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Enabling opportunities for innovation

Shared access to spectrum supporting mobile technology

CONSULTATION:

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Annex

1. Overview

Spectrum provides the airwaves that support wireless services, including mobile phones, used by people and businesses every day. Ofcom manages the use of spectrum in the UK. Our ambition is to see comprehensive mobile coverage for people across the UK, and to create opportunities for innovation across the UK economy.

This document consults on proposals to make spectrum available in a range of spectrum bands on a shared basis. This spectrum could support deployment of local networks in sectors including industrial Internet of Things (IoT), enterprise, logistics, mining and agriculture, as well as help to improve the quality of coverage in poorly served areas.

It complements our proposals[1] to award national licences for the 700 MHz and 3.6-3.8 GHz mobile spectrum by auction.

In brief

In order to ensure users have access to suitable spectrum to meet their needs, we propose to:

enable them to access a number of spectrum bands, which support mobile technology, in locations unused by other licensed users. These are: 3.8-4.2 GHz, the 1800 MHz shared spectrum[2] and the 2300 MHz shared spectrum[3] ("the three shared access bands"). Potential users would be able to make a simple request to Ofcom specifying the bands and the locations in which they wish to operate. To achieve a simple process applicable across the three shared access bands, we are also proposing to change the current authorisation approach in the 1800 MHz shared spectrum from "self managed" to "Ofcom managed"; and

facilitate access, through engagement with incumbent licensees, to awarded mobile spectrum covered by the Mobile Trading Regulations.[4] These are currently the 800 MHz, 900 MHz, 1400 MHz, 1800 MHz, 1900 MHz, 2100 MHz, 2.3 GHz, 2.6 GHz and 3.4 GHz bands.

This overview is a simplified high-level summary only. The proposals we are consulting on and our reasoning are set out in the full document.

Our aim

1.1 We want to see good quality wireless broadband coverage where people live, work and travel across the UK, both now and in the future as the next generation of mobile technologies (5G) becomes available. We also want to encourage the development of new

[1] Ofcom, *Award of the 700 MHz and 3.6-3.8 GHz spectrum bands,* 18 Dec 2018, https://www.ofcom.org.uk/consultations-and-statements/category-1/award-700mhz-3.6-3.8ghz-spectrum
[2] 1781.7-1785 MHz paired with 1876.7-1880 MHz
[3] 2390-2400 MHz
[4] Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011, as amended, http://www.legislation.gov.uk/uksi/2011/1507/contents

uses which will benefit both businesses and consumers. Facilitating access to spectrum for new users plays an important role in encouraging innovation.

1.2 We have published a document[5] setting out our proposals to award national licences for some spectrum to deliver mobile broadband for consumers. Alongside this, we recognise there is growing interest in using mobile technologies (including 5G) for a range of applications on a localised basis.

1.3 Stakeholders have indicated that access to spectrum, amongst other requirements, could enable:

- private networks that could facilitate industrial IoT applications, including wireless automation and robotics, that require low latency and high reliability connectivity;
- rural broadband connectivity using fixed wireless access (FWA), especially in areas where rolling out fast fixed broadband may not be not commercially viable. This would add to existing spectrum options for FWA; and
- improved mobile coverage, addressing urban and rural not-spots (indoors and outdoors), provided by third parties acquiring spectrum in specific locations (subject to roaming agreements with mobile network operators).

1.4 We've considered the local nature of demand, and the fact that bands supporting mobile technologies are generally in use but may not be used everywhere. We think spectrum sharing in bands supporting mobile technologies could provide spectrum options for innovation and new uses.

Our proposals

Proposals for the three shared access bands

1.5 We are proposing to enable shared access in three bands ("the three shared access bands") that support mobile technology, each of which is adjacent to bands which have been made available, or are being considered for, national mobile use:

- **3.8-4.2 GHz**: This band is currently used by satellite Earth stations, point-to-point fixed links and wireless access applications (fixed) by UK Broadband.[6] Deployments in the band are technically coordinated by Ofcom on a first come, first served basis. We have already indicated in our Annual Plan[7] our intention to consult on proposals for greater shared access in this band. The band could be used for private networks that automate processes in a range of industries and more broadly support IoT. It is adjacent to the 3.4-3.8 GHz band which has been identified as a primary 5G band in Europe. 5G technology standards cover this band and radio chipsets[8] supporting this band are available for equipment vendors to develop equipment. Several countries are looking

[5] Ofcom, *Award of the 700 MHz and 3.6-3.8 GHz spectrum bands,* 18 Dec 2018, https://www.ofcom.org.uk/consultations-and-statements/category-1/award-700mhz-3.6-3.8ghz-spectrum
[6] Acquired by Hutchison 3G UK Limited in 2017.
[7] Ofcom, *Annual Plan 2018/19*, 28 March 2018, https://www.ofcom.org.uk/__data/assets/pdf_file/0017/112427/Final-Annual-Plan-2018-19.pdf
[8] In this context, we refer to RF modules that could be integrated into radio equipment.

to make this band available for 5G. This band, in addition to a number of existing bands, could also be suitable for providing rural broadband connectivity. We understand some FWA equipment adopts proprietary technology which could be tuned to the 3.8-4.2 GHz band. The ability of existing users to continue to access the band on a first come first served basis will continue under these proposals.

- **1800 MHz shared spectrum**: This is the 1781.7-1785 MHz paired with 1876.7-1880 MHz band which is currently authorised to 12 Concurrent Spectrum Access (CSA) licensees on a shared basis through an award process. We have previously indicated that we are considering expanding access to the band to a wider set of users.[9] This band is already supported by mobile networks and handsets (using either 2G or 4G technology), meaning it can be used immediately. It is suitable for voice, text and low data rate applications. It could be used by third parties seeking to extend mobile coverage in rural areas and in buildings, or for local private mobile networks.
- **2300 MHz shared spectrum**: This is the 2390-2400 MHz band. There are some MOD deployments in this band. As above, this band is already supported by 4G mobile networks and handsets making it suitable for similar applications as in 1800 MHz shared band but with more capacity.

1.6 We propose a common approach for users to access these bands. Companies will apply to Ofcom for a licence for a specific location. For each licence application, we will assess interference with regards to and from other licensees in the band, based on our proposed coordination parameters and methodology. Assignments will be made on a first come, first served basis with regards to other users in the band (both new and incumbent). This will provide a simple way for users to access spectrum where they need it, with a choice of bands to suit their needs and with certainty in spectrum access and quality of service.

1.7 We propose two types of licence (distinguished primarily by permitted power levels) to cater for different types of potential uses:

- **Low power licence for local connectivity (per area licence)**. This would allow users to deploy as many base stations as they like within a 50 metre radius circle without further authorisation from Ofcom. Potential licensees could apply for multiple adjacent licence areas if the required coverage area is larger than the area defined by a single licence.
- **Medium power licence for longer range connectivity (per base station licence).** Given the higher transmit power and larger potential interference area, we propose to authorise medium power base stations on a per base station basis and to initially limit deployments to rural areas only,[10] where they are unlikely to constrain low power users.

1.8 Annex A7 shows the potential spectrum availability in the 3.8-4.2 GHz band for the proposed low and medium power licence.

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[9] Ofcom, *Update on the DECT guard band policy*, 30 June 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/103617/Update-on-the-DECT-guard-band-policy.pdf

[10] In this document, we define rural as in paragraph 4.15 which is different from the definition used in other Ofcom documents.

1.9 We propose cost-based licence fees to recover Ofcom's cost of managing the licensing process where spectrum demand does not outstrip supply. Fees would be applicable for both the low power (charged on a per area basis) and medium power (charged on a per base station basis), and payable annually:

- **£80 per 10 MHz** (for 3.8-4.2 GHz and 2300 MHz shared spectrum, so 20 MHz = £160; 100 MHz = £800 etc.
- **£80 for 2x3.3 MHz** (for 1800 MHz shared spectrum).

1.10 As the demand for these new licences is currently uncertain, we will keep fees under review, following implementation, as we gather more evidence on actual use. We expect to consult on proposals to change the fee only if we believe there is evidence to do so.

1.11 We will add additional spectrum to this framework when we believe it appropriate to do so.

Proposals to change the authorisation approach for existing CSA licensees in 1800 MHz shared spectrum

1.12 Our aim is to have a single authorisation approach for new users to access all the three shared access bands. Consequently, we propose to change the existing approach for CSA licensees in the 1800 MHz shared spectrum to align with what we are proposing for new users in the band.

1.13 We are proposing that Ofcom authorises, coordinates and charges licence fees on a per base station/area basis. This will remove the current need for existing CSA licensees to continue maintenance of a deployment database and to self-coordinate with other users.

Proposals for access to awarded mobile spectrum

1.14 We recognise that in relation to some of the uses discussed above (in particular, for private networks and mobile coverage improvement schemes) a number of third parties have also expressed a wish to exploit mobile bands, which are licensed to mobile network operators (MNOs) but may be "unused" in some locations. We also recognise that initiatives such as coverage improvement schemes, if realised, have the potential to deliver significant benefits for the individual communities that they serve. Our new approach to facilitating third party access to awarded mobile spectrum (discussed below) will remove one of the barriers to establishing these schemes.

1.15 Our proposed authorisation approach to the three shared access bands recognises that in those bands, existing and future use is licensed subject to coordination for each local deployment. In this case, a first come first served approach in areas where there is not an existing licensed deployment is appropriate. However, in the case of awarded mobile spectrum, the incumbent licensees have been granted licences which allow them to deploy anywhere on a national basis in the bands described in their licence. This means that there are no "unlicensed" areas. There may, nevertheless, be areas where licensed spectrum is not being used and could be shared at that location with a third party. Local shared access in this case though must respect the rights of the existing licensee and not interfere with or constrain their operations.

1.16 We are therefore proposing an approach for new users to access awarded mobile spectrum in locations where we agree this would not adversely impact the incumbent licensee's planned use of the spectrum.

1.17 Under this approach, a third party would apply to us for a local access licence to use specific frequencies at a particular location (this can be in any of the mobile bands licensed to MNOs as set out in the Mobile Trading Regulations).[11] We would engage with the relevant MNO(s). If they raise a reasonable objection, then the application would be declined. If they agree this does not adversely impact their planned use of the spectrum, then a local licence would be issued.

1.18 Depending on the request received, we may authorise a single transmitter site or local area. Each request will be dealt with on a case by case basis, with the licence reflecting the agreed transmission location/service area, frequency and power parameters.

1.19 We propose that the new local access licence will be time limited and have a minimum period of three years. We believe that the minimum three-year period is a reasonable time frame over which an MNO will have sufficient certainty about their deployment plans to respond quickly to the request. It also provides new users with a substantial time period over which they can expect to use the spectrum. Nevertheless, we recognise that some users may want to agree access for more than three years. We will grant a longer duration licence if this has support of the relevant MNO(s) – this could be on the back of a commercial agreement between the MNO(s) and the third party. We note here that this longer-term view requires more detailed analysis of future plans. In either case, we propose a one-off cost-based licence fee of £950 per licence. At the end of the three-year licence term (or the longer term as supported by MNOs), users can reapply for a new licence and would again pay the associated licence fee.

1.20 This licensing approach would sit alongside our existing spectrum trading framework. Although the spectrum trading process provides for a licensee to share access to spectrum with a third party, most spectrum trades tend to involve the outright transfer of rights from one party to the other and result in new licences being issued to both parties to reflect this change. For trades involving mobile spectrum, Ofcom may first consider whether approving a trade could distort competition.

1.21 In circumstances where access to spectrum is only required in specific locations and is being shared with the existing licensee, we consider that our proposed approach could provide an option that is less burdensome than spectrum trading, both for new users and incumbent licensees.

1.22 Some stakeholders have asked whether we would allow spectrum leasing in mobile bands as an alternative to the spectrum trading process. Spectrum leasing is not currently permitted in most of our licences, including the mobile licences (it is only allowed in some business radio and spectrum access licences on a case by case basis). Unlike spectrum trading, leasing does not require any changes to the incumbent's licence since the lessee operates under the terms of that licence and in accordance with an agreement reached

[11] Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011, as amended, http://www.legislation.gov.uk/uksi/2011/1507/contents

with the primary licensee. So far, we have not seen demand for an extension of the leasing approach to other licences. We believe licensees may have little incentive to engage with third parties to lease their spectrum given the potential risk to them; i.e. the process requires the licensee take responsibility for the actions of its lessees. We will keep our spectrum leasing policy under review, particularly in the light of our alternative proposal. We have noted in previous consideration of leasing in mobile bands that this may raise competition issues.

1.23 We believe our proposed local licensing approach can achieve the same outcomes as leasing but is more likely to be successful in encouraging an agreement between parties since it does not place responsibility for the third party on the incumbent licensee.

Evolution towards Dynamic Spectrum Access (DSA)

1.24 We believe our proposals would provide the quickest route for new users to access the proposed three shared access bands.

1.25 We note that a DSA approach could provide users more flexible access to spectrum as devices would automatically connect to a central database and be assigned spectrum based on availability at that time and location. From a spectrum management perspective, this would also ensure an efficient use of shared spectrum but a DSA solution would likely take longer to develop and test.

1.26 We will, however, explore the potential for introducing DSA in the three shared access bands. We would like to work with industry to define the appropriate specification for both DSA equipment and database capability that would enable future transition to DSA.

Next steps

1.27 We intend to publish a statement in Q2 2019 to confirm our proposals. Subject to the statement, we expect to consult on the exemption regulations for mobile terminals.

1.28 We intend to make new licences available in the second half of 2019 and will confirm the timing when we publish our statement.

1.29 In addition, following our decision and subject to the outcome of the consultation, we would implement licence variation process for existing CSA licensees in the 1800 MHz shared spectrum as soon as practical.

2. Shared access in spectrum bands supported by mobile technology

Relevant statutory duties and powers

The Wireless Telegraphy Act 2006 ("the WT Act")

Duties imposed by the WT Act

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

2.2 We also have a duty to have regard, in particular, to the desirability of promoting: (i) the efficient management and use of the spectrum for wireless telegraphy, (ii) the economic and other benefits that may arise from the use of wireless telegraphy, (iii) the development of innovative services and (iv) competition in the provision of electronic communications services (WT Act, s. 3(2)).

Securing optimal use of spectrum

2.3 Spectrum is a scarce resource. There is increasing demand for new wireless applications in frequency bands already allocated to other users.

2.4 In particular, there is growing interest in the use of mobile technology (LTE, 5G New Radio[12] or proprietary adaptations) as the technology of choice for wireless applications beyond consumer mobile broadband, such as provision of local private networks for manufacturing, enterprise, logistics, mining and agriculture. This is influenced by the availability of global harmonised standards for the development of radio chipsets that can be adapted for different wireless connectivity solutions.

2.5 Spectrum where mobile technology can be used has generally been licensed on a national basis to enable operators to offer mobile services to meet national demand for mobile broadband. We consider that this is the most efficient way to meet this demand and for the same reason are proposing a similar approach in our upcoming award of the 700 MHz and 3.6-3.8 GHz bands.

2.6 Alongside this, our aim is to ensure that alternative spectrum is available which could support the rollout of new wireless applications addressing local connectivity needs through localised access.

2.7 We consider that access to spectrum in bands where mobile technology is supported could offer important benefits to citizens and consumers, complementing the benefits from the

[12] Next generation mobile technology

award of national licences. Specifically, we consider that this could unlock opportunities for innovation and facilitate new investment models.

Encouraging innovation

2.8 Making additional spectrum available to meet this demand is in line with our duties to have regards to promote innovation.

2.9 One way in which innovation would be supported is by unlocking the benefits provided by 5G for applications beyond consumer mobile broadband, which may not require a national licence, by providing an alternative mechanism to access suitable spectrum.

2.10 Additional spectrum for localised use could provide connectivity solutions for the deployment of private networks across a number of sectors including industrial Internet of Things (IoT) devices.

Encouraging investment

2.11 We consider that early signalling of spectrum availability and the terms of access removes spectrum uncertainty for innovation and provides clarity in support of equipment development for new wireless applications in bands where there is currently no equipment ecosystem.

2.12 Clarity on the mechanism to access spectrum would also support infrastructure investment by new users looking to deploy private wireless communications within their premises.

2.13 Providing additional spectrum options for new users may also support new investment models, for example, provision of spectrum could support rural wholesale access provided by third parties cooperating with mobile network operators (MNOs) through roaming agreements to provide coverage in key not-spots.

Our approach

2.14 In our Spectrum Management Strategy,[13] we highlighted the important role of sharing in addressing increasing demand for spectrum access and identified sharing as an area of increased emphasis to ensure the ongoing optimal use of spectrum.

2.15 In line with our duties with regards to encouraging innovation and investment, we have been considering ways in which we could permit more intensive use of existing spectrum by means of spectrum sharing. In particular, we have considered how we could enable new users to operate in locations not used by others in the same frequency band.

The three shared access bands

2.16 We propose to extend shared access in a number of spectrum bands adjacent to awarded (or planned for award) mobile spectrum, which supports mobile technology. These are 3.8-

[13] Ofcom, *Spectrum management strategy*, 30 April 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0021/71436/statement.pdf

4.2 GHz, 1781.7-1785 MHz paired with 1876.7-1880 MHz ("1800 MHz shared spectrum") and 2390-2400 MHz ("2300 MHz shared spectrum").

2.17 To support innovation and new investment models, our aim is to provide new users more certainty over access to spectrum and to support a more predictable quality of service for services than could be offered through licence exempt use of spectrum. We also want to create a simple and easy way for users to access spectrum on a shared basis, which would lower barriers of entry for new users, particularly for smaller spectrum users. Therefore, we consider that there is benefit in Ofcom taking a more proactive role in managing access to these bands.

2.18 Our proposed approach for spectrum sharing in these bands is for:

- users to apply for the location(s), band(s) and bandwidth(s) that they need to provide a service;
- Ofcom to assess requests with regards to interference to and from other licensees in the band;
- Ofcom to grant individual licence(s) for the requested location(s), band(s) and bandwidth(s) on a first come first served basis, where there is no undue interference to other users; and
- cost-based licence fees to recover the cost of Ofcom managing the licence, where spectrum demand does not outstrip supply (consistent with our established pricing principles). This will help to keep the licence product affordable for smaller users.

2.19 By introducing additional users in the same spectrum as existing users, we are not proposing to change incumbent users' existing and future rights to deploy. Incumbent users will continue to be able to deploy in accordance with their licence terms and conditions.

2.20 Once the new spectrum sharing arrangements are in place, we may make additional spectrum available on the same basis in the future.

Awarded mobile spectrum

2.21 We propose to authorise new users wishing to access awarded mobile spectrum in locations where this would not adversely impact the incumbent licensee's planned use of the spectrum.

2.22 As the frequency bands have already been awarded to MNOs on a national basis, their existing and future use is already licensed for each local deployment. This means that there are no "unlicensed" areas. There may nevertheless be areas where licensed spectrum is not being used and could be shared at that location with a new user. Local shared access in this case though must respect the rights of the existing user and not interfere with or constrain their operations.

2.23 Our proposed approach for spectrum sharing in these bands is:

- users to apply to us for a local licence to use specific frequencies at a particular location (this can be in any of the mobile bands licensed to MNOs), indicating whether they require access beyond the default three-year licence term;

- Ofcom would engage with the relevant MNO(s);
- if the MNO raises a reasonable objection, then the application would be declined; or
- if the MNO agrees this does not adversely impact them, then a local licence would be issued.

2.24 This licensing approach would sit alongside our existing spectrum trading framework. In circumstances where access to spectrum is only required in specific locations and is being shared with the existing licensee, we consider that our approach could provide an option that is less burdensome than spectrum trading, both for new users and incumbent licensees. We further believe our proposed local licensing approach can achieve the same outcomes as leasing but is more likely to be successful in encouraging an agreement between parties, since doing so does not place a responsibility for the third party on the incumbent licensee.

Enabling future use of Dynamic Spectrum Access

2.25 In designing the spectrum sharing approach we have outlined above, our aim is to enable, as quickly as practical, access to spectrum which can be used immediately with existing equipment, so that citizens and consumers can benefit from new services as soon as possible.

2.26 In parallel, we aim to work towards a Dynamic Spectrum Access (DSA) approach in bands where this is appropriate and practical to implement when suitable equipment is available.

2.27 Under a DSA approach, equipment communicates directly with a database to be granted access to spectrum at the location and time required on whichever frequencies are unused at the time by existing users. This is the approach which underpins TV white space devices in the UK,[14] and the CBRS proposal in the USA.[15]

2.28 This model may facilitate more efficient sharing of spectrum and flexibility in spectrum authorisation. In any static spectrum authorisation (whether through Ofcom authorisation or user self-registration in a database), there is a risk of spectrum inefficiency where, for example, spectrum is authorised to users who no longer require the spectrum but have not cancelled their licence, or is authorised to users who do not require access to spectrum all the time.

2.29 However, creating a regulatory framework for DSA requires appropriate specification of the required capability of both the DSA equipment and database. The requirements could vary depending on the bands and the nature of applications. Therefore, to facilitate the evolution towards DSA, we consider there is benefit in creating an industry group to discuss both the technical requirement of the DSA equipment and database to inform a future regulatory framework for DSA.

[14] Ofcom, *TV White Space Databases*, 14 January 2016, https://www.ofcom.org.uk/spectrum/spectrum-management/TV-white-space-databases

[15] Federal Communications Commission, *3.5 GHz Band / Citizens Broadband Radio Service*, https://www.fcc.gov/wireless/bureau-divisions/broadband-division/35-ghz-band/35-ghz-band-citizens-broadband-radio

Structure of this document

2.30 The rest of this document is set out as follows:

- **Section 3** provides an overview of the current and proposed authorisation approaches for users in the three shared access bands.
- **Section 4** outlines our proposal for a new shared access licence for the three shared access bands.
- **Section 5** contains the proposed technical conditions for the new licence product for the three shared access bands, as well as our proposed coordination parameter and methodology.
- **Section 6** sets out our approach to setting the licence fee for the three shared access bands.
- **Section 7** summarises our proposals to change the authorisation approach for existing Concurrent Spectrum Access licensees in the 1800 MHz shared spectrum.
- **Section 8** outlines our proposals for a new licence which would enable users to access awarded mobile spectrum in areas where there is no planned use by incumbent.
- **Section 9** outlines our proposed next steps following this consultation.
- **Annexes A1-A4** outline how to respond to this consultation, and provide Ofcom's overall consultation principles, a copy of the questions we ask throughout this document, and a cover sheet for responses.
- **Annex A5** gives our detailed adjacent band interference analysis for the 3.8-4.2 GHz band.
- **Annex A6** gives our detailed interference analysis for the 2300 MHz shared spectrum.
- **Annex A7** provides our analysis of predicted spectrum availability in the 3.8-4.2 GHz band, taking into account incumbent users.
- **Annex A8** provides a draft example of the Shared access low power licence outlined in sections 4-6.
- **Annex A9** provides a draft example of the Shared access medium power licence outlined in sections 4-6.
- **Annex A10** provides a draft example of the Local access licence outlined in section 8.
- **Annex A11** contains a glossary of terms used in this document.

3. The three shared access bands

Introduction

3.1 In this section, we set out an overview of the three bands adjacent to mobile spectrum that we are proposing to make available for further shared access. These are the 3.8-4.2 GHz band (paragraphs 3.4 to 3.14), 1800 MHz shared spectrum (paragraphs 3.15 to 3.34) and 2300 MHz shared spectrum (paragraphs 3.35 to 3.41).

3.2 For each band, we describe the authorisation of existing users, explain our proposed future authorisation to enable new users in the spectrum and finally identify some of the potential new uses that could be enabled by our proposals.

3.3 In developing our proposals, our aim is to have a single authorisation approach for new users across the three shared access bands. This would make it easy for users to access any of the spectrum in locations where spectrum is available.

3.8-4.2 GHz band

3.4 The 3.8-4.2 GHz band is adjacent to the 3.4-3.8 GHz band, which has been identified as a 5G band. 5G technology standards cover the 3.8-4.2 GHz band and chipsets supporting this band are available. Several countries are looking to open up 5G access in this band. By making spectrum available, our aim is to promote the development of an equipment ecosystem that would support bespoke 5G equipment.

3.5 In 2016, we published a call for input (CFI)[16] seeking input from stakeholders on the potential of the 3.8-4.2 GHz band as a candidate band for enhanced spectrum sharing and new applications. In Ofcom's 2018-19 Annual Plan,[17] we said that we would continue our work to enable greater shared access in the 3.8-4.2 GHz band and consult this year on proposals to do this. We also said our aim would be to protect existing users' rights in the band while promoting access for new users.

Existing authorisation and use

3.6 The 3.8-4.2 GHz band is currently used by three main types of users:[18] satellite Earth stations, point-to-point fixed links and wireless access applications (fixed) by UK Broadband.[19] Deployments in the band are technically coordinated by Ofcom in order not to cause undue interference between users.

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[16] Ofcom, *3.8 GHz to 4.2 GHz band: Opportunities for Innovation*, 14 April 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0031/79564/3.8-GHz-to-4.2-GHz-band-Opportunities-for-Innovation.pdf

[17] Ofcom, *Annual Plan 2018/19*, 28 March 2018, p. 28, https://www.ofcom.org.uk/__data/assets/pdf_file/0017/112427/Final-Annual-Plan-2018-19.pdf

[18] The spectrum information portal provides information on licenses granted by Ofcom and is found at https://www.ofcom.org.uk/spectrum/information/spectrum-information-system-sis/spectrum-information-portal

[19] Acquired by Hutchison 3G UK Limited in 2017.

3.7 **Satellite Earth stations**: Ofcom authorises access on a first-come-first served basis through licences for assignments to permanent earth stations (PES) and grants of Recognised Spectrum Access (RSA) for receive only earth stations (RSA for ROES). Access is authorised to a licensee depending on the outcome of Ofcom coordination with other services. Satellite Earth stations in this band are used for a number of services, including broadcasting contribution and distribution from overseas, as well as some corporate data communications. The number of Earth stations using this band has been stable for some time and we have no evidence to suggest that the number of sites is likely to materially increase in the near future.

3.8 **Fixed links**: Ofcom authorises point to point fixed links on a first come first served basis, subject to Ofcom coordination and Ofcom technical frequency assignment criteria.[20] These links use a fixed channel plan covering the 3800-3875 MHz and 3925-4195 MHz ranges within the 3.8-4.2 GHz band, which is part of the wider 3.6-4.2 GHz fixed link harmonised duplexed channel plan.[21] Ofcom is currently undertaking work to clear the 3.6-3.8 GHz band to make this spectrum available for nationwide high power mobile use.[22] One of the effects of this clearance work will be to clear some channels of fixed links in the 3.8-4.2 GHz band, due to the duplex nature of the fixed link channel plan between 3.6-4.2 GHz. This will likely mean that fixed links remain in 3815-3875 MHz and 4135-4195 MHz only. Fixed links in this band are used for a range of infrastructure and backhaul applications including applications that benefit from the low latency properties of point to point fixed wireless links.

3.9 **UK Broadband (UKB)**: UK Broadband has a spectrum access licence for an 84 MHz block of spectrum at 3925-4009 MHz with individual assignments coordinated by Ofcom on a first come first served basis, vis a vis both satellite earth stations and fixed links. When UK Broadband wishes to request a new assignment in this spectrum, it submits technical information to Ofcom which is then assessed against incumbent deployments of fixed links and satellite Earth stations using Ofcom's technical coordination tool as given in the coordination guidelines covering this band.[23]

Proposed authorisation for new users

3.10 Under our proposed spectrum sharing approach, we propose to carry out technical coordination for new users in the 3.8-4.2 GHz band, to minimise the risk of interference between new and incumbent users, as well as between new users in the band. We propose to grant new users individual licences on a per location basis (see section 4 for our proposed licence categories) where this technical coordination check is successful. This is similar to the current coordination approach for existing users in the 3.8-4.2 GHz band. For

[20] Ofcom, *Technical Frequency Assignment Criteria for Fixed Point-to-Point Radio Services with Digital Modulation (OfW 446)*, July 2018, https://www.ofcom.org.uk/__data/assets/pdf_file/0017/92204/ofw446.pdf
[21] CEPT/ERC/REC 12-08 E Annex A Part 2, https://www.ecodocdb.dk/download/9c8220e1-3ab3/REC1208E.PDF
[22] Ofcom, *Improving consumer access to mobile services at 3.6 GHz to 3.8 GHz*, 26 October 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0019/107371/Consumer-access-3.6-3.8-GHz.pdf
[23] Ofcom, *UK Spectrum Co-Ordination Document: Co-ordination of licensed services in the band 3605 to 3689 MHz paired with 3925 to 4009 MHz (OfW 188)*, 28 January 2008, https://www.ofcom.org.uk/__data/assets/pdf_file/0027/85086/coordination_processes.pdf

existing users, this would maintain their existing protection requirements, and for new users this will offer certainty in spectrum access and quality of service.

Implications for existing licensees

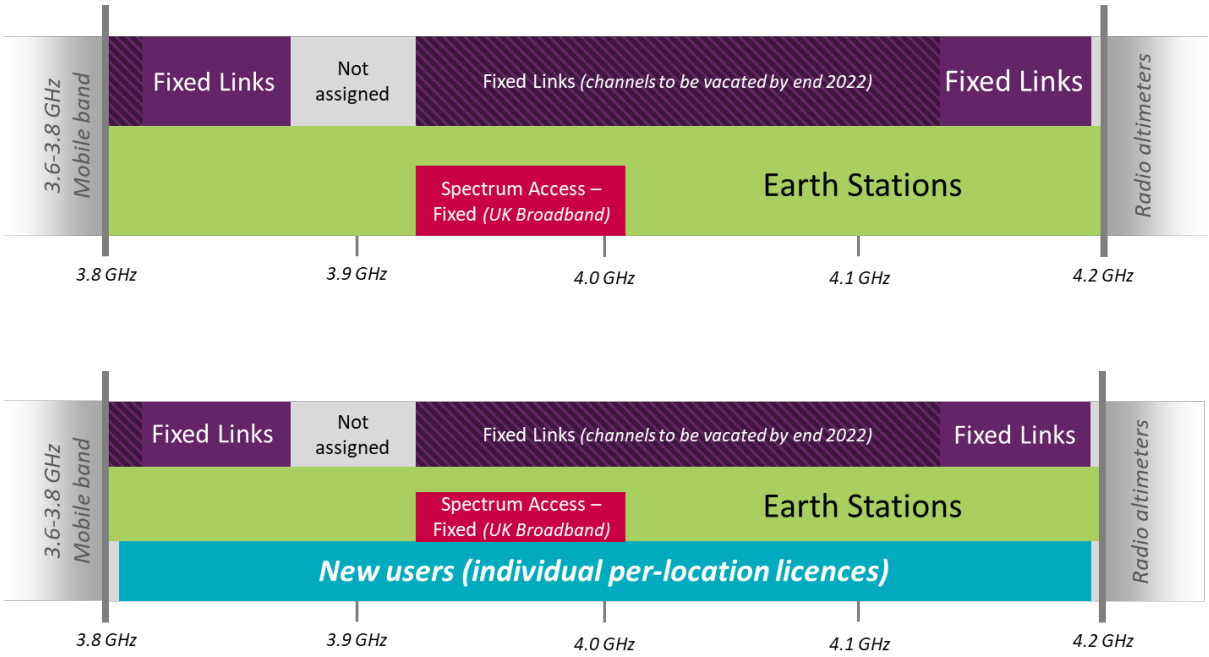
3.11 Existing and future deployments by fixed links, satellite Earth stations and UK Broadband will continue to be able to access this band on a first come first served basis in accordance with their current licence terms and conditions. We are proposing that new users will have first come first served access on the same basis, and with equal priority, as existing users.

3.12 We note that expanding access to new users may reduce the amount of spectrum available for incumbent users in some locations. However, we do not consider that the impact on incumbent users is likely to be significant for the following reasons:

- **Fixed links:** As mentioned above, existing and any future fixed links would continue to be taken into account under the existing link by link coordination approach. Usage has been relatively stable over the last few years and we have no evidence of additional demand in this band except for focused applications on specific routes.[24]
- **Earth stations (ES):** PES and registered ROES would continue to be taken into account through site by site coordination. Given relatively stable usage in recent years, we also consider it unlikely that Earth stations will be deployed at new locations. Where there is new demand, this may be for additional frequency assignments at existing sites, following the removal of protections in the 3.6-3.8 GHz band. Introducing new users on an equal priority access basis may reduce the availability of spectrum at some locations. However, this is similarly possible under the existing sharing arrangements with UKB and fixed links.
- **UK Broadband (UKB):** Introduction of new users in the current UKB holding may reduce the availability of channels for UKB deployment in some regions. However, this could happen under the existing sharing arrangements with fixed links and Earth stations.

[24] We have recently carried out our *Review of spectrum used by fixed wireless services* (https://www.ofcom.org.uk/consultations-and-statements/category-2/fixed-wireless-spectrum-strategy) and engaged extensively with stakeholders.

Figure 1: Diagram showing existing (top) and proposed (bottom) band plan for 3.8-4.2 GHz band



Potential new uses

3.13 The current authorisation approach in this band has allowed several different types of user to coexist, based on first come first served licensing. Expanding this approach to new users will facilitate new uses of the band whilst allowing existing users to operate under their existing authorisations. It is likely to represent more efficient use of this spectrum because new users will be able to occupy channels which are not currently used by incumbents in any given location, whilst avoiding interference to incumbent users' operations.

3.14 As discussed above, mobile standards cover the range from 3.3-4.2 GHz (3GPP 5G NR Band 77). Our sharing proposal could enable various uses such as:

- **Local private networks:** Operating using LTE, 5G New Radio (5G NR) or any other suitable technology, a private wireless network could be deployed by many different kinds of users for a wide range of purposes, including IoT devices. Larger bandwidths, available in this band, would support wideband IoT devices or any system that needs to quickly transfer large amounts of data. 5G technology could support ultra-reliable, low-latency communications which may be needed for some industrial uses such as wireless automation, control and monitoring.
- **Fixed Wireless Access (FWA):** In addition, this band would be suitable for the provision of fixed wireless access for rural broadband connectivity, given that some FWA equipment already operates in the 3.x GHz band and could be tuned to the 3.8-4.2 GHz band. FWA could offer more cost-effective delivery of wireless broadband to consumer premises, particularly in rural areas where fibre is not available or is too expensive to install. The principal spectrum band currently used by rural FWA providers is the 5.8 GHz band, in which a light licensing regime is in place. The 3.8-4.2 GHz spectrum could complement the 5.8 GHz band to enable greater coverage from a single FWA base station and provide additional bandwidth to support FWA services.

1800 MHz shared spectrum

3.15 The 1800 MHz shared spectrum is a 2x3.3 MHz block of spectrum at the frequencies 1781.7-1785.0 MHz paired with 1876.7-1880.0 MHz. The lower portion lies at the top of the uplink part of the 1800 MHz Frequency Division Duplex (FDD) mobile band, next to the duplex gap, and the upper portion lies at the top of the downlink part of the 1800 MHz mobile band, adjacent to the spectrum used by cordless phones using the Digital Enhanced Cordless Telecommunications (DECT) standard in the neighbouring 1880-1900 MHz band.

3.16 This spectrum is already supported by mobile networks and handsets (for both 2G and 4G technology), meaning it can be used immediately.

Existing authorisation and use

3.17 Following an award process in April 2006, 12 nationwide Concurrent Spectrum Access (CSA) licences were issued by Ofcom which granted shared access to this spectrum.[25] The spectrum was awarded on a technology neutral basis but with additional provisions to ensure compatibility with GSM networks in adjacent frequency bands. All the licensees have equal rights to use all the spectrum, but were required to jointly develop and abide by an agreed Code of Practice on Engineering Coordination (and jointly agree to any subsequent changes) to facilitate deployment and efficient use of spectrum. The licensees subsequently appointed the Federation of Communication Services (FCS) to maintain a register of deployments.

3.18 Current CSA licensees have deployed systems to provide private mobile phone networks for organisations.

3.19 In September 2016, Ofcom approved a licence variation request[26] which facilitated the CSA licensees to deploy equipment using wider channels in this band, such as LTE, as well as GSM. We also published a consultation[27] on the future of the 1800 MHz shared spectrum following the end of the initial ten-year term of the CSA licences. In June 2017, we published an update[28] on the 1800 MHz shared spectrum, in which we confirmed that whilst we were not minded to change the authorisation approach to allow a single user to deploy high power mobile, we would still consider ways to provide additional spectrum access opportunities in the band.

[25] These licences are held by BT plc, BT OnePhone Ltd, Colt, FMS Solutions Ltd, TalkTalk Communications Ltd, PLDT (UK) Ltd, Shyam Telecom Ltd, Telefónica (UK) Ltd, Teleware plc, UK Broadband Ltd, Vectone Ltd and Vodafone Ltd.
[26] Ofcom, *Variation of Concurrent Spectrum Access 1781 MHz Licence*, 29 September 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0024/90447/160929-1781-MHz-Variation-Statement_final.pdf
[27] Ofcom, *Policy for the DECT guard band*, 29 September 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0032/90977/Consultation-DECT-guardband-final-for-publication.pdf
[28] Ofcom, *Update on the DECT guard band policy*, 30 June 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/103617/Update-on-the-DECT-guard-band-policy.pdf

Proposed authorisation for new users

3.20 We have considered three authorisation options in relation to expanding new users' access to the 1800 MHz shared spectrum:

- **Option 1**: Maintain existing concurrent access approach where all users have to agree coordination arrangements (self-coordination).
- **Option 2**: Retain existing self-coordination approach but transfer the maintenance of the database from the current third party to Ofcom ("light licensing approach").
- **Option 3**: Ofcom managed approach where Ofcom coordinates access to spectrum.

3.21 In relation to expanding access to the band to new sharing users, the responses to the 1800 MHz shared spectrum consultation[29] generally favoured the continuation of a self-coordinated approach, as opposed to moving to a licence exempt approach (or repurposing the band for high power mobile).

3.22 The existing concurrent access approach (**Option 1**), while suited for a limited number of users where coordination agreements and any subsequent changes could be reached by all parties, is not practical when there are more users in the band to reach agreement with.

3.23 We have considered whether we could implement a self-coordinated, licensed approach in the 1800 MHz shared spectrum for all users (both incumbent licensees and new users) whereby Ofcom would maintain a database of registered deployments, replacing the existing FCS register (**Option 2**). Future deployment by both incumbent and new licensees would have to be registered in the database, with users taking responsibility to coordinate and resolve interference.

3.24 This authorisation approach would be suitable where the risk of interference is low and where the main aim of a database of deployments is to identify parties to coordinate with should interference occur. However, we note that there could be an increased risk of interference between wideband users in close proximity, even at low power, and therefore interference coordination would be required prior to users registering deployments.

3.25 In view of this, and our aim to have a single authorisation approach across the three shared access bands to make it easy for users to access spectrum, we propose that Ofcom manages access to this shared spectrum and performs coordination between users (**Option 3**). This would avoid the burden of self-coordination for new users and create a consistent process for users to access spectrum in the 1800 MHz and 2300 MHz shared spectrum, as well as the 3.8-4.2 GHz band.

Implications for existing licensees

3.26 Given current limited use in the band, we do not consider that expanding access for new users will impact on the future ability of existing licensees to continue to deploy.

[29] Ofcom, *Policy for the DECT guard band*, 29 September 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0032/90977/Consultation-DECT-guardband-final-for-publication.pdf

3.27 In order to ensure that existing deployments by incumbent licensees are taken into account by Ofcom when performing coordination for future new users, we will need to have access to the current third-party register of deployments.

3.28 It would not be practical to maintain two different coordination mechanisms, so we propose to change the current self-coordination approach by the CSA licensees to one where we manage the spectrum and perform the coordination for both existing licensees and future new users. Changing the process by which incumbent licensees will deploy does not affect their rights to deploy. Future deployments by these licensees will be made through individual licence applications to Ofcom and will be coordinated by us on a first come first served basis and authorised on a per location basis.

3.29 We will need to liaise with incumbent licensees to transfer existing deployments held by the current third-party register into our coordination tools. We do not consider that there will be material costs incurred by incumbent licensees associated with this task.

3.30 We do not consider that moving to an Ofcom-coordinated approach (**Option 3**) will incur significant additional spectrum management costs to us, given that we already have coordination tools to perform this function and a licensing system already in place to process licence applications. We will incur ongoing spectrum management costs to process licences, however this is comparable with the alternative "light licensing approach" where we would still have to issue licences and maintain a database of deployments (**Option 2**).

3.31 Overall, we consider that the benefits to citizens and consumers generated by the change in authorisation from current self-coordination to Ofcom coordination outweighs the costs in effecting these changes for the following reasons:

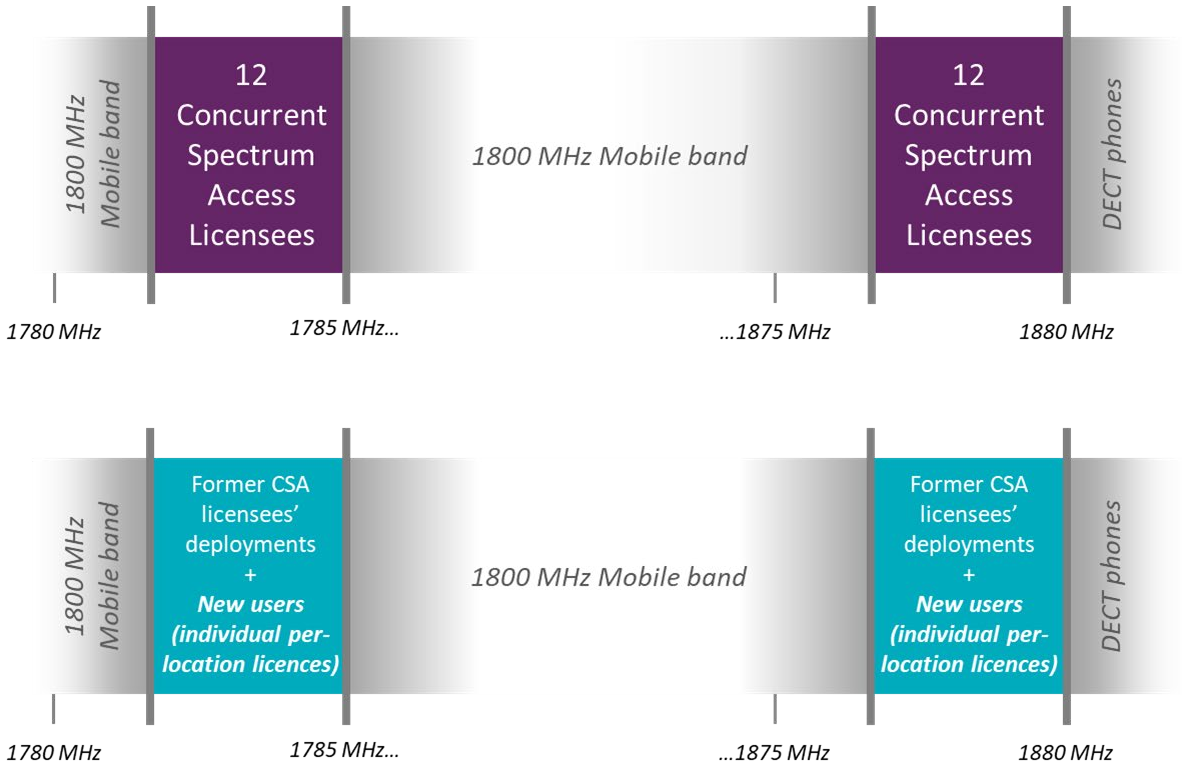
- a simple licensing process where users only need to apply to us for new deployments would save time and effort for users in performing coordination;
- incumbent licensees will no longer be required to fund maintenance of the existing database by a third party, in addition to future licence fees to us for access to spectrum;[30]
- we understand that the current database contains a large number of defunct deployments and that there is no process for removing entries in the register which have been decommissioned, or which were not subsequently deployed in the first place. Spectrum will not be used efficiently if these deployments are not removed and this can be achieved through our new process; and
- our approach will also enable medium power users (see section 4) to deploy in rural areas. Although it is possible for medium power users[31] to deploy at the moment, this requires all 12 of the CSA licensees and Ofcom to agree to the use, and this has never been done.

[30] We set out in our *Update on the DECT guard band policy* in 2017 that we would continue to consider our approach to setting fees for the CSA licensees following the end of the initial ten-year term, which expired in 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0018/103617/Update-on-the-DECT-guard-band-policy.pdf

[31] GSM max EIRP 30 dBm, LTE max EIRP 42 dBm

3.32 We invite views in section 5 on our proposed coordination parameters that aim to strike the right balance between spectrum efficiency and providing users with a reliable service quality.

Figure 2: Diagram showing existing (top) and proposed (bottom) plan for 1800 MHz shared spectrum



Potential new uses

3.33 Most of the respondents to our 2016 consultation[32] on the 1800 MHz shared spectrum agreed that there was scope for using the spectrum for more than the existing 12 users. The spectrum can be used immediately given that it is part of the 1800 MHz mobile band where commercially available base stations and handsets can be used. This spectrum could also be coupled with licence exempt LTE in the 5150-5925 MHz band (3GPP Band 46) to provide additional channels to support higher capacity applications.

3.34 Our proposal to enable sharing in this band could enable:

- **Improved mobile coverage:** There is some interest amongst smaller providers who say they are looking to build their own network to improve mobile coverage in areas currently lacking good coverage in cooperation with MNOs through a roaming agreement. Such networks could be built in specific buildings, for example office buildings and shopping centres, or holiday parks to provide a better experience to the users of the premises. In addition, we note some interest to build network to improve

[32] Ofcom, *Policy for the DECT guard band*, 29 September 2016, https://www.ofcom.org.uk/consultations-and-statements/category-1/DECTGB?showall=1

mobile coverage in rural areas, although we note that spectrum access is not the only barrier to achieving this.

- **Private networks:** The band could be used to provide local private networks as outlined above for 3.8-4.2 GHz, additionally also providing private mobile voice services. Since the amount of bandwidth available in the 1800 MHz shared spectrum is relatively small, private data networks using this band alone would only support narrowband data applications, such as basic wireless sensors or devices such as smart meters. However, as noted above, it could be used with other bands to support higher speed applications.

2300 MHz shared spectrum

3.35 This is the spectrum between the recently awarded[33] 2350-2390 MHz mobile spectrum and licence exempt uses above 2.4 GHz. We have identified that in addition to the 1800 MHz shared spectrum, the 2300 MHz shared spectrum could also be suitable for new sharing users looking to access mobile spectrum, as it is already available in mobile handsets as part of the wider 2300 MHz mobile band.

Existing authorisation and use

3.36 There are currently no licensed users at present. However, we need to take account of usage by the Ministry of Defence (MOD), for airborne systems providing telemetry in air-to-ground or air-to-air configurations. Many applications have wide coverage areas but the majority of the time they avoid urban areas. In addition, there are also some land-based systems that operate in this band.

3.37 A number of Short Range Devices (SRDs) such as WiFi, assisted listening devices (ALDs) and Bluetooth operate under a licence exempt basis in the adjacent Industrial, Scientific and Medical (ISM) band between 2400-2483.5 MHz.

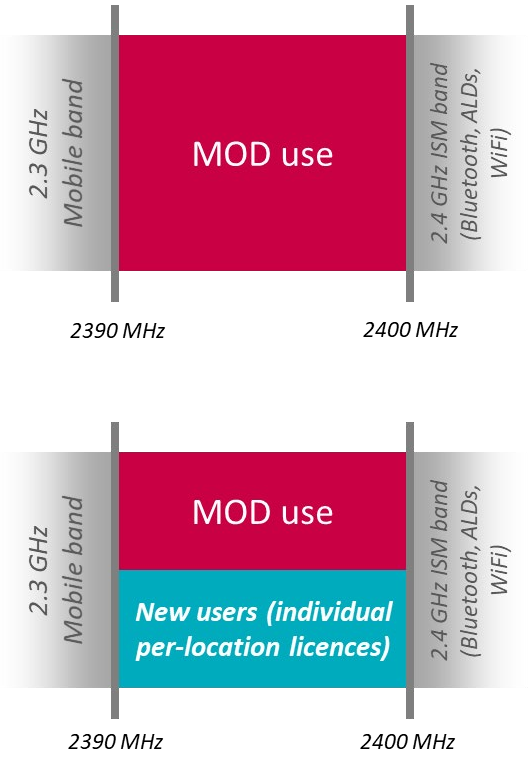
Proposed authorisation for new users

3.38 As with the 3.8-4.2 GHz band and 1800 MHz shared spectrum, we propose that access in the 2300 MHz shared spectrum be coordinated by Ofcom and authorised on a per location, first come first served basis.

3.39 This would provide a single process for users to access the three shared access bands under the same authorisation approach. This would be in line with our overall authorisation objective of making it simple and straightforward for users to access spectrum at the location they intend to provide a service, and with a choice of bands to suit their needs.

[33] Ofcom awarded the frequencies 2350-2390 MHz to Telefónica in April 2018 as the result of an auction.

Figure 3: Diagram showing current (top) and proposed (bottom) band plan for 2300 MHz shared spectrum



Potential new uses

3.40 We believe that the wider bandwidth available in the 2300 MHz shared spectrum would complement the 1800 MHz shared spectrum to support in-building mobile coverage improvement and possibly outdoor rural deployments in certain areas, as well as private mobile or data networks, as outlined in the 3.8-4.2 GHz section above. Similar to the 1800 MHz shared spectrum, this spectrum may also be coupled with the 5150-5925 MHz band (3GPP Band 46) for licence exempt LTE to provide an additional licensed channel to support higher capacity applications.

Summary of bands and uses

3.41 In summary, we propose that access to spectrum by new users in the three shared access bands will be coordinated by Ofcom and authorised through individual licensing on a per location, first come first served basis. We consider that this will enable a range of services, including but not limited to those outlined in the table below.

Table 1: Summary assessment of potential new services by band

Uses	3.8-4.2 GHz	1800 MHz shared spectrum	2300 MHz shared spectrum
Private network	✓	✓ (narrowband)	✓
Mobile coverage (rural)	✗	✓	certain locations[34]
Mobile coverage (indoor)	✗	✓	✓
Fixed Wireless Access	✓	✗	✗

Question 1: Do you agree with our proposal for a single authorisation approach for new users to access the three shared access bands and that this will be coordinated by Ofcom and authorised through individual licensing on a per location, first come first served basis? Please give reasons supported by evidence for your views.

Question 2: Are there other potential uses in the three shared access bands that we have not identified?

Question 3: Do you have any other comments on our authorisation proposal for the three shared access bands?

Question 4: What is your view on the status of equipment availability that could support DSA and how should DSA be implemented?

[34] Due to coexistence with other users, the availability of medium power use will likely be limited to rural areas only.

4. Proposals for a new licence for the three shared access bands

Introduction

4.1 This section outlines our proposal for two categories of licence, for users wishing to access any of the three shared access bands for localised deployment. We also set out the associated propose non-technical licence conditions for the licence.

We propose two categories of licence to facilitate different potential uses

4.2 As discussed in section 2, users (particularly smaller spectrum users) are likely to want simple and cost-effective access to spectrum and a managed interference environment, beyond what can be achieved using licence exempt spectrum.

4.3 We believe that the best way to address this objective would be to have a common licence across the three shared access bands. This would make it easy for users to access spectrum where they need it and offer a choice of bands to suit their needs.

4.4 The various potential uses of the bands we are making available (including those discussed in section 3), have different coverage areas, ranging from the inside of a single building to across a scattered rural community, and hence have different transmit power requirements. To facilitate this, we propose two categories of licence: a low power per area licence; and a medium power per base station licence.

Low power per area licence

4.5 Low power use will typically be concentrated in a small area, for example to extend indoor mobile coverage or to deploy a private local network for enterprise or industrial use.

4.6 Given that users could deploy multiple low power small cells in a given area or premises and the locations may vary from time to time, we consider that it would be easier for users to have a single authorisation for an area containing multiple small cells, rather than individually coordinating and authorising each base station.

4.7 We therefore propose an area licence that would authorise all the low power base stations operating within an area, including all the associated fixed and installed terminals connected to a base station operated within the range of the licensed area.

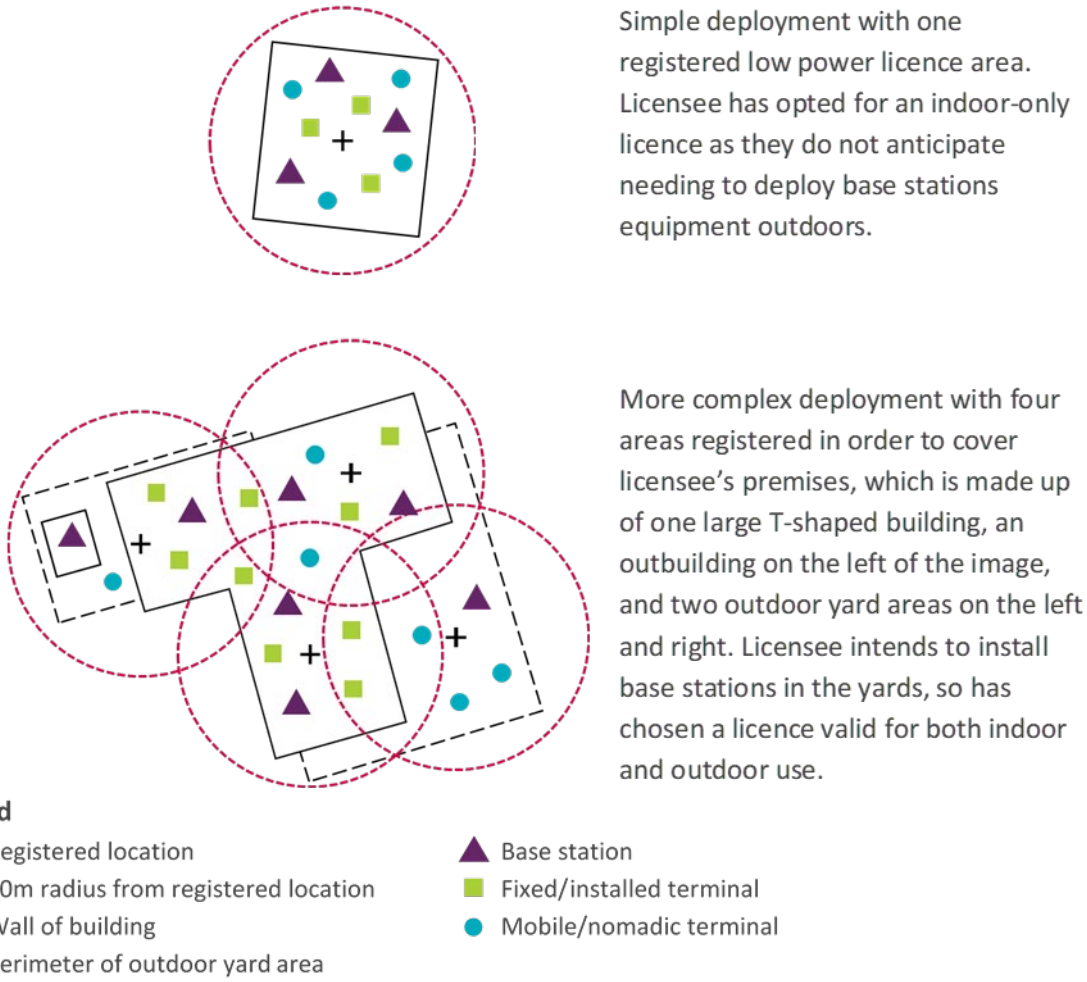
4.8 This would provide users with the flexibility to deploy as many cells as they like, anywhere within their premises, and to relocate these as they wish, without requiring any change to their licence.

4.9 We propose that the mobile and nomadic terminals connected to licensed base stations will be licence exempt in line with existing exemptions for mobile terminals which connect to a licensed network.

4.10 We propose to define the licence area as a circular area with a radius of 50 metres. In determining the appropriate radius, we have taken account of the potential uses and consider that this offers the right balance between spectrum efficiency and facilitating these uses. If users require a coverage area exceeding a 50-metre radius they could apply for multiple overlapping areas to create a large enough contiguous licensed area to suit their needs, as outlined in Figure 4 below.

4.11 We also propose that licensees will have the choice of applying for a licence for indoor-only deployment or a licence that additionally allows outdoor use. One advantage of applying for an indoor-only licence is that in areas of high demand there would be greater likelihood of this licence being granted than one also allowing outdoor use.

Figure 4: Examples of low power area licence use



Medium power per base station licence

Deployment restrictions based on location

4.12 The proposed medium power licence will allow higher power and therefore an increased transmission range, making it suitable for users looking to provide wireless connectivity in rural areas.

4.13 We anticipate that users wanting to deploy services using the low power licence product are more likely to do so in urban areas or on industrial sites (which are often, though not exclusively, located in or on the outskirts of urban areas). Therefore, if we were to make medium power licences available in urban areas there is a greater risk that this could result in limited or no availability of spectrum for low power users.

4.14 Because of this, we initially propose that medium power licence applications should be limited to rural areas only. This is consistent with the potential uses we identified in section 3 such as fixed wireless access for rural broadband connectivity, and community-led mobile coverage improvements in rural areas.

4.15 We therefore propose only to authorise medium power deployments in:

a) any location in England or Wales in an ONS 2011 Census Output Area which falls into categories E1, E2, F1 or F2 (i.e. "villages" and "hamlets and isolated dwellings");[35]

b) any location in Scotland which falls into categories 6-8 based on the Scottish Government's 8 fold Urban Rural Classification (i.e. any area outside a settlement of over 3,000 people);[36] and

c) any location in Northern Ireland which falls into bands G or H of the Northern Ireland Statistics and Research Agency's settlement classification bands (i.e. any area outside a settlement of over 2,500 people).[37] [38]

4.16 We refer to the above areas as "rural areas" throughout the rest of this document. We believe that restricting medium power licences in this way better enables the deployment of likely services both in urban and rural areas. We are aware that the categories for rurality defined by public authorities for different nations are not exactly the same across different parts of the UK, but our preference is to use existing definitions and publicly-available data to enable prospective applicants to check for themselves where medium power base stations could be deployed.

4.17 However, as no categorisation can be perfect, we propose that if applicants wish to deploy in an area which falls outside the above areas, but which they believe is still consistent with our policy objectives, they can approach Ofcom for us to consider their individual case.

4.18 We will keep location restrictions under review, as well as whether the categories outlined above serve as a suitable mechanism for achieving our policy aims, and invite respondents' views on this.

[35] Office of National Statistics, *2011 Rural/Urban Classification*, https://www.ons.gov.uk/methodology/geography/geographicalproducts/ruralurbanclassifications/2011ruralurbanclassification

[36] Scottish Government, *Scottish Government Urban Rural Classification*, https://www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification

[37] Northern Ireland Statistics and Research Agency, *Urban-Rural Classification*, https://www.nisra.gov.uk/support/geography/urban-rural-classification

[38] Following initial discussions with the authorities in the Isle of Man and Channel Islands, we are not at this time proposing a restriction of this type for medium power deployments in these areas.

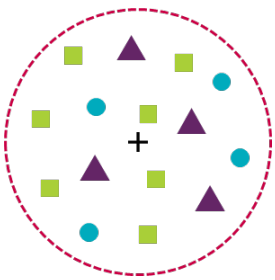
Per base station authorisation

4.19 Given the higher transmit power and their typical deployment outdoors, base stations operating under medium power licences could create interference over a much greater range than low power use. Therefore, we propose to license these base stations on a per base station basis.

4.20 For the 1800 MHz shared spectrum, mobile/nomadic stations connected to base stations of the existing licensees are already licence exempt. We will retain a similar mobile/nomadic authorisation for new users in the band.

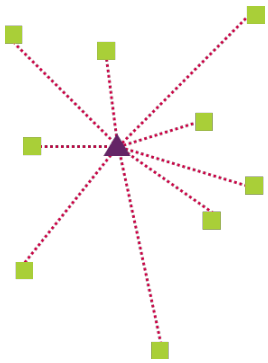
4.21 For the 3.8-4.2 GHz band, given the existing equipment ecosystem and expected uses, we propose to make the medium power licence product in the band available for fixed services only, and to authorise both the base station and the associated fixed and installed terminal stations in the same licence.

Figure 5: Low power licence (left) compared to medium power licence (right)



Licence authorises all base stations and associated fixed and installed terminals operating within a 50m circular radius from a given location.

Mobile and nomadic terminals connected to the licenced base stations are licence exempt.



Licence authorises a base station at a given location and associated fixed and installed terminals.

1800 MHz and 2300 MHz shared bands: mobile and nomadic terminals connected to the licenced base stations are licence exempt.

Legend

- Base station
- Fixed/installed terminal
- Mobile/nomadic terminal

Question 5: Do you agree with our proposal for the low power and medium power licence? Please give reasons supported by evidence for your views.

Question 6: Are there potential uses that may not be enabled by our proposals? Please give reasons supported by evidence for your views.

Question 7: Do you agree with our proposal to limit the locations in which medium power licences are available? Please give reasons supported by evidence for your views.

Question 8: Do you have other comments on our proposed new licence for the three shared access bands?

Proposed non-technical licence conditions

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

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

Duration of the licence

4.24 Similar to existing licence terms and conditions, we propose the licence is for an indefinite duration, subject to the payment of an annual licence fee. The licence also permits Ofcom to give 5 years' notice to revoke the licence for spectrum management purposes.

Licence transfer through spectrum trading

4.25 We are proposing that the licensee will be able to transfer their spectrum rights and obligations in the following ways:

- outright total transfer of all rights to another party;
- concurrent transfer of all rights so two or more parties jointly hold the licence; or
- partial transfers of frequency rights in one or more blocks of 10 MHz in the 3.8-4.2 GHz band.

Access and Inspection

4.26 In accordance with our standard spectrum licence conditions, the licence includes a condition that reserves to Ofcom the right to access and inspect the licensee's radio equipment. This is so we can check the licensee's compliance with the terms of its licence, should we decide that is appropriate.

Modification, Restriction and Closedown

4.27 In accordance with our standard spectrum licence conditions, the licence includes a condition that reserves to Ofcom the right to require the licensee to modify, restrict or close down the use of its radio equipment, should we have reasonable grounds to believe that the licensee has breached the terms of its licence, or we consider this necessary in the event of a national or local state of emergency being declared.

Geographical boundaries

4.28 The licence allows the deployment of transmitters at the locations defined in the licence. Licences will be available for locations within the United Kingdom and territorial seas. Authorisation in the Channel Islands and Isle of Man may be possible, but this is subject to further discussions with the island authorities.

Provision of information to facilitate optimal spectrum use

4.29 In line with our duty to manage the spectrum efficiently, the licence includes standard conditions to require licensees to provide us – on request – with general information regarding their equipment and use of frequencies, or the rollout of their network.

4.30 Provision of this information could help identify actual spectrum usage and facilitate authorisation of frequencies for other purposes where we consider this appropriate in line with our statutory duties.

Question 9: Do you agree that our standard approach to non-technical licence conditions is appropriate? Please give reasons supported by evidence for your views.

Other authorisation issues

Numbering

4.31 The introduction of new licensees in mobile bands could potentially have an impact on demand for mobile numbers and Mobile Network Codes (MNCs). If a user sets up a mobile network, or infrastructure which provides services using a publicly-available mobile network, an MNC is required to ensure calls can be routed through to users on the network. For example, most of the existing CSA licensees have MNCs and some have had mobile numbers assigned to them.

4.32 The UK has 200 MNCs assigned to it by the International Telecommunications Union (ITU). Of these, around 60 have been allocated, leaving us a limited supply to meet future demand. However, we do not anticipate that the influx of new users requiring an MNC as a result of our proposals would put pressure on the remaining supply of available MNCs, although we will keep this, and demand for mobile numbers, under review.

4.33 If new users want to offer commercial mobile services directly to consumers they will need to have mobile numbers assigned to them, either directly by Ofcom or by another provider with an allocation of mobile numbers. The standard size of a block of mobile numbers for allocation by Ofcom is 100,000. Therefore, there is the possibility for increased demand for mobile numbers arising from our proposals which we would need to accommodate. However, our initial assessment suggests that the potential increase in demand for mobile numbers would not put undue pressure on our current supply of mobile numbers.

Question 10: Are you aware of any issues regarding numbering resources and Mobile Network Codes raised by our proposals which we have not considered here?

5. Technical proposal for the three shared access bands

5.1 In this section, we present our proposed technical conditions for each band followed by our approach to coordination between new and existing users within each band. Finally, we provide our analysis of adjacent channel coexistence and details of the approaches that we propose to ensure that undue interference is not caused to services in those adjacent bands.

We propose technology neutral transmission characteristics for new users

5.2 We propose that the technical conditions for the new shared licences be based on existing technology neutral technical conditions stipulated in the relevant European Commission (EC) and Electronic Communications Committee (ECC) decisions for these bands or in the case of the 3.8-4.2 GHz band, the ECC Decision for use of the adjacent 3.4-3.8 GHz band.

3.8-4.2 GHz

5.3 We propose that use of a range of unpaired channel sizes, up to 100 MHz in bandwidth in the 3.8-4.2 GHz band, be on a technology neutral basis for Time Division Duplex (TDD) operation. More specifically, our proposal includes channel sizes of 10, 20, 30, 40, 50, 60, 80 and 100 MHz which are compatible with 3GPP standards.[39]

In-block power limits

5.4 The maximum EIRP that we propose for *low power* base stations is 24 dBm per carrier for carriers up to 20 MHz or 18 dBm / 5 MHz for larger bandwidth carriers. These EIRP limits are per sector.

5.5 In addition, we propose that the *medium power* base stations support a *fixed* service only. The maximum EIRP that we propose for these is 42 dBm per carrier up to a 20 MHz carrier or 36 dBm / 5 MHz for larger bandwidth carriers. These EIRP limits are also per sector.

5.6 We propose a maximum power of 23 dBm[40] for terminal stations connected to low power base stations. This will be a TRP limit for mobile or nomadic terminals and an EIRP limit for fixed or installed terminals operating in the low power licence products.

5.7 We also propose the same maximum power of 23 dBm, specified as an EIRP limit, for fixed or installed terminals[41] operating in the medium power product. We consider that keeping

[39] 3GPP, *TS 38.104 V15.3.0: Technical specification Group Radio Access Network; NR; Base Station radio transmission and reception*, https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3202

[40] The European harmonisation and our authorisation includes an additional 2 dB measurement uncertainty taking the limit to 25 dBm in this band.

[41] Mobile terminals are not permitted as part of the medium power product as it is intended to provide a Fixed Service only.

fixed or installed terminal powers at these levels is important to avoid the risk that terminals (the locations of which we are not specifically coordinating) cause interference to other uses, such as fixed links, which may have particularly directional antennas with the main beam pointing at a terminal rather than the coordinated base station.

Antenna height limits

5.8 Outdoor low power base stations will be limited to a maximum height of 10 metres above ground level. This is in order to reduce the risk of interference to other new users of the same channel.

5.9 We do not propose to limit the height of outdoor medium power base stations in the same way, as these are only permitted in rural areas and there are likely to be multiple channels available in many areas.

5.10 There are no indoor height limits proposed.

Frame structure and out of block emissions requirements

5.11 In order to facilitate sharing between new users in this TDD band, we propose to impose a frame alignment and frame structure requirement on any authorised outdoor base stations. We propose a 3:1 frame structure which is compatible with both LTE and 5G NR. In addition, if any other licensees of the 3.8-4.2 GHz band demonstrate that they are suffering harmful interference in a shared indoor environment, then the user must also comply with these frame alignment and frame structure requirements.

5.12 A user may deviate from the required frame structure (but must still align the start of the frame at a common time) provided that they also apply a more restricted emission mask outside of the authorised bandwidth.

5.13 We propose that emission limits outside of the authorised bandwidth will be similar to the non-AAS BEM requirements in the 3.4-3.8 GHz bands which are based on CEPT Report 67[42] (see Figure 6).

5.14 For transmissions following the preferred frame structure on the downlink frequencies, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following transitional and baseline requirements:

Frequency offset	Maximum mean EIRP density
-5 to 0 MHz offset from lower block edge 0 to 5 MHz offset from upper block edge	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna
-10 to -5 MHz offset from lower block edge 5 to 10 MHz offset from upper block edge	Min(PMax – 43, 15) dBm / 5 MHz EIRP per antenna

[42] https://www.ecodocdb.dk/download/561367fd-1ac6/CEPT%20Report%2067.pdf

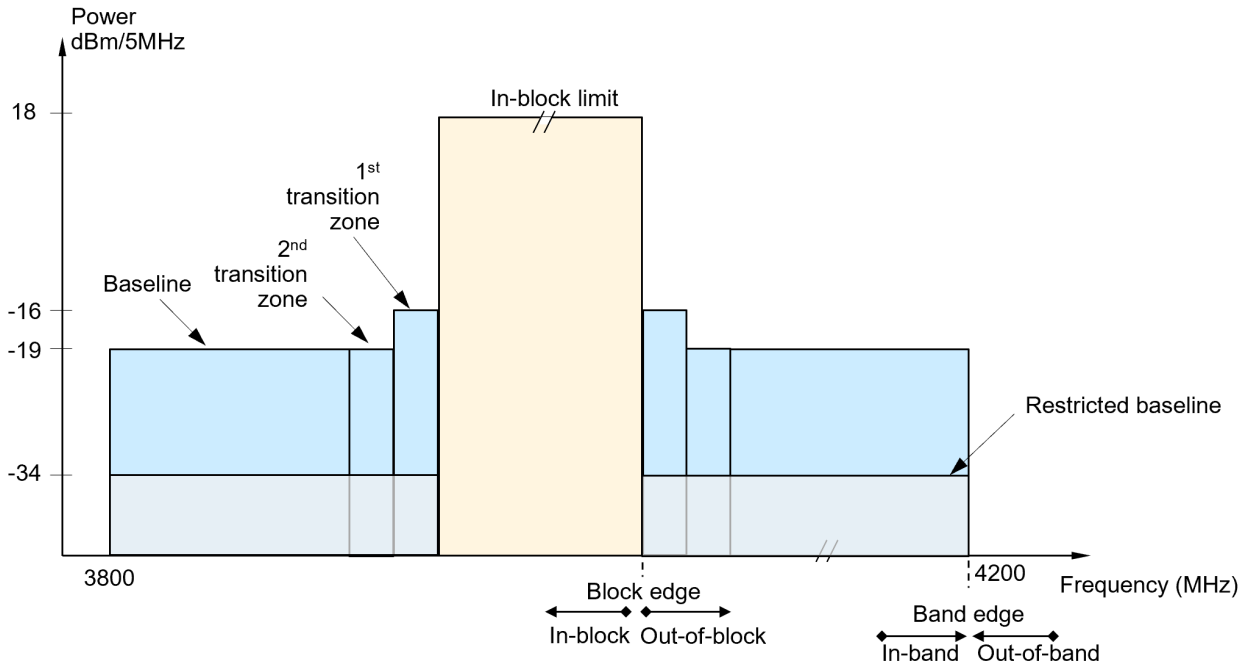
Out of block baseline power limit (BS) < -10 MHz offset from lower block edge > 10 MHz offset from upper block edge	Min(PMax – 43, 13) dBm / 5 MHz EIRP per antenna

5.15 For transmissions not following the required frame structure on the downlink frequencies, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following baseline:

Out of block baseline power limit (BS)	- 34 dBm / 5 MHz EIRP*

* The maximum mean power relates to the EIRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.
PMax is the maximum mean carrier power for the base station in question

Figure 6: Example block edge mask (BEM) of a low power BS with EIRP 24 dBm / 20 MHz in 3.8-4.2 GHz band



5.16 The proposed frame structure options are as follows:

- the preferred frame structure is shown in Figure 7;
- timeslots (or subframes) 0, 2 to 5 and 7 to 9 must be allocated to Downlink (D) or Uplink (U) transmissions as indicated or may be left with no transmissions;
- the Licensee must ensure that the special subframe (S) in timeslots 1 and 6 has a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2;
- all timeslots must be 1 millisecond in duration and the frame must start at a common reference time so that frames are aligned with Telefónica and transmissions synchronised;
- TD-LTE frame configuration 2 (3:1) is compatible with this frame structure. Other technologies are permitted provided that the requirements are met;
- the alternative frame structure is shown in Figure 8;

- timeslots (or subframes) 0 and 2 must be allocated to Downlink (D) or Uplink (U) transmissions as indicated or may be left with no transmissions;
- the Licensee must ensure that the special subframe (S) in timeslots 1 has a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2;
- all other timeslots may have no transmission or must be determined as a Downlink, Uplink or Special subframe as necessary;
- all timeslots must be 1 millisecond in duration and the frame must start at a common reference time so that frames are aligned with other licensees[43] and transmissions synchronised;
- all current TD-LTE frame configurations are compatible with this frame structure as are several NR ones. Other technologies are permitted provided that the requirements are met.

Figure 7: Preferred Frame Structure

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
3:1	D	S	U	D	D	D	S	U	D	D

Figure 8: Alternative Frame Structure

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
Any	D	S	U							

1800 MHz shared spectrum

5.17 We propose use of the 1800 MHz shared spectrum (a paired bandwidth up to 3.3 MHz in both the downlink and uplink) should be on a technology neutral basis. This will support an LTE channel up to 3 MHz wide or several 200 kHz GSM channels, both of which may already be deployed by current licensees in the band.

In-block power limits

5.18 The maximum EIRP that we propose for *low power* base stations is 24 dBm per carrier per sector.

5.19 In addition, the maximum EIRP that we propose for *medium power* base stations is 42 dBm per carrier per sector. This is consistent with the higher power carrier using the majority of the bandwidth in the current authorisation for this band.

5.20 For both cases, we propose to maintain the existing current power density restrictions in the lower 200 kHz and upper 100 kHz of the 3.3 MHz spectrum. The in-block powers will therefore be:

[43] UKB's existing authorisation does not have this frame alignment requirement but has an existing emission mask that is more restrictive.

Frequency offset from the lower frequency of the band edge	**Maximum mean EIRP density**	
	Low Power	*Medium Power*
0 to 0.05 MHz	-33.6 + 153.2 x Δ_{FL}* dBm / kHz	
0.05 to 0.1 MHz	-26 + 60 x (Δ_{FL}*- 0.05) dBm / kHz	
0.1 to 0.2 MHz	-23 + 230 x (Δ_{FL}*- 0.1) dBm / kHz	-23 + 300 x (Δ_{FL}*- 0.1) dBm / kHz
0.2 to 3.2 MHz	24 dBm / carrier	42 dBm / carrier
3.2 to 3.3 MHz	-23 + 230 x (3.3 - Δ_{FL}*) dBm / kHz	-23 + 300 x (3.3 - Δ_{FL}*) dBm / kHz

* Note: Δ_{FL} in MHz is the offset from the lower edge of the permitted frequency band at 1876.7 MHz (it has values in the range 0 to +0.2 MHz and +3.2 to +3.3 MHz)

5.21 We propose a maximum power of 23 dBm for terminal stations attached to both the low and medium power base station. This will be a TRP limit for mobile or nomadic terminals and an EIRP limit for fixed or installed terminals

5.22 We recognise that the base station has a higher power allowed under the current CSA licences for systems using channels that are wider than 200 kHz. Similarly, fixed and installed terminal stations are permitted higher powers for those wider channels. In addition, the current higher power authorisation would permit GSM class 1 and 3 mobile terminals at 30 and 36 dBm power respectively.

5.23 Whilst these higher powers are currently permitted under the current authorisation on a technology neutral basis, the original authorisation was based around GSM channels and other narrowband CDMA systems as these were the relevant technology at the time. We are not aware that indoor products with carrier power greater than 24 dBm are widely available in any case, although some outdoor products may be.

5.24 Nevertheless, with increased usage in this band proposed, we consider it is appropriate to limit base station powers of more than 24 dBm to rural areas only. This would reduce the risk of spectrum unavailability for low users in urban areas arising from authorised medium power users.

5.25 We therefore consider that our proposals balance this risk with our ability to permit different uses.

5.26 We consider that our proposals for limiting terminal power to 23 dBm will not have any impact on existing deployments because:

- we are not aware that there are currently any deployments made under the current higher power option by existing licensees; and
- the current licence exemption regulations only permit powers up to 23 dBm for technologies with bandwidths greater than 200 kHz and therefore we do not expect that there is much demand for higher terminal powers.

Height limits

5.27 Outdoor low or medium power base stations will be limited to a maximum of 10 metres above ground level consistent with the current authorisation approach for CSA in this band.

5.28 There are no indoor height limits proposed.

Out of block emissions requirements

5.29 We propose that the base station emission limits outside of the 1800 MHz shared spectrum will be identical to those permitted already in the 1800 MHz shared spectrum following the TalkTalk licence variation in 2016:[44]

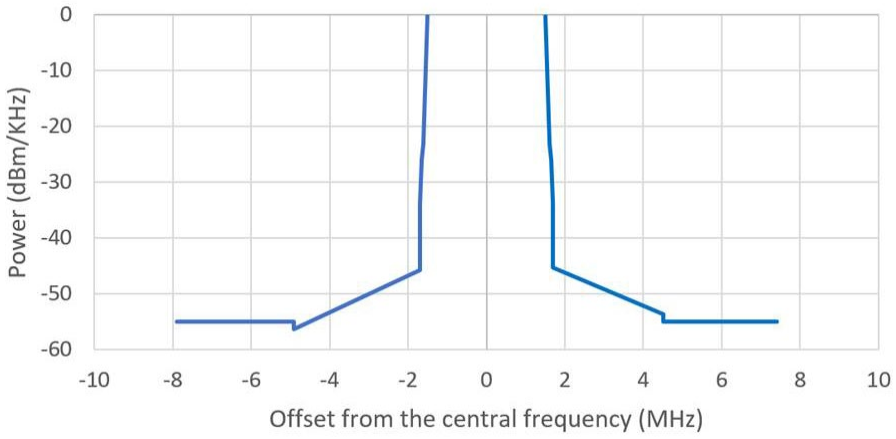
Frequency offset from the lower frequency of the band edge	**Maximum mean EIRP density**
-6.2 to -3.2 MHz	-55 dBm / kHz
-3.2 to 0 MHz	-45 + 10 x (Δ_{FL}*- 0.2)/3 dBm / kHz [45]
Frequency offset from the upper frequency of the band edge	**Maximum mean EIRP density**
0 to 0.05 MHz	-23 – 60 x Δ_{FH}* dBm / kHz
0.05 to 0.1 MHz	-26 – 153.3 x (Δ_{FH}* - 0.05) dBm / kHz
0.1 to 2.8 MHz	-45 - 10 x (Δ_{FH}* - 0.2)/3 dBm / kHz
2.8 to 5.8 MHz	-55 dBm dBm / kHz

* Note: Δ_{FL} in MHz is the offset from the lower edge of the permitted frequency band at 1876.7 MHz (it has values in the range -3.2 to 0 MHz)
Δ_{FH} in MHz is the offset from the upper edge of the permitted frequency band at 1880 MHz (it has values in the range 0 to 2.8 MHz)

[44] Ofcom, *Variation of Concurrent Spectrum Access 1781 MHz Licence*, 29 September 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0024/90447/160929-1781-MHz-Variation-Statement_final.pdf

[45] This reflects the emission limits in the current CSA licenses. We will consider further whether a minor relaxation may be needed to ensure there is no negative step at 3.2 MHz from the lower edge as shown in Figure 9.

Figure 9: Example of block edge mask (BEM) in the 1800 MHz shared spectrum



5.30 We do not propose to impose any additional restrictions on terminal emissions outside of the authorised bandwidth, instead we will rely on emission requirements in the relevant harmonised standards.

2300 MHz shared spectrum

5.31 We propose use of an unpaired channel up to 10 MHz bandwidth in the 2300 MHz shared spectrum and on a technology neutral basis.

In-block power limits

5.32 The maximum EIRP that we propose for *low power* base stations is 24 dBm per carrier per sector.

5.33 In addition, the maximum EIRP that we propose for *medium power* base stations is 42 dBm per carrier per sector, provided that we are assured that these deployments won't cause harmful interference to other existing uses, including those of MOD in the band.

5.34 We propose a power of up to 23 dBm[46] for terminal stations. This will be a TRP limit for mobile or nomadic terminals and an EIRP limit for fixed or installed terminals.

Antenna height limits

5.35 Outdoor low power base stations will be limited to a maximum height of 10 metres above ground level. This is in order to reduce the risk of interference to other new users of the same channel.

5.36 Any permitted outdoor medium power base stations will also likely be limited to a maximum of 10 metres above ground level in order to reduce the risk of interference to other users.

5.37 There are no indoor height limits proposed.

[46] The European harmonisation, and our authorisation, includes an additional 2 dB measurement uncertainty taking the limit to 25 dBm in this band, similar to existing terminals in the 2350-2390 MHz band.

Frame structure and out of block emissions requirements

5.38 In order to facilitate sharing between new users and the licensee of the 2350-2390 MHz spectrum, we propose to impose a frame alignment and frame structure requirement on any authorised *outdoor* base stations. An LTE 3:1 frame structure will be compatible with these requirements. In addition, if the licensee of the 2350-2390 MHz spectrum demonstrates that they are suffering harmful interference in a *shared indoor environment*, then the user must also comply with these frame alignment and frame structure requirements.

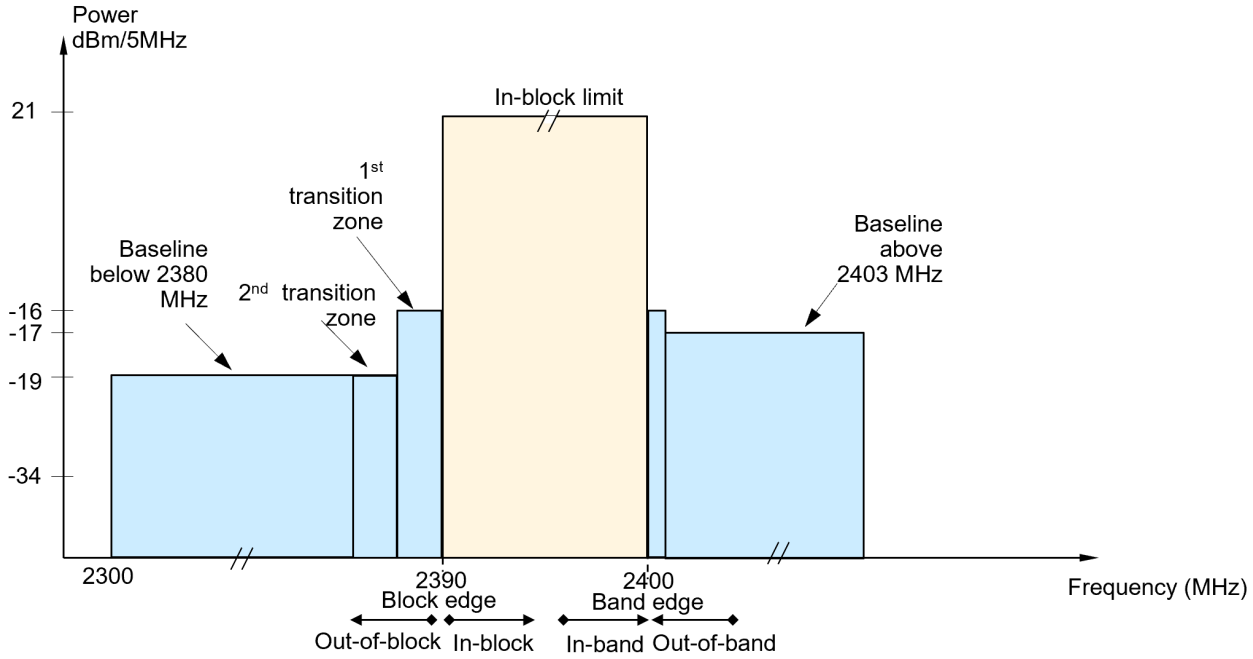
5.39 We propose that emission limits outside of 2300 MHz shared spectrum will be similar to those in the current 2350-2390 MHz licences (See Figure 10).

5.40 For transmissions on the downlink frequencies, we propose that the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following transitional and baseline requirements:

Frequency	**Maximum mean EIRP density**	
2385 to 2390 MHz 2400 to 2403 MHz	Min(Pmax – 40, 21) dBm / 5 MHz EIRP per antenna	
2380 to 2385 MHz	Min(Pmax – 43, 15) dBm / 5 MHz EIRP per antenna	
2300 to 2380 MHz	Min(Pmax – 43, 13) dBm / 5 MHz EIRP per antenna	
Above 2403 MHz	24 dBm < PMax ≤ 42 dBm	(Pmax -41) dBm / 5 MHz EIRP*
	Pmax ≤ 24 dBm	-17 dBm / 5 MHz EIRP*

* The maximum mean power relates to the EIRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.
Pmax is the maximum mean carrier power for the base station in question.

Figure 10: Example block edge mask (BEM) of a low power BS with EIRP 24 dBm / 10 MHz in 2300 MHz shared spectrum.



5.41 Any indoor base station where the licensee in the 2350-2390 MHz spectrum demonstrates that it is suffering harmful interference in a shared indoor environment (or authorised outdoor base station) must follow the frame structure shown in Figure 11:

- timeslots (or subframes) 0, 2 to 5 and 7 to 9 must be allocated to Downlink (D) or Uplink (U) transmissions as indicated or may be left with no transmissions;
- the Licensee must ensure that the special subframe (S) in timeslots 1 and 6 has a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2;
- all timeslots must be 1 millisecond in duration and the frame must start at a common reference time so that frames are aligned with Telefónica and transmissions synchronised; and
- TD-LTE frame configuration 2 (3:1) is compatible with this frame structure. Other technologies are permitted provided that the requirements are met.

Figure 11: Frame Structure

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
3:1	D	S	U	D	D	D	S	U	D	D

Summary of proposals

5.42 Table 2 and Table 3 below summarise our proposals for the low and medium power technical licence conditions for the three shared access bands.

Table 2: Proposed technical licence conditions for low power licence

Proposals	Bands		
	3.8-4.2 GHz	*1800 MHz shared spectrum*	*2300 MHz shared spectrum*
Permitted deployment	Indoor and outdoor *Outdoor antenna system limited to 10 metres height above ground*		*Initially will likely to be widely available for indoor only*
Authorised bandwidth	10, 20, 30, 40, 50, 60, 80 and 100 MHz (actual frequency range provided by Ofcom)	A paired 2 x 3.3 MHz	10 MHz
Maximum base station power (EIRP)	24 dBm / carrier for carriers ≤ 20 MHz; *OR* 18 dBm / 5 MHz for carriers > 20 MHz	24 dBm / carrier (up to 3 MHz)[47]	24 dBm / carrier (up to 10 MHz)
Maximum terminal station (TRP for mobile/ nomadic or EIRP for fixed/ installed)	23 dBm[48]	23 dBm	23 dBm[48]
Frame structure requirements	3:1 structure for all outdoor deployments and certain indoor deployments	Not applicable	3:1 structure for all outdoor deployments and certain indoor deployments

[47] This power will only be available over 3 MHz of the 3.3 MHz bandwidth as existing power density requirements restrict the power in the first 200 kHz and last 100 kHz of the bandwidth

[48] The authorisation will list this as 25 dBm including a 2 dB measurement uncertainty consistent with the European harmonisation, unlike the 1800 MHz shared spectrum where harmonisation specified plus the 2 dB measurement uncertainty.

Table 3: Proposed technical licence conditions for medium power licence

Proposals	Bands		
	3.8-4.2 GHz (fixed)	*1800 MHz shared spectrum*	*2300 MHz shared spectrum*
Permitted deployment	Rural areas	Rural areas *Outdoor antenna systems limited to 10 metres height above ground* *Will be available in select rural locations only for the 2300 MHz shared spectrum if we consider that interference to other users is minimal.*	
Authorise bandwidth	10, 20, 30, 40, 50, 60, 80 and 100 MHz (actual frequency range provided by Ofcom)	A paired 2 x 3.3 MHz	10 MHz
Maximum base station power (EIRP)	Up to 42 dBm / carrier for carriers ≤20 MHz *OR* 36 dBm/5 MHz for carriers > 20 MHz	Up to 42 dBm / carrier (up to 3 MHz)[49]	Up to 42 dBm / carrier (up to 10 MHz)
Maximum terminal station (TRP for mobile/ nomadic or EIRP for fixed/ installed)	23 dBm[50]	23 dBm	23 dBm[50]
Frame structure requirements	3:1 structure for all deployments	Not applicable	3:1 structure for all deployments

Question 11: Do you agree with the proposed technical licence conditions for the three shared access bands? Please give reasons supported by evidence for your views.

Question 12: Are there other uses that these bands could enable which could not be facilitated by the proposed technical licence conditions? Please give reasons supported by evidence for your views.

[49] This power will only be available over 3 MHz of the 3.3 MHz bandwidth as existing power density requirements restrict the power in the first 200 kHz and last 100 kHz of the bandwidth

[50] The authorisation will list this as 25 dBm including a 2 dB measurement uncertainty consistent with the European harmonisation, unlike the 1800 MHz shared spectrum where harmonisation specified plus the 2 dB measurement uncertainty.

Proposed coordination approach and methodology

Coordination approach

5.43 We propose to coordinate new users with other licensed users in the *same* band but, in line with our standard approach, we propose not to consider coordination with other uses in *adjacent* bands.

5.44 We propose to coordinate potential assignments on the basis that the proposed deployment may both cause interference to other users within the shared spectrum as well as suffer interference from them. This would provide users with an understanding of the likely quality of service that they will experience.

5.45 More specifically, for new sharers in the 3.8-4.2 GHz band, we propose to coordinate proposed base stations with both existing and new users as follows:

- other licensees' co-channel low and medium power base stations in the band;
- co-channel and adjacent channel[51] fixed links – typically we expect these to operate in channels 8 and 9 only (3815-3875 MHz paired with 4135-4195 MHz) following clearance of the 3.6-3.8 GHz band;
- co-channel and adjacent channel UKB deployments within the 3925-4009 MHz spectrum; and
- co-channel and adjacent channel Earth stations (receive-only in this band) which have protection afforded to them as part of a PES licence or grant of RSA for ROES. We also propose to consider the additional Crown use by MOD at Bude and Menwith Hill.

5.46 For new sharers in the 1800 MHz shared spectrum, we propose to coordinate proposed base stations with other licensees' low and medium power base stations (including existing deployments by CSA licensees) in the band. As there is a single bandwidth available in this band, we propose to treat all base stations as co-channel assuming the carrier power is spread across a 3 MHz bandwidth, even if they are using only a portion of the available bandwidth.

5.47 For new sharers in the 2300 MHz shared spectrum, we propose to coordinate proposed base stations with other licensees' low and medium power base stations in the band on a single 10 MHz co-channel basis.

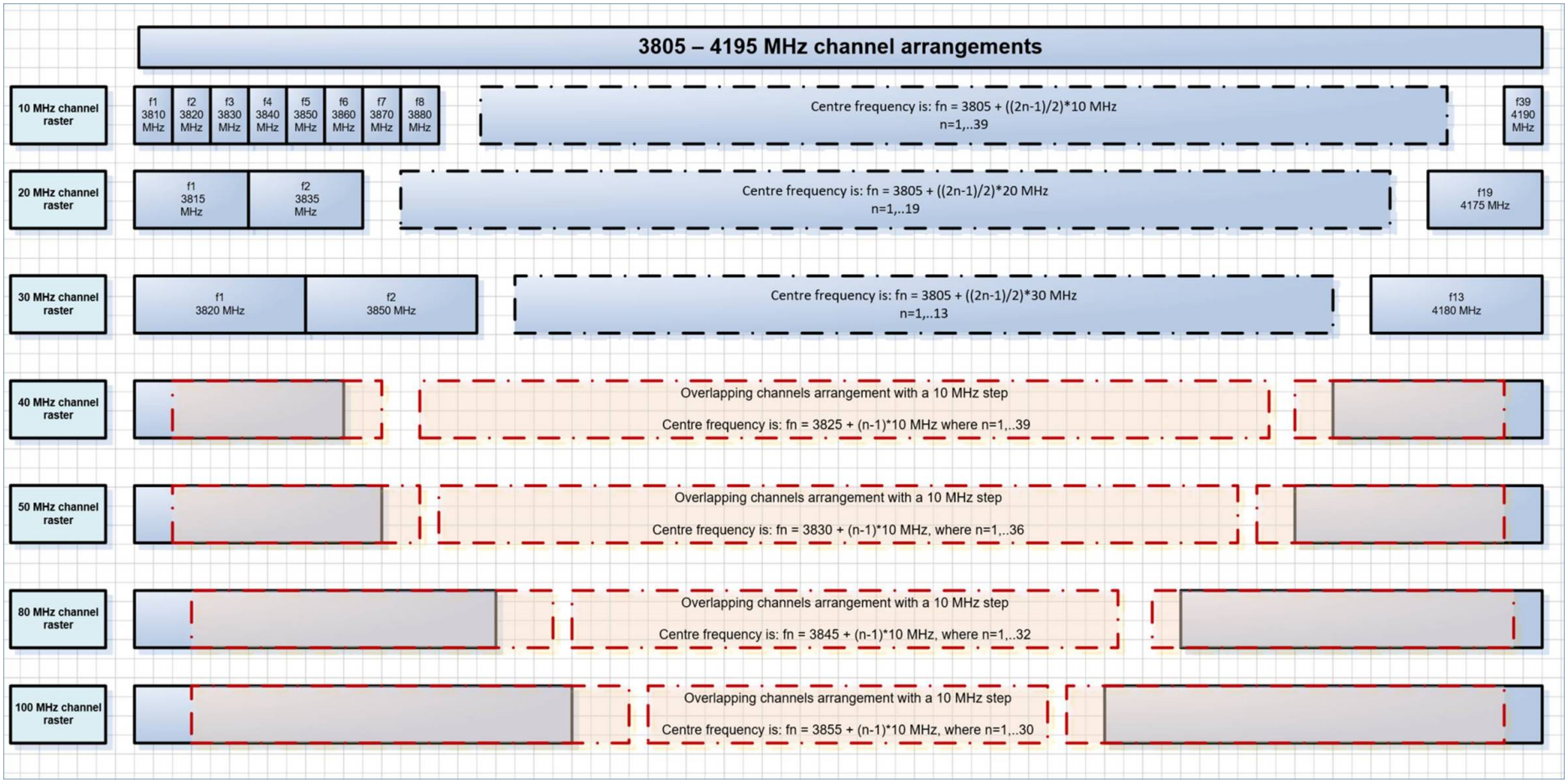
5.48 Finally, we do not propose to consider other base stations of the same licensee in our coordination approach as we consider that the licensee is better placed to manage interference in its own network(s).

5.49 Our proposed channel plan for 3.8-4.2 GHz is in Figure 12 below, where we show the centre frequencies for each raster of different bandwidths. In the case of the larger bandwidths, we propose to have channels that overlap with a 10 MHz offset. Whilst multiple overlapping channels will not be usable within the same area, this approach will give us the most flexibility when assigning frequencies to be able to avoid those

[51] All adjacent channel coordination for all services we propose will be undertaken up to a limit of ±2.5 times the bandwidth.

frequencies used by earth stations, fixed links or existing UKB coordinated base stations within a given area. We propose not to allocate spectrum in the bottom and top 5 MHz blocks of the band. We explain below our rationale for this, from paragraph 5.84.

Figure 12: Available channels in the 3.8-4.2 GHz band



Coordination parameters

5.50 In order to undertake the coordination described above, we need relevant parameters of both new users and other services operating within the shared spectrum environment. In some cases, we propose that these parameters will be provided as part of the licence application and enforced via the resulting licence, for example, the site location and EIRP. In other cases, we propose making some assumptions about equipment performance or deployment approaches, for example, assumptions about the transmit and receive antenna patterns. We describe below our proposed assumptions for a number of parameters required for undertaking the technical coordination.

Antenna patterns

5.51 For both indoor and outdoor low power base stations, we propose to use an omnidirectional antenna pattern based on ITU-R F.1336-4[52] with a 0 dBi gain. The use of an omnidirectional antenna pattern allows us to consider transmissions to all possible directions from the terminal stations as well as other additional BS within the authorised deployment area of a low power licence.

5.52 Similarly, for medium power base stations, we propose to use an omnidirectional antenna pattern based on ITU-R F.1336-4 but with the antenna gain as declared on the application form. The assumption of an omnidirectional antenna pattern at the licensed location, even for sectorised sites, allows us to include the impact of terminal stations, particularly those which are fixed or nomadic, without requiring the additional coordination of each and every terminal station which would be burdensome for both us and the user.

Antenna gain

5.53 This is implicitly included with EIRP and therefore is only an important parameter for understanding the impact of interference from other users. For indoor low power base stations, we propose to assume a 0 dBi antenna gain whereas for outdoor low power and for medium power base stations we propose to use the antenna gain as declared on the application form.

Indoor losses

5.54 When considering indoor-only low power base station deployments, we need to take some building penetration loss into account when considering the impact to or from other users. We therefore propose a 12 dB attenuation value, which represents an average building entry loss for traditional and energy efficient buildings.[53] In taking this approach, we

[52] ITU-R, *Recommendation ITU-R F.1336-4: Reference radiation patterns of omnidirectional, sectoral and other antennas for the fixed and mobile services for use in sharing studies in the frequency range from 400 MHz to about 70 GHz, February 2014*, https://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.1336-4-201402-I!!PDF-E.pdf

[53] ITU-R, *Recommendation ITU-R P.2109-0: Prediction of building entry loss*, June 2017, https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.2109-0-201706-I!!PDF-E.pdf. We produced the CDFs of the building entry losses for traditional and energy efficient buildings. We then integrated over each CDF curve to calculate a single attenuation value for each building type. Finally, we combined the losses of the two types of buildings based on a 70-30 weighting factor to calculate a single building entry loss value.

recognise that some buildings will have more loss in practice, meaning that the risk of interference is decreased and that we may have been able to achieve a greater spectrum reuse. However, we also acknowledge that some other buildings will have less loss than our assumption, which may lead to an increased risk of interference to or from other users.

Impact of area authorisation

5.55 As we are proposing to authorise the deployment of low power base stations that could operate anywhere within an area of 50 metres radius, we need to consider in our coordination approach that deployments may be multiple base stations and can be anywhere within that area. We therefore propose to coordinate on the basis of an assumed single "proxy" base station at the centre of the authorised area.

5.56 Firstly, we consider that a base station could be deployed close to the edge of the authorisation area. Coordination based on the central point leads to a particular path loss requirement and corresponding separation distance from another user. However, if the base station was in practice up to 50 metres closer to the other user than we assumed then this could lead to an increased interference signal strength received by the other user. The likely separation distances for low power indoor base stations are in the order of a couple of hundred metres and reducing this by 50 metres may have a noticeable impact.

5.57 Secondly, we consider that multiple base stations in an area may aggregate to provide an increased interference power to the other user. Typical network design creates a good degree of dominance of a single cell in most circumstances, we therefore consider that the aggregation effect of multiple base stations is likely to be minimal in any given direction as other base stations would be located behind local clutter in order to provide good isolation.

5.58 We therefore propose that in our coordination calculations our "proxy" base station will have an additional 2 dB EIRP to account for these effects. This applies to both indoor and outdoor base stations.

5.59 In a similar way, when considering the proposed base stations as potential victims of interference from other users, we need to take account of the building entry losses for indoor-only base stations and also the deployment nearer to the interferer within the authorised area. We don't need to take account of any aggregation on the receive side and therefore we assume only half of the 2 dB impact. This results in a proposed receive relative gain of +1 dB.

Out of block emissions

5.60 In the 3.8-4.2 GHz band the out of block emissions are important when considering users of adjacent channels that are not synchronized.[54] It is noted in ECC Report 249[55] that emissions are often better than the regulatory masks that have been set. Results for base station emissions presented in that report showed emission levels that were between 5

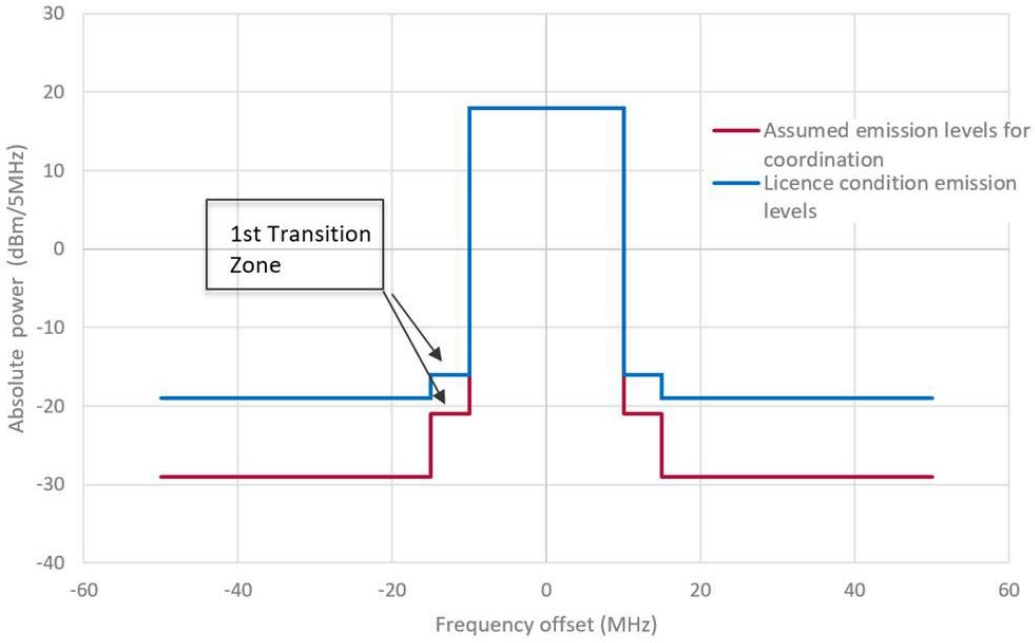
[54] Synchronised means using the same frame structure which is frame aligned in time with the other licensee.
[55] CEPT ECC, *ECC Report 249: Unwanted emissions of common radio systems: measurements and use in sharing/compatibility studies*, 29 April 2016, https://www.ecodocdb.dk/download/32604bf0-7ac0/ECCRep249.pdf

and 15 dB lower than the masks for the base stations in question. This is to be expected as manufacturers design their products to meet the regulatory levels with some margin. We expect a similar level of typical performance in the 3.8-4.2 GHz band. We note that network loading lower than 100 % may also lead to some further reductions in emissions.

5.61 We therefore propose to take reduced emissions into account in our coordination approach. Specifically, we propose to assume the emission levels are reduced by 5 dB in the adjacent 5 MHz and 10 dB thereafter.

5.62 An example of the proposed emission levels for coordination for a low power base station operating in a 20 MHz channel is shown in Figure 13. For comparison, we also present our proposed licence conditions which are based on those in CEPT Report 67[56].

Figure 13: Emissions based on licence conditions and proposed emissions assumed for coordination



Protecting incumbent users in 3.8-4.2 GHz

5.63 We have existing defined protection criteria for earth stations, fixed links and UKB deployments that are used to coordinate new deployments within the 3.8-4.2 GHz band. We propose to maintain these protection levels for these services when coordinating with the new users in the band, so that there will be no change to the current protection levels that these users are being afforded.

5.64 Based on the protection criteria of the existing users in the 3.8-4.2 GHz band, we have developed a map of predicted spectrum availability in this band for the low and medium power licences in annex A7.

[56] CEPT ECC, *CEPT Report 67: Review of the harmonised technical conditions applicable to the 3.4-3.8 GHz ('3.6 GHz') frequency band,* 6 July 2018, https://www.ecodocdb.dk/download/561367fd-1ac6/CEPT%20Report%2067.pdf

Protecting new sharers

5.65 For all bands, we need to consider the impact on proposed base stations from other new and existing users in the band. We also need to consider the protection of the existing base stations that are operating in the 1800 MHz shared spectrum where these are currently self managed by existing CSA licensees. However, in this latter case, we do not propose to perform any checks between existing base stations as we note that these are already deployed and operating. Rather, we propose to consider protection for existing base stations from proposed new base stations only.

5.66 We propose that on a co-channel basis, we will consider the minimum acceptable interference power at the receive base station to be a level that does not exceed an interference to noise ratio (I/N) of 0 dB. We assume for low power base stations that the base station noise figure is 13 dB[57] and for medium power base stations that it is 10 dB.[58]

5.67 We recognise that a more typical value for systems using mobile technology might be an I/N of -6 dB[59] which leads to an overall noise rise of 1 dB rather than our proposal for 0 dB which would lead to a 3 dB noise rise overall in the base station. We consider that our proposal is a proportionate balance of minimising undue interference whilst maximising spectrum reuse in an area and therefore spectrum efficiency and overall availability for these bands. In making this proposal, we consider:

- In practice when base stations are using FDD or follow the same synchronised frame structure in TDD operation (as we are proposing) then base station to base station interference does not occur and the interference that is more likely is base station to other users' terminal stations. However, we note that interference can occur at a base station receiver from other users of different frame structures such as fixed links and potentially UKB base stations. Calculating base station to base station interference in our coordination tool is therefore a proxy for the real interference mechanisms affecting terminals in unknown locations.
- We have not accounted for any practical deployment losses in our proposed technical assignment approach. For example, equipment may operate at slightly lower power than predicted due to additional feeder losses, polarisation loss or other equipment inefficiencies that we don't take into account. We also do not propose to consider that terminal stations are often at a lower height than base stations and affected more by local clutter than base stations may be.
- We tend to find in practice that systems are more tolerant to interference than our theoretical predictions suggest.

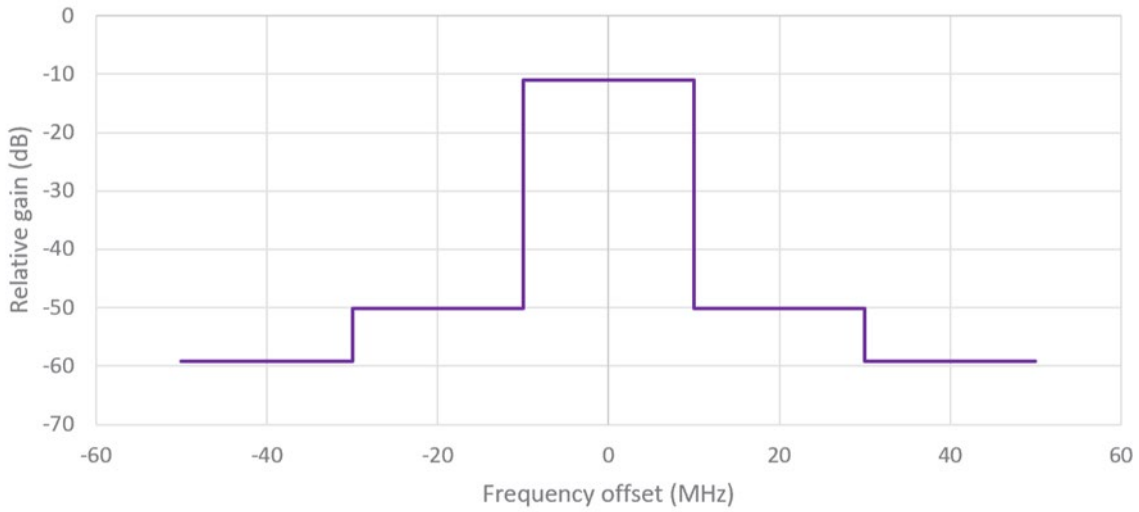
[57] ITU-R, *Report ITU-R M.2292-0: Characteristics of terrestrial IMT-Advanced systems for frequency sharing/ interference analysis*, December 2013, https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2292-2014-PDF-E.pdf (Table 1, pico/femto cell)
[58] ITU-R, *Report ITU-R M.2292-0: Characteristics of terrestrial IMT-Advanced systems for frequency sharing/ interference analysis*, December 2013, https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2292-2014-PDF-E.pdf (Table 1, micro cells)
[59] ITU-R, *Report ITU-R M.2292-0: Characteristics of terrestrial IMT-Advanced systems for frequency sharing/ interference analysis*, December 2013, https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2292-2014-PDF-E.pdf (Table 5)

- In addition, our assumption of modelling an omnidirectional antenna for low and medium power base stations might not reflect accurately the off-beam gain of the receive antenna resulting in an over-estimation of the likely interference.
- Likely technology candidates for the sharing bands covered in this consultation are quite interference resilient in any case. They have the ability to adapt to the quality of the channel by varying the modulation and coding schemes which changes the overall data rate available but not the availability of the service.

5.68 In addition, in the 3.8-4.2 GHz band we need to consider the impact on new sharers from users operating in adjacent channels. This is considered using the concept of receiver performance in our coordination tool. Based on 3GPP specifications we have derived a receiver performance from the specifications for adjacent channel selectivity and blocking within those specifications.[60]

5.69 As described above, we propose to include the impact of the area authorisation and indoor building entry losses where relevant within this receiver performance. An example of a 20 MHz receiver performance of an indoor low power BS is shown in Figure 14 below.

Figure 14: Assumed receiver performance for a 20 MHz indoor base station with indoor offsets included



Coordination methodology

5.70 When coordinating between users as described in 5.45, we propose to assess whether the interference threshold has been exceeded for a particular user at their location. To assess whether a proposed base station will cause or suffer interference from other users, we must take into account the separation distance between the interferer (along with its EIRP) and the victim system (along with its protection threshold). In the case of adjacent channel

[60] 3GPP TS 38.104 specifies the reference sensitivity levels for a 20 MHz local area BS. It notes that the Adjacent Channel Selectivity (ACS) requirements are satisfied with a mean interfering signal power of -44 dBm and the wanted signal 6 dB above the reference sensitivity level. For a BS with 13 dB Noise Figure, a wanted signal level of 6 dB above the reference sensitivity level is equivalent to a wanted signal level 4.7 dB above thermal noise floor. The difference between the wanted and interference levels defines the first adjacent ACS level. The values for channels further away can be derived from the blocking requirements of 3GPP TS 38.104.

assessment in the 3.8-4.2 GHz band, we also need to take account of the out of block emissions and the receiver performance.

5.71 In some cases, the bandwidth of the new base station and that of the system being protected are different or have EIRP and protection levels which are defined against different reference bandwidths. In this case, we will also take a correction factor into account to align the parameters of the two systems.

Propagation losses

5.72 A propagation loss depends on distance as well as the obstacles and clutter in between the two locations. Our current coordination tool for coordinating new UKB deployments or fixed links uses ITU-R P.452[61] with different percentages of time depending on the service being protected. We will maintain the current assumptions for the existing Earth stations, fixed links and UKB base station protections.

5.73 Going forward we propose that we will use P.452 with a percentage of time equal to 20% when considering protection of other base stations by new users in these bands (including existing 1800 MHz shared spectrum deployments).

5.74 We propose to use terrain and clutter maps of 50-metre resolution from Infoterra[62] as part of the path loss model.

5.75 Propagation losses are also significantly affected by the height of the transmitter and receiver in the calculations. We propose to use the height of the base station declared on the application form for outdoor deployments (up to a maximum of 10 metres in the cases where the height limit applies).

5.76 However, we propose to always assume that the indoor base stations are at a height of 5 metres irrespective of the actual height or floor they are deployed on. This approach simplifies the application process for users and avoids situations where a deployment in a high-rise building is assumed to have poor local clutter losses by being above the surrounding clutter but in practice may have increased building entry losses.

Potential risks with our approach to coordination

Local negotiations

5.77 Overall, we recognise that in circumstances when users have the ability to coordinate with other users, for example though local site-specific considerations, using Ofcom's technically assigned criteria may result in spectrum being used a little less efficiently. Given our proposal to make available three bands and with multiple channels available in the 3.8-4.2 GHz band, we do not consider that there is a very high likelihood of coordination failure. However, we note that coordination negotiations between users could be lengthy

[61] ITU-R, *Recommendation ITU-R P.452-10: Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz*, 2001, https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.452-10-200102-S!!PDF-E.pdf
[62] http://www.infoterra.es/en-products

and with no guarantee of success, and the likelihood of local coordination failure increases when there are multiple users in the vicinity.

5.78 This situation may also occur in multi-storey buildings, particularly in the 1800 MHz and 2300 MHz shared spectrum bands, where there is only one channel available – other users could be denied access to spectrum if the available channel has already been authorised to another user. However, our proposals allow a concurrent trade where, with agreement between users, multiple licensees could jointly hold the licence covering the same building and coordinate between themselves as needed.

Using narrower carriers

5.79 We also recognise that our authorisation approach allows the required 24 dBm or 42 dBm EIRP per carrier. Particularly, in the case of the 1800 MHz shared spectrum, a user will be authorised for the full 3.3 MHz of bandwidth but many sites today use one or more 200 kHz GSM carriers within that bandwidth. Our coordination approach, however, assumes that the carrier power is spread across a 3 MHz bandwidth.

5.80 Where a site is using a narrowband carrier such as GSM, our coordination approach may underestimate the separation required by up to 12 dB in the case of another GSM base station suffering interference. If we were to adjust our coordination calculation to account for this, then for wider channels up to 3 MHz wide we would be overprotecting by 12 dB and this would reduce the availability of spectrum for other sharers unnecessarily.

5.81 However, there are a number of reasons why we think the risk of interference caused by this approach will be low:

- We propose that all existing GSM deployments will automatically be assumed to be coordinated and authorised on that basis without the need to have undertaken any calculations.
- Newer 4G technology is more spectrally efficient than older 2G (GSM) technology and therefore we do not expect there to be many new GSM deployments in the band.
- GSM deployments will typically only use 1 or 2 channels of 200 kHz (up to a maximum of 4 channels) within the 3.3 MHz bandwidth at any location. Therefore, if the situation does arise where one GSM base station is causing interference to another co-channel GSM system, then retuning one of the base stations to an adjacent channel will mitigate the interference.
- Our proposed coordination approach for base stations is a proxy for the interference that would be caused to other users' handsets or fixed terminals and therefore the impact would be from both base stations to a handset or from a handset to multiple base stations. Handsets are mobile devices typically and therefore any interference is transient.
- Where the victim is a wideband carrier such as LTE, then the impact of a narrowband GSM carrier would be to affect one or two of the resource blocks within the bandwidth. LTE technology has the ability to adjust the scheduling of data in such a way as to avoid resource blocks that have a particularly bad quality caused by any

interference. Therefore, other than a small impact in the maximum throughput for a particular user, the interference will have negligible impact.

Coordination summary

5.82 Our proposed coordination approach for the three shared access bands is shown in Figures 15 and 16 below.

Figure 15: Coordination approach in 3.8-4.2 GHz

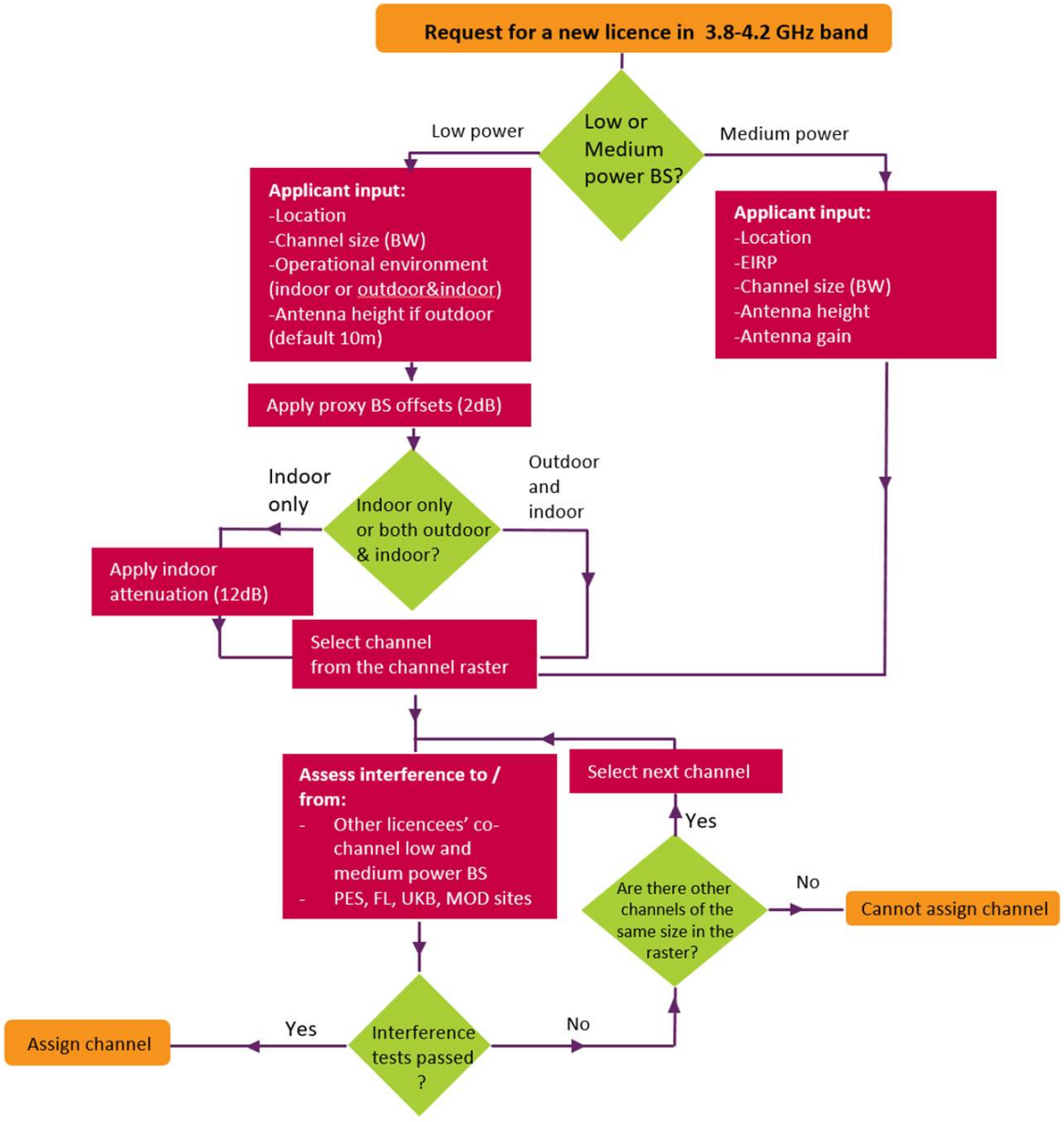
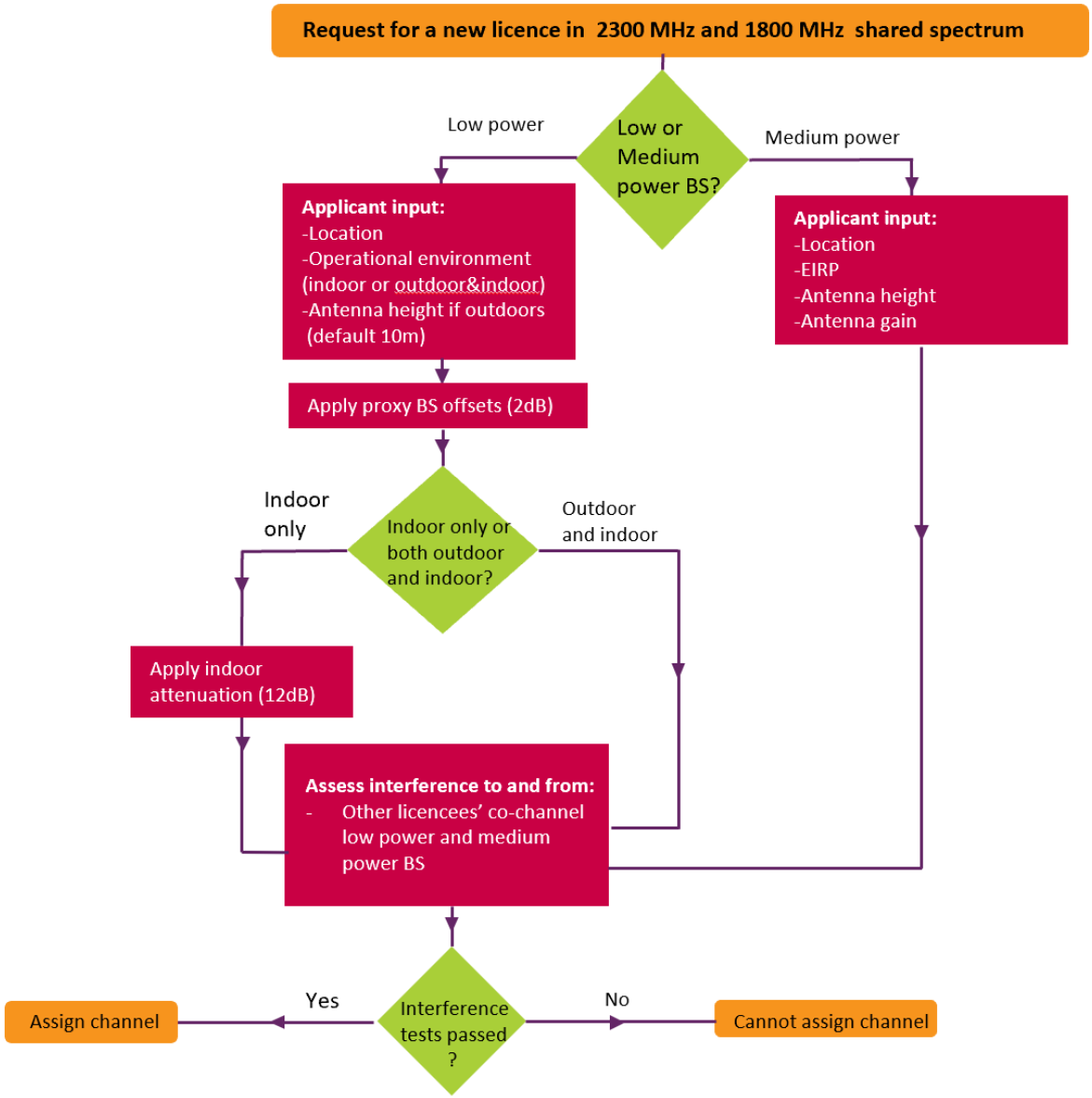


Figure 16: Coordination approach in 2300 MHz and 1800 MHz shared spectrum



5.83 The table below summarises the parameters required as input from the applicant for the coordination process.

Table 4: Input parameters required from the applicant for the coordination process

	Low power BS	*Medium power BS*
Channel size	Yes	Yes
Channel size	3.8-4.2 GHz: 10, 20, 30, 40, 50, 60, 80, 100 MHz 1800 MHz shared: Default 2x3.3 MHz 2300 MHz shared: Default 10 MHz	
Environment (indoor / outdoor & indoor)	Yes	N/A
Max EIRP	No	Yes Up to 42 dBm / carrier *For carriers > 20 MHz in 3.8-4.2 GHz: 36 dBm / 5 MHz*
Rx antenna gain	No	Yes
Antenna height	Yes, if outdoors (max 10 metres AGL)	Yes

Question 13: Do you agree with our proposed coordination parameters and methodology? Please give reasons supported by evidence for your views.

Question 14: What is your view on the potential use of equipment with adaptive antenna technology (AAS) in the 3.8-4.2 GHz band? What additional considerations would we need to take into account in the technical conditions and coordination methodology to support this technology and to ensure that incumbent users remain protected?

Protecting users adjacent to the three shared access bands

3.8-4.2 GHz band

Spectrum access licences below 3.8 GHz

5.84 We propose not to authorise new use in the 5 MHz block between 3800-3805 MHz. This reduces the risk of interference to and from the uncoordinated and potentially unsynchronised base stations below 3.8 GHz.

5.85 We set out in annex A5 the reasons for this. We note that this does not materially reduce spectrum availability as our proposed channel plan now aligns with the UKB channels starting at 3925 MHz.

Radio altimeters above 4.2 GHz

5.86 We also set out in annex A5 our analysis for ensuring that undue interference is not caused to radio altimeters operating above 4.2 GHz. We have considered three different interference mechanisms: receiver overload, desensitization, and false altitude reports. We do not see any evidence that our proposed low or medium power technical conditions will lead to any interference at or around airports where aircraft have an altitude low enough to potentially suffer interference and where they rely heavily on the altimeters.

5.87 Each aircraft has up to three radio altimeters that are separated by 5 MHz. By taking a slightly cautious approach and proposing a 5 MHz frequency separation between 4195-4200 MHz, we align the upper end of the new uses in the 3.8-4.2 GHz band with the upper end of the existing fixed links uses where the upper channel stops at 4195 MHz.

5.88 This 5 MHz separation also ensures that the radio altimeter receivers have sufficient attenuation to signals below 4195 MHz and that the out of band emissions of new users' base stations falling above 4.2 GHz are low enough for no undue interference to be caused to the radio altimeter service.

1800 MHz shared spectrum

5.89 We consider that the technical conditions applicable to this band have already been set in order to protect adjacent users. We do not consider that we are changing the conditions in a way that will materially affect the existing interference environment. We have therefore not undertaken any further studies.

2300 MHz shared spectrum

Protecting users below 2.39 GHz

5.90 We note in annex A6 that there is some increased risk of interference between unsynchronised base stations in the 3.8-4.2 GHz band. In that case we include a 5 MHz frequency separation in order to reduce any risk of interference to and also from the adjacent band users whose exact base station locations are unknown.

5.91 Similarly, the locations of Telefónica's base stations operating in 2350-2390 MHz are not known to us. However, the conditions of its licence require that it operates using a TDD frame structure that is identical to the one we are proposing for our low and medium power base stations in 2300 MHz shared spectrum. We therefore consider that the outdoor base stations and certain indoor base stations either side of the 2.39 GHz boundary will be fully synchronised and no further considerations are needed.

Protecting users in the 2.4 GHz band

5.92 Alongside the 5 GHz band, use of WiFi in the 2.4 GHz band is licence exempt from 2402 MHz onwards. We have analysed some previous studies in annex A6, where we recognise that there could be a risk of some degradation to the performance of WiFi when a combination of circumstances happens at the same time. In particular, if the following circumstances occur in parallel:

- the WiFi signal is very weak, operating at its minimum signal levels; and
- the WiFi equipment does not have sufficiently good filters to reject signals from the adjacent mobile band; and
- mobile handsets use 2390-2400 MHz; and
- mobile handsets transmit at near full power of +23 dBm; and
- the mobile handset is particularly close to the WiFi receiver, i.e. less than one metre away.

5.93 Assistive Listening Devices (ALDs) operate in the 2.4 GHz band on a licence exempt basis and regularly "hop" their transmission frequency around in order to be able to share with other ALD users, other technologies in the band or to avoid interference from outside of the band. We analysed some previous studies in annex A6. Whilst these suggest that ALDs are quite robust to 4G interference in most real-life scenarios, they also indicated that, when a combination of circumstances occurs in combination, there could be a risk of interference leading to a severe audio degradation. These are:

- the ALD system is working at or beyond its normal maximum range and therefore has a very weak signal; and
- the mobile handset transmits at near full power of +23 dBm; and
- the mobile handset is located particularly close to the ALD receiver, i.e. less than one metre away.

5.94 We consider that these circumstances have a low likelihood of occurring individually in practice and an even lower likelihood of occurring in combination. We therefore consider that the overall risk of interference is likely to be low.

5.95 We provide further details of risk of interference to ALDs and WiFi in annex A6, but we consider:

- that with the technical conditions proposed, any risk of interference will be predominantly from handsets and not the base stations;
- that mobile handsets' powers are rarely above 10 dBm in an indoor environment where coverage is provided by indoor base stations;
- that it is unlikely that a WiFi or ALD receiver will be in sustained close proximity to a mobile handset used by someone else; and
- that normal day to day use of ALD systems and WiFi does not have very weak signals, meaning they are more robust to interference.

5.96 We are already taking measures to reduce the risk of interference by:

- following the introduction of the Radio Equipment Directive (RED)[63] in 2014, we have been working with industry to improve harmonised standards so that new ALD and WiFi equipment has improved receiver performance and is more robust to interference; and
- as part of our previous work on the 2.3 GHz award, we worked closely with different charities involved with those who use ALDs. As part of this we contributed to some

[63] European Commission, *Radio Equipment Directive (RED)*, https://ec.europa.eu/growth/sectors/electrical-engineering/red-directive_en

guidance information for ALD users to help them avoid circumstances that could lead to very small separations between mobile handsets and ALDs.

5.97 We note that in the unlikely event that interference was to occur in practice, an ALD or WiFi user may be able to move or re-orientate their device slightly in order to reduce any impacts.

5.98 Although we do not consider that interference is likely to occur, we recognise that the existing information on which we base our assessment was not specifically developed for the particular deployment scenarios and frequencies that we are now proposing. In the context of widescale use of WiFi and the more vulnerable nature of users of ALD systems, albeit operating on a non-interference non-protection licence exempt basis, we are initially taking a more cautious approach for the introduction of new users in the 2300 MHz shared spectrum. We are therefore proposing additional measures:

- firstly, we propose to let licensees know that new low power base stations should not be located very close to WiFi access points which are using the lowest frequency WiFi channels unless those access points have good filtering in them;
- secondly, licensees should consider carefully whether there is a risk of mobile handsets in 2300 MHz shared spectrum being operated in close proximity to those ALD receivers that are operating over an increased range (such as in the school classroom) and consider whether one of the alternative shared access bands is more appropriate for their uses; and
- finally, through our technically assigned coordination approach, we have the ability to consider whether specific proposed deployments are likely to cause a higher than expected risk of interference to other users. We therefore expect that initially, spectrum is likely to be widely available for indoor low power uses but outdoor and medium power base stations may be available in select locations only. As we gather more evidence, we expect that availability of outdoor and medium power base stations to increase.

Protecting MOD uses

5.99 As part of the 2.3 GHz award, we set additional emission restrictions below 2340 MHz in order to protect Ministry of Defence (MOD) ongoing uses of the lower 2.3 GHz band. Whilst MOD still has those systems, we consider that no additional limits are required for base stations in the 2300 MHz shared spectrum. The low density of medium power base stations and 50 MHz frequency separation means that interference is unlikely in practice. Whilst we expect a greater number of low power base stations, the typical emissions from these will be lower than the limit that was previously set.

5.100 The 2300 MHz shared spectrum is also currently used by the MOD for airborne systems providing telemetry in air-to-ground or air-to-air configurations. Many applications have wide coverage areas but the majority of the time they avoid urban areas. In addition, there are also some land-based systems that operate in this band. These land-based systems typically have a similar coverage area to that of the low power systems that we are proposing to introduce in the band.

5.101 Typically, MOD's uses will be geographically separated from the new users within the band and therefore there is unlikely to be any interference caused by new users to MOD uses or vice versa. Low power systems indoors will have additional isolation from outdoor MOD systems, which reduces the risk further.

5.102 However, we acknowledge that there remains the possibility that both types of usage could be in exactly the same area and we will work with MOD to understand how this risk can best be managed. This may to lead to Ofcom considering MOD uses as part of our technically assigned process at some MOD training locations or other buildings, which will prevent new users being deployed at those locations.

5.103 We are continuing to work with MOD regarding their use of airborne telemetry systems in order to understand the likely risk that they will either suffer or cause interference to new uses in this spectrum. As our understanding increases of the protection these systems will require, and the interference that they may cause, we will consider further whether additional outdoor uses may be possible in these locations.

Question 15: Do you agree with our proposal not to assign spectrum to new users in the 3800-3805 MHz band and the 4195-4200 MHz band?

6. Licence fee proposal for the three shared access bands

Introduction

6.1 In this section, we set out our licence fee proposal for the proposed low power and medium power licence for the three shared access bands.

6.2 We have a duty to secure the optimal use of the radio spectrum.[64] We interpret "optimal use" to mean that the spectrum is used in a way that maximises the value that citizens and consumers derive from it, including the wider social value of spectrum use, and taking into account the specific consumer and citizen interests, including the interests of particular groups within society.

6.3 As set out in Ofcom's Strategic Review of Spectrum Pricing ("the SRSP"),[65] where we expect spectrum to be in excess demand[66] from existing and/or feasible alternative uses in future, if cost-based fees were applied, then we apply charges that reflect the opportunity cost of the spectrum. We consider that in these situations pricing on the basis of opportunity cost provides incentives for the efficient use of scarce spectrum. We refer to fees based on the opportunity cost of spectrum as administered incentive pricing (AIP).

6.4 Where we do not expect there to be excess demand for the spectrum or where excess demand can be managed differently, for example, through technical requirements, and therefore it is not appropriate to apply AIP, we charge fees that reflect our spectrum management costs, i.e. cost-based fees. In cases where no licence is required (e.g. WiFi) there would be no charge. Where fees based on the opportunity cost of the spectrum would be lower than the relevant costs incurred in managing the spectrum we would charge cost-based fees even if there was excess demand.

Approach to pricing the proposed new licence

6.5 The existing users in the 3.8-4.2 GHz band (that is, satellite Earth stations, fixed links and UK Broadband) are charged AIP-based fees as we expect that the demand for spectrum from these users is likely to lead to excess demand in the locations where they deploy.

6.6 In determining the appropriate pricing approach for the new users in the band, we have considered whether the demand from these new users will be such that it is likely to lead to excess demand in the locations where they deploy. If it does not, then charging an AIP-based fee which was higher than the cost-based fee would risk leading to an inefficient use of spectrum. This could arise if some potential users, whose specific deployment would not

[64] See section 3(2)(a) of the Communications Act 2003, which requires Ofcom to secure (among other things) in the carrying out of its functions, the "optimal use for wireless telegraphy of the electromagnetic spectrum".
[65] Ofcom, *SRSP: The revised Framework for Spectrum Pricing*, 17 December 2010, https://www.ofcom.org.uk/__data/assets/pdf_file/0024/42909/srsp-statement.pdf
[66] Excess demand refers to the situation where there is more spectrum demanded in a band (either nationally or in a given location) than there is available supply of that spectrum band.

lead to excess demand, would be willing and able to pay a cost-base fee, but be unwilling/unable to pay the AIP-based fee. As a result, the AIP-based fee may lead to some potential users, who would have deployed if a cost-based fee was in place, deciding not to deploy.

6.7 To assess this, we have considered the potential uses of the propose new low and medium power licence.[67]

6.8 We anticipate that the medium power licence is likely to be used for FWA and mobile coverage improvements in rural areas. Given the nature of these services, it is likely that there would only be interest from either a single user or at most a small number of users in a given geographic area. For example, it is unlikely to be economically viable for a large number of FWA providers to be supplying FWA services to a particular rural location. As a result, we consider it likely that (in the vast majority of cases) there will be sufficient spectrum available for all users who wish to deploy these services in a given area, and therefore that the demand from these new users is unlikely to lead to excess demand.

6.9 In the case of low power use there is the possibility for more users to be in very close proximity. We recognise this could lead to a situation of very localised excess demand, particularly in urban areas. However, at this stage we do not have evidence as to how likely this is to occur, or in which areas. We consider that in most instances, the demand from these new users is unlikely to lead to excess demand given the availability of multiple bands, and of multiple channels in the 3.8-4.2 GHz band.

6.10 We recognise that forecasting future demand for a new licence is highly uncertain. Given this uncertainty, our assessment of the potential for the new licence to lead to excess demand set out above, and our duty to encourage innovation, we provisionally conclude that implementing AIP for the propose new licence would not be appropriate. We therefore propose to set cost-based fees for the new licence to cover our spectrum management costs associated with these licences.

6.11 We may reassess our position once the new licences have been rolled out and evidence of their actual demand and use is available. If there is evidence of excess demand, particularly for low power use, then we would consider undertaking a fee review and potentially move to AIP-based fees to ensure the continued efficient use of spectrum. However, in doing so we would be mindful of the potential impact on licensees of large fee increases. Any fee review would include an impact assessment and we would consider phasing-in an increase in fees, where appropriate.

Implications for other licensed users in the 3.8-4.2 GHz band

6.12 As set out in paragraph 6.5 above, existing users in the 3.8-4.2 GHz band are charged AIP-based fees. We continue to consider that demand for spectrum from fixed links and satellite Earth stations is likely to lead to excess demand in the locations where they deploy, given the larger sterilisation areas resulting from these users. We therefore plan to continue to charge AIP-based fees for those users at present. We will continue to monitor

[67] See section 3 for a fuller discussion of the potential uses in the three shared access bands.

the demand for spectrum in the 3.8-4.2 GHz band in the future to ensure that the fees we charge remain appropriate.

6.13 In designing the proposed new licence, we have been mindful of the potential impact on existing users. Existing users who require additional spectrum in the future will be able to request this in the usual way. As set out above, although uncertain, we consider that whilst introducing new users may reduce the amount of spectrum available for sharing by existing users already operating under a first come first served basis, we do not consider that the impact to existing users is likely to be significant given the pattern of demand by these users.

6.14 However, we may reassess our position if it appears there is a significant problem with existing users being unable to access additional spectrum, due to new users in the band. In such a situation we may consider it appropriate to move to AIP-based fees for all users to ensure the efficient use of spectrum.

Potential unintended consequences with proposed pricing approach

6.15 As set out above, while forecasting future demand for the proposed new licence is highly uncertain, at present we consider it unlikely that the new licence will create excess demand. However, we recognise that the use of cost-based fees coupled with a first come first served approach to licensing has the potential to lead to unintended inefficient outcomes. In this section we discuss some of these unintended consequences and how we propose to mitigate them.

6.16 As set out in more detail below we consider that most of these issues will not be significant and should be adequately addressed either through modest incentives or through monitoring and enforcement where necessary.

6.17 In particular, we are mindful that this is a new licence product, possibly with uses that have yet to be envisaged. It is therefore important that we monitor the evolution of the bands and adopt a flexible approach that facilitates new technologies and services. We consider that a first come first served approach to licensing with a cost-based fee is the appropriate approach to facilitate these developments at this time.

Failure to surrender licences that are no longer being used

6.18 If the licence fee is low there is a risk that some licensees may (possibly inadvertently) retain their licences even if they are no longer using them. This could lead to a situation where in certain localised areas a new user may be unable to be authorised as the spectrum has been authorised to another licensee who may no longer be planning to use some or all of the bandwidth they have licensed.

6.19 If such a situation arose, the new user will normally be able to identify nearby existing users via our Spectrum Information Portal[68] and engage with them to understand whether the existing licence was in use and, if not, whether it could be relinquished or traded.

Users requesting more bandwidth than necessary

6.20 If the licence fee does not vary by the amount of bandwidth requested there could be a risk that licensees request more bandwidth in 3.8-4.2 GHz than they actually require. For example, a user may require 40 MHz of 3.8-4.2 GHz spectrum in a given location but may request 100 MHz in that location if doing so carried no additional cost. This issue is not relevant to other bands where there is only one channel that can be requested.

6.21 While this risk could arise we would expect that, in most cases, even if it were to occur, it would be unlikely to deny another user access to the spectrum they wanted. This is because, as set out in paragraphs 6.8 and 6.9, for medium power rural use in most cases we expect there will be a limited number of users in a given location, and even if users requested the maximum possible bandwidth it is likely that there would still be sufficient available spectrum for other users. Nonetheless, to minimise this risk we are proposing to implement a modest incentive in the pricing to encourage the efficient use of spectrum, specifically charging a cost-based fee that varies by bandwidth. We discuss this further in the next section.

Anti-competitive behaviour by licensees

6.22 We have considered the potential for anti-competitive behaviour by some licensees.

Hoarding and speculative acquisition

6.23 We would be concerned if a licensee sought to hoard spectrum; that is, where a licensee requests more spectrum than it requires in a given location with the intention of not deploying that spectrum. The intention could be to prevent others from using the spectrum in that location, perhaps to reduce competition. For example, a service provider could request more spectrum than it required in an area in order to prevent other service providers from being able to access sufficient spectrum to offer a competing service in that area.

6.24 We would also be concerned if a potential provider of services deliberately sought to limit competition in a given area (for example, a commercial building) by acquiring all the available spectrum for that site. While we do not expect this to be a significant problem, we are clear that the first come first served basis of these proposed licence products must not be exploited to limit local competition.

6.25 For example, if party A acquired a low power licence to use the spectrum in a specific commercial building or industrial park, we would not expect that to prevent the landlord being able to appoint party B to provide services to that building/park. In that case we

[68] The spectrum information portal provides information on licenses granted by Ofcom and is found at https://www.ofcom.org.uk/spectrum/information/spectrum-information-system-sis/spectrum-information-portal

would see no reason why A and B would not be able to reach an agreement to transfer the licence from A to B. However, given that the shared access licence is not an exclusive licence, in extreme cases where no agreement can be reached, we could authorise B over the top of the existing licensee A if it is found that A could not legitimately deploy.

6.26 More generally, we note that the existing sharing environment and geographic availability means these bands are suitable for localised and rural access. If stakeholders wish to acquire a large number of licences to provide wide area mobile coverage, then they should instead consider participating in the upcoming 3.6-3.8 GHz spectrum auction which is intended for that use.

6.27 If individual licensees appear to be acquiring large volumes of licences in an attempt to achieve a wide coverage area, then we may review access to the band for these users, particularly if there is a risk that their behaviour is sterilising spectrum access for a large number of other users. We may also consider measures such as introducing a cap on the number of assignments each licensee can hold or limiting the number of applications that can be made over a given period.

Determination of fees

Proposed approach

6.28 As set out above, we propose that the new licence will be subject to an annual fee which will be cost-based.

6.29 In line with our framework for setting cost-based fees[69] we intend to set these fees to fully reflect our spectrum management costs applicable to these licence products.

6.30 Conceptually there are three types of economic costs that are relevant:

- **Variable costs:** These are costs related to the issuance of each licence, for example the time spent by the person running the coordination process and issuing the relevant documentation. These costs vary with the number of licences issued.
- **Specific fixed costs:** These are costs which are fixed (that is, they do not vary with the number of licences issued) but are specific to the new licence product. For example, the cost of the specific coordination IT system specifically developed for this product.
- **Common costs:** These costs are fixed and shared with other licence products (that is, they are not specific to the new licence product). Common costs include building costs, IT and contribution to international spectrum agencies. Each licence class makes a contribution to the recovery of these costs.

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

[69] Ofcom, *Spectrum Pricing: A framework for setting cost-based fees*, 17 March 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/50247/cbfstatement.pdf

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

6.33 Instead, we provisionally conclude that the most appropriate approach is to use the actual per-licence costs associated with a similar licence product. Specifically, we propose to use the costs associated with the Business Radio Tech Assigned licence product as the reference product.[70] Firstly, this is because the process of issuing the licence for this product is very similar to the proposed new product, namely that applications have to be run through a coordination system before licences are issued. Secondly, the ongoing costs of managing interference etc. are likely to be similar.

6.34 We also considered whether to use the costs associated with the Business Radio Tech Assigned licence product as a starting point, and then make adjustments to reflect potential differences between the licence products, for example to adjust for the cost of the new coordination system. However, we considered that this approach would be difficult to implement as it would be difficult to unpick the underlying cost data to make the necessary adjustments. Given the similarities in the licence products (and the associated specific fixed costs, such as the coordination IT system) it appears reasonable to assume that the specific fixed costs for the two products are similar.

6.35 Therefore, on balance, we provisionally conclude that the appropriate and proportionate approach to estimating the cost-based fees is to base them on the per licence costs associated with the Business Radio Tech Assigned licence product. We consider this approach has the benefit of simplicity and transparency in terms of how we have derived the fee and avoids the estimate of the fee being driven by highly uncertain assumptions around the likely take-up of the new licence product.

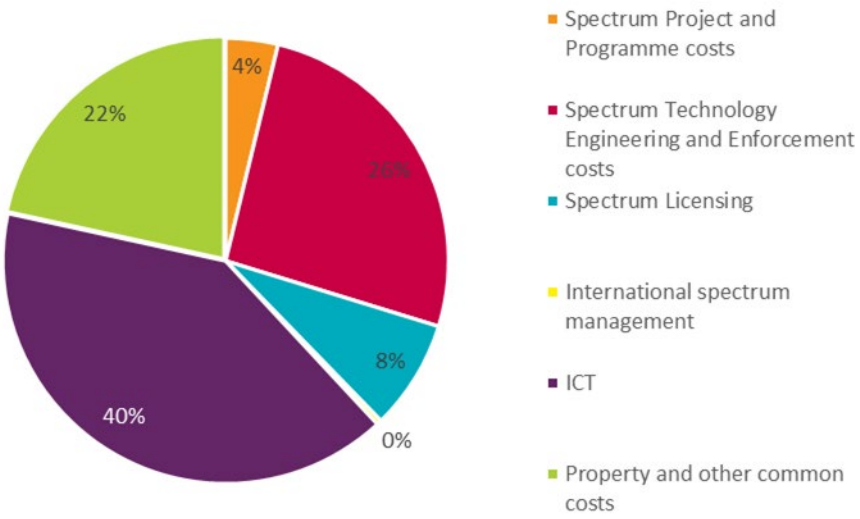
Analysis of spectrum management costs

6.36 By applying our cost allocation methodology,[71] we have identified spectrum management costs for the Business Radio Tech assigned licence totalling £9.04m in 2016/17 (the latest year for which we have cost data). There were 26,961 licences as at 31 March 2017. This implies an average cost per licence of the Business Radio Tech Assigned licence of £335.

6.37 The relevant cost categories and cost breakdown for Business Radio Tech Assigned licence product is shown in Figure 17.

[70] It is important to note that the proposal is to base the cost-based fees for the new licence products on the spectrum management *costs* associated with the Business Radio Tech Assigned licence product. This is different from the current *fees* associated with the Business Radio Tech Assigned licence products which are based on AIP.
[71] Ofcom, *Spectrum Pricing: A framework for setting cost-based fees*, 17 March 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/50247/cbfstatement.pdf

Figure 17: Breakdown of costs for the Business Radio Tech Assigned licence product (2016/17)



6.38 To test the robustness of our 2016/17 analysis, we analysed the costs and licence numbers in the preceding three years as well. These are set out in Table 5 below.

Table 5: Spectrum management costs and number of licences for Business Radio Tech Assigned licence product

	Total costs	No. of licences	Average cost per licence
2013/14	£7.31m	27,077	£270
2014/15	£6.95m	27,199	£255
2015/16	£8.28m	27,298	£303
2016/17	£9.04m	26,961	£335

Source: Ofcom

6.39 The average cost per licence over the four years is £291, with the average cost per licence increasing over the past couple of years to £335 in 2016/17. We propose to use **£320 per year** as the basis for our cost-based fee, as we consider that it is a reasonable indicator of the likely future average costs.

Analysis of considerations relevant for fee setting

6.40 In line with the approach set out in the SRSP[72] and our framework for setting cost-based fees[73] we have considered the policy and sectoral considerations relevant for the setting of fees for the propose new licence, namely:

- the practicalities of implementation, such as our implementation costs, and whether the cost of collecting fees would form a material (and/or disproportionate) part of the overall fee before resetting/ introducing new fees;
- our spectrum management duties, for example, whether the benefits of the use – to society overall[74] or in promoting innovation – justify an adjustment to fees (i.e. where charging fees that fully reflect our spectrum management costs would risk damaging the delivery of these objectives); and
- our wider duties, for example, whether any particular group of citizens or consumers would be unfairly and adversely affected by fee levels that reflected our spectrum management costs, or if charging a fee risked damaging the delivery of a wider public policy agenda within the communications sector.

6.41 We do not consider that these considerations are of relevance to the proposed new licence such that they should justify an adjustment to fees which fully reflect our spectrum management costs. We have taken this view for the following reasons:

- we do not anticipate the practicalities of implementation or the cost of collecting fees will form a material part of the overall proposed fee;
- we do not anticipate any significant risks to the delivery of the benefits of proposed uses of this spectrum as a result of setting the fees to fully reflect our spectrum management costs. In particular, we note that the proposed fees are likely to be comparatively low relative to the other costs incurred by licensees in providing the services using this spectrum;
- we have not identified any considerations relevant to our wider duties which justify an adjustment of the level of fees levied on these licence products; and
- we are not aware of any particular group of citizens or consumers who would be unfairly and adversely affected by fee levels that reflected our costs.

6.42 On this basis, we have not identified any reason for providing a concession to licensees and accordingly we propose to introduce fees that fully reflect our spectrum management costs. Furthermore, we have not identified any need to phase in the introduction of fees given this is a new licence product.

[72] Ofcom, *SRSP: The revised Framework for Spectrum Pricing*, 17 December 2010, https://www.ofcom.org.uk/__data/assets/pdf_file/0024/42909/srsp-statement.pdf
[73] Ofcom, *Spectrum Pricing: A framework for setting cost-based fees*, 17 March 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/50247/cbfstatement.pdf
[74] As set out in the SRSP, where the benefits of the use to society overall are greater than our costs and no other funding is available to users to support their spectrum use, we may consider it appropriate to provide a concession to licensees.

Cost-based fee proposal

6.43 As set out in paragraph 6.21 above, we propose that the cost-based fees we will charge will vary by bandwidth to give a modest incentive to encourage efficient use of the spectrum.

6.44 To ensure consistency with our cost recovery guidelines, in implementing how the cost-based fees vary by bandwidth we have considered the following principles:

a) in aggregate, what we collect in fees from the propose new licence should fully recover our spectrum management costs. That is, the average cost-based fee charged should be £320;

b) all fees should cover at least the notional variable costs of issuing the licence, which we estimate based on the Business Radio Tech Assigned cost data to be roughly 10% of the average cost per licence. That is, the fee for the smallest bandwidth should be no lower than £32; and

c) all fees should make a contribution towards common and specific fixed costs but we consider it reasonable and appropriate for higher bandwidth licences to make a greater contribution towards these costs.

6.45 We have assumed the average bandwidth to be 40 MHz and therefore propose to set the fee for a 40 MHz licence at £320 p.a. We propose that the fees for higher and lower bandwidths will be proportional (that is, for example, the fee for 80 MHz will be twice the fee for 40 MHz). Table 6 below sets out our proposed fees by bandwidth.

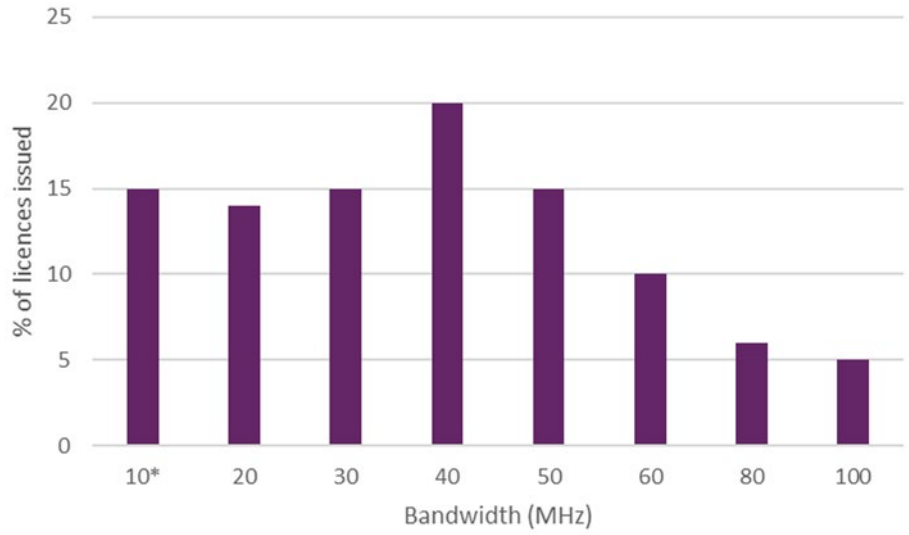
Table 6: Proposed cost-based fees per annum by bandwidth

Channel size	Price per channel
2x3.3 MHz	£80
10 MHz	£80
20 MHz	£160
30 MHz	£240
40 MHz	£320
50 MHz	£400
60 MHz	£480
80 MHz	£640
100 MHz	£800

6.46 We propose that users of the 1800 MHz shared spectrum and 2300 MHz shared spectrum pay the same fee as that charged for 10 MHz in the 3.8-4.2 GHz band, that is £80 p.a.

6.47 These proposed fees satisfy principles b) and c) as set out in paragraph 6.44 above. In order to consider the prospect of satisfying principle a) and achieve full cost recovery in aggregate, we need to make some assumptions in terms of the distribution of licences by bandwidth. There are of course an infinite number of possible distributions, some of which will lead to under-recovery, some of which will lead to full cost recovery and others which will lead to over-recovery. The following chart shows one example of a distribution that would lead to full cost recovery.

Figure 18: Distribution consistent with full cost recovery



** 10 MHz bar includes 1800 MHz shared spectrum and 2300 MHz shared spectrum licences.*

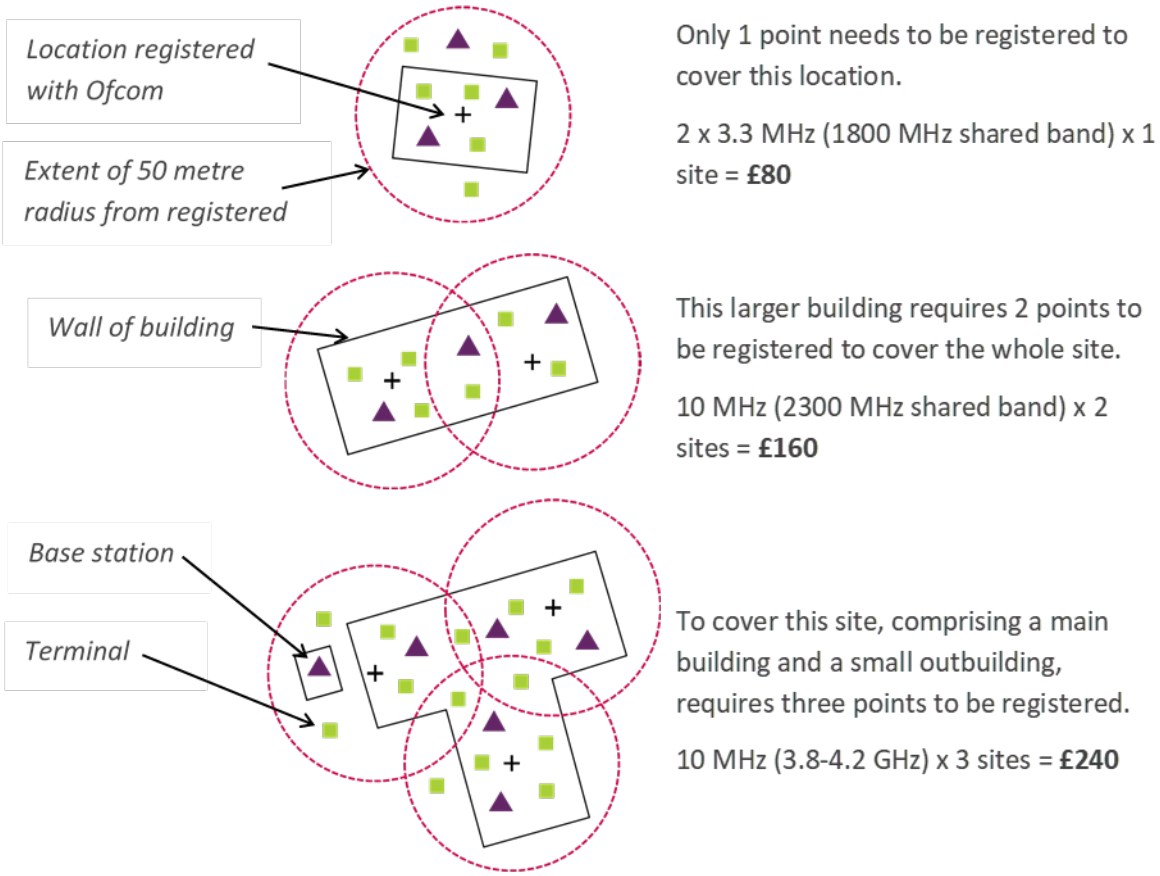
6.48 We will keep these fees under review following implementation as we gather more evidence on the actual issuance of the propose new licence. We recognise the importance of providing certainty to licensees, particularly in bands such as these where there is opportunity for innovation in the uses of the spectrum. We would therefore expect to review these fees only if, following implementation, we considered that:

- there was a significant misalignment with costs in the future; or
- there was evidence of excess demand such that it was appropriate to move to AIP-based fees.

Examples of low power licence use and associated fees

6.49 Figure 19 below provides some illustrative examples of potential low power licence use and the associated fees.

Figure 19: Examples of low power licence use and associated fees



Implication on fee for existing CSA licensees in the 1800 MHz shared spectrum

6.50 Given our proposal to align the current authorisation approach in the 1800 MHz shared spectrum with our proposed Ofcom managed approach, we propose to charge existing licensees in the 1800 MHz shared spectrum licence fees in a similar way as with the new sharing users.

6.51 Existing 1800 MHz shared spectrum deployments will either fall under the low power area-based licence product (if a licensee has multiple deployments that are close enough to each other to fit inside a single licence area) or medium power licence depending on the transmit power.

6.52 We discuss this further in section 7.

Question 16: Do you agree with our fee proposal for the new shared access licence? Please give reasons supported by evidence for your views.

7. Summary of proposed change to authorisation approach for existing CSA licensees in the 1800 MHz shared spectrum

7.1 Our proposal to change the existing authorisation approach in the 1800 MHz shared spectrum to align with our proposed authorisation approach in the three shared access bands, where Ofcom authorises and coordinates on a per location basis, will require us to vary the licences of the existing 12 CSA licensees. We consider that the benefit of this proposal outweighs the potential costs in effecting this change as outlined in paragraph 3.31.

7.2 This section summarises what these proposed changes are and the process by which we will effect the change. In this section we refer to previous Ofcom publications on the "DECT guard band" which is the term previously used for the 1800 MHz shared spectrum.

Licence variation

7.3 The full details of our proposals are provided in sections 4, 5, and 6 of this document. We provide in Table 7 below a summary of the differences between the existing CSA licence and our propose new licences which would replace the existing CSA licences.

Table 7: Comparison of the current and proposed approach

	Concurrent Spectrum Access	New low power licence	New medium power licence
No. of licensees	12	Unlimited	Unlimited
Frequency	1781.7-1785 MHz paired with 1876.7-1880 MHz		
Geographical rights (per licence)	UK wide subject to coordination	Authorised for a 50 metre area at a specific location	Authorised at a specific location
Access arrangements	Coordinated on a first come first served basis. Coordination supported by third-party database.	Coordinated on a first come first served basis. Coordination carried out by Ofcom	
Coordination approach	Self-coordinated based on agreed Code of Practice on Engineering Coordination. Transmitter locations logged on a third-party register.	Technically assigned based on BS location, power and indoor/outdoors. All information stored in Ofcom's licensing system.	
Technology	Neutral (but supports 2G and 4G mobile technology)		

	Concurrent Spectrum Access	New low power licence	New medium power licence
Fee	No fee currently set but band is subject to a fee review as ten-year initial term has expired.	Cost-based fee of £80 per area of 50 metre radius	Cost-based fee of £80 per base station
Deployment restrictions	Maximum outdoor height of 10 metre	Maximum outdoor height of 10 metre	Maximum outdoor height of 10 metre Rural areas only
Maximum base station power (EIRP)	23 dBm* for GSM carrier Up to 35 dBm* for 3 MHz LTE carrier Higher power needs other licensees' approval	24 dBm/carrier (up to 3 MHz)	42 dBm/ carrier (up to 3 MHz)[75]
Maximum terminal station power (TRP for mobile/nomadic or EIRP for fixed/installed)	23 dBm (licence exempt) Up to 35* dBm for 3 MHz carrier (licensed)	23 dBm (licence exempt)	
Tradable	Yes – outright and concurrent.		
Available information	No information on deployments is publicly available.	Licence information to be published on the WTR.	

* The current CSA licence permits higher powers allowing 30 dBm for a 200 kHz GSM carrier and 42 dBm for a 3 MHz carrier provided that the agreement is reached between *all* licensees and notification of that agreement is provided to Ofcom. We are not aware that any such agreement has been made.

Authorisation change

7.4 When the new licence product is in place, we propose that:

- authorisation of existing deployments by CSA licensees be varied to either the low or medium power licence, and be transferred to Ofcom's database so they can be coordinated by Ofcom against new deployments by both incumbent and new users (as per our proposed coordination approach and methodology as outlined in section 5); and

[75] This power will only be available over 3 MHz of the 3.3 MHz bandwidth as existing power density requirements restrict the power in the first 200 kHz and last 100 kHz of the bandwidth

- future deployments by existing CSA licensees be coordinated by Ofcom and authorised on a per base station basis (or per area of 50 metres radius for low power base stations).

Technical change

7.5 As outlined in Table 7 above, we propose some changes to the power levels that may be used by both base stations and terminal equipment in the band. Our low power area authorisation will permit up to 24 dBm per carrier and our medium power base station authorisation will permit up to 42 dBm per carrier for deployment in rural areas.

7.6 In addition to changes on the base station powers, we are proposing to limit the power of all mobile, nomadic or fixed terminals to 23 dBm. In line with our current approach to authorising terminals, power spectral density requirements, both in band and out of band, will not be required within the licence.

7.7 We set out below why we consider that these changes are proportionate and why we expect that they will not cause any significant impact to existing licensees.

Impact of new technical conditions on existing deployments

7.8 There is no impact as all existing deployments would continue to be able to operate under the new technical licence conditions.

7.9 Should there be any existing deployments operating above 24 dBm/carrier (up to 3 MHz), these will be transferred to a medium power licence and will not face the proposed geographic restrictions (i.e. rural areas only) that would apply for new deployments.

Impact of new technical conditions on future deployments

7.10 After the licence variation process has completed, licensees would still be able to access spectrum subject to the new coordination regime. However, under the proposed new technical conditions, base stations transmitting at powers higher than 24 dBm/carrier (up to 3 MHz) would only be permitted in rural areas.

7.11 Given that we are not aware of any existing deployments above 23 dBm, we do not consider that our proposal to limit future higher power deployments to rural areas only would have a significant impact on the rollout of CSA licensees' services in the band.

7.12 Moreover, indoor base stations typically transmit with a maximum EIRP of 20 to 24 dBm irrespective of the bandwidth of the carrier and therefore we do not anticipate that our proposals will cause any constraints for licensees' current or future deployments in these areas.

7.13 In relation to our proposal to limit the power of all mobile, nomadic or fixed terminals to 23 dBm, we noted that current regulations allow terminals using 4G technology[76] to operate on a licence exempt basis up to 23 dBm only. We do not consider that our

[76] It is only current terminals using more than 200 kHz of spectrum that through the power density limits are permitted a total power of greater than 23 dBm in the existing authorisation.

proposal would have significant impact on future deployment as we consider that it is highly unlikely that there are any terminals operating at a higher power than this in practice in the foreseeable future.

Proposed new licence fees

7.14 We consulted in late 2016 on a number of policy options relating to the authorisation of the 1800 MHz shared spectrum including spectrum pricing options.[77] In that document we noted that the Initial Term of the existing 12 CSA licences expired in May 2016 and as per Ofcom's policy we would consider the introduction of fees. We outlined a range of options for setting the fees for spectrum use in this band, including fees based on Administrative Incentive Pricing (AIP), set with reference to the opportunity cost of high power mobile (as the relevant alternative use of the band), and cost-based fees. On 30 June 2017, we published an update that advised amongst other things that we were still considering the options for fees.[78]

7.15 In line with our proposal that all new and existing deployments will be coordinated by Ofcom and authorised on a per base station basis (or per area of 50 metres radius for low power base stations), we propose that licence fees will be charged on that basis as well.

7.16 As discussed in section 6, for the 1800 MHz shared spectrum we are proposing an annual cost-based fee of £80 per location. As part of the proposed variation, we will work with existing CSA licensees in migrating their record of deployments into Ofcom's licensing system, and then use this to calculate the licence fee for each licensee. We propose not to introduce fees until we switch the existing licensees from the old licence product onto the new one.

Timing of any licence variation

7.17 We propose that the CSA licences will continue as they are until such time that the new licence product is in place, i.e. licensees should continue to register new deployments with the FCS according to the current authorisation regime for the band.

7.18 Closer to the implementation date, we will again write to all licensees giving formal notice of our intention to vary their licence. Alongside that letter will be a record of the locations we have recorded in our licensing system and the fee that will need to be paid.

7.19 As set out in Schedule 1 of the WT Act, we will provide at least a month for licensees to make representations. We will consider any representations received and make our decision within a month. Once a decision has been made whether to proceed with the variation as notified, we will inform licensees within 7 days of us making that decision.

[77] Ofcom, *Policy for the DECT guard band*, 29 September 2016, Section 5, https://www.ofcom.org.uk/__data/assets/pdf_file/0032/90977/Consultation-DECT-guardband-final-for-publication.pdf
[78] Ofcom, *Update on the DECT guard band policy*, 30 June 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/103617/Update-on-the-DECT-guard-band-policy.pdf

Question 17: Do you agree with our proposal to change the approach to authorising existing CSA licensees in the 1800 MHz shared spectrum? Please give reasons supported by evidence for your views.

8. Proposal for a new licence for access to awarded mobile spectrum

Introduction

8.1 This section sets out our proposals for a new licence (called the Spectrum Access – Local licence) that would enable new users to access awarded mobile spectrum in locations where we agree this does not adversely impact the incumbent licensee's planned use of spectrum.

Access to mobile spectrum

8.2 The frequency bands we are proposing to include under this licence are the bands that support mobile technology and have been awarded on a national basis (as set out in the Mobile Trading Regulations).[79] These frequency bands are used by the MNOs to provide mass market mobile services to consumers. The operators use a range of technologies including GSM (a 2G technology), UMTS (3G), LTE (4G) and some are trialing the deployment of emerging 5G technologies. The frequency bands have differing properties that make them more suitable for certain user cases, with lower frequencies good for providing coverage (e.g. 800 MHz band) and higher frequencies to provide data capacity (e.g. 3.4 GHz).

Potential uses

8.3 As outlined in section 3 of this document, a number of potential use cases have been identified by stakeholders. These cover a diverse range of services from local mobile connectivity solutions such as in valleys or tunnels; automation in discrete settings for example factories; private networks in remote secure locations such as an oil refinery; or improving broadband connectivity in hard to reach local communities.

Proposed authorisation for new users

8.4 New users seeking access to spectrum can do so under the current spectrum trading regime. This requires them to enter into an agreement to transfer some or all of the spectrum rights from the licensed user.

8.5 The trading framework allows spectrum to be transferred to help secure optimal use of limited and valuable spectrum resources. However, in the particular case of enabling access to a specific geographic area (covered by a national licence) the process can be complex in order to "carve out" for or share the area with a third party and reflect this in both the existing licensee's rights and the new licence. The proposed Spectrum Access –

[79] Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011, as amended, http://www.legislation.gov.uk/uksi/2011/1507/contents

Local licence is intended to complement and not replace the other ways in which Ofcom already enables to access spectrum through spectrum trading.

What about spectrum leasing?

8.6 Some stakeholders have asked whether we would enable spectrum leasing in mobile bands as a simpler alternative to the spectrum trading process. Spectrum leasing is not currently authorised in most of our licences, including the mobile licences (it is only allowed in some business radio and spectrum access licences on a case by case basis). Unlike spectrum trading, leasing does not require any changes to the incumbent's licence since the lessee operates under the terms of that licence and in accordance with an agreement reached with the incumbent licensee. We have noted in previous consideration of leasing in mobile bands that this process may raise competition issues (as Ofcom is not involved in the leasing arrangement, there is no opportunity to assess the impact on competition).

8.7 Allowing leasing would remove some of the complexities associated with a spectrum trade, though it also has its drawbacks. We believe licensees may have little incentive to engage with third parties to lease their spectrum given the additional responsibility this brings; i.e. under the leasing framework the incumbent licensee remains liable for any breaches of the licence caused by a third-party lease holder. So far, there has been a general lack of demand for an extension of the leasing approach to other licences. However, we will keep this position under review. We would consider extending leasing if we think there are likely to be net benefits, including sufficient demand to lease spectrum, particularly in the light of our alternative proposal.

Proposed new licence product

8.8 We share the objective, set out in the Department for Digital, Culture, Media and Sport's *Future Telecoms Infrastructure Review*,[80] of wanting third parties to be able to have access to awarded mobile spectrum in places where it is not being used by the MNOs. However, we believe that the best way to do this would be to create a process for new, local licences for third parties who wish to exploit unused mobile spectrum. In our view, this approach would achieve the same objective as extending leasing to mobile bands but without some of the drawbacks of leasing. In our proposed approach the third party is licensed by Ofcom instead of becoming the responsibility of the licensee. This approach maintains the existing rights of the incumbent licensee but allows a new user to be licensed to use spectrum in an agreed location in parallel.

8.9 This new approach would enable us to issue a licence to a new user while at the same time providing a mechanism that would mean that the incumbent licensee does not suffer interference. This would be a flexible approach to enable access to spectrum on a local and time limited basis, for areas where spectrum is not being used or there are no immediate plans for it to be used by the incumbent licensee.

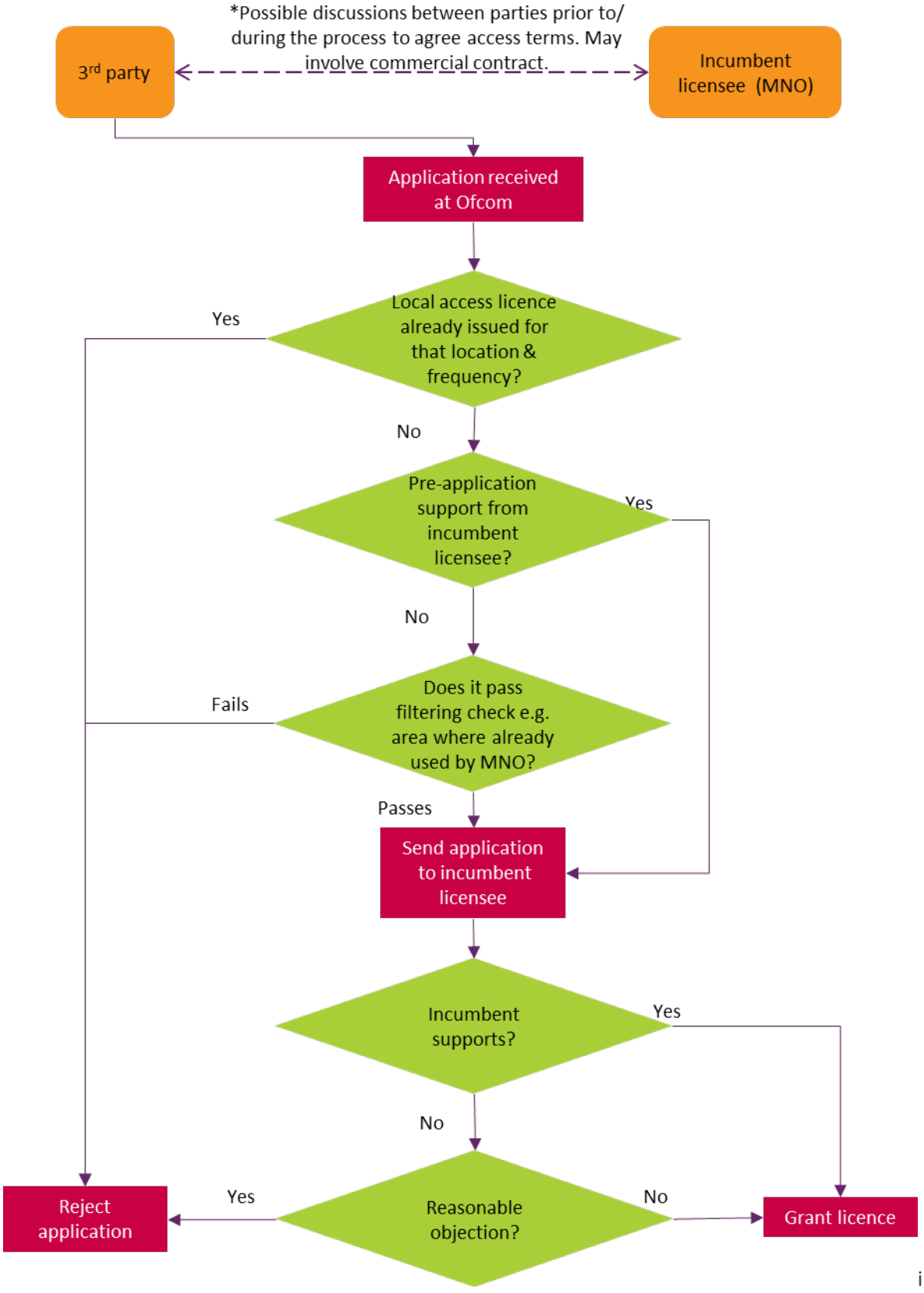
[80] DCMS, *Future Telecoms Infrastructure Review*, 23 July 2018, https://www.gov.uk/government/publications/future-telecoms-infrastructure-review

Proposed licensing process

8.10 The proposed licensing process is set out in Figure 20 below. The process builds upon Ofcom's experience in providing access to spectrum through its Innovation and Trial licensing framework.[81] At the heart of this process is working with the incumbent licensee(s) to facilitate third party access which does not interfere with the existing licensee and provide a central point of contact to ensure all requests are considered.

[81] Ofcom, *Innovation and trial licensing*, https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences/non-operational-licences

Figure 20: Proposed Local Access licensing process



8.11 In a situation where the applicant has already obtained support from the incumbent licensee(s) prior to applying for a licence, we will send the request to the MNO for confirmation. Other requests without such prior support will need to be assessed by Ofcom. This process would involve Ofcom undertaking some initial filtering checks that may result in the refusal of some applications without sending them on to the incumbent MNO in question. These checks could include whether the request is in an area that already has good coverage in that frequency band, or whether there are existing Local Access licences issued in or close to the area.

8.12 If a request for access straddles the spectrum used by more than one mobile operator, then all parties will need to agree to the request for shared access. If one party raises a reasonable objection to the request, then we will not proceed with the authorisation.

Question 18: Do you agree with our proposal for the Local Access licence? Please give reasons supported by evidence for your views.

Question 19: Do you have any other comments on our proposal?

Information on existing use

8.13 We note that information regarding where an operator may not be using its allocated spectrum plays an important part in this process. However, access to this information is not currently publicly available. There is information that may help potential applicants, such as coverage maps[82] and planning records,[83] but these do not usually provide information on the use of a specific frequency band. Information can also be gathered through the use of specialist spectrum monitoring equipment that provides a useful snap shot of the spectrum's use at the time of monitoring.

8.14 We would recommend that any prospective applicants contact Ofcom to discuss their plans. Where a new user is seeking longer term access to the spectrum we would seek to put the new user in contact with the incumbent licensee to discuss the proposals further. These discussions may provide information on current and future rollout plans in the area where the new user is interested in deploying.

8.15 We will continue to investigate ways in which to make available more information regarding actual use.

Question 20: What information should Ofcom consider providing for potential applicants in the future and why would this be of use?

Other issues

8.16 We believe that other non-spectrum related issues surrounding this licence such as MNCs and mobile numbering will be the same as those outlined in paragraphs 4.31 to 4.33.

[82] Ofcom, MNOs and a number of other companies provide information on mobile coverage. See https://checker.ofcom.org.uk/ for Ofcom's mobile coverage checker tool.
[83] Local councils may have records showing the deployments of transmitters within their areas.

Proposed licence terms and conditions

8.17 The following paragraphs set out the proposed licence conditions that would be associated with the licence and the authorisation process. At the heart of this process is the engagement with the incumbent licence holder who will be able to object to a request for access providing they have reasonable objections for doing so. The proposed detailed licence terms and conditions are set out in more detail below and in a copy of the draft licence is provided in annex A10, however we list here a summary of the key features:

- Will be for a single location or area;
- Not restricted to the same technology as the incumbent licensee;
- The licence would be time limited and for a proposed fixed duration of a minimum of three years, with longer periods available only for those that have reached a specific agreement with the incumbent;
- Can be traded outright to another party;
- Requires licensees to notify any customers of the time limits on the authorisation; and
- A cost-based one-off fee of £950 per licence.

Proposed technical licence conditions

Spectrum bands

8.18 The proposed licence will be for all bands that are covered by the Mobile Trading Regulations. Currently, these are: 791-821 MHz paired with 832-862 MHz ("800 MHz band"); 880-915 MHz and 925-960 MHz ("900 MHz band"); 1452-1492 MHz ("1400 MHz band"); 1710-1781.7 MHz and 1805-1876.7 MHz ("1800 MHz band"); 1900-1920 MHz ("1900 MHz band"); 1920-1980 MHz and 2110-2170 MHz ("2100 MHz band"); 2350-2390 MHz ("2.3 GHz band"); 2500-2690 MHz ("2.6 GHz band"); and 3410-3600 MHz ("3.4 GHz band"). As new bands are introduced into the Mobile Trading Regulations, such as the upcoming award of 700 MHz and 3600-3800 MHz, we will also include these in the list of frequency bands which could be covered by the licence.

Authorised locations

8.19 Depending on the request received we may authorise a single base station location or a local area. Each request will be dealt with on a case by case basis with the licence reflecting the agreed transmission location or service area details.

Authorised technology

8.20 We expect that in most use cases the parties will wish to take advantage of being able to use existing mobile technologies and deploy equipment that is of a similar nature to the incumbent licensee. However, there may be cases where a user may wish to deploy an alternative technology and our current proposal is not to prohibit this.

8.21 Given that the initial coordination request with the incumbent licensee would have been based on a specific technology and technical parameters, the Local Access licence will reflect these. Licensees wishing to change these will need to request a variation to their

licence. As part of this process we may need to liaise with the incumbent licensee to ensure that any change does not impact on their spectrum use.

Coordination and interference management

8.22 To minimise the risks of interference we propose that the licence will include the following provisions:

- our standard requirements for the licensee to abide by any coordination procedures, both national and international, as notified by Ofcom;
- the provision that the licensee must liaise and co-operate with other holders of licences in the same frequency band(s). This may require if necessary adjusting transmission power and other technical parameters of transmission in such a way that harmful interference is not caused by one network deployment to that of another licensee within the band. This condition is also included in the low and medium power licences; and
- where a licensee is deploying a mobile service, we will expect them to follow the appropriate in block and out of block power limits. This will include, when deploying TDD systems outdoors or shared indoor locations, the requirement to synchronise with other users in the band or use a restrictive mask. These provisions will mirror those in the incumbent licensee's authorisation.

8.23 The incumbent operator's rights to deploy, even after a new user is issued with a licence, will not be affected. In practice we expect parties to agree coordination terms between themselves in line with their licence obligations to avoid interference. We believe that the measures outlined above should be sufficient to avoid any harmful interference from occurring. However, where there are disputes between parties, and no contractual agreement exists, we will deal with these on a case by case basis.

Proposed non-technical licence terms and conditions

8.24 In the following paragraphs, we summarise the proposed non-technical licence conditions.

Duration of the licence

8.25 Unlike many of our licence products, we are proposing that the Local Access licence will be authorised for a time limited period. We are proposing this to be for a minimum period of three years, with the option of longer periods if agreement is reached with the incumbent licensee(s). A shorter duration we believe would not provide a sufficient case for investment.

8.26 We also propose to include our standard revocation notice period of five years for spectrum management purposes. We acknowledge that this will only come into effect for those licensees who have an agreed licence duration of over five years.

Question 21: Do you agree with our proposal to have a defined licence period and do you have any comments on the proposed licence term of three years?

Licence transfer

8.27 We propose that this licence class should be tradable. However, we are proposing that the licences can only be traded outright and will not permit the trading of partial frequencies or geographic areas.

Access and Inspection

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

Modification, Restriction and Closedown

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

Geographical boundaries

8.30 The licence will cover the deployment of transmitters only at the defined location or an area defined in the licence. Licences will be for locations within the United Kingdom including the territorial waters. Authorisation in the Channel Islands and Isle of Man may be possible, but this would be subject to the new user discussing any request with the relevant competition authorities that are responsible for the issuing of telecommunications licences.

Provision of information to facilitate optimal spectrum use

8.31 In line with our duty to manage the spectrum efficiently, the licence includes standard conditions to require licensees to provide us, on request, with general information regarding their equipment and use of frequencies, the rollout of their network or any such information we require.

Provision of information to customers

8.32 We are also proposing to include a provision that will require the licensee to inform any customers of the service, provided over the frequencies authorised by the Local Access licence, of the time limited nature of the access to the spectrum. Customers should be made aware of this before signing up to any service and it should be included in any contract terms and conditions.

Question 22: Do you have any other comments on the proposed Local Access licence terms and conditions?

Proposed licence fee

8.33 In paragraphs 6.3 and 6.4 we set out our general approach to setting fees. For the proposed Local Access licences, the spectrum rights have already been granted, therefore are only available in situations where the spectrum rights holder has not/is not intending to deploy. We would presume that where there is high demand to use the spectrum the incumbent licensee would have likely already deployed in that area. Based on the volumes of enquiries we currently receive we do not consider there to be a significant demand for these licences in any given area. As noted in paragraph 8.3, these requests are often to address a very localised use case and it is unlikely that there would be more than one party wanting access at that particular location and frequency. Based on the evidence we have, we do not think there will be excess demand and therefore propose to apply a cost-based fee.

8.34 In line with our framework for setting cost-based fees[84] we intend to set these fees to fully reflect our spectrum management costs applicable to these licence products. We therefore intend to follow the same approach of using the actual per-licence costs associated with a similar licence product, as outlined in section 6 of this document for the low and medium power licences.

8.35 The costs associated with issuing and managing this Local Access licence product will be different to low and medium power licences. Unlike our other proposal, which relies on our licensing systems to allocate assignments, these licences will be bespoke and require Ofcom to manually assess each request and liaise with the incumbent licence holder. Given the differences in the way that the spectrum will be allocated and the estimated volume, we do not consider that the same pricing proposals are appropriate for this licence product. However, we will follow the same approach of using the actual per-licence costs associated with a similar licence product, as outlined in section 6.

8.36 We have looked at our existing licence products and we believe that the Innovation and Trial licensing products are the closest to the licensing process that we are proposing. The Innovation and Trial licences are also manually built, bespoke licences and follow a similar process of consulting with incumbent licensees or spectrum users prior to a licence being granted. Given the similarity between these two products we believe that this is the most appropriate product to base our fees on.

Analysis of spectrum management costs

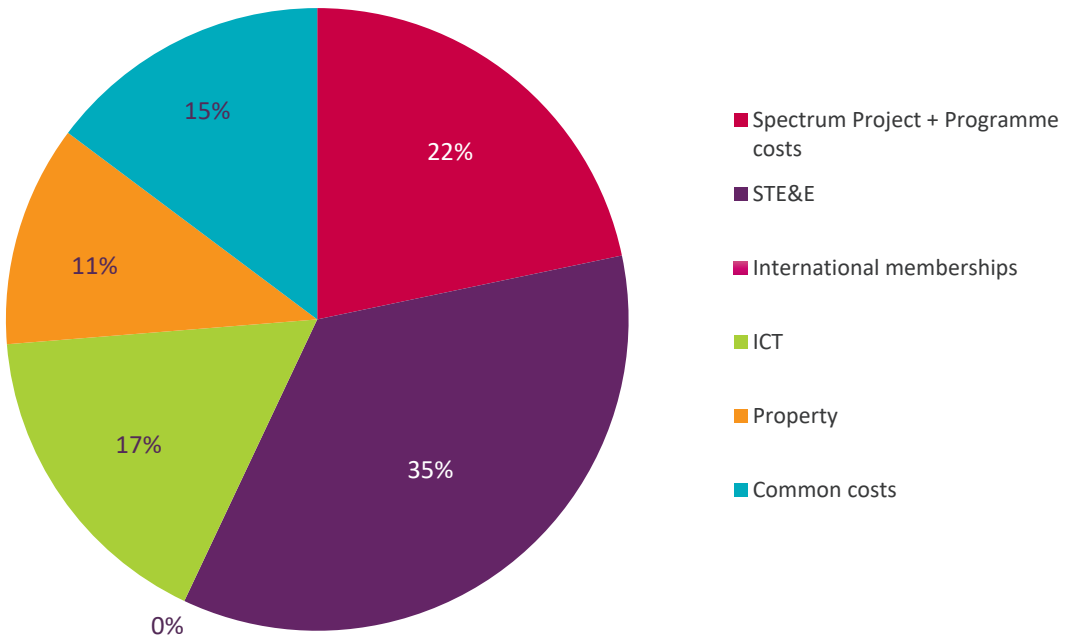
8.37 By applying our cost allocation methodology,[84] we have identified spectrum management costs for the Innovation and Trail licence totalling £707,253 in 2016/17 (the latest year for

[84] Ofcom, *Spectrum Pricing: A framework for setting cost-based fees*, 17 March 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/50247/cbfstatement.pdf

which we have cost data). There were 696 licences issued from 1 April 2016 to 31 March 2017. This implies an average cost per licence of the Innovation and Trial licence of £1,016.

8.38 The relevant cost categories and cost breakdown for Innovation and Trial licence product is shown in Figure 21 below.

Figure 21: Breakdown of costs for the Innovation and Trial licence product (2016/17)



8.39 To test the robustness of our 2016/17 analysis, we analysed the costs and licence numbers in the preceding three years as well. These are set out in Table 8 below.

Table 8: Spectrum management costs and number of licences for Innovation and Trial licence product

	Total costs	No. of licences	Average cost per licence
2013/14	£675.1k	563	£1,199
2014/15	£497.6k	608	£818
2015/16	£452k	590	£766
2016/17	£707.3k	696	£1,016

Source: Ofcom

8.40 The average cost per licence over the four years is £950 with the cost per licence increasing to £1,199 in 2016/17. Given the varying differences in total costs over the four-year period

we propose to use the average of £950 as the basis for our cost-based fee. We consider that it is a reasonable indicator of the likely future average costs.

8.41 Given that these requests are of an ad-hoc nature and are only for areas where the incumbent licensee has no foreseeable use of the spectrum we do not believe there are the same issues surrounding licensees requesting more bandwidth than is necessary. For this reason, we do not believe that any fee charged should vary with bandwidth and should therefore be a flat fee.

Question 23: Do you agree with our fee proposal for the new local access licence? Please give reasons supported by evidence for your views.

Analysis of considerations relevant for fee setting

8.42 In line with the approach set out in the SRSP[85] and our framework for setting cost-based fees[86] we have considered the policy and sectoral considerations relevant for the setting of fees for these new licence products, namely:

- the practicalities of implementation, such as our implementation costs, and whether the cost of collecting fees would form a material (and/or disproportionate) part of the overall fee before resetting/ introducing new fees;
- our spectrum management duties, for example, whether the benefits of the use – to society overall[87] or in promoting innovation – justify an adjustment to fees (i.e. where charging fees that fully reflect our spectrum management costs would risk damaging the delivery of these objectives); and
- our wider duties, for example, whether any particular group of citizens or consumers would be unfairly and adversely affected by fee levels that reflected our spectrum management costs, or if charging a fee risked damaging the delivery of a wider public policy agenda within the communications sector.

8.43 We do not consider that these considerations are of relevance to this licence product such that they should justify an adjustment to fees which fully reflect our spectrum management costs. We have taken this view for the following reasons:

- we do not anticipate the practicalities of implementation or the cost of collecting fees will form a material part of the overall proposed fee;
- we do not anticipate any significant risks to the delivery of the benefits of proposed uses of this spectrum as a result of setting the fees to fully reflect our spectrum management costs. In particular, we note that the proposed fees are likely to be comparatively low relative to the other costs incurred by licensees in providing the services using this spectrum;

[85] Ofcom, *SRSP: The revised Framework for Spectrum Pricing*, 17 December 2010, https://www.ofcom.org.uk/__data/assets/pdf_file/0024/42909/srsp-statement.pdf
[86] Ofcom, *Spectrum Pricing: A framework for setting cost based fees*, 17 March 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0018/50247/cbfstatement.pdf
[87] As set out in the SRSP, where the benefits of the use to society overall are greater than our costs and no other funding is available to users to support their spectrum use, we may consider it appropriate to provide a concession to licensees.

- we have not identified any considerations relevant to our wider duties which justify an adjustment of the level of fees levied on these licence products; and
- we are not aware of any particular group of citizens or consumers who would be unfairly and adversely affected by fee levels that reflected our costs, as per our equality impact assessment.

8.44 On this basis, we have not identified any reason for providing a concession to licensees and accordingly we propose to introduce fees that fully reflect our spectrum management costs. Furthermore, we have not identified any need to phase in the introduction of fees given this is a new licence product.

9. Proposed next steps

9.1 We intend to publish a statement by Q2 2019 to confirm our proposals, for shared access. Subject to the outcome of this consultation, we will also consult on the exemption regulations for mobile terminals.

9.2 We intend to make new licences available in the second half of 2019, and will confirm the timing when we publish our statement.

9.3 In addition, following our decision and subject to the outcome of the consultation, we will be effecting the licence variation process for existing CSA licensees in the 1800 MHz shared spectrum as soon as practical.

A1. Responding to this consultation

Confidentiality

A1.1 Consultations are more effective if we publish the responses before the consultation period closes. In particular, this can help people and organisations with limited resources or familiarity with the issues to respond in a more informed way. So, in the interests of transparency and good regulatory practice, and because we believe it is important that everyone who is interested in an issue can see other respondents' views, we usually publish all responses on our website, www.ofcom.org.uk, as soon as we receive them.

A1.2 If you think your response should be kept confidential, please specify which part(s) this applies to, and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we don't have to edit your response.

A1.3 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.4 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further at https://www.ofcom.org.uk/about-ofcom/website/terms-of-use.

Next steps

A1.5 Following this consultation period, Ofcom plans to publish a statement in Q2 2019.

A1.6 If you wish, you can register to receive mail updates alerting you to new Ofcom publications; for more details please see https://www.ofcom.org.uk/about-ofcom/latest/email-updates

Ofcom's consultation processes

A1.7 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in annex A2.

A1.8 If you have any comments or suggestions on how we manage our consultations, please email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

A1.9 If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact the corporation secretary:

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

How to respond

A1.10 Ofcom would like to receive views and comments on the issues raised in this document, by 5pm on 12 March 2019.

A1.11 You can download a response form from https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation. You can return this by email or post to the address provided in the response form.

A1.12 If your response is a large file, or has supporting charts, tables or other data, please email it to SharedSpectrumAccess@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet (https://www.ofcom.org.uk/consultations-and-statements/consultation-response-coversheet). This email address is for this consultation only, and will not be valid after 12 March 2019.

A1.13 Responses may alternatively be posted to the address below, marked with the title of the consultation:

Siew Yoon Tan
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.14 We welcome responses in formats other than print, for example an audio recording or a British Sign Language video. To respond in BSL:

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

A1.15 We will publish a transcript of any audio or video responses we receive (unless your response is confidential)

A1.16 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt if your response is submitted via the online web form, but not otherwise.

A1.17 You do not have to answer all the questions in the consultation if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A1.18 It would be helpful if your response could include direct answers to the questions asked in the consultation document. The questions are listed at annex A4. It would also help if you

could explain why you hold your views, and what you think the effect of Ofcom's proposals would be.

A1.19 If you want to discuss the issues and questions raised in this consultation, please contact Siew Yoon Tan on 020 7981 3000, or by email to SharedSpectrumAccess@ofcom.org.uk.

A2. Ofcom's consultation principles

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

Before the consultation

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

During the consultation

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

A2.3 We will make the consultation document as short and simple as possible, with a summary of no more than two pages. We will try to make it as easy as possible for people to give us a written response. If the consultation is complicated, we may provide a short Plain English / Cymraeg Clir guide, to help smaller organisations or individuals who would not otherwise be able to spare the time to share their views.

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

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

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

After the consultation

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

A3. Consultation coversheet

BASIC DETAILS

Consultation title: **Enabling opportunities for innovation: Shared access to spectrum supporting mobile technology**

To (Ofcom contact): **Siew Yoon Tan**

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

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

Nothing	☐
Name/contact details/job title	☐
Whole response	☐
Organisation	☐
Part of the response	☐

If there is no separate annex, which parts? _____

_____

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

DECLARATION

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

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

Name Signed (if hard copy)

A4. Consultation questions

Question 1: (Section 3) Do you agree with our proposal for a single authorisation approach for new users to access the three shared access bands and that this will be coordinated by Ofcom and authorised through individual licensing on a per location, first come first served basis? Please give reasons supported by evidence for your views.

Question 2: (Section 3) Are there other potential uses in the three shared access bands that we have not identified?

Question 3: (Section 3) Do you have any other comments on our authorisation proposal for the three shared access bands?

Question 4: (Section 3) What is your view on the status of equipment availability that could support DSA and how should DSA be implemented?

Question 5: (Section 4) Do you agree with our proposal for the low power and medium power licence? Please give reasons supported by evidence for your views.

Question 6: (Section 4) Are there potential uses that may not be enabled by our proposals? Please give reasons supported by evidence for your views.

Question 7: (Section 4) Do you agree with our proposal to limit the locations in which medium power licences are available? Please give reasons supported by evidence for your views.

Question 8: (Section 4) Do you have other comments on our proposed new licence for the three shared access bands?

Question 9: (Section 4) Do you agree that our standard approach to non-technical licence conditions is appropriate? Please give reasons supported by evidence for your views.

Question 10: (Section 4) Are you aware of any issues regarding numbering resources and Mobile Network Codes raised by our proposals which we have not considered here?

Question 11: (Section 5) Do you agree with the proposed technical licence conditions for the three shared access bands? Please give reasons supported by evidence for your views.

Question 12: (Section 5) Are there other uses that these bands could enable which could not be facilitated by the proposed technical licence conditions? Please give reasons supported by evidence for your views.

Question 13: (Section 5) Do you agree with our proposed coordination parameters and methodology? Please give reasons supported by evidence for your views.

Question 14: (Section 5) What is your view on the potential use of equipment with adaptive antenna technology (AAS) in the 3.8-4.2 GHz band? What additional considerations would we need to take into account in the technical conditions and coordination methodology to support this technology and to ensure that incumbent users remain protected?

Question 15: (Section 5) Do you agree with our proposal not to assign spectrum to new users in the 3800-3805 MHz band and the 4195-4200 MHz band?

Question 16: (Section 6) Do you agree with our fee proposal for the new shared access licence? Please give reasons supported by evidence for your views.

Question 17: (Section 7) Do you agree with our proposal to change the approach to authorising existing CSA licensees in the 1800 MHz shared spectrum? Please give reasons supported by evidence for your views.

Question 18: (Section 8) Do you agree with our proposal for the Local Access licence? Please give reasons supported by evidence for your views.

Question 19: (Section 8) Do you have any other comments on our proposal?

Question 20: (Section 8) What information should Ofcom consider providing for potential applicants in the future and why would this be of use?

Question 21: (Section 8) Do you agree with our proposal to have a defined licence period and do you have any comments on the proposed licence term of three years?

Question 22: (Section 8) Do you have any other comments on the proposed Local Access licence terms and conditions?

Question 23: (Section 8) Do you agree with our fee proposal for the new local access licence? Please give reasons supported by evidence for your views.

A5. Adjacent band interference risk assessment in 3.8-4.2 GHz band

Bands below 3.8 GHz

We assume that new base stations above 3.8 GHz will be unsynchronised with base stations below 3.8 GHz

A5.1 As part of the harmonised technical conditions in the 3.4-3.8 GHz band,[88] ECC has considered the likely interference between networks operating in adjacent channels in both synchronised and unsynchronised operation. The required out of block emission levels are therefore set to avoid interference being caused from one network to another.

A5.2 We indicate in our consultation on the award of 3.6-3.8 GHz that we recognise that the technical conditions will be needed to support base stations with active antenna systems (AAS) as well as those using more traditional passive antennas (non-AAS).

A5.3 The frame structure we are proposing in the 3.8-4.2 GHz band aligns with what we currently propose for the 3.6-3.8 GHz award.[89] However, we note in that consultation that if new synchronisation options are presented within CEPT[90] that existing 3.4 GHz licensees might prefer before we make our final decisions, we will consider whether it would be appropriate to make any changes to the proposed 3.6-3.8 GHz licence conditions for consistency with those preferences. There are a range of potential uses for spectrum in 3.8-4.2 GHz, as we describe in section 3. These will not all be the same as the use cases in 3.4-3.8 GHz and so we do not intend to follow any frame structure changes that are implemented for 3.4-3.8 GHz. As such, we assume in our analysis below that the base stations operating in the 3.8-4.2 GHz band will be unsynchronised with those operating below 3.8 GHz. Where there are benefits of time aligning the frames in both bands, we will encourage that to occur.

Coexistence with unsynchronised base stations below 3.8 GHz based on ECC analysis

A5.4 There are two ECC Reports that provide some analysis of the likely interference between base stations in adjacent channels.

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[88] CEPT ECC, *ECC Report 203: Least Restrictive Technical Conditions suitable for Mobile/Fixed Communication Networks (MFCN), including IMT, in the frequency bands 3400-3600 MHz and 3600-3600 MHz*, https://www.ecodocdb.dk/document/310; CEPT ECC, *ECC Report 281: Analysis of the suitability of the regulatory technical conditions for 5G MFCN operation in the 3400-3800 MHz band*, https://www.ecodocdb.dk/document/3360

[89] Ofcom, *Award of the 700 MHz and 3.6-3.8 GHz spectrum bands,* 18 Dec 2018, https://www.ofcom.org.uk/consultations-and-statements/category-1/award-700mhz-3.6-3.8ghz-spectrum

[90] CEPT ECC, Draft ECC Report 296 National synchronisation regulatory framework options in 3400-3800 MHz: a toolbox for coexistence of MFCNs in synchronised, unsynchronised and semi-synchronised operation in 3400-3800 MHz https://cept.org/files/9522/Draft%20ECC%20Report%20296.docx

A5.5 ECC Report 203[88] analyses various scenarios of base station to base station interference when they are using frame structures that are unsynchronised. It is an earlier report and therefore considers only non-AAS to non-AAS scenarios.

A5.6 There are a number of studies in Draft ECC Report 296[90] that consider interference between different types of base stations, the majority of which are for AAS base stations, although it does include some limited analysis of non-AAS base stations

A5.7 The proposed technical conditions are based on non-AAS base stations and we note that base stations below 3.8 GHz may be a mix of AAS and non-AAS depending on the deployment scenarios and business cases of the licensees. Both the ECC reports therefore contain some useful information to help inform the compatibility between systems above and below 3.8 GHz. However, neither report has a complete set of scenarios and so we also provide some additional interpretation for our systems.

Non-AAS to Non-AAS base station analysis

A5.8 ECC Report 203[88] looked at interference to and from four different types of base stations: outdoor macro, outdoor micro, indoor pico and indoor femto. The micro is equivalent to our medium power base station and the pico to our low power base station, although that report only studied the indoor scenario. The report assumed some inter-base station separation distances and associated coupling losses and derived the out of band emission levels necessary to protect the various base station types with an I/N of -6 dB and noise figure of 8 dB for a micro base station and 13 dB for a pico base station.

A5.9 The results in ECC Report 203[88] show that out of block emission levels from a micro base station must be below -20 dBm / 5 MHz to protect a macro base station in the adjacent channel which is 30 metres away. But interference to a micro base station is likely to be more significant due to the different antenna coupling between the two and lower emission limits will be needed.

A5.10 These results led to the derivation of a generic block edge mask (BEM) in that report including a baseline of -34 dBm / 5 MHz for unsynchronised base stations.

A5.11 This BEM was re-labelled as Non-AAS and further analysis was provided in the more recent ECC Report 281[88] to consider base stations using AAS. ECC Report 281 notes that the out of band emissions from non-AAS base stations must not exceed -34 dBm / 5 MHz EIRP per sector, and from AAS base stations must not exceed -43 dBm / 5 MHz TRP per sector for unsynchronised base stations in order to avoid interference. These values are referred to as restricted baselines and are based on a macro to micro base station separation distance of 30 metres and a macro to macro base station separation of 70 metres.

AAS to AAS and Non-AAS base station analysis

A5.12 Draft ECC report 296[90] is the most recent analysis and is in a consultation phase prior to being formally published. Its analysis is predominantly based around the use of AAS at both the interfering and victim base station.

A5.13 The configuration of indoor small cells in Draft ECC Report 296 matches our low power indoor scenario and the micro base stations are similar to our medium power scenario –

although 40 dBm TRP for an AAS is likely to be slightly higher power than the 42 dBm EIRP that we propose for our medium power base stations.

A5.14 Draft ECC Report 296[90] presents simulation results from AAS micro to macro base stations. The results depend on the study and whether the micro base station is in line of sight to the macro base station. Assuming, as that report does, that interference is dominated by the out of band emissions of the micro base station, then with a 30 metres assumed separation and 60 MHz channels, around 10 to 15 dB additional emission reduction compared to the BEM or isolation is required in order for the micro base station not to cause undue interference to the macro base stations.

A5.15 The simulation results also suggested that the static nature of non-AAS macro base stations meant that they would need an additional protection of 5 or 6 dB. This aligns reasonably well with the emission levels determined in the analysis in ECC Report 203 when protecting macro base stations.

Interpreting the ECC Report results in our scenarios

A5.16 Draft ECC Report 296 notes that to achieve the restricted baseline levels required for unsynchronised use, equipment will require additional filtering which is likely to be applied externally in the case of non-AAS base stations but may not be feasible at all for AAS base stations with integrated antennas. We note that this additional filtering will also result in some internal guard bands and will lead to non-generic equipment.

A5.17 The report also notes that in some circumstances, unsynchronised operation remains possible using the more permissive transition regions and baseline rather than the restricted baseline where there is additional isolation between base stations (for example, increased physical separation or indoor low power base stations).

A5.18 In order to avoid the requirements and complexity of additional filtering, we have based our proposals for the BEM for low and medium power base stations on these transition regions and baseline levels and so we recognise that for unsynchronised operation, we need to be satisfied that in practice emission levels will be lower or additional isolation from increased clutter or separation distances will likely occur to ensure interference is not caused to (or from) unsynchronised macro or micro base stations below 3.8 GHz.

A5.19 When considering the emission levels or increased isolation required to protect unsynchronised base stations below 3.8 GHz, we also recognise in 5.60 et seq. and in line with ECC Report 249[91] that real emissions will always be better than the mask as this is a regulatory limit and that co-existence studies should take these real emissions into account. However, the basis of the analysis in ECC Reports 203 and 281, and Draft ECC Report 296, were on the basis of the BEM. Part of the necessary increased isolation will be provided by the improvement in performance of emissions which we assume to be 10 dB better when more than 5 MHz from the block edge.

[91] CEPT ECC, *ECC Report 249: Unwanted emissions of common radio systems: Measurements and use in sharing/ compatibility studies*, https://www.ecodocdb.dk/document/953

Low power base stations

A5.20 Taking the results from Draft ECC Report 296[90] and the analysis in ECC Report 203,[88] we note that our proposals for outdoor low power base stations have an emission level requirement that is at least 16 dB lower than the micro base stations simulated in Draft ECC Report 296 and we expect the actual emission levels to be lower in practice. These lower levels of emissions would therefore be sufficient to meet the 10 to 15 dB additional requirement noted in A5.14 and the -20 dBm / 5 MHz requirement for macro cells noted in A5.9.

A5.21 We therefore do not expect that outdoor low power base stations will cause any interference to unsynchronised AAS or non-AAS macro or AAS micro base stations below 3.8 GHz. Indoor low power will have additional building entry loss and so will have a lower impact.

A5.22 However, non-AAS micro cells below 3.8 GHz may be more susceptible to interference if the antenna patterns of both base stations align. Given that in practice, emission limits will be lower than the BEM, then a separation distance of around 60 metres rather than 30 metres used in the simulations will be sufficient to ensure that interference is not caused to those non-AAS micro base stations.

Medium power base stations

A5.23 In the case of medium power base stations, the power may only be a few dB lower than the modelled micro base stations in Draft ECC Report 296. Therefore, with our conservative assumption of up to 10 dB additional reduction in emissions, an increased minimum separation distance from unsynchronised non-AAS macro or micro base stations from 30 metres in the simulation up to around 100 metres will be needed.

A5.24 By comparison, the results from ECC Report 203 imply a similar distance increased is needed from unsynchronised *macro* base stations. However, an additional 30 to 35 dB isolation would be needed from unsynchronised micro base stations below 3.8 GHz, leading to a separation distance of around 1-1.8 kilometres.

A5.25 Up to 1.8 kilometres is unachievable where we have no knowledge of the base station locations in the block assigned licences below 3.8 GHz. Micro base stations in block assigned spectrum tend to be used in areas where high capacity is needed and are therefore predominantly in urban areas. Rural areas will have a lower density of base stations and are more likely to be macro base stations. We therefore consider that in these areas it is more realistic to assume that the medium power to micro base station interference scenarios are unlikely to occur and that separation distances from macro base stations of up to 100 metres is achievable in an uncoordinated way.

A5.26 We therefore propose that limiting medium power deployments to rural areas only will help to manage the risk of interference.

Increased frequency separation

A5.27 In our assumption on typical emission levels from base stations we note that that levels in practice are likely to be at least 5 dB better than the mask in the adjacent 5 MHz and 10 dB better further away from the block edge.

A5.28 In our analysis above, we have assumed a 10 dB improvement in emission levels is likely and this reduces the separation distances to more manageable levels. This may not be achievable in the 5 MHz adjacent to the block edge and therefore we also propose to not allocate the 5 MHz between 3800 and 3805 MHz. This has very little impact on spectrum availability in practice as our proposed channel plan will align better with existing spectrum used by fixed links and UK Broadband.

Other interference considerations

Interference from base stations below 3.8 GHz

A5.29 Draft ECC Report 296[90] also shows that the interference from macro base stations to micro base stations is greater by around 15 dB than from the micro to macro base stations. We therefore consider that the risk of interference *from* unsynchornised macro base stations below 3.8 GHz will be higher than *to* those base stations from new medium or low power base stations in 3.8-4.2 GHz.

A5.30 There is also an additional requirement for the BEMs in ECC Report 281[88] (which has been reflected in the draft 3.6-3.8 GHz licences) that requires an additional 15 dB reduction in emissions above 3840 MHz. We also recognise that the out of block emissions from base stations below 3.8 GHz will also be lower than the BEM levels. Therefore, if there is any increased risk of interference it will only be in the lower channel(s) of the 3.8-4.2 GHz band.

Interference between unsynchronised terminals

A5.31 We note that Draft ECC Report 296 observes that whilst base station to base station interference is the greatest concern in unsynchronised networks, there remains the possibility that terminal to terminal interference can occur in some circumstances. The static nature of terminals in FWA applications would be the application of greatest concern.

A5.32 With our proposed terminal power of 23 dBm, we consider that fixed terminals are unlikely to cause a significant risk of interference to other unsynchronised terminals provided that terminals of unsynchronised networks are not less than the modelled 30 metres separation. We would expect licensees in both the 3.8-4.2 GHz band and those below 3.8 GHz to cooperate in the unlikely event that either party was suffering significant interference as a result of fixed terminal to terminal interactions.

Bands above 4.2 GHz

A5.33 The 4.2-4.4 GHz band is used by radio altimeters in the UK. Radio altimeters are used by nearly all aircraft in order to determine their altitude and therefore have some associated safety aspects.

A5.34 ITU-R M.2059[92] notes that there are three primary electromagnetic interference coupling mechanisms between radio altimeters and interfering signals from other transmitters: receiver overload, desensitisation, and false altitude generation. It also notes that both out-of-band and in-band interference can affect a radio altimeter performance and there are no clear demarcations to determine which type of impact will occur. Therefore, all factors must be accommodated when conducting sharing studies.

A5.35 ITU-R M.2059 also lists parameters for a range of different altimeter types. We are aware from the CAA and MOD that there are range of radio altimeters in use on aircraft covering different types, ages and with differing performance. Their concern was that the older FMCW type altimeters may be the most susceptible. On that basis, we consider below the three ITU-R protection requirements based on the worst-case radar type.

ITU-R protection requirements

Protection 1: Receiver overload

A5.36 Receiver overload occurs when interfering signals saturate the front end of a radio altimeter causing a non-linear behaviour of the amplifiers. Radio altimeters are protected when the interference signal power (I_{RF}) at the input of the altimeter receiver is less than or equal to the threshold level (P_{RF}) at which the front end overloads.

A5.37 For our analysis, we considered an RF filter providing 24 dB per octave of filtering for the altimeters and the lowest protection threshold listed in ITU-R M.2059 for radar A3 of -56 dBm. For base stations at the upper end of the 3.8-4.2 GHz band, the filter will produce very little benefit. We also note that many of the other listed radar types have a higher threshold level of -40 dBm or in some cases -30 dBm and so will be much more protected against interference from receiver overload.

Protection 2: IF Desensitisation

A5.38 Receiver desensitisation is related to the intensity of the interfering signal that falls into the IF bandwidth of the radio altimeter, i.e. the out of band emissions from the 3.8-4.2 GHz base stations. The performance of the radio altimeter is considered degraded when the interfering signal causes a noise floor increase of 1 dB at the IF bandwidth of the receiver. The criterion to protect receiver desensitisation means that the interference signal power in the IF bandwidth (I_{IF}) is less than or equal to 6 dB below the thermal noise floor (N).

[92] ITU-R, *Recommendation ITU-R M. 2059-0: Operational characteristics and protection criteria of radio altimeters utilising the band 4200-4400 MHz*, February 2014, https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2059-0-201402-I!!PDF-E.pdf

A5.39 We consider that out of band emissions from the 3.8-4.2 GHz band could fall across the whole of the 4.2-4.4 GHz band and is defined as a power density per 5 MHz, although we would expect the levels to be lower at the upper end of the band. We therefore consider that we should not apply the interference duty cycle scaling factor that is also considered in ITU-R M.2059. In our analysis, we considered radar A3, which is once again the radar that needs the greatest protection and has a 2 MHz IF bandwidth. The RF interference threshold can be determined based on a 6 dB Noise Figure and an I/N requirement of -6 dB. The interference threshold at the radio altimeter must therefore not exceed -111 dBm / 2 MHz in this case.

Protection 3: False Altitude Report

A5.40 Radio altimeters can estimate their altitude by calculating the time difference between the transmitted and the received signal. In FMCW based altimeters, false altitude reports occur when interference signals are detected as frequency components within the IF bandwidth. If the interfering signal is higher than the detection threshold, then this might be falsely interpreted as a valid measurement causing a false altitude report. ITU-R M.2059 states that the interference threshold to protect altimeter from false altitude measurements is -143 dBm / 100 Hz. As the out of band emissions from the 3.8-4.2 GHz band can be assumed to be additive white gaussian noise (AWGN) then it is not appropriate to take account of the amount of time that the interference signal is the detector bandwidth as it must always be assumed to be there. Normalising to the same 2 MHz IF bandwidth for comparison means that the interference at the radio altimeter must not exceed -100 dBm / 2 MHz.

A5.41 It can be seen that the IF desensitisation is the more restrictive requirement and no further analysis is needed for the false altitude protection requirement.

Frequency separation

A5.42 Aircraft typically have three radio altimeters installed on them which work independently, and then the results are combined through a voting mechanism. The frequencies of each are offset by 5-10 MHz in order to avoid interference between the multiple units.

A5.43 ITU-R M.2059 notes that where parameters are unknown, those parameters in ITU-R M.1461[93] should be used as a guideline for analysing compatibility with other services. ITU-R M.1461 notes that where the radar receiver IF selectivity is not provided, selectivity fall-off of 80 dB per decade should be used from the 3 dB bandwidth edge frequency down to a selectivity threshold of 70 dB, which is the floor.

A5.44 Radio altimeters do not operate right to the edge of the band. The worst case FMCW, type A3 in ITU-R M.2059, has a 3 dB RF bandwidth of 171 MHz and an IF bandwidth of 2 MHz. We therefore consider that a small separation below 4.2 GHz will be required to ensure

[93] ITU-R, *Recommendation ITU-R M.1461-2: Procedures for determining the potential for interference between radars operating in the radiodetermination service and systems in other services*, January 2018, https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1461-2-201801-I!!PDF-E.pdf

that the selectivity of the altimeter is sufficient that interference is dominated by out of band emissions and not the altimeter receiver performance.

A5.45 We therefore propose that, given there is no measurement data available to us, we will take a cautious approach to the protection and introduce a frequency separation between 4195-4200 MHz.

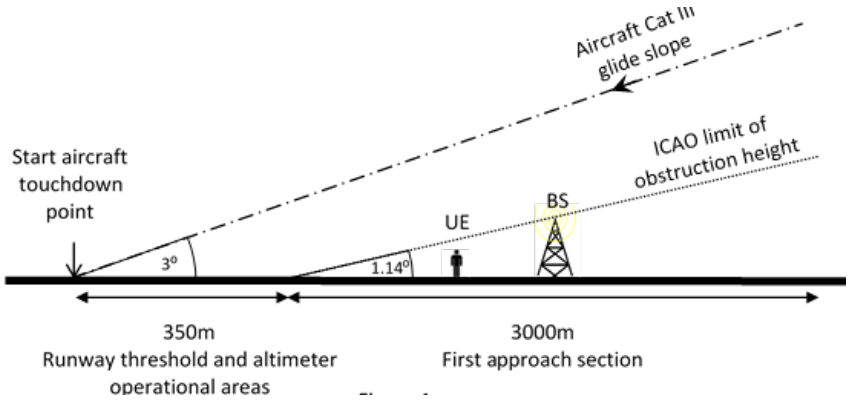
A5.46 Given that we are also proposing a 5 MHz separation at the lower end of the band at 3.8 GHz, 5 MHz separation at the top end of 4.2 GHz has no negative consequences as it does not reduce the number of available channels of any bandwidth.

Coexistence analysis

A5.47 ICAO has previously undertaken studies on the compatibility of radio altimeters with services in adjacent bands.[94] We have taken some of their analysis as the basis for our coexistence analysis. Looking at their assumed worst-case scenario of an aircraft on final approach in a Cat III landing passing directly over a base station, it produces the minimum separation distance when the radio altimeter is providing height information to the autopilot during landing.

A5.48 The geometry is provided in Figure 22, including the limits of deployments that are permitted along a final approach path. These limits allow a 25-metre base station to be placed 1,600.1 metres at its closest location to the aircraft touchdown point along the approach path.

Figure 22: Aircraft geometry at the end of a runway[95]



Source: ICAO

A5.49 In our analysis, we considered a base station with a 25-metre height at the same location of 1,600.1 metres away from the aircraft's touchdown point. For the radio altimeters, we assumed an antenna with 13dBi gain and 60 degrees HPBW, with the main beam pointing directly towards the ground.

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[94] ITU-R, *Recommendation ITU-R M. 2059-0: Operational characteristics and protection criteria of radio altimeters utilising the band 4200-4400 MHz*, February 2014,

[95] Image taken from *ACP-WG-F30/WP-14: Preliminary study into Radio Altimeter Adjacent Band Compatibility*, March 2014, https://www.icao.int/safety/acp/acpwgf/forms/allitems.aspx?RootFolder=%2Fsafety%2Facp%2FACPWGF%2FACP-WG-F-30&FolderCTID=0x012000C5EA3D5EC521BD4EB177DB3692EE06C1004AE5E3CA4B43024983D017A05C27C82C&View=%7BC1EF2BE0-84AC-456D-88D8-CCFF0C146B24%7D

A5.50 We modelled three scenarios for the base station type: an outdoor low power BS with 2 dBi antenna gain and two medium power BSs with 8 dBi and 16 dBi antenna gain. The higher the gain of the base station antenna, the less power is radiated towards the radio altimeter and the interference risk is lower. All scenarios used a 40 MHz channel bandwidth and, consistent with our approach for the 3.8 GHz boundary, we also assumed the realistic emission levels of 10 dB better than the BEM requirements in the licence.

A5.51 We modelled an aircraft following the Cat III glide slope from approximately 10 kilometres out to the touchdown point. The interference level received at the radio altimeter at each position along the glide slope was simulated and compared to the relevant thresholds for the worst-case type A3 radio altimeter taken from ITU-R M.2059.

A5.52 Figure 23 shows the total RF interference at the radio altimeter and Figure 24 shows the IF desensitisation from the out of band emissions falling within the 4.2-4.4 GHz band. We present the results from the medium power base station with 8 dBi antenna gain as this has the smallest margin to the thresholds.

A5.53 It can be seen that neither threshold is exceeded with our pessimistic modelling assumptions and that there remains some margin in the worst medium power case. Our provisional conclusion is therefore that our proposed technical conditions for shared access in the 3.8-4.2 GHz band will not cause any undue interference to radio altimeters.

Figure 23: RF overload risk assessment from a base station to a radio altimeter

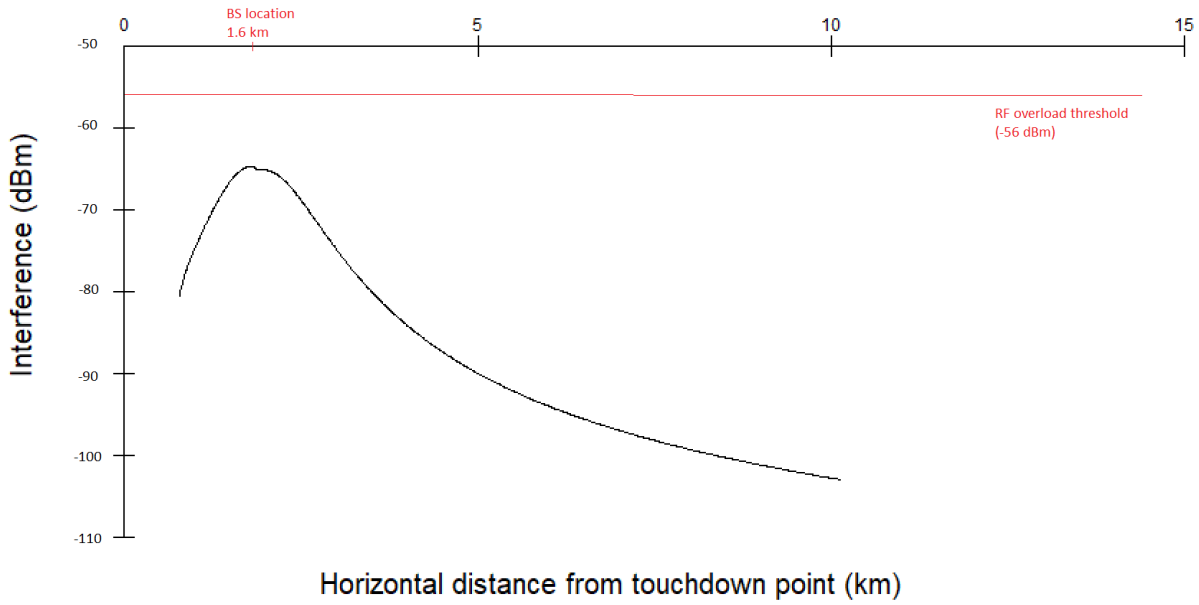
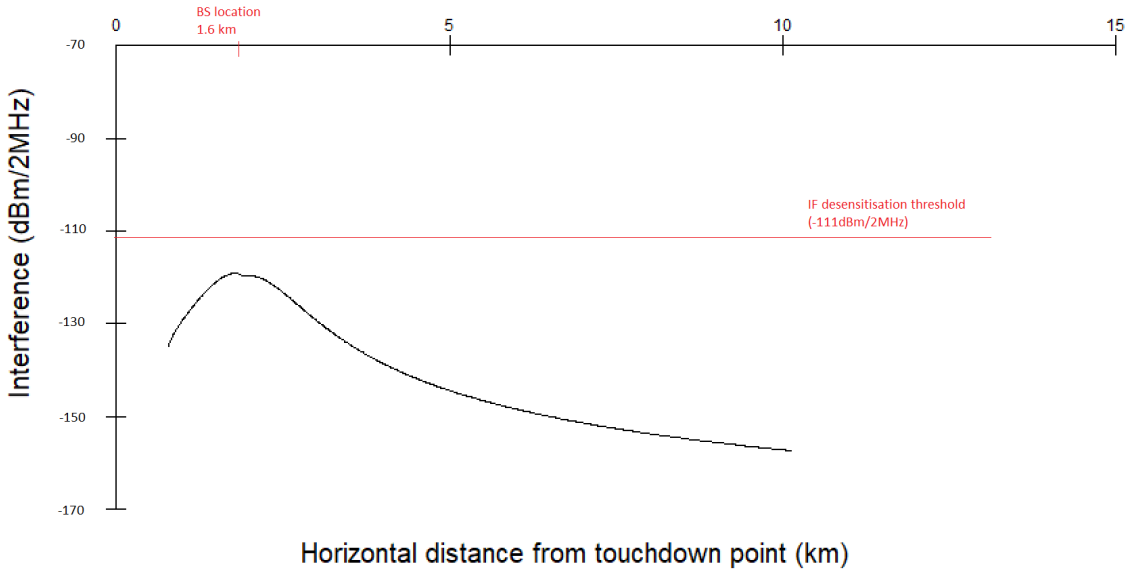


Figure 24: Radio altimeter desensitisation risk assessment from a base station



A6. Interference risk assessment in 2300 MHz shared spectrum

Co-channel interference with MOD

A6.1 We note in 5.100 et seq. that the 2300 MHz shared spectrum is also used by MOD for airborne systems providing telemetry in air-to-ground or air-to-air configurations. Many applications have wide coverage areas but the majority of the time they avoid urban areas. In addition, there are also some land-based systems that operate in this band.

A6.2 We are continuing to work with MOD regarding their use of spectrum in order to understand the likely risk that they will either suffer or cause interference to new uses in this band.

Adjacent band interference

A6.3 The 2300 MHz shared spectrum sits between the 2350-2390 MHz spectrum (2.3 GHz award) recently awarded to Telefónica and the 2.4 GHz band used by WiFi and Bluetooth or Bluetooth-like technologies such as assistive listening devices (ALD) on a licence exempt basis.

A6.4 In this section, we present the qualitative analysis on the possible risks of interference from proposed mobile use in the 2300 MHz shared spectrum to uses in the 2.4 GHz band. We focus on WiFi as one of the most widely used technologies in that band and ALD as some stakeholders raised a particular concern regarding ALDs during the preparations of the 2.3 GHz award.

A6.5 We review below, the relevant findings from our coexistence analysis undertaken for the 2.3 GHz award,[96] [97] [98] as well as some independent studies undertaken by the European Commission's Joint Research Centre (JRC) which focused particularly on the 2300 MHz shared spectrum.[99] [100] We also consider the factors contributing to interference in realistic use cases as well as additional mitigations that might reduce the risk of certain sets of circumstances occurring where the risk of interference is the highest.

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[96] Ofcom, *Public Sector Spectrum Release (PSSR): Technical coexistence issues for the 2.3 and 3.4 GHz award*, https://www.ofcom.org.uk/consultations-and-statements/category-1/pssr-2014

[97] Ofcom, *Technical coexistence issues for the 2.3 and 3.4 GHz award: Annexes 7-13*, 19 February 2014, https://www.ofcom.org.uk/__data/assets/pdf_file/0034/46699/annexes_7-13.pdf

[98] Ofcom, *Compatibility of 2.3 GHz 4G mobile with Assistive Listening Devices, 11 May 2017*, https://www.ofcom.org.uk/research-and-data/technology/radio-spectrum/compatibility-of-2.3-ghz-4g-mobile-with-assistive-listening-devices

[99] European Commission Joint Research Centre, *JRC Study on Coexistence between 2.3 GHz TD-LTE and 2.4 GHz Wi-Fi: Preliminary findings*, 24 June 2016, https://www.cept.org/Documents/wg-se/32511/se-16-info024_tdd-lte-and-wi-fi-at-24-ghz

[100] European Commission Radio Spectrum Committee, *Presentation of the study on Assistive Listening Devices (ALDs) in the 2.3-2.4 GHz band by the JRC: Working Document (RSCOM17-17)*, 9 March 2017, https://circabc.europa.eu/d/d/workspace/SpacesStore/e47fae70-e491-450d-ba18-46e58647d639/RSCOM17-17%20JRC_study_on_ALDs.pdf

Existing studies

WiFi

A6.6 WiFi operates using the 2.4 GHz band on a licence exempt basis, with the edge of channel 1 at approximately 2402 MHz.

A6.7 Our previous WiFi assessment[96] [97] consisted of:

- lab based measurements of WiFi devices to quantify their vulnerability to 4G signals from both base stations and mobile handsets;
- field trials to validate the effects predicted in real world environments; and
- quantitative analysis, using measurement results, to extrapolate the potential scale of interference between large scale 4G networks and WiFi deployments, based on a 10% reduction in throughput.

A6.8 Based on these laboratory measurements and field trials (including measuring the performance impact in a congested environment at London Victoria Station), we concluded that the overall impact of potential interference from 4G operating in 2350-2390 MHz was small and likely to affect only a very limited number of WiFi users. As a result, no intervention in the market was necessary to protect WiFi from potential interference.

A6.9 Nevertheless, we recognised at the time that the risk could be reduced further for WiFi devices if they had improved receiver performance.

A6.10 In 2016, JRC also carried out a study[99] on coexistence between 4G in 2300 MHz shared spectrum and WiFi in the adjacent 2.4 GHz band. Measurement of performance degradation was undertaken on a selection of WiFi devices using simulated and recorded 4G signals considering both base station and handset signal configurations. The testing demonstrated that some WiFi equipment suffered from what they termed minor to significant throughput loss depending on the frequency offset and separation distance from the 4G interference sources.

A6.11 We recognise that the results in the existing studies suggest that there could be a risk of some degradation to the performance of WiFi when a combination of circumstances occur at the same time. In particular, if:

- the WiFi signal is very weak, operating at its minimum signal levels; and
- the WiFi equipment does not have sufficiently good filters to reject signals from the adjacent mobile band; and
- mobile handsets use the 2300 MHz shared spectrum; and
- mobile handsets transmit at near full power of +23 dBm; and
- the mobile handset is particularly close to the WiFi receiver, i.e. less than one metre away.

Assistive Listening Devices

A6.12 ALDs operate using the 2.4 GHz band on a licence exempt basis. As part of the 2.3 GHz award and in response to stakeholder concerns, we carried out a comprehensive and real-

life based test programme[98] to investigate the risk of 4G mobile handsets[101] in the 2350-2390 MHz spectrum causing interference to ALDs above 2.4 GHz. The test programme included comprehensive testing of 46 equipment combinations provided by thirteen ALD manufacturers. We found in that study that no ALDs suffered from any kind of link failure, or complete audio drop out, the risk of which concerned some ALD stakeholders the most. Furthermore, there was no other obvious interference effects like audio delay when a smartphone was close to an ALD. Although some minor degradation was observed, we demonstrated that this did not result directly from 4G interference.

A6.13 When undertaking additional tests on a small sample of ALD devices with 4G operating in the 2300 MHz shared spectrum, two devices were potentially affected by interference from a mobile handset transmitting close to maximum power,[102] and within 0.5 metres of the ALD. On one occasion, nearly one second of audio was lost at the beginning of an ALD transmission. However, the underlying adaptive algorithm of the ALD radio technology then worked as it should do and the ALD link recovered and worked well afterwards.

A6.14 We did not investigate further at the time as the 2300 MHz shared spectrum was not part of the award spectrum. However, we did not believe that there was sufficient consistency in the results of the additional tests to determine an underlying cause of the interference.

A6.15 In contrast, JRC's work[100] focused on testing with 4G use in the 2300 MHz shared spectrum. However, they used a more laboratory focused methodology compared to our user scenario focused approach. Rather than using real handsets as the interferer, two signal generators were set up to replay signals recorded from handsets on a previous occasion. The JRC setup used a range of wanted signal levels for the ALD link, including a weaker level than would be expected from a system operating at its maximum practical distance.

A6.16 Despite these pessimistic operating conditions, the JRC report concluded that ALDs were very robust to interference when configured in line with typical operational conditions, so that the frequency hopping mechanism of the underlying technology worked effectively to combat aggressive interference. They did note, however, that at very weak ALD signal strengths, some devices exhibited audio performance degradation, which they classified as ranging between minor and severe.[103] However, in our view, this was a more susceptible configuration than the way ALDs would be used in practice.

A6.17 We note that when an ALD link was established with a very low wanted signal strength, representing a very large separation between the ALD transmitter and receiver, some performance degradation would be exhibited even before any interference is introduced. Moreover, during our previous engagements with manufacturers and users, they indicated that ALDs utilising Bluetooth or Bluetooth-like technologies were not designed for long-range use.

[101] Our previous analysis had demonstrated that the greatest risk of interference would be from handsets in close proximity rather than from base stations which, although output higher power, would be further away.
[102] Measured mean power of +20 dBm
[103] The JRC studies defines a "severe" degradation as a "temporary or permanent loss of signal, more than two glitches or short dropouts, strong wobbling or other distortions reducing speech intelligibility, strong increase in background noise"

A6.18 In summary, although the previous coexistence studies suggest that ALDs are quite robust to 4G interference in most real-life scenarios, they also indicated that, when a combination of circumstances occurs in parallel, there could be a risk of interference leading to a severe audio degradation. In particular if:

- the ALD system is working at or beyond its normal maximum range and therefore has a very weak signal; and
- the mobile handset transmits at near full power of +23 dBm; and
- the mobile handset is located particularly close to the ALD receiver, i.e. less than one metre away.

Assessment of interference risk from new uses in 2300 MHz shared spectrum

A6.19 Whilst we considered the risk of interference from base stations when preparing for the 2.3 GHz award, the maximum base station powers are much lower in 2300 MHz shared spectrum compared with that award band. We therefore consider that any risk of interference will be from handsets in 2300 MHz shared spectrum.

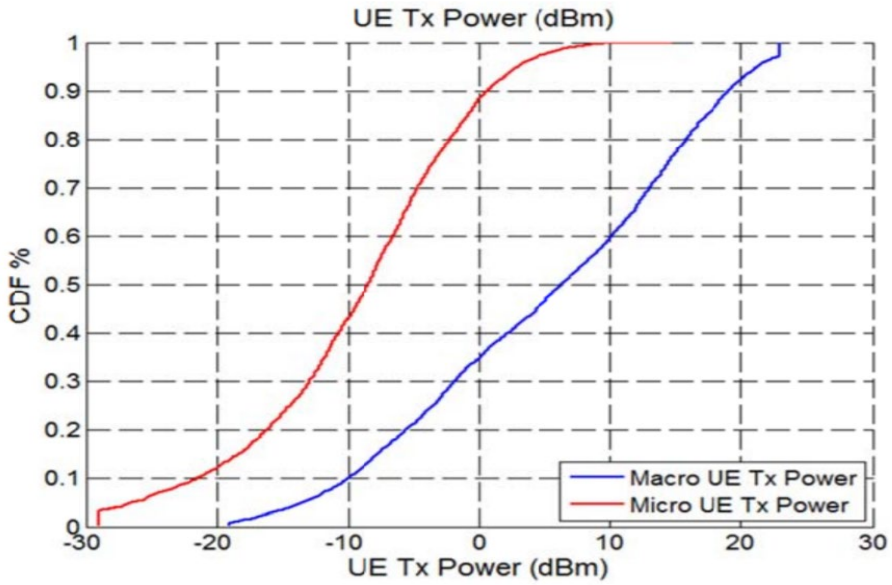
A6.20 As indicated above, there could be a risk of interference to WiFi and ALDs if a number of circumstances were to combine. In practice, we consider that there is a low likelihood that these circumstances will occur individually and a much lower likelihood that they will occur simultaneously. We set out the reasons for this below.

Moderate handset transmit power

A6.21 We consider the likelihood of mobile handsets transmitting at near full power to be low. Mobile handsets are designed to optimise the performance of the communication link and to minimise power consumption to extend battery life. They operate under power control from the base station and typically only operate at full power when they are far from the serving base station or the signal is blocked by obstacles such as tress, buildings, etc. Figure 25 below (taken from ECC report 203)[104] illustrates that a mobile handset – also known as user equipment (UE) – would transmit much less power (rarely above 10 dBm) when connected to a medium power micro base station than when connected to a high power macro base station (which would be above 10 dBm for 40% of the time).

[104] ECC, *ECC Report 203*, 14 March 2014, https://www.ecodocdb.dk/download/f5cd8793-5692/ECCREP203.PDF

Figure 25: Comparison of transmit power profiles of handsets. Macro UE refers to a handset connecting to a macro base station while Micro UE refers to a handset connecting to a micro base station



Source: ECC Report 203

A6.22 Indoor base stations are similarly likely to lead to much lower handset powers as indoor coverage solutions are designed to provide strong coverage across the area. However, when an indoor mobile handset is connected to an outdoor base station, there are additional building entry losses that degrade the signal and lead to a requirement for the handset to transmit at a higher power.

Operating in close proximity

A6.23 There are two potential interference scenarios where mobile handsets could operate in close proximity with ALDs and WiFi devices.

A6.24 In the first scenario, if a user was to hold a handset directly next to their ALD or WiFi receiver, this would create a circumstance with almost no separation between the two devices.

A6.25 In the second scenario, disruption or reduced quality could occur as a result of some circumstances created by another party and the user is unaware.

A6.26 Similar to the 2.3 GHz award analysis, we are not concerned about the use of 2.3 GHz and WiFi or ALD technology within the same device as we expect the manufacturer to ensure that both systems would work together in the device.

A6.27 We noted that if indoor base stations were located very close to WiFi access points that the static nature of both devices could lead to performance reduction of both systems. However, we further noted that where these are installed in close proximity, the installation would be under the control of the licensee.

A6.28 In general, we are less concerned about a small risk of interference when it is likely to be transient and under the influence of the affected party. Therefore, we would be more

concerned with a risk that the second scenario above would occur. In addition, handsets operating in an indoor environment may be more static than those outdoors where the users are moving around more. So, of more concern is the situation where handsets are indoors (and therefore more static) but using higher power (as a consequence of being connected to an outdoor base station).

Victim receiver operating in weak signal

A6.29 For ALDs, normal day to day use of ALD systems does not typically involve operating with very weak wanted signals at the ALD receivers, meaning that they are more robust to interference in practice than the JRC report suggested. We also understand that information on the distance range of the link, or how reducing the range can have a positive impact in mitigating any interference, is often provided as part of the ALD equipment specification. We believe that these extremely weak signals will not occur very often.

A6.30 For WiFi that has been designed to provide good coverage throughout an area such as an office block or warehouse, the wanted power levels will also remain high in order to maximise the performance of the network.

What we are doing already to reduce the risk

A6.31 In the unlikely event that interference was to occur in practice it would be possible for either the 2300 MHz shared spectrum user or the ALD or WiFi user to adjust their location slightly in order to increase the separation distance between the two devices or to improve the radio conditions.

A6.32 Whilst we showed in our analysis for the 2.3 GHz auction that interference was unlikely, we also noted that improvements to the receiver performance of WiFi devices would be beneficial in reducing the risk of interference.

A6.33 The Radio Equipment Directive (RED)[105] was introduced in 2014 and came into force in 2016. Amongst other things, this directive added a requirement for radio equipment to have appropriate receiver performance. Since 2015, we have been working with industry and ETSI[106] to ensure that harmonised equipment standards for the 2.4 GHz band include requirements for improved receiver performance. These new standards will lead to a reduction in the risk of interference for new equipment.

A6.34 As part of our previous work on ALDs, we worked closely with different charities involved with those who use ALDs. As part of this we contributed to some guidance information for ALD users to help them understand the possible impacts of using a mobile handset in very close proximity to their ALD and therefore to help them avoid those circumstances with very low physical separation between the mobile handset and the ALD receiver.

[105] European Commission, *Radio Equipment Directive (RED)*, https://ec.europa.eu/growth/sectors/electrical-engineering/red-directive_en
[106] European Telecommunication Standards Institute, https://www.etsi.org/

Further approaches to reducing risk

A6.35 Although we do not consider that interference is likely to occur, we recognise that the existing information on which we base our qualitative assessment was not specifically developed for the particular deployment scenarios and frequencies that we are now proposing. In the context of widescale use of WiFi and the more vulnerable nature of users of ALD systems, albeit operating on a non-interference non-protection licence exempt basis, we are initially taking a more cautious approach for the introduction of new users in the 2300 MHz shared spectrum.

A6.36 In particular, we are proposing three additional measures.

- Firstly, we recognise that the risk of interference with fixed infrastructure may be mitigated with careful deployment and use of the 2300 MHz shared spectrum system. For example, we consider that it might be appropriate to let licensees know that new low power base stations should not be located very close to WiFi access points which are using the lowest frequency WiFi channels unless those access points have good filtering in them;
- Secondly, licensees should consider carefully whether there is a risk of mobile handsets using the 2300 MHz shared spectrum operating in close proximity to those ALD receivers that are operating over an increased range (such as in the school classroom scenario that we studied in our previous work as one of the worst-case scenarios). In those circumstances, the building owners/integrators may wish to consider whether one of the alternative frequency bands is more appropriate for their uses; and
- Finally, through our technically assigned coordination approach, we have the ability to consider whether specific proposed deployments are likely to cause a higher than expected risk of interference to other users (such as ALDs, WiFi and existing MOD). We therefore expect that initially spectrum is likely to be widely available for indoor low power uses but outdoor and medium power base stations may be available in select locations only. As we gather more evidence on uses and how resilient ALDs, WiFi and the MOD uses are in practice, we expect the availability of outdoor and medium power base stations to increase over time.

Summary

Low power use

A6.37 Overall, we believe the risk of interference from low power deployments in 2300 MHz shared spectrum to co-channel MOD uses and ALD/WiFi in the adjacent 2.4 GHz band to be low. There remain some sets of circumstances which, although are very unlikely to occur in real life, could lead to interference. We propose to make applicants aware that careful base station deployment should be considered in locations close to WiFi access points and in environments where long-range ALD systems are more likely. We will consider on a case by case basis whether outdoor base stations can be authorised when taking the various other uses and risks into account at those locations.

Medium power use

A6.38 Medium power base stations are more likely to be outdoors and as we noted above this will increase the handset power for handsets located in an indoor environment. We therefore propose to take a precautionary approach and expect that medium power will be available in selected rural locations only if we consider that interference to other users is minimal.

A6.39 As we gather more evidence, we expect the availability of outdoor and medium power uses to be more generally available.

A7. Predicted spectrum availability in 3.8-4.2 GHz

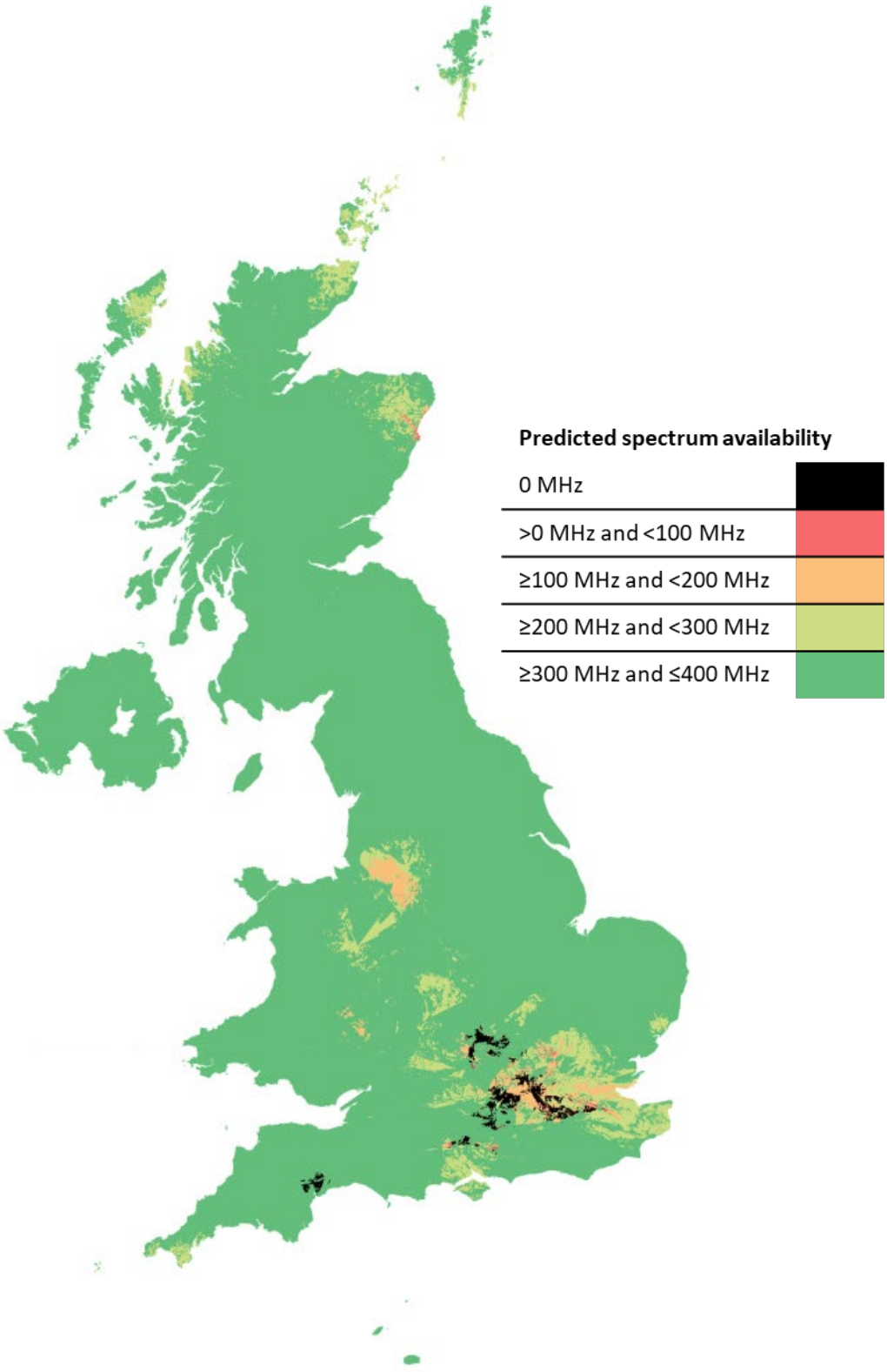
A7.1 We have predicted the likely initial spectrum availability based on our proposed protection criteria for incumbent services. We have taken account of the current deployments of satellite Earth stations, fixed links (after clearance of the 3.6-3.8 GHz band) and the currently coordinated UKB deployments in 3925-4009 MHz.

A7.2 As the following plots provide an overview over the whole UK, we also used lower resolution terrain and clutter data than we propose to use in our coordination tool and applied a generic antenna pattern for each type of use. Additionally, we did not consider the adjacent channel in our analysis. These simplifications mean that the exact amount of spectrum available at a given location may differ slightly when we consider the full set of parameters in our coordination tool.

A7.3 We assumed a simple 20 MHz channel plan in our analysis and summed the number of these 20 MHz channels available at each location. The following spectrum availability maps provide an indicative view of the spectrum availability for the following proposed new services:

- Low power outdoor base stations (Figure 26)
- Low power indoor base stations (Figure 27)
- Medium power outdoor base stations in rural areas only (Figure 28)
- Medium power outdoor base stations without the rural restriction (Figure 29)

Figure 26: Low power outdoor base stations[107]



[107] Note, the spectrum availability maps were calculated in 20 MHz blocks. Therefore, the range ">0 and <100 MHz" includes availability of radio spectrum of either 20 MHz, 40 MHz, 60 MHz, or 80 MHz.

Figure 27: Low power indoor base stations

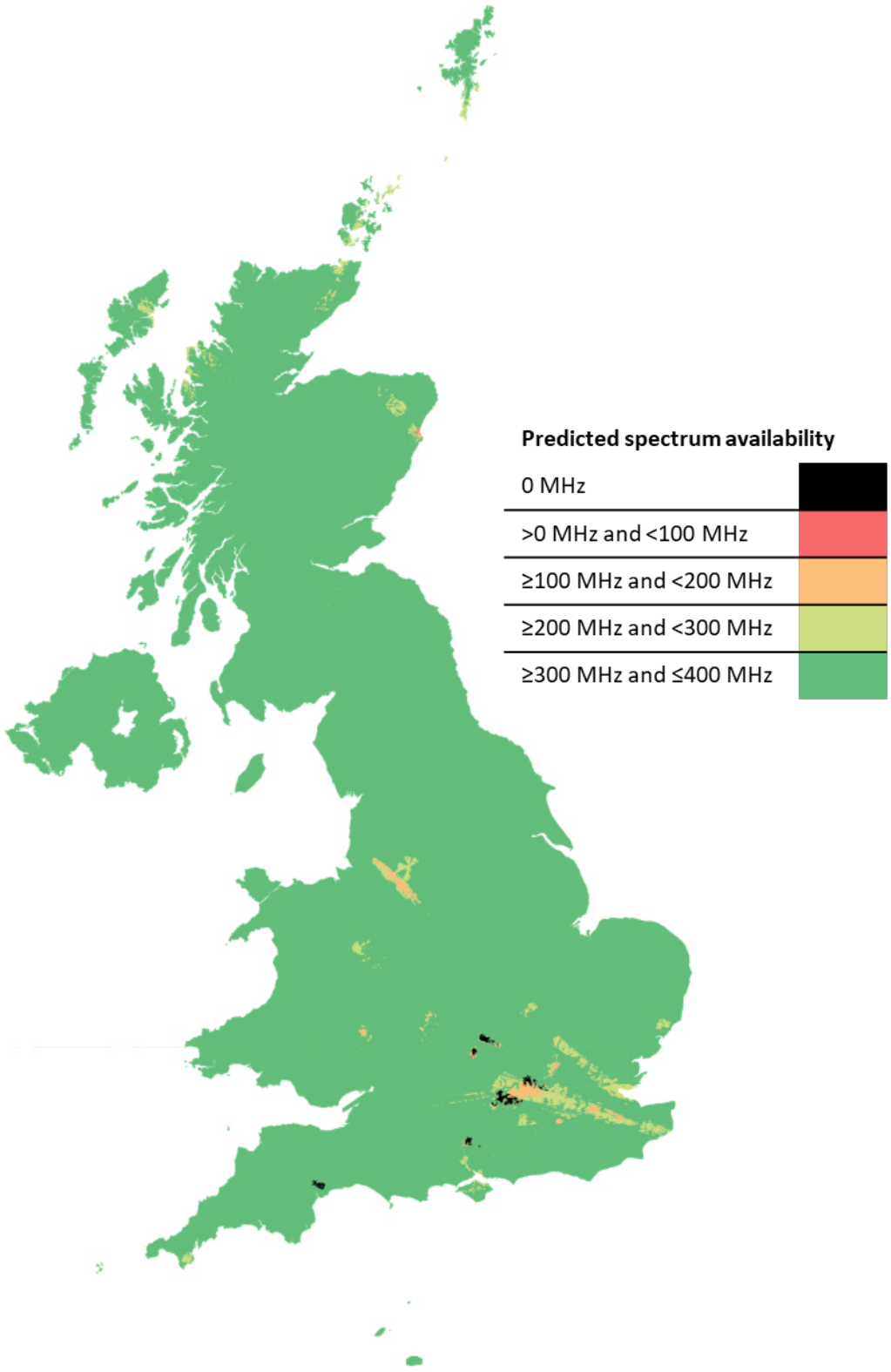


Figure 28: Medium power outdoor base stations in rural areas only

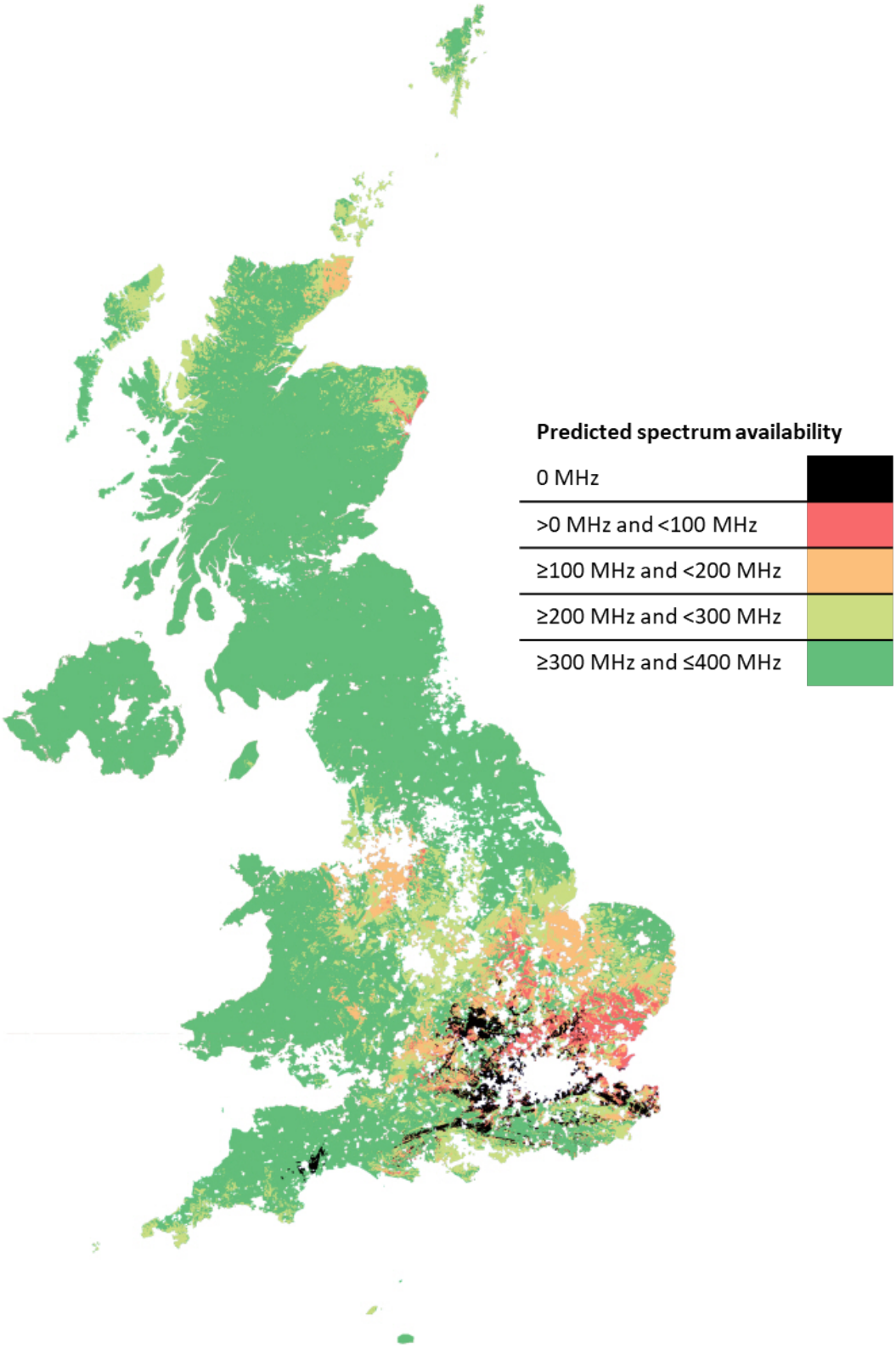
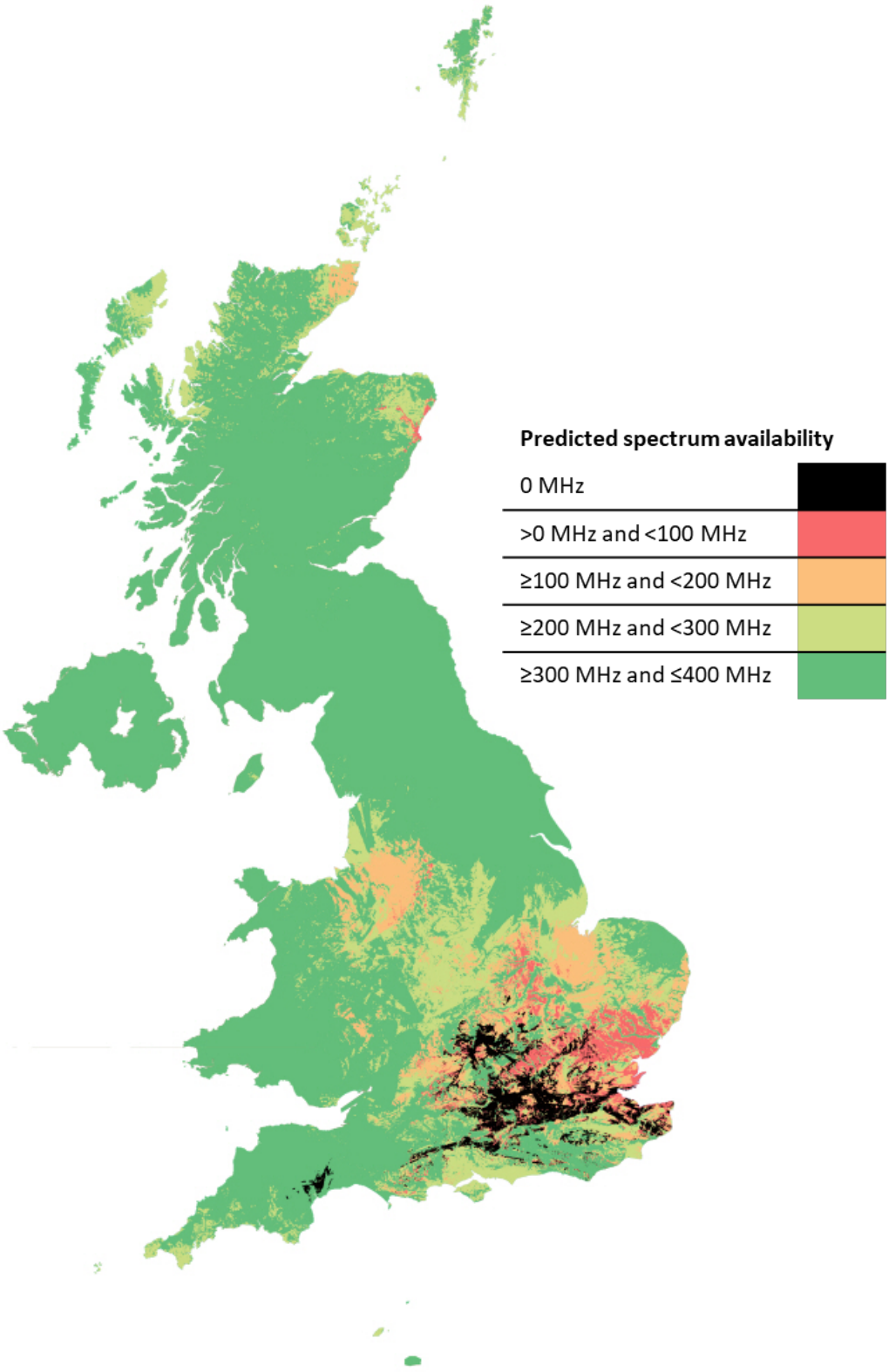


Figure 29: Medium power outdoor base stations without the rural restriction



A8. Draft shared access low power licence

Office of Communications (Ofcom)
Wireless Telegraphy Act 2006

SPECTRUM SHARED ACCESS LOW POWER LICENCE

Licence no:	**xxxxxx**
Date of issue:	**xx xxxx 201x**
Fee payment date	**xx xxxx**
Payment Interval	**tbd**

1. The Office of Communications (Ofcom) grants this wireless telegraphy licence ("the Licence") to

   Company
   (Company registration number xxxxxxxx)
   ("the Licensee")
   Add 1
   Add 2
   Add 3

   to establish, install and use wireless telegraphy stations and/or wireless telegraphy apparatus as described in the schedules to this Licence (together "the Radio Equipment") subject to the terms set out below.

Licence Term

2. This Licence shall continue in force until revoked by Ofcom or surrendered by the Licensee.

Licence Variation and Revocation

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

   (a) at the request, or with the consent, of the Licensee;

   (b) if there has been a breach of any of the terms of this Licence;

   (c) in accordance with schedule 1 paragraph 8(5) of the Act;

(d) if it appears to Ofcom to be necessary or expedient to revoke the Licence for the purpose of complying with a direction by the Secretary of State given to Ofcom under section 5 of the Act or section 5 of the Communications Act 2003;

(e) for reasons related to the management of the radio spectrum provided that in such a case the power to revoke may only be exercised after at least five years notice is given in writing.

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

Transfer

5. This Licence may not be transferred. The transfer of rights and obligations arising by virtue of this Licence may however be authorised in accordance with regulations made by Ofcom under powers conferred by section 30 of the Act[108].

Changes to Licensee details

6. The Licensee shall give prior notice to Ofcom in writing of any changes to the Licensee's name and/or address as recorded in paragraph 1 of this Licence.

Fees

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

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

Radio Equipment Use

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

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

Access and Inspection

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

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

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

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

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

Modification, Restriction and Closedown

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

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

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

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

Geographical Boundaries

14. Subject to the requirements of any coordination procedures notified to the Licensee pursuant to the schedules to this Licence, the Licensee is authorised to establish, install and use the Radio Equipment in the authorised service area(s) set out the schedules to this Licence.

Interpretation

15. In this Licence:

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

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

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

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

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

SCHEDULE 1 TO LICENCE NUMBER: xxxxxx

Schedule Date: **xx xxxx 201x**

Licence category: **Spectrum Shared Access Low Power**

Description of Radio Equipment

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

Interface Requirements for the Radio Equipment

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

   [UK Interface Requirement xx Spectrum Shared Access – Low power]

Special conditions relating to the Radio Equipment

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

Coordination at frequency and geographical boundaries

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

International cross-border coordination

5. The Licensee shall ensure that the Radio Equipment is operated in compliance with such cross-border coordination and sharing procedures as may be notified to the Licensee by Ofcom from time to time.

Cooperation between Licensees

6. In addition to complying with the specific transmission terms, conditions and limitations set out in this Licence, the Licensee must liaise and co-operate with other holders of licences within band (if necessary adjusting transmission power and other technical parameters of transmission) in such a way that harmful interference is not caused by one network deployment to that of another Licensee within the band.

Interpretation of terms in this schedule

7. In this schedule:

"IR" means a United Kingdom Radio Interface Requirement notified by Ofcom in accordance with Article 8 of Directive 2014/53/EU of the European Parliament and of the Council on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment (known as the Radio Equipment Directive)

SCHEDULE 2 TO LICENCE NUMBER: xxxxxx

Schedule Date: **xx xxxx 201x**

Licence category: **Spectrum Shared Access Low Power**

<table>
<tr><th colspan="2">Transmitter(s)</th></tr>
<tr><td>Authorised Service Area</td><td>Area of 50 metre radius from the following location NGR [xxx xxx]</td></tr>
<tr><td>Deployment location</td><td>[Indoor/Indoor & Outdoor]

NB.

Outdoor antenna systems limited to 10 metre height above ground</td></tr>
<tr><td>Permitted Frequency Block</td><td>[xxx – xxx / xxx – xxx] MHz</td></tr>
<tr><td>Maximum power (eirp)/ / Maximum power within the Permitted Frequency Blocks</td><td>
<table>
<tr><th>Radio Equipment</th><th>Band</th><th>Maximum mean power (eirp)</th></tr>
<tr><td rowspan="3">Base station</td><td>1800 MHz shared spectrum</td><td>24 dBm / carrier (up to 3 MHz)</td></tr>
<tr><td>2300 MHz shared spectrum</td><td>24 dBm / carrier (up to 10 MHz)</td></tr>
<tr><td>3.8 – 4.2 GHz</td><td>24 dBm / carrier for carriers ≤ 20 MHz; OR 18 dBm / 5 MHz for carriers > 20 MHz</td></tr>
<tr><td rowspan="3">Mobile nomadic terminal station</td><td>1800 MHz shared spectrum</td><td>23 dBm TRP</td></tr>
<tr><td>2300 MHz shared spectrum</td><td>25 dBm* TRP</td></tr>
<tr><td>3.8-4.2 GHz</td><td>25 dBm* TRP</td></tr>
<tr><td rowspan="3">Fixed or installed terminal station</td><td>1800 MHz shared spectrum</td><td>23 dBm EIRP</td></tr>
<tr><td>2300 MHz shared spectrum</td><td>25 dBm* EIRP</td></tr>
<tr><td>3.8-4.2 GHz</td><td>25 dBm* EIRP</td></tr>
</table>
The maximum mean power relates to the EIRP or TRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.
* The 25 dBm includes a 2 dB measurement uncertainty consistent with the European harmonisation decision.
</td></tr>
</table>

SCHEDULE 3 TO LICENCE NUMBER: xxxxxx

Schedule Date: **xx xxxx 201x**

Licence category: **Spectrum Shared Access Low Power**

Maximum power of base stations outside the Permitted Frequency Blocks

1800 MHz shared spectrum

1. When transmitting, the Licensee must transmit within the limits set out below.

Frequency offset from the lower frequency of the band edge	**Maximum mean EIRP density**
-6.2 to -3.2 MHz	-55 dBm / kHz
-3.2 to 0 MHz	-45 + 10 x (Δ_{FL}*- 0.2)/3 dBm / kHz
Frequency offset from the upper frequency of the band edge	**Maximum mean EIRP density**
0 to 0.05 MHz	-23 – 60 x Δ_{FH}* dBm / kHz
0.05 to 0.1 MHz	-26 – 153.3 x (Δ_{FH}* - 0.05) dBm / kHz
0.1 to 2.8 MHz	-45 - 10 x (Δ_{FH}* - 0.2)/3 dBm / kHz
2.8 to 5.8 MHz	-55 dBm dBm / kHz

* Note: Δ_{FL} in MHz is the offset from the lower edge of the permitted frequency band at 1876.7 MHz (it has values in the range -3.2 to 0 MHz)
Δ_{FH} in MHz is the offset from the upper edge of the permitted frequency band at 1880 MHz (it has values in the range 0 to 2.8 MHz)

2300 MHz shared spectrum

2. When transmitting, the Licensee must transmit within the limits of the Permissive Transmission Mask. The Permissive Transmission Mask means that –

for transmissions on the downlink frequencies, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following transitional, baseline and band edge requirements:

2385 to 2390 MHz 2400 to 2403 MHz	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna	
2380 to 2385 MHz	Min(PMax – 43, 15) dBm / 5 MHz EIRP per antenna	
2300 to 2380 MHz	Min(PMax – 43, 13) dBm / 5 MHz EIRP per antenna	
Above 2403 MHz	24 dBm < PMax ≤ 42 dBm	(PMax -41) dBm / 5 MHz EIRP*
	PMax ≤ 24 dBm	-17 dBm / 5 MHz EIRP*

* The maximum mean power relates to the EIRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

3. For all indoor base stations, where the licensee in the 2350 – 2390 MHz spectrum demonstrates that they are suffering harmful interference as a result of an indoor base station, and for all outdoor base stations, the licensee must also transmit within the limits of transmission Frame Structure A. Frame Structure A (also commonly known as the "Preferred Frame Structure") means that:

   a. transmissions from the Licensee's base stations have a frame structure as shown in Figure 1. Timeslots (or subframes) 0, 2 to 5 and 7 to 9 must be allocated to Downlink (D) or Uplink (U) transmissions as indicated or may be left with no transmissions;

   b. the Licensee must ensure that the special subframe (S) in timeslots 1 and 6 have a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2 (DwPTS: GP: UpPTS). For the avoidance of doubt, a special subframe structure is compatible where there are no uplink transmissions within the downlink pilot timeslot (DwPTS) or guard period (GP) and no downlink transmissions within the uplink pilot timeslot (UpPTS) or guard period (GP);

   c. timeslots must have a duration of 1 millisecond;

   d. the Licensee shall ensure that frames start at a common reference time so that all licensees' frames are aligned and transmissions synchronised;

   e. TD-LTE frame configuration 2 (3:1) is compatible with this frame structure. Other technologies are permitted provided that the requirements of 2(a) to 2(d) are met.

Frame Structure A

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
3:1	D	S	U	D	D	D	S	U	D	D

3.8 – 4.2 GHz

4. For all indoor base stations, where another licensee in the 3.8-4.2 GHz spectrum demonstrates that they are suffering harmful interference as a result of an indoor base station, and for all outdoor base stations, when transmitting, the Licensee must either transmit in accordance with the condition in paragraph (a) or in accordance with the condition in paragraph (b) or in accordance with the condition in paragraph (c)–

   a. The condition referred to is that the Licensee must transmit within the limits of the Permissive Transmission Mask and, if doing so, the Licensee must also transmit within the limits of transmission Frame Structure A.

   b. The condition referred to is that the Licensee must transmit within the limits of the Restrictive Transmission Mask, and, if doing so, it must also transmit and within the limits of transmission Frame Structure B.

   c. The condition referred to is that the Licensee must transmit within the limits of the Permissive Transmission Mask but is not required to comply with either Frame Structure A or B. This condition applies only to indoor base stations with PMax ≤ 24 dBm and provided that another licensee in the 3.8-4.2 GHz spectrum has not demonstrated that they are suffering harmful interference as a result of the Indoor base station.

5. The Permissive Transmission Mask means that –

for transmissions on the downlink frequencies, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following transitional and baseline requirements:

-5 to 0 MHz offset from lower block edge 0 to 5 MHz offset from upper block edge	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna
-10 to -5 MHz offset from lower block edge 5 to 10 MHz offset from upper block edge	Min(PMax – 43,15) dBm / 5 MHz EIRP per antenna
Out of block baseline power limit (BS) < -10 MHz offset from lower block edge > 10 MHz offset from upper block edge	Min(PMax – 43,13) dBm / 5 MHz EIRP per antenna

6. The Restrictive Transmission Mask means that –

for transmissions on the downlink frequencies, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following baseline:

Out of block baseline power limit (BS)	- 34 dBm / 5 MHz EIRP*

* The maximum mean power relates to the EIRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

7. Frame Structure A (also known as the "Preferred Frame Structure") means that:

   a. Transmissions from the Licensee's base stations have a frame structure as shown in Figure 1. Timeslots (or subframes) 0, 2 to 5 and 7 to 9 must be allocated to Downlink (D) or Uplink (U) transmissions as indicated or may be left with no transmissions;

   b. The Licensee must ensure that the special subframe (S) in timeslots 1 and 6 have a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2 (DwPTS: GP: UpPTS). For the avoidance of doubt, a special subframe structure is compatible where there are no uplink transmissions within the downlink pilot timeslot (DwPTS) or guard period (GP) and no downlink transmissions within the uplink pilot timeslot (UpPTS) or guard period (GP);

   c. Timeslots must have a duration of 1 millisecond;

   d. The Licensee shall ensure that frames start at a common reference time so that all licensees' frames are aligned and transmissions synchronised;

   e. TD-LTE frame configuration 2 (3:1) is compatible with this frame structure. Other technologies are permitted provided that the requirements of 7(a) to 7(d) are met.

8. Frame Structure B (also known as the "Compatible Frame Structure") means that:

   a. transmissions from the Licensee's base stations must have a frame structure as shown in Figure 2. Timeslots (or subframes) 0 and 2 must be allocated to Downlink (D), or Uplink (U) transmissions as indicated;

   b. the Licensee must ensure that the special subframe (S) in timeslot 1 has a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2 (DwPTS:

GP: UpPTS). For the avoidance of doubt, a special subframe structure is compatible where there are no uplink transmissions within the downlink pilot timeslot (DwPTS) or guard period (GP) and no downlink transmissions within the uplink pilot timeslot (UpPTS) or guard period (GP);

c. timeslots must have a duration of 1 millisecond;

d. the Licensee shall ensure that frames start at a common reference time so that all licensees' frames are aligned and transmissions synchronised;

e. all current TD-LTE frame configurations are compatible with this frame structure. Other technologies are permitted provided that the requirements of 8(a) to 8(d) are met;

f. timeslots with no transmission indicated may have no transmission or must be determined as a Downlink, Uplink or Special subframe as necessary in order to ensure compliance with paragraph 8(c) and 8(g);

g. the Licensee must cooperate to minimise harmful sub-frame overlaps if different technologies are used. On rare occasions this may require the frame alignment or guard period to be slightly offset;

h. for the avoidance of doubt all-downlink frame structures such as Supplementary Downlink (SDL) are not permitted.

Frame Structure A

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
3:1	D	S	U	D	D	D	S	U	D	D

Frame Structure B

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
Any	D	S	U							

9. Irrespective of whether the Restrictive Transmission Mask or the Permissive Transmission Mask is being used, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following additional band edge requirements:

3795 MHz – 3800 MHz 4200 MHz – 4205 MHz	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna
3790 MHz – 3795 MHz 4205 MHz – 4210 MHz	Min(PMax – 43,15) dBm / 5 MHz EIRP per antenna
3760 MHz - 3790 MHz 4210 MHz – 4240 MHz	Min(PMax – 43,13) dBm / 5 MHz EIRP per antenna
Below 3760 MHz Above 4240 MHz	-2 dBm / 5 MHz EIRP per antenna

Interpretation of terms in this schedule

10. In this schedule:

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

b) “Downlink” means transmissions from a base station to a terminal station (handset);

c) “EIRP” means the equivalent isotropically radiated power. This is the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain), measured during the “on” part of the transmission;

d) “Fixed or installed” means used or installed at specific fixed points;

e) “Indoor” means a location inside a building or place in which the shielding will typically provide the necessary attenuation to protect wireless telegraphy against harmful interference;

f) “lower block edge” means, in relation to each Permitted Frequency Block, the lowest frequency in that Permitted Frequency Block;

g) “mobile or nomadic” means intended to be used while in motion or during halts at unspecified points;

h) “PMax” is the maximum mean power for the base station in question, measured as EIRP per carrier and determined irrespective of the number of antennas;

i) “TDD” means the application of time-division multiplexing to separate outward and return signals;

j) “TD-LTE” means the TDD variant of LTE (Long Term Evolution or 4G technology);

k) “TRP” means the total radiated power. This is the integral of the power transmitted in different directions over the entire radiation sphere, measured during the on part of the transmission;

l) “Uplink” means transmissions from a terminal station (handset) to a base station; and

m) “upper block edge” means, in relation to each Permitted Frequency Block, the highest frequency in that Permitted Frequency Block.

A9. Draft shared access medium power licence

Office of Communications (Ofcom)
Wireless Telegraphy Act 2006

SPECTRUM SHARED ACCESS MEDIUM POWER LICENCE

Licence no:	**xxxxxx**
Date of issue:	**xx xxxx 201x**
Fee payment date	**xx xxxx**
Payment Interval	**tbd**

1. The Office of Communications (Ofcom) grants this wireless telegraphy licence ("the Licence") to

   Company
   (Company registration number xxxxxxxx)
   ("the Licensee")
   Add 1
   Add 2
   Add 3

   to establish, install and use wireless telegraphy stations and/or wireless telegraphy apparatus as described in the schedules to this Licence (together "the Radio Equipment") subject to the terms set out below.

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Licence Variation and Revocation

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

   (a) at the request, or with the consent, of the Licensee;

   (b) if there has been a breach of any of the terms of this Licence;

   (c) in accordance with schedule 1 paragraph 8(5) of the Act;

   (d) if it appears to Ofcom to be necessary or expedient to revoke the Licence for the purpose of complying with a direction by the Secretary of State given to Ofcom under section 5 of the Act or section 5 of the Communications Act 2003;

(e) for reasons related to the management of the radio spectrum provided that in such a case the power to revoke may only be exercised after at least five years notice is given in writing.

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

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5. This Licence may not be transferred. The transfer of rights and obligations arising by virtue of this Licence may however be authorised in accordance with regulations made by Ofcom under powers conferred by section 30 of the Act[109].

Changes to Licensee details

6. The Licensee shall give prior notice to Ofcom in writing of any changes to the Licensee's name and/or address as recorded in paragraph 1 of this Licence.

Fees

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

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

Radio Equipment Use

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

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

Access and Inspection

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

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

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

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

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

Modification, Restriction and Closedown

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

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

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

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

Geographical Boundaries

14. Subject to the requirements of any coordination procedures notified to the Licensee pursuant to the schedules to this Licence, the Licensee is authorised to establish, install and use the Radio Equipment in the authorised service area(s) set out the schedules to this Licence.

Interpretation

15. In this Licence:

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

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

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

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

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

SCHEDULE 1 TO LICENCE NUMBER: xxxxxx

Schedule Date: **xx xxxx 201x**

Licence category: **Spectrum Shared Access Medium Power**

Description of Radio Equipment

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

Interface Requirements for the Radio Equipment

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

   [UK Interface Requirement xx Spectrum Shared Access Medium power]

Special conditions relating to the Radio Equipment

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

Coordination at frequency and geographical boundaries

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

International cross-border coordination

5. The Licensee shall ensure that the Radio Equipment is operated in compliance with such cross-border coordination and sharing procedures as may be notified to the Licensee by Ofcom from time to time.

Cooperation between Licensees

6. In addition to complying with the specific transmission terms, conditions and limitations set out in this Licence, the Licensee must liaise and co-operate with other holders of licences within band (if necessary adjusting transmission power and other technical parameters of transmission) in such a way that harmful interference is not caused by one network deployment to that of another Licensee within the band.

Interpretation of terms in this schedule

7. In this schedule:

"IR" means a United Kingdom Radio Interface Requirement notified by Ofcom in accordance with Article 8 of Directive 2014/53/EU of the European Parliament and of the Council on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment (known as the Radio Equipment Directive)

SCHEDULE 2 TO LICENCE NUMBER: xxxxxx

Schedule Date: xx xxxx 201x

Licence category: Spectrum Shared Access Medium Power

<table>
<tr><th colspan="2">Transmitter(s)</th></tr>
<tr><td>Base station location</td><td>NGR [xxx xxx]</td></tr>
<tr><td>Deployment location</td><td>1800 MHz shared spectrum and 2300 MHz shared spectrum - outdoor antenna systems limited to 10 metre height above ground</td></tr>
<tr><td>Permitted Frequency Block</td><td>[xxx – xxx / xxx – xxx] MHz</td></tr>
<tr><td>Base Station Maximum power (eirp)/ / Maximum power within the Permitted Frequency Blocks</td><td>
<table>
<tr><th>Radio Equipment</th><th>Band</th><th>Maximum power (eirp)</th></tr>
<tr><td rowspan="3">Base Station</td><td>1800 MHz shared spectrum</td><td>Up to 42 dBm / carrier (up to 3 MHz)</td></tr>
<tr><td>2300 MHz shared spectrum</td><td>Up to 42 dBm / carrier</td></tr>
<tr><td>3.8 – 4.2 GHz</td><td>Up to 42 dBm / carrier for carriers ≤ 20 MHz OR 36 dBm / 5 MHz for carriers > 20 MHz</td></tr>
</table>
</td></tr>
<tr><td>Terminal Maximum power (eirp)/ / Maximum power within the Permitted Frequency Blocks</td><td>
<table>
<tr><th>Radio Equipment</th><th>Band</th><th>Maximum power (eirp)</th></tr>
<tr><td rowspan="3">Fixed or nomadic terminal station</td><td>1800 MHz shared spectrum</td><td>23 dBm EIRP</td></tr>
<tr><td>2300 MHz shared spectrum</td><td>25 dBm* EIRP</td></tr>
<tr><td>3.8-4.2 GHz</td><td>25 dBm* EIRP</td></tr>
<tr><td rowspan="2">Mobile terminal station</td><td>1800 MHz shared spectrum</td><td>23 dBm TRP</td></tr>
<tr><td>2300 MHz shared</td><td>25 dBm* TRP</td></tr>
</table>
The maximum power relates to the EIRP or TRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.
* The 25 dBm includes a 2 dB measurement uncertainty consistent with the European harmonisation decision.
</td></tr>
</table>

SCHEDULE 3 TO LICENCE NUMBER: xxxxxx

Schedule Date: **xx xxxx 201x**

Licence category: **Spectrum Shared Access Medium Power**

Maximum power of base stations outside the Permitted Frequency Blocks

1800 MHz shared spectrum

1. When transmitting, the Licensee must transmit within the limits set out below.

Frequency offset from the lower frequency of the band edge	**Maximum mean EIRP density**
-6.2 to -3.2 MHz	-55 dBm / kHz
-3.2 to 0 MHz	-45 + 10 x (Δ_{FL}*- 0.2)/3 dBm / kHz
Frequency offset from the upper frequency of the band edge	**Maximum mean EIRP density**
0 to 0.05 MHz	-23 – 60 x Δ_{FH}* dBm / kHz
0.05 to 0.1 MHz	-26 – 153.3 x (Δ_{FH}* - 0.05) dBm / kHz
0.1 to 2.8 MHz	-45 - 10 x (Δ_{FH}* - 0.2)/3 dBm / kHz
2.8 to 5.8 MHz	-55 dBm dBm / kHz

* Note: Δ_{FL} in MHz is the offset from the lower edge of the permitted frequency band at 1876.7 MHz (it has values in the range -3.2 to 0 MHz)
Δ_{FH} in MHz is the offset from the upper edge of the permitted frequency band at 1880 MHz (it has values in the range 0 to 2.8 MHz)

2300 MHz shared spectrum

2. When transmitting, the Licensee must transmit within the limits of the Permissive Transmission Mask. The Permissive Transmission Mask means that –

for transmissions on the downlink frequencies, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following transitional, baseline and band edge requirements:

2385 to 2390 MHz 2400 to 2403 MHz	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna	
2380 to 2385 MHz	Min(PMax – 43, 15) dBm / 5 MHz EIRP per antenna	
2300 to 2380 MHz	Min(PMax – 43, 13) dBm / 5 MHz EIRP per antenna	
Above 2403 MHz	24 dBm < PMax ≤ 42 dBm	(PMax -41) dBm / 5 MHz EIRP*
	PMax ≤ 24 dBm	-17 dBm / 5 MHz EIRP*

* The maximum mean power relates to the EIRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

3. For all indoor base stations, where the licensee in the 2350 – 2390 MHz spectrum demonstrates that they are suffering harmful interference as a result of an indoor base station, and for all outdoor base stations, the licensee must also transmit within the limits of transmission Frame Structure A. Frame Structure A (also commonly known as the "Preferred Frame Structure") means that:

    a. transmissions from the Licensee's base stations have a frame structure as shown in Figure 1. Timeslots (or subframes) 0, 2 to 5 and 7 to 9 must be allocated to Downlink (D) or Uplink (U) transmissions as indicated or may be left with no transmissions;

    b. the Licensee must ensure that the special subframe (S) in timeslots 1 and 6 have a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2 (DwPTS: GP: UpPTS). For the avoidance of doubt, a special subframe structure is compatible where there are no uplink transmissions within the downlink pilot timeslot (DwPTS) or guard period (GP) and no downlink transmissions within the uplink pilot timeslot (UpPTS) or guard period (GP);

    c. timeslots must have a duration of 1 millisecond;

    d. the Licensee shall ensure that frames start at a common reference time so that all licensees' frames are aligned and transmissions synchronised;

    e. TD-LTE frame configuration 2 (3:1) is compatible with this frame structure. Other technologies are permitted provided that the requirements of 3(a) to 7(d) are met.

Frame Structure A

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
3:1	D	S	U	D	D	D	S	U	D	D

3.8 – 4.2 GHz

4. For all indoor base stations, where another licensee in the 3.8-4.2 GHz spectrum demonstrates that they are suffering harmful interference as a result of an indoor base station, and for all outdoor base stations, when transmitting, the Licensee must either transmit in accordance with the condition in paragraph (a) or in accordance with the condition in paragraph (b) or in accordance with the condition in paragraph (c)–

    a. The condition referred to is that the Licensee must transmit within the limits of the Permissive Transmission Mask and, if doing so, the Licensee must also transmit within the limits of transmission Frame Structure A.

    b. The condition referred to is that the Licensee must transmit within the limits of the Restrictive Transmission Mask, and, if doing so, it must also transmit and within the limits of transmission Frame Structure B.

    c. The condition referred to is that the Licensee must transmit within the limits of the Permissive Transmission Mask but is not required to comply with either Frame Structure A or B. This condition applies only to indoor base stations with PMax ≤ 24 dBm and

provided that another licensee in the 3.8-4.2 GHz spectrum has not demonstrated that they are suffering harmful interference as a result of the Indoor base station.

5. The Permissive Transmission Mask means that –

for transmissions on the downlink frequencies, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following transitional and baseline requirements:

-5 to 0 MHz offset from lower block edge 0 to 5 MHz offset from upper block edge	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna
-10 to -5 MHz offset from lower block edge 5 to 10 MHz offset from upper block edge	Min(PMax – 43,15) dBm / 5 MHz EIRP per antenna
Out of block baseline power limit (BS) < -10 MHz offset from lower block edge > 10 MHz offset from upper block edge	Min(PMax – 43,13) dBm / 5 MHz EIRP per antenna

6. The Restrictive Transmission Mask means that –

for transmissions on the downlink frequencies, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following baseline:

Out of block baseline power limit (BS)	- 34 dBm / 5 MHz EIRP*

* The maximum mean power relates to the EIRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

7. Frame Structure A (also known as the “Preferred Frame Structure”) means that:

    a. Transmissions from the Licensee’s base stations have a frame structure as shown in Figure 1. Timeslots (or subframes) 0, 2 to 5 and 7 to 9 must be allocated to Downlink (D) or Uplink (U) transmissions as indicated or may be left with no transmissions;

    b. The Licensee must ensure that the special subframe (S) in timeslots 1 and 6 have a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2 (DwPTS: GP: UpPTS). For the avoidance of doubt, a special subframe structure is compatible where there are no uplink transmissions within the downlink pilot timeslot (DwPTS) or guard period (GP) and no downlink transmissions within the uplink pilot timeslot (UpPTS) or guard period (GP);

    c. Timeslots must have a duration of 1 millisecond;

    d. The Licensee shall ensure that frames start at a common reference time so that all licensees’ frames are aligned and transmissions synchronised;

    e. TD-LTE frame configuration 2 (3:1) is compatible with this frame structure. Other technologies are permitted provided that the requirements of 5(a) to 5(d) are met.

8. Frame Structure B (also known as the “Compatible Frame Structure”) means that:

    a. transmissions from the Licensee’s base stations must have a frame structure as shown in Figure 2. Timeslots (or subframes) 0 and 2 must be allocated to Downlink (D), or Uplink (U) transmissions as indicated;

b. the Licensee must ensure that the special subframe (S) in timeslot 1 has a structure that is compatible with TD-LTE special subframe configuration 6, also known as 9:3:2 (DwPTS: GP: UpPTS). For the avoidance of doubt, a special subframe structure is compatible where there are no uplink transmissions within the downlink pilot timeslot (DwPTS) or guard period (GP) and no downlink transmissions within the uplink pilot timeslot (UpPTS) or guard period (GP);

c. timeslots must have a duration of 1 millisecond;

d. the Licensee shall ensure that frames start at a common reference time so that all licensees' frames are aligned and transmissions synchronised;

e. all current TD-LTE frame configurations are compatible with this frame structure. Other technologies are permitted provided that the requirements of 8(a) to 8(d) are met;

f. timeslots with no transmission indicated may have no transmission or must be determined as a Downlink, Uplink or Special subframe as necessary in order to ensure compliance with paragraph 8(c) and 8(g);

g. the Licensee must cooperate to minimise harmful sub-frame overlaps if different technologies are used. On rare occasions this may require the frame alignment or guard period to be slightly offset;

h. for the avoidance of doubt all-downlink frame structures such as Supplementary Downlink (SDL) are not permitted.

Frame Structure A

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
3:1	D	S	U	D	D	D	S	U	D	D

Frame Structure B

DL/UL ratio	Subframe number									
	0	1	2	3	4	5	6	7	8	9
Any	D	S	U							

9. Irrespective of whether the Restrictive Transmission Mask or the Permissive Transmission Mask is being used, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following additional band edge requirements:

3795 MHz – 3800 MHz 4200 MHz – 4205 MHz	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna
3790 MHz – 3795 MHz 4205 MHz – 4210 MHz	Min(PMax – 43,15) dBm / 5 MHz EIRP per antenna
3760 MHz - 3790 MHz 4210 MHz – 4240 MHz	Min(PMax – 43,13) dBm / 5 MHz EIRP per antenna
Below 3760 MHz Above 4240 MHz	-2 dBm / 5 MHz EIRP per antenna

Interpretation of terms in this schedule

10. In this schedule:

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

b) "Downlink" means transmissions from a base station to a terminal station (handset);

c) "EIRP" means the equivalent isotropically radiated power. This is the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain), measured during the "on" part of the transmission;

d) "Fixed or installed" means used or installed at specific fixed points;

e) "Indoor" means a location inside a building or place in which the shielding will typically provide the necessary attenuation to protect wireless telegraphy against harmful interference;

f) "lower block edge" means, in relation to each Permitted Frequency Block, the lowest frequency in that Permitted Frequency Block;

g) "mobile or nomadic" means intended to be used while in motion or during halts at unspecified points;

h) "PMax" is the maximum mean power for the base station in question, measured as EIRP per carrier and determined irrespective of the number of antennas;

i) "TDD" means the application of time-division multiplexing to separate outward and return signals;

j) "TD-LTE" means the TDD variant of LTE (Long Term Evolution or 4G technology);

k) "TRP" means the total radiated power. This is the integral of the power transmitted in different directions over the entire radiation sphere, measured during the on part of the transmission;

l) "Uplink" means transmissions from a terminal station (handset) to a base station; and

"upper block edge" means, in relation to each Permitted Frequency Block, the highest frequency in that Permitted Frequency Block.

A10. Draft local access licence

Office of Communications (Ofcom)
Wireless Telegraphy Act 2006

SPECTRUM LOCAL ACCESS LICENCE

Licence no: **xxxxxx**

Date of issue: **xx xxxx 201x**

1. The Office of Communications (Ofcom) grants this wireless telegraphy licence ("the Licence") to

Company
(Company registration number xxxxxxxx)
("the Licensee")
Add 1
Add 2
Add 3

to establish, install and use wireless telegraphy stations and/or wireless telegraphy apparatus as described in the schedules to this Licence (together "the Radio Equipment") subject to the terms set out below.

Licence Term

2. This Licence shall continue in force until [DATE] unless earlier revoked by Ofcom or surrendered by the Licensee.

Licence Variation and Revocation

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

(a) at the request, or with the consent, of the Licensee;

(b) if there has been a breach of any of the terms of this Licence;

(c) in accordance with schedule 1 paragraph 8(5) of the Act;

(d) if it appears to Ofcom to be necessary or expedient to revoke the Licence for the purpose of complying with a direction by the Secretary of State given to Ofcom under section 5 of the Act or section 5 of the Communications Act 2003;

(e) for reasons related to the management of the radio spectrum, provided that in such a case the power to revoke may only be exercised after at least 5 years' notice is given in writing.

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

Transfer

5. This Licence may not be transferred.

Changes to Licensee details

6. The Licensee shall give prior notice to Ofcom in writing of any changes to the Licensee's name and/or address as recorded in paragraph 1 of this Licence.

Fees

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

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

Radio Equipment Use

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

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

Access and Inspection

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

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

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

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

Modification, Restriction and Closedown

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

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

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

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

Geographical Boundaries

14. Subject to the requirements of any coordination procedures notified to the Licensee pursuant to the schedules to this Licence, the Licensee is authorised to establish, install and use the Radio Equipment in the authorised service areas set out the schedules to this Licence.

Interpretation

15. In this Licence:

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

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

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

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

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

SCHEDULE 1 TO LICENCE NUMBER: xxxxxx

Schedule Date: xx xxxx 201x

Licence category: Spectrum Local Access

Description of Radio Equipment

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

Interface Requirements for the Radio Equipment

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

   [To be determined by the application]

Special conditions relating to the Radio Equipment

3.

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

   b) The Licensee shall ensure that any Third Party Participants are made aware of the time limited nature of access to the authorised frequencies.

Co-ordination at frequency and geographical boundaries

4.

   a) The Licensee shall ensure that the Radio Equipment is operated in compliance with the co-ordination procedures set out in this schedule and any other co-ordination procedures as may be notified to the Licensee by Ofcom from time to time.

   b) The Radio Equipment will operate on a non-interference basis. For the avoidance of doubt, this means that the licensee must not cause undue interference to other authorised uses of radio spectrum.

International cross-border coordination

5. The Licensee shall ensure that the Radio Equipment is operated in compliance with such cross-border co-ordination and sharing procedures as may be notified to the Licensee by Ofcom from time to time.

Cooperation between Licensees

6. In addition to complying with the specific transmission terms, conditions and limitations set out in this Licence, the Licensee must liaise and co-operate with other holders of licences in the same frequency band(s) (if necessary adjusting transmission power and other technical parameters of transmission) in such a way that harmful interference is not caused by one network deployment to that of another Licensee within the band.

Interpretation of terms in the schedules

7. In the schedules to this Licence:

"IR" means a United Kingdom Radio Interface Requirement notified by Ofcom in accordance with Article 8 of Directive 2014/53/EU of the European Parliament and of the Council on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment (known as the Radio Equipment Directive).

“Third Party Participants” means persons other than the licensee, its employees servants or agents who are provided an electronic communications network or an electronic communications service, using the equipment authorised under the Licence.

SCHEDULE 2 TO LICENCE NUMBER: xxxxxx

Schedule Date: **xx xxxx 201x**

Licence category: **Spectrum Local Access**

[The licence technical provisions will vary dependent on the use that is authorised. The table below is for reference only. Other provisions such as out of block emissions and frame structures may also be included.]

Transmitter(s)	
Authorised Service Area	
Deployment location	
Permitted Frequency Block	[xxx – xxx / xxx – xxx] MHz
Maximum power (eirp)/ / Maximum power within the Permitted Frequency Blocks	
Antenna details (Type, polarisation, gain, height)	

A11. Glossary of terms used in this consultation

3GPP	3rd Generation Partnership Project (3GPP). A body that develops standards for mobile technology.
2G	Second generation mobile phone standards and technology
4G	Fourth generation mobile phone standards and technology
5G	Fifth generation mobile phone standards and technology
5G NR	5G New Radio. A new air interface developed for 5G.
AAS	Active Antenna Systems
AIP	Administered incentive pricing. A fee charged to users of the spectrum to encourage them to make economically efficient use of their spectrum.
ALD	Assistive Listening Device. Used by people with hearing impairments, often in conjunction with hearing aids or similar devices, to better distinguish speech from noise. An ALD often consists of a microphone used by the speaker and a receiver used by the listener.
BEM	Block edge mask. The emissions mask within a band of spectrum, but outside a licensee's specific block.
BS	Base station
CEPT	The European Conference of Postal and Telecommunications Administrations
CFI	Call for Input
Communications Act	The Communications Act 2003
CSA	Concurrent Spectrum Access
dB / dBm	Decibel. A notation for dealing with ratios that vary over several orders of magnitude by using logarithms.
dBm	Decibels relative to an isotropic radiator.
DSA	Dynamic Spectrum Access. This is a technology for a variety of reconfigurable radio equipment allowing it to select the frequency on which it will operate at a given location and over a given period of time to optimise the use of available spectrum and avoid interference with other radios or other systems.

Earth station	A station located either on the earth's surface or within the major portion of the Earth's atmosphere and intended for radio communication with one or more satellites or space stations.
EC	European Commission. Executive branch of the European Union.
ECC	Electronic Communications Committee. One of the three business committees of the European conference of Postal and Telecommunications.
EIRP	Equivalent Isotropically Radiated Power. This is the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain).
ETSI	European Telecommunications Standards Institute
EU	European Union
FDD	Frequency Division Duplex. A technology that deals with traffic asymmetry between uplink and downlink where separate frequency bands are used for send and receive operations.
FL	Fixed link. A terrestrial-based wireless system operating between two or more fixed points.
FWA	Fixed Wireless Access. Radio link to the home or the office from a cell site or base station, replacing the traditional local loop.
Hz	Hertz. Basic unit of frequency; one hertz is equivalent to one cycle per second. (kHz = 1000 Hz, MHz = 1000 kHz, GHz = 1000 MHz)
ICAO	The International Civil Aviation Organisation
IMT	International Mobile Telecommunications. The ITU term that encompasses 3G, 4G and 5G wireless broadband systems
I/N	Interference to noise ratio. An important figure in coexistence calculations between users of radio spectrum.
Interference	Unwanted disturbance caused in a radio receiver or other electrical circuit by electromagnetic radiation emitted from an external source.
IoT	Internet of things
IR	Interface requirement. These provide a link between the requirements of the Radio Equipment Directive (RED) and how spectrum is used nationally for radio equipment.
ITU	International Telecommunications Union. Part of the United Nations with a membership of 193 countries and over 800 private-sector entities and academic institutions.
ITU-R	International Telecommunications Union Radiocommunication Sector

Licence exemption	Exemption regulations made by Ofcom allow anyone to use specified radio equipment without the need to have a WT Act licence.
LTE	Long Term Evolution. Part of the development of 4G mobile systems that started with 2G and 3G networks. Aims to achieve an upgraded version of 3G services having up to 100 Mbps downlink speeds and 50 Mbps uplink speeds.
MNC	Mobile network codes
MNO	Mobile Network Operator
MOD	Ministry of Defence
NISRA	Northern Ireland Statistics and Research Agency
Ofcom	The Office of Communications
ONS	Office for National Statistics
PES	Permanent Earth station
RED	Radio Equipment Directive. The European regulatory framework for placing radio equipment on the single market.
RF	Radio frequency
ROES	Receive-Only Earth Station. A satellite earth station which receives radio signals but does not transmit.
RSA	Recognised Spectrum Access
SRD	Short range devices
TDD	Time Division Duplex. A technology that deals with traffic asymmetry where the uplink is separated from the downlink by the allocation of different time slots in the same frequency band.
TRP	Total Radiated Power
UE	User Equipment
UL/DL	Uplink/Downlink
WiFi	Commonly used to refer to wireless local area network (WLAN) technology, specifically that conforming to the IEEE 802.11 family of standards.
WSD	White Space Devices. Devices which make use of transmission frequencies that are nominally allocated to other services but which are unused in the vicinity of the device.
WT Act	The Wireless Telegraphy Act 2006