Intel's point not to jeopardise the initiatives to enable RLANs in 5925-6425 MHz, we note that technical studies are currently being undertaken to assess the coexistence of fixed wireless links and RLAN services in this band. We are involved in the Spectrum Engineering Project Team SE45, which will produce ECC Reports considering the potential for sharing and compatibility for RLAN services across CEPT/EU in the 5925 – 6425 MHz. The studies are underway and are scheduled to conclude next year.

3.59 In terms of other possible uses raised in the responses we refer to the information we provided in our consultation about the current use of the 1492 – 1517 MHz band and our Mobile Data Strategy[36] which highlighted the high priority status and direction of travel for the band for future mobile applications.

3.60 Following the European Commission Decision 2018/661 of 26 April 2018 harmonising the 1492-1517 MHz band for downlink-only mobile services on a EU wide basis, we are taking steps to start the process for implementing this Decision. We discuss these further in the next section including the closure of the 1.4 GHz band to new fixed wireless links.

Making the bands 52 GHz and 55 GHz available under alternative authorisation approaches

3.61 Our consultation sought stakeholder views on whether we should consider alternative authorisation approaches in the 52 GHz and 55 GHz bands which have remained unused for some time. We noted that both bands had harmonised CEPT channel plans and were made available for high density applications in the Fixed Service. We further noted the lack of equipment availability in these bands and we sought views from stakeholders on whether there would be merit in considering alternative authorisation approaches in these bands.

3.62 There were no indications from the main or smaller fixed service manufacturers of their intentions to develop equipment for these bands with most responses not commenting nor indicating reasonably evidenced support for these bands to be retained for future use. Vodafone, Nokia AMNS XHAUL and Huawei indicated no immediate demand or usage for these bands for fixed wireless links with Nokia AMNS XHAUL further indicating that these bands do not have a key difference to the bands below 42 GHz where we note that our findings in the 20-40 GHz range would see a decline in use of Ofcom managed spectrum for fixed wireless links. CBNL supported both bands for both point to point and point to multipoint use. In addition, there was further suggestion from SIAE Microelettronica to review the CEPT recommendations with a view to pairing the two bands in order to create much larger channels enabling fixed wireless links supporting 2-5 Gbit/s.

3.63 There was limited information provided in the responses to suggest that the spectrum would be used if it were block assigned, although there are some views indicating that all link topologies should be permitted under a block assignment approach. CBNL indicated that the blocks could be used for displaced links due to 5G mobile services. On the other hand, BT/EE saw no benefit in block assignment of these bands and instead preferred the bands to be authorised on a conventional basis with individual links licensed on a first come first served basis. Alternatively, CCS and Telefónica supported licence exemption and CSS further suggested licensing to allow mesh, point to point and point to multipoint systems. CCS's view was that in the future, interference should be intelligently managed by the radio system itself rather than by the user.

[36] https://www.ofcom.org.uk/__data/assets/pdf_file/0033/79584/update-strategy-mobile-spectrum.pdf

Ofcom's response

3.64 With responses indicating no evidenced demand for these two bands for the foreseeable future there would be little merit in considering future authorisation approaches. We noted that in this review, respondents have instead strongly focused efforts on higher bands that would deliver the future high capacity needs required such as the higher bands (>92 GHz), which were indicated as more suitable to support the much higher capacity systems envisaged and planned for the future.

3.65 We are therefore of the view that these bands should be deprioritised from a fixed wireless link perspective and may benefit from being considered for other uses. We consider this further in the next section.

Authorisation approaches for new spectrum at 92-114.5 GHz (W) and 130-174.8 GHz (D) bands

3.66 Our findings strongly suggested that future demand for fixed wireless links, particularly for mobile backhaul networks, was expected to move further towards the edge of networks with shorter high capacity connections from the fibre point of presence to facilitate dense small cell backhaul and last mile fixed wireless connectivity. This has led to an industry drive to plan for such high capacity millimetre wave spectrum in bands above 92 GHz to complement the current bands between 57 to 86 GHz. We sought views on how this new spectrum at W and D bands should be authorised.

3.67 All respondents that replied to our questions on these bands agreed that these bands could provide the extremely high capacity requirements relevant for future 5G developments or other uses such as broadband access to citizens using both point to point and point to multipoint fixed wireless access, CCTV and Wi-Fi. We noted that there is also significant industry collaboration on developing these bands for future fixed wireless link use. W band (92-114.5GHz) was generally seen as a future complement to E band (70/80 GHz) and D (130-174.8 GHz) band as a future complement to V (60 GHz) band.

3.68 On how these bands should be authorised, responses seemed more consistent that D band should be block assigned or indicated some form of this approach. Regarding timing for spectrum availability, the main message was that these bands are not likely to be required immediately but were more of a medium to longer timeframe requirement. However, on W band, the messages on authorisation were more mixed. It seemed from the responses that equipment is unlikely to be available for this band before 2020.

Ofcom's response

3.69 We note the industry drive to consider these bands for future fixed wireless links offering enhanced capacity options particularly at the edges of evolving networks. We also consider from the responses that the 130-178.5 GHz requirement could arise before the 92-114.5 GHz requirement. While responses consider that it may be a little early to consider authorisation approaches, there are strong indications that regulatory considerations for

these bands would need to commence during the period covered by our programme of work over the next 5 years. We will therefore further consider both bands as part of our future programme of work prioritising on the 130-178.5 GHz range and subsequently the 92-114.5 GHz.

New capacity enhancing techniques

3.70 Our consultation sought more information from stakeholders on two capacity enhancing techniques that were detailed, Band Aggregation and Full duplex operation.

- Band Aggregation: We've noted that this technique was favoured by most stakeholders who responded in indicating they were investigating the possibility of deploying this solution.
- Full duplex operation: Stakeholders agreed with our reservation on this technique in the current Ofcom managed technically assigned bands. They believe that more work would be needed before the implementation of this technique could be considered.

3.71 Stakeholders recognised the efficiency of the re-use factor of millimetre waves and supported other existing capacity enhancement techniques such as cross polarisation operation and higher-order modulation. Stakeholders expressed a particular interest in Time Division Duplex (TDD) and wished to have this technique included in future regulation of microwaves bands, and more specifically to new bands such as W band (92-114.8GHz).

Ofcom's response

3.72 Considering the emerging interest in band aggregation techniques and stakeholders responses indicating that they were at the stage of exploring this approach, we will continue to gather information on this development as part of our ongoing programme of work.

3.73 Full duplex operation appears to be less of a priority for stakeholders and difficult from an implementation perspective at this stage i.e. alongside other fixed wireless links. As equipment supporting the technique does not yet appear to be widely available on the market and may not be in the near future, we will continue to monitor developments in this area.

Views on our band by band approach and on authorisation approaches

3.74 Based on the findings detailed in our consultation, we have concluded the following:

- **Bands below 20 GHz:** bands below 20 GHz will continue to be required by users requiring longer links for both rural and suburban areas as well as for applications that require increased capacity over longer routes or where low latency (compared to fibre) is a key design objective.
- **Bands between 20-45 GHz:** Mobile backhaul connectivity is the primary use in this frequency range. With fibre penetration in urban areas, we expect the very high

capacity uses in the future to focus on bands above 60 GHz as mobile backhaul connectivity requirements move towards the edges of the network. For all other uses of fixed wireless links, we expect a continued dependency on bands up to 38 GHz. We also expect that with greater use of block assigned[37] bands within this range, that enough spectrum will remain for future uses, including where 26 GHz is made available for future mobile uses.

- **Bands above 45 GHz:** Over the next 5 years we expect greater focus and take up in the 60/65 GHz bands as well as continued growth in 70/80 GHz. There is also a strong interest in complementing these bands with higher capacity spectrum above 92 GHz.

3.75 Most responses[38] agreed with our conclusion on spectrum implications based on the key drivers we identified in the consultation and the next steps we proposed for each band. Our specific responses to issues raised on specific bands is given in Annex 1.

3.76 Regarding general views on authorisation of fixed wireless links, most respondents indicated that they did not see any need for changes to the authorisation approaches to any other band. Specifically, Blu Wireless did not believe that any changes to other bands for fixed wireless links were appropriate at this time. BT/EE indicted that they had not identified any other fixed wireless link band for which the authorisation regime should be changed. Ruckus believed that a combination of Ofcom proposals for the 60 GHz band and current practice for the other bands meets user requirements now and for the foreseeable future.

3.77 Other specific additional issues raised that we have not already covered are listed below.

Spectrum bands being considered for other uses including 5G

3.78 Our consultation highlighted the range of bands used for fixed wireless links that are being considered for other uses including future (5G) mobile services which could impact the future nature of availability of these bands for fixed wireless links.

3.79 Specifically, Ofcom is working towards the making the 3.6-3.8 GHz and 26 GHz band available for 5G. Ofcom has also identified 40.5-43.5 GHz as a priority band for study for future 5G use as part of a global tuning range for 5G equipment across 37-43.5 GHz.

3.80 The 3.8-4.2 GHz band is being considered by Ofcom for enhanced sharing for potentially new innovative applications. Additionally, we noted that alternative RLAN uses are being considered in CEPT in in the 6 GHz bands.

3.6-3.8 GHz and 3.8-4.2 GHz

3.81 BT/EE supported the clearance of 3.6-3.8 GHz for 5G and encouraged Ofcom to support efforts to accommodate displaced links in other spectrum bands where feasible. Intel also

[37] Block assigned bands referred to in this review are bands that were made available through auction on a technology neutral basis and licensees have chosen to utilise these blocks for fixed wireless links

[38] BT/EE, Blu Wireless CBNL, CCS, Horsebridge Network Systems, Huawei, Lattice Semiconductor, Optimity, Siklu, SIAE Microelettronica, techUK, Telefónica, Vodafone

supported Ofcom's approach for the 3.6-3.8 GHz band for 5G and Ofcom's approach to clear the band.

3.82 On 3.8-4.2 GHz Intel indicated that it supported enhanced sharing initiatives while continuing to allow a small number of existing Fixed and Fixed Satellite services. SSE also welcomed the proposed consultation for further sharing in the 3.8-4.2 GHz band due to the potential for provision for fixed wireless broadband.

3.83 UKWISPA proposed that Ofcom should review the authorisation approach at 3.4-3.6 GHz, 3.6-3.8 GHz, 3.8-4.2 GHz which in their view should be made available for spectrum sharing for rural FWA and mobile wireless urban applications.

Ofcom response

3.84 The 3.4-3.8 GHz band has been identified as the primary band for 5G in Europe as it offers increased capacity for mobile broadband over wide areas. We have completed the process of awarding 3.4-3.6 GHz and plan to award spectrum in the 3.6-3.8 GHz band in 2019. We will consult on our proposals for this award later in 2018[39]

3.85 We plan to consider spectrum within the 3.8-4.2 GHz range for enhanced sharing which could include applications such as rural fixed wireless access. As indicated in our 5G discussion document we plan to increase shared use of the 3.8-4.2 GHz spectrum, while taking into account existing use as well as compatibility with adjacent uses. We consider that this band could be used by a range of different players. We believe we could extend shared access to broadband wireless systems, building on the current coordination arrangements for shared use already in place in the lower part of band and we plan to consider these ideas further and to publish a consultation on this band towards the end of 2018.

26 GHz, 38 GHz and 42 GHz

3.86 Some comments received on these bands indicated support of Ofcom's position on these bands for 5G. Huawei identified 32 GHz as a replacement for 26 GHz fixed wireless links and a target for new fixed wireless links due to very similar propagation conditions and current low usage of the band. This would be to discourage operators from further investments in fixed wireless links at 26 GHz. Intel however suggested the importance of understanding the extent to which coexistence is likely to be a problem and whether greater geographic reuse would be possible with links migrated to other bands if problematic.

3.87 JRC cautioned that if the ongoing access to the Fixed Service was removed in its entirety, this would result in a forced migration of links utilised by 4 electricity distribution network operators. JRC encouraged Ofcom to seek to adopt an approach that facilitates coexistence of 5G with incumbent users with a portion of the band given over to 5G as this would be

[39] https://www.ofcom.org.uk/spectrum/spectrum-management/spectrum-awards

consistent with the approach proposed by RSPG[40]. Western Power Distribution raised concerns over the 26 GHz band being made available solely to mobile operators. They indicated that the energy industry need to be engaged to future proof requirements and spectrum sharing/coexistence within this band should be explored. Western Power Distribution specifically indicated that the electricity sector uses spectrum between 20-45 GHz, 23 GHz, 26 GHz and 38 GHz often used for a large number of embedded generation sites i.e. wind and solar farms. They indicated that the 26 GHz band and other fixed wireless link bands is used for microwave communication for substation communications including electricity circuit protection. SSE raised concerns regarding the 5G global tuning range as if enacted would appear to leave 23 GHz as the only Ofcom managed band within the 20-45 GHz range which is available on a non-block assigned basis. They also indicated that the use of higher light licensed or licence exempt bands as an alternative option to Ofcom managed bands would not be appropriate for utility communications in their view due to the unprotected nature of spectrum assignment and due to degraded latency performance of packet radio prevalent in the millimetre band environment.

3.88 UKWISPA proposed that Ofcom should review the authorisation approach at 26 GHz which should be made available for spectrum sharing for rural FWA and mobile wireless urban applications.

3.89 On merging 38 GHz and 42 GHz for 5G, Nokia AMNS XHAUL highlighted the 38 GHz the band was heavily populated by the Fixed Service and a backup solution for backhaul should be provided.

Ofcom response

3.90 The specific aspects of making the 24.5-26.5 GHz are being considered as part of our wider 5G programme which includes work on making the 26 GHz band available as a global pioneer band for 5G.

3.91 In our evidence gathered that we put forward for consultation we considered that the 26 GHz being made available for mobile is unlikely to have an adverse impact on the overall ability to provide connectivity using fixed wireless links in bands between 20-45 GHz as we expect to see greater shift of the major uses in this range to focus on higher bands for high capacity shorter hop links and more use of self-managed spectrum. We therefore consider that for all other uses which we consider would have a continued dependency of this range of bands could be accommodated in the remaining Ofcom managed bands in this range. We therefore proposed in our consultation and are confirming the continued access to fixed wireless links in the 38 GHz band.

3.92 Regarding the UKWISPA point on FWA we note that this is one of the use cases of the 5G eco system which we covered in our 26 GHz Call for Inputs published in July 2017.

[40] 2nd draft RSPG opinion on 5 GH networks (23 Nov 2017)

Review of the 31 GHz band

3.93 CBNL considered that the 31 GHz band should reviewed. They proposed that the band should be made available via block assignment on a technology neutral basis. With its smaller size it may be suitable for both mobile backhaul and FWA applications.

Ofcom response

3.94 We agree that this band should be reviewed as part of our ongoing programme of work. There appears to be little to no demand for new 31 GHz analogue CCTV links for which the band is currently available. The usage of this application is now very low with many new uses of CCTV systems being based on digital technology. The 31-31.3 GHz part of this band has a Fixed Service allocation on a primary basis in Europe including the UK. The paired band 31.5-31.8 GHz has a secondary fixed service allocation in Europe but within the UK this allocation to the Fixed Service has a primary status through a country specific footnote in the Radio Regulations. The band is also allocated to other services including the Earth Exploration Satellite Service (passive) on a global basis

Consideration of more shared approaches to spectrum management

3.95 CCS recommended that more shared spectrum approaches should be considered as done by the FCC in the USA. CCS indicated that microwave and millimetre wave bands could be managed on a coordinated and shared basis using spectrum allocation servers

Ofcom response

3.96 In our approach to spectrum management Ofcom is always considering ways in which sharing could be further enhanced and facilitated. For example, building on our sharing work and call for input we are planning to publish a consultation towards end of 2018 with a proposal to facilitate enhanced sharing in the 3.8 – 4.2 GHz band.

Returning unused licences to Ofcom

3.97 Horsebridge Network Systems recommended that a system should be developed for the 6-38 GHz bands to ensure that any unused licences are handed back to the pool to avoid users sitting on unused spectrum and blocking others.

Ofcom response

3.98 Our current licences for fixed wireless links do not include mandatory requirements for link deployment within a given time period. Fixed wireless link licences are subject to administrative incentive pricing (AIP) and are also tradable. We are of the view that these measures are sufficient to allow for unwanted licenses to be traded to third parties as part of a normal market-based approach or surrendered back to Ofcom.

Further changes at 70/80 GHz

3.99 Huawei envisaged the need to provide 10 Gbps at E band in Europe and to make this viable a wider channel of 2 GHz would be recommended for E Band.

3.100 Nokia AMNS XHAUL proposed a revision of E band in the future according to V band outdoor fixed operations introduction.

3.101 Optimity proposed that Ofcom should review the differentiation between the two management approaches at E band. Siklu recommended the re-examination of the demarcation at E band. Siklu believes since the introduction of the mixed management approach for this band, the trend for self-coordinated use is much greater than that of Ofcom coordinated approach and that the reserved tranche should be made available as 2x4 GHz for self-coordinated use and 2x1 GHz for Ofcom coordinated use.

Ofcom response

3.102 A 2 GHz channel size is currently facilitated in the self-coordinated part of the band however, in our review of the 71-76 GHz and 81-86 GHz band we indicated that we would enable further access to spectrum to the 1 GHz currently available when there was enough evidence to suggest that this should be made available. We will therefore consider this possibility along with our plans to consider removing the temporary frequency separation between the two approaches.

3.103 Regarding the proposal from Nokia AMNS XHAUL, fixed outdoor operations are already permitted at 70/80 GHz and we will monitor how technology will develop within this band as part of our ongoing understanding of developments in this sector.

Automated licensing and reducing licence turnaround times

3.104 techUK had not identified any changes to the authorisation approach of any other existing fixed wireless link bands. They referred to one issue that had been discussed in the UK Spectrum Policy Forum which was the desirability of significantly reducing the time taken to authorise fixed wireless links. techUK indicated that the statutory target of 42 days was quite long compared with the requirements to rapidly roll out networks and was arguably more relevant to the past than the present era of modern spectrum management with sophisticated computer tools for interference coordination and licensing.

3.105 techUK members (and the UK Spectrum Policy Forum) saw benefits in online licensing with rapid decisions and encouraged Ofcom to explore what may be possible, both for existing fixed wireless links bands as well as future bands under consideration. techUK highlighted that they believed rapid authorisation of spectrum will be increasingly important as 5G networks are rolled out, with potentially large numbers of cells being deployed in the future as network densification occurs. BT/EE had a similar response on the need for an online licensing system.

Ofcom response

3.106 The Wireless Telegraphy (Licensing Procedures) Regulations 2010 provide the time limit for dealing with an application. Not considering international coordination this allows a period of up to six weeks after the day of the receipt of the application but in any case, it should be processed as soon as possible after the day of receipt. Ofcom has for many years offered a batch electronic transfer mechanism for fixed wireless links which helps reduce turnaround times but does require some bespoke development by the applicant and is possibly not attractive to a smaller operator. Ofcom already uses automated assignment wizards and while these continue to improve will not dramatically reduce turnaround time. Ofcom is also considering on more e-enabled licence products where applicants can self-serve bringing more choice and flexibility in the application process.

Next section

3.107 In the next section we set out our decision for all the spectrum bands that we reviewed and indicate our forward programme of work.

4. Our Decisions

Introduction

4.1 In this section we:

- Set out our plan for each band to enable futures uses of fixed wireless links. This has resulted from the key drivers of change that this review has identified. This also includes the specific further action(s) we are taking on some of these bands
- Set out how we are changing the regulatory framework for the 57-71 GHz band which we consider to be the highest priority.
- Indicate our forward programme of work on items we consider will need specific focus in the short to medium term.

Our band by band plan

4.2 Table 2 below summarises our band by band plan for each Ofcom managed band that was considered by this review. Below this table we detail specific action we are taking.

Table 2 – Plan for each fixed wireless link band

Frequency band	Frequency range[41]	Approach for this band and where appropriate further action required
1.4 GHz	1350 - 1375 MHz 1492 – 1517 MHz	1492-1517 MHz: New EC harmonisation decision for downlink-only mobile services[42] applies. Start the process to implement new EC decision. The band will close to new fixed wireless links and technical variations from 5 January 2019. Existing links licensed up to this date will be permitted to continue until Ofcom makes a further announcement regarding this band. Consider alternative options further for current fixed wireless links that use this band (i.e. small channels in 6 GHz guard bands/centre gaps)
4 GHz[43]	3815 - 3875 MHz	3.6-3.8 GHz: Closed to new fixed wireless links.

[41] Note that the ranges given may include edge guard bands and centre gaps. Specific band edges are defined in Ofcom document OfW48.
[42] Also referred to as mobile fixed communication network supplementary downlink (MCFN-SDL) or simply SDL. The mode of operation is limited to base station transmission.
[43] The 3.6-3.8 GHz frequency range (channels 1-7 on the 30MHz channel plan) is closed to new applications for fixed wireless link licences.

	4135 - 4195 MHz	Existing links have received notice of revocation and are leaving the band. 3.8 – 4.2 GHz: Continue with fixed wireless link assignments, on a first come first serve basis, on channels 8 and 9 on the 30MHz plan. Band also being considered for increased sharing with a consultation planned towards the end of 2018.
5.8 GHz	5725 – 5850 MHz	Ofcom has recently published[44] the statement to remove the 20 MHz frequency 'notch' between 5795 and 5815 MHz to allow fixed wireless links to access these frequencies, enabling a greater number of higher capacity channels within the 5.8 GHz band.
Lower 6 GHz	5925 - 6425 MHz	Continue access for fixed wireless links
Upper 6 GHz	6425 - 7125 MHz	Continue access for fixed wireless links Consider band gaps for low capacity options
7.5 GHz	7425 - 7900 MHz	Continue access for fixed wireless links
13 GHz	12.75 -13.25 GHz	Continue access for fixed wireless links
15 GHz	14.5 - 15.35 GHz	Continue access for fixed wireless links
18 GHz	17.7 - 19.7 GHz	Continue access for fixed wireless links
23 GHz	22 - 23.6 GHz	Continue access for fixed wireless links
26 GHz[45]	24.5 - 26.5 GHz	Being considered as a pioneer band for 5G mobile access. Following the publication of our Update on 5G[46] spectrum in the UK and more recent 5G Discussion document[47], applicants for fixed wireless link licences in the 26 GHz band are advised to take note that the 26 GHz band has been identified by the European Radio Spectrum Policy Group (RSPG) as the pioneer band in Europe (and wider) for 5G. The UK supports this action.

[44] https://www.ofcom.org.uk/consultations-and-statements/category-2/improving-access-5.8-ghz-broadband-fixed-wireless-access
[45] The 26 GHz band is being considered in https://www.ofcom.org.uk/__data/assets/pdf_file/0014/104702/5G-spectrum-access-at-26-GHz.pdf
[46] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf
[47] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/111883/enabling-5g-uk.pdf

		Applicants of fixed wireless links are therefore advised to take this into account in any future applications for this band and where possible should consider alternative fixed wireless link bands to meet their requirements.
31 GHz	31.0 - 31.3 GHz 31.5 - 31.8 GHz	Candidate band for review due to reduced/no demand for analogue CCTV backhaul
38 GHz	37 - 39.5 GHz	Continue access for fixed wireless links.
52 GHz	51.4 - 52.6 GHz	Monitor developments
55 GHz	55.78 – 57 GHz	Monitor developments
60 GHz ("V" band)	57 - 64 GHz	Implement regulatory changes to enable new fixed outdoor use cases on a licence exempt basis.
65 GHz ("V" band)	64 - 66 GHz	Implement change in authorisation approach to licence exempt and with similar technical conditions as the 57-64 GHz band.
66-71 GHz	66 – 71 GHz	Make available by a licence exempt authorisation approach with similar technical conditions as the 57 – 66 GHz band.
70/80 GHz ("E" band)	71.125 - 75.875 GHz 81.125 - 85.875 GHz	Continue access for fixed wireless links Consider the gap between the self-coordinated and Ofcom coordinated parts of the band.

Closure of the 1498.5-1517 MHz to new fixed wireless links

4.3 The new European Commission Implementation Decision 2018/661 of 26th April 2018, requires that 1492-1517 MHz is made available for downlink-only mobile use from 1st October 2018. This is a mandatory harmonisation measure on a EU wide basis that the UK is required to implement. Furthermore, in our programme of work to make spectrum available for future mobile uses, we raised the 1492-1517 MHz to high priority in our Mobile Data Strategy in June 2016.

4.4 Given that technical work conducted by CEPT in the run up to this decision indicates that fixed wireless links and downlink-only mobile services cannot share the same spectrum in the same geographic area and in preparation to make this band available for this use, we are taking the decision to close the 1492-1517 MHz band and the paired 1350-1375 MHz band to new applications for fixed wireless links and technical variations. This closure will take place on 5 January 2019 which allows for a period of six months from this statement

for any immediate change / implementation plans that stakeholders may have. It should be noted that part of this band, 1492-1498.5 MHz paired with 1356.5-1375 MHz has already been closed to new applications and technical variations for fixed wireless links since 2015 so this decision will now apply to the remainder of the band.

4.5 For those existing links licensed before 5 January 2019 we will permit their continuation until we issue specific plans on the timing to clear these links to implement the EC Decision.

4.6 The table 3 below summarises our decision for the band.

Table 3: Summary of decision for 1.4 GHz fixed wireless links

	1492-1498.5 MHz and 1350-1356.5 MHz	**1498.5-1517 MHz and 1356.5-1375 MHz**
5 July 2018 to 4 January 2019	No change to current policy	No change to current policy
From 5 January 2019 until further notice	No change to current policy	Closed to new fixed wireless links. No technical variations to existing links. Existing links can remain operating until further notice. Trading of existing links permitted.

4.7 We will continue the process of considering the remaining aspects of implementing the EC decision in our forward programme of work.

Consideration of lower capacity systems at 6 GHz

4.8 We plan to consider whether we can make low capacity channels available for future links that currently use the 1.4 GHz band. We plan to concentrate on band gaps within the Upper 6 GHz band through further engagement with stakeholders. The approach we will take will be alongside our plans to implement the EC Decision 2018/661.

Future of the 26 GHz band

4.9 High-frequency (millimetre wave) spectrum which, to date, has not been used to deliver mobile services, is likely to be used to support new 5G applications in the future, in particular those that require high capacity and very low latency by both MNOs and other players.

4.10 While responses to our 26 GHz call for input indicated that the 26 GHz band is likely to be become important for 5G, many suggested that it is too early to say how the band will be

used, and for what purposes. We will continue to collate evidence from stakeholders across different sectors and continue our engagement internationally to inform our understanding given the wide international interest in using high frequency spectrum for mobile. We are particularly keen to encourage trials at 26 GHz, the 5G millimetre wave pioneer band. Further details on innovation and trial licensing can be found on our website[48]

4.11 While uncertainty remains around how the 26 GHz band will be used by mobile in the future, along with the different use cases, we remain committed to supporting this band as the global pioneer band for 5G and making this spectrum available in the future for mobile. Applicants of fixed wireless links are therefore advised to take this into account in any future applications for this band and where possible should consider alternative fixed wireless link bands to meet their requirements.

Consider 52 GHz and 55 GHz bands for potential new uses

4.12 We will monitor developments in the 52 GHz and 55 GHz bands. However, with limited interest in these bands for future fixed wireless links we do not plan to do anything specific in the near future but will keep options under review for potential new uses.

Regulatory framework across 57 – 71 GHz band

Common technical conditions across 57 – 71 GHz band for licence exempt fixed and mobile use

4.13 We have decided

a) for short range wideband data transmission:

(i) extend the current licence exemption and technical conditions (from 57 – 66 GHz) up to 71 GHz; and
(ii) introduce new technical conditions to allow licence exempt use of lower power equipment operating in a fixed outdoor installation in the 57 – 71 GHz band.

b) for fixed wireless systems:

(i) extend the current licence exemption (from 57.1 GHz – 63.9 GHz) to 70.875 GHz, and by doing so, change the current authorisation approach for fixed wireless systems operating in the 64 – 66 GHz band from light licence to licence exempt; and
(ii) extend the current technical conditions (from 57.1 – 63.9 GHz) up to 70.875 GHz.

4.14 We intend to proceed to implement changes in regulation in accordance with the technical conditions as shown in Figure 4.

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

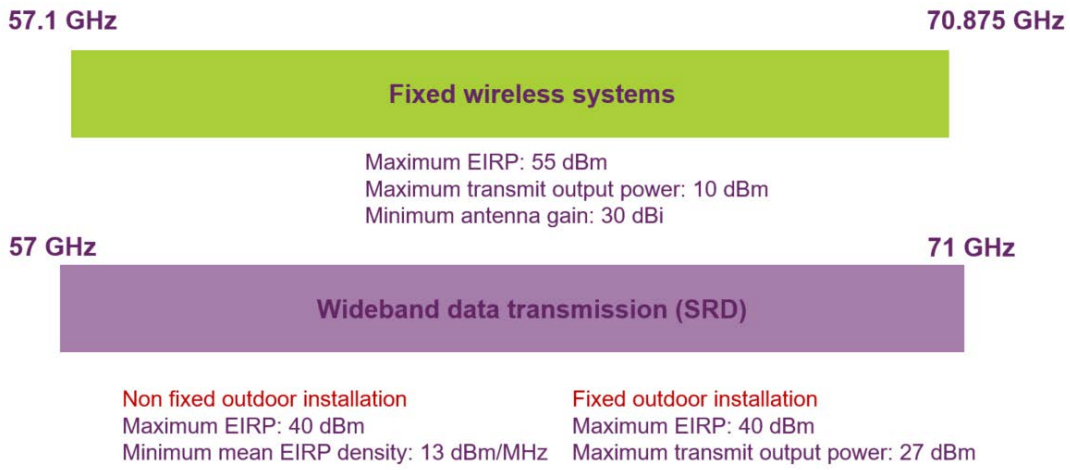

Figure 4: Summary of technical conditions for licence exempt use in the 57 – 71 GHz band

4.15 In order to give effect to these decisions, at the same time as the publication of this statement, we are giving a notice of proposal[49] to make the Wireless Telegraphy (Exemption and Amendment) (Amendment)(No. 2) Regulations 2018 (the "Proposed Regulations")[50] to amend existing exemption regulations to refer to an updated version of the Interface Requirement (IR). Specifically, we are proposing to amend

a) IR 2030 (short range devices)

i) we will include a new section outlining the technical condition for wideband data transmission equipment operating at EIRP up to and including 40 dBm in a fixed outdoor installation in the 57–71 GHz band. This represents a relaxation to the fixed wireless technical condition specified in IR 2078 and is intended to facilitate equipment utilising antenna beamforming technology in a point to multipoint/ mesh topology and with intelligent self-organising capability. The mandatory exclusion zones within the 57.1 - 63.9 GHz sub band specified in IR 2078 will continue to apply. To reflect the requirement for intelligent self-organising capability to manage the interference environment, we will require equipment to implement techniques to mitigate interference, similar to those required for wideband data transmission below.

ii) we will extend the frequency range for short range wideband data transmission (excluding fixed outdoor installation) from 57 – 66 GHz to 71 GHz. This implements our decision to make available additional spectrum on a licence exempt basis and to facilitate the 5G mobile use cases for mobile/portable equipment.

b) IR2078 (fixed wireless systems)

[49] https://www.ofcom.org.uk/__data/assets/pdf_file/0016/115630/Implementing-decisions-5771-GHz-band.pdf
[50] See Annex A1 of https://www.ofcom.org.uk/__data/assets/pdf_file/0016/115630/Implementing-decisions-5771-GHz-band.pdf

i) we will extend the frequency range for fixed wireless system intended for equipment operating above 40 dBm EIRP from 57.1 – 63.9 GHz to 70.185 GHz. This implements our decision to change the authorisation approach for fixed wireless systems in the 64 – 66 GHz band to licence exempt and to make available additional spectrum on a licence exempt basis to facilitate fixed outdoor use cases. This is an interim measure and we intend to review the technical conditions for higher power outdoor operation as well as the need for the frequency separation below 71 GHz upon completion of the work in CEPT.

4.16 We intend to publish a statement setting out Ofcom's decision in relation to the Proposed Regulations as soon as practicable. When the Proposed Regulations are in force, equipment complying with the relevant technical conditions will be able to operate on a licence exempt basis across the entire 57.1 – 70.185 GHz band (higher power mode) / 57 - 71 GHz band (lower power mode).

4.17 Further, we intend to work actively within CEPT to promote our regulatory approach to achieve a harmonised European regulatory framework therefore benefiting economy of scale for equipment. As indicated above, pending completion of the CEPT work, we will further review the regulation for systems operating at EIRP above 40 dBm.

Change in authorisation regime for fixed wireless systems in the 64 – 66 GHz band to licence exempt

4.18 As a consequence of adopting a common authorisation approach, and based on consultation responses, we have decided to change the authorisation regime for fixed wireless systems in the 64 – 66 GHz band to licence exempt.

4.19 When the Proposed Regulations are in force, in particular the licence exemption for the 57.1 – 70.875 GHz band, fixed wireless systems that comply with the relevant technical conditions will no longer require a licence to operate in the 64 – 66 GHz band.

4.20 Therefore, when the Proposed Regulations are in force:

a) we intend to remove the 65 GHz band Self Coordinated licence product;

b) we intend to write to all existing 65/70/80 GHz Self Coordinated licensees on our intention to vary their licence to remove reference to the 65 GHz band; and

c) when the licences have been varied, we no longer intend to retain the 65 GHz section of the wireless telegraphy register[51].

[51] The 65 GHz Section of the Wireless Telegraphy Register is the publicly available spreadsheet on our website which lists the licensee and technical details of registered self-coordinated fixed wireless links in the 64-66 GHz band.

Review of the frequency separation between the management approaches in the 71-76 GHz and 81-86 GHz bands (70/80 GHz)

4.21 The 71-76 GHz and 81-86 GHz bands continue to be the fastest growing Ofcom managed bands and the findings of this review has further indicated the strategic importance of these bands for future uses of fixed wireless links to facilitate high capacity for future backhaul and access connectivity.

4.22 There are currently two authorisation approaches that apply in separate parts of the 70/80 GHz band:

- Ofcom coordinated in the 71.125-73.125 GHz and 81.125-83.125 GHz and;
- Self-coordinated in the 73.375-75.875 GHz and 83.375-85.875 GHz as shown in figure 5 below:

Figure 5: Frequency separation for mixed management approach in the 70/80 GHz band

4.23 When the band was reviewed in 2013, 250 MHz of spectrum was introduced in each sub band which separated the spectrum blocks under each authorisation approach as a practical interference mitigation measure. At that time, we agreed that the size of this separation should be kept under review and further considered when more technical evidence is available with a view to possibly reducing the size of the separation in the future.

4.24 Some stakeholders have suggested a review of this separation. Although specific supporting studies were not contributed in the current consultation responses, our view is that with increasing popularity of this band, we should gather further evidence and study the reduction of the 250 MHz frequency separation in each block.

Facilitating future fixed wireless links in bands above 92 GHz

4.25 We will take steps to consider how to make available the bands above 92 GHz for high capacity fixed wireless links. Specifically, this will be spectrum in the 92-114.5 GHz (W band) and 130-174.8 GHz (D Band) for which there are strong indications for future 5G backhaul requirements. We plan that this work would be a medium-term priority in our

forward work plan noting that the priority for D band was before W band according to respondents. We will engage further with stakeholders during our considerations.

Spectrum availability for point to multipoint fixed wireless links

4.26 In this statement we have taken immediate steps to facilitate point to multipoint / mesh connectivity in 14 GHz of spectrum at 60 GHz under a licence exempt authorisation approach. In addition, there is 125 MHz of spectrum at 5.8 GHz (5725 – 5850 MHz) which will also remain available for point to multipoint fixed wireless links via a light licensed approach. Furthermore, licensees with access to the block assigned spectrum (in the 10 – 40 GHz award bands) could use these bands for fixed wireless access links. In addition, there is also 255 MHz of spectrum in the lower power 5.4 GHz (5470-5725 MHz) licence exempt band that can be used for wireless access systems.

4.27 In addition to the bands highlighted above Ofcom is currently considering enhanced sharing in the 3.8 – 4.2 GHz band (see section 2) which will include consideration of fixed wireless access systems.

4.28 We have started the process of engaging[52] with stakeholders on our plans to include data from FWA networks in future Connected nations reports. Due to the large number of wireless internet service providers operating in the UK, and the variety of network technologies and network architectures used, collecting reliable and comparable data on coverage of these networks is challenging. Over the coming months we plan to develop a consistent methodology to determine effective coverage from FWA providers to ensure comparability with fixed wireline, cable or fibre services.

Consideration of possible new uses of fixed wireless links in HF[53] bands

4.29 Although not covered by this review we note as part of our ongoing Fixed Wireless Services programmatic work, an increased interest in accessing spectrum in the HF bands (3-30 MHz) for long distance communications between two points. Most enquiries have been related to the spectrum for civil applications. However, Ofcom does not currently have a fixed wireless link licence product available for operation in the HF bands. These bands are significantly different to the higher microwave bands from a capacity and propagation perspective. Within the HF bands the main propagation mechanisms are ground and sky wave meaning that signals (and therefore interference potential) can travel significant distance and in different directions depending on the time of day, season and sun spot cycle. Noting that the interference environment in these HF ranges presents specific interference management challenges further work would be required if Ofcom were to consider developing a licence product. While we do not consider this is a priority we aim to consider the HF bands further and would be interested to hear more from stakeholders

[52] If you wish to be involved in this process, please contact us at connectednationsreport@ofcom.org.uk
[53] High Frequency

with an interest in these bands (including likely demand) through our normal programme of work.

Improving our products and services

4.30 We plan to consider ways in which our assignment approach can be improved. Specific aspects of this include areas such as:

a) Considering ways in which we can make the assignment of fixed wireless links more efficient such as consideration of reducing clashes between transmitting in the high part of a frequency division duplexed sub-band and the corresponding lower sub-band;

b) Supporting further work to better characterise the propagation environment particularly in the higher frequency bands;

c) Consider further efficiencies in in-band coexistence as well as gather information on self-organising, self-healing properties of new equipment when available;

d) Further evidence gathering on specific capacity enhancement techniques;

e) Consideration of permitting access to the additional spectrum at 70/80 GHz in the Ofcom coordinated blocks.

4.31 We plan to conduct such work assessing priority through discussion with stakeholders and wider engagement though our fixed wireless industry liaison forum.

Our key priorities in the forward programme

4.32 Based on the decisions above, below we show our forward work programme and our indicative timing for when we plan to start our consideration of each item:

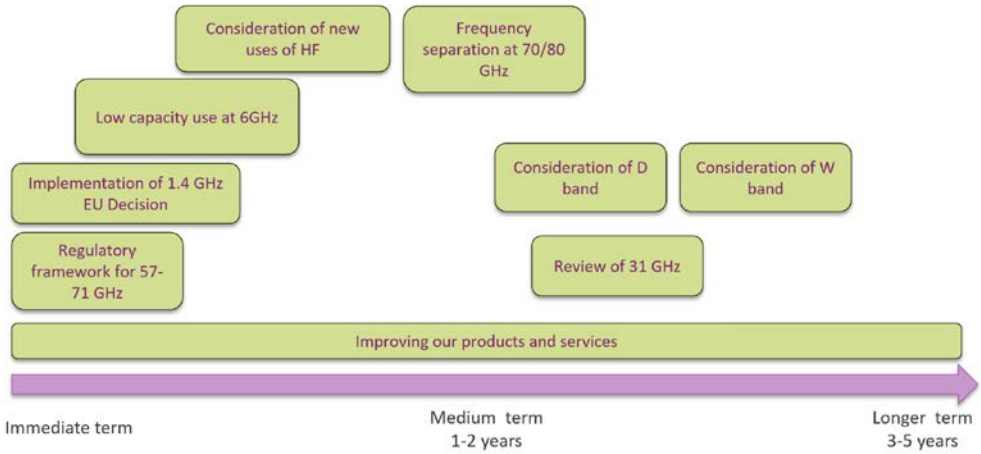

Figure 6: Forward work programme

4.33 We plan to continue to engage with stakeholders at both national and international level including engagement in international committees as appropriate in our work on these items.

A1. Summary of Consultation responses

A1.1 This annex provides a summary of comments received from stakeholders in response to our consultation, published on 7 December 2017, together with our responses to these comments and/or a reference to where our response is contained in the main sections of this document. A total of 27 responses were received to the consultation.

A1.2 Where stakeholders have made the same, or very similar, comments to multiple questions in their response we have included the comment only once under the question to which the comment has greatest relevance.

A1.3 Organisations that submitted responses are listed below:

- British Entertainment Industry Radio Group ("BEIRG")
- Blu Wireless Technology Ltd
- British Telecommunications Plc and EE Limited ("BT/EE")
- Cambridge Broadband Networks Ltd ("CBNL")
- Cambridge Communications Systems Ltd ("CCS")
- Facebook Inc
- Horsebridge Network Systems
- Huawei Technologies ("Huawei")
- IEEE 802 LAN/MAN Standards Committee
- Intel Corporation ("Intel")
- Intelsat
- Joint Radio Company Ltd ("JRC")
- Lattice Semiconductor
- NOKIA AMNS XHAUL
- Optimity
- Rukus Wireless UK Ltd ("Rukus")
- SAF Tehnika JSC
- SES
- SIAE Microelettronica SpA ("SIAE")
- Siklu Communications
- SSE plc
- techUK
- Telefónica UK Limited ("Telefónica")
- The UK Wireless Industry Service Providers Association ("UKWISPA")
- Vodafone
- Western Power Distribution
- Wi-Fi Alliance

Question 1	
Do you agree that we have identified the key drivers likely to have a significant impact on the spectrum demand for fixed wireless links? If not, please provide further detail and evidence to support your answer. **Do you have other comments to make/points to raise with us on these issues?**	
Issue Raised	Ofcom Response
CBNL, CCS, Horsebridge Network Systems, Huawei, Lattice Semiconductor, Nokia AMNS XHAUL, Optimity, Ruckus, SIAE, Siklu Communications, techUK, Telefónica, Vodafone agreed with Ofcom's identification of the key drivers. In addition: **BT/EE** agreed with Ofcom's assessment of key drivers in particular the demand arising from the implementation of 5G and mobile network densification requiring the need for millimetre wave spectrum. **Blu Wireless** raised two additional drivers for the 57-64 GHz and 66-71 GHz band to deliver gigabit broadband using a common network approach using the 5G network as: • Fixed Wireless Access direct to homes and businesses using both P-MP and P-P solutions and; • dedicated vertical applications in the transport sector such as track to train **Huawei** emphasised the necessity to provide better broadband through fixed wireless links where fibre isn't available **Horsebridge Network systems** mentioned that spectrum must be maintained in future plans for standardised radios (for ITSG5/801.11p) for autonomous vehicles now being trialled.	We note that that there was broad agreement across the responses received and that we had identified the key drivers likely to have a significant impact on spectrum demand for fixed wireless links. Regarding the additional drivers raised: Our decision on 60 GHz will facilitate a wide range of use cases across the 57-71 GHz band, including FWA for homes and businesses utilising either point to multipoint or point to point topologies. Regarding the need to consider trackside to train applications at 60 GHz, Ofcom is currently considering the spectrum options for supporting this application. We agree that fixed wireless links provide a means of connectivity where fibre is unavailable including to provide better broadband connectivity. The proposal that municipal and transport infrastructure, and vehicle to infrastructure networks should be added to the key drivers that are likely to have significant impact on the spectrum demand but did not provide any supporting evidence. While we acknowledge that Intelligent Transport Systems and connected cars and autonomous vehicles are likely to increase connectivity needs, we are not of the view that this will

Question 1	
Do you agree that we have identified the key drivers likely to have a significant impact on the spectrum demand for fixed wireless links? If not, please provide further detail and evidence to support your answer. **Do you have other comments to make/points to raise with us on these issues?**	
Issue Raised	Ofcom Response
Lattice semiconductor responded that fixed wireless links would be a key tool for competitive service providers/ISPs and proposed to add municipal and transport infrastructure networks and vehicle to infrastructure networks. **Nokia AMNS XHAUL** referred to Band and Carrier aggregation should be taken into careful consideration as it can have significant implications on spectrum usage. **Optimity** referred for the need to consider growth in demand for fixed wireless links for public networks such as CCTV, public Wi-Fi, and the need to strengthen publicly owned networks as more devices are supported. **Siklu** highlighted the trend in that could result in increasing demand for spectrum for council owned networks such as increase in fixed wireless links to extent council owned fibre networks. Such networks are used to service facilities and community anchor institutions, as well as connect CCTV, variable messaging signs, public Wi-Fi, and linking the continuously increasing number of devices and applications. **techUK** concurred that the requirements of 5G backhauling including for dense urban small cells have been discussed in the UK Spectrum Policy Forum and are one important area that Ofcom should consider.	specifically have an impact on spectrum demand for fixed wireless links beyond what we have already considered in this review. On trials for autonomous vehicles, no supporting information was provided on demand for additional spectrum for fixed wireless links in the backhaul context. However, we plan to monitor these developments along with the general impact of new use cases and their associated requirements for fixed wireless backhaul. We consider band and carrier aggregation further in Q11 For council CCTV and further Wi-Fi provision we consider that the range of spectrum bands available for fixed wireless links over the next 5 years are adequate to meet the requirements to facilitate the wireless backhaul needs within the UK including both CCTV and Wi-Fi backhaul. We agree on the need for 5G backhaul requirements using wireless connectivity and have considered this in the development of our decisions and forward work plan. In our March 2018 publication "Enabling 5G in the UK", we have recognised the role of wireless for backhaul solutions

Question 1	
Do you agree that we have identified the key drivers likely to have a significant impact on the spectrum demand for fixed wireless links? If not, please provide further detail and evidence to support your answer. **Do you have other comments to make/points to raise with us on these issues?**	
Issue Raised	Ofcom Response
Telefónica referred to the need for mesh architectures at 60 GHz closer to the edges of the network. **Vodafone** referred to the need for additional marginal sites which could only be connected economically by wireless solutions at the edges of a 5G dense networks. And further referred to Ofcom's correct identification of network connectivity evolving as C-RAN architectures are deployed.	We agree with the need for the ability to deploy point to point, point to multipoint and mesh architectures at 60 GHz and have made decisions in this statement to enable these different topologies to be deployed.
Facebook appreciated Ofcom's acknowledgment that HAPS could "extend coverage and capacity to areas where other technologies may not be available or suitable" and that HAPS use cases include the potential to extend the reach of backhaul and for emergency and disaster recovery situations. **Facebook** considers that Ofcom should preserve a role for HAPS within the 5G ecosystem and for emergency communications particularly in the 26 GHz and 37-40 GHz bands	HAPS is an interesting area of development which is also currently being discussed in preparation for the forthcoming WRC[54]. We recognise HAPS could play a role within the 5G ecosystem in particular for backhaul fixed wireless links to complement and extend 5G connectivity in areas where other technologies may not to be available or suitable. We are interested in understanding more about spectrum demand for HAPS in terms of both how much and where this may be needed. Our priority for the 26GHz is a global harmonisation for 5G/IMT.
Intel indicated that fixed wireless links used where the cost of laying fibre is prohibitive, would be replaced by fibre as usual when the demand for throughput, latency and reliability grows.	We agree that where available and cost effective fibre is likely to offer the best possible backhaul connectivity option. However, we consider there will remain the need for fixed wireless links where fibre is not an option and in certain use cases that require lower latency connections.

[54] WRC-19 (28 October – 22 November 2019).

Question 1	
Do you agree that we have identified the key drivers likely to have a significant impact on the spectrum demand for fixed wireless links? If not, please provide further detail and evidence to support your answer. **Do you have other comments to make/points to raise with us on these issues?**	
Issue Raised	Ofcom Response
Intel also indicated that greater demand for more backhaul would not necessarily mean an increase in number of fixed wireless link deployments as this could be met by using more spectrally efficient equipment or network sharing. However fixed wireless link capacities will not meet or surpass that of fibre. **Intel** believes it is important to ensure that mobile services and applications are enabled.	We agree that it is important that future mobile services are enabled and spectrum does not become a barrier. Our 5G programme of work provides more details and our objective is to ensure spectrum is not an inhibitor of 5G rollout and have identified different bands with different characteristics. In our March 2018 discussion document[55], we recognised that wireless can play a role for the provision of backhaul
Intelsat's view was to enable FSS operators to use the entire 14-14.5 GHz band for new satellite applications, access to the closed fixed wireless link band 14.25-14.5 GHz would be required. **Intelsat's** response referred to the declining number of fixed wireless links in this band and that that this spectrum should be made available for future satellite use. In addition, **Intelsat** notes that HTS satellites are being considered for potentially delivering 5G backhaul solutions.	Closed bands such as the 14.25 – 14.5 GHz band for fixed wireless links were not included in this review as these bands are no longer accessible to new fixed wireless links. However, regarding the request for additional spectrum for uncoordinated satellite earth stations, this is outside the scope of this review, but our annual plan covers this specific topic and indicates that we do not currently have any plans to remove the remaining fixed wireless links in the upper half of the band.
SES raised that in Section 3's discussion of last-mile connectivity and rural areas, it is important to note that broadband connections via satellite are also available, not just via fibre or fixed wireless links. **SES** supported the discussion in Section 3.19 of the use of satellite technology by utilities such as electricity, gas, and water installations.	In section 3 of our consultation we reflect what stakeholders have indicated to us regarding provision for last mile connectivity, taking into account this is a sectorial review focused on the fixed wireless sector. We agree that satellite links could also form part of such connectivity

[55] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/111883/enabling-5g-uk.pdf

Question 1	
Do you agree that we have identified the key drivers likely to have a significant impact on the spectrum demand for fixed wireless links? If not, please provide further detail and evidence to support your answer. **Do you have other comments to make/points to raise with us on these issues?**	
Issue Raised	Ofcom Response
SES noted with some concern the reference in section A2.32 to the fact that fixed network operators that have access to block-assigned bands indicated that they expect to make increased use of the 28 GHz for 5G fixed wireless access, and of the 32 GHz band for mobile backhaul. **SES** expected that fixed services and satellite services will form part of the ecosystem that supports 5G applications, and **SES** support the use of the 32 GHz band for mobile backhaul. However, **SES** indicated that ubiquitous mobile devices are not able to share with any other services in the same band, and if such devices are allowed to use the 28 GHz band, the effective exclusion of satellites from that band would be devastating to the existing networks and future plans of most satellite operators.	solutions and our Space Spectrum Strategy covers this sector in more detail. Within the UK the 28 GHz band has several types of licence approaches, the main ones being Block/Award licences, licence exempt for uncoordinated satellite terminals, and licensed for higher power satellite earth stations. Details of the block / award licences including the technical conditions can be found on our website. Block licensees are free to deploy stations (including satellite ESs) within the terms of their licences. A decision on whether or not to allow ubiquitous mobile devices to use the 28 GHz band is not within the scope of this review.
SSE responded that the challenging objectives of resilience required in utility networks mean that there would be a continued requirement for a defined network best ensured through a self-provide/owned/operated basis. **SSE** indicated that meeting these objectives would be complicated with low fibre penetration within rural UK and SSE's challenging geography of operation means that **SSE** continually require access to radio spectrum that has favourable propagation characteristics, enables connectivity over long paths and provides redress in the event of interference from other uses.	Our view as indicated in our consultation on the need for spectrum for future utility networks was that although alternative means such as fibre or satellite links are considered by the utilities the frequency bands between 7.5 GHz and 38 GHz continue to be used to deliver telemetry, voice, data and video services to many electricity gas and water installations. Noting the key shifts we expect in mobile backhaul uses of fixed wireless links, we therefore consider that our plan for bands as

Question 1	
Do you agree that we have identified the key drivers likely to have a significant impact on the spectrum demand for fixed wireless links? If not, please provide further detail and evidence to support your answer. **Do you have other comments to make/points to raise with us on these issues?**	
Issue Raised	Ofcom Response
SSE commented at millimeter bands such as V and E band were inappropriate for critical traffic associated with control and stability of the electrical network due to susceptibility to fading limiting path length of the connections in conjunction with the associated licensing regime. **SSE** therefore comment that access to appropriate, protected spectrum in Ofcom managed microwave bands will remain essential for the operation of the utility networks and development of smart energy systems. **SSE** also commented on the importance of priortising the need to meet potential demand of high bandwidth channels within licensed microwave bands over low bandwidth channel.	proposed in table 2 is adequate to meet the requirements for key UK services such as the utilities.
UKWISPA responded that Ofcom have missed a key driver that wireless internet service providers need access to 3.4-3.8 GHz spectrum for delivering broadband service in rural areas.	The 3.4-3.8 GHz band has been identified as the primary band for 5G in Europe as it offers increased capacity for mobile broadband over wide areas. We have completed the process of awarding 3.4-3.6 GHz and plan to award spectrum in the 3.6-3.8 GHz band in 2019. We will consult on our proposals for this award later in 2018.
Western Power Distribution agreed with Ofcom's findings in principle however raised the concern of Ofcom's continual removal of fixed wireless link frequencies for 5G and now perceive further reduction in spectrum access to the Energy industry. With the active electricity system growing,	Regarding the provision of spectrum for new 5G services we consider that over the next 5 years that while there will be changes to some of the spectrum bands currently available for fixed wireless links, the spectrum

Question 1	
Do you agree that we have identified the key drivers likely to have a significant impact on the spectrum demand for fixed wireless links? If not, please provide further detail and evidence to support your answer. **Do you have other comments to make/points to raise with us on these issues?**	
Issue Raised	Ofcom Response
Western Power Distribution expressed that there is presently no other resilient alternative to fixed wireless links to maintain and grow a cost effective and resilient communications system to manage the electricity network.	that will continue to be available for fixed wireless services is considered adequate.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
CBNL, Lattice Semiconductor, Optimity, Siklu, techUK, Telefónica, Vodafone agreed with Ofcom's conclusions on spectrum implications and our proposed strategy/next steps for each band. In addition: **Rukus** commented that they had nothing to add at the current time. **CBNL,** agreed with Ofcom's strategy and provided further detail in specific questions,	We agree that the frequency separation between the ofcom coordinated and self-coordinated approaches in the 70 and 80 GHz band should be reviewed and have included this in our forward programme of work. See our response to Q1 on 14 GHz Our decision on 60 GHz will enable new mesh/multipoint uses.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
Optimity would like Ofcom to review the boundary between the self-coordinated block and the Ofcom coordinated block at E band. **Siklu** encourage Ofcom to review the demarcation between E-band self-coordinated and Ofcom coordinated blocks **techUK** mentioned that the future of the closed 14.25-14.5 GHz is not mentioned in Ofcom's analysis, noting also that this band is not used for fixed wireless links in many European countries. With the low and declining number of existing fixed wireless links in this band, Ofcom could consider the extent to which these links constrain satellite deployments and whether these links should be migrated from this band. **Telefónica** further mentioned that agreement that the V band (57-64 GHz) should be earmarked for multipoint/mesh technologies on a licence exempt basis.	
Blu Wireless agreed with Ofcom and raised the following: • Generally, in line with FCC rules, to encourage the use of active phased array antennas for 60 GHz and support ETSI Millimetre Wave Transmission Industry Specification Group submissions to CEPT SE19 on this. **Blu Wireless** strongly	See our response to Question 5 and Question 6.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
supported Ofcom's proposals to licence exempt 65 GHz in line with 57-64 GHz • To further encourage consultation at 66-71 GHz to enable increased EIRP levels compatible with electrically steered phased array antennas for applications such as transport.	
BT/EE agreed with Ofcom's summary and strategy for each band in particular supporting the need to initiate change where there is a clear benefit to do so in the interest of UK and deriving greatest benefits from the use of the spectrum. In particular **BT/EE** supported the clearance of 3.6-3.8 GHz for 5G and encouraged Ofcom to support efforts to accommodate displaced links in other spectrum where feasible. **BT/EE** also supported Ofcom's proposal to make the 57-66 GHz exempt from licensing to support mesh/P-MP/P-P solutions. **BT/EE** welcome the initiation to authorise W and D bands.	We plan to initiate our work on W and D band as indicated in our forward programme of work.
CCS agreed with Ofcom's conclusions. They further believe that spectrum allocations should be made for both FDD and TDD in large block allocations where Self Organising can be used to manage interference for P-MP and Mesh in 56/112 MHz channels. **CCS** also indicated agreement with Ofcom	Our changes at 60 GHz will enable access for a range of new uses cases and technologies including applications that include self organising capabilities across 14 GHz of spectrum.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
proposals for 57-64 GHz to enable mesh and multipoint solution but would like to see EIRP levels in line with FCC rules.	
Facebook as indicated above would like to see Ofcom preserve the role for HAPS allowing flexible use across platforms within the 26 GHz and 37-40 GHz bands and support licensing regimes that would enable HAPS use as in band backhaul for 5G applications.	See Response under Question 1 above.
Horsbridge Network Systems agreed with Ofcom conclusions and further added the need to look at ways to allow higher capacity across all links in licensed bands using MIMO which will achieve this aim and allow efficient use of narrower channels at the same time. When combined with potentially wider channels (56/112 MHz) would allow for longer higher capacity links.	On point to point Line of Sight (LoS) MIMO uses there was limited evidence of demand provided in the responses for this approach. As part of our ongoing work we take into account and consider new technologies and would welcome any further evidence from stakeholders on the benefits, costs and demand of such techniques along with of ideas on how this could be facilitated in the practical assignment environment.
Horsbridge Network Systems also referred to the interest in the SME network in use of 60 GHz mesh technology for alternative CCTV/Wi-Fi access point backhaul. On W and D band equipment for SME **Horsebridge Network Systems** indicated would be determined by use requirements and equipment availability.	Our changes at 60 GHz will enable access for a range of new use cases and technologies, including access points and backhaul provision, across 14 GHz of spectrum. We note the point made by Horsebridge on the availability of equipment at D and W bands. Along with this and other evidence provided we plan to consider D and W bands in the medium term in our forward programme of work.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
Huawei agreed with Ofcom's overall analysis and provided the following additional comments: • On bands between 20-45 GHz, Huawei identified 32 GHz as a replacement for 26 GHz fixed wireless links and a target for new fixed wireless links due to very similar propagation conditions and current low usage of the band. This would be to discourage operators from further investments in fixed wireless links at 26 GHz. • On demand for bands below 20 GHz, Huawei encourages Ofcom to consider migration of 1.4 GHz low capacity fixed wireless links to other bands in order to make the band available for mobile communications in the UK benefitting from EU wide harmonisation.	• The 32 GHz band is a block assigned band in the UK and our analysis of the 20-45 GHz range has shown that making the 26 GHz band available for mobile uses is unlikely to have an adverse impact on the overall ability to provide connectivity using fixed wireless links given the greater use of self-managed spectrum (such as the block assigned 28 GHz, 32 GHz and 40 GHz bands) and a shift in focus on the higher bands for higher capacity shorter hop systems. • In this statement we have started our process for implementing EU harmonisation measures by indicating closure of the remaining parts of 1492-1517 MHz to new fixed wireless links from 5 January 2019.
On 6 GHz **the IEEE 802 LAN/MAN Standards Committee** indicated support of the CEPT work (SE45 and FM57) and agreed with the view that international co-existence studies will first need to be completed to understand the feasibility of sharing with all existing services and new services before any decision is made on the 5925-7125 MHz band.	We agree with the view that co-existence studies would first need to be completed at 6 GHz to understand the feasibility of sharing between existing and new uses before a decision is made to facilitate RLANS in 5925-7125 MHz. Our changes to the 60 GHz band will make the whole 57-71 GHz available under a new set of regulations.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
On 60 GHz **the IEEE 802 LAN/MAN Standards Committee supports** the IEEE 802.11ad and P802.11ay and want to see the full 57-71 GHz made available for licence exempt sharing and believe that an IMT-2020 designation would inhibit global harmonisation.	
Intel agreed that 1492-1517 MHz is a high priority band for mobile and support EU harmonisation measures for SDL for both 1427-1452 MHz and 1492-1518 MHz. However, **Intel** cautioned the relocation of existing users in 1492-1517 MHz to 6 GHz in that it should not jeopardise the initiatives to enable RLANs in 5925-6425 MHz. **Intel** suggest an alternative solution to migrate these links to optical fibre. **Intel** supports Ofcom's approach for the 3.6-3.8 GHz band for 5G and support Ofcom's proposals to clear the band. On 3.8-4.2 GHz **Intel** supports enhanced sharing initiatives while continuing to allow a small number of existing Fixed and Fixed Satellite services. **Intel** fully supports initiatives to find new spectrum for RLANS in 5925-6425 MHz and 6425- 6925 MHz.	Our review has concluded that provision for low capacity uses at 6 GHz should be further considered. CEPT channel arrangements have been developed to accommodate such low capacity uses in the Lower 6 GHz band gaps and we plan to consider this further. We plan to further consider enhanced sharing at 3.8-4.2 GHz with a consultation planned later this year. On the consideration of RLANS at 6 GHz, we are involved in the Spectrum Engineering Project Team SE45, looking at the potential for sharing and compatibility analysis for RLAN services across CEPT/EU in the 5925 – 6425 MHz. The studies are underway and are scheduled to conclude next year. We note the views expressed by Intel regarding the incumbent 26 GHz services and are continuing with our policy development work, both nationally and internationally, to facilitate access to 26GHz for mobile 5G services.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
Intel supports the prioritisation of **24.25-27.5 GHz** as a pioneer band for 5G in Europe. **Intel** suggests that in geographic areas where coexistence with 5G and fixed wireless links is likely to be problematic, that these links should be migrated to other band(s) or directly to optical fibre. **Intel** however suggest the importance of understanding the extent to which coexistence is likely to be a problem and whether greater geographic reuse is possible. **Intel** agrees that 37-40.5 GHz and 40.5-43.5 GHz as a globally harmonised tuning range for 5G but 24.25-27.5 GHz as higher priority. **Intel** supports a single authorisation approach to facilitate fixed outdoor use across the full 57-66 GHz and supports that the full 66-71 GHz band should be made available for licence exempt use, but **Intel** do not believe it is necessary to have an IMT identification to allow 5G deployments as other technologies could be deliberately precluded by this identification. Furthermore, **Intel** states that licence exempt use of 66-71 GHz band by multi-gigabit applications can be implemented in a similar way to for the 57-66 GHz band based on RR Mobile Service allocations and as detailed in ITU-R M.2003.	Our changes to the 60 GHz band will make the whole 57-71 GHz available under a new set of regulations. Regarding the topic of IMT identification in the Radio Regulations this is currently under discussion as part of the WRC-19 preparatory process. We agree that the 70/80 GHz band is considered an important band for future backhaul and access applications.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
Intel considers that the 71-76 GHz and 81-86 GHz band is an important band for 5G backhaul. For those administrations looking for both access and backhaul coexistence in this band, **Intel** states that an IMT identification is not required since the appropriate regulatory framework is in place due to the RR Mobile allocation for those administrations to make national decisions.	
Intelsat makes the same point as that in Q1 above about making the 14.25-14.5 GHz band available for satellite services. **Intelsat** suggests that Ofcom should consider migration of existing fixed wireless links from this band.	Please see our response to Q1
JRC acknowledges that a range of technologies are to be used to meet Smart Grid requirements indicating the range would be from low data rate 12.5/25 kHz narrow band systems to medium data rate wideband systems to high data rate broadband systems. **JRC** therefore supports the proposed Ofcom consideration of the 1350 MHz band and 6 GHz band for narrow band/low data rate point to point and point to multipoint systems. On the identification of 26 GHz as a pioneer band for 5G in Europe **JRC** emphasised that if the ongoing access to the Fixed Service was removed in its entirety, this would result in a forced migration of links utilised by 4	No further evidence was provided to indicate TDD s solutions within the 1350-1375 MHz band are available, or likely to be made available. Therefore, we consider it would be premature for Ofcom to take a decision to focus on making a low capacity TDD spectrum available. We agree that 6 GHz should be considered further for possible future low capacity fixed links and this forms part of our future work plan. We note the views expressed by JRC regarding the incumbent 26 GHz services. We are continuing with our policy development work both

<table>
<tr><td colspan="2">Question 2</td></tr>
<tr><td colspan="2">Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band?

Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?

Please provide as much detail as possible to support your answer.</td></tr>
<tr><td>Issue Raised</td><td>Ofcom Response</td></tr>
<tr><td>electricity distribution network operators (DNO). JRC encourage Ofcom to seek to adopt an approach that facilitates coexistence of 5G with incumbent users with perhaps a portion of the band given over to 5G as this would be consistent with the approach proposed by RSPG[56].</td><td>nationally and internationally to facilitate access to 26 GHz for mobile 5G services.</td></tr>
<tr><td>Nokia AMNS XHAUL responded to Ofcom’s proposed strategy for each band as follows:

Bands below 20 GHz
Lower 6 and Upper 6 GHz bands are valuable bands for long haul applications. New deployment of long haul in this band should be allowed and existing Fixed Service use protected.
Bands in the 11-18 GHz range should be exploited for the Band and Carrier Aggregation concept (BCA)
BCA should also be used for in-band aggregation.
20 GHz- 45 GHz
Welcomes Ofcom action on 26 GHz</td><td>For bands below 20 GHz:
We agree that the Lower 6 and Upper 6 GHz bands should be retained for continued access to fixed wireless links and this has been reflected in our band by band plan.
We consider BCA under Q11
For bands between 20-45 GHz
On 38 GHz our view as reflected in our decision is that this band will continue to be available for fixed wireless links
BCA is covered under Q 11
For bands above 45 GHz</td></tr>
</table>

[56] 2nd draft RSPG opinion on 5 GH networks (23 Nov 2017)

<table>
<tr><td colspan="2">Question 2</td></tr>
<tr><td colspan="2">Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band?

Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?

Please provide as much detail as possible to support your answer.</td></tr>
<tr><td>Issue Raised</td><td>Ofcom Response</td></tr>
<tr><td>• On merging 38 GHz and 42 GHz for 5G, Nokia AMNS XHAUL points out as massively populated by the Fixed Service and a backup solution for backhaul should be provided
• BCA can be applied here as well
• Even though self-backhauling could be used in theory, it is not clear how effective this would be in terms of capacity offload and how it could be implemented and therefore Nokia AMNS XHAUL is sceptical in the consideration of self-backhauling as a possible enabler for reducing the likelihood of spectrum scarcity in the 20-40 GHz range for the provision of backhaul.

Bands above 45 GHz

• Nokia AMNS XHAUL fully supports promoting 66-71 GHz for 5G rather than the wider 66-76 GHz.
• Nokia AMNS XHAUL indicates that the 71-76 GHz band is precious for fixed service applications. In addition to standalone backhaul, stresses that the 70/80 GHz band should be considered for BCA coupling with lower frequency bands.</td><td>• Our changes to enable multigigabit wireless systems under a licence exempt regime extend to 71 GHz.
• We agree that 70/80 GHz is a band of strategic importance for current and future fixed wireless links
• We agree that 52 GHz and 55 GHz should be monitored with a view to them being considered for alternative uses
• We agree there is no immediate requirement to consider authorisation approaches at D band and therefore plan to consider these in the medium term.</td></tr>
</table>

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
• BCA also applies in this range • **Nokia AMNS XHAUL** believes that it is premature to consider the regulatory framework for D band though in principle, considering a dense network connectivity in an urban environment, a block assigned approach is most suitable. • **Nokia AMNS XHAUL** do not see any interest in investing in 52 GHz and 55 GHz for Fixed Service applications as these bands do not have any key differences with traditional bands below 42 GHz. • **Nokia AMNS XHAUL** agrees with a common authorisation approach in the 57-64 GHz and 64-66 GHz in allowing P-MP and mesh technologies on a licence exempt basis.	
Regarding 40.5-43.5 GHz, **SES** referred to the USA's recent FCC decision to keep 40-42 GHz and 48.2-50.2 GHz exclusively for FSS and to give satellite operators an opportunity to provide services in these bands.	Our Space Spectrum Strategy[57] provides further details regarding satellite service spectrum access. We would also clarify that our reference to the block assigned spectrum within the 20-45 GHz range was in relation to possible trends due to

[57] https://www.ofcom.org.uk/__data/assets/pdf_file/0030/96735/Statement-Space-Spectrum.pdf

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
SES indicated that they fully supported Ofcom's suggestion that existing fixed wireless link users at 28 GHz might be encouraged to migrate to other bands indicating that that portion of Ka band has seen increasing demand and rapid growth by satellite services. **SES** expect that satellite services will use that capacity for mobile backhaul, maritime, aeronautical connectivity and other applications. **SES** was concerned with Ofcom's position referred to in section 4.24 of the consultation to the global tuning range for 5G in the bands 40.5-43.5 GHz and 37-40.5 GHz. This could create a fragmented terrestrial frequency allocation which could cause significant restrictions on and potential viability of important satellite services. For the flexibility that this position affords to individual countries, **SES** submitted that this should ensure that out of band emissions are not caused that could negate the use of adjacent bands and the need for harmonised frequencies across a multinational region rather than national fragmentation.	increasing mobile capacity requirements over the next 10 years. Our view indicated that there could be a natural shift in urban areas where links supporting 5G networks could be replaced by fibre rather than any specific regulatory action to encourage migration to other bands. Regarding future bands for 5G our March 2018 5G discussion document[58] provides further details.
SIAE agreed with Ofcom's general overview and comment that they have a worldwide growing trend in E band use and urge Ofcom to take care of this	We agree and note this comment on 70/80 GHz.

[58] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/111883/enabling-5g-uk.pdf

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
band to prevent any new service that could affect the use of the Fixed Service.	
SSE responded on specific bands as follows: • 1.4 GHz: **SSE** has deployed very few links in the 1.4 GHz band partly due to the depth of microwave in the SSE network with subsequent aggregate capacity prohibiting the deployment of low capacity links. However, **SSE** cite that the propagation characteristics of this band both in relation to resilience, rain fading and diffracted path working which are useful in resolving links to remote and obstructed locations. With predicted growth in Smart Grid connectivity needs, this band would have been of significant value in resolving remote and small site connectivity at the network edge. **SSE** consider that latency constraints for tele-protection signalling will likely negate the use of TDD equipment and therefore duplexed frequencies are essential should this band be considered for smart grid applications.	As indicated in the main body of this document the 1492 – 1517 MHz band is now subject of a EU mobile downlink only harmonising decision and while we note the beneficial propagations conditions from a fixed link perspective the future of this band is mobile. We have therefore included in our future work plan a work item to explore the Lower 6 GHz band as a possibility for future low capacity fixed wireless links. As indicated in table 2 we plan to continue to make the 38 GHz band available for fixed wireless links. Similarly, we note the importance of the Lower 6 and Upper 6 GHz bands therefore our decision to continue to provide these bands for fixed wireless links

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
• 3.6-3.8GHz and 3.8-4.2GHz: **SSE** welcomes the proposed consultation to all for further sharing in the 3.8-4.2 GHz band due to the potential for fixed wireless broadband. • Lower 6 GHz and Upper 6 GHz: **SSE** considers that the Lower 6 and Upper 6 GHz are essential for future deployment of high capacity links over very long paths. Spectrum congestion would rule out the use of the 7.5 GHz band. It is essential that high bandwidth channels in the Lower 6 and Upper 6 GHz bands are given priority over low capacity channels to enable the deployment of high capacity links over contiguous sites • Bands between 20 GHz and 45 GHz: **SSE** raises concerns regarding the 5G global tuning range as if enacted would appear to leave 23 GHz as the only Ofcom managed band within the 20-45 GHz range which is available on a non-block assigned basis. The use of higher bands suggested as an alternative option to Ofcom managed bands would not be appropriate for utility communications due to the “light licensed”/unprotected nature of spectrum assignment and	

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
due to degraded latency performance of packet radio prevalent in the millimetre band environment • Bands above 45 GHz: Proposals at V band may enable access and backhaul for fixed wireless broadband and C-RAN. The performance demands for tele-protection signalling place heavy constraints on technology utilisation and configuration parameters and currently dictates the retention of TDM based radio equipment with packet radio for tele-protection was still under research.	
UKWISPA raised the following: • On 1.4 GHz **UKWISPA** would like to see this band made available for wireless internet service providers for fixed wireless broadband access in rural settings and would further welcome the opportunity discuss dynamic spectrum management to accommodate the needs of both mobile downlink and fixed rural broadband. • **UKWISPA** supported the unification of 57-64 GHz and 64-66 GHz and accommodating point to multipoint use.	To start the process of our considerations in relation to EU mandatory hamornisation measures, we have taken a decision to close the 1.4 GHz band to new links in 6 months from the publication of this statement. We note the comments on 60 GHz and 70/80 GHz and are making regulatory changes at 60 GHz to enable point to multipoint and mesh configuration of fixed wireless links. W and D bands are bands on which we plan to conduct further work and will take into consideration the types of fixed wireless links that could be used in future.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
• **UKWISPA** supported the continued access for fixed wireless links at E-band • **UKWISPA** considers that W and D bands have the potential to deliver high speed and reliable broadband services to citizens and consumers using point to point and point to multipoint solutions.	
Western Power Distribution raised serious concerns over the 26 GHz band being made available solely to mobile operators. They indicated that the energy industry need to be engaged to future proof requirements and explore spectrum sharing/coexistence within this band. **Western Power Distribution** specifically raised the following: • The electricity sector uses spectrum between 20-45 GHz, 23 GHz, 26 GHz and 38 GHz often used for a large number of embedded generation sites i.e. wind and solar farms. • The fixed wireless links provide **Western Power Distribution** with a cost effective and resilient solution that has already replaced BT private wires due to the BT21CN project. The current proposal will result in further impact with no resilient alternative available at present.	As highlighted in the main body of the document we are continuing with our policy development work both nationally and internationally to facilitate access to 26 GHz for mobile 5G services. We note the comment on the 20-45 GHz range and the importance of this range and other bands to the electricity sector. We however consider that the spectrum availability in this range for all uses of fixed wireless links will be adequate to meet future needs. As indicated in our consultation, our view is that making the 26 GHz band available for mobile is unlikely to have an adverse impact on the overall ability to provide connectivity by fixed wireless links given the greater use of self-managed spectrum expected by the dominant mobile backhaul uses as well as the shift in focus to higher frequency bands for higher capcity shorter hop links.

Question 2	
Do you agree with our conclusions on spectrum implications and our proposed strategy/next steps for each band? **Are there any other considerations of significance that you feel we should have included or do you have other comments to make/points to raise with us on these issues?** **Please provide as much detail as possible to support your answer.**	
Issue Raised	Ofcom Response
The 26 GHz band and other fixed wireless link bands is used for microwave communication for substation communications including electricity circuit protection.	
Wi-Fi Alliance supports initiatives associated with 5925-6425 MHz and 6425-6925 MHz for new spectrum for RLANs. On 66-71 GHz **Wi-Fi Alliance** refers to ITU and a number of countries for non IMT 5G licence expect use of "WiGig" technologies. **Wi-Fi Alliance** also refers to the FCC decision to maintain licence exempt use of 64-71 GHz and to expand these operations on board aircraft. **Wi-Fi Alliance** in addition indicates that there is no technical basis to confirm compatibility between IMT-2020 with planned licence exempt 5G operation in 64-71 GHz which negates harmonisation benefits.	Regarding possible RLAN use at 6 GHz, we are participating in the Spectrum Engineering Project Team SE45, which will produce ECC Reports considering the potential for sharing and compatibility analysis for RLAN services across CEPT/EU in the 5925 – 6425 MHz. The studies are still underway and are scheduled to conclude next year. Please see our responses to Q4-6 on 60 GHz

Question 3	
Do you agree with the items we have identified for further consideration? Are there any other significant areas that you believe should be included? If so, please include all necessary evidence to support your view.	
Issue Raised	Ofcom Response
Blu Wireless, BT/EE, CBNL, CCS, Lattice Semiconductor, Nokia AMNS XHAUL, Ruckus Wireless, techUK, UKWISPA, Vodafone agreed with the items we have identified for further consideration. In addition: **Blu Wireless** add that additional urgent priority should be given to consultation on the regulations for the 66-71 GHz band. **CCS** add that self-organising self-healing capabilities should be supported in the future to be able to deliver better QoS and coordination with higher capacity and efficiency. **techUK** further adds information about CEPT survey on 14.25-14.5 GHz indicating that only 5 administrations out of 25 have FS links in this band and that the band is not open in these countries (UK, France, Italy, Germany, Russia) for Fixed Satellite and Mobile Satellite Services and limit the growth of these services. **UKWISPA** believe that 55 GHz, W and D bands should be made available for fixed point to point and point to multipoint as these bands will be extremely valuable in allowing ultrafast and hyperfast short range links.	Our changes at 60 GHz will enable access for a range of new uses cases and technologies including applications that include self organising capabilities across 14 GHz of spectrum. See above re 14.25-14.5 GHz Our proposals to consider the 52 GHz and 55 GHz bands received very little evidence of demand to continue retaining these bands for fixed wireless links. Given our immediate proposals to make 14 GHz of spectrum licence exempt we consider that the 52 GHz and 55 GHz should be monitored with a view to making this spectrum available for other uses. See our responses to Q10 on W and D bands.
Facebook believes that Ofcom should further consider identifying additional mid-band frequencies for indoor and outdoor licence-exempt use such as 6 GHz (5925-7125 MHz) as this will be critical to growth of 5G as well as supporting existing, growing demand for RLANs. Facebook refers	Regarding possible RLAN use at 6 GHz, we are participating in the Spectrum Engineering Project Team SE45, which will produce ECC Reports considering the potential for sharing and compatibility analysis for RLAN

Question 3	
Do you agree with the items we have identified for further consideration? Are there any other significant areas that you believe should be included? If so, please include all necessary evidence to support your view.	
Issue Raised	Ofcom Response
to next generation of Wi-Fi standards IEEE802.11ax currently under development to support 6 GHz operations.	services across CEPT/EU in the 5925 – 6425 MHz. The studies are still underway and are scheduled to conclude next year.
Huawei adds • There is no need to promote 52 GHz and 55 GHz for future fixed wireless links • D band and its favourable propagation characteristics make it a high priority band for the industry with active work on this being conducted in ETSI and CEPT. • On W band **Huawei** encourage CEPT SE19 to draft regulations to secure the spectrum for the fixed service without pressing for industry investment in this band. • On V-Band **Huawei** encourage the allowed use of FWA, Wi-Gig like outdoor installations with EU regulations adapted accordingly.	We agree regarding the comment on 52 GHz and 55 GHz – little evidence was provided during the course of this review that suggested the requirement to retain this spectrum for fixed wireless links. We agree with the priority for D band and our decision is to further consider how we make this band available for future fixed wireless links. On W band we are engaged in the work of CEPT SE19 in relation to this band. On V band we agree with the comments made and are making changes to facilitate multigigabit wireless applications in the 57-71 GHz range.
The **IEEE 802 LAN/MAN Standards Committee** referred to the need for additional review of the 57-66 GHz and 66-71 GHz bands. **IEEE 802 LAN/MAN Standards Committee** indicated support for enabling alternative fixed wireless topologies, point to multipoint, mesh and others as mobile applications.	Please see out responses to Q4-6
Amongst other ideas identified by Ofcom, **Intel** indicates the need for further review and discussion relating to the 57-66 GHz and 66-71 GHz	Please see out responses to Q4-6

Question 3	
Do you agree with the items we have identified for further consideration? Are there any other significant areas that you believe should be included? If so, please include all necessary evidence to support your view.	
Issue Raised	Ofcom Response
band (V Band). **Intel** believes that an appropriate regulatory framework is needed to enable alternative fixed wireless topologies such as point to multipoint, mesh and others as mobile applications and services.	
Amongst other ideas identified by Ofcom, **Wi-Fi Alliance** indicates the need for further review and discussion relating to the 57-66 GHz and 66-71 GHz band (V Band). **Wi-Fi Alliance** believes that a regulatory framework is needed to enable alternative fixed wireless topologies such as point to multipoint, mesh and others as mobile applications and services.	Please see out responses to Q4-6
Intelsat makes the point about 14.25-14.5 GHz for new satellite applications covered in questions 1 and 2. It further adds information about CEPT survey on 14.25-14.5 GHz indicating that only 5 out of 25 administrations have FS links in this band and that the band is not open in these countries (UK, France, Italy, Germany, Russia) for Fixed Satellite and Mobile Satellite Services and limit the growth of these services.	Please see our response to Q1
JRC agrees with Ofcom's perspective on the need for reliable infrastructure to support energy distribution and Ofcom's need to monitor the change to a more distributed model which could result in the need for more fixed wireless links. **JRC** advises that the current resilient monitoring and control systems will need access to additional spectrum to support both an increase in active components being monitored and controlled and a geographic expansion of the active components.	We plan to consider the requirements of the electricity sector in Ofcom's wider work to understand how these needs are changing.

Question 3	
Do you agree with the items we have identified for further consideration? Are there any other significant areas that you believe should be included? If so, please include all necessary evidence to support your view.	
Issue Raised	Ofcom Response
SSE responded that proposed developments within millimetre wave bands should be considered complementary to conventional microwave bands. Millimetre wave spectrum cannot be considered as providing a direct replacement for microwave band spectrum for Utility applications due to the lack of protection and practical constraints of diminished availability and shorter path lengths.	Our decisions ensure that access to appropriate bands for fixed wireless links would continue.
Telefónica agree that unused bands 52 GHz and 55 GHz should be looked at to see if they too can be included for multipoint/mesh technologies.	Our proposals to consider the 52 GHz and 55 GHz bands received very little evidence of demand to continue retaining these bands for fixed wireless links. Given our immediate proposals to make 14 GHz of spectrum licence exempt we consider that the 52 GHz and 55 GHz should be monitored with a view to making this spectrum available for other uses.
Western Power Distribution's movement to DSO already requires additional spectrum to support the rising number of active components within a distributed and active electricity network. The rise in the number of active components and therefore the associated data will increase exponentially and will become increasingly critical to maintain a reliable electricity supply to connected customers and smart cities. **Western Power Distribution** therefore agrees that energy distribution – along with all the necessary communications and network management, monitoring and control functions – all require high reliability communications infrastructures. Reliable to the energy industry however also means resilient to power failure. As the energy industry moves to a	We agree that there is a need to look at the changes in the energy sector and consider what the impact would be on spectrum requirements. We plan to consider this in our wider work on this sector.

Question 3	
Do you agree with the items we have identified for further consideration? Are there any other significant areas that you believe should be included? If so, please include all necessary evidence to support your view.	
Issue Raised	Ofcom Response
distributed model indicated that they will and do require more fixed wireless links.	

Question 4	
Do you agree with our proposal to change the authorisation regime in the 64 – 66 GHz band to licence exempt to create a common authorisation approach across the 57 – 66 GHz band for fixed outdoor installation use and that this would be a benefit to UK citizens and consumers?	
Issue Raised	Ofcom Response
Blu Wireless, BT/EE, CBNL, CCS, Facebook, Huawei, Intel, Lattice Semiconductor, Nokia AMNS XHAUL, Optimity, Ruckus, Siklu, SSE, techUK, Telefónica, Vodafone and **Wi-Fi Alliance** agreed with our proposal to change the authorisation approach in the 64 – 66 GHz band to licence exempt. **A confidential respondent** indicated that since the IEEE802.11ad band plan covers the entire 57 – 66 GHz band, it would be reasonable to have access to the whole band without restriction or different constraints. It further pointed out that multipoint equipment will be operating in an environment with unpredictable quality of service which is not compatible with guaranteed quality provided by point to point radio links.	As set out in the main body of this statement we have decided to make the 64 – 66 GHz band licence exempt. With regards to the proposal for block assignment, as indicated in our impact assessment, whilst this could provide a better quality of service for individual mesh networks, we consider that there would be a number of disadvantages to this type of approach for this band, including limiting the possibilities for multiple different networks sharing the same spectrum and a potential reduction in innovation. Given the very limited take-up in the band, we don't consider it proportionate to retain the existing licensing regime. With regards to road transport and telematics, we are not changing the existing ITS regulations at 63- 64 GHz, at this stage, given ongoing work in CEPT. However, we note that the decision we are taking to extend the

Question 4	
Do you agree with our proposal to change the authorisation regime in the 64 – 66 GHz band to licence exempt to create a common authorisation approach across the 57 – 66 GHz band for fixed outdoor installation use and that this would be a benefit to UK citizens and consumers?	
Issue Raised	Ofcom Response
Horsebridge suggested that block assignment could be used to ensure better quality of service for mesh networks and **WISPA** suggested to retain the existing licensing regime and to review after two years. **Intel** and **Wi-Fi Alliance** indicated that the current technical conditions for wideband data transmission for road transport and telematics (SRD) with a maximum EIRP of 40 dBm for operation in a non-fixed outdoor installation remain appropriate to facilitate outdoor mobile/portable devices however they should be moved into the Channel 4 (63.72-65.88 GHz) to align it with WiGig channel arrangement.	technical conditions for licence exempt use in the 57 – 66 GHz band to 71 GHz band would enable road applications within the 63-64 GHz frequency range operating under the WiGig channel arrangement.

Question 5	
a) Do you agree with the proposed new technical conditions in Table 6 to facilitate equipment intended for fixed outdoor installation in the 57 – 66 GHz band? Please provide evidenced views /alternatives if you disagree with our proposal. Do you consider any additional conditions should be mandated as part of a licence exemption to manage the interference environment? **b) Do you agree with our assessment that the proposed changes in technical conditions will have minimal impact on existing use and are appropriate to manage the future outdoor interference environment?** **c) Are there likely to be any fixed outdoor installation use cases that will require operation at EIRP levels above 55 dBm? If so, please provide evidence of how the coexistence with the different outdoor users could be ensured?**	
Issue Raised	Ofcom Response
a) <u>Technical condition</u>	

Question 5	
a) Do you agree with the proposed new technical conditions in Table 6 to facilitate equipment intended for fixed outdoor installation in the 57 – 66 GHz band? Please provide evidenced views /alternatives if you disagree with our proposal. Do you consider any additional conditions should be mandated as part of a licence exemption to manage the interference environment? **b) Do you agree with our assessment that the proposed changes in technical conditions will have minimal impact on existing use and are appropriate to manage the future outdoor interference environment?** **c) Are there likely to be any fixed outdoor installation use cases that will require operation at EIRP levels above 55 dBm? If so, please provide evidence of how the coexistence with the different outdoor users could be ensured?**	
Issue Raised	Ofcom Response
Horsebridge, IEEE802 LAN/MAN Standards Committee, Intel, Optimity, Siklu, SSE, Vodafone Wi-Fi Alliance and WISPA agreed with the technical condition proposed by Ofcom. **Huawei** agreed with the technical condition for EIRP ≤ 40 dBm. A **confidential respondent** indicated that the technical requirement will not be applicable for fixed point to point service which is not compatible with the envisaged point to multipoint use cases. Additionally, for EIRP below 40 dBm, **Blu Wireless** and **Lattice Semiconductor** suggested relaxing minimum antenna gain to 15 dBi to enable practical implementation of 3D phased array antennas with simultaneous horizontal and vertical steering range. **CBNL** expressed that a value of 20 dBi is still high when accounting for losses in antenna systems and proposed a minimum antenna gain of 18 dBi. A **confidential respondent** indicated that setting an absolute minimum antenna gain could bring some implementation difficulties for phase	For EIRP ≤ 40 dBm, we have decided to specify a maximum transmit output power of 27 dBm which has replaced our consultation proposal of a minimum antenna gain of 20 dBi. This change will enable greater flexibility in the design of phased array antennas and implicitly requires a higher antenna gain to achieve higher EIRPs. For EIRP above 40 dBm, we consider that there is merit to consider further relaxation to the existing fixed wireless technical condition (30 dBi minimum antenna gain and 10 dBm maximum transmit power). We are of the view that this is best done as part of the ongoing work in CEPT to ensure a consistent European approach before changes are made to the national regulations. In the meantime, in line with our consultation proposals, we will retain the current technical conditions including the maximum EIRP at 55 dBm given there is limited evidence suggesting the need to increase EIRP above 55 dBm.

Question 5	
a) Do you agree with the proposed new technical conditions in Table 6 to facilitate equipment intended for fixed outdoor installation in the 57 – 66 GHz band? Please provide evidenced views /alternatives if you disagree with our proposal. Do you consider any additional conditions should be mandated as part of a licence exemption to manage the interference environment? **b) Do you agree with our assessment that the proposed changes in technical conditions will have minimal impact on existing use and are appropriate to manage the future outdoor interference environment?** **c) Are there likely to be any fixed outdoor installation use cases that will require operation at EIRP levels above 55 dBm? If so, please provide evidence of how the coexistence with the different outdoor users could be ensured?**	
Issue Raised	Ofcom Response
antenna arrays and that it is more realistic to introduce the notion of a margin (i.e. ±5dBi, as per typical values in commercial phase antenna arrays) to accommodate gain variations when the beam direction is off the boresight angle e.g. around the limit of its scan range. For EIRP above 40 dBm, **CCS, Facebook** and **Telefónica** suggested scaling the EIRP with antenna gain similar to the FCC approach with **Huawei** suggesting that the EIRP be capped at 55 dBm with maximum output power of 17 dBm at 38 dBi antenna gain. **Lattice** proposed that for 1 dB EIRP increase above 40 dBm, the antenna gain increase by 1 dBi starting from 15 dBi while **Blu Wireless** proposed similar relationship but with antenna gain starting from 20 dBi. **SSE** proposed that Class 4 antenna is mandated for higher EIRP but did not indicate the value of what the higher EIRP is. b) <u>Impact of technical condition</u>	

Question 5	
a) Do you agree with the proposed new technical conditions in Table 6 to facilitate equipment intended for fixed outdoor installation in the 57 – 66 GHz band? Please provide evidenced views /alternatives if you disagree with our proposal. Do you consider any additional conditions should be mandated as part of a licence exemption to manage the interference environment? **b) Do you agree with our assessment that the proposed changes in technical conditions will have minimal impact on existing use and are appropriate to manage the future outdoor interference environment?** **c) Are there likely to be any fixed outdoor installation use cases that will require operation at EIRP levels above 55 dBm? If so, please provide evidence of how the coexistence with the different outdoor users could be ensured?**	
Issue Raised	Ofcom Response
Most respondents agree that the proposed technical condition will have minimal impact on other services and that interference can be mitigated by intelligent self organising network capability. c) <u>Use cases above 55 dBm</u> **A confidential respondent, BT/EE, CBNL, Horsebridge, Intel, Lattice, Optimity, Ruckus, Siklu, SSE, techUK, Wi-Fi Alliance** and **WISPA** indicated that there are no envisaged use cases requiring EIRP above 55 dBm. **Blu Wireless, CCS** and **Facebook** suggested that higher EIRP could deliver longer range operation including for longer range access and backhaul application as well as for transport (road and rail connectivity). A **confidential respondent** indicated higher EIRP is not required in both the conventional point to point and multigigabit applications.	

Question 6	
a) What are the use cases and technical parameters envisaged for the 66 - 71 GHz band? Are they likely to be similar to those in the 57 – 66 GHz band? If so, what are your views on extending the same or similar technical conditions as described above for the 57 - 66 GHz band (both existing wideband data transmission (SRD) and new fixed outdoor technical conditions) to the 66 – 71 GHz band to facilitate both fixed and mobile use cases. **b) Please provide your view on whether the technical parameters of wideband data transmission (SRD) as shown in Figure 4 are suitable to facilitate mobile/portable equipment including use outdoor? If you do not consider they are suitable, what alternative technical parameters do you think should be considered?** **Please provide as much detail to your answer as possible and your considerations on the co-existence aspects.**	
Issue Raised	Ofcom Response
a) <u>Use cases and technical parameter in the 66- 71 GHz</u> **BT/EE, CCS, Facebook, Intel, Lattice, Optimity, Ruckus, Siklu, techUK, Telefónica, Vodafone, Wi-Fi Alliance** and **WISPA** agreed that the same technical condition in 57 – 66 GHz could be extended to the 66 – 71 GHz band. **A confidential respondent, BT/EE, Facebook, Intel, Ruckus, techUK, Vodafone** and **Wi-Fi Alliance** agreed that the 66 – 71 GHz is likely to be suitable to be made available on a licence exempt basis with **CSS, Huawei, IEEE802 LAN/MAN Standards Committee, Intel, techUK** and **Wi-Fi Alliance** further agreed that the band will be important for 5G. **Huawei** and **Nokia AMNS XHAUL** considered it premature to make the 66 – 71 GHz band available on a licence exempt basis noting that 57 – 66 GHz band has not been fully exploited.	We have decided to make the 66 – 71 GHz band licence exempt and with similar technical condition as the 57 – 66 GHz band. We disagree with the views that it would be premature to make the band available. Ofcom's duty is to secure the most optimal use of spectrum and we have a duty to exempt equipment if its installation or use is not likely to involve undue interference with wireless telegraphy. We consider that making available additional contiguous spectrum on a licence exempt basis and with the same technical conditions will secure optimal use of radio spectrum, facilitate innovation, lower the entry barrier and enable UK citizen consumer to enjoy the benefits provided by multigigabit applications and 5G as soon as possible. In relation to the guard band proposal, we have decided to introduce a 250 MHz frequency separation between the 57 – 71 GHz band (managed under licence exempt approach) and the Ofcom coordinated 70/80 GHz band for operation above 40 dBm EIRP. This is consistent with the approach taken

Question 6	
a) What are the use cases and technical parameters envisaged for the 66 - 71 GHz band? Are they likely to be similar to those in the 57 – 66 GHz band? If so, what are your views on extending the same or similar technical conditions as described above for the 57 - 66 GHz band (both existing wideband data transmission (SRD) and new fixed outdoor technical conditions) to the 66 – 71 GHz band to facilitate both fixed and mobile use cases. **b) Please provide your view on whether the technical parameters of wideband data transmission (SRD) as shown in Figure 4 are suitable to facilitate mobile/portable equipment including use outdoor? If you do not consider they are suitable, what alternative technical parameters do you think should be considered?** **Please provide as much detail to your answer as possible and your considerations on the co-existence aspects.**	
Issue Raised	Ofcom Response
Siklu recommended leaving a small guard band between the 66 – 71 GHz and E band to account for the different licensing schemes. b) Other comment **IEEE802 LANMAN Standards Committee, Intel** and **Wi-Fi Alliance** prefer not to seek IMT identification in the 66 - 71 GHz band due to potential to hinder other technologies currently accessing the 57 – 66 GHz band from accessing the 66 – 71 GHz band.	in the 70/80 GHz band separating the Ofcom coordinated and self-coordinated block. With regards to the proposal on technical conditions, as indicated in our response to Question 5, we will consider reviewing the technical condition for higher power operation above 40 dBm EIRP when CEPT has completed its work, which has been extended to include the 66-71 GHz band. In relation to comments on IMT identification, we note that this item is being dealt with as part of our WRC-19 preparation. Our current view is that we support an option to identify the band with an IMT identification footnote within the Radio Regulations at WRC-19 highlighting its use by technology neutral applications (for instance in a WRC Resolution).

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
BT/EE responded that their use of low capacity fixed wireless link applications has declined, and they have in the past experienced interference problems in the 1.4 GHz band, leading them to avoid new deployments. **BT/EE** do not presently foresee significant growth in demand for low capacity fixed wireless links. If the 1.4 GHz band were to no longer be available **BT/EE** indicated that they would consider whether use of other bands, including potential new low capacity channels at 6 GHz as mentioned by Ofcom, would be suitable.	We note the decline in some 1.4 GHz uses. We have decided to further consider making low capacity channels available in the 6 GHz bands in our forward programme of work.
BEIRG indicated that in light of the 700 MHz clearance, BEIRG has repeatedly pointed out to Ofcom UK that audio PMSE access to the 1350-1400 MHz band, in addition to the three sub-bands between 960 and 1164 MHz, could go a long way to mitigating the loss of PMSE access to the 700 MHz band as well as the resulting severe disruption of the 500 & 600MHz bands. ECC REC 70-03 and ECC REC 25-10 both now list the 1350-1400 MHz band as suitable for audio PMSE deployment. **BEIRG** indicated that Germany and Austria have opened the band to audio PMSE with consideration by others, notably France. **BEIRG** expresses regret that Ofcom UK does not currently share the same progressive approach to the band as other CEPT administrations, and **BEIRG** encourages Ofcom to	The potential future requirements for PMSE this is outside the scope of this review. Our view is that it is unlikely to be a feasible future solution. This is because the 1375-1400 MHz is used by the Ministry of Defence. However, given the uncertain availability in both the short and long term, we do not see this band as currently viable for allocation to PMSE use.

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
reconsider their approach in order to promote pan-European harmony in this area of spectrum and to provide support to a vital part of the UK's creative industries.	
CCS agreed that there would be a need for low capacity links in the future. However, **CCS** are seeing that in most industries the demand for data is shifting towards higher capacities	We agree that most demand in the future for fixed wireless links will be for high capacity uses, however our view is that we should considered he requirements for niche uses as well and we have decided to explore possibilities for low capacity uses at 6 GHz.
Huawei thinks there would be limited interest in such links and would encourage Ofcom to consider migration of such links to other bands to allow the availability of the 1.4 GHz band for mobile communications in the UK, benefiting from Europe-wide harmonisation measures.	We have decided to start the process of making the 1492-1517 MHz band for future downlink-only mobile use by taking the initial step to close this band and the paired sub-band to new fixed wireless links from 5 January 2019.
IEEE 802 LAN/MAN Standards Committee believes that relocating the current 26 MHz of 1.4 GHz users to 5925-5950 MHz or 7100-7125 MHz, will have minimal impact on proposed 6 GHz band.	We note this view and will take it into account in our considerations at 6 GHz.

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
Intel and Wi-Fi Alliance do not consider it spectrally efficient to migrate narrow 3.5 MHz channel fixed wireless links from 1.4 GHz to the 6 GHz band. **Intel and Wi-Fi Alliance** indicated that there is a lack of equipment availability for narrow band deployment at 6 GHz. The 3.5 MHz channel fixed wireless links at 1.4 GHz was a technology of the last century already replaced by 5 MHz and wider channels due to increased throughput demand. **Intel and Wi-Fi Alliance** consider that in most of the areas where the fixed wireless links at 1.4 GHz were deployed there is sufficient density of optical fibre backhaul where these links could be migrated to.	It should be noted that the most links at 1.4 GHz utilise channel sizes that are less the indicated 3.5MHz. As part of our future work we will consider the Lower 6 GHz band for possible future low capacity uses.
JRC notes that a range of technologies and systems are likely to be used to meet future Smart Grid requirements and suitable spectrum needs to remain available. **JRC** therefore agrees with the proposed access to the 1350 MHz Band and 6 GHz Band for narrow band / low data rate systems. **JRC** notes that utilities currently have approximately 300 1400 MHz FDD links. If necessary, and available, it is expected that these links would migrate to 1350 MHz TDD systems.	We note the comment from JRC about the possibility to migrate all 1.4 GHz links to TDD. We also however noted another response indicating that TDD may not be suitable for teleprotection applications of the utility sector. In the absence of further information on the potential for TDD use at 1350 MHz we therefore consider that we should consider the Lower 6 GHz band for possible future uses as CEPT channel plans have been developed for such uses and it is a possible solution that was also supported for exploration in the JRC response. We will however note the increase in

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
In addition, **JRC** notes that it is anticipated that the 1400 / 1350 MHz Bands will be used extensively with the planned geographic expansion of the monitoring and control components to encompass the Medium and Low Voltage layers of the energy networks. This may include a 100 times increase in channel access requirements across bands offering low data rate channels.	channel access requirements that are referred to in any further work we undertake on the wider spectrum needs of the electricity sector.
Ruckus agrees that there will continue to be a demand for narrow band low capacity links to satisfy the remote monitoring of national infrastructure and that this should be accommodated in UHF spectrum in the 450 MHz, where equipment is already available, range rather than centre gaps at 6 GHz with no equipment or standards currently available. **Ruckus** indicates that from a manufacturer's previous response to an Ofcom consultation highlight concerns that the 6 GHz band would not be a suitable alternative. **Ruckus** also referred to previous responses to another Ofcom consultation from some existing 1.4 GHz users that suitable spectrum between 420-470 MHz would be more appropriate. And with the move of some applications	We will consider this further in our considerations of Upper 6 GHz as a possible alternative low capacity band and our wider work on assessing the spectrum requirements with changes in the electricity sector

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
e.g. emergency services to LTE spectrum, finding 450 MHz spectrum is a feasible alternative.	
SAF Tehnika agree with the continued need for future low capacity fixed wireless link applications. **SAF Tehnika** referred to the need for power utilities and public safety companies to retain existing 1.4 GHz cabling and antenna infrastructure to avoid costly upgrades migrating to new (i.e. 6 or 7 GHz). In some cases, such upgrades would simply not possible due to the unavailability additional repeater sites. On the consideration of 'orphaned' fixed wireless link band at 1350-1375 MHz for use as a TDD fixed wireless link band in the future - as a major 1.4 GHz equipment supplier in EU, **SAF Tehnika** indicated that it had studied and concluded that it is possible to customize and tune the existing 1.4 GHz fixed FDD product to use 1350 – 1400 MHz band. Such product would still support narrow channels from 256kHz up to 8 MHz. Providing throughputs of up to 43Mbps in **SAF Tehnika's** opinion it would fully satisfy the demand for higher throughputs in utilities and public safety networks. At the same time will allow utilities and public safety companies to retain existing 1.4 GHz cabling and antennas infrastructure greatly reducing total cost of ownership.	We note the comment made about "migrating" existing links to 6 or 7 GHz and agree that our consideration of a possible solution at 6 GHz is unlikely to be a "migration" solution. We however consider that the spectrum at 6 GHz should be explored for a possible future solution for low capacity fixed wireless links. On the proposed request to consider the wider 1350-1400 MHz band for a potential future FDD solution for low capacity fixed wireless links, we consider it is unlikely to be a feasible future solution. This is because the 1375-1400 MHz is used by the Ministry of Defence.

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
As the 1375-1400 MHz spectrum used by the MoD, **SAF Tehnika** asks whether there is any possibility of releasing this band so that that it could be paired with civil spectrum 1350 – 1375 MHz just below it, thereby increasing the commercial value of the whole spectrum block 1350 – 1400 MHz.	
SIAE indicated as that their reference market is based on mobile backhaul and Industrial, Public and Safety applications, low capacity radio links are marginal and the minimum channel size, in case of microwave radio links, is today 3.5 MHz. They indicated that the use of low capacity links at 6 GHz, or generally up to 11 GHz, could fit a market overlap with current mobile backhaul equipment with the minimum information rate, in order of 10 Mbit/s, would allow migrating current narrowband application to IP platforms. The major benefits are a common technology currently based on large volumes. If an application is requiring hundreds of kbit/s, **SIAE** indicated that point-to-multipoint solutions offering similar capacities below 1 GHz, enabling nLoS links is available today.	We agree that the main trend is towards the use of high capacity fixed wireless links. We have therefore proposed to consider the bands gaps of the Upper 6 GHz band for future low capacity links.

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
SSE referred to the extent of the geography which their utility communications network covers means that they remain reliant both on high capacity radio links in the core network and on low capacity radio links at the edge of the network. As the penetration of fibre increases over time – for example with transmission line re-conductorisation including fibre provision – it is envisaged that fixed radio links will become less prevalent within the core network, but more so to the edge of the network given the anticipated growth in connectivity requirements. At this point in time, **SSE** indicated that requirements could be met by low capacity links although the capacity required per-site is likely to rise with implementation of new services. As requirements for connectivity penetrates deeper into the electrical network, **SSE** views that this is likely to bring significant challenge in establishing Line of Sight paths to very remote sites, which is where the propagation characteristics of lower frequency bands (e.g. 1.4 GHz) may enable links which otherwise would not be viable. The critical aspect of this is the ability to provide connectivity (as opposed to capacity), which may entail implementation of links over diffracted paths and with a low modulation scheme to maximise system gain and availability.	We agree that the utility sector makes use of fixed wireless links in a range of different bands to meet their requirements. We have noted the migration trend that could occur due to further fibre penetration in the core network and the associated impact of greater requirements for fixed wireless links at the edges of networks. We note the advantages that the 1.4 GHz band can offer from a fixed wireless link perspective however, this band has been identified for future mobile services.

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
TDD operation within the 1.4 GHz band is unlikely to meet latency objectives and therefore a band with comparable propagation characteristics would be required. Lower/Upper 6GHz is unlikely to fulfil these requirements and is likely to result in larger form factor antennas and the requirement for more rigid mounting structures and for taller structures to enable higher antenna elevation.	
Although **techUK** indicate that they had not come to a view, they note some members operate existing 1.4 GHz links and have an interest in continued narrowband access.	This response has been noted and as indicated we are proposing to consider the Upper 6 GHz band for possible future low capacity fixed wireless links.
UKWISPA consider that there will be a continued need for low capacity links to help achieve overall basic mobile coverage as well as to deliver the government's commitment to broadband USO. The 1.4 GHz band may well play a helpful role in this alongside TVWS. Equipment is available today that could be used by UKWISP members to provide low capacity broadband connections in excess of 10 Mbps to very low density populations.	We note the response in relation to the possible need for future low capacity links. Regarding possible future consideration of the 1.4 GHz band for TWVS including in low population areas, the EC Decision 2018/661 mandates the future use of this band for downlink only mobile services.
Vodafone indicated that they do not operate links in this band so consider the answer is best addressed by the incumbent users. **Vodafone** note that if incumbent usage is to continue, then the relevant Annual Licence Fee	We note this response. As indicated above the 1.4GHz has been harmonsied across Europe for downlink only mobile services.

Question 7	
Do you agree that there is a continued need for future low capacity fixed link applications? **If so, please provide information to support your view and what alternatives you would consider appropriate should the upper 1.4 GHz band no longer be available.** **Please provide clear evidence to support the reasons for your views.**	
Issue Raised	Ofcom Response
should reflect the opportunity cost of alternative applications being unable to use the band.	
Western Power Distribution currently does not have any links in the 1.4 GHz band as they have previously migrated onto the 26 GHz band due to the previous proposal to clear the 1.4 GHz band. **Western Power Distribution** strongly believes there is still a requirement for low capacity fixed wireless link applications as the equipment for this is cost effective, easily deployable and therefore a suitable solution to renewable energy generation and potentially future requirements of smart grid and smart cities.	We note this response and will consider the Upper 6 GHz as a possible future solution for low capacity fixed wireless links

Question 8	
Do you consider there is merit in considering making the bands 52 GHz and 55 GHz available under alternative authorisation approach(es) such as block assignment? If so, what would you consider to be the best approach(es)? Please provide detailed views to support your response.	
Issue Raised	Ofcom Response
BT/EE see no benefit in block assignment of these bands. Instead **BT/EE** would prefer the bands to be authorised on a conventional basis with individual links licensed on a first come first served basis.	We will monitor developments in the 52 GHz and 55 GHz bands. However, with limited interest in these bands for future fixed wireless links we do not plan to do anything specific in the near future but will keep options under review for potential new uses.
CBNL support block assignment of these bands on a technology neutral basis allowing both point to point and point to multipoint use. **CBNL** indicated preferential use by licensees made logical sense and that the blocks could be used to for displaced links due to 5G mobile services.	
CCS supports licence exemption or by licensing to allow mesh, p-p and p-mp systems. **CCS's** view is that in the future interference should be intelligently managed by the system than by the user. Alternatively, CCS indicate that microwave and millimetre wave bands could be managed on coordinated and shared basis using spectrum allocation servers.	
Horsbridge Network Systems indicated that if block assignment is used then this should be the same as the present E band model.	
Huawei indicated that here is no need to promote 52GHz and 55 GHz for future fixed wireless links given the limited amount of spectrum and scarce component availability in these bands.	
Nokia AMNS XHAUL do not see any interest in investing in 52 GHz and 55 GHz for Fixed Service applications as these bands do not have any key differences with traditional bands below 42 GHz.	

Question 8	
Do you consider there is merit in considering making the bands 52 GHz and 55 GHz available under alternative authorisation approach(es) such as block assignment? If so, what would you consider to be the best approach(es)? Please provide detailed views to support your response.	
Issue Raised	Ofcom Response
SIAE recommends that the ERC-Recommendation 12-11 is reviewed with a view to pairing the two bands to permit multigigabit links (from 2-5 Gbps) and that block assignment would be a preferred option.	
Telefónica considered that these bands should be made licence exempt similar to that being proposed for the 60 GHz band.	
Vodafone considered that there is no immediate demand or usage for these bands.	
Western Power Distribution would only consider this band as an alternative to the 38 GHz band.	

Question 9	
Do you think we should review our authorisation approach to any other band used for fixed wireless links?	
Issue Raised	Ofcom Response
Blu Wireless do not believe that any changes to other bands for fixed wireless links are appropriate at this time.	We have noted this view.
BT/EE have not identified any other fixed wireless link band for which the authorisation regime should be changed.	We have noted this view
CBNL suggested that the 31 GHz band should be made available via block assignment on a technology neutral basis. With its smaller size it may be suitable for both mobile backhaul and FWA applications	We agree that the 31 GHz band should be reviewed and have committed to reviewing this band in our forward programme of work.
CCS recommend that shared spectrum approaches should be considered as done by the FCC in the USA.	Most fixed wireless link bands are already shared with other uses. We will however continue explore ways in which further sharing could be considered.
Horsebridge recommend that a system should be developed for the 6-38 GHz bands to ensure that any unused licences are handed back to the pool to avoid users sitting on unused spectrum and blocking others.	Our current licences for fixed wireless links do not include mandatory requirements for link deployment within a given time period. Fixed wireless link licences are subject to administrative incentive pricing (AIP) and are also tradable. We are of the view that these measures are sufficient to allow for unwanted licenses to be traded to third parties as part of a normal market-based approach or surrendered back to Ofcom.
Huawei envisages the need to provide 10 Gbps at E band in Europe and to make this viable wider channel of 2 GHz would be recommended for E Band.	2.5 GHz channels are already possible at 70/80 GHz in the self-coordinated management block. We will however continue to monitor developments in the 70/80 GHz band

Question 9	
Do you think we should review our authorisation approach to any other band used for fixed wireless links?	
Issue Raised	Ofcom Response
Intelsat makes the point about making 14 GHz available for satellite applications as described in previous questions	Please see our response to Q1
Nokia AMNS XHaul propose a revision of E band in the future according to V band outdoor fixed operations introduction.	Little information was provided during the course of this review to suggest that the regime at 70/80 GHz should be made licence exempt similar to our decision at 60 GHz.
Optimity feel that Ofcom should review the differentiation between the two management approaches at E band.	We agree, and we plan to consider this as part of our forward programme of work.
Ruckus believes that a combination of Ofcom proposals for the 60 GHz band and current practice for the other bands meets user requirements now and for the foreseeable future.	We agree and have noted this response.
Siklu recommends the re-examination of the demarcation at E band. Siklu believes since the introduction of the mixed management approach for this band, the trend for self-coordinated use is much greater than that of Ofcom coordinated approach and that the reserved tranche should be made available as follows: 2x4 GHz for self-coordinated use 2x1 GHz for Ofcom coordinated use	We agree that the trend for usage in the self-coordinated blocks has been much greater than Ofcom coordinated blocks however evidence has shown that the 70/80 GHz is a band of strategic importance for future backhaul and access applications. We however do agree that the frequency separation should be reviewed, and further evidence should be gathered on this.
techUK has not identified any changes to the authorisation approach of any other existing fixed wireless link bands. One issue that has been discussed in the UK Spectrum Policy Forum is the desirability of significantly reducing the time taken to authorise fixed wireless links (issue	The Wireless Telegraphy (Licensing Procedures) Regulations 2010 provide the time limit for dealing with an application. Not considering international coordination this allows a period of up to six weeks after the day of the receipt of the application but in any case, it should be processed as soon as

Question 9	
Do you think we should review our authorisation approach to any other band used for fixed wireless links?	
Issue Raised	Ofcom Response
licences). The statutory target of 42 days is quite long compared with the requirements to rapidly roll out networks and is arguably more relevant to the past than the present era of modern spectrum management with sophisticated computer tools for interference coordination and licensing. **techUK** members (and the UK Spectrum Policy Forum) see benefits in online licensing with rapid decisions and would encourage Ofcom to explore what may be possible, both for existing fixed wireless links bands as well as future bands under consideration. Rapid authorisation of spectrum use will be increasingly important as 5G networks are rolled out, with potentially large numbers of cells being deployed in the future as network densification occurs.	possible after the day of receipt. Ofcom has for many years offered a batch electronic transfer mechanism for fixed wireless links which helps reduce turnaround times but does require some bespoke development by the applicant and is possibly not attractive to a smaller operator. Ofcom already uses automated assignment wizards and while these continue to improve will not dramatically reduce turnaround time. Ofcom is also considering on more e-enabled licence products where applicants can self-serve bringing more choice and flexibility in the application process.
UKWISPA believe that Ofcom should review the authorisation approach at 3.4-3.6 GHz, 3.6-3.8 GHz, 3.8-4.2 GHz and 26 GHz bands which should be made available for spectrum sharing for rural FWA and mobile wireless urban applications.	The 3.4-3.8 GHz band has been identified as the primary band for 5G in Europe as it offers increased capacity for mobile broadband over wide areas. We have completed the process of awarding 3.4-3.6 GHz and plan to award spectrum in the 3.6-3.8 GHz band in 2019. We will consult on our proposals for this award later in 2018. We plan to consider spectrum within the 3.8-4.2 GHz range for enhanced sharing which could include applications such as rural fixed wireless access. As indicated in our 5G discussion document we plan to further consider the 3.8-4.2 GHz spectrum on an increased shared basis, while taking into account existing use as well as compatibility with adjacent uses. We consider that this band could be used by a range of different players. We believe we could extend shared access to broadband wireless systems,

Question 9	
Do you think we should review our authorisation approach to any other band used for fixed wireless links?	
Issue Raised	Ofcom Response
	building on the current coordination arrangements for shared use already in place in the lower part of band and we plan to consider these ideas further and to publish a consultation on this band later in the year.

Question 10	
a) How do you envisage W band and D band will be used for mobile backhaul provision and the likely timescales? Please provide as much detail as possible on deployment scenarios and whether this would include indoor use. Are there any other types of applications (other than mobile backhaul) that could be suited for these bands? **b) What are your views on the most appropriate authorisation approach for the W and D bands? Please provide as much detail and technical evidence as possible in your answer.**	
Issue Raised	Ofcom Response
On future use and scenarios: • **BT/EE** indicated interest in utilising W Band for their backhaul architecture due to the large bandwidths available and suitable propagation characteristics. D band will support the extremely high capacity fixed wireless links relevant for future 5G developments. They indicate that these bands play an essential role in realising truly dense and heterogeneous mobile networks. • **CBNL** consider that these bands will come into use when E band is saturated. Expected use will be for middle mile transport for FWA • **Blu Wireless** refer to D band considerations for high capacity 5G backhaul by several manufacturers and operators in ETSI mWT Industry Specification Group on high capacity backhaul. **Blu Wireless** considers primary use in the USA by government applications may restrict operation at W band.	We note the industry drive to consider these bands for future fixed wireless links offering enhanced capacity options particularly at the edges of evolving networks. We also consider from the responses that the 130-178.5 GHz requirement could arise before the 92-114.5 GHz requirement. While responses consider that it may be a little early to consider authorisation approaches, there are strong indications that regulatory considerations for these bands would need to commence during the 5-year period covered by our forward work plan. We will therefore further consider both bands as part of our future programme of work prioritising on the 130-178.5 GHz range and subsequently the 92-114.5 GHz.

Question 10	
a) How do you envisage W band and D band will be used for mobile backhaul provision and the likely timescales? Please provide as much detail as possible on deployment scenarios and whether this would include indoor use. Are there any other types of applications (other than mobile backhaul) that could be suited for these bands? **b) What are your views on the most appropriate authorisation approach for the W and D bands? Please provide as much detail and technical evidence as possible in your answer.**	
Issue Raised	Ofcom Response
• **CCS** believes that these bands will be used for mobile backhaul in the future and that use will also be for both indoor and outdoor applications. This will allow quick and easy deployment of meshed 5G. • In addition to mobile backhaul, **Horsbridge** also consider use of these bands CCTV and Wi-Fi access point backhaul with radios that could be integrated into end devices especially in areas that can't be connected by fibre. Indoor uses would be application dependent. • **Huawei** envisage two applications: backhaul and fronthaul for 4.5G and 5G (exploiting wide channels for ultra-high capacity and small antennas) and for Fixed Wireless Access (safe cities, urban areas, exploiting high frequencies for very compact low power consumption and TCO). **Huawei** expects that commercial equipment will not be likely before 2020. • **A confidential respondent** considers W band to be an extension for E band but not before 10 years from now. D band could start to be exploited from 4-5 years from now.	

Question 10	
a) How do you envisage W band and D band will be used for mobile backhaul provision and the likely timescales? Please provide as much detail as possible on deployment scenarios and whether this would include indoor use. Are there any other types of applications (other than mobile backhaul) that could be suited for these bands? **b) What are your views on the most appropriate authorisation approach for the W and D bands? Please provide as much detail and technical evidence as possible in your answer.**	
Issue Raised	Ofcom Response
The main scenarios envisaged by **the respondent** are extremely high capacity fronthaul/backhaul for dense urban small cells (also a shift toward C-RAN); Extremely high capacity fronthaul/backhaul for macro cells using BCA approach with lower frequency bands; Wireless fibre access; high capacity street level connectivity (e.g. smart city, public safety) • **SIAE** indicated that W band will be used where E band is congested to carry a maximum capacity of 20 Gbps. **SIAE** believe that D band requires on-going technology development of active components and antenna systems and a timescale of 5-10 years seems a reasonable plan to introduce equipment in this band. **SIAE** raise the allocation method, optical line interface cost and power consumption and the applications anticipated as key factors that will impact the introduction of this band. • **techUK** refer to the importance of both bands for the support of extremely high capacity transmission which could be important for mobile network infrastructure and	

Question 10	
a) How do you envisage W band and D band will be used for mobile backhaul provision and the likely timescales? Please provide as much detail as possible on deployment scenarios and whether this would include indoor use. Are there any other types of applications (other than mobile backhaul) that could be suited for these bands? **b) What are your views on the most appropriate authorisation approach for the W and D bands? Please provide as much detail and technical evidence as possible in your answer.**	
Issue Raised	Ofcom Response
stress the importance of devising the authorisation regime at an early stage and that innovation and exploitation of these bands are encouraged. On timescale, **techUK** indicate would to some extent depend on how soon the bands are available and the authorisation approach. • **UKWISPA** raises concerns that Ofcom only mentions mobile backhaul and believes that these bands should be made available for point to point fixed wireless links and should be made available for point to multipoint for high speed last mile access if equipment vendors are able to develop products in these bands. • **Vodafone** refers to a certain amount of technology trialling of equipment, particularly in the D band. **Vodafone** expects equipment for D-band will likely be used either on a full duplex/FDD or TDD basis, most likely for fronthaul capability to small cells. **Vodafone** however do not realistically expect commercial availability of equipment until 2022 at the earliest.	

Question 10	
a) How do you envisage W band and D band will be used for mobile backhaul provision and the likely timescales? Please provide as much detail as possible on deployment scenarios and whether this would include indoor use. Are there any other types of applications (other than mobile backhaul) that could be suited for these bands? **b) What are your views on the most appropriate authorisation approach for the W and D bands? Please provide as much detail and technical evidence as possible in your answer.**	
Issue Raised	Ofcom Response
On authorisation for W Band: • **BT/EE, SIAE** intend for W Band to be expansion band for the Ofcom coordinated part of E Band. **BT/EE** propose a similar licensing regime with and online, on demand licensing system. **techUK** suggests that to allow the rapid deployment required, licences should be via an online system with licenses agreed in principle and instantly confirmed in a few days • **CBNL** believe that W band should be block assigned on a technology neutral basis. **Huawei** propose a block-based approach enabling flexible duplexing or duplex free operation or fixed duplexing. • **Blu Wireless** consider W band requires further consultation with government users before an approach can be determined. • **CCS** recommend that W band is not limited to point to point only – mesh and point to multipoint should be permitted. **CCS** recommend licence exempt or block allocation.	

Question 10	
a) How do you envisage W band and D band will be used for mobile backhaul provision and the likely timescales? Please provide as much detail as possible on deployment scenarios and whether this would include indoor use. Are there any other types of applications (other than mobile backhaul) that could be suited for these bands? **b) What are your views on the most appropriate authorisation approach for the W and D bands? Please provide as much detail and technical evidence as possible in your answer.**	
Issue Raised	Ofcom Response
• **Horsebridge** propose light licensing of W band • **A confidential respondent** proposes geographic based block assignment but with a reasonable area size. To preserve access to smaller users some block should be left for self-coordinated use on a link by link basis. **SIAE** also propose that W band should be allocated by geographic based block assignment. • **UKWISPA** believe it is relatively early to judge on the authorisation approach for these bands. • Due to the expected development of these bands **Vodafone** considers that although a light-touch regime appears appropriate (potentially, per E-band with a mix of licensed and licence-exempt frequencies), it is premature to reach firm conclusions with respect to licensing models. On authorisation for D Band: • **BT/EE** consider that D band should be block assigned to MNOs to build ultra-dense networks and to support innovation. **CBNL** also propose block assignment but on a	

Question 10	
a) How do you envisage W band and D band will be used for mobile backhaul provision and the likely timescales? Please provide as much detail as possible on deployment scenarios and whether this would include indoor use. Are there any other types of applications (other than mobile backhaul) that could be suited for these bands? **b) What are your views on the most appropriate authorisation approach for the W and D bands? Please provide as much detail and technical evidence as possible in your answer.**	
Issue Raised	Ofcom Response
technology neutral basis. **teckUK** also propose block allocation - with the very large bandwidths available, multiple operators could be accommodated. • **Blu Wireless** express a general view that D band should be lightly licensed for MNO deployment and **Horsbridge** also propose a light licensing approach • **CCS** recommend that W band is not limited to point to point only – mesh and point to multipoint should be permitted. **CCS** recommend licence exempt or block allocation. • **Huawei** propose a block-based approach enabling flexible duplexing or duplex free operation or fixed duplexing. Channel sizes of 5GHz at D band is suggested for the applications envisaged. • **A confidential respondent** proposes area-based block assignment but with a reasonable area size. To preserve access to smaller users some block should be left for self-coordinated use on a link by link basis. **SIAE** also propose	

Question 10	
a) How do you envisage W band and D band will be used for mobile backhaul provision and the likely timescales? Please provide as much detail as possible on deployment scenarios and whether this would include indoor use. Are there any other types of applications (other than mobile backhaul) that could be suited for these bands? **b) What are your views on the most appropriate authorisation approach for the W and D bands? Please provide as much detail and technical evidence as possible in your answer.**	
Issue Raised	Ofcom Response
that D band should be allocated by geographic based block assignment but be limited to nx10 Gbps links. • **UKWISPA** believe it is relatively early to judge on the authorisation approach for these bands. • Due to the expected development of these bands **Vodafone** considers that although a light-touch regime appears appropriate (potentially, per E-band with a mix of licensed and licence-exempt frequencies), it is premature to reach firm conclusions with respect to licensing models.	

Question 11	
Which capacity enhancing technique(s) are you using or planning to use? Please provide detail / evidence and clearly explain why and how each technique is planned to be used and if you consider there are any other aspects that should be considered.	
Issue Raised	Ofcom Response
TDD **Siklu,** recommends that TDD is viewed as capacity enhancing, and as such, is not excluded in future regulation of millimetre wave bands. **BT**, consider that TDD operation is interesting, noting the issues about the current band-plans and usage, they would be interested in exploring TDD for W-band, as this would align well with the data centric traffic of ultra-dense networks. **Optimity**, consider that TDD is the most effective way to maximise the spectrum	We note the comments with respect to the Time Division Duplex (TDD) technique and that a number of bands already support this including the 5.8 GHz, the block assigned awarded bands, 60 GHz and 70/80 GHz bands
Re-Use factor of millimetre waves **Siklu**, consider that is already very high re-use factor in millimetre waves and see this as a good capacity enhancing technique. **Optimity**, recognise that the re-use factor makes technology very efficient already	We have noted the comments relating to the re-use of millimetre waves and agree that high re-use factor is a component of overall spectrum efficiency.
Band aggregation, Multiband aggregation, Multi band link aggregation **Blu Wireless Technology Ltd,** indicated that relevant and emerging wireless industry standards such as IEEE 802.11ay4, aimed at ratification during 2019, will support band aggregation (from 4.3 to 8.6 GHz) and	We note the comments on the potential interest inBand/Multiband aggregation. From a licensing perspective this would require the fixed wireless links to be individually coordinated and licensed. We intend to

Question 11	
Which capacity enhancing technique(s) are you using or planning to use? Please provide detail / evidence and clearly explain why and how each technique is planned to be used and if you consider there are any other aspects that should be considered.	
Issue Raised	Ofcom Response
therefore recommend that Ofcom monitors developments in this forum to anticipate any impact on required regulations. **BT**, are investigating the possibility of deploying multi-band solutions. **Nokia AMNS XHAUL,** considers that Band and Carriers Aggregation, BCA is the most innovative technique on top of existing ones (such as packet compression, high QAM). **Huawei Technologies,** envisage carrier and/or band aggregation to enable higher capacities links **One respondent** considers that Multi-band link aggregation is another viable approach for capacity enhancing. **SSE,** indicated that availability of multiband systems appears of interest with the potential to enable a microwave Point to Point link transporting latency-critical traffic, in conjunction with a higher capacity millimetre band Point to Point link to meet capacity demands. However, a ring topology is probably more appropriate to improve on the degraded availability of the millimetre link component. **Vodafone Limited,** sees merit in the band aggregation approach.	monitor developments and we will continue to gather information on this as part of our ongoing programme of work.

Question 11	
Which capacity enhancing technique(s) are you using or planning to use? Please provide detail / evidence and clearly explain why and how each technique is planned to be used and if you consider there are any other aspects that should be considered.	
Issue Raised	Ofcom Response
MIMO **Horsebridge Network Systems,** Licensed MIMO would be considered instead of XPIC in the lower frequency bands especially for longer links and frequency availability. **Huawei Technologies,** consider that MIMO techniques to improve spectral efficiency and capacity, at least for those frequency bands which allow a reduced spatial antenna separation (higher frequency bands) **Nokia AMNS XHAUL,** consider that block assigned would enable innovation in networking and equipment solution itself, such as FD, MIMO, OAM and so on. **One respondent** considered that the capacity enhancement technologies that are used in 3.6 GHz spectrum include special antennas for both frequency reuse and MUMIMO (Multi-user MIMO). A least one company provides a system which enables 5.6 Gbps from 80MHz bandwidth in 4 sectors. i.e. 70 bps/Hz.	We note the views on line of sight MIMO and we will monitor work being carried out at international level.

Question 11	
Which capacity enhancing technique(s) are you using or planning to use? Please provide detail / evidence and clearly explain why and how each technique is planned to be used and if you consider there are any other aspects that should be considered.	
Issue Raised	Ofcom Response
XPIC **BT,** currently use XPIC (cross-polarisation interference cancelling technology) to enable optimisation of single channel usage and increase overall data rate. **Horsebridge Network Systems,** are looking at using XPIC links where possible under the current regulatory scheme, for a fixed wireless network operating in the 6 – 38 GHz bands. **Nokia AMNS XHAUL,** consider that cross-polar operation in traditional bands (up to 42 GHz) should be favoured. **One respondent**, indicated that the most reliable current technique is the XPIC with continuous improvements based on the growth of modulation complexity (4096-QAM and over) and/or higher frequencies (E band).	XPIC is currently permitted under the current regulation for fixed wireless links. Ofcom encourage the use of XPIC where possible to enhance capacity.

Question 11	
Which capacity enhancing technique(s) are you using or planning to use? Please provide detail / evidence and clearly explain why and how each technique is planned to be used and if you consider there are any other aspects that should be considered.	
Issue Raised	Ofcom Response
Full Duplex **BT/EE** indicated that there is also future potential for full-duplex however it seems like there is much to do before we could implement such solutions. **CBNL, concur** with the reservations at ¶5.48 about its introduction to existing bands. Full duplex operation requires very accurate cancellation of transmitted signals. It is unclear how this can be effected in real-world scenarios with a plurality of links, where adjacent channel transmissions from collocated equipment may cause interference. (These signals would normally not interfere because of the high-low coordination). **Vodafone UK,** believes that at this stage they remain agnostic as to the benefits of full duplex operation but will review this should equipment supporting this mode come to market – we do not envisage this until 2022 at the earliest.	We note the views on Full Duplex operations which show that there is still more to do before this technique can be implemented. As indicated in our consultation document we consider that is unlikely that this type of operation could be deployed in the current Ofcom managed technically assigned fixed wireless links bands without significant replanning, particularly due to high-low clashes that will be generated with such configuration.

Question 11	
Which capacity enhancing technique(s) are you using or planning to use? Please provide detail / evidence and clearly explain why and how each technique is planned to be used and if you consider there are any other aspects that should be considered.	
Other issues raised	Ofcom Response
CCS have developed cognitive radio intelligence SON using dynamic spatial multiplexing techniques to ensure that system capacity is delivered at maximum spectral efficiency, within a single frequency channel. This is achieved by continually measuring self and 3rd party interference and then harnessing switch beam antennas or multiple high capacity phased array transceivers. **Horsebridge Network Systems,** believe that in the SME field, any capacity enhancement will be driven by the need to the customer and the application**.** **Huawei**, envisage a sophisticated interference mitigation technique like CCIC (co-channel interference canceller) to allow and improve efficient use of spectrum **SSE,** believes that within the microwave bands and in relation to Utility use, most capacity enhancing techniques (e.g. Adaptive Modulation or improved system gain through advanced Forward Error Correction) are complicated due to degradation in latency performance and variation.	Ofcom notes these views and will monitor developments in these areas.