OfW 590

Technical Frequency Assignment Criteria for Shared Access Radio Services

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Contents

Section

Annex

Forward

The Wireless Telegraphy Act 2006 requires that only radio equipment that the Office of Communications (Ofcom) has granted a licence to, unless licence exempt, can be installed and used in the United Kingdom. This is under the condition that the radio equipment meets certain minimum requirements set in the appropriate Interface Requirement.

- IR2103 (Shared Access Low Power)
- IR2104 (Shared Access Medium Power)

This document details the technical frequency assignment criteria and the principles that Ofcom will employ in the frequency bands for use by Shared Access systems.

This Technical Frequency Assignment Criteria (TFAC) is subject to revision. A further revision is expected to be published later in 2025, when LPE-3.1 enables further Shared Access improvements, including the new option for all bands to select from a library of antenna envelopes to inform coordination decisions.

Operators and manufacturers can obtain the latest copy of this document from the Ofcom website. If you do not have access to the internet, you can request a printed copy to be posted to you from Spectrum Licensing, contact details are below.

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Introduction

Shared Access products are part of a framework[1] enabling shared use of spectrum. This product provides a simple method for users to access spectrum which could support the rollout of a wide range of local wireless connectivity applications.

Spectrum Bands available for Shared Access are listed below:

Band	Channel Bandwidths Available
1.8 GHz band FDD band: Lower Duplex 1.7817 – 1.785 GHz (terminal transmit) Upper Duplex 1.8767 – 1.880 GHz (base station transmit)	2 x 3.3 MHz
2.3 GHz band TDD band: 2.32 – 2.34 GHz, 2.39 – 2.4 GHz	10 MHz
3.8-4.2 GHz band TDD band: 3.805 – 4.195 MHz	10 MHz, 20 MHz, 30 MHz, 40 MHz, 50 MHz, 60 MHz, 80 MHz and 100 MHz
26 GHz band TDD band: 24.45 – 27.5 GHz	50 MHz, 100 MHz, 200 MHz, 400 MHz and 800 MHz

A common authorisation approach applies for access to any of these bands. Potential applicants will apply to Ofcom for a licence for a specific location. For each licence application, we will assess interference to and from other licensees[2] in the band, based on our coordination parameters and methodology outlined in this document. Assignments will be made on a first come, first served basis with regards to other users in the band.

There are two types of licence 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 (except in the 26 GHz band, where if transmitting in 24.45-25.05 GHz the Licensee is authorised to deploy no more than 3 outdoor transmitters[3]). Licensees can apply for multiple licence areas if the required coverage area is larger than the coverage 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 will authorise medium power base stations on a per base station basis.

[1] https://www.ofcom.org.uk/spectrum/frequencies/shared-access

[2] Self-interference for Shared Access stations isn't taken account of within the technical assignment process. A Licensee is determined by the organisation name and organisation code used by the Ofcom Licensing Systems

[3] A sector antenna equates to one outdoor transmitter (i.e. a sector antenna is counted as one base station)

- Usage will be designated for indoor or outdoor use. “Indoor” means a location inside a premises in which the shielding will provide additional attenuation and therefore protection against harmful interference to wireless telegraphy equipment. For the low power licence, where a user can deploy multiple base stations using a single licence, an indoor-only licence requires all base station and fixed terminal deployments to be indoors, whereas an outdoor licence allows base stations and fixed terminals to be deployed both outdoors and indoors.

Shared Access base stations are not licenced in the Isle of Man and Channel Islands.

2.3 GHz band Low Power licences are currently not available for outdoor use (i.e. only indoor-only licences are available at this time). 2.3 GHz band Medium Power licences are current not available.

For 26 GHz band Low Power licence applications, the frequency range 25.1 – 27.5 GHz will not be available for assignment in High Density Areas.

26 GHz band Medium Power licences are not available for use in High Density Areas.

Ofcom has defined “High Density Areas” for the purposes of the 26 GHz band in the September 2023 Statement: “*Enabling mmWave spectrum for new uses*”.[4] [5]

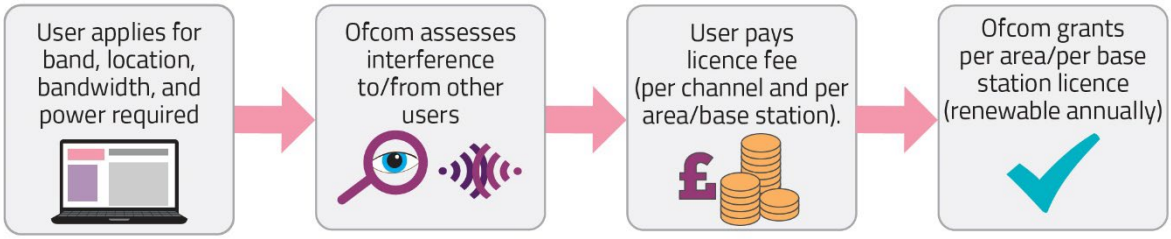
The licence terms and conditions will have a requirement for equipment to start transmitting within six months of the licence being issued and continue to be operational afterwards. If spectrum is not used in this timeframe, Ofcom may revoke the licence with one month’s notice.

[4] Geographical boundaries of the ‘Spectrum Access High Density 26 GHz’ licences and the ‘Spectrum Access High Density 40 GHz’ licences (ofcom.org.uk)

[5] Shapefiles of final geographical boundaries of the ‘Spectrum Access High Density 26 GHz’ licences and the ‘Spectrum Access High Density 40 GHz’ licences (ofcom.org.uk)

Application Process

High level process for new applications:



Frequency Assignment

Each licence application will be assessed against a series of tests, as outlined in Table 1.

Table 1: Outline of frequency assignment tests for each Shared Access band

Test Category	Test	1.8 GHz	2.3 GHz	3.8-4.2 GHz	26 GHz Low Power	26 GHz Medium Power
Distance Checks	Exclusion zone checks	-	✓	-	✓	✓
	Separation distance checks	-	-	✓	✓	-
Exclusion zone checks	Exceptions	✓	-	✓	-	-
Technical Coordination: High density area boundary	High density area boundary coordination in 26 GHz	-	-	-	-	✓ 25.1-27.5 GHz Only
Technical Coordination: Inter-service	Coordination with Fixed Links	-	-	✓	✓ Long Term Protection Only Outdoor 26 GHz Deployments Only	✓ Long Term Protection Only
	Coordination with Permanent Earth Stations	-	-	✓	✓ Long Term Protection Only Outdoor 26 GHz Deployments Only	✓ Long Term Protection Only
	Coordination with UK Broadband	-	-	✓	-	-
Technical Coordination: Intra-service	Coordination with other Shared Access users	✓	✓	✓	✓ If both the interferer and victim are Low Power licences, no technical coordination is carried out	✓

Test Category	Test	1.8 GHz	2.3 GHz	3.8-4.2 GHz	26 GHz Low Power	26 GHz Medium Power
Technical Coordination: National and international requirements	National coordination (MOD)	-	✓	✓	-	-
	International Coordination / MoU check[6]	✓	-	-	✓ Republic of Ireland Only	✓
Base Station Density Check	24.25-25.05 GHz base station density check	-	-	-	✓	✓ 24.25-25.05 GHz Only

[6] Memorandum of understanding

The details of these tests are expanded on in the next Section – "*Assignment Test Details*".

After the above tests have been completed, any remaining frequencies that are available will follow the assignment process given in the paragraph below, excluding any channels outside of tuning range (if provided).

Note: There is only a single channel in the 1.8 GHz band. In the 2.3 GHz band there are three 10 MHz channels available, which where possible the assignment will be top down. In the 3.8-4.2 GHz band where possible the channel assignment will be top down. In the 26 GHz band where possible the channel assignment will be as follows:

a) Start at 25.1 GHz down to 24.45 GHz;
b) Then 25.1 GHz up to 27.5 GHz.

Assignment Test Details

Distance Checks

Exclusion zone checks

Shared Access base stations in the lower part of 2.3 GHz band (2.32 – 2.34 GHz) will be excluded from Salisbury Plain, based on the exclusion zones listed below:

Table 2: Salisbury Plain Training Area exclusion zone definition for 2.3 GHz Shared Access deployments

Location	Coordinate	Radius of exclusion zone
Salisbury Plain Training Area	ST 94000 48500	7.2 km
	SU 05500 48500	7.5 km
	SU 18700 49400	9.5 km

Indoor Low Power Shared Access base stations in the 26 GHz band will initially be excluded from areas within 1 km of Harwell Earth Exploration Satellite Service earth station, Oxfordshire.

Outdoor Shared Access base stations in the 26 GHz band will be excluded from the areas surrounding various Radio Astronomy sites, based on exclusion zones listed below:

Table 3: Radio Astronomy site exclusion zone definitions for Outdoor 26 GHz Shared Access deployments

Location	Coordinate	Radius for 24.25 – 25.05 GHz	Radius for 25.05 – 27.5 GHz
Cambridge	TL 39400 54000	2.5 km	1 km
Jodrell Bank	SJ 79650 70950	2.5 km	1 km
Darnhall	SJ 64275 62265	2.5 km	1 km
Defford	SO 90200 44700	2.5 km	1 km
Knockin	SJ 32855 21880	2.5 km	1 km
Pickmere	SJ 70404 76945	2.5 km	1 km

Separation distance checks

3.8-4.2 GHz band Shared Access licences

If an existing Fixed Link is within 500 m of the of the proposed Shared Access base station location, frequencies with a frequency offset of less than 2.5 times bandwidth[7] from the existing Fixed Link's allocation will be excluded from the available frequencies for assignment.[8]

Fixed Links are additionally protected through technical coordination, as detailed in the Section "*Technical Coordination: Inter-service*".

26 GHz band Low Power Shared Access licences

If the distance from an existing Low Power Shared Access deployment to the proposed Low Power Shared Access base station location is less than that defined in Table 4, frequencies which are co-channel[9] with the existing Shared Access allocation will be excluded from the available frequency assignment.

If the distance from the High Density Area boundary to the proposed Low Power Shared Access base station location is less than that defined in Table 4, the frequencies 25.1-27.5 GHz will be excluded from the available frequency assignment.

If the distance from an existing Fixed Link to the proposed Low Power Shared Access base station location is less than that defined in Table 4, frequencies with a frequency offset of less than 2.5 times bandwidth from the existing Fixed Link's allocation will be excluded from the available frequencies for assignment.

Table 4: 26 GHz Low Power Shared Access deployment separation distance check summary

New user	Existing user			
	26 GHz low power indoor	**26 GHz low power outdoor**	**Fixed links**	**26 GHz High Density Area boundary**
26 GHz low power indoor	100 m	200 m	*N/A*	50 m
26 GHz low power outdoor	200 m	200 m	200 m	100 m

[7] Throughout this document, "2.5 times bandwidth" refers to any case where the frequency offset between victim and interferer centre frequencies, denoted f_V and f_I respectively, meets the condition $|f_V - f_I| = 2.5 \cdot (B_V + B_I)$, where B_V and B_I denote the bandwidths of the victim and interferer carriers respectively

[8] In the case of 3.8-4.2 GHz shared access licensees using narrower carrier bandwidths (e.g. 20 MHz) and depending on the performance of the base station receiver, there exists a theoretical risk of a fixed link transmitter causing blocking at a shared access base station receiver at frequency separations larger than 2.5 times bandwidth. However, as this is extremely unlikely to occur in practice, this will not be assessed in the coordination, and instead resolved through local level interference management measures

[9] Throughout this document, "co-channel" refers to any case where the victim carrier and interferer carrier overlap (partially or fully), i.e. the frequency offset between victim and interferer centre frequencies, denoted f_V and f_I respectively, meets the condition $|f_V - f_I| < 0.5 \cdot (B_V + B_I)$, where B_V and B_I denote the bandwidths of the wanted and unwanted carriers respectively

Note, 26 GHz Medium Power Shared Access base stations are not subject to separation distance checks, as protection of the High Density Area boundary, Fixed Links and other Shared Access deployments is assessed through technical coordination. This is detailed later in this document.

Exceptions Process Checks

Exceptions

1.8 GHz band and 3.8-4.2 GHz band Medium Power licences are available as standard for use outside Greater London. Applications inside Greater London will be considered as exceptions and will only be permitted if the application passes the 'premises sterilisation' test, as outlined in the Shared Access Licence Guidance document.

Ofcom has defined "Greater London" as the geographical boundary for Greater London defined in the September 2023 Statement: "*Enabling mmWave spectrum for new uses*".[4] [5]

Some applications outside Greater London will also be considered as exceptions, as defined below.

1.8 GHz band Medium Power licences are available as standard elsewhere when applications use an antenna height of 10 m Above Ground Level (AGL) or less. Applications for antenna heights greater than 10 m AGL will be considered as exceptions and will only be permitted if the application passes the 'premises sterilisation' test, as outlined in the Shared Access Licence Guidance document.

3.8-4.2 GHz band Medium Power licences with an antenna height of greater than 10 m AGL are available as standard when the application is in a Rural location. Applications for antenna heights greater than 10 m AGL in Urban locations will be considered as exceptions, and will only be permitted if the application passes the 'premises sterilisation' test as outlined in the Shared Access Licence Guidance document. Applications for antenna heights of 10 m AGL or less are available as standard in both Urban and Rural locations (except for applications in Greater London, as explained previously).

Ofcom has defined "Rural" for the purposes of these licences as:

a) any location in England or Wales in an ONS 2011 Census Output Area which falls into categories D1, D2, E1, E2, F1 or F2 (i.e. "town and fringe", "villages" and "hamlets and isolated dwellings");[10]
b) any location in Scotland which falls into categories 3-8 based on the Scottish Government's 8-fold Urban Rural Classification; (i.e. any area outside a settlement of over 3,000 people);[11] and,

[10] Office of National Statistics, *2011 Rural/Urban Classification (RUC2011)*, https://www.ons.gov.uk/methodology/geography/geographicalproducts/ruralurbanclassifications/2011ruralurbanclassification

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

c) any location in Northern Ireland which falls into bands E-H of the Northern Ireland Statistics and Research Agency's Statistical Classification and Delineation of Settlements bands (i.e. any area outside a settlement of over 2,500 people);[12] and,
d) in addition, any location which falls outside of the ONS 2011 Census Output Area, the Scottish Government's 8-fold Urban Rural Classification, and the Northern Ireland Statistics and Research Agency's Statistical Classification and Delineation of Settlements bands, but which is within the limit of the UK's territorial seas, will be considered as rural.[13]

For the purposes of these licences, "Urban" is defined as any location which is not Rural.

Technical Coordination: High density area boundary

High density area boundary coordination in 26 GHz

Proposed 26 GHz Medium Power Shared Access base stations will be checked against the peak field strength limit of 93 dBµV/m / 200 MHz at 3 m height at the High Density Area boundary, using ITU-R P.452-18 at 20% time with terrain and clutter maps of 50-metre resolution. If this field strength limit is breached, then the frequencies 25.1-27.5 GHz will be excluded from the available frequencies for assignment.

Technical Coordination: Inter-service

It should be noted that, when referring to the protection of Shared Access receivers, this Section captures the methodology used for the assessment of inter-service coordination only (i.e. the protection of Shared Access receivers from and Fixed Links and UK Broadband). The methodology used for the assessment of intra-service coordination (i.e. the protection of Shared Access receivers from other Shared Access deployments) differs, with details given in the subsequent section (see Page 18).

Coordination is carried out for every existing Fixed Link, Permanent Earth Station (PES) or UK Broadband (UKB) deployment where the distance to the proposed Shared Access base station location is less than that defined in Table 5. All existing deployments beyond this distance will not be assessed.

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

[13] For more information, see the UK Government website: https://www.gov.uk/guidance/uk-maritime-limits-and-law-of-the-sea. The UK Hydrographic Office also produces a map showing the limits of the UK's territorial seas, for reference: https://data.admiralty.co.uk/portal/apps/sites/#/marine-data-portal

Table 5: Coordination distance limit for inter-service technical coordination

New user	Existing user
	Fixed Link, PES or UKB deployment
3.8-4.2 GHz low or medium power	287 km
26 GHz low power indoor	N/A – no inter-service technical coordination is done for 26 GHz band Low Power indoor licences
26 GHz low or medium power outdoor	200 km

Propagation model ITU-R P.452-18 will be used for the interference-to-noise ratio (I/N) or threshold-to-interference ratio (T/I) calculation. Terrain and clutter maps of 50-metre resolution are used as part of the path loss model.

Inter-service technical coordination is assessed using the interference analysis calculations described in Annex A1, "*Inter-service protection calculations*", with the outcome based on the protection criteria test(s) defined for each service below.

The technical parameters for the Shared Access deployments are based on the parameters given in Section "*Technical Frequency Assignment Data*". The technical parameters for the other users are present in our licensing tool.

Considerations for Low Power Shared Access licences

Low Power Shared Access licences are granted on a per area basis. The technical coordination procedures for Low Power Shared Access applications use the licence coordinates provided by the licensee.

The transmit power (EIRP for 3.8-4.2 GHz or TRP for 26 GHz) used for coordination is the maximum allowed transmit power per base station, with the addition of 2 dB.[14] This is to account for the base station being located anywhere within the circulate licence area with radius 50 m.

Similarly, the I/N protection criteria for Low Power Shared Access deployments is increased by 1 dB compared to the Medium Power protection criteria, to account for 50 m radius licence area.

[14] For clarity, the transmit power used for coordination of Medium Power Shared Access is that provided by the applicant, as shown in Section "Technical Frequency Assignment Data"

Coordination with Fixed Links

Protection of Fixed Links

The protection of Fixed Link station receivers from Shared Access base stations transmitters is ensured through the threshold-to-interference ratio (T/I) calculations.[15] These interference analysis calculations are performed when the frequency offset between the Fixed Link station's centre frequency and the new Shared Access allocation's centre frequency is less than 2.5 times bandwidth. Fixed Link stations with larger frequency offset will not be assessed.

The calculations test whether the interfering signal is less than or equal to $T - W/U$, where T is the Receiver Sensitivity Level (RSL) and W/U is the wanted-to-unwated ratio in dB. The test must be satisfied at all assessed Fixed Link receivers within the defined coordination distance of a Shared Access application for a deployment to proceed.

The parameters used for the T/I calculations are given in the Table below.

Table 6: Fixed Link protection criteria used for inter-service coordination

Test	W/U	T	Percentage time used in the propagation model
Long Term protection	Equipment specific, present in our licensing tool	RSL specified in TFAC OFW446	50%
Short Term protection		RSL specified in TFAC OFW446 + fade margin	(100 – link availability)%

The 26 GHz band is not subject to the Short Term protection test. Additionally, in the 26 GHz band Shared Access interference link budget there will be a 12 dB worst case reduction factor (F_{WCR}). Further information on the F_{WCR} can be found in Enabling mmWave spectrum for new uses: Statement and consultation on auction design (ofcom.org.uk).

Protection of Shared Access

The protection of Shared Access base stations receivers from Fixed Link station transmitters is ensured through the interference-to-noise ratio (I/N) calculations.[16] Interference analysis calculations are performed when the frequency offset between the new Shared Access base stations' centre frequency and the Fixed Link station's centre frequency is less than 2.5 times bandwidth.

The calculations test whether the interfering signal is less than or equal to the noise power of the receiver. The test must be satisfied against all assessed Fixed Link transmitters within the defined coordination distance of a Shared Access application for a deployment to proceed.

The parameters used for the I/N calculations are given in the Table below.

[15] See Annex A1 – "*Inter-service protection calculations*"
[16] See Annex A1 – "*Inter-service protection calculations*"

Table 7: Shared Access protection criteria used for inter-service coordination

Shared Access application	I/N	Noise Figure (NF)	Percentage time used in the propagation model
3.8-4.2 GHz Low Power	−5 dB	13 dB	20%
3.8-4.2 GHz Medium Power	−6 dB	10 dB	20%
26 GHz Low Power	1 dB	13 dB	20%
26 GHz Medium Power	0 dB	10 dB	20%

Coordination with Permanent Earth Stations

Protection of Permanent Earth Stations

The protection of PES receivers from Shared Access base stations transmitters is ensured through the interference-to-noise ratio (I/N) calculations.[17] These interference analysis calculations are performed when the frequency offset between the PES's centre frequency and the new Shared Access allocation's centre frequency is less than 2.5 times bandwidth. PES with larger frequency offset will not be assessed.

The calculations test whether the interfering signal is less than or equal to the noise power of the receiver. The test must be satisfied at all assessed PES receivers within the defined coordination distance of a Shared Access application for a deployment to proceed.

The parameters used for the I/N calculations are given in the Table below.

Table 8: PES protection criteria used for inter-service coordination

Test	NF	I/N	Percentage time used in the propagation model
Long Term protection	Equipment specific, present in our licensing tool	10 dB	20%
Short Term protection		0 dB	0.005%

Receive Only Earth Stations (ROES) granted Recognised Spectrum Access (RSA) are not subject to the Short Term protection test.

[17] See Annex A1 – "*Inter-service protection calculations*"

The 26 GHz band is not subject to the Short Term protection test. Additionally, in the 26 GHz band Shared Access interference link budget there will be a 12 dB worst case reduction factor (F_{WCR}). Further information on the F_{WCR} can be found in Enabling mmWave spectrum for new uses: Statement and consultation on auction design (ofcom.org.uk).

Coordination with UK Broadband

Protection of UK Broadband deployments

The protection of UKB base station receivers from Shared Access base stations transmitters is ensured through the threshold-to-interference ratio (T/I) calculations.[18] These interference analysis calculations are performed when the frequency offset between the UKB centre frequency and the new Shared Access allocation's centre frequency is less than 2.5 times bandwidth. UKB deployments with larger frequency offset will not be assessed.

The calculations test whether the interfering signal is less than or equal to $T - W/U$, where T is the Receiver Sensitivity Level (RSL) and W/U is the wanted-to-unwated ratio in dB. The test must be satisfied at all assessed UKB base station receivers within the defined coordination distance of a Shared Access application for a deployment to proceed.

The parameters used for the T/I calculations are given in the Table below.

Table 9: UKB protection criteria used for inter-service coordination

Test	W/U	T	Percentage time used in the propagation model
Long Term protection	27 dB	75 dBm	50%
Short Term protection	6.5 dB	75 dBm	0.001%

Protection of Shared Access

The protection of Shared Access base stations receivers from UKB base station transmitters is ensured through the interference-to-noise ratio (I/N) calculations.[19] Interference analysis calculations are performed when the frequency offset between the new Shared Access base stations' (victim) centre frequency and the UKB base station's (interferer) centre frequency, denoted f_V and f_I respectively, meets the condition $|f_V - f_I| < 0.5 \cdot (B_V + B_I) + 5$, where B_V and B_I are the bandwidths of the Shared Access and UK Broadband carriers respectively.

The calculations test whether the interfering signal is less than or equal to the noise power of the receiver. The test must be satisfied against all assessed UKB base station transmitters within the defined coordination distance of a Shared Access application for a deployment to proceed.

The parameters used for the I/N calculations are given in the Table 7.

[18] See Annex A1 – "*Inter-service protection calculations*"
[19] See Annex A1 – "*Inter-service protection calculations*"

Technical Coordination: Intra-service

Coordination with other Shared Access users

Coordination is carried out for every existing Shared Access deployment where the distance to the proposed Shared Access base station location is less than that defined in Table 10 (1.8 GHz), Table 11 (2.3 GHz), Table 12 (3.8-4.2 GHz) and Table 13 (26 GHz). All existing deployments beyond this distance will not be assessed.

Table 10: Coordination distance limit for inter-service technical coordination in the 1.8 GHz band

New user	Existing user	
	1.8 GHz low power	1.8 GHz medium power
1.8 GHz low power	20 km	50 km
1.8 GHz medium power	50 km	50 km

Table 11: Coordination distance limit for inter-service technical coordination in the 2.3 GHz band

New user	Existing user
	2.3 GHz low power
2.3 GHz low power	20 km

Table 12: Coordination distance limit for inter-service technical coordination in the 3.8-4.2 GHz band

New user	Existing user	
	3.8-4.2 GHz low power	3.8-4.2 GHz medium power
3.8-4.2 GHz low power	20 km	50 km
3.8-4.2 GHz medium power	50 km	50 km

Table 13: Coordination distance limit for inter-service technical coordination in the 26 GHz band

New user	Existing user	
	26 GHz low power	26 GHz medium power
26 GHz low power	N/A	50 km
26 GHz medium power	50 km	50 km

For the 26 GHz band, if both the interferer and victim are Low Power licences, no technical coordination is carried out because coordination between Low Power licences is managed by minimum separation distances only (see "*Separation distance checks*" Section above).

Propagation model ITU-R P.452-18 for 20% of time will be used for the I/N calculation. Terrain and clutter maps of 50-metre resolution are used as part of the path loss model.

Intra-service technical coordination is assessed using the interference analysis calculation described in Annex A2, "*Intra-service protection calculations*", with the outcome based on the protection criteria test(s) defined in Table 14 below.

The technical parameters for the Shared Access deployments are based on the parameters given in Section "*Technical Frequency Assignment Data*".

1.8 GHz band is FDD with the base station as transmit (Tx) on the Upper Duplex and receive (Rx) on the Lower Duplex. The intra-service interference paths being assessed in this band is both from one licensee's base station to another licensee's terminal (base-to-mobile), and from one licensee's terminal to another licensee's base station (mobile-to-base). To enable this coordination with terminals (mobiles), the licensing tool will model the virtual terminal (mobile) at the base station location, at 2 m above ground, acting as transmitter on the Lower Duplex and receiver on the Upper Duplex for interference calculation.

Users in the 2.3 GHz band, 3.8-4.2 GHz band and 26 GHz band are coordinated based on the assumption that transmissions are synchronised. The intra-service interference path being assessed is base-to-mobile only. To enable this coordination with terminals (mobiles), the licensing tool will model a virtual terminal at the base station location, 3 m above ground, acting as a receiver for interference calculation.

Considerations for Low Power Shared Access licences

Low Power Shared Access licences are granted on a per area basis. The technical coordination procedures for Low Power Shared Access applications use the licence coordinates provided by the licensee.

The EIRP (or TRP for 26 GHz) used for coordination is the maximum allowed EIRP (or TRP for 26 GHz) per base station, with the addition of 2 dB.[20] This is to account for the base station being located anywhere within the circulate licence area with radius 50 m.

Similarly, the I/N protection criteria is increased by 1 dB compared to the Medium Power protection criteria, to account for 50 m radius licence area.

Intra-service coordination

Protection of Shared Access

The protection of Shared Access terminal receivers from Shared Access station base station transmitters is ensured through the interference-to-noise ratio (I/N) calculations.[21] Interference analysis calculations are performed when the new Shared Access application's carrier and the

[20] For clarity, the EIRP (or TRP for 26 GHz) used for coordination of Medium Power Shared Access is that provided by the applicant, as shown in Section "Technical Frequency Assignment Data"

[21] See Annex A2 – "*Intra-service protection calculations*"

existing Shared Access deployment carrier are co-channel. When the carriers are not co-channel, interference will not be assessed.

The calculations test whether the interfering signal is less than or equal to the noise power of the receiver. The test must be satisfied against all existing assessed Shared Access deployments within the defined coordination distance of the new Shared Access application, in both the case of the new Shared Access application acting as an interferer (base station) and the new Shared Access application acting as a victim (terminal), for a deployment to proceed.

The parameters used for the I/N calculations are given in the Table below.

Table 14: Shared Access protection criteria used for intra-service coordination

Protected system	I/N	Noise Figure (NF)	Percentage time used in the propagation model
Low Power Shared Access terminal	1 dB	10 dB	20%
Low Power Shared Access base station (1.8 GHz band lower duplex only)	1 dB	13 dB	20%
Medium Power Shared Access terminal	0 dB	10 dB	20%
Medium Power Shared Access base station (1.8 GHz band lower duplex only)	0 dB	10 dB	20%

Technical Coordination: National and International Requirements

National coordination (MOD)

The lower part of 2.3 GHz band (2.32 – 2.34 GHz) will be coordination with the MOD sites at Aberporth and St Kilda. Any station that would breach the required protection threshold at these sites will be rejected.

The 3.8-4.2 GHz band will be coordinated with the MOD sites at GCHQ Bude and RAF Menwith Hill. A site protection threshold of −69 dBm / 5 MHz at 18 m AGL shall apply. Any station that would breach this threshold at these sites will be rejected.

International coordination / MoU checks

1.8 GHz band

Coordination check will be carried out for medium power licences in the 1.8 GHz band. Ofcom will either pass or fail the assignment if it breaches the limits in tables below:

Countries	Medium power threshold	Propagation model parameters
From the UK (England, Scotland, Northern Ireland) to France	37dBµV/m/3.3 MHz at 3m AGL for all points on the coastline of France	ITU-R P.1546-5 50% of time and 50% of locations
From the UK (England, Scotland, Northern Ireland) to the Republic of Ireland	37dBµV/m/3.3 MHz at 3m AGL for all points at the border or coastline of the Republic of Ireland	ITU-R P.1546-5 50% of time and 50% of locations
From the UK (England, Scotland, Northern Ireland) to the Isle of Man	37dBµV/m/3.3 MHz at 3m AGL for all points at the border or coastline of the neighbouring country	ITU-R P.1546-5 50% of time and 50% of locations

26 GHz band

Coordination check will be carried out for medium power licences in the 26 GHz band. Low power licences in 26 GHz will only be subject to the coordination check to the Republic of Ireland. Ofcom will either pass or fail the assignment if it breaches the limits in tables below:

Countries	Medium power threshold	Low power Threshold	Propagation model parameters
From the UK (England, Scotland, Northern Ireland) to France	93dBµV/m/200 MHz at 3m AGL for all points on the coastline of France		ITU-R P.452-18 20% of time and 20% of locations

Countries	Medium power threshold	Low power Threshold	Propagation model parameters
From the UK (England, Scotland, Northern Ireland) to the Republic of Ireland	93dBµV/m/200 MHz at 3m AGL for all points at the border or coastline of the Republic of Ireland	93dBµV/m/200 MHz at 3m AGL for all points at the border or coastline of the Republic of Ireland	ITU-R P.452-18 20% of time and 20% of locations
From the UK (England, Scotland, Northern Ireland) to the Isle of Man	93dBµV/m/200 MHz at 3m AGL for all points at the border or coastline of the neighbouring country		ITU-R P.452-18 20% of time and 20% of locations

Base Station Density Check

24.25-25.05 GHz base station density check

The lower 800 MHz of the 26 GHz band (24.25 – 25.05 GHz) is subject to an interference power limit of -8.44 dBW / 200 MHz (0.1432 W / 200 MHz) in any 300 km^2 area, to protect adjacent band (23.6 – 24 GHz) use of Earth Exploration Satellite Service (EESS).

The licensing tool will calculate the total interference contribution from all outdoor low power Shared Access base stations and all medium power Shared Access base stations in a 300 km^2 (9.78 km radius) area and compare this with the interference limit using equation below.

$$\sum_{n=1}^{n=N} I_{c_n} + I_{c_{MOD}} \leq 0.1432 \text{ W / 200 MHz}$$

where

N is the total number of base stations in the 300km^2 area

n is the nth base station

I_{c_n} is the interference contribution from the nth base station, as calculated below (in linear units W / 200 MHz)

$I_{c_{MOD}}$ is 0.00317 W / 200 MHz for Ministry of Defence (MOD) use in the band

To identify all outdoor low power Shared Access licences and medium power Shared Access licences deployed in this 800 MHz and in any 300 km^2 area, the licensing tool will use the site location of the new Shared Access deployment as the centre of the 300 km^2 area.

In order to take account of the fact that licensees can deploy more than one base station under the terms of each licence, the licensing tool will multiply all outdoor low power Shared Access licences

and medium power Shared Access licences by three (if transmitting in the lower 800 MHz of the 26 GHz band (24.25 – 25.05 GHz) and within the 300 km^2 area). This determines the total number of base stations within the 300 km^2 area.

The licensing tool will then calculate all the individual contributions per base station using equation below, including the new Shared Access deployment, then adding together all the individual contributions to calculate the overall limit.

$$I_c = 10^{\left(\frac{P_{OOBE_{dB}} - 2 - \left(\frac{\left(f_{centre} - \frac{Ch_{size}}{2}\right) - 24.25}{0.05}\right)}{10}\right)}$$

where

I_c is the contribution of single base station in W / 200 MHz

$P_{OOBE_{dB}}$ = -39 dBW/200 MHz

f_{centre} is the centre frequency of assigned channel in GHz

Ch_{size} is the channel bandwidth in GHz

To calculate the combined civil and MOD use and simplify coordination with MOD use, we have jointly agreed with MOD a maximum density limit of 40 MOD base stations per 300 km^2. We propose to add a margin of 0.00317 W / 200 MHz[22] for potential future MOD use in 24.25 – 24.45 GHz for every out of band emission (OOBE) limit calculation per 300km^2 area. Any additional use above this limit would be captured as and when Ofcom is notified by the MOD.

If the total calculated value is less than or equal to 0.1432 W/200 MHz, the new Shared Access deployment would pass the base station density check.

[22] Derived from 40 base stations operating on frequency 24.35 GHz (200 MHz channel) at the OOBE limit −39 dBW/200 MHz

Technical Frequency Assignment Data

The following table outlines the technical data that is required to process the application.

Information type required for Technical Assignment / Coordination	Required from applicant	1.8 GHz (1781.7 – 1785 MHz/ 1876.7 – 1880 MHz)	2.3 GHz (2.32 – 2.34 GHz, 2.39 – 2.40 GHz)	3.8-4.2 GHz (3.805 – 4.195 GHz)	26 GHz (24.45 – 27.5 GHz)
Licence Product	Yes	Low Power, or Medium Power	Low Power (only)	Low Power, or Medium Power	Low Power, or Medium Power
Station Coordinate	Yes	NGR or Latitude, Longitude	NGR or Latitude, Longitude	NGR or Latitude, Longitude	NGR or Latitude, Longitude
Antenna Location	Yes	Indoor, Outdoor	Indoor (only)	Indoor, Outdoor	Indoor, or Outdoor
Antenna Type	No	Omni	Omni	Omni	Omni
Low Power Transmit Antenna Gain[23]	No	0 dBi used for coordination	0 dBi used for coordination	0 dBi used for coordination	22 dBi used for inter-service coordination 10 dBi used for intra-service coordination

[23] An omnidirectional antenna pattern is assumed in coordination. In the 1.8 GHz, 2.3 GHz and 3.8-4.2 GHz bands, the transmit antenna gain is accounted for in the EIRP. For the 26 GHz band, the gain of the antenna is added to the TRP, as defined in this table

Information type required for Technical Assignment / Coordination	Required from applicant	1.8 GHz (1781.7 – 1785 MHz/ 1876.7 – 1880 MHz)	2.3 GHz (2.32 – 2.34 GHz, 2.39 – 2.40 GHz)	3.8-4.2 GHz (3.805 – 4.195 GHz)	26 GHz (24.45 – 27.5 GHz)
Low Power Receive Antenna Gain[24]	No	0 dBi used for coordination	0 dBi used for coordination	0 dBi used for coordination	22 dBi used for inter-service coordination 10 dBi used for intra-service coordination
Medium Power Transmit Antenna Gain[25]	Yes	0 dBi used for coordination	*N/A*	0 dBi used for coordination	As per application for inter-service coordination 16-29 dBi max range 16 dBi for intra-service coordination
Medium Power Receive Antenna Gain[26]	Yes	0 dBi used for coordination	*N/A*	As per application 0-16 dBi max range	As per application for inter-service coordination 16-29 dBi max range 16 dBi for intra-service coordination

[24] An omnidirectional antenna pattern is assumed in coordination. For the 26 GHz band, the gain of the antenna is taken into consideration on the receive path, as defined in this table

[25] An omnidirectional antenna pattern is assumed in coordination. In the 1.8 GHz, 2.3 GHz and 3.8-4.2 GHz bands, the transmit antenna gain is accounted for in the EIRP. For the 26 GHz band, the gain of the antenna is added to the TRP, as defined in this table

[26] An omnidirectional antenna pattern is assumed is coordination. For the 3.8-4.2 GHz and 26 GHz bands, the receive gain is taken into consideration on the receive path, as defined in this table

Information type required for Technical Assignment / Coordination	Required from applicant	1.8 GHz (1781.7 – 1785 MHz/ 1876.7 – 1880 MHz)	2.3 GHz (2.32 – 2.34 GHz, 2.39 – 2.40 GHz)	3.8-4.2 GHz (3.805 – 4.195 GHz)	26 GHz (24.45 – 27.5 GHz)
Medium Power Application Location: Rural or Urban	Yes	Yes	*N/A*	Yes	*N/A*
Medium Power Application Location: High Density Area or not	Yes	*N/A*	*N/A*	*N/A*	Yes
Low Power Indoor Base Station Antenna Height AGL	No	5 m height used for coordination purpose	5 m height used for coordination purpose	5 m height used for coordination purpose	5 m height used for coordination purpose
Low Power Outdoor Base Station Antenna Height AGL	Yes	As per application 0-10 m max range	*N/A*	As per application 0-10 m max range	As per application 0-10 m max range
Medium Power Indoor Base Station Antenna Height AGL	Yes	As per application	*N/A*	As per application	As per application
Medium Power Outdoor Base Station Antenna Height AGL	Yes	As per application *Note: Applications for antenna heights greater than 10 m AGL will be considered as exceptions*	*N/A*	As per application *Note: Applications for antenna heights greater than 10 m AGL in urban locations will be considered as exceptions*	As per application

Information type required for Technical Assignment / Coordination	Required from applicant	1.8 GHz (1781.7 – 1785 MHz/ 1876.7 – 1880 MHz)	2.3 GHz (2.32 – 2.34 GHz, 2.39 – 2.40 GHz)	3.8-4.2 GHz (3.805 – 4.195 GHz)	26 GHz (24.45 – 27.5 GHz)
Terminal Antenna Height AGL, used for the purpose of intra-service coordination	No	2m	3m *N/A for Outdoor*	3m	3m
Bandwidth	Yes	*N/A* *There is only a single bandwidth available, 2x3.3 MHz FDD channel, in the 1.8 GHz band*	10 MHz channels	10, 20, 30, 40, 50, 60, 80 and 100 MHz channels	50, 100, 200, 400 and 800 MHz channels
Equipment tuning range	No	*N/A*	*N/A*	Start and end frequency in MHz	Start and end frequency in MHz
Low Power EIRP[27]	No	24 dBm / 3 MHz + 2 dB	24 dBm per carrier + 2 dB	27 dBm per carrier + 2 dB for carriers ≤ 20 MHz; 21 dBm / 5 MHz + 2 dB for carriers > 20 MHz	*N/A*
Low Power TRP[28]	No	*N/A*	*N/A*	*N/A*	25 dBm / 200 MHz + 2 dB

[27] As described in the "Inter-service technical coordination" and "Intra-service technical coordination" Sections of this document, the EIRP used for coordination of Low Power Shared Access licences is the maximum allowed EIRP per base station, with the addition of 2 dB

[28] As described in the "Inter-service technical coordination" and "Intra-service technical coordination" Sections of this document, the TRP used for coordination of Low Power Shared Access licences is the maximum allowed TRP per base station, with the addition of 2 dB

Information type required for Technical Assignment / Coordination	Required from applicant	1.8 GHz (1781.7 – 1785 MHz/ 1876.7 – 1880 MHz)	2.3 GHz (2.32 – 2.34 GHz, 2.39 – 2.40 GHz)	3.8-4.2 GHz (3.805 – 4.195 GHz)	26 GHz (24.45 – 27.5 GHz)
Medium Power EIRP	Yes	As per application 42 dBm / 3 MHz max	*N/A*	As per application 42 dBm per carrier max for carriers ≤ 20 MHz; 36 dBm / 5 MHz max for carriers > 20 MHz	*N/A*
Medium Power TRP	No	*N/A*	*N/A*	*N/A*	As per application 36 dBm / 200 MHz max

Channel Plan Design

The 1.8 GHz band has a single 2 x 3.3 MHz channel, which is lower duplex (terminal transmit) 1.7817 – 1.785 GHz and upper duplex (base station transmit) 1.8767 – 1.880 GHz.

The 2.3 GHz band has three 10 MHz channels, centred on 2.325 GHz, 2.335 GHz and 2.395 GHz.

Our channel plan for 3.8-4.2 GHz is below. In the case of the larger bandwidths, we will 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 frequencies used by earth stations, fixed links or UK Broadband base stations within a given area. We do not allocate spectrum in the bottom and top 5 MHz blocks of the band, therefore the actual available band is 3.805 – 4.195 GHz.

f_n is the centre frequency (MHz) of a radio-frequency channel in the band; and individual channel frequencies are expressed by the following relationships:

a) For systems with a carrier spacing of 10 MHz:
   $f_n = 3805 + ((2n-1)/2)*10$ MHz
   where n = 1, …39

b) For systems with a carrier spacing of 20 MHz:
   $f_n = 3805 + ((2n-1)/2)*20$ MHz
   where n = 1, …19

c) For systems with a carrier spacing of 30 MHz:
   $f_n = 3805 + ((2n-1)/2)*30$ MHz
   where n = 1, …13

d) For systems with a carrier spacing of 40 MHz (overlapping channel arrangement with a 10 MHz step):
   $f_n = 3825 + (n-1)*10$ MHz
   where n = 1, …36

e) For systems with a carrier spacing of 50 MHz (overlapping channel arrangement with a 10 MHz step):
   $f_n = 3830 + (n-1)*10$ MHz
   where n = 1, …35

f) For systems with a carrier spacing of 60 MHz (overlapping channel arrangement with a 10 MHz step):
   $f_n = 3835 + (n-1)*10$ MHz
   where n = 1, …34

g) For systems with a carrier spacing of 80 MHz (overlapping channel arrangement with a 10 MHz step):
   $f_n = 3845 + (n-1)*10$ MHz
   where n = 1, …32

h) For systems with a carrier spacing of 100 MHz (overlapping channel arrangement with a 10 MHz step):
   $f_n = 3855 + (n-1)*10$ MHz
   where n = 1, …30

Our channel plan for 26 GHz (24.25 – 27.5 GHz) is provided below. [29]

f_n is the centre frequency (MHz) of a radio-frequency channel in the band; and Individual channel frequencies are expressed by the following relationships:

a) For systems with a carrier spacing of 50 MHz:
   $f_n = 24225 + (n)*50$ MHz
   where n = 1, …65

b) For systems with a carrier spacing of 100 MHz:
   $f_n = 24250 + (n)*100$ MHz
   where n = 1, …32

c) For systems with a carrier spacing of 200 MHz:
   $f_n = 24200 + (n)*200$ MHz
   where n = 1, …16

d) For systems with a carrier spacing of 400 MHz:
   $f_n = 24100 + (n)*400$ MHz
   where n = 1, …8

e) For systems with a carrier spacing of 800 MHz:
   $f_n = 23900 + (n)*800$ MHz
   where n = 1, …4

[29] 24.25 GHz – 24.45 GHz (200 MHz) is closed for Ministry of Defence (MOD) use, this means the first: 5x50 MHz, 2x100 MHz, 1x200 MHz, 1x400 MHz, 1x800 MHz are not available for Shared Access

Band Specific Issues

Band specific issues are listed below:

Band	Description
1.8 GHz band	As there is a single bandwidth available in this band, all base stations are treated 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; Not available in Isle of Man or Channel Islands; It's possible that users of the shared spectrum could experience periodic interference from MoD use of this band in some locations. This could happen near three specific sites: RAF Colerne in Wiltshire, RAF Oakhanger in Hampshire, and RAF Menwith Hill in North Yorkshire. We consider the risk of interference to be very low.
2.3 GHz band	This band is currently only available for low power indoor use; Not available in Isle of Man or Channel Islands; and Users of this band should be aware that the band is shared by amateur radio users. These uses are mainly temporary, and we expect the risk of interference to be very small. However, it is possible that Shared Access licence users in this band could experience interference from amateur radio users, as Ofcom does not coordinate these. If you do receive interference to your licensed equipment, you can report this to Ofcom – although it should be noted that Ofcom cannot guarantee spectrum will always be free of interference.
3.8 – 4.2 GHz band	Not available in Isle of Man or Channel Islands
26 GHz band	Not available in Isle of Man or Channel Islands; The lower 800 MHz of the 26 GHz band (24.25-25.05 GHz) are subject to base station density limit of -8.44 dBW / 200 MHz in any 300 km^2 area, to protect adjacent band (23.6 – 24 GHz) use of Earth Exploration Satellite Service (EESS). In addition, 6 radio astronomy sites known as the eMerlin array will be protected via exclusion zones, which impacts the whole band. Further details can be found in the Statement: Protecting passive services at 23.6-24 GHz from future 26 GHz uses (ofcom.org.uk)

Supplementary Notes

Maximum power of Radio Equipment outside the Permitted Frequency Channel

1.8 GHz band

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 / kHz

ΔFL 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)
ΔFH 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)

2.3 GHz band

When transmitting, the Licensee must transmit within the limits set out below.

Frequency offset from the Permitted Channel edge	Power
-5 to 0 MHz offset from lower Permitted Channel edge **0 to 5 MHz offset from upper Permitted Channel edge**	(PMax – 40) dBm / 5 MHz EIRP per antenna
-10 to -5 MHz offset from lower Permitted Channel edge **5 to 10 MHz offset from upper Permitted Channel edge**	(PMax – 43) dBm / 5 MHz EIRP per antenna
< -10 MHz offset from lower Permitted Channel edge **> 10 MHz offset from upper Permitted Channel edge**	(PMax – 43) dBm / 5 MHz EIRP per antenna

In addition, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Channel shall not exceed the following additional requirements:

Frequency	Power
2400-2403 MHz	(PMax – 40) dBm / 5 MHz EIRP per antenna

Frequency	Power
Above 2403 MHz*	−17 dBm / 5 MHz EIRP**

*The limit defined above 2403 MHz given here takes precedence over the limits defined previously
**The maximum mean power relates to the EIRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

For licensees with a Permitted Channel within the range 2390-2400 MHz, the licensee's base stations must transmit within the limits of transmission Frame Structure A, except for indoor base stations. If indoor base stations cause undue interference to the licensee in the 2350-2390 MHz band, we reserve the right to require the indoor base stations to transmit within the limits of transmission Frame Structure A.

Frame Structure A means:

- 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 licensee(s) that hold a Spectrum Access licence in 2350-2390MHz 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.

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

For licensees with a Permitted Channel within the range 2320-2340 MHz, no such synchronisation requirements apply. If base stations cause undue interference to the authorised user in the 2340-2345 MHz band, we reserve the right to require the base stations to transmit using a frame structure which mitigates this interference.

3.8–4.2 GHz band

When transmitting, the Licensee must transmit within the limits set out below.

Frequency offset from the Permitted Channel edge	Power
-5 to 0 MHz offset from lower channel edge **0 to 5 MHz offset from upper channel edge**	(PMax – 40) dBm / 5 MHz EIRP per antenna
-10 to -5 MHz offset from lower channel edge **5 to 10 MHz offset from upper channel edge**	(PMax – 43) dBm / 5 MHz EIRP per antenna

Frequency offset from the Permitted Channel edge	Power
Out of channel baseline power limit (BS) **< -10 MHz offset from lower channel edge** **> 10 MHz offset from upper channel edge**	(PMax – 43) dBm / 5 MHz EIRP per antenna

In addition, the EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Channel shall not exceed the following additional band edge requirements:

Frequency	Power
3795 MHz – 3800 MHz **4200 MHz – 4205 MHz**	(PMax – 40) dBm / 5 MHz EIRP per antenna
3760 MHz - 3795 MHz **4205 MHz – 4240 MHz**	(PMax – 43) dBm / 5 MHz EIRP per antenna
Below 3760 MHz **Above 4240 MHz**	-2 dBm / 5 MHz EIRP per antenna

26 GHz band

When transmitting, the Licensee must transmit within the limits set out below.

Frequency offset from the lower and upper frequency of the channel edge	Maximum base station power (TRP)
Up to 50 MHz	12 dBm / 50 MHz
Beyond 50 MHz	4 dBm / 50 MHz
Within the frequency band 23.6 – 24 GHz	-39 dBW / 200 MHz
	Maximum terminal station power (TRP)
Within the frequency band 23.6 – 24 GHz	-35 dBW / 200 MHz

A1 Inter-service protection calculations

Calculations

Threshold-to-interference ratio (T/I) calculation

Threshold-to-interference calculation is described below in equation below:

$$\frac{T}{I} = \left(T - \frac{W}{U}\right) - P_t + G_r + L_{fixed} - L_{prop} - F_{WCR} - NFD - A_d - BEL$$

where:

$\frac{T}{I}$ is the threshold-to-interference ratio at the victim receiver in dB

T is the receiver sensitivity level (RSL) in

$\frac{W}{U}$ is the wanted to unwanted ratio in dB

P_t is the transmit power (EIRP) of the interfering system in dBm

G_r is the gain of the victim receiver towards the interfering system in dBi

L_{fixed} is the combined feeder and other losses of the receiver in dB

L_{prop} is the propagation loss between the interfering system and the victim receiver in dB (P.452)

F_{WCR} is the worst case reduction factor which removes 12 dB for the interference budget (26 GHz only where the interfering signal is Shared Access transmitter to Fixed Link receiver)

NFD is the net filter discrimination in dB[30]

A_d is the antenna discrimination for the interfering system towards the victim receiver in dB

BEL is the additional attenuation for outgoing and incoming signals (indoor use only) in dB

The details of these parameters are given below in Section "*Parameters used in T/I and I/N calculations*".

The interfering signal must be less than or equal to $T - W/U$.

Wanted-to-Unwanted ratios (W/U) are evaluated at each receiver in the co-ordination zone.

The W/U test must be satisfied at all assessed receivers in the co-ordination zone for a deployment to proceed. In practical terms this means that the unwanted signal level must be less than the interference threshold at the victim receiver. Interference calculations take account of antenna discrimination at both ends of the interference path, losses on the path and any Net Filter Discrimination available.

[30] See Annex A3 – "Net Frequency Discrimination"

Interference-to-noise ratio (I/N) calculation

Interference-to-noise calculation is described below in equation below.

$$\frac{I}{N} = \left(P_t + \mathrm{G_r} + L_f - L_{prop} - NFD - A_d - BEL\right) - N$$

where:

$\frac{I}{N}$ is the interference-to-noise ratio at the victim receiver in dB

P_t is the transmit power (EIRP) of the interfering system in dBm

G_r is the gain of the victim receiver towards the interfering system in dBi

L_f is the combined feeder and other losses of the receiver in dB

L_{prop} is the propagation loss between the interfering system and the victim receiver in dB (P.452)

NFD is the net filter discrimination in dB[31]

A_d is the antenna discrimination for the interfering system towards the victim receiver in dB

BEL is the additional attenuation for outgoing and incoming signals (indoor use only) in dB

N is the Noise power

The details of these parameters are given below in Section "*Parameters used in T/I and I/N calculations*" below.

Interference-to-Noise ratios (I/N) are evaluated at each receiver in the co-ordination zone.

The I/N test must be satisfied at all assessed receivers in the co-ordination zone for a deployment to proceed. In practical terms this means that the unwanted signal level must be less than the interference threshold at the victim receiver. Interference calculations take account of antenna discrimination at both ends of the interference path, losses on the path and any Net Filter Discrimination available.

Parameters for inter-service coordination

Parameters used in T/I and I/N calculations

Fixed Link W/U requirements are defined in Table 6, referencing OfW 446: Technical Frequency Assignment Criteria for Fixed Point-to-Point Radio Services with Digital Modulation (ofcom.org.uk). Fixed Link equipment specific W/U requirements data can be found in the published Equipment Reference Codes list (XLSX, 406.1 kb, ofcom.org.uk).

UK Broadband W/U requirements are defined in Table 9.

[31] See Annex A3 – "Net Frequency Discrimination"

The noise power (N) value in the I/N requirement is thermal noise (kTB)[32] in decibels plus the equipment noise figure (NF):

$$N\ (dBm) = 10 \times \log_{10}(kTB) + NF + 30$$

PES NF and I/N requirements are defined in Table 8.

Shared Access NF and I/N requirements, for the purpose of inter-service coordination, are defined in Table 7.

For 26 GHz band Shared Access base stations, the EIRP $P_{t(EIRP)}$ is calculated with the following equation:

$$P_{t(EIRP)} = P_{t(TRP)} + G_t$$

where

$P_{t(EIRP)}$ is the transmit power (EIRP) in a specific direction in dBm

$P_{t(TRP)}$ is the transmit power (TRP) over the whole radiation sphere of the radio equipment in dBm

G_t is the gain of the antenna in a specific direction in dBi

The antenna gain (G_t) taken into consideration on the transmit path will be as follows:

	Low power (indoor)	Low power (outdoor)	Medium power
Peak antenna gain towards the horizon in all directions	22 dBi	22 dBi	16-29 dBi

G_r (gain of the victim receiver towards the interfering system in dB) is calculated by determining the angle of arrival of the interfering signal to the victim receiver, and applying the victim antenna radiation pattern to the peak gain.

Fixed Link antenna patterns are available on the Ofcom website: Fixed terrestrial links (ofcom.org.uk).

PES antenna patterns are based on the technical parameters present in our licensing tool, modelled using ITU-R Recommendation S.580 or ITU-R Recommendation S.465. [33] [34]

For protection of 3.8-4.2 GHz band low power Shared Access base stations, a 0 dBi omnidirectional antenna pattern is assumed.

For protection of 3.8-4.2 GHz band medium power Shared Access base stations, an omnidirectional antenna pattern is assumed, using the antenna gain as defined by the applicant (0-16 dBi max range).

[32] kTB is the total thermal noise power (kTB) in Watts, it is a function of three quantities, (i) Boltzmann's constant "k" in Joules/˚K, (ii) temperature "T" is 290˚Kelvin, and (iii) the overall bandwidth "B" (Hz) of the channel

[33] S.580: Radiation diagrams for use as design objectives for antennas of earth stations operating with geostationary satellites (itu.int)

[34] S.465: Reference radiation pattern of earth station antennas in the fixed-satellite service for use in coordination and interference assessment in the frequency range from 2 to 31 GHz (itu.int)

For protection of 26 GHz band Shared Access base stations, the antenna gain will be taken into consideration on the receive path as follows:

	Low power (indoor)	Low power (outdoor)	Medium power
Peak antenna gain towards the horizon in all directions	22 dBi	22 dBi	16-29 dBi

The Shared Access masks used in the calculation of NFD (net filter discrimination) are given Table 15, Table 16 and Table 17, with the calculation of NFD explained in Annex A3

A_d (antenna discrimination of the interfering system towards the victim receiver in dB) is calculated by determining the angle of transmission of the interfering signal towards the victim receiver.

For 3.8-4.2 GHz band Shared Access base stations, a 0 dBi omnidirectional antenna pattern is assumed.

For 26 GHz band Shared Access base stations, the antenna discrimination is accounted for in the calculation of P_t as described above.

For indoor Shared Access deployments, an attenuation (BEL) of 14 dB is added to the calculation for the outgoing signal (when the indoor Shared Access deployment is the interferer) and the ingoing signal (when the indoor Shared Access deployment is the victim).

Shared Access transmit and receive masks for inter-service technical coordination

3.8-4.2 GHz band

Table 15: 3.8-4.2 GHz Shared Access base station transmit (Tx) mask for all channel bandwidth sizes for inter-service coordination

Offset from centre operational frequency (MHz)	Channel bandwidth (MHz)							
	10	20	30	40	50	60	80	100
	Tx mask, relative emission level (dBc)							
–2.5xBW (Note 1)	-50	-47	-45.2	-44	-43	-42.2	-41	-40
–BW/2–5	-50	-47	-45.2	-44	-43	-42.2	-41	-40
–BW/2–5	-42	-39	-37.2	-36	-35	-34.2	-33	-32
–BW/2	-42	-39	-37.2	-36	-35	-34.2	-33	-32
–BW/2	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
BW/2	0	0	0	0	0	0	0	0
BW/2	-42	-39	-37.2	-36	-35	-34.2	-33	-32

Offset from centre operational frequency (MHz)	Channel bandwidth (MHz)							
	10	20	30	40	50	60	80	100
	Tx mask, relative emission level (dBc)							
BW/2+5	-42	-39	-37.2	-36	-35	-34.2	-33	-32
BW/2+5	-50	-47	-45.2	-44	-43	-42.2	-41	-40
2.5xBW (Note 1)	-50	-47	-45.2	-44	-43	-42.2	-41	-40

Note 1: The licencing software assumes perfect relative selectivity beyond the defined frequency offset, i.e. −∞ a for frequency offset of more than 2.5xBW in this case

BW = Channel bandwidth (MHz)
Relative emission level gives the emissions at the specified frequency offset relative to the wanted channel power

Table 16: 3.8-4.2 GHz Shared Access base station receive (Rx) mask for all channel bandwidth sizes[35] for inter-service coordination

Offset from centre operational frequency (MHz)	Channel bandwidth (MHz)							
	10	20	30	40	50	60	80	100
	Rx mask, selectivity (dBc)							
−2.5xBW (Note 1)	-51.2	-48.2	-46.5	-45.2	-44.2	-43.5	-42.2	-41.2
−BW/2−5	-51.2	-48.2	-46.5	-45.2	-44.2	-43.5	-42.2	-41.2
−BW/2−5	-42.2	-39.2	-37.5	-36.2	-35.2	-34.5	-33.2	-32.2
−BW/2	-42.2	-39.2	-37.5	-36.2	-35.2	-34.5	-33.2	-32.2
−BW/2	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
BW/2	0	0	0	0	0	0	0	0
BW/2	-42.2	-39.2	-37.5	-36.2	-35.2	-34.5	-33.2	-32.2
BW/2+5	-42.2	-39.2	-37.5	-36.2	-35.2	-34.5	-33.2	-32.2
BW/2+5	-51.2	-48.2	-46.5	-45.2	-44.2	-43.5	-42.2	-41.2

[35] 3GPP TS 38.104 specifies the Adjacent Channel Selectivity (ACS) test requirement and in-band blocking test requirement for local area (low power) and medium range (medium power) base stations. Using these requirements, with noise figure assumptions of 13 dB and 10 dB for low power and medium power base stations respectively, the relative selectivity levels for the 1st adjacent and further adjacent channels can be calculated. Note: For wanted carrier bandwidths wider than 20 MHz, 3GPP TS 38.104 defines the 2nd adjacent channel (where the in-band blocking test requirement begins to apply) as starting 20 MHz from the wanted carrier band edge, whereas for carrier bandwidths of 20 MHz or less the 2nd adjacent channel is defined as starting 5 MHz from the wanted carrier band edge. However, we have decided to apply the in-band blocking requirement as starting 5 MHz from the wanted carrier band edge for all carrier bandwidths, reflecting the behaviour of the operating band unwanted emissions limits used to define the BS Tx mask

Offset from centre operational frequency (MHz)	Channel bandwidth (MHz)							
	10	20	30	40	50	60	80	100
	Rx mask, selectivity (dBc)							
2.5xBW (Note 1)	-51.2	-48.2	-46.5	-45.2	-44.2	-43.5	-42.2	-41.2

Note 1: The licencing software assumes perfect relative selectivity beyond the defined frequency offset, i.e. −∞ a for frequency offset of more than 2.5xBW in this case

BW = Channel bandwidth (MHz)

26 GHz Band

Table 17: 26 GHz Shared Access Low Power outdoor and Medium Power base station transmit (Tx) and receive (Rx) mask for all channel bandwidth sizes[36] for inter-service coordination

Offset from centre operational frequency (MHz)	Channel bandwidth (MHz)				
	50	100	200	400	800
	Tx mask, relative emission level / Rx mask, relative selectivity (dBc)				
−2.5xBW (Note 1)	-29.5	-31	-34	-40	-52
−BW/2	-28	-28	-28	-28	-28
−BW/2	0	0	0	0	0
0	0	0	0	0	0
BW/2	0	0	0	0	0
BW/2	-28	-28	-28	-28	-28
2.5xBW (Note 1)	-29.5	-31	-34	-40	-52

Note 1: The licencing software assumes perfect relative selectivity beyond the defined frequency offset, i.e. −∞ a for frequency offset of more than 2.5xBW in this case

BW = Channel bandwidth (MHz)
Relative emission level gives the emissions at the specified frequency offset relative to the wanted channel power

[36] The Tx/Rx mask values given at an offset from centre operational frequency of ±2.5xBW are calculated using an assumption that out-of-block emissions decay by 3 dB / 200 MHz from the block edge (where the block edge starts at an offset from centre operational frequency of ±0.5xBW)

A2 Intra-service protection calculations

Calculations

Interference-to-noise ratio (I/N) calculation

Interference-to-noise calculation is described below in equation below.

$$\frac{I}{N} = \left(P_t + G_r + L_f - L_{prop} - NFD - A_d - BEL\right) - N$$

where

$\frac{I}{N}$ is the interference-to-noise ratio at the victim receiver in dB

P_t is the transmit power (EIRP) of the interfering system in dBm

G_r is the gain of the victim receiver towards the interfering system in dBi

L_f is the combined feeder and other losses of the receiver in dB

L_{prop} is the propagation loss between the interfering system and the victim receiver in dB (P.452)

NFD is the net filter discrimination in dB[37]

A_d is the antenna discrimination for the interfering system towards the victim receiver in dB

BEL is the additional attenuation for outgoing and incoming signals (indoor use only) in dB

N is the Noise power

The details of these parameters are given below in Section "*Parameters used in I/N calculations*" below.

Interference-to-Noise ratios (I/N) are evaluated at each receiver in the co-ordination zone.

The I/N test must be satisfied at all assessed receivers in the co-ordination zone for a deployment to proceed. In practical terms this means that the unwanted signal level must be less than the interference threshold at the victim receiver. Interference calculations take account of antenna discrimination at both ends of the interference path, losses on the path and any Net Filter Discrimination available.

[37] See Annex A3 – "Net Frequency Discrimination"

Parameters for intra-service coordination

Parameters used in I/N calculations

The noise power (N) value in the I/N requirement is thermal noise (kTB)[38] in decibels plus the equipment noise figure (NF):

$$N\ (dBm) = 10 \times \log_{10}(kTB) + NF + 30$$

Shared Access NF and I/N requirements, for the purpose of intra-service coordination, are defined in Table 14.

For 26 GHz band Shared Access base stations, the EIRP $P_{t(EIRP)}$ is calculated with the following equation:

$$P_{t(EIRP)} = P_{t(TRP)} + G_t$$

where

$P_{t(EIRP)}$ is the transmit power (EIRP) in a specific direction in dBm

$P_{t(TRP)}$ is the transmit power (TRP) over the whole radiation sphere of the radio equipment in dBm

G_t is the gain of the antenna in a specific direction in dBi

The antenna gain (G_t) taken into consideration on the transmit path will be as follows:

	Low power (indoor)	Low power (outdoor)	Medium power
Average antenna gain towards the horizon in all directions	10 dBi	10 dBi	16 dBi

G_r (gain of the victim receiver towards the interfering system in dB) is calculated by determining the angle of arrival of the interfering signal to the victim receiver, and applying the victim antenna radiation pattern to the peak gain.

In all bands, for the protection of a Shared Access terminals, a 0 dBi omnidirectional antenna pattern is assumed.

For protection of 1.8 GHz band lower duplex base stations, a 0 dBi omnidirectional antenna pattern is assumed.

The Shared Access masks used in the calculation of NFD (net filter discrimination) are given Table 18, with the calculation of NFD explained in Annex A3.

A_d (antenna discrimination of the interfering system towards the victim receiver in dB) is calculated by determining the angle of transmission of the interfering signal towards the victim receiver.

[38] kTB is the total thermal noise power (kTB) in Watts, it is a function of three quantities, (i) Boltzmann's constant "k" in Joules/˚K, (ii) temperature "T" is 290˚Kelvin, and (iii) the overall bandwidth "B" (Hz) of the channel

For 1.8 GHz band low and medium power Shared Access base stations, 2.3 GHz band low power Shared Access base stations and 3.8-4.2 GHz band low and medium power Shared Access base stations, a 0 dBi omnidirectional antenna pattern is assumed.

For 26 GHz band Shared Access base stations, the antenna discrimination is accounted for in the calculation of P_t, as described above.

For indoor Shared Access deployments, an attenuation (BEL) is added to the calculation for the outgoing signal (when the indoor Shared Access deployment is the interferer) and the ingoing signal (when the indoor Shared Access deployment is the victim) as per table below:

	1.8 GHz & 2.3 GHz	3.8-4.2 GHz & 26 GHz
Indoor attenuation	12 dB	14 dB

The noise power (N) value in the interference-to-noise ratio (I/N) is thermal noise (kTB)[39] in decibels plus the equipment noise figure (NF):

$$N\ (dBm) = 10 \times \log_{10}(kTB) + NF + 30$$

Shared Access transmit and receive masks for intra-service technical coordination

1.8 GHz band

A transmit and receive mask will not be used as there is only a single channel.

2.3 GHz band, 3.8-4.2 GHz band and 26 GHz band

Table 18: Shared Access base station transmit (Tx) and receive (Rx) mask for all channel bandwidth sizes used for intra-service technical coordination[40]

Offset from centre operational frequency (MHz)	Tx mask, relative emission level / Rx mask, relative selectivity (dBc)
-BW/2 (Note 1)	0
0	0
BW/2 (Note 1)	0

Note 1: The licencing software assumes perfect relative selectivity beyond the defined frequency offset, i.e. $-\infty$ a for frequency offset of more than BW/2 in this case

BW = Channel bandwidth (MHz)

[39] kTB is the total thermal noise power (kTB) in Watts, it is a function of three quantities, (i) Boltzmann's constant "k" in Joules/˚K, (ii) temperature "T" is 290˚Kelvin, and (iii) the overall bandwidth "B" (Hz) of the channel

[40] Our policy is that the NFD calculation should be based on the full (i.e. 2.5xBW) Tx and Rx masks. However, since we only coordinate in the co-channel case (i.e. when an interferer's assigned channel has some overlap with the victim's channel), in practice the NFD calculation gives the same result when using a perfect Tx and Rx masks (given here) compared to using the full Tx and Rx masks. Therefore, for simplicity, we have made the decision to implement perfect Tx and Rx masks in our licencing software

A3 Net Frequency Discrimination

Calculation of Net Frequency Discrimination

The Net Filter Discrimination, or NFD, available between victim and interfering stations is used to adjust the predicted interfering signal level incident to the victim receiver, accounting for the frequency offset between the unwanted and wanted system, the Tx mask of the unwanted system and the Rx mask of the wanted system.

For Fixed Links ETSI Out-of-Band masks are used to characterise the unwanted signal and the wanted receiver mask is derived using the 'conservative' method set out in ETSI TR 101 854. Default masks are employed in cases where legacy equipment cannot be mapped to the modern ETSI Standard.

For PES, the wanted receiver mask is as agreed by the FSS earth station operator, the satellite operators' requirements and Ofcom, with the mask for each licence given in our licencing tool.

For UK Broadband, the Out of Block emission requirements defined in UK Broadband's 3.9 GHz Spectrum Access Licence are used to characterise the unwanted signal, and the wanted receiver mask is also derived from these Out of Block emission requirements.

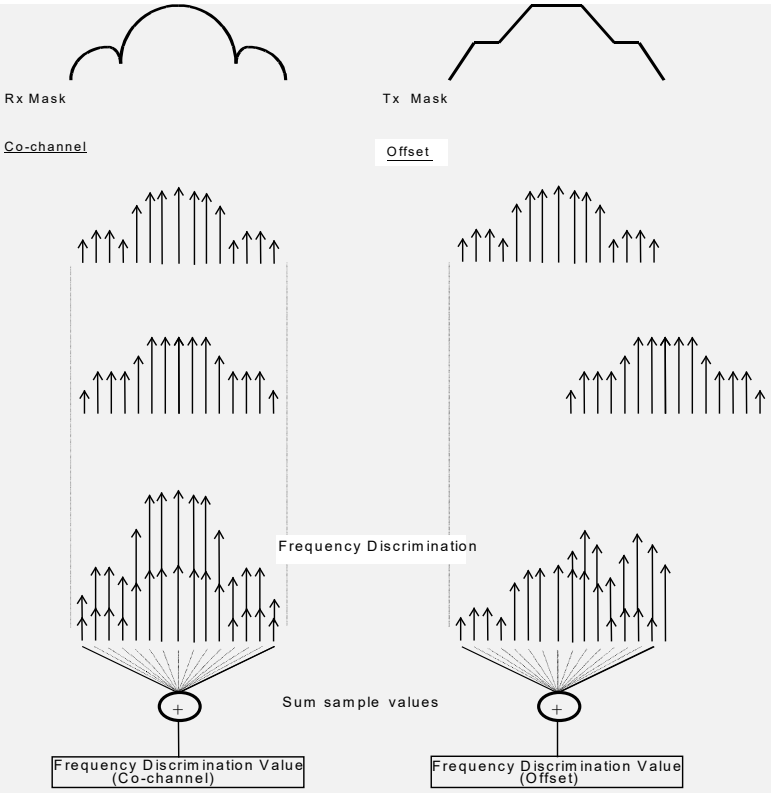
For Shared Access, the unwanted signal and receiver masks are defined in the "Technical Coordination: Inter-service"and "Technical Coordination: Intra-service

Intra-service technical coordination" Sections of this document.

The two masks are sampled 'on the fly' and the NFD calculated using equation below:

$$NFD = 10\log\left[\frac{\sum_{i=0}^{i=n-1} 10^{\left(\frac{U_i+W_i}{10}\right)}}{\sum_{i=0}^{i=n-1} 10^{\left(\frac{U_{i(offset)}+W_i}{10}\right)}}\right] (\mathrm{dB})$$

Where U_i and W_i are values sampled from the unwanted and wanted signal masks set co-frequency, U_i are samples from the unwanted mask offset in frequency from the victim receiver and n is the number of samples taken from the wanted and unwanted masks. The process is illustrated in NFD concept below:



The maximum value for NFD, termed NFD_{max} given by equation below:

$$NFD_{max} = \frac{W}{U} + 40(\text{dB})$$

This facilitates a lower bound for $\frac{W}{U} = 40$ dB.

A4 Document history

Version	Date	Changes
1.0	9 December 2019	Published
1.1	16 April 2020	Edited section 3 and 4 for EIRP clarification
1.2	16 September 2022	Amending the out-of-band emissions as per our statement to implement the harmonised limits and removing the 1 km exclusion zones around Jodrell Bank and Cambridge radio astronomy sites.
2.0	2 December 2024	Document refresh for clarity and completion. Technical updates accounting for those decisions made in the July 2024 Statement "*Statement and further consultation on enhancing the Shared Access Licence Framework*" which are being implemented immediately as described in December 2024 Statement "*Statement on further measures to support licensees and enable new use cases*"
2.1	14 January 2025	Additional document refresh for further clarity. Technical updates accounting for the remainder of the decisions made in the July 2024 Statement "*Statement and further consultation on enhancing the Shared Access Licence Framework*" (regarding the 1.8 GHz, 2.3 GHz and 3.8-4.2 GHz bands)[41] and the decisions made in September 2023 Statement "*Making the 26 GHz and 40 GHz bands available for mobile technology*" (regarding the 26 GHz band)

[41] With the exception of being able to select 20 MHz channels in 2.3 GHz, and the option for all bands to select from a library of antenna envelopes to inform coordination decisions, as explained on Ofcom's Licencing updates