The award of 2.3 and 3.4 GHz spectrum bands

Information Memorandum

Publication date: 11 July 2017

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Contents

Section 1

Introduction

1.1 This Memorandum provides information for those parties considering bidding in this Award Process for one or more Wireless Telegraphy Act 2006 (WT Act) licences to establish or use stations for wireless telegraphy or to install or use apparatus for wireless telegraphy in one or both of the 2.3 and 3.4 GHz bands. This version of the document replaces a previous edition published on 26 October 2015.

1.2 The frequencies being auctioned in the 2.3 GHz band (2350 to 2390 MHz) will be available for use throughout Great Britain (i.e. in England, Scotland and Wales, but not in Northern Ireland). The licences will not extend to the Channel Islands or the Isle of Man, and there will be some exclusion and coordination zones to protect ongoing Ministry of Defence (MOD) use.

1.3 The 3.4 GHz frequencies (3410 to 3480 MHz and 3500 to 3580 MHz) will be available for use throughout the whole of the UK. The licences will not extend to the Channel Islands and the Isle of Man, and there will be some exclusion and coordination zones.

1.4 In particular, this Memorandum:

- Describes the characteristics of the bands for which licences are to be awarded;
- Explains some factors that may affect licensees' use of the bands;
- Summarises some of the principal terms of the licences that will be issued following completion of the Award Process, and provides at annexes 1 to 5 draft templates of the licences that will be issued for the 2.3 and 3.4 GHz bands;
- Sets out the spectrum lots that will be available in the Award Process and the reserve price for each lot;
- Provides certain information in relation to the Award Process; and
- Provides information on a range of other associated issues.

1.5 Certain terms used in this Memorandum are explained in the glossary at annex 10.

1.6 This Memorandum may be further updated following its publication, and parties considering bidding in this Award Process should check the latest available information on the award website.

Section 2

The spectrum bands to be awarded

2.3 GHz

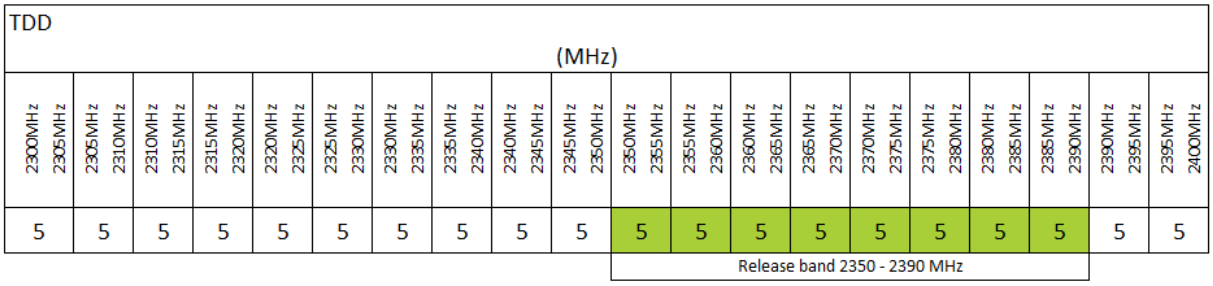
2.1 The availability of spectrum for award in the 2.3 GHz band (2350 to 2390 MHz) arises from a decision by MOD to relinquish its use of the band.

2.2 There is an ECC Decision[1] that sets out harmonised technical and regulatory conditions for the band. The ECC Decision is based on the CEPT's final report to the Radio Spectrum Committee of the EU which was submitted in March 2015. This provides detailed information on the least restrictive technical parameters, sharing conditions and views on how spectrum sharing, including a licensed shared access (LSA) approach could be implemented in the band at national level if it is required. A Radio Spectrum Committee draft harmonisation decision for this band is unlikely in the near future.

2.3 We will proceed with the award with licence conditions aligned with the ECC Decision. In the unlikely event of a subsequent Commission Decision from the Radio Spectrum Committee mandating different conditions, we would consider our obligations arising from that Decision, including whether it was necessary to change the licences to comply with any European law resulting from the Decision.

2.4 The parameters set out in the annexes to the ECC Decision include the frequency arrangement in the band. The harmonised frequency arrangement is for 1 x 100 MHz, based on a block size of 5 MHz on a Time Division Duplex (TDD) basis. This is illustrated by Figure 2.1 below, alongside an indication of the position of the 2.3 GHz release band to be awarded.

Figure 2.1: Frequency arrangement in the 2.3 GHz band



2.5 We discuss in section 6 how we will package the 2.3 GHz spectrum for the Award Process.

[1] http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCDEC1402.PDF Further information on the ECC is available at: https://cept.org/ecc/

3.4 GHz

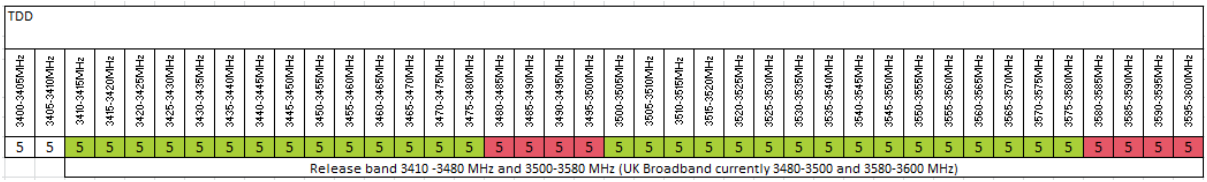
2.6 On 21 May 2008, the European Commission adopted the 3.4 GHz Decision[2]. In relation to the 3400 to 3600 MHz band, this decision required Member States, within six months of the 3.4 GHz Decision's entry into force, to designate and make available the band, on a non-exclusive basis, for terrestrial electronic communications networks, in compliance with a number of technical parameters set out in the annex to the 3.4 GHz Decision.

2.7 The Commission Decision was implemented in the UK by way of the 3400-3800 MHz Frequency Band (Management) Regulations 2008, which required Ofcom to exercise its functions under the WT Act so as to give effect to the obligations of the UK under the Commission Decision.

2.8 On 2 May 2014, the European Commission adopted Decision 2014/276/EU[3] which amended the 3.4 GHz Decision, primarily in relation to the technical conditions, set out in the annex. It stated that the preferred duplex mode of operation in the 3.4 to 3.6 GHz sub-band shall be Time Division Duplex (TDD). Our award of the 3.4 GHz band is compliant with the amended Commission Decision. The Commission Decision was implemented in the UK by SI 2016 No. 495. Since the Decision, the Radio Spectrum Policy Group (RSPG) has identified the wider 3.4 to 3.8 GHz band as the *"primary band suitable for the introduction of 5G use in Europe even before 2020"*. If this turns out to be the case, then different technical conditions may be required.

2.9 Figure 2.2 below illustrates the frequency arrangement of the 3.4 GHz band. The harmonised frequency arrangement is for 1 x 200 MHz, based on a block size of 5 MHz on a Time Division Duplex (TDD) basis. This is illustrated, alongside an indication of the position of the 3.4 GHz release band to be awarded.

Figure 2.2: Frequency arrangement for the 3.4 GHz band based on TDD



2.10 We discuss in section 6 how we propose to package the 3.4 GHz spectrum for the Award Process.

Overview of spectrum use allocations in and adjacent to the 2.3 GHz and 3.4 GHz bands

2.11 Figure 2.3 below provides a summary of the existing uses in the bands adjacent to the 2.3 GHz and 3.4 GHz bands.

[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:144:0077:0081:EN:PDF
[3] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014D0276&qid=1414427840029&from=EN

Figure 2.3: Summary of spectrum uses adjacent to the 2.3 and 3.4 GHz award bands

Uses		Frequencies	Description/devices
Public Sector uses including MOD and other Government departments		2200-2290MHz 2302–2350MHz 2390-2500 MHz 2700-3410 MHz	A range of terrestrial, airborne, maritime and satellite systems including telemetry, radiolocation and radio navigation and other communications systems. Further details are provided in section 4.
Licence exempt uses	Wi-Fi	2400–2483.5 MHz	Domestic devices (e.g. wireless internet accessing laptops, tablets and smartphones); Wi-Fi routers; outdoor networks; indoor public networks (hotels, pubs, cafes etc); commercial closed networks (e.g. internal company systems).
	Bluetooth	As above	Includes wireless headsets; phone to phone transfer; in-car devices for mobile phones; keyboards, mice and games controllers; and hearing aid applications.
	ZigBee	As above	A range of home and industrial automation applications, including smart meters; street lighting control; medical monitoring and agricultural usage.
	Others	As above	Wideband transmission and short range device applications using less common or bespoke proprietary protocols (often similar to Wi-Fi and Bluetooth). Includes medical monitoring equipment, assisted listening devices, analogue CCTV, audio microphones, video baby monitors and other consumer (e.g. model aircraft) and industrial devices (Radio Frequency Identification (RFID)) .
		2446-2454 MHz	Other Industrial, scientific and medical applications including railway applications, RFID, radio determination and industrial and commercial telemetry and telecommunications services.
PMSE		2200-2290 MHz 2290-2300 MHz 2310-2350 MHz* 2390-2400 MHz 2400-2500 MHz 3400-3410 MHz	Equipment used in the television industries including wireless cameras, and communications systems. * 2310–2350 MHz used occasionally by PMSE for peak demand events subject to agreement from Emergency Services and MOD. 2390-2500 MHz is assigned to PMSE on a shared basis; however there may be adjacent channel interference which could limit its utility. 3400-3410 MHz is available but may be unusable due to adjacent channel interference.
Amateur radio		2300-2302 MHz 2310-2350 MHz 2390-2400 MHz 2400-2450 MHz 3400–3410 MHz	Uses range from simple voice communication to more sophisticated functions such as use of TV repeaters and beacons, sometimes for amateur research and experimentation. Includes 'moon bounce' (the practice of broadcasting signals to the moon and testing its return echo). Amateur satellite services operate in 2400 – 2450 MHz.
Radar	Maritime	2900-3100 MHz	Radars used by ships and for harbours/coastguards. Necessary for compliance with International Maritime Organisation requirements.
	Aeronautical	2700-3100 MHz	Air Traffic Control services in UK airspace for commercial and military aircraft plus recreational flying.
	Military Maritime and Aeronautical	2700-3400 MHz	Radars used for Navy and Air Force tasks in the UK.
Satellite	Fixed Earth stations	2200-2290 MHz	Range of uses in particular parts of the band, including space research, space operations amateur satellites and commercial application.
	Mobile satellite downlink	2170-2200 MHz	Band assigned to Echostar and Inmarsat for European S Band MSS
	Mobile satellite downlink	2483.5-2500 MHz	Globalstar mobile satellite service downlink.
	Future Galileo allocation	2483.5-2500 MHz	Band allocated for future use by Galileo navigation system.

	Fixed satellite downlinks	3600-4200 MHz	This is used by: • Receive-only satellite earth stations holding grants of Recognised Spectrum access; and • Receive satellite earth stations used for space to Earth links, under WT Act licence, typically transmitting at 5825-6725 MHz. This band is used by several earth stations across the UK for broadcast contribution and monitoring, data communications and other services.
Other licensed uses of the 3.4 GHz band	UK Broadband	3605-3689 MHz 3925-4009 MHz (plus 40 MHz of spectrum within 3.4 GHz award band)	UK Broadband provides wireless data capacity, equipment and services to customers and to the telecoms industry, service providers, and the public sector.
Fixed links		2200 - 2290 MHz 3605 – 3689 MHz 3695-3875 MHz 4015-4195 MHz	Approximately 5 legacy fixed links are in use, predominantly in the areas around the Hebrides Currently no fixed links in use Fixed link licences are available on a shared basis.

UK allocations within and adjacent to the 2.3 GHz band

2.12 Figure 2.4 below illustrates the current spectrum allocations within and adjacent to the 2.3 GHz band. The illustration is based on the UK Frequency Allocation Table (UKFAT), the current issue of which is 2017, Issue No. 18.[4]

2.13 The UKFAT is published by Ofcom. It identifies how various frequency bands are currently used in the UK (referred to as 'allocations'). The UKFAT covers both civilian and non-civilian uses of spectrum within the UK. It is updated from time to time in the light of spectrum policy decisions nationally and internationally.[5]

2.14 The allocations in Figure 2.4 are identified in terms of primary and secondary services, the distinction defined in the Radio Regulations[6] of the ITU being that stations of a secondary service shall not cause harmful interference to stations of primary services nor claim protection from harmful interference from stations of a primary service. However, stations of a secondary service can claim protection from harmful interference from stations of the same or other secondary service(s) that are assigned at a later date. The Radio Regulations apply in interference disputes between countries, but not ordinarily between users within the UK.

2.15 The 2310 to 2450 MHz band is allocated to fixed and mobile services on a primary basis. There are secondary allocations for amateur radio, amateur satellite and radiolocation services. On 13 October 2015 administration of the band 2350 to 2390 MHz for fixed and mobile services was moved to Ofcom from the MOD with immediate effect.

[44] https://www.ofcom.org.uk/spectrum/information/uk-fat

[5] Footnote from previous edition removed

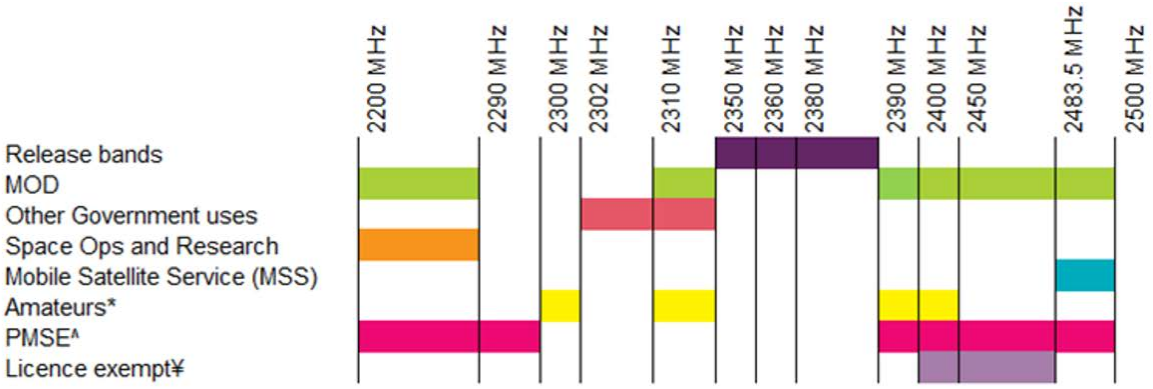
[6] An international treaty published by the ITU, an agency of the United Nations - see http://www.itu.int and http://www.itu.int/opb/sector.aspx?lang=en&sector=1

Figure 2.4: current spectrum allocations within and adjacent to the 2.3 GHz band

Frequency	Primary Service	Secondary Service
2170 – 2200 MHz	FIXED MOBILE MOBILE-SATELLITE (space to Earth)	
2200 – 2290 MHz	EARTH EXPLORATION SATELLITE (space to Earth) (space to space) FIXED MOBILE SPACE OPERATION (space to Earth) (space to space) SPACE RESEARCH (space to Earth) (space to space)	
2290 – 2300 MHz	FIXED MOBILE	Space Research (space to Earth) (deep space)
2300 – 2302 MHz	FIXED MOBILE	Amateur
2302 – 2310 MHz	FIXED MOBILE	
2310 – 2450 MHz	FIXED MOBILE	Amateur Amateur-Satellite Radiolocation
2450 – 2483·5 MHz	FIXED MOBILE	Radiolocation
2483·5 – 2500 MHz	FIXED MOBILE (except aeronautical mobile) MOBILE-SATELLITE (space to Earth) RADIODETERMINATION-SATELLITE (space-to-Earth)	Radiolocation

2.16 Figure 2.4 above provides the high level service allocation. Figure 2.5 below outlines the use of the spectrum by different applications or users.

Figure 2.5: Use of spectrum in the 2.3 GHz and neighbouring spectrum bands



* 2400 to 2450 MHz may also be used by the amateur satellite service.

^ The bands 2200-2300 and 2390-2500 MHz are allocated to PMSE (on a shared basis). Access to the 2300-2390 MHz band may sometimes allowed on a coordinated basis with users as a 'spectrum loan' to facilitate high demand events

¥ 2400 -2450 MHz is designated for Industrial, Scientific and Medical (ISM) applications

BT has a small number of fixed links in the 2200-2290 MHz band. We do not perceive there to be any interference issues with the release band.

MOD use below 2350 MHz and above 2390 MHz

2.17 The bands below 2350 MHz and above 2390 MHz continue to be used by the MOD. We explain in section 4 how co-existence of mobile services in the 2.3 GHz band with adjacent MOD use will be managed.

Other Government use below the 2350 MHz band

2.18 The frequency band from 2302 to 2350 MHz is available to Emergency Services and a number of systems are in use throughout the UK. We explain in section 4 how this may affect mobile services in the 2.3 GHz band.

MSS and Space services

2.19 The band 2170 to 2200 MHz is available for mobile satellite services and associated complementary ground stations which may transmit in this band. The band 2200 to 2290 MHz is available for space research, space operations and Earth-exploration. All transmissions in this band are space to earth or space to space and there are no ground-based transmissions. We have published a decision to enable the use of MSS user terminals (e.g. mobile and satellite phones) on a licence exempt basis within the 1980 to 2010 MHz and 2170 to 2200 MHz ('2 GHz') band: https://www.ofcom.org.uk/__data/assets/pdf_file/0032/93659/Statement-Wireless-Telegraphy-Exemption-Regulations-2016.pdf

Licence exempt devices in the 2400 to 2483.5 MHz band

2.20 A number of Short Range Devices (SRDs), including Wi-Fi, operate in the European harmonised frequency band between 2400 and 2483.5 MHz.

2.21 The 2400 to 2483.5 MHz band is used for licence exempt wideband data transmission systems including Wireless Local Area Network (WLAN) based on the IEEE 802.11 and 802.15 standards (which include Wi-Fi and Bluetooth). The maximum EIRP for wide band data transmission systems is 20 dBm (100mW), only when using the specific mitigation techniques equivalent to those described in

harmonised standards adopted under Directive 2014/53/EU. The relevant standard is EN 300 328[7]. The Interface Requirements for Wideband Transmission Systems are set out in IR 2030/7/1.

2.22 Additionally, the 2400 to 2483.5 MHz band is used in the UK for non-specific licence exempt short range devices (SRDs) operating at up to 10mW effective isotropic radiated power (EIRP). The Interface Requirements for Non-Specific SRD 2400 to 2483.5 MHz are set out in IR 2030/1/22. However higher powers up to 500mW (outdoors) EIRP and 4W (indoors) EIRP are permitted within the sub-band 2446 to 2454 MHz for RFID. The Interface Requirements for RFID 2446 to 2454 MHz are set out in IR 2030/13/5 and IR2030/13/6.

2.23 The SRD use of the spectrum above 2400 MHz is harmonised across Europe by EU law via Commission Decisions 2006/771/EC[8], 2008/432/EC[9], 2009/381/EC[10], 2010/368/EU[11], 2011/829/EU[12] and 2013/752/EU[13].

2.24 We explain in section 3 our conclusions on how these may be affected by mobile services in the 2.3 GHz band.

PMSE

2.25 The 2200 to 2300 MHz and 2390 to 2500 MHz bands are available for PMSE use, although the 2390 to 2500 MHz band is lightly used due to interference from and to Wi-Fi applications. The 2200 to 2300 MHz band is typically used for wireless video applications such as cordless cameras operating at less than 0 dBW. It is noted that the technical conditions allow for a maximum ERP of 20 dBW for long distance video links, and airborne use is allowed at a maximum ERP of 13 dBW in the 2200 to 2290 MHz band. For 2290 to 2300 MHz ERP is limited to 0 dBW and airborne use is not permitted. Some geographical restrictions apply. The Interface Requirements for PMSE use within the UK are set out in IR 2038[14].

2.26 Although the 2300 to 2390 MHz band is not allocated to PMSE, access to the band is sometimes allowed under a coordinated 'loan' arrangement with incumbent users to meet specific spectrum demands for an event. This opportunity will continue with new licensees post award.

Amateur Radio

2.27 Holders of Amateur Radio Licences have access to defined spectrum frequencies. On 7 April 2014 we issued a statement on amateur radio use in the award and adjacent bands ("Public Sector Spectrum Release")[15], which followed a consultation the previous year. In accordance with that statement, amateur radio access has been removed from the 2.3 GHz award band.

[7] http://www.etsi.org/deliver/etsi_en/300300_300399/300328/01.09.01_60/en_300328v010901p.pdf
[8] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006D0771(01)&rid=2
[9] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:151:0049:0054:EN:PDF
[10] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:119:0032:0039:EN:PDF
[11] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010D0368&rid=1
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[13] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0752&rid=3
[14] http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/interface-requirements/ir2038.pdf
[15] http://stakeholders.ofcom.org.uk/binaries/consultations/public-sector-spectrum-release/statement/PSSR_amateur_statement.pdf

2.28 Between April and June 2015, following a further statement ("Updating the Amateur Radio Licence", December 2014)[16], Ofcom varied the licences issued to all radio amateurs to remove access to the award bands[17]. However, holders of the Amateur Radio (Full) Licence and Amateur Radio (Intermediate) Licence continue to have access to the 2310 to 2350 MHz and 2390 to 2450 MHz frequency bands. Holders of the Amateur Radio (Full) Licence may also request access to 2300 to 2302 MHz through an individual licence variation. We discuss the coexistence of mobile broadband with amateurs in neighbouring bands in section 3.

Mobile satellite – Globalstar (2483.5 to 2500 MHz)

2.29 The primary allocation to the mobile satellite service in the 2483.5 to 2500 MHz band is used by the Globalstar system, which transmits a space to Earth link in that band. Ofcom understands that Globalstar is the only mobile satellite services system currently operational within the band. It is identified as HIBLEO-4 in the ITU Space Radiocommunication Stations database and non-GSO-D in ITU-R Recommendation M.1184. The Globalstar mobile Earth-station terminals are licence-exempt in the UK with the minimum performance requirements and technical characteristics specified in ETSI standard EN 300 733. The Interface Requirements for mobile earth-station terminals are set out in IR 2016.4[18].

UK allocations within and adjacent to the 3.4 GHz band

2.30 The 3400 to 3600 MHz band is allocated to mobile and radiolocation on a primary basis in the UKFAT. There is a secondary allocation for amateur radio services that was amended to include only 3400 to 3410 MHz when the UKFAT was last updated. As described below, amateur radio licences, which had formerly allowed access to 3410 to 3475 MHz, were varied in 2015 to remove that access. . On 13 October 2015, administration of the band 3410 to 3600 MHz was moved to Ofcom from MOD with immediate effect.

2.31 Figure 2.6 below illustrates the current spectrum allocations within and adjacent to the 3.4 GHz band.

Figure 2.6: Service allocations for the 3.4 GHz band and adjacent spectrum

Frequency	Primary Service	Secondary Service
2700 – 2900 MHz	AERONAUTICAL RADIONAVIGATION	Radiolocation
2900 – 3100 MHz	RADIOLOCATION RADIONAVIGATION	
3100 – 3300 MHz	RADIOLOCATION	Earth Exploration-Satellite (active) Mobile
3300 – 3410MHz	RADIOLOCATION	Amateur Mobile
3410 – 3600 MHz	MOBILE	

[16] http://stakeholders.ofcom.org.uk/consultations/amateur-radio-licence/

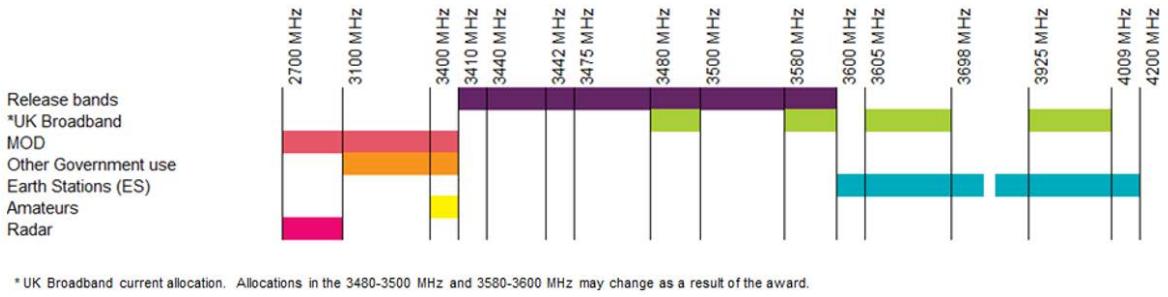
[17] www.ofcom.org.uk/__data/assets/pdf_file/0031/80788/statement_updating_the_amateur_radio_licence.pdf

[18] www.ofcom.org.uk/__data/assets/pdf_file/0032/84659/ir2016.pdf

3600 - 4200 MHz	FIXED FIXED-SATELLITE (space to Earth)	Mobile

2.32 Figure 2.6 above provides the high level service allocation. Figure 2.7 below outlines the use of the spectrum by different applications or users.

Figure 2.7: Service allocations for the 3.4 GHz band and adjacent spectrum



* UK Broadband current allocation. Allocations in the 3480-3500 MHz and 3580-3600 MHz may change as a result of the award.

MOD and other Government use

2.33 The frequencies below 3410 MHz continue to be used by MOD and other Government departments. Uses are predominantly for radiolocation services, both airborne, land and maritime based. However there are also non-radiolocation services operating in this band. We explain in section 4 how these uses might affect mobile services in the 3.4 GHz band.

Aeronautical radionavigation and radiolocation (2700 to 3100 MHz)

2.34 The 2700 to 2900 MHz band has a primary allocation to the aeronautical radionavigation service and a secondary allocation to the radiolocation service. In addition, the 2900 to 3100 MHz band has a primary allocation for radiolocation and radionavigation.

2.35 It is extensively used for air traffic control (ATC) and air traffic management (ATM) by several UK airports and by NATS; by the MOD for military ATM purposes; and at other fixed military locations and designated training areas. It is also used extensively by civil and military users for maritime and naval radiolocation services.

2.36 We discuss in section 3 the coexistence of radar and mobile broadband.

UK Broadband

2.37 40 MHz of spectrum in the 3.4 GHz band is already licensed for mobile use in two separate 20 MHz blocks (3480 to 3500 MHz and 3580 to 3600 MHz). Details of how this spectrum may be included in the Award Process are set out in section 8 of this document. The licence is held by UK Broadband Limited, and that company has now (2017) been acquired by H3G (Three). UK Broadband Limited also holds 2 x 84 MHz of spectrum for fixed broadband wireless access in the band 3605 to 3689 MHz paired with 3925 to 4009 MHz. The lower of this duplex pair is also used for 4G technology.

PMSE

2.38 PMSE previously had access to spectrum in the 3400 to 3440 MHz and 3500 to 3580 MHz bands. This was mainly used by video applications. As part of the decision to

release the 3.4 GHz band, PMSE will no longer have general access to the band. However, as with the 2.3 GHz band, coordinated access for PMSE may be arranged on a case by case basis with the award licensees where there is a need to source additional spectrum outside the core PMSE bands (see also section 3).

Amateur radio

2.39 Amateur Radio previously had access to 3400 to 3475 MHz. In our statement on amateur use of the bands ("Public Sector Spectrum Release", April 2014)[19] we published our decision that amateur radio would no longer have access to the 3410 to 3475 MHz band.

2.40 Between April and June 2015, following another statement ("Updating the Amateur Radio Licence", December 2014[20]), we varied all Amateur Radio licences to remove access to the band from 3410 MHz to 3475 MHz. However, holders of the Amateur Radio (Full) Licence and Amateur Radio (Intermediate) Licence continue to have access to the 3400 to 3410 MHz band.

ES use

2.41 Receiving satellite earth station sites are permitted in the UK within 600 MHz between 3.6 GHz and 4.2 GHz. These are receive-only for space to Earth communications and there are no Earth-to-space transmissions using these C-band frequencies. There are 26 of these sites with satellite earth stations in the UK registered under Permanent Earth Station (WT Act) licences, grants of Recognised Spectrum Access for Receive Only Earth Stations, or Crown usage. Ofcom will shortly publish a statement setting out our intention to make the 3.6 to 3.8 Ghz band available for mobile, and our proposed approach to future arrangements for these frequencies.

Fixed Links

2.42 Fixed Links operate in the 3695 to 3875 MHz and 4015 to 4195 MHz band and share the band with ES. These fixed links are licensed on an individual link basis. There are around 47 licences on issue. The band is open for new assignments to be made in the 3815 to 3875 and 4135 to 4195 MHz parts of the band, subject to coordination with existing ES deployments. As noted above, Ofcom will shortly publish a statement setting out our intention to make the 3.6-38 GHz band available for mobile, and our proposed approach to future arrangements for these frequencies.

International allocations and uses within and adjacent to the 2.3 GHz band

2.43 Figure 2.8 below outlines the designated allocations across the world in the 2200 to 2500 MHz band as set out in the ITU Radio Regulations based on the outcome of the World Radiocommunication Conference 2015 (WRC-15). [21]

[19] http://stakeholders.ofcom.org.uk/binaries/consultations/public-sector-spectrum-release/statement/PSSR_amateur_statement.pdf
[20] http://stakeholders.ofcom.org.uk/binaries/consultations/amateur-radio-licence/statement/Updating_the_Amateur_Radio_Licence.pdf
[21] Footnote from previous edition removed

Figure 2.8: ITU Radio Regulations allocations in the 2200 to 2500 MHz band

<table>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td colspan="3">2200 – 2290
SPACE OPERATION (space-to-Earth)(space-to-space)
EARTH EXPLORATION-SATELLITE (space-to-Earth)(space-to-space)
FIXED
MOBILE 5.391
SPACE RESEARCH (space-to-Earth)(space-to-space)
5.392</td></tr>
<tr><td colspan="3">2290 – 2300
FIXED
MOBILE except aeronautical mobile
SPACE RESEARCH (deep space) (space-to-Earth)</td></tr>
<tr><td>2300 – 2450
FIXED
MOBILE 5.384A
Amateur
Radiolocation
5.150 5.282 5.395</td><td colspan="2">2300 – 2450
FIXED
MOBILE 5.384A
RADIOLOCATION
Amateur
5.150 5.282 5.393 5.394 5.396</td></tr>
<tr><td>2450 – 2483.5
FIXED
MOBILE
Radiolocation
5.150</td><td colspan="2">2450 – 2483.5
FIXED
MOBILE
RADIOLOCATION
5.150</td></tr>
<tr><td>2483.5 – 2500
FIXED
MOBILE
MOBILE-SATELLITE
(space-to-Earth) 5.351A
RADIODETERMINATION-
SATELLITE (space-to-Earth)
5.398
Radiolocation 5.398A
5.150 5.399 5.401 5.402</td><td>2483.5 – 2500
FIXED
MOBILE
MOBILE-SATELLITE
(space-to-Earth) 5.351A
RADIOLOCATION
RADIODETERMINATION-
SATELLITE (space-to-Earth)
5.398
5.150 5.402</td><td>2483.5 – 2500
FIXED
MOBILE
MOBILE-SATELLITE
(space-to-Earth) 5.351A
RADIOLOCATION
RADIODETERMINATION-
SATELLITE (space-to-Earth)
5.398
5.150 5.401 5.402</td></tr>
</table>

2.44 The Radio Regulations specify the following allocations in the 2300 to 2450 MHz band:

- A primary allocation to the mobile service in ITU Regions 1, 2 and 3. According to the conditions of footnotes 5.384A the band 2300 to 2400 MHz is identified for use by administrations wishing to implement International Mobile Telecommunications (IMT) in accordance with Resolution 223 (Rev.WRC-15). This identification does not preclude use of the band by any application of the services to which they are allocated and does not establish priority in the Radio Regulations. Footnote 5.395 applies to France and Turkey in the band 2310 to 2360 MHz and gives the aeronautical mobile service for telemetry priority over other uses by mobile services (WRC-03);

- A primary allocation to the fixed service in all three ITU Regions;

- A secondary allocation to the radiolocation service in ITU Region 1 and a primary allocation to this service in Regions 2 and 3; and

- A secondary allocation to amateur services in all three ITU Regions. Footnote 5.282 allocated the band 2400 to 2450 MHz band in all three regions for the amateur-satellite service. The amateur-satellite service must not cause harmful interference to or claim protection from other services in the band.

2.45 Harmonisation work within the ECC has produced the following Decision relevant to the 2.3 GHz band:

- ECC/DEC (14)02 June 2014 on the harmonised technical and regulatory conditions for the use of the band 2300 to 2400 MHz for Mobile/Fixed Communications Networks (MFCN)[22].

2.46 Border coordination between European administrations is considered in ECC Recommendation (14)04[23]. Amongst its recommendations are that coordination shall be based on bilateral or multilateral agreements between administrations. The Recommendation also provides field strength levels as a basis for coordination between IMT systems and a separate set of field strength levels for coordination between dissimilar systems.

France

2.47 There is currently a Memorandum of Understanding (MoU) covering use of the 2.3 GHz band for IMT services between France and the UK. A link to this MoU is included in annex 9 to this Memorandum.

2.48 This MOU does not cover defence uses by either country, however ANFR, the French regulator, has told us that the French MOD makes use of telemetry systems that use channels having a bandwidth of a few MHz. Their studies have shown that, with a free space propagation model, these services may provide an interfering field strength from 37 dBµV/m in Cornwall, to 34 dBµV/m in the Isle of Wight. A reduction of 1.5dB may be possible if polarisation discrimination is taken into account. These levels may occur for tens of hours per year.

Ireland

2.49 The UK has an MoU with Ireland covering use in the 2.3 GHz band. A link to this MoU is included in annex 9 to this Memorandum.

2.50 We are aware that the 2.3 GHz band has been identified through a recent consultation as a possible candidate for release by ComReg in the Republic of Ireland. We understand that this band (including frequencies in our award band) may be included in a subsequent award with other bands including the 700 MHz band. Further consultation by ComReg is expected prior to any award by them.

Isle of Man

2.51 The UK has an MoU with the Isle of Man for the 2.3 GHz band. A link to this is included at annex 9 to this Memorandum.[24]

International allocations and uses within and adjacent to the 3.4 GHz band

2.52 Figure 2.9 below outlines the designated allocations across the world in the 2700 to 4400 MHz band as set out in in the ITU Radio Regulations as agreed at the WRC-15.

[22] http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCDEC1402.PDF
[23] http://www.erodocdb.dk/Docs/doc98/official/pdf/REC1404.PDF
[24] Footnote from previous edition removed[25]
http://www.erodocdb.dk/Docs/doc98/official/pdf/REC1501.PDF

Figure 2.9: ITU Radio Regulations allocations in the 2700 to 4400 MHz band

<table>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td colspan="3">2700 – 2900
AERONAUTICAL RADIONAVIGATION 5.337
Radiolocation
5.423 5.424</td></tr>
<tr><td colspan="3">2900 – 3100
RADIOLOCATION 5.424A
RADIONAVIGATION 5.426
5.425 5.427</td></tr>
<tr><td colspan="3">3100 – 3300
RADIOLOCATION
Earth exploration-satellite (active)
Space research (active)
5.149 5.428</td></tr>
<tr><td>3300 – 3400
RADIOLOCATION

5.149 5.429 5.430</td><td>3300 – 3400
RADIOLOCATION
Amateur
Fixed
Mobile
5.149</td><td>3300 – 3400
RADIOLOCATION
Amateur

5.149 5.429</td></tr>
<tr><td rowspan="2">3400 – 3600
FIXED
FIXED-SATELLITE
(space-to-Earth)
MOBILE except aeronautical mobile 5.430A
Radiolocation

5.431</td><td>3400 – 3500
FIXED
FIXED-SATELLITE
(space-to-Earth)
MOBILE except aeronautical mobile 5.431A 5.431B
Amateur
Radiolocation 5.433
5.282</td><td>3400 – 3500
FIXED
FIXED-SATELLITE
(space-to-Earth)
Amateur
Mobile 5.432 5.432B
Radiolocation 5.433
5.282 5.432A</td></tr>
<tr><td>3500 – 3600
FIXED
FIXED-SATELLITE
(space-to-Earth)
MOBILE except aeronautical mobile 5.431B
Radiolocation 5.433</td><td>3500 – 3600
FIXED
FIXED-SATELLITE
(space-to-Earth)
MOBILE except aeronautical mobile 5.433A
Radiolocation 5.433</td></tr>
<tr><td rowspan="2">3600 – 4200
FIXED
FIXED-SATELLITE
(space-to-Earth)
Mobile</td><td>3600-3700
FIXED
FIXED-SATELLITE (space-to-Earth)
MOBILE except aeronautical mobile 5.434
Radiolocation 5.433</td><td>3600 – 3700
FIXED
FIXED-SATELLITE
(space-to-Earth)
MOBILE except aeronautical mobile
Radiolocation
5.435</td></tr>
<tr><td colspan="2">3700 – 4200
FIXED
FIXED-SATELLITE (space-to-Earth)
MOBILE except aeronautical mobile</td></tr>
<tr><td colspan="3">4200 – 4400
AERONAUTICAL MOBILE (R) 5.436AERONAUTICAL RADIONAVIGATION 5.438
5.437 5.439 5.440</td></tr>
</table>

2.53 The Radio Regulations specify the following allocations in the 3.4 GHz band:

- Primary allocations to the fixed and fixed-satellite services in the 3400 to 4200 MHz band in all three ITU Regions;

- In ITU Regions 2 and 3 there is a primary allocation from 3500 to 4200 MHz for mobile, excluding aeronautical mobile use;
- Secondary allocation for radiolocation in the band 3400 to 3600 MHz in ITU Region 1 and 3400 to 3700 MHz band in Regions 2 and 3; and
- A primary allocation in ITU Region 1 for mobile except aeronautical mobile in the 3400 to 3600 MHz band.

2.54 The Radio Regulations also contain footnote 5.430A against the mobile allocation in the 3400 to 3600 MHz band. The footnote advises that in ITU Region 1 countries, which includes the UK, the mobile except aeronautical service is allocated on a primary basis. This was subject to agreement obtained under Number 9.21 and has been identified for IMT use. This identification does not preclude the use of the band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. Before an administration brings into use a station it shall ensure that the power flux-density (pfd) produced at 3m above ground does not exceed -154.5 dB(W/m2 .4 kHz)) for more than 20% of time at the border of the territory of any other administration. This limit can be exceeded based on agreements between administrations.

2.55 ITU Footnote 5.431 previously noted that in Germany, Israel and the UK, the band 3400 to 3475 MHz was allocated to amateur services on a secondary basis. In light of our decision to award the spectrum, we amended this footnote at WRC-15 to remove the UK allocation to amateur services, although it remains allocated in the UK in 3400 – 3410 MHz only but it must not cause interference to other allocated services.

2.56 Border coordination between European administrations is considered in ECC Recommendation (15)01[25]. Amongst its recommendations is one that coordination shall be based on bilateral or multilateral agreements between administrations. The recommendation also provides field strength levels as a basis for coordination between FDD systems and between TDD systems, and specific guidance for border coordination between LTE systems.

France

2.57 The UK has entered into an MoU with France for the 3.4 GHz band. A link to this is included at annex 9 to this Memorandum.

Ireland

2.58 The UK has an MoU with the Republic of Ireland for the 3.4 GHz band. A link to this is included at annex 9 to this Memorandum.

2.59 We are aware that ComReg has recently awarded the 3.6 GHz band (covering 3.4 to 3.8 GHz) on a service and technology-neutral basis for wireless broadband communications covering fixed and mobile applications.

[25] http://www.erodocdb.dk/Docs/doc98/official/pdf/REC1501.PDF

Isle of Man

2.60 The UK has an MoU with the Isle of Man for the 3.4 GHz band. A link to this is included at annex 9 to this Memorandum.[26]

Other emissions in the 2.3 GHz and 3.4 GHz band

Ultra Wideband (UWB)

2.61 UWB technologies were harmonised in the European Community in 2007 (Decision 2007/131/EC27). This harmonisation measure was subsequently amended by Commission Decision 2009/343/EC28 and 2014/702/EU[29]. These harmonisation measures were implemented by the Wireless Telegraphy (Ultra-Wideband Equipment (Exemption)) Regulations 2015[30], which came into force on 25 March 2015. The European Commission Decision harmonised the use of UWB apparatus across the 2.3 GHz and 3.4 GHz bands.

[26] Footnote from previous edition removed
[27] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:055:0033:0036:EN:PDF
[28] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:105:0009:0013:EN:PDF
[29] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014D0702&from=EN
[30] S.I. 2015/591

Section 3

Factors affecting use of the award bands - civil

3.1 Use of the 2.3 and 3.4 GHz bands for new electronic communications services such as LTE may be affected by other users of radio spectrum. The other civil uses we have identified are summarised in Figure 3.1 below and described more fully in subsequent paragraphs.

Figure 3.1: uses of spectrum that may affect use of the award bands

Use	*Band*	*Impact*
Wi-Fi and other LE	2.3 GHz	We believe that there is a negligible risk of Wi-Fi and other licence exempt devices causing interference to LTE devices. However, we believe there is a very small chance that some 2.4 GHz Wi-Fi and other licence exempt (LE) devices might be affected by signals from LTE base stations or mobile devices in certain scenarios. We have not put restrictions in place to protect LE use.
PMSE	Both award bands	PMSE use in the 3.4 GHz award band ceased on 31 January 2016. However, we may request coordinated access to both bands on a case by case basis where there is a need to source additional spectrum outside the core PMSE bands.
Radar	3.4 GHz	Bidders should be aware of the risk that high power signals from radars may pose to mobile communications systems located in close proximity. In addition, coordination will be required to protect aeronautical radars at about 88 sites across the UK. This is the same protection as is required for 2.6 GHz spectrum. As a result, 3.4 GHz base station deployments may be slightly constrained within approximately 1.5 km of these radars.
Satellite	Both award bands	There are currently 26 C-band ES sites in the UK between 3.6 GHz and 4.2 GHz. These do not transmit in this band and so will not cause harmful interference to new uses in the award bands. We do not require formal coordination between new licensees and satellite services. However, informal cooperation between receiving earth stations and new uses at the upper end of the 3.4 GHz award band may be required on a site-by-site basis in the unlikely event that new uses cause interference to satellite uses. Local site engineering of the 3.4 GHz base station should be sufficient if this situation occurs.
Amateurs	Both award bands	Radio amateur use of the award bands has ceased throughout the UK. Amateurs retain access to some adjacent bands and we require them to avoid causing harmful interference under the terms of their licences.
Government uses	Both award bands	Government uses are discussed in section 4

Wi-Fi and other use of the 2.4 GHz licence exempt band

3.2 We believe there is a negligible risk of Wi-Fi and other licence exempt devices causing interference to LTE devices. However, in our consultation of February 2014[31] and our technical update of December 2014[32] we identified a potential risk of interference from new 2.3 LTE services to Wi-Fi in the 2.4 GHz licence exempt band (2400 to 2483.5 MHz). The risk could stem from LTE base stations or from user devices, such as mobile phones. It would be caused mainly by Wi-Fi equipment (routers, laptops, tablets etc.) picking up signals from outside the designated Wi-Fi operating band, leading to signal blocking. It is not typically caused by LTE emissions outside its own band interfering with Wi-Fi frequencies.

3.3 Our technical testing suggests the risk is very low in practice. If it occurs, it is likely to result in a drop in Wi-Fi throughput which may not be noticed by many users. We have not considered it necessary to apply specific measures to protect Wi-Fi, apart from restrictions on base station emissions above 2403 MHz, in line with ECC Decision (14)02. However, our statement of May 2015[33] noted that Ofcom would assist internet service providers (ISPs) in gathering information about LTE roll-out, subject to respecting commercial confidentiality, if this proves necessary. Under the 2.3 GHz and 3.4 GHz licence conditions, licensees are required to retain certain information in relation to their radio equipment and to provide it to Ofcom if requested. In addition, we have decided to make additional spectrum in the 5 GHz band available for Wi-Fi (https://www.ofcom.org.uk/__data/assets/pdf_file/0027/98154/5p8-Regs.pdf). This could be used as an alternative to continued use of the 2.4 GHz band.

3.4 We will encourage manufacturers of 2.3 GHz femto-cell equipment to include advice in packaging and/or installation guides on appropriate separation distances from Wi-Fi routers. The advice could be in the form of labels on equipment. This practice is in line with existing advice provided by operators who supply 2.1 GHz femto-cells. We also encourage the inclusion of plugs with long cables in femto-cell packaging.

3.5 There is a similar very low risk of interference from new 2.3 GHz LTE services to other licence exempt equipment in the 2.4 GHz band, including Bluetooth, ZigBee, medical monitoring equipment and assistive listening devices (ALDs) used in places such as school classrooms. We have published further research into the risk of interference to ALDs and this is available on the Ofcom website at www.ofcom.org.uk/research-and-data/technology-research-reports/compatibility-of-2.3-ghz-4g-mobile-with-assistive-listening-devices. As with Wi-Fi we have not considered it necessary to apply specific measures to protect licence exempt equipment.

3.6 However, we advise that 2.3 GHz licensees looking to locate base stations on or near hospital premises should work closely with hospital trusts to ensure there is no interference to hospital systems. We will write to hospital trusts to make them aware of any risks for medical equipment.

[31] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/summary/pssr.pdf
[32] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/updated-analysis.pdf
[33] http://stakeholders.ofcom.org.uk/binaries/consultations/2.3-3.4-ghz-auction-design/statement/statement.pdf

3.7 Similarly, we note that mobile network operators are encouraged to consult with education authorities when seeking to locate base stations near school premises, as set out in such industry guidelines as the Code of Best Practice for England.[34]

PMSE

3.8 Our decision to clear the 3.4 GHz band and release it for mobile services means that the band is no longer available for general use by PMSE. However, as detailed in our statement on the strategy for video PMSE published in October 2014[35] we have decided that coordinated access for PMSE will be considered on a case by case basis, with the award licensees where there is a need to source additional spectrum outside the core PMSE bands. We would expect requests for access to this band to decline over time.

3.9 As noted in section 2, similar arrangements for ad hoc access will also apply to the 2.3 GHz band.

Radar

3.10 Aeronautical radionavigation and radiolocation services operate in the S-band[36], with at least 310 MHz of frequency separation from the 3.4 GHz band. As noted in section 2, the lower part of this band, 2700 to 2900 MHz is mainly used for primary surveillance radar, used for civil and military ATM, as well as some other military and civil radars. The upper part of the band, 2900 to 3100 MHz, is also used for maritime radar.

Interference from radars to LTE

3.11 Radars are designed to have relatively high transmit power, commensurate or even greater than the typical powers from a mobile communications macro cell. Bidders should be aware of the risk that these high power signals may pose to mobile communications systems located in close proximity.

3.12 In the frequency band 2700 to 3100 MHz there are ATC and ATM radars, civil (and military), used for aviation radio navigation purposes.

3.13 In total there are currently 88 S-band protected ATC/ATM radar locations distributed around the UK that are protected by coordination (not all are permanent radars sites, although there could be other unprotected radar locations). These radars are primary sensors, and their effective operation is integral to the air traffic management of UK airspace. The target detection range is from 40 to 80 nautical miles. They are generally located at airports, military bases or other positions that allow the air traffic management function to be achieved. There are a number of radars located to allow the detrimental effects of wind farms to be mitigated.

3.14 As part of an award of 2.6 GHz licences in 2013 we found that some radars in the 2700 to 2900 MHz band, particularly the older magnetron or TWT types, may have

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[34] http://www.mobilemastinfo.com/images/stories/2013_Code_of_best_practice/Code_of_Best_Practice_on_Mobile_Network_Development_-_Published_24-07-2013.pdf

[35] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/statement/Statement_on_camera_strategy.pdf

[36] The **S band** is defined by an IEEE standard for radio waves with frequencies that range from 2 to 4 GHz, crossing the conventional boundary between UHF and SHF at 3.0 GHz.

significant out-of-band (OOB) or spurious emissions that can extend for many tens of MHz beyond their operating frequencies. If these radars operate on frequencies above 2900 MHz close to the 3100 MHz band edge, their emissions could extend into the bottom channels of the 3.4 GHz band.

3.15 Ofcom licenses use on the basis of conditions which are set out in documents known as Interface Requirements. Interface Requirement, IR 2050[37], notes that frequency planning assumptions for radars are in accordance with ITU Radio Regulations Appendix 3, Recommendation ITU-R SM. 329-10 (Unwanted emissions in the spurious domain) and Recommendation ITU-R SM.1541-6 (Unwanted emissions in the out-of-band domain). It should also be noted that currently there is no regulatory basis for limiting OOB emissions for ground-based military radar systems, the operational requirements of which are subject to change. Civil radar systems are subject to the requirements of the Radio Equipment Directive[38] and associated UK implementation instruments.

3.16 The following documents provide information on typical radar RF parameters, possible unwanted emission characteristics, and the different types of radar usage within the UK:

- "Study into spectrally efficient radar systems in the L and S bands." A report by BAE Systems Integrated Systems Technology Limited for the Ofcom Spectrum Efficiency Scheme, May 2006[39];
- "The report of an investigation into the characteristics, operation and protection requirements of civil aeronautical and civil maritime radar systems." A report by Alenia Marconi Systems Limited for the Radiocommunications Agency, October 2002[40];
- Recommendation ITU-R M.1461-1. Procedures for determining the potential for interference between radars operating in the radiodetermination service and systems in other services;
- Recommendation ITU-R M.1464-2. Characteristics of non-meteorological radiolocation radars, and characteristics and protection criteria for sharing studies for aeronautical radionavigation radars in the radiodetermination service operating in the 2700-2900 MHz frequency band;
- Recommendation ITU-R SM 1541-6. Unwanted emissions in the out-of-band domain, Annex 8, OOB domain emission limits for primary radar systems; and
- Recommendation ITU-R SM 329-12. Unwanted emissions in the spurious domain.

[37] http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/interface-requirements/ir2050.pdf

[38] Directive 2014/53/EU

[39] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/35838/serslong1.pdf

[40] http://webarchive.nationalarchives.gov.uk/20090905131631/http://www.ofcom.org.uk/static/archive/ra/topics/research/topics/s-studies/civil-radio-systems.pdf

3.17 Some information on possible interference mechanisms was included in chapter 8 of a Real Wireless report[41] "Low-power shared access to spectrum for mobile broadband", published alongside Ofcom's March 2011 consultation on the 800 MHz and 2.6 GHz award[42]. Interested parties should make their own assessment of the potential impact of unwanted emissions from radars on their intended use of the award spectrum.

Interference from LTE to radars

3.18 Radars are designed to detect very low power signals in their own frequency bands, and receivers may be filtered to ensure that transmissions from adjacent frequency bands are not also detected. However, where filtering is insufficient, higher power transmissions from adjacent bands, even those which are well separated in frequency terms, can still be detected by radars and their performance can be degraded as a result. Some radars in the S-band have poor receiver selectivity and are vulnerable to interference from use of the 3.4 GHz band for mobile services compared to typical modern receivers.

Maritime Radar

3.19 Our technical analysis for the February 2014 consultation on coexistence found low risk of potential interference from LTE to S-band maritime radars in 'real-life' testing. In view of the results of these tests, we agreed with the Maritime and Coastguard Agency (MCA) that it was not necessary to propose any additional mitigations (such as coordination) to address interference from new 3.4 GHz uses such as LTE.

Aeronautical radar

3.20 Between late 2010 and early 2013 there was a Government (Civil Aviation Authority, Department for Transport, Ministry of Defence) and Ofcom radar remediation programme to ensure that ATC/ATM radars in the 2.7 GHz band (2700 to 3100MHz) were modified to become more resilient to interference due to emissions from new communications users in the 2.6 and 3.4 GHz bands. However, these radars continue to have some residual sensitivity to emissions from the 3.4 GHz band, and a coordination procedure needs to be implemented to ensure that when networks are deployed in the 3.4 GHz band, they do not cause harmful interference to civil and military aeronautical radars in the 2.7 GHz band. The details of this coordination procedure are set out in annex 8, and its impact on deployments is set out in section 5 of this Memorandum.

Satellite

3.21 The February 2014 consultation included discussion of a range of satellite services operating close to both the 2.3 and the 3.4 GHz bands. These services include, but are not limited to, broadcast contribution, distribution and monitoring, data communications and other services.[43.]

[41] http://stakeholders.ofcom.org.uk/binaries/consultations/combined-award/annexes/real-wireless-report.pdf
[42] http://stakeholders.ofcom.org.uk/consultations/combined-award/

[43] Footnote not used

3.22 ES sites do not transmit between 3.6 GHz and 4.2 GHz and so will not cause any harmful interference to new uses in the award bands.

3.23 Our February 2014 consultation specifically addressed:

- MSS 2 GHz - mobile satellite and integrated Complementary Ground Component (CGC) mobile receivers (2170 to 2200 MHz);
- MSS 2.4 GHz - mobile satellite services (MSS) (2483.5 to 2500 MHz);
- SR and SO - space research and space operations (2200 to 2290 MHz);
- AmSat - amateur satellite services (2400 to 2450 MHz); and
- C-band - receiving satellite earth stations (3600 to 4200 MHz)

3.24 The technical analysis included in our February 2014 consultation[44] suggested there would be no significant interference to satellite operations close to the award bands, and no formal coordination procedures were necessary. Instead, coexistence issues should be addressed through informal co-operation between users. We confirmed this approach in our May 2015 statement.[45]

3.25 Our analysis showed that *some* interference from LTE may occur within around 8.5 km of each of the two worst affected ES sites when the antennas of a full power LTE base station and ES site were aligned. We also showed that 10 dB of additional loss between the LTE base station and the ES would reduce this to around 1 to 3km, making the likelihood of interference very low. Additional coupling losses in the order of 10 dB are likely with practical deployment scenarios.

3.26 As set out in paragraph 2.41, there are 26 ES sites registered under Permanent Earth Station (WT Act) licences, grants of Recognised Spectrum Access for Receive Only Earth Stations or Crown usage. Of all the sites referred to above only seven are registered to receive signals that extend below 3660 MHz. Only two extend below 3625 MHz and will be most affected by the change in block-edge masks (see our consultation on technical coexistence for the 2.3 and 3.4 GHz award[46]).

3.27 Therefore, consistent with our usual policy only to consider adjacent channel coordination in exceptional circumstances, we have not put in place any formal coordination procedures between UK Broadband Limited or any new licensee in the top part of the band and these registered C-band earth station operators[47]. Any licensee operating in the top part of the 3.4 GHz band with our specified licence conditions will have no additional responsibility to protect the ES sites, other than the general licence obligation not to cause harmful interference[48]. Nor will they have any requirement to pay for remediation of these ES sites should that prove necessary.

3.28 In practice, we expect the 2.3 GHz and 3.4 GHz licensee and the ES operator to co-operate should interference occur. They would be expected to share information and re-engineer or remediate their own sites - where this is proportionate - to ensure

[44] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/summary/pssr.pdf
[45] http://stakeholders.ofcom.org.uk/binaries/consultations/2.3-3.4-ghz-auction-design/statement/statement.pdf
[46] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/summary/pssr.pdf
[47] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/updated-analysis.pdf
[48] We note that our auction design proposals may allow for a licensee other than UK Broadband to end up with the 3580–3600 MHz allocation after the award.

harmful interference is not caused. In some cases this may require the fitting of filters by the earth station operator; in other cases it might be small changes in power or antenna orientation by the LTE licensee to increase the coupling loss between the two sites.

3.29 Ofcom will shortly publish a statement setting out our intention to make the 3.6 to 3.8 GHz band available for mobile and our approach to future arrangements for these frequencies..

Amateurs

3.30 On 7 April 2014, in our statement "Public Sector Spectrum Release", we gave radio amateurs 12 months' notice of a licence variation requiring them to vacate the 2350 to 2390 MHz and 3410 to 3475 MHz bands. We announced that amateurs retained access to the adjacent bands 2310 to 2350; 2390 to 2400 and 3400 to 3410 MHz.

3.31 Holders of Amateur Radio Licences have access to the spectrum adjacent to the award bands on a non-interference basis. This means they should not cause harmful interference to the award band. Following our statement "Updating the Amateur Radio Licence" (December 2014)[49], we added a new clause to the Amateur Radio Licence (Clause 4(6)) allowing us to vary the licence to remove the bands from 2310 MHz to 2350 MHz, from 2390 MHz to 2400 MHz and from 3400 MHz to 3410 MHz, for reasons related to interference management, after first giving reasonable notice of three months. Clause 7(3) of the Amateur Radio Licence requires the licensee to ensure that the radio equipment does not cause undue interference to any wireless telegraphy.

3.32 Transmit power levels up to 400 Watts (peak envelope power) could be used in these bands, however much lower powers are typically used in practice. More information on the technical characteristics of how the amateurs tend to use these frequencies can be found in "Amateur use of 2310 to 2450 and 3400 to 3475 MHz" (June 2013)[50]. This consultation document provides typical characteristics of the systems that are now using the spectrum adjacent to the award bands only.

[49] http://stakeholders.ofcom.org.uk/binaries/consultations/amateur-radio-licence/statement/Updating_the_Amateur_Radio_Licence.pdf

[50] http://stakeholders.ofcom.org.uk/binaries/consultations/public-sector-spectrum-release/summary/condoc.pdf

Section 4

Factors affecting use of the award bands – public sector uses

4.1 Public sector users will retain access to spectrum in bands adjacent to the award bands. Specifically these adjacent bands are: 2302 to 2310 MHz; 2310 to 2350 MHz; 2390 to 2450 MHz; and bands directly below 3410 MHz. Uses are mainly those associated with the MOD and Emergency Services but in some cases other Government users.

Crown use

4.2 Some public sector users, such as those in the military, are classed as Crown users. Such users are not required to hold a licence under the WT Act in order to transmit on radio frequencies. Crown users are therefore legally entitled to transmit on all radio frequencies[51]. In practice, however, Crown users may hold a grant of Recognised Spectrum Access (RSA) - which recognises and demarcates spectrum use - and/or act in accordance with long standing administrative agreements within wider Government about which frequencies they may use.

4.3 While the award bands have now been released to Ofcom, there is still some ongoing Crown use within the bands in particular locations. There are also uses in neighbouring bands.

4.4 As a result, it is possible that harmful radio interference from Crown users may occur to those licensed to use the award bands, even after the spectrum awards. Interference may stem from Crown use of the bands themselves and/or from Crown use of adjacent bands. We believe this is likely to be occasional in nature – if it arises at all – but Ofcom can offer no guarantees that this is the case. Bidders should therefore note this interference as a possibility which may arise.

Assessment of interference risk

4.5 In order to understand the particular situations where there is a risk of interference, we have undertaken extensive consultation with the MOD. We set out below a description of some relevant situations - together with such information that we are able to make available - in order to help bidders come to a more informed understanding of any risks.

4.6 Bidders should note that the situations we set out do not amount to an exhaustive list. It is possible that interference may arise from these situations in ways we do not currently anticipate, or from other situations which are not yet foreseen or about which the MOD has not informed us[52]. Nor do we describe possible risks from systems which the MOD considers will not cause interference to new uses in the award bands, nor from any systems that operate outside UK territorial sea (i.e. in international waters, beyond 12 nautical miles from the coast). We also note that the MOD and other Government departments may develop future uses of the adjacent

[51] By constitutional convention the Crown is not bound by the prohibition in the Act which makes transmission without holding a wireless telegraphy licence a criminal offence

[52] In doing so, we are restricted by concerns related to national security which prevent public disclosure of some systems and their parameters.

bands, and note the possibility that such future uses may also carry some risk of interference into the award bands.

4.7 The information in this section has been provided to us by the MOD and other Government users, albeit working in collaboration with Ofcom. It is based on analysis and studies carried out by the MOD, other Government users, or their contractors. Ofcom is therefore unable to give assurances concerning the correctness and completeness of this source information. However, having worked closely with relevant departments in the development of this analysis, we agree with the interpretation of the studies regarding the likely risk of interference to new uses within the award bands.

4.8 The MOD studies considered that interference occurs to an LTE base station when signal levels received at the base station cause an interference to noise ratio (I/N) of greater than -6dB. This leads to a 1dB desensitisation (noise rise) of the base station. In the context of these particular frequency bands and the types of Crown use we have been considering, we have taken this as a broad benchmark of interference. The calculation is based on thermal noise plus a noise figure of 5dB. This is consistent with parameters typically used in CEPT studies and takes into account the self-interference already present in a single frequency network. If a greater desensitisation is acceptable to a licensee then the risk of unacceptable interference will be reduced. We have indicated the impact of this in certain cases in this section.

4.9 The MOD has an ongoing programme of remediation of its systems from the award bands and some adjacent channels in order to ensure that any significant interference is not caused from new uses in the award bands to its systems or from its systems to new uses in the award bands. Irrespective of the ongoing risks of interference described in this section, these uses ceased by 31 March 2016 in most cases.

4.10 If it is of interest, Ofcom can facilitate more detailed bilateral discussions between the MOD and licensees after the award. This may assist in planning and deploying networks to minimise the risk of interference from MOD and other Government users. Licensees in the award bands must provide personnel with appropriate security clearance in order to view information on the relevant systems.

4.11 Finally, we note that under the terms of their licences, 2.3 GHz and 3.4 GHz licensees have to comply with coordination procedures to protect MOD use. The impact of those coordination procedures on deployments is set out in Section 5.

Assumptions

4.12 In order to meet the requirement for out-of-block emissions below 2340 MHz, additional filtering (when compared to a standard base station) is likely to be required. We have assumed in the analysis presented in this section that any additional filters will be located within the base station such that they also provide additional filtering in the uplink path. This will lead to increased receiver selectivity below 2350 MHz compared with the assumptions used within ECC Report 172 for coexistence analysis. The MOD analysis informing this section has been based on

the assumption that 10dB per 10 MHz below 2350 MHz (but with a maximum of 30dB) of additional filtering is achievable[53].

Reducing interference

4.13 Additionally, equipment vendors or operators may choose to have improved receiver performance of their base stations in either band in order to facilitate greater spectrum sharing, irrespective of the adjacent band neighbours. In most cases any risk of interference from other public sector uses can be reduced with improved selectivity characteristics.

4.14 Local site engineering such as antenna height, orientation and pattern can also have an important part to play in reducing any possible risk of interference to new uses in the award bands. If licensees avoid pointing base station antennas directly at public sector uses then any risk of interference can be significantly reduced.

2.3 GHz band

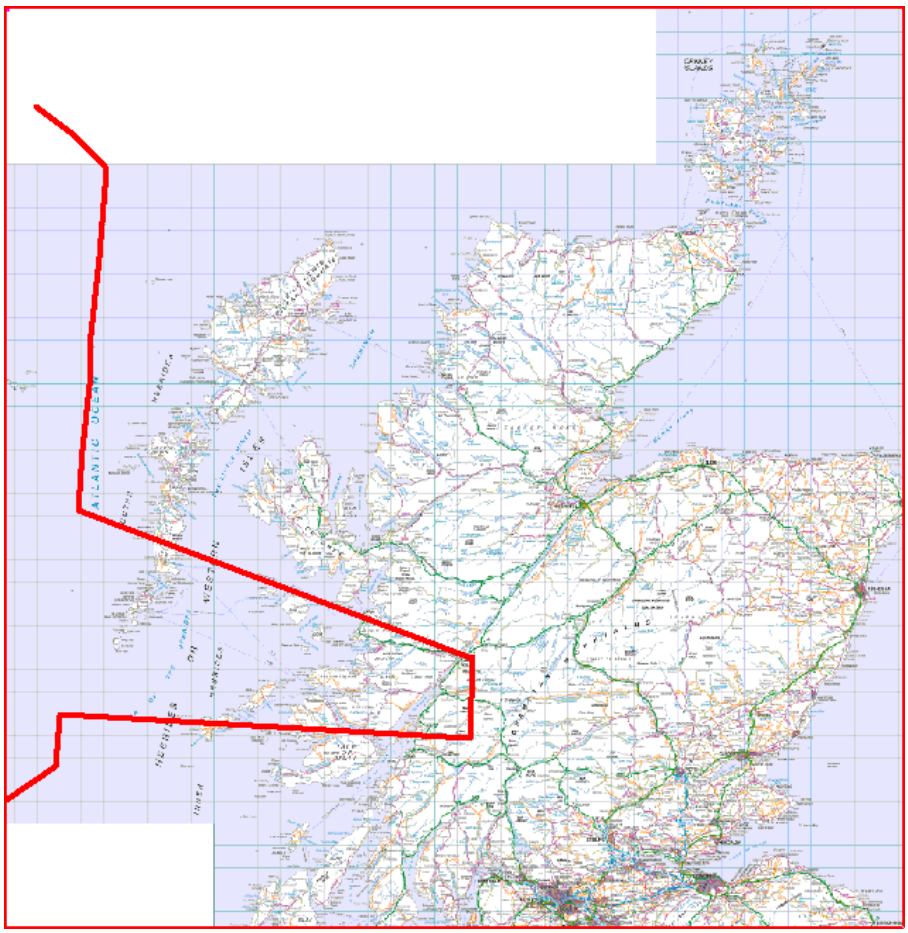
Co-channel

4.15 As discussed further in section 5 below, the MOD will retain a small amount of spectrum use within the 2350 to 2360 MHz band at its test range near to the Hebrides. This is for an airborne telemetry system of 5W EIRP. The transmissions conform to IRIG 106 specifications[54]. MOD estimates that this system will be used around six times a year for approximately 30 – 60 minutes on each occasion. Flights will occur on the approach into and within the Hebrides test range (the area enclosed by red in Figure 4.1 below). In addition, there will be an initial ground based test at Warton of this system for approximately one minute duration prior to each of these flights.

[53] Report 172 assumes an adjacent channel selectivity (ACS) of 46dB and a second ACS of 54dB. For a 20 MHz LTE channel, with a filter in place, a combined selectivity of 84dB has been assumed for MOD transmissions on or below 2320 MHz.

[54] http://www.irig106.org/

Figure 4.1: Hebrides test range and approach corridor: area to the west of the red line



4.16 To protect this, the MOD uses the coordination procedure with which licensees will be required to comply under their 2.3 GHz licence (described more fully in annex 6). This requires coordination of base stations that are a distance up to 225km away from St Kilda. In addition, the Outer Hebrides, Isle of Skye and the Small Isles are excluded from the 2.3 GHz licence.

4.17 During the flight times referred to in paragraph 4.15, interference may be caused in the form of desensitisation to base stations up to 300km from the airborne system (which may itself be anywhere within the Hebrides range and associated flight corridor – see area to the west of the red line in Figure 4.1). The coordination requirement referred to in paragraph 4.16 is likely to lead to a greater degree of antenna discrimination within the coordination area, and therefore the impact should be no more than a few dB of noise rise for the flight duration.

Adjacent bands

4.18 There are a number of MOD systems remaining in the bands adjacent to the 2.3 GHz spectrum being awarded. Those that are relevant are broadly described below under the categories of land based and airborne systems.

Land based systems

4.19 There are three locations around the coast of Great Britain that are used for electromagnetic compatibility (EMC) testing of MOD systems. One location uses spot frequencies that are co-channel with the award band as well as adjacent to it. The

other locations do not have any transmissions within the 2.3 GHz award band. In all cases the transmit antenna is pointing out to sea and transmissions are of a narrowband nature, and in some cases are pulsed radar transmissions.

4.20 Testing occurs for around 2-3 days at a time. In total there are approximately twenty five tests per year spread across the locations, although no more than six tests make use of frequencies within the award band. In addition, frequencies that are close to or within the award band are used as part of a much larger set of test frequencies. Therefore the dwell time on an individual frequency is limited.

4.21 All transmissions occur in an infrequent manner and are only likely to have an intermittent localised affect at most.

4.22 In addition to EMC testing, there are a number of land based systems using spectrum below 2350 MHz and above 2390 MHz. These typically operate at a few metres above ground with an EIRP of 30 - 32dBm. A small number may transmit at up to 42dBm EIRP but these have a greater frequency separation from the award band. There remains a limited risk of interference to a base station within a few hundred metres of these sites.

Emergency Services Air to Ground and gateway communications

4.23 The Emergency Services are considering making use of 2340 to 2350 MHz for two-way communications between the ground and airborne assets. This network would use an LTE (5 MHz) carrier centred on 2345 MHz. They are also considering the use of 2340 to 2350 MHz or 2390 to 2400 MHz for vehicle mounted gateway small cells (gateways) to improve network coverage in the vicinity of emergency services vehicles.

4.24 The proposed associated technical parameters for 2345 MHz are in line with those for the award band with a number of exceptions. Bidders should be aware of the following relevant exceptions:

- Emissions above 2350 MHz will not exceed -36dBm/5 MHz except in the case of indoor small cells;
- Except in the case of indoor small cells, the network will be required to align its frame with LTE systems in the award band and use frame structure B (Figure 4.2). The Home Office has indicated to us that it believes it will be likely to use TD-LTE configuration 1 (a 2:2 ratio).

Figure 4.2: Frame structure B

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

The proposed associated technical parameters for gateways (if they are used) are in line with those for the award band with a number of exceptions. Bidders should be aware of the following relevant exceptions:

- Gateways will only be operational when emergency services vehicles are stationary. Further details can be found at https://www.ofcom.org.uk/__data/assets/pdf_file/0032/96566/Statement-EE-

application-for-licence-variations-in-support-of-enhanced-mobile-communications-for-the-emergency-services.pdf

- Emissions in either 2340 to 2350 MHz or 2390 to 2400 MHz will not exceed 43dBm / 5 MHz

- the network will be required to align its frame with LTE systems in the award band and use frame structure B (Figure 4.2); the Home Office has not yet indicated to us its preferred frame structure but it is likely to use TD-LTE configuration 1 (a 2:2 ratio) or 2 (the same as the award band).

4.25 The Emergency Services network would not be required to comply with the same Frame Structure requirements as the 2.3 GHz licensees. Nor would it be required to agree or comply with any changes to those requirements.

Airborne systems

4.26 There are a number of airborne systems providing telemetry in air to ground or air to air configurations. These airborne systems have been categorised below as flights limited to localised areas and flights that are UK wide.

4.27 Parties considering bidding in this award should consider the following general points in their analysis of the impact of these systems:

- Many applications have wide coverage areas but the majority of the time they avoid built up areas.

- The majority of systems are below 2340 MHz, although there are a small number of systems above 2390 MHz.

- Airborne transmissions can and do operate at a range of heights and periods throughout the day.

- Aircraft speeds (MOD analysis was based on 600 knots) mean that any interference or reduction in SINR at the base station is for a limited period of time.

Flights limited to localised areas

<u>Around MOD test ranges at Aberporth and Hebrides</u>

4.28 A number of airborne systems are used in the test Ranges at Hebrides (St Kilda) and Aberporth. The main flight areas are indicated in Figure 4.3 (Aberporth - bounded by red line) and Figure 4.1 (Hebrides – area to west of the red line) and may transit into these Ranges from MOD airbases, in particular Warton (near Blackpool). These systems operate in the lower part of 2.3 GHz as well as above 2390 MHz with an EIRP of around 5 watts.

4.29 With the exception of the co-channel system described in paragraph 4.15 above, these are unlikely to cause any degradation to any LTE base stations with additional filtering below 2340 MHz. Where the base station selectivity is not better than the assumptions used in ECC Report 172 then there could be interference to LTE base stations when the airborne systems are at or below approximately 1000 feet. Care should be taken when locating base stations close to MOD used airfields to avoid

interference from these systems below 1000 feet – during take-off and landing. Currently these flights occur at Warton, although very occasional use is possible at other airfields.

Figure 4.3: MOD test range at Aberporth

Around Warton and Boscombe Down

4.30 Warton and Boscombe Down airfields are home locations for some airborne systems transmitting with EIRPs of up to 10 Watts. Each location typically supports a single aircraft (although on occasions this may increase to two).

4.31 Neither system is likely to cause any significant interference to LTE base stations that have additional filtering below 2340 MHz. Where the selectivity is not better than the assumptions used in ECC Report 172 then there could be interference to LTE base stations when the airborne systems are at or below approximately 1000 feet. These altitudes are classed as “low flying” and tend to occur only close to the airfields in question.

UK wide flights

4.32 Telemetry systems on MOD aircraft will continue to use spectrum adjacent to the award band. These systems are used for up to 8 hours a day, 5 days a week and consist of transmissions within one timeslot of around 1 to 2 millisecond duration per aircraft. The nature of these transmissions means that each aircraft transmission has a duty cycle of 3-6% depending on the system. Aircraft may fly anywhere in the UK. These systems operates the majority of the time above 5000 feet altitude and modelling was undertaken based on an aircraft speed of 600 knots (300m per sec). Each system (described below) will typically be in use on between 5 and 15 in-flight aircraft at any one time and the systems are deployed on different aircraft.

4.33 There are three systems that have the following parameters:

- System A: Peak power of 125W with occasional 160W burst with 3% duty cycle per aircraft
- System B: Peak power of 50W with 6% duty cycle per aircraft
- System C: Peak power of 22.7W with 5% duty cycle per aircraft

4.34 MOD aircraft using these telemetry systems fly from the following MOD locations: RAF Coningsby, RAF Leeming, RAF Lossiemouth, RAF Leuchars, RAF Marham, RAF Lakenheath, RAF Valley, and Teeside. Other airfields are used on an occasional basis.

4.35 When modelling the potential impact of these airborne systems on LTE receivers, the MOD analysis assumed an equivalent impact from a lower power but continuous signal based on the system duty cycle. On this basis, with the exception of one system described below, the impact to LTE in typical MOD flight scenarios is negligible. However, bidders should be aware that some base station desensitisation may occur during the "on" part of the MOD transmission but that on average over the whole duty cycle the impact will be low. Additionally there remains a very localised risk when MOD systems are at low altitude (below 2500 feet) and with multiple aircraft in an area. This may be particularly the case during take-off, landing and in close proximity to MOD airfields. Licensees are therefore advised to consider any impact before deploying in close proximity to any MOD airfields.

4.36 System A will use an additional frequency above 2390 MHz commencing in 2017. In this situation it is considered that the risk of interference to LTE systems will be higher for the following reasons.

- It is unlikely that there will be significantly better base station receiver selectivity than the ECC Report 172 assumptions as no additional downlink filtering will be needed.
- One example measurement of a single LTE device undertaken by Ofcom suggest that the effect of an MOD signal within the adjacent 10 MHz to the award band has a greater impact on LTE performance than an equivalent lower power continuous signal.

4.37 Nevertheless, as this system operates the majority of its time above 5000 feet altitude and with a speed of 600 knots (300m per sec), the equivalent of a few dB desensitisation may be experienced for a few 10s of seconds as an aircraft flies overhead, although this will depend on the base station antenna pattern in the vertical direction.

3.4 GHz bands

Co-channel

4.38 The MOD has one ground-based radar system that operates from either Portland or Applecross (on the west coast of Scotland) that will continue to transmit twice a year across much of the 3.4 GHz award band. The transmit antenna is highly directional and pointing out to sea during its typical use.

4.39 There remains some theoretical risk of interference to base stations located around the coast from these locations or on the islands opposite and to the south of

Applecross. However, the MOD will need to limit the impact to its system from LTE base stations transmissions and therefore the antenna is unlikely to be pointed directly at any high power base stations, therefore minimising any risk of interference to LTE as well. It is anticipated that ultimately transmissions in this band will cease, although the timescale is unclear at this stage.

Adjacent bands

4.40 There are a number of MOD systems remaining in the adjacent band to the 3.4 GHz spectrum being awarded. Those that are relevant are broadly described below under the categories of land based, radar and other airborne systems.

Land based systems

4.41 There are two locations around the coast of Great Britain that are used for EMC testing of MOD systems. In both cases the transmit antenna is pointing out to sea and transmissions are pulsed radar transmissions.

4.42 Testing occurs for around 2-3 days at a time. In total there are approximately 25 tests per year spread across the locations. However frequencies that are close to the award band are used as part of a much larger set of test frequencies. Therefore the dwell time on an individual frequency is limited.

4.43 Both locations do not have any transmissions within the 3.4 GHz award band. All transmissions occur in an infrequent manner and are only likely to have at most an intermittent localised effect.

Radar systems

4.44 The MOD operates a number of radar systems below 3410 MHz. These include ground-based air traffic and test range control radars, shipborne Navy radars and an airborne radar system.

4.45 The locations of fixed air traffic control radars are protected by the coordination procedure specified in annex 8 and therefore bidders should expect radar transmissions from these locations. Occasional use is also made of transportable systems although these are usually located close to MOD facilities or are shipborne. There are a small number of radar systems associated with operations within MOD test ranges.

4.46 Navy radars are predominantly shipborne. However there are a small number of land-based systems that complement the Navy capability. Any shipborne system operating above 3100 MHz is not permitted to radiate within 5km of the UK coastline. There are occasional exceptions where limited transmissions for calibration and maintenance purposes are permitted in the Portsmouth area (see annex 5 for the exact locations). However, in these circumstances there are restrictions placed on transmissions to limit all or some of power, elevation and azimuth.

4.47 The MOD operates an airborne radar system. Its parameters are similar to airborne system A in “Recommendation ITU-R M.1465-2”[55], which describes an approximation to its parameters.

[55] https://www.itu.int/rec/R-REC-M.1465/en

Other airborne systems

4.48 There are a small number of airborne systems in the adjacent band below 3410 MHz, which are unlikely to cause any significant interference. However, a helicopter-borne system at 100m altitude in very close proximity to a base station may cause a noise rise of 2 to 3dB.

Section 5

The licences

Introduction and summary

5.1 In this section we summarise some of the licence conditions we will include in the licences to be awarded to the winning bidders. The drafting of the licences has changed since the publication of our statement and consultation in May 2015 (see https://www.ofcom.org.uk/__data/assets/pdf_file/0027/68337/Public_Sector_Spectrum_Release_statement.pdf). The changes do not affect the terms of the licences but are designed to improve clarity. There are five types of licences available in the Auction:

- A licence for use of frequencies in the 2.3 GHz band (an example template for this type of licence is set out at annex 1).
- A licence for use of frequencies in the 2.3 GHz band in respect of withdrawn auction bids. This licence is offered to any bidder who withdraws a bid in the auction, if that withdrawal results in spectrum being unallocated. The licence is similar to the standard 2.3 GHz licence except for the fee that is payable. Details are set out in the Auction Regulations (an example template for this type of licence is set out at annex 2).
- A licence for use of frequencies in the 3.4 GHz band (an example template for this type of licence is set out at annex 3).
- A licence for use of frequencies in the 3.4 GHz band in respect of withdrawn auction bids. This licence is offered to any bidder who withdraws a bid in the auction, if that withdrawal results in spectrum being unallocated. The licence is similar to the standard 3.4 GHz licence except for the fee that is payable. Details are set out in the Auction Regulations (an example template for this type of licence is set out at annex 4).
- A replacement licence for 3.4 GHz frequencies currently held by UK Broadband Limited. In addition to applying for other licences, the pre-existing 3.4 GHz licence holder may apply for the grant of a licence for 40 MHz of contiguous 3.4 GHz spectrum to replace the current non-contiguous blocks at 3480-3500 MHz and 3580-3600 MHz. The manner in which this is dealt with in the Auction is set out in the Auction Regulations, and in section 8 of this document (an example template for this type of licence is set out at annex 5).

5.2 For the avoidance of doubt the licences will not guarantee exclusive use of the spectrum awarded. In the future, we may grant additional authorisations to allow the use of all, or part, of the spectrum, including the spectrum that is the subject of this Award Process. Such authorisation may occur, for example, by way of the grant of new licences, decisions as to the variation of existing licences, or decisions as to exemptions from licensing. We would develop and consult on the conditions of use under any such additional authorisations in order to manage the risk of harmful interference.

5.3 The licences will contain only those technology and usage restrictions that are in our view proportionate and necessary for spectrum management reasons to manage the risk of harmful interference and to ensure compliance with our statutory duties and

international obligations. It should be noted, however, that the services that a licensee intends to offer may be constrained by regulation of downstream services (at retail or wholesale level) such as the General Conditions of Entitlement under the Communications Act 2003 and other legislation. Potential bidders should seek their own advice in this regard.

5.4 The licences will be awarded under the WT Act. Each licence grants the licensee the right to establish, install and use radio equipment in accordance with specific technical parameters set out in the licence for an indefinite term (see paragraph 5.8). The licence also sets out the conditions that apply to the licensee in respect of:

- The circumstances in which we may revoke the Licence (see paragraph 5.10)
- Licence variation (see paragraphs 5.11 to 5.12);
- Fees (see paragraphs 5.14 to 5.15); and
- Modification, restriction and closedown (see paragraphs 5.17 to 5.18).

5.5 We explain below in paragraphs 5.23 to 5.29 how spectrum trading applies to the licence.

5.6 We have not summarised all of the licence terms in this section, and in particular have not summarised the technical parameters to be included in the schedule to the licences. However, draft template licences are annexed to this Memorandum as set out at 5.1 above (we have made some changes to the structure of the schedule to the annexes. These are intended to improve the drafting but not to change the legal effect).

5.7 We note that, as further discussed in section 8, the pre-existing 3.4 GHz licence holder may apply for a licence to replace its current licence at 3480-3500 MHz and 3580-3600 MHz. The licence conditions discussed in this section do not reflect any specific conditions attached to the pre-existing licensee's replacement licence as a result. Those are discussed in section 8 and reflected in the draft licence available at annex 5.

Term, revocation and variation

5.8 Each licence will have an indefinite term and will continue in force from the date of grant until revoked by Ofcom or surrendered by the licensee.

5.9 There will be limited rights of revocation during an initial term (the Initial Term) of 20 years. After the Initial Term, Ofcom will be able to revoke the licence for spectrum management reasons, provided we have given the licensee at least five years' notice. As set out in the licences in annexes 1-5, the 5 years' notice can be given after the relevant date in 2032.

5.10 The licence can also be revoked, including during the Initial Term, in the following circumstances:

- At the request or with the consent of the licensee;
- If there has been a breach of any of the terms of the licence;

- If it appears to be necessary or expedient to do so in the interests of national security or for the purpose of complying with an international obligation of the UK;
- If it appears necessary or expedient to do so for the purpose of complying with a direction by the Secretary of State to us under Section 5 of the Communications Act 2003 or Section 5 of the WT Act;
- If the licensee has not complied with any requirement of any relevant trading regulations; or
- If the licensee has not complied with certain requirements of the regulations.

5.11 Where we propose to vary or revoke a licence, we must follow the procedure in paragraphs 6, 6A and 7 of Schedule 1 to the WT Act. The notice under the WT Act must state the reasons for the proposed variation or revocation and specify a period during which the licensee may make representations, or where the notice relates to a failure to observe licence conditions, meet those licence conditions.

5.12 Any variation of the licence will be in accordance with the requirements of the WT Act.

Changes to licensee's details

5.13 The licensee must give prior notice to us in writing of any proposed changes to the licensee's name and address.

Sum payable for the licence

5.14 The sum payable in respect of each licence will be determined through the Award Process in accordance with the Regulations.

Licence fee after the Initial Term

5.15 Licensees will be liable to pay additional licence fees in respect of the licences if they continue to hold them after the end of the initial 20 year period. The level of these fees will depend on our general approach to fees for the use of spectrum at the relevant time, and how that general approach relates to these licences and to our statutory duties at that time. The level of the fees cannot therefore be determined now. Note that we would expect to give prior notice of our specific proposals to charge fees, and to consult as appropriate, before fees are introduced.

Access and inspection

5.16 Licensees will be required to permit any person authorised by Ofcom to have access to and to inspect the radio equipment specified in the licence at all reasonable times (or, when an urgent situation arises, at any time) to ensure that the licensee is using the radio equipment in accordance with the conditions of the licence.

Modification restriction and closedown

5.17 We may require the radio equipment or any part of it to be modified, restricted in use or temporarily or permanently closed down if:

- A licensee has breached the terms of its licence; and/or

- Use of radio equipment is or may be causing or contributing to undue interference to the operation of other authorised radio equipment.

5.18 We may also require the radio equipment to be modified, restricted in use or temporarily or permanently closed down if it appears to be requisite or expedient to do so in the event of a national or local state of emergency. We 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.

Territorial extent of licences

2.3 GHz

5.19 Subject to any restrictions imposed by any coordination procedures, including those listed at paragraph 5.33 below, the licences will permit use within Great Britain, but not Outer Hebrides, the Isle of Skye and the Small Isles. The licences do not extend to Northern Ireland, the Channel Islands and Isle of Man. They also exclude use in the territorial sea and any inland waters adjacent to the territorial sea, but in the case of streams, rivers or other watercourses which form part of such inland waters, the licences only exclude use where these are more than 2km wide.

5.20 As explained in section 9, Ofcom will issue licences to use the band in territorial sea on a first come first serve basis following coordination with the MOD.

3.4 GHz

5.21 Subject to any restrictions imposed by any coordination procedures, including those listed at paragraph 5.33 below, the licences will permit use within the UK. For the avoidance of doubt, the UK excludes the Channel Islands and the Isle of Man. The licences also exclude use in the territorial sea and any inland waters adjacent to territorial sea, but in the case of streams, rivers or other watercourses which form part of such inland waters,the licences only exclude use where these are more than 2km wide.

5.22 As explained in section 9, Ofcom will issue licences to use the band in territorial sea on a first come first served basis following coordination with the MOD.

Spectrum trading

5.23 A licensee cannot assign its licence to another party, but it may transfer the rights and obligations to another person under the spectrum trading regime. We began the implementation of spectrum trading for selected licence classes in 2004, through the Wireless Telegraphy (Spectrum Trading) Regulations 2004[56] (the Spectrum Trading Regulations)[57]. The Spectrum Trading Regulations introduced the possibility for licensees in specific classes to carry out:

- Outright total transfers, i.e. transfers of all of the rights and obligations arising under a licence to a third party;

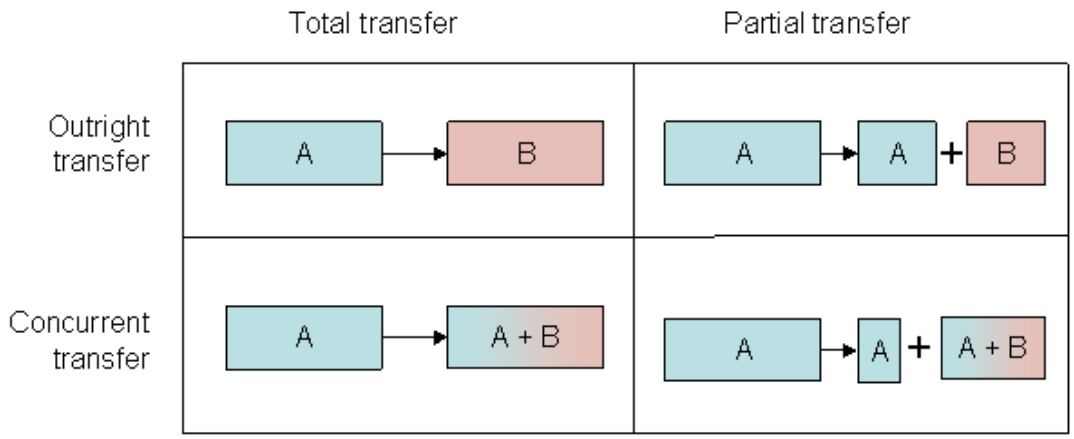
[56] http://www.legislation.gov.uk/uksi/2004/3154/contents/made

[57] http://www.legislation.gov.uk/all?title=The%20Wireless%20Telegraphy%20%28Spectrum%20Trading%29%20Regulations%202012

- Concurrent total transfers, i.e. transfers of all of the rights and obligations arising under a licence to a third party which result in a concurrent holding of those rights and obligations by the transferor and the transferee(s);
- Outright partial transfers, i.e. outright transfers of some of the rights and obligations arising under a licence to a third party; and
- Concurrent partial transfers, i.e. transfers of some of the rights and obligations arising under a licence to a third party which results in a concurrent holding of those partial rights and obligations by the transferor and the transferee(s).

5.24 Figure 5.1 illustrates these four generic types of transfer.

Figure 5.1 Illustration of some possible types of transfer



Source: Spectrum Trading Guidance Notes

5.25 We describe this process as 'transfer' because the spectrum access rights are transferred by the grant of a new licence.

5.26 The Spectrum Trading Regulations did not extend to the 900 MHz, 1800 MHz and 2100 MHz bands. On 20 December 2010, the Secretary of State made a Direction pursuant to Section 5 of the WT Act, which among other things required us to make new regulations to extend trading to these bands. The Wireless Telegraphy (Mobile Spectrum Trading) Regulations 2011 (the Mobile Spectrum Trading Regulations) came into force on 4 July 2011[58].

5.27 We have amended[59] the Mobile Spectrum Trading Regulations to extend their provisions to the 1400 MHz, 2.3 GHz and 3.4 GHz bands[60], so that:

[58] http://www.legislation.gov.uk/2011/1507

[59] https://www.ofcom.org.uk/__data/assets/pdf_file/0026/83942/statement_making_of_trading_regs_1.4-2.3-3.4_ghz.pdf

[60] Spectrum covered by the Mobile Spectrum Trading Regulations as amended by the Wireless Telegraphy (Mobile Spectrum Trading) (Amendment) Regulations 2015 (SI 2015/1339) is 791-821 MHz, 832-862 MHz, 880-915 MHz, 925-960 MHz, 1452-1492 MHz, 1710-1781.7 MHz, 1805-1876.7 MHz, 1899.9-1980 MHz, 2110-2170 MHz, 2350-2390 MHz, 2500-2690 MHz and 3410-3600 MHz.

- The rights and obligations under licences in these bands will be tradable;
- Our consent will be required for a transfer; and
- Before giving consent we may undertake an *ex ante* competition check.

5.28 In 2011 we introduced a new type of trading called 'spectrum leasing', in which spectrum could be accessed by entering into a lease with a licensee without obtaining a new licence from Ofcom. Currently, leasing is permitted for a limited set of licence classes - Area Defined Business Radio licences, Suppliers Light Business Radio licences and some licences awarded following an auction. We have not yet considered whether to extend this policy to licences covered by the Mobile Spectrum Trading Regulations. We may consider this at a future date.

5.29 We provide guidance on our website on the spectrum trading process[61].

Non-technical restrictions on use

5.30 We do not propose to impose any non-technical restrictions on the use to which the spectrum could be put in the licences (such as specifying the type of service that should be offered, the technology that should be deployed or the equipment that should be used).

Coordination Procedures

5.31 Licensees will be required to comply with coordination procedures referred to in schedule 1 of the licence and notified to them by Ofcom from time to time.

5.32 These coordination procedures specify signal power limits or power flux densities at certain locations, that must not be exceeded, based on a methodology that must be followed in determining if a 2.3 or 3.4 GHz deployment will exceed those thresholds. Deployments of base stations or fixed terminal equipment that exceed the specified thresholds must not proceed without the agreement of the operator of the protected site. Ofcom will make the necessary introductions.

5.33 Ofcom intends to notify all relevant licensees of the following coordination procedures at the time of initial grant of licences:

- Coordination procedures for 2.3 GHz licensees with respect to MOD systems. A draft of the Notice is annexed to this Memorandum at annex 6. This includes a procedure for ensuring that interference is not caused to systems operating in Northern Ireland (which is not part of this award);
- Coordination procedures for 3.4 GHz licensees with respect to MOD systems. A draft of the Notice is annexed to this Memorandum at annex 7;
- Aeronautical Radar coordination procedure for 3.4 GHz licensees. A draft of the Notice is annexed to this Memorandum at annex 8;

[61] See https://www.ofcom.org.uk/__data/assets/pdf_file/0029/88337/Trading-guidance-doc-jul15v0-1-2.pdf

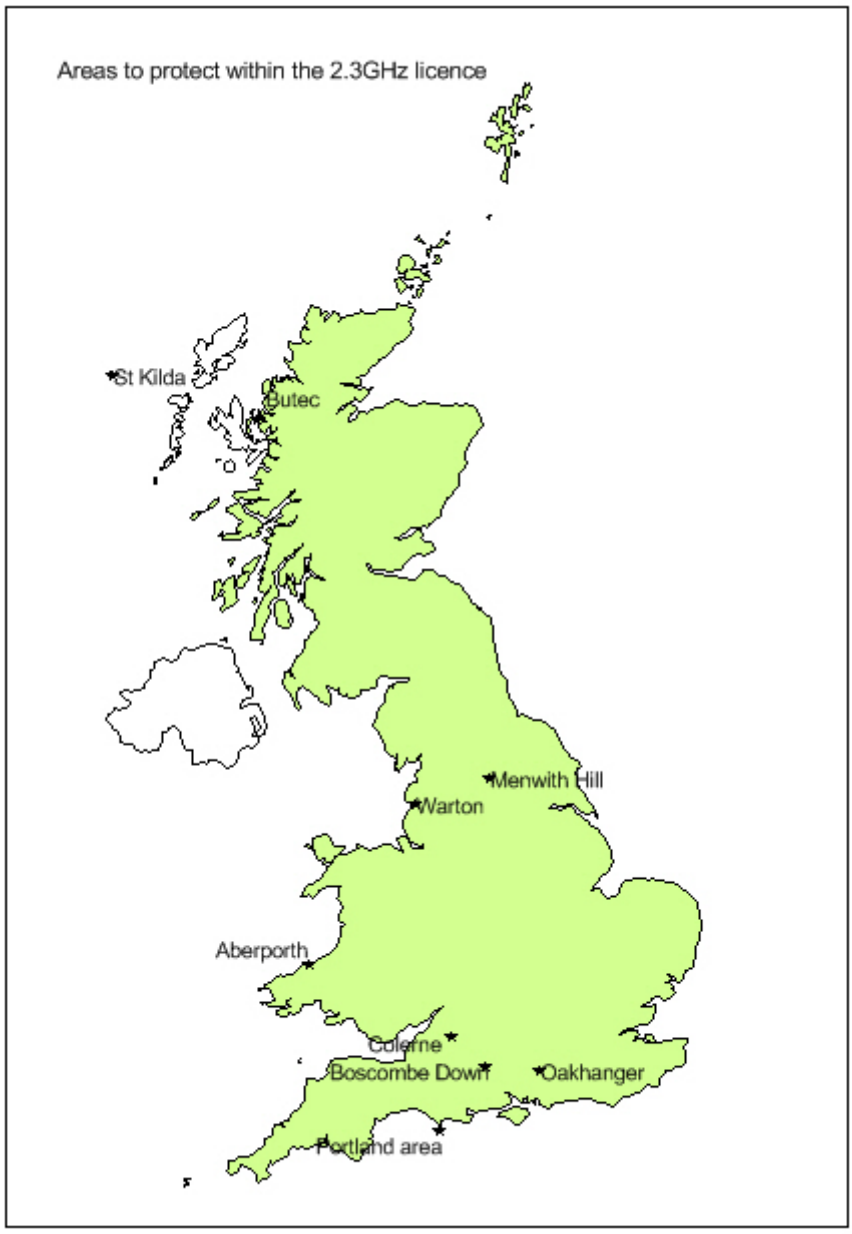
- International coordination arrangements. Memoranda of understanding (MoU) with each of France, Ireland and the Isle of Man are referred to in annex 9 of this Memorandum.

5.34 In addition, 2.3 and 3.4 GHz licensees will be required to comply with certain frame structures as discussed further in paragraph 5.62 and as specified in Schedule 1 of the relevant licence.

5.35 The information in this section on coordination requirements with respect to MOD uses has been provided to us by the MOD, albeit working in collaboration with Ofcom. It is based on analysis and studies carried out by the MOD. Ofcom is therefore unable to give assurances concerning the correctness and completeness of this source information. However, having worked closely with the MOD in the development of this analysis, we agree with the interpretation of the studies regarding the likely impact to new uses within the award bands of the coordination requirements as presented in this section.

2.3 GHz band national coordination requirements

Figure 5.2: 2.3 GHz coordination locations (green colouring shows licence area)



5.36 2.3 GHz licensees will be required to comply with coordination procedures to protect MOD use in the following locations (as set out in more detail in the coordination procedure at annex 6 and shown in Figure 5.2 above):

- Up to 225 km from St Kilda for deployed sites in 2350 to 2360 MHz (the area of the Outer Hebrides, the Isle of Skye and the Small Isles are not included as part of the 2.3 GHz Award);
- A small coastal area around Aberporth, West Wales;
- Up to 5km of Oakhanger, Colerne and Menwith Hill;
- Up to 10km of Boscombe Down and Warton;

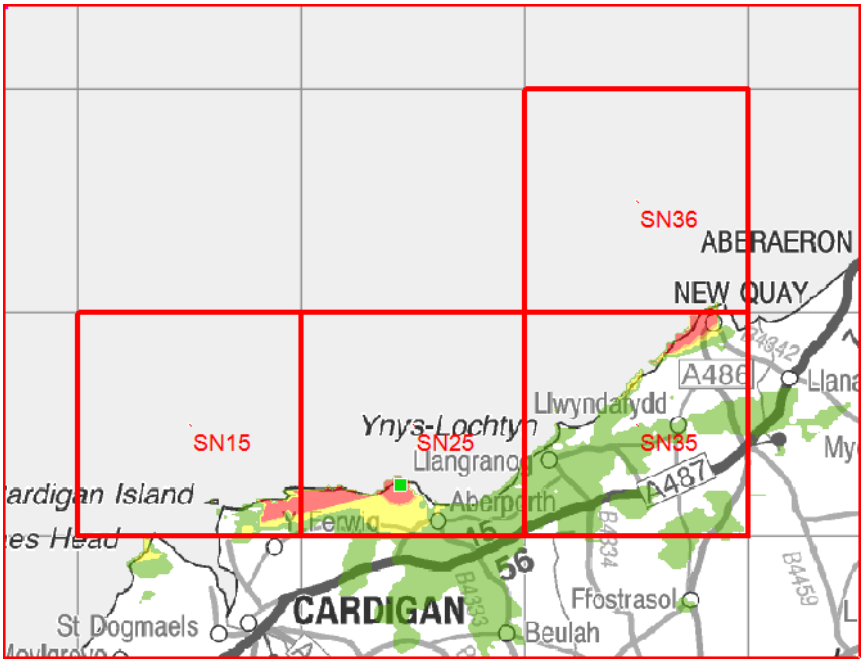
- Coastal areas around Portland and BUTEC (near Applecross in Scotland);
- Northern Ireland (Northern Ireland is not included as part of the 2.3 GHz award).

5.37 Licensees must undertake calculations which are required by these coordination requirements within the calculation areas described in annex 4. These calculation areas have been determined based on the assumption of high power base stations with antennas pointing directly at the MOD locations. In practice this may not be the case, in which case the likely constraints on the licensees' deployments will be over a smaller area. The following paragraphs describe the likely impact of these coordination requirements.

5.38 The impact of the coordination zone around St Kilda means that network deployments in parts of NW Scotland are likely to require careful deployment of locations and antennas in order to use the shielding effect of the local terrain. In some cases close to the west coast of Scotland antennas may need to point away from St Kilda or have transmit powers reduced. However, this is unlikely to have a significant impact on the available services that can be offered in that area.

5.39 The coordination zone around Aberporth is unlikely to cause any significant restrictions on deployments in practice. In a few cases within about 20km along the coastal strip near Aberporth, this is likely to mean that local site engineering should be sufficient to ensure that deployments can take place. Careful selection of antenna directions, downtilt and powers may be required within this area (as highlighted in the red and yellow areas of Figure 5.3).

Figure 5.3: Coordination zones around Aberporth



5.40 The coordination zones around Oakhanger, Colerne, Menwith Hill, Boscombe Down and Warton are unlikely to cause any significant restrictions on deployments in practice. Within 5 to 10km of each site, this is likely to mean that local site engineering should be sufficient to ensure that deployments can take place. Careful selection of antenna directions, downtilt and power may be required within this area.

5.41 The coordination requirements around Portland and BUTEC are related to ongoing MOD remediation of Royal Navy systems and will expire at the end of 2020 and 2023

respectively. During the coordination period there may be some restrictions to deployments within the coastal area between Dartmouth and Southampton (including parts of the Isle of Wight) and in the coastal area either side of Applecross in Scotland. This is particularly the case for deployments on higher ground in these areas.

5.42 The coordination requirements to protect public sector systems in Northern Ireland are the same as the international coordination requirement for the Republic of Ireland referred to in paragraph 5.33 and detailed in annex 9. We therefore consider that this is unlikely to cause any significant additional restrictions to deployments in practice.

5.43 Any risk that MOD systems will interfere with new uses in the 2.3 GHz award band is described in section 4.

3.4 GHz band national coordination requirements

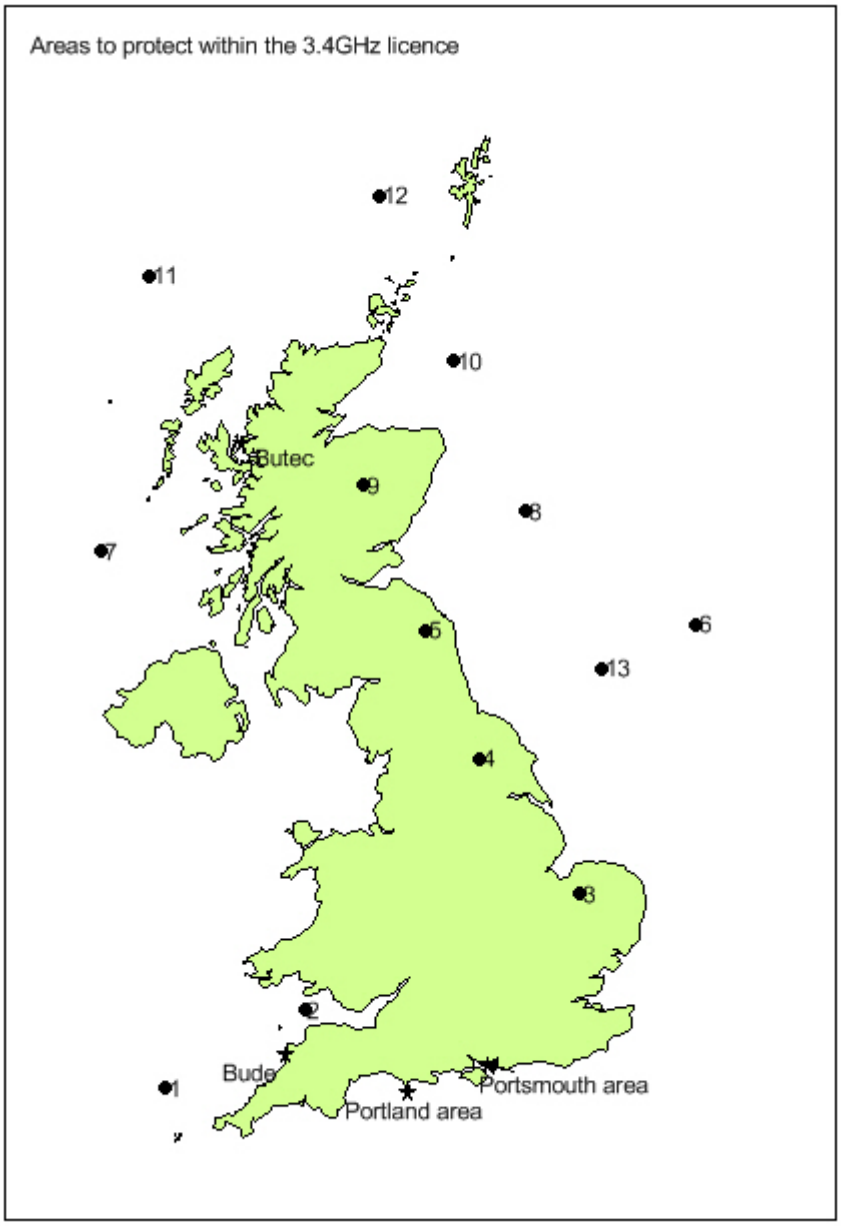
MOD use

5.44 3.4 GHz licensees will be required to comply with coordination procedures to protect MOD use in the following locations, as set out in more detail in the coordination procedure at annex 5 and shown in Figure 5.4 below:

- Up to 25km of Bude,
- Around Portsmouth and some coastal areas around Portland and BUTEC
- At 13 airborne radar locations around the UK

5.45 Licensees must undertake calculations which are required by these national coordination requirements within the calculation areas described in annex 7. These calculation areas have been determined based on the assumption of high power base stations with antennas pointing directly at the MOD locations. In practice this may not be the case, in which case the likely constraints on the licensees' deployments will be over a smaller area. The following paragraphs describe the likely impact of these coordination requirements.

Figure 5.4: 3.4 GHz coordination locations including airborne locations (# 1-13)



5.46 The coordination requirements around Bude are likely to cause some restrictions to 3.4 GHz deployments within approximately 5km of the MOD location. Out to 25km from the site, this is likely to mean that local site engineering should be sufficient to ensure that deployments can take place. Careful selection of antenna directions, downtilt and powers may be required within this area.

5.47 The coordination requirements around Portsmouth are likely to expire in the future, although the timing is currently uncertain. These coordination requirements will be reviewed three years after the award. The MOD analysis suggests that the coordination requirements around Portsmouth are unlikely to cause any significant restrictions on deployments in practice. In a few cases within a few km of each site, this is likely to mean that local site engineering should be sufficient to ensure that deployments can take place. Careful selection of antenna directions, downtilt and powers may be required within this area.

5.48 The coordination requirements around Portland and BUTEC are related to ongoing MOD remediation and will expire at the end of 2020 and 2023 respectively. The MOD analysis shows that during the coordination period there should not be any significant restrictions to deployments in practice. Careful selection of base station power along with antenna directions and downtilt may be required within the coastal area between Dartmouth and Southampton (including parts of the Isle of Wight) and in the coastal area either side of Applecross in Scotland.

5.49 MOD has an airborne system which operates below 3410 MHz, which will need to be filtered in order to afford it protection from uses in the 3.4 GHz award band. Prior to remediation being finalised, the MOD's operation may be impacted in situations where 3.4 GHz licensees' total power flux density (pfd) at the MOD's airborne locations exceeds a level approximately equivalent to -58 dBm / m^2 / 5 MHz. Licensees will therefore be required to ensure that the pfd at 13 airborne locations does not exceed -58 dBm / m^2 / 5 MHz, using the methodology described in annex 5.

5.50 MOD has now confirmed that the coordination requirements around the 13 airborne locations will expire at the end of 2018.

5.51 In light of the anticipated development of the 3.4 GHz ecosystem and network rollout, it is not expected that the restrictions on a licensee as a result of the coordination requirement will significantly impact the use of the spectrum. The exact impact will depend upon licensee's deployment scenarios including: density of deployed base stations and their locations, actual EIRP, frequency used and bandwidth transmitted.

5.52 As illustration of the impact of the coordination requirement, we have considered three possible deployment scenarios and the restrictions on such deployments resulting from the coordination requirement. However, potential bidders should undertake their own analysis as to the impact of this requirement on their intended use of the spectrum.

5.53 First, a licensee could deploy 3.4 GHz as capacity spectrum on an existing network with a phased approach. Our analysis of this scenario assumed that a network was deployed using a single 20 MHz carrier on all sectors (but that the licensee had acquired at least 40 MHz). We also assumed that the phased approach meant that the density of base stations deployed by March 2018 within urban areas (as representative of a worst case situation)[62] would be around 10 – 20% of that existing 3G network. In this scenario, base station powers of at least 55 dBm/ 5 MHz (61 dBm / 20 MHz) should be possible. This scenario applies in the case of a high power urban deployment only.

5.54 Second, a licensee could deploy a network in more rural areas (such as for rural broadband services). In such a case, the density of base stations in a given radar sector will be considerably lower and the base station power could be higher than 55 dBm / 5 MHz. The exact power would depend on the proposed network and bidders should use the coordination procedure in annex 7 of this Memorandum in order to calculate what those restrictions (if any) on network design will be.

[62] Our analysis has shown that the radar beams which are orientated towards urban environments are affected by the largest number of base stations. Licensees will then need to reduce their base station powers more in these areas to still comply with the total PFD requirement.

5.55 Third, a licensee could deploy a network of small or indoor cells (ETSI define this equipment as having a maximum EIRP of 30 – 35 dBm[63]). In such case, the coordination requirement is highly unlikely to cause any restrictions.

5.56 MOD has indicated that it is willing to discuss ways of making the coordination requirement more flexible in relation to specific airborne locations with individual licensees. Ofcom will facilitate those discussions. For the avoidance of doubt, licensees may only exceed the pfd threshold set out in the coordination agreement in relation to a specific airborne location following agreement with the MOD.

5.57 Any risk that MOD systems will interfere with new or existing users in the 3.4 GHz band is described in section 4.

ATC radar

5.58 3.4 GHz licensees will be required to comply with coordination procedures to protect civil and military ATC radars, and a small number of air defence radars, operating in the 2.7 GHz band in the UK. The list of radars is published on the Ofcom website and may be periodically updated and reissued by Ofcom[64]. A link is provided in the Notice of coordination in annex 8 of this Memorandum, along with full details of the process that must be followed. This process has now been simplified compared to the one applicable to deployments in the 2.6 GHz band to apply on a per base station basis only. 3.4 GHz licensees must ensure that their deployment is able to comply with the threshold in relation to all of the area over which the radar could be located which is limited by the airfield boundary.

5.59 We would expect spectrum availability in the 3.4 GHz band to be good, similar to that of the 2.6 GHz band which we described in our July 2012 Information Memorandum[65]. The propagation losses will be slightly higher for 3.4 GHz. However, the permitted transmit power is also 4dB higher for 3.4 GHz. The radar remediation programme discussed in the July 2012 Information Memorandum is now complete and so a separation distance of up to approximately 1.5 km for a base station operating at full licence power might be required to prevent interference to radars. However, this depends on the out of band emissions from the base station. If these emissions are higher than the assumptions that we have made, then there may be some restrictions up to 7 km (the distance over which coordination calculations in annex 8 must be undertaken).

5.60 We commissioned a study as part of our 2.6 GHz award to consider specifically deployment of LTE mobile services at airports. In July 2011, we published the Airport Deployment Study[66], which considered the potential airport deployments of mobile broadband technology in the 2.6 GHz band and its potential interference impact on nearby radars operated in the S-band. The results indicate deployments of radio equipment in the 2.6 GHz band are feasible with sensible measures by both parties in and around airports. We would expect the results for the 3.4 GHz band to be similar and these measures may be able to be relaxed further as there is a greater frequency separation between 3.4 GHz systems and the radar bands than between 2.6 GHz and the radar bands.

[63] We assume a 6 – 11 dBi antenna is used with a a Local Area base station defined in 3GPP TS 36.104 (Release 10) http://www.etsi.org/deliver/etsi_ts/136100_136199/136104/10.02.00_60/ts_136104v100200p.pdf
[64] When a new radar is deployed, it will need to take account of existing deployment in the 3.4 GHz band. 3.4 GHz Licensees will not be required to adjust the technical parameters of base stations that have already been deployed.
[65] http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/IM.pdf
[66] http://www.ofcom.org.uk/static/spectrum/Airport_Deployment_Study.pdf

5.61 Any risk that aeronautical radars will interfere with new or existing users in the 3.4 GHz band is described in section 3.

Conditions relating to the synchronisation of networks

5.62 Licensees will be required to synchronise their networks in order to avoid interference to one another. The details of the parameters for synchronisation that licensees will need to adhere to can be found in Schedule 1 to the licences in annexes 1-5. Figure 5.5 provides a high level overview of the requirements.

Figure 5.5 Overview of synchronisation requirements

Band	Synchronisation procedure
2.3 GHz	We mandate identical frame structures. Licensees must use the mandated or equivalent frame structure. All licensees can therefore use the permissive mask. This means there is certainty of the frame structure of an adjacent licensee. Specific rules for small cells are also set out in schedule 1 to Annexes 1 and 2.
3.4 GHz	We mandate traffic frame alignment and the requirements for certain sub-frames but not a fully identical frame structure. We permit licensees to use the permissive mask if they are using the specified or equivalent frame structure. If they are not using the frame structure specified in the licence, they must use the restrictive mask. This means that a licensee may change its frame structure without agreement from the neighbour, however this could result in two adjacent licensees operating on different frame structures, one with the permissive mask and one with the restrictive mask. Specific rules for small cells are also set out in schedule 1 to Annexes 3 and 4.

Coverage obligation

5.63 None of the licences will include a coverage obligation. However, use of this spectrum may be used to contribute to meeting obligations, in other licences, for providing a level of service and coverage across the UK.

Provision of information to facilitate optimal spectrum use

5.64 A condition in the licence will require licensees to provide us, on request, with certain specified information regarding their use of radio equipment, including information to facilitate ad hoc access to spectrum by PMSE in order to meet demands arising from peak events.

Section 6

Spectrum packaging and reserve prices

Introduction

6.1 This section sets out the spectrum lots that will be available in the Award Process and the reserve price for each lot.

Available spectrum

6.2 As already noted, the frequencies being awarded comprise 40 MHz of spectrum at 2350 to 2390 MHz and 150 MHz of spectrum at 3410 to 3480 MHz and 3500 to 3580 MHz.

6.3 40 MHz of spectrum in the 3.4 GHz band is already licensed for mobile use. This spectrum is made up of two non-adjacent 20 MHz spectrum blocks at 3480 to 3500 MHz and 3580 to 3600 MHz. These frequencies may be added to the frequencies to be allocated in the assignment stage. More details are contained in section 8 of this document.

Categories and lots

6.4 There will be two lot categories in the principal stage of the auction. One category will comprise the 2350 to 2390 MHz spectrum (the 2.3 GHz band) and the other will comprise the 3410 to 3480 and 3500 to 3580 MHz spectrum (the 3.4 GHz band).

6.5 Each category will consist of a number of generic lots; that is, in the principal stage, bids for lots in a category will relate not to specific frequencies within the corresponding band, but to lots of unspecified frequencies within that band. The lots will each comprise 10 MHz in the 2.3 GHz band and 5 MHz in the 3.4 GHz band.

6.6 The specific frequencies awarded to each winner in the principal stage of the auction will be determined in the assignment stage.

Reserve prices

6.7 The reserve price for each lot in the 2.3 GHz band category will be £10 million and the reserve price for each lot in the 3.4 GHz band category will be £1 million.

Section 7

The Award Process

Introduction

7.1 The Award Process will be conducted in accordance with the Auction Regulations, which set out the Award Process in detail. We have published a Notice of Ofcom's proposal to make regulations in connection with the award of 2.3 GHz and 3.4 GHz spectrum alongside this document. The Notice is a consultation on the draft Auction Regulations (https://www.ofcom.org.uk/__data/assets/pdf_file/0021/103827/Notice-of-proposal-to-make-regulations-in-connection-with-the-award-of-2.3-GHz-and-3.4-GHz-spectrum.pdf). Following the consultation, the final Regulations will be published on our website and will also be available at www.legislation.gov.uk. They include details of constraints on the amount of spectrum which can be bid for during the process.

7.2 Anyone making or considering making an application for a spectrum licence by bidding in the auction should read and understand the rules of the Award Process as set out in the Regulations. The information in this section should be read in conjunction with the Regulations. If there is any discrepancy between this Information Memorandum and the Regulations, the Regulations are definitive and will prevail.

7.3 The purpose of this section is to provide a short description of the Award Process, particularly in relation to timing, the electronic auction system and certain other practical matters.

Summary of Award Process

7.4 In summary, the auction process will be as follows:

- Interested persons are required to apply for the grant of a licence;
- Applicants need to qualify to participate in the Award Process. An applicant may be disqualified where Ofcom determines that it is not fit to hold a licence. An applicant will also be unable to qualify if a member of its bidder group (i.e. a related company) is also a member of the bidder group of another applicant;
- The first stage of the auction is the principal stage, consisting of a number of rounds. The principal stage results in the determination of the winning principal stage bids and the base price for each winning principal stage bid;
- The second stage of the auction is the assignment stage, whereby specific frequencies are assigned to principal stage winning bidders. In addition, we may also assign new frequencies to the pre-existing licence holder in the 3.4 GHz band, as further discussed in Section 8. The assignment stage results in the determination of the winning assignment stage bids and the additional price for each winning assignment stage bid;
- The final stage is the grant stage, whereby Ofcom grants licences to winning bidders.

Expected Timings

7.5 The Regulations do not impose a timetable for the Award Process, but in this section Ofcom provides some guidance as to the time periods that it currently expects to apply to the various stages of the Award Process. We currently expect applications for the auction to take place in late September/October 2017 with initial deposits at that time. Further deposits will be required in late October/early November 2017 when eligibility points will be determined, with bidding commencing shortly thereafter.

Start of the Award Process

7.6 The Award Process may only begin after the Regulations have come into force. The Regulations state the date when they come into force.

7.7 We will publish a notice of the deadline for applications on the Ofcom website.

Questions and answers before the deadline for applications

7.8 Any party interested in participating in the Award Process may submit questions in writing to Ofcom in relation to any aspect of the Award Process. Questions should be submitted at least five business days before the provisional deadline for applications. We will indicate a provisional deadline when we publish a Statement on the making of the Auction Regulations. We will aim to respond to all questions at least two business days before the deadline for applications. Questions should be sent by email to PSSR.award@ofcom.org.uk.

7.9 Our normal manner of responding to a question will be by email. We will then consider whether to publish a copy of the question and of any response, in whole or in part, on the Ofcom website. In doing so, we will not normally identify the person who has asked the question without their consent. Any person not wishing any part of their question to be published, should clearly mark the relevant part(s) "Confidential" and we will take this into account in deciding whether and what to publish.

Application Stage

7.10 We will publish on the spectrum awards section of the Ofcom website the details of the application procedures, including the time period for delivery of application forms as well as the deadline for and guidance on the payment arrangements for the initial deposit of £100,000.

7.11 In exceptional circumstances, we may be required to change the day, time or place for delivery of application forms or the payment of the initial deposit. We will take reasonable steps to inform interested parties of a change.

7.12 When it applies, the applicant should specify whether it wishes to have a minimum spectrum requirement of 10, 15 or 20 MHz in the 3.4 GHz band.

7.13 We will grant applicants access to some features of the bidder and auctioneer interface through a version of the software that will be used in the auction. We expect login details and a user manual for the electronic auction system to be sent by email to applicants the day after they submit their application. Applicants will need digital certificates to be able to login to the software at this stage, although these will be different from those used in the actual auction. Details will be provided in the email. Unless they are disqualified, or withdraw their applications within the period allowed for such withdrawals, applicants will be able to use the software to run internal mock auctions and training throughout the auction. Training may also be organised by Ofcom.

Qualification Stage

7.14 We expect to notify each applicant of the names and associates of each other applicant shortly after the application day. This notification will also set a deadline by which applicants must notify us of whether or not any members of their applicant group are also associates of another applicant or are also an applicant. In such cases, applicants must also notify the other applicant(s) concerned. We expect applicants will have about two business days to complete this exercise.

7.15 In parallel with this exercise, we will also consider whether any members of one applicant group are also members of another applicant group.

7.16 If it appears to us that a member of one applicant group is also a member of another applicant group, we will notify the applicants and ask them to resolve any common memberships. We expect applicants will have five business days to do so.

7.17 In determining whether applicants are qualified to bid in the Award Process we will take into account whether the applicant or any member of its applicant group is receiving or attempting to receive services in relation to the Award Process from anyone who has provided or is providing services to Ofcom in relation to the Award Process. For these purposes the advisers to Ofcom in connection with certain aspects of the Award Process hitherto appointed (others may be added to this list nearer to the auction) are DotEcon Ltd, Copenhagen Economics, Cramton Associates LLC, Auctionomics, KPMG, NIIT Technologies and NCC Group.

7.18 We expect to record the details of each bidder's applicant group (for the purposes of determining which applicants have qualified) as soon as reasonably practicable after expiry of the period for resolving any common memberships.

7.19 We expect to determine which applicants have qualified to bid in the Award Process within approximately 12 business days after recording details of the applicant groups.

Preparations for the Principal Stage

7.20 Once we have qualified applicants as bidders, and after the time allowed for withdrawals, we will:

- Notify each bidder of passwords and make available to each bidder digital certificates required to access and use the electronic auction system and verify its identity (these will be changed for the actual auction);
- Notify each bidder of the bidder training arrangements;
- Notify each bidder of the deadline by when bidders may pay additional deposits, and details of the relevant bank account.

Principal Stage Rounds

7.21 We will give each bidder at least 15 minutes' prior notice before the start of each principal stage round by making an announcement via the electronic auction system. The duration of each principal stage round is expected to be 30 or 60 minutes, but we may announce in advance of a round that it will be of a different duration.

7.22 There is no limit on the number of principal stage rounds that may be held on a business day. Ofcom may decide not to hold any principal stage rounds on a

business day. We will give further guidance on the scheduling of rounds before the start of the principal stage rounds.

Notification of the outcome of principal stage

7.23 Bidders will be notified of the outcome of the principal stage following the last round of that stage.

Assignment stage

7.24 There will be at least one clear business day between the conclusion of the principal stage and the start of the assignment stage. We expect that the assignment stage will take place on a single business day and last for at least two hours, but no more than seven hours.

Granting the licences

7.25 We will determine the outcome of the assignment stage in accordance with the Regulations and will notify bidders. Licences will be granted only after receipt by Ofcom of any sums owing.

Submission of principal stage or assignment stage bid forms in exceptional circumstances

7.26 This sub-section relates to the submission of either a principal stage bid form (which may include bids, withdrawals or a waiver) or an assignment stage bid form. Where a bidder is unable to make a submission using the electronic auction system (see below) because of technical failure (or an event or circumstance with similar effect on that bidder's ability to use the electronic auction system), the bidder may seek permission to make a submission by an alternative method for a specific round. If Ofcom gives permission, the bidder must make the submission to us by an alternative method. Any submission by that bidder via the electronic auction system after we have granted permission to use the alternative method will not be accepted. In these circumstances, submissions by an alternative method must be received by the date and time specified. The results of the round will only be processed once we receive the bidder's submission.

7.27 Submissions by an alternative method must comply with any requirements relating to the authentication of communications made by the alternative method that are notified to that bidder by Ofcom.

7.28 Further guidance on this will be provided before the start of the principal stage.

Electronic auction system

7.29 Both the principal stage and the assignment stage will be conducted using an electronic auction system. Bidders will be able to access the system over the public internet using a standard web-browser. The minimum requirements in terms of hardware and software are described in a user manual distributed to bidders after their application is submitted. However, these requirements will not be onerous – a typical PC running Windows and using Internet Explorer or Firefox or an Apple Mac using Safari or Firefox should usually be sufficient.

7.30 Bidders will need to have a reliable internet connection (512Kbit/s download speed or better). We recommend that bidders have at least one backup computer and a backup internet connection in place for the duration of the auction.

7.31 Bidders will each have their own electronic security details to connect to the electronic auction system and will need to ensure that these details are not disclosed to third parties. In the event of any actual or suspected breach of security, bidders should contact us at the earliest opportunity.

7.32 The electronic auction system only allows a bidder to be logged in from one computer at any one time.

7.33 The electronic auction system allows bidders to make submissions and observe the progress of the auction, including the number of completed rounds; whether a round is currently running; and a countdown timer for making submissions when deadlines are in force. It also displays a clock synchronised with the auction server. Deadlines apply according to the time submissions are received at the server, not the time they are sent from the bidder's computer. Therefore, it is prudent for bidders to make submissions in good time prior to the end of each round to allow for network delays. Submissions are not processed by the electronic auction system and results are not released until after the end of each round, so there is no strategic advantage to bidders in delaying submissions.

7.34 Making submissions during the principal stage using the electronic auction system involves a two-step checking and confirmation process. The electronic auction system will check that each submission is consistent with the Regulations. If not, the bidder will be given an explanation of the problem and be returned to the relevant screen to allow further editing. If consistent with the Regulations, the electronic auction system will return a summary of the principal stage submission, which can then be submitted. If a bidder checks a principal stage submission but fails to submit it, the bid will not be considered.

7.35 The electronic auction system will provide summaries of each bidder's own submissions and also a history of round prices and any information to be disclosed about aggregate demand (in accordance with the Regulations). Downloadable files of a bidder's own bids and of the auction history will be provided for transferring data to other software applications. These will be available in native Excel and comma separated value (.CSV) formats.

7.36 The electronic auction system provides a one-way messaging system that allows us to send notices to bidders. This will be our primary means of communicating with bidders about round schedules, deposit increase deadlines and other aspects of the Award Process. If bidders need to contact us, they will need to do so in accordance with the Regulations. We will provide specific contact details before the start of the principal stage.

Ofcom events related to the Award Process

7.37 We will undertake remote training for bidders on the use of the electronic auction system, if this is required. This is in addition to applicants having access to a version of the software to run internal mock auctions and training.

Payment of Deposits and Ofcom's Bank Account

7.38 Any sum payable by an applicant or bidder must be paid into the bank account specified by Ofcom, with accompanying information which identifies that applicant or bidder the value and date paid. We will publish on the spectrum awards section of the Ofcom website (http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-in-progress/) details of the bank account into which deposits must be paid.

7.39 The Regulations set out when we may or will require deposit payments. We expect to give bidders at least one full business day to pay a deposit into Ofcom's bank account. After the auction has concluded, any excess funds placed on deposit in Ofcom's auction account, i.e. funds not subsequently required for payment in connection with the auction, will be returned to bidders. Any interest earned on deposits will be paid to HM Treasury.

Section 8

Pre-existing 3.4 GHz licence holder

8.1 UK Broadband Limited currently holds a licence for 40 MHz of spectrum made up of two non-adjacent 20 MHz spectrum blocks at 3480 to 3500 MHz and 3580 to 3600 MHz. On 6 February 2017 it was announced that UK Broadband Limited would be acquired by H3G (Three), subject to the agreement of the Competition and Markets Authority (CMA). The agreement was cleared by the CMA on 3 May 2017 and completed on 31 May 2017.

8.2 The pre-existing 3.4 GHz licence holder may apply for the grant of a licence for 40 MHz of contiguous 3.4 GHz spectrum to replace the current licence (a 'replacement licence'). As further explained below, the specific eight lots to be included in its replacement licence (the replacement lots) would be determined by bidding in the assignment stage. If the pre-existing licence holder applies for a replacement licence, it is required to commit to surrendering the current licence upon grant of the replacement licence.

8.3 That licence holder may also participate in the principal stage. If it acquires additional lots in the principal stage, it will bid for assignment stage options which include both the eight replacement lots and any additional lots acquired in the principal stage. However, in such a case, Ofcom would grant two licences: the replacement licence for the replacement lots, and a separate licence for the additional lots. In such a case, the additional price payable by the licence holder, which reflects the bids made in the assignment stage, would be part of the licence fee payable for the licence for the additional lots.

8.4 If the licence holder does not participate in the principal stage (or does not acquire any additional lots), it can participate in the assignment stage and bid for assignment stage options which include the eight replacement lots. In such a case, any additional price payable by the licence holder would be part of the licence fees payable for the replacement licence. The pre-existing licence holder will also pay annual licence fees from 17 July 2018 for the replacement licence.

8.5 In light of the above, if the pre-existing licence holder applies for a replacement licence, 30 lots will be available in the principal stage, whereas 38 lots will be available in the assignment stage.

8.6 For further details, please refer to the Auction Regulations, which are published alongside this Memorandum.

8.7 If the pre-existing licence holder applies for a replacement licence, and is assigned different frequencies from its current holding, it will be allowed six months under temporary arrangements to move to the new frequencies. If another licensee wins spectrum held at present by the pre-existing licence holder , the pre-existing licence holder and the new licensee(s) will be required to co-operate to protect the pre-existing licence holder's services during that period.

8.8 A draft template of the replacement licence is attached as annex 5. Any licence for additional lots in the 3.4 GHz band will be granted on the same conditions as licences granted to other bidders in this award.

Section 9

Additional matters

Ofcom's approach to the regulation of the radio spectrum

9.1 Radio spectrum is a major asset to the UK, providing a critical input to a wide range of services including mobile communications, television and radio broadcasting services, emergency services and aeronautical communications and many more. By enabling this array of applications, spectrum use delivers substantial benefits to citizens and consumers.

9.2 Two Acts of Parliament give Ofcom responsibility for managing UK spectrum[67]. Because our decisions have significant long term impacts on spectrum use, it is important that we take a strategic approach to managing this valuable resource. It is also important that we help stakeholders plan their own spectrum use by providing guidance on the nature of the regulatory action we expect to take over the coming five to 10 years.

9.3 Our approach to managing spectrum is set out in our Spectrum Management Strategy[68]. This begins by explaining the context within which our strategy has been developed. It then draws attention to those aspects of our spectrum management approach on which we expect to place greater emphasis. Finally, it identifies six sector-focused priorities which we expect to be a particular focus for regulatory action.

9.4 The strategy is summarised in Figure 9.1 overleaf.[69].

Annual licence fees for mobile spectrum licences

9.5 Our spectrum pricing policy is set out in our revised Framework for Spectrum Pricing[70] (the SRSP 2010). This notes that where we license spectrum, we employ one of three mechanisms for setting fees for rights to use the frequencies: auctions; cost based pricing, and administered incentive pricing (AIP).

9.6 Spectrum access rights granted via auctions – such as the rights to use the newly available 2.3 and 3.4 GHz frequencies - are subject to payment of a sum determined through the Award Process itself. They are not subject to additional fees until after the end of the initial licence term. We will consider what fee level to apply at that time, and once we impose a fee, payment is usually required annually.

9.7 Accordingly, no additional annual licence fees will apply to the 40 MHz of spectrum being auctioned in the 2.3 GHz band or the 150 MHz of newly available spectrum being auctioned in the 3.4 GHz band before the expiry of the initial 20 year licence term.

[67] The Communications Act 2003 and the Wireless Telegraphy Act 2006. These Acts also include provisions for the UK Government to direct us in the execution of our spectrum functions under certain conditions.
[68] http://stakeholders.ofcom.org.uk/consultations/spectrum-management-strategy/statement/
[69] www.gov.uk/government/uploads/system/uploads/attachment_data/file/287994/UK_Spectrum_Strategy_FINAL.pdf
[70] http://stakeholders.ofcom.org.uk/binaries/consultations/srsp/statement/srsp-statement.pdf

9.8 The 40 MHz of spectrum in the 3.4 GHz band that is already licensed for mobile (3480 to 3500 MHz and 3580 to 3600 MHz) is in a different situation to the new frequencies being auctioned in the same band. Until now, this holding has not attracted annual licence fees because it was awarded through an auction in 2003. The initial licence term in that case was for 15 years, expiring in July 2018 and annual licence fees will be payable from that date.

9.9 In October 2014, Ofcom agreed to extend the licence for an indefinite period[71]. In doing so we said that annual fees based on AIP principles should apply from the current expiry date. We said we would consider the level of this fee nearer the time, but that bids and prices in the new 3.4 GHz award were expected to provide a good indication of the opportunity cost of spectrum at the time of the auction. We said this would be relevant for us to take into account, along with any other relevant evidence, when we consider the appropriate level of annual fees to apply from 2018. Accordingly, the fee provisions of the licence have been modified to read as follows:

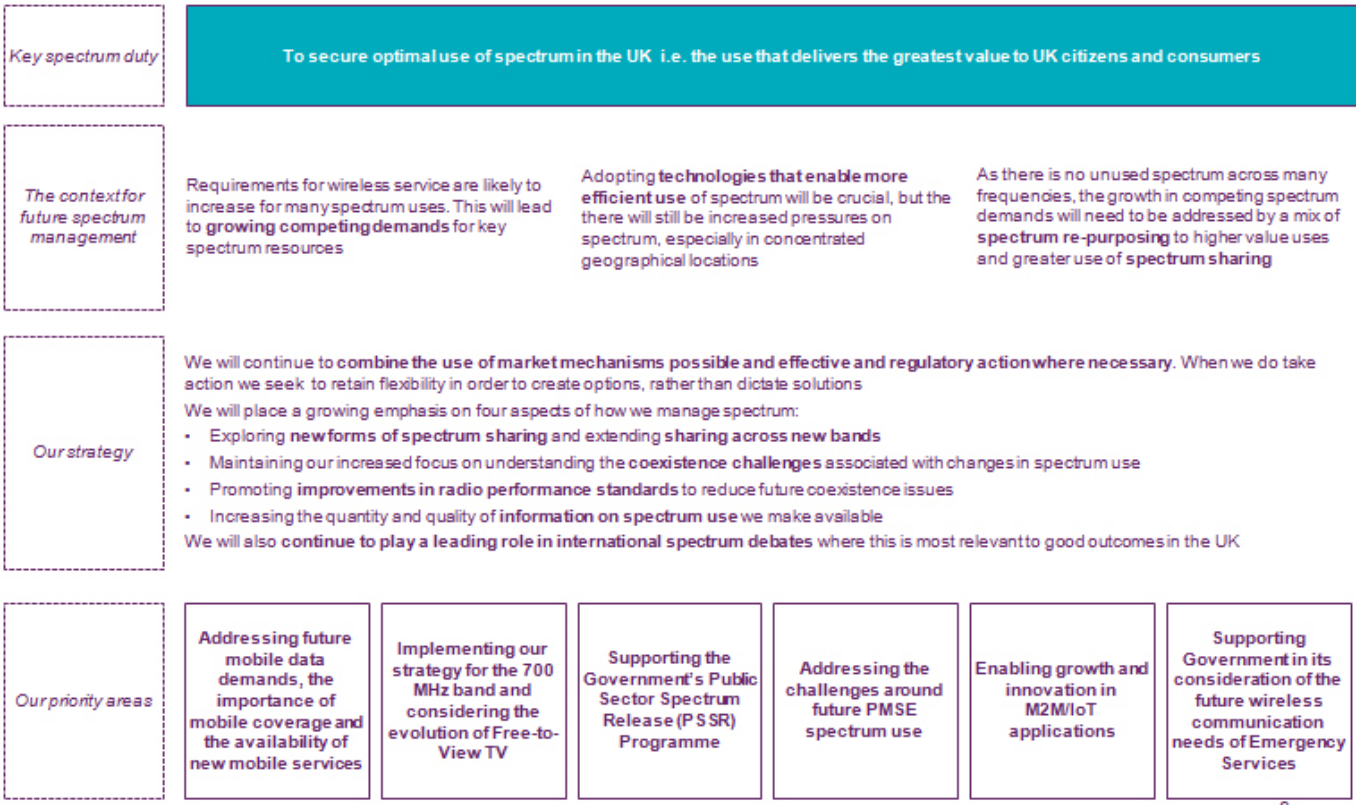
> *"From 17 July 2018, the Licensee shall each year pay to Ofcom the relevant fee as provided under section 12 of the Act and regulations made thereunder on or before the fee payment date, or on or before such dates as shall be notified in writing to the Licensee, failing which Ofcom may revoke this Licence."*

9.10 If the licence holder is awarded a new licence for 40 MHz of contiguous spectrum in the 3.4 GHz band, annual licence fees will remain due from July 2018 for such spectrum.

9.11 If the specific frequencies held under the existing licence are subsequently acquired in the assignment stage of the auction by one or more other parties under new licences, then those frequencies will not attract fees before the expiry of the initial 20 year licence term i.e. licence fees payable from 17 July 2018 will apply to the current licence holder only.

[71] http://stakeholders.ofcom.org.uk/binaries/consultations/uk-broadband-licence/statement/UK_Broadband_Statement.pdf

Figure 9.1: Ofcom's Spectrum Management Strategy



Licensing position in other spectrum bands that are used for mobile communications

9.12 The following spectrum bands are licensed in the UK for mobile communications services:

- 791-821 MHz and 832-862 MHz (the 800 MHz band);
- 880-915 MHz paired with 925-960 MHz (the 900 MHz band);
- 1452-1492 MHz (the 1400 MHz band or 'L' band);
- 1710-1781.7 MHz paired with 1805-1876.7 MHz (the 1800 MHz band);
- 1781.7-1785 MHz paired with 1876.7-1880 MHz (the concurrent 1800 MHz band; sometimes referred to as the DECT Guard Band). Use of this band is constrained by low power and height restrictions;
- 1900-1920 (1900 MHz band unpaired);
- 1920-1980 MHz paired with 2110-2170 MHz (2.1 GHz paired);
- 2570-2620 (2.6 GHz unpaired)
- 2620-2690 paired with 2500-2570 (2.6 GHz paired)
- 3480-3500 MHz and 3580-3600 MHz (UK Broadband's 3.4 GHz holding)

9.13 Details of current mobile spectrum holdings are as set out in the table below.

Figure 9.2: Spectrum licensed for mobile communicationswhich is covered by the mobile trading regulations[72]

Band	BT/EE	Telefónica	H3G	Vodafone	UKB
800 MHz	10	20	10	20	-
900 MHz	-	34.8	-	34.8	-
1400 MHz SDL	-	-	20	20	-
1800 MHz	90	11.6	30	11.6	-
1900 MHz unpaired	10	5	5.1	-	-
2.1 GHz paired	40	20	29.5	29.6	-
2.6 GHz unpaired	25	-	-	25	-
2.6 GHz paired	100	-	-	40	-
3.4 GHz		-	-	-	40*
Total	275	91.4	94.6	181	40

*As noted UK Broadband and its associated mobile spectrum was acquired by H3G. However, its spectrum currently remains licensed to UK Broadband Limited.

N.B. Figure 9.2 identifies all spectrum licensed for mobile and includes frequencies not included as 'relevant' with respect to calculations for the purpose of mobile spectrum caps for the 2.3 and 3.4 GHz auction. Details of relevant spectrum are included in the Auction Regulations.

9.14 The 900, 1800 and 2.1 GHz bands have been liberalised and are now licensed for 2G, 3G or 4G. The 1900 MHz unpaired band is liberalised for 3G or 4G.

Other licences

9.15 Subject to coordination with MOD on a case by case basis, Ofcom will permit the use of the 2.3 and 3.4 GHz bands in UK territorial sea through individual offshore licences issued to users on a first come first served basis, as requested. Any system must not cause harmful interference to deployments in the rest of the UK. In order to achieve this, these licences will contain a specific provision which requires that the field strength at the UK coast must not exceed 30 dBµV/m/5 MHz for 2.3 GHz systems or 32 dBµV/m/5 MHz for 3.4 GHz systems. These values are in line with those for un-synchronised systems contained in international coordination recommendations from ECC (ECC/REC/ (14)04[73] and ECC/REC/ (15)01)[74].

9.16 There are a number of offshore licences granted already for example, to oil exploration platforms or to offshore windfarms, including in the 2.3 or 3.4 GHz bands and further applications are either in progress or likely to be received in future which will also be coordinated with MOD.

Public Sector Spectrum Release (PSSR)

9.17 The award of the 2.3 and 3.4 GHz bands is part of the Government's Public Sector Spectrum Release (PSSR) programme. In October 2010, the Government announced its intention to free up at least 500 MHz of public sector spectrum below 5

[72] Excluding the concurrent 1800 MHz band
[73] http://www.erodocdb.dk/Docs/doc98/official/pdf/REC1404.PDF
[74] http://www.erodocdb.dk/Docs/doc98/official/pdf/REC1501.PDF

GHz for mobile communication uses, including mobile broadband.[75]. This target was subsequently increased in the 2016 Budget to *"750MHz of valuable public sector spectrum in bands under 10GHz will be made available by 2022, of which 500MHz will be made available by 2020".* The level of demand for mobile spectrum is identified in our May 2014 Mobile Data Strategy statement[76], amongst other places.

9.18 Updates on the progress of the PSSR programme have been published by the Government. The latest publication was in April 2016.[77]

9.19 In addition to releases of cleared spectrum, the PSSR programme involves plans to enable sharing of public sector used spectrum with civil users. Ofcom is working with the MOD to look at the potential for making spectrum available in a number of bands including those noted in the Government's recent PSSR programme update; 380 to 385 MHz paired with 390 to 395 MHz, 406.2 to 430 MHz, 5350 to 5470 MHz, 5725 to 5850 MHz, 7900 to 8400 MHz, 4800 to 4900 MHz, 2300 to 2350 MHz and 1427 to 1452 MHz. Investigation into these bands is at various stages but it is unlikely that any which are to be made available for mobile could be awarded for at least the next three years.[78]

9.20 As we noted in the April 2014 statement 'The future role of spectrum sharing for mobile and wireless data services', the 2.3 GHz band is currently in a period of transition, while government users redeploy their equipment to other frequencies.[79] We are now working with MOD to explore the potential for civil and defence users to make available additional spectrum below the 2350 MHz range on a time limited basis and/or in limited geographic areas. Such opportunities remain uncertain at this stage and in any case will not be awarded for at least three years.

Future mobile spectrum

9.21 Ofcom's programme of spectrum awards is subject to change from time to time, as are other aspects of spectrum policy and regulations. The latest information on Ofcom's programme of spectrum awards is given on our spectrum awards website.[80]

700 MHz

In addition to award of the 2.3 and 3.4 GHz spectrum bands, we are planning to release the 700 MHz band (703 to 733 MHz and 758 to 788 MHz). There is also a centre gap of 733 to 758 MHz, 20 MHz of which will become available for mobile downlink use. This spectrum is currently used to deliver DTT and PMSE services in the UK. However, in the future, this spectrum will be made available for mobile services.

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75 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/203826/Spending_review_2010.pdf

76 http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/statement.pdf

77 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/518303/enabling_uk_growth_pssr_programme_annual_report.pdf

78 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/518303/enabling_uk_growth_pssr_programme_annual_report.pdf

79 http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-sharing/statement/spectrum_sharing.pdf

80 http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/

3.6 to 3.8 GHz

9.22 EC Decision 2008/411/EC[81], as amended by Decision 2014/276/EU, covers spectrum in the 3.6 to 3.8 GHz band (in addition to spectrum in the 3.4 to 3.6 GHz band). Article 2 provides that Member States should designate and subsequently make available, on a non-exclusive basis, the 3.4 to 3.8 GHz band for ECN use (including for example, 5G). Since then, the EC's Radio Spectrum Policy Group (RSPG) has identified the 3.4 GHz to 3.8 GHz band as the *"primary band suitable for the introduction of 5G use in Europe"* although no final decisions have yet been taken. In the UK, satellite earth stations and fixed links are currently licensed and operate within this band, and UK Broadband (now acquired by H3G) is also licensed to use 84 MHz[82] of this spectrum. Ofcom will shortly publish a statement setting out our intention to make the 3.6-3.8 GHz band available for mobile, and our proposed approach to future arrangements for these frequencies.

3.8 to 4.2 GHz

9.23 In April 2016, we published a Call for Input (CFI) to gauge stakeholders' interest in sharing spectrum at 3.8 GHz to 4.2 GHz. Our analysis suggested sharing is possible given the spectrum is not currently used in many areas of the UK, and different channels have a varying degree of use. In this document we discussed the potential to introduce a three-tiered approach (existing users, geographic licences, opportunistic users) to enable innovation in the band. Following responses to this CFI we published a short Update in August 2016 (https://www.ofcom.org.uk/consultations-and-statements/category-2/opportunities-for-spectrum-sharing-innovation), confirming the potential of this band for further shared access on a geographic basis. On the basis of our analysis we continue to see this band as candidate for providing shared access for innovative services in the 3 to 4 GHz range.

26 GHz

9.24 On 8 February 2017 Ofcom published an 'Update on 5G spectrum in the UK'. The Update provided an overview of the international process that has led to the identification of appropriate bands to meet the requirements of 5G. The bands include the 700 MHz band; the 3.6-3.8 GHz band; and the 26 GHz band. The Update also listed a number of other bands that will be considered at WRC-19. The 26 GHz band (24.25 GHz to 27.5 GHz) already has a mobile allocation in the ITU Radio Regulations across most of the band. We have initiated a program of work to develop proposals on how to make all or part of the 26 GHz band available for early 5G deployment. We intend to publish a consultation on this shortly.

White Space Devices: Implementing Geolocation

9.25 On 12 February 2015 we published a statement entitled 'Implementing TV White Spaces'[83]. The document set out our decision to allow White Space Devices (WSDs) to access the white space (or interleaved) spectrum between 470 MHz and 790 MHz on a licence exempt basis. WSDs share the spectrum with Digital Terrestrial

[81] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:144:0077:0081:EN:PDF

[82] This is paired with a further 84 MHz between 3900-4009 MHz

[83] http://stakeholders.ofcom.org.uk/binaries/consultations/white-space-coexistence/statement/tvws-statement.pdf

Television (DTT) and Programme Making and Special Events (PMSE) services. The sharing is controlled by databases designated by Ofcom.

9.26 We subsequently published a statement on 25 September 2015 setting out our decision to authorise on a licensed basis, WSDs which do not comply with our licence exemption regulations[84]. We will review whether authorisation is still required around three years after the date of the above statement.

The Government's work examining operational and passenger rail coverage

9.27 In February 2015, the Government announced its intention to rollout free Wi-Fi on most rail routes from 2017 in addition to its intent to provide mobile broadband for rail passengers from 2019.

9.28 The railway industry currently uses GSM-R for its communications networks. However, we understand that GSM-R technology will become end-of-life within the next decade. The railway industry, led by UIC, is therefore considering its future communication requirements for voice and data communications as well as train signalling systems. Spectrum requirements are being considered by ETSI and CEPT initially.

Ofcom's work on mobile coverage

Coverage obligations and commitments

9.29 In January 2014 Ofcom announced that all of the UK's major mobile phone networks had met their licence obligation requiring them to provide 3G coverage to 90% of UK homes. This extended the previous obligation which required operators to provide 80% premises coverage by 31 December 2007.

9.30 In February 2013, as part of the auction of spectrum for 4G services, Ofcom attached a coverage obligation to one of the 800 MHz lots of spectrum. This lot was won by Telefónica UK Ltd (O2). O2 is obliged to provide indoor coverage at a level capable of supporting a 2Mbps service to at least 98% of the UK population and at least 95% of the population of each of the UK nations – England, Northern Ireland, Scotland and Wales - by the end of 2017 at the latest.

9.31 In December 2014 the Government secured an agreement with the mobile networks EE, O2, Three and Vodafone.

9.32 Under the agreement all four of the mobile networks agreed to implement voice coverage across 90 per cent of the UK geographic area, at signal strengths that met agreed thresholds, by 2017. In January 2015 Ofcom varied the licences of the mobile operators to reflect the coverage commitment.

Consumer information

9.33 Ofcom publishes a number of reports that provide information on the coverage and quality of mobile networks. This information allows consumers to make more informed purchasing decisions and can encourage competition between network operators.

[84] http://stakeholders.ofcom.org.uk/binaries/consultations/manually-configurable-wsds/statement/Licensing_manually_configurable_white_space_devices.pdf

9.34 In August 2014 we published a report which included information on the consumer experience of making mobile voice calls and included comparisons of call success rates for the four major networks in urban and rural areas.[85]

9.35 In November 2014 Ofcom published its first report comparing the speeds achieved on 3G and 4G networks. The report highlighted that 4G networks were providing average download speeds that were over twice that achieved on 3G networks.[86] The information included in these reports is updated each year in our Connected Nations documents (https://www.ofcom.org.uk/research-and-data/infrastructure-research/connected-nations-2016).

9.36 In our Infrastructure Report of 8 December 2014 we included coverage statistics for each mobile network for the first time. We reported on premises, geographic and roads coverage for 2G, 3G and 4G networks.[87]

9.37 In August 2015 we commenced regular monthly updated publication of interactive coverage maps that allow consumers to compare the predicted coverage of mobile voice and data services for each of the UK mobile networks across the UK.

Emergency Services Mobile Communications Programme (ESMCP)

9.38 The Government will make use of commercial mobile communications providers in order to provide the mobile communications needs of the emergency services. BT/EE has been selected as the emergency services network services provider and the Government is currently procuring additional elements required for the service, including capability for air-ground-air communications (See paragraphs 4.23 to 4.25).

9.39 The ESMCP Programme will undertake the development of additional sites in order to provide coverage in parts of England, Scotland, and Wales where BT/EE has not provided, nor has plans to provide, mobile coverage. Whilst the development will be for the purpose of meeting ESMCP coverage requirements, other operators will be able to access the sites, subject to negotiation, planning consent, and contract.

Ofcom Consultations

9.40 Details of Ofcom consultations, those that are currently open and those that are closed, can be found on our website at https://www.ofcom.org.uk/consultations-and-statements

Competition from other services

9.41 Any party considering participating in the Award Process must make its own independent assessment of the competition that its services using the 2.3 or 3.4 GHz bands will face from existing and future services, and the implications of this competition for the potential value of a licence.

9.42 As noted, Ofcom may authorise others to use spectrum to offer such services. Such authorisation may occur, for example, by way of the grant of new licences, decisions as to the variation of existing licences, or decisions as to exemptions from licensing.

[85] http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/consumer-experiences-mobile-phone-calls/
[86] http://media.ofcom.org.uk/news/2014/3g-4g-bb-speeds/
[87] http://stakeholders.ofcom.org.uk/binaries/research/infrastructure/2014/infrastructure-14.pdf

9.43 As set out in the Spectrum Management Strategy and elsewhere, Ofcom's general policy is to move towards authorising the use of spectrum on a basis that provides much greater flexibility for the use of spectrum to respond to demand and to be economically efficient.

Non-operational licences

9.44 We currently issue two classes of short-term non-operational wireless telegraphy licences:

- Non-operational temporary use – licensed for up to six months; and
- Non-operational development – licensed for up to12 months.

9.45 These licences enable the use of spectrum on a non-commercial, non-permanent basis for activities such as the testing and development of wireless telegraphy (radio) equipment, scientific research and experimentation, and trials and demonstrations of radio apparatus in a range of different frequency bands. Such licences are issued following a coordination procedure to assess the risk of harmful interference to existing services, which may also involve Ofcom contacting existing licensees or other authorised users of the spectrum in order to assist Ofcom in its assessment. Licences issued are under the condition that the equipment must not cause harmful interference to any other authorised services and that no protection will be given from harmful interference received from other authorised services. There is no right of renewal at the end of the term of a non-operational licence. At the time of this award, there may be a number of non-operational licences in force in the spectrum bands being awarded.

9.46 Any existing non-operational licences in the award bands may need to be re-assessed at the time of award. However, interested parties should note that we may issue further non-operational licences in the spectrum bands being awarded following the completion of the Award Process.

Other non-commercial usage

9.47 Ofcom may from time to time receive requests from the Crown for frequency clearances at specified locations, which include frequency requests from the Foreign and Commonwealth Office for short-term use by visiting diplomats and dignitaries. Ofcom may give advice or provide services which are appropriate for facilitating or managing the use of spectrum, but Ofcom does not authorise the Crown. Ofcom may also seek to coordinate requests for Crown frequency use directly with the licence holder. Should the Crown decide to use spectrum it is on the understanding that the assessment of and the responsibility arising from any interference caused to civil radio services rests with the Crown and not Ofcom. The Crown may request coordination directly with spectrum users.

R&TTE Directive and Radio Equipment Directive (RED)

9.48 The R&TTE Directive has been replaced by Directive 2014/53/EU, the Radio Equipment Directive (RED), which has an expanded scope, essential requirements and is designed to serve a similar function for placing products on the European market. From 13 June 2017, the R&TTE can no longer be used to place products on the European market. The Radio Equipment Directive has not yet been transposed into UK law. All products within the scope of the Radio Equipment Directive placed on the European market must be “CE” marked.

9.49 The European Commission's "Blue Guide" (Guide on the implementation of EU product rules) was updated in 2016 for the introduction of the New Legislative Framework and Radio Equipment Directive. It is available from the Commission's website[88] and gives detailed guidance on the product rules and the CE marking of products and equipment. A guide to the Radio Equipment Directive is available on the Commission's website at: http://ec.europa.eu/docsroom/documents/23321

Electronic Communications Code

9.50 The UK Electronic Communications Code enables electronic communications network providers to construct electronic communications networks. The UK Electronic Communications Code enables these providers to construct infrastructure on public land (streets), to take rights over private land, either with the agreement of the landowner or applying to a County Court or the Sheriff in Scotland. It also conveys certain immunities from Town and Country Planning legislation in the form of Permitted Development. In addition to providers of electronic communications networks the UK Electronic Communications Code is also available to those who wish to construct conduits to be made available to network providers.

9.51 The UK Electronic Communications Code is granted to network providers by Ofcom by a direction made following a public consultation and consideration of the responses to that consultation. Further information on the UK Electronic Communications Code is available on the Ofcom website[89].

9.52 The UK Electronic Communications Code has effect in all cases subject to the conditions and restrictions set out in the Electronic Communications Code (Conditions and Restrictions) Regulations 2003[90] as amended by the Electronic Communications Code (Conditions and Restrictions) (Amendment) Regulations 2009[91].

9.53 In April 2017 the Digital Economy Bill received Royal Assent following its passage through Parliament. The Digital Economy Act 2017 reforms the UK Electronic Communications Code by introducing a range of measures to make it easier for network operators to rollout infrastructure (such as phone masts, exchanges and cabinets) on public and private land. These reforms to the UK Electronic Communications Code are wide-ranging and will be of particular significance for network operators and landowners. We published a consultation document on 24 March 2017[92] which closed on 2 June 2017. Following review of submitted responses we will publish finalised versions of the Code of Practice and accompanying standard terms and notices in a final statement which will be published towards the end of November 2017.

[88] http://ec.europa.eu/DocsRoom/documents/18027/

[89] http://stakeholders.ofcom.org.uk/telecoms/policy/electronic-comm-code/

[90] S.I. 2003/2553

[91] S.I. 2009/584

[92] https://www.ofcom.org.uk/consultations-and-statements/category-1/electronic-communications-code

Other regulation of the provision of electronic communication services and networks

9.54 It is the responsibility of interested parties who are considering using the spectrum bands being awarded to provide electronic communication services or electronic communications networks to familiarise themselves with any relevant regulation. It should be noted that all aspects of regulation are subject to change from time to time, including without limitation the relevant legislative framework and the nature of regulation within any given legislative framework. In addition, decisions taken pursuant to existing regulation or decisions to establish or vary existing regulation may be subject to an appeal to the Competition Appeal Tribunal or (where relevant) the subject of judicial review proceedings and as a result of any decision, or subsequent appeal, the underlying regulation, provision or decision may need to be re-considered.

9.55 In general and by way of example, interested parties should note:

- That there are General Conditions with which they may need to comply as described in more detail below;
- That a number of operators may be subject to conditions imposed as a result of a finding of significant market power (SMP), which conditions may enable another operator to rely upon e.g. a right to obtain network access (which may be of a specified type) and other obligations, such as regulated prices;
- That if licensees wish to purchase access and interconnection from operators of existing networks for services in markets where those operators do not have SMP, our expectation is that these services should be negotiated commercially.

General Conditions

9.56 All providers of Electronic Communications Networks (ECNs) and Electronic Communications Services (ECSs) in the UK are covered by the General Conditions. Some conditions apply to particular categories of ECN or ECS provider, mainly depending on whether they provide public services or networks and whether they provide publicly available telephone services or public telephone networks.

9.57 It is the responsibility of any undertaking involved in providing an ECN or ECS to identify which conditions apply to it and ensure that it complies with them. Further information relating to the General Conditions can be found on the Ofcom website[93].

9.58 It should be noted that from time to time we consult on changing the General Conditions and any such proposals can be found on the Ofcom website[94]. A consultation entitled 'Review of the General Conditions of Entitlement' was published on 2 August 2016, a consultation entitled 'Review of the General Conditions of Entitlement' was published on 20 December 2016 and a consultation entitled 'Consumer switching: Proposals to reform switching of mobile communications services' was published on 19 May 2017.

[93] https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/telecoms-competition-regulation/general-authorisation-regime

[94] https://www.ofcom.org.uk/consultations-and-statements

International frequency allocation and harmonisation

9.59 All aspects of international arrangements are subject to change from time to time. Licensees will be required to ensure that their use of spectrum is consistent with the UK's international obligations. Interested parties should note that we cannot offer any protection to a licensee from spectrum users in neighbouring countries operating in accordance with international agreements.

European Regulatory Framework

9.60 Interested parties should note that there is an important EU dimension to spectrum management. At a general level, European law provides a regulatory framework for electronic communications, including provisions on the use of spectrum. In 2009 the European regulatory framework for networks and services was amended and, as a result of changes provided for in the Better Regulation Directive[95], a number of amendments to key provisions of the relevant directives, including the Framework Directive[96] and the Authorisation Directive[97] have been implemented in UK law including provisions on trading and leasing. This framework is currently being reviewed at the European level with a proposal for one European Electronic Communications Code to replace the existing Directives. It is not yet clear how the UK's relationship with the Framework will be affected by the decision to withdraw from the European Union.

Radio Spectrum Policy Programme

9.61 The Radio Spectrum Policy Programme (RSPP) was agreed by the European Council and Parliament in March 2012[98]. The RSPP sets out the policy orientations and objectives for the strategic planning and harmonisation of the use of spectrum with the aim of enhancing the internal market for wireless electronic communications services and equipment as well as other EU policies requiring spectrum use.

9.62 The RSPP included ensuring the:

- availability of spectrum to meet future wireless broadband demand;
- promoting competition and innovation to facilitate the availability of broadband services and to respond effectively to increased wireless data traffic; and
- fostering different modes of spectrum sharing in Europe, to ensure efficient use of spectrum and to increase spectrum access opportunities for wireless innovation.

Tax

9.63 Any party considering participation in the Award Process must take its own advice on the tax consequences of being awarded a licence.

[95] Directive 2009/140/EC

[96] Directive (2002/21/EC)

[97] Directive (2002/20/EC)

[98] Decision 243/2012/EU

9.64 Payments for WT Act licence fees are not subject to VAT. The question of whether VAT should be payable in the case of the 3G mobile telephone WT Act licences auctioned in 2000 was heard by the European Court of Justice, which delivered its judgement on the matter on 26 June 2007[99]. The Court held that in the case of these licences, the Government issued them in a regulatory capacity which was not an economic activity and consequently their issue was outside the scope of VAT.

9.65 The Court's judgement confirms the UK interpretation of VAT legislation, namely that where a WT Act licence is issued by a public authority pursuant to public law and in order to regulate the use of the radio frequencies, that activity is outside the scope of VAT.

[99] http://curia.europa.eu/jurisp/cgi-bin/form.pl?lang=en&Submit=Rechercher&alldocs=alldocs&docj=docj&docop=docop&docor=docor&docjo=docjo&numaff=C-284/04&datefs=&datefe=&nomusuel=&domaine=&mots=&resmax=100, and http://curia.europa.eu/jurisp/cgi-bin/form.pl?lang=en&Submit=Rechercher&alldocs=alldocs&docj=docj&docop=docop&docor=docor&docjo=docjo&numaff=C-369/04&datefs=&datefe=&nomusuel=&domaine=&mots=&resmax=100

Section 10

Application instructions

Application Procedure

10.1 The procedure for making an application for a licence will be set out in the Regulations. As explained in section 7, Ofcom will announce details of the relevant time and date for an application to be made.

Contacts for enquiries

10.2 Any further enquiries relating to this Memorandum and the Award Process should be addressed in writing and sent by email directly to Ofcom at PSSR.award@ofcom.org.uk. These should be marked for the attention of: Robert Emson and also marked: “Spectrum Auction Question – Award of 2.3 and 3.4 GHz bands.”

Disclosure of further information

10.3 Following issue of this Memorandum, Ofcom has the discretion to publish further information and to publish questions and the answers provided. Ofcom may, however, exercise its discretion not to publish a particular question and answer, in whole or in part. Ofcom also reserves the right not to respond to such a question, and to publish relevant guidance arising from an answer to such a question. The identity of questioners will not normally be published without their permission.

Annex 1

Example 2.3 GHz licence

[Header (to all pages)]

[Company] – Spectrum Access 2.3 GHz Licence Company registration number: XXXXX First issued: xx/xx/xx – Licence Number: xxxxxxx – xx/xx/xx

Office of Communications (Ofcom)
Wireless Telegraphy Act 2006

SPECTRUM ACCESS 2.3GHz LICENCE

Licence no: **XXXX**

Date of issue: **XXXX**

Fee payment date [(from **XXXX 2037**] **XXXX (annually)**

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

   [Company]
   (Company registration number **XXXX**)
   ("the Licensee")
   Add 1
   Add 2
   Add 3
   Postcode

   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) if, in connection with the transfer or proposed transfer of rights and obligations arising by virtue of the Licence, there has been a breach of any provision of regulations made by Ofcom under the powers conferred by section 30(1) and 30(3) of the Act[100];

(f) 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 (such notice not to be given before XXXX 2032; or

(g) if the Licensee has been found to the reasonable satisfaction of Ofcom to have been involved in any act, or omission of any act, constituting a breach of the [Wireless Telegraphy (Licence Award) Regulations 20xx ("the Regulations")].

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[101].

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. In accordance with the Regulations, the fee in consideration of which this licence is granted is [£**XXXX**].

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

9. The Licensee shall also pay interest to Ofcom on any amount which is due to Ofcom under the terms of this Licence or provided for in any regulations made by Ofcom under sections 12 and 13(2) of the Act from the date such amount falls due until the date of payment, at the then applicable Bank of England base rate. In accordance with section 15 of the Act any such amount and any such interest is recoverable by Ofcom.

[100] These are regulations on spectrum trading.

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

10. 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 the Regulations, 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

11. 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.

12. 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

13. 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

14. 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.

15. 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

16. Subject to the requirements of any coordination procedures notified to the Licensee pursuant Schedule 1 to this Licence, and excluding the areas set out in condition 17, the Licensee is authorised to establish, install and use the Radio Equipment in Great Britain. (The Licensee is not authorised to establish, install and use the Radio Equipment in Northern Ireland, the Channel Islands or the Isle of Man).

17. The areas excluded from this licence are:

(a) the Outer Hebrides, the Isle of Skye and the Small Isles;

(b) the territorial sea and any inland waters adjacent to the territorial sea, but in the case of streams, rivers or other watercourses which form part of such inland waters they are only excluded where such stream, river or watercourse is more than 2km wide.

Interpretation

18. 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 expression "territorial sea" shall be determined in accordance with the Territorial Sea Act 1987;

(e) the expression "inland waters" shall have the meaning given by section 221(1) of the Water Resources Act 1991;

(f) The Schedule(s) form part of this Licence together with any subsequent Schedule(s) which Ofcom may issue as a variation to this Licence.

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

Issued by Ofcom
Office of Communications

SCHEDULE 1 TO LICENCE NUMBER: XXXX

Schedule Date:XXXX 20XX

Licence category: Spectrum Access 2.3 GHz

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 this Schedule.

Interface Requirements for the Radio Equipment

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

   IR 2098: Terrestrial systems capable of providing electronic communications services in the 2.3 GHz band.

Special conditions relating to the Radio Equipment

3.

a) Subject to paragraph 3(b) of this Schedule, during the period that this Licence remains in force, unless consent has otherwise been given by Ofcom, the Licensee shall compile and maintain accurate written records of the following details relating to the Radio Equipment:

   i) postal address (including post code);

   ii) National Grid Reference, to at least 10m resolution;

   iii) antenna height (above ground level), type, and boresight bearing east of true north (if applicable);

   iv) radio frequencies which the Radio Equipment uses; and

   v) Transmitted power expressed in dBm / 5 MHz EIRP per cell.

and the Licensee must produce these records if requested by any person authorised by Ofcom.

b) The conditions relating to the keeping of records contained in sub-paragraphs 3(a)(ii) and (iii) of this Schedule shall not apply in respect of femto cell equipment and smart/intelligent low power repeater equipment.

c) The conditions relating to the keeping of records contained in paragraph 3(a) of this Schedule shall not apply in respect of licence exempt radio equipment.

d) The Licensee shall submit to Ofcom copies of the records detailed in sub-paragraph 3(a) above at such intervals as Ofcom may notify to the Licensee.

e) 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 in the 2350 MHz – 2390 MHz 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.

Permitted Frequency Blocks

7. The Radio Equipment may only transmit within the following frequency bands (the "Permitted Frequency Blocks"):

XXXX - XXXX MHz

Maximum power within the Permitted Frequency Blocks

8. Subject to any more restrictive limitations imposed by the coordination requirements notified by Ofcom in accordance with paragraphs 4 and 5 of this schedule, the power transmitted in the Permitted Frequency Blocks shall not exceed:

Radio Equipment	**Maximum mean power**
Base station (see Note 1)	61 dBm / 5 MHz EIRP*
Mobile or nomadic terminal station	25 dBm TRP*
Fixed or installed terminal station	25 dBm EIRP*

* The maximum mean power relates to the EIRP or TRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

Note 1: For femtocell base stations, power control must be applied to minimise interference to adjacent channels.

Maximum power of base stations outside the Permitted Frequency Blocks

9. When transmitting, 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;

10. 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

11. 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 12(a) to 12(d) are met.

Figure 1: 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

12. The EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following band edge requirements:

2345 MHz – 2350 MHz 2390 MHz – 2395 MHz	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna	
2340 MHz – 2345 MHz 2395 MHz – 2400 MHz	Min(PMax – 43, 15) dBm / 5 MHz EIRP per antenna	
2300 – 2340 MHz	PMax > 35 dBm	-36 dBm / 5 MHz EIRP*
	PMax ≤ 35 dBm	-20 dBm / 5 MHz EIRP*
2400 MHz – 2403 MHz	Min(PMax – 43, 13) dBm / 5 MHz EIRP per antenna	
Above 2403 MHz	PMax > 42 dBm	1 dBm / 5 MHz EIRP*
	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.

Small Cells

13. The Licensee is required to comply with the Permissive Transmission Mask as set out in paragraph 10 of this Schedule but is not required to comply with the frame structure requirements set out in paragraph 11 for:

a) Indoor Domestic Small Cells; or

b) Indoor Non-domestic Small Cells, except where another licensee demonstrates that they are suffering undue interference as a result.

If another licensee demonstrates that they are suffering undue interference as a result of an Indoor Non-domestic Small Cell, the Indoor Non-domestic Small Cell must comply with the requirements set out in both paragraphs 9, and 11 above.

Interpretation of terms in this Schedule

14. 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) "femtocell" means Radio Equipment transmitting on the downlink frequencies, which operates at a power not exceeding 24 dBm EIRP per carrier, and which is or will be used only by and under the control of the Licensee, following the

establishment of a telecommunications link between the femtocell and a network of the Licensee;

e) "Fixed or installed" means used or installed at specific fixed points;

f) "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;

g) "Indoor Domestic Small Cell" means a base station with an EIRP of less than or equal to 24dBm per 20 MHz carrier that is located within a residential property;

h) "Indoor Non-domestic Small Cell" means a base station with an EIRP of less than or equal to 24dBm per 20 MHz carrier that is located Indoors but not within a residential property;

i) "IR" means a United Kingdom Radio Interface Requirement notified by Ofcom in accordance with Article 4.1 of Directive 1995/5/EC of the European Parliament and of the Council on radio equipment and telecommunications terminal equipment (RTTE) and the mutual recognition of their conformity;

j) "lower block edge" means, in relation to each Permitted Frequency Block, the lowest frequency in that Permitted Frequency Block;

k) "mobile or nomadic" means intended to be used while in motion or during halts at unspecified points;

l) "Permitted Frequency Blocks" has the meaning given to it in paragraph 7 of this Schedule;

m) "PMax" is the maximum mean power for the base station in question, measured as EIRP per carrier and determined irrespective of the number of transmit antennas;

n) "smart/intelligent low power repeater" means a repeater which operates with power not exceeding 24 dBm EIRP per carrier, which may be established by customers of the Licensee who have written agreements with the Licensee and:

- The Licensee has ultimate control of the repeater, i.e. each individual repeater can be disabled remotely by the Licensee;
- The repeater operates only on the Licensee's frequencies and with their valid Public Land Mobile Network Identifier;
- Must not cause undue interference to other spectrum users; and
- The repeater only transmits on the uplink timeslot when actively carrying a call (voice, video or data) or signalling from serviced handsets.

o) "TDD" means the application of time-division multiplexing to separate outward and return signals;

p) “TD-LTE” means the TDD variant of LTE (Long Term Evolution or 4G technology);

q) “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;

r) “Uplink” means transmissions from a terminal station (handset) to a base station; and

s) “upper block edge” means, in relation to each Permitted Frequency Block, the highest frequency in that Permitted Frequency Block.

Ofcom

Annex 2

Example 2.3 GHz withdrawn lot licence

[Header (to all pages)]

[Company] – Spectrum Access 2.3 GHz Licence Company registration number: XXXXX First issued: xx/xx/xx – Licence Number: xxxxxxx – xx/xx/xx

Office of Communications (Ofcom)
Wireless Telegraphy Act 2006

SPECTRUM ACCESS 2.3GHz LICENCE

Licence no: **XXXX**

Date of issue: **XXXX**

Fee payment date [(from **XXXX 2037**] **XXXX (annually)**

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

   [Company]
   (Company registration number **XXXX**)
   ("the Licensee")
   Add 1
   Add 2
   Add 3
   Postcode

   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) if, in connection with the transfer or proposed transfer of rights and obligations arising by virtue of the Licence, there has been a breach of any provision of regulations made by Ofcom under the powers conferred by section 30(1) and 30(3) of the Act[102];

(f) 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 (such notice not to be given before XXXX 2032; or

(g) if the Licensee has been found to the reasonable satisfaction of Ofcom to have been involved in any act, or omission of any act, constituting a breach of the [Wireless Telegraphy (Licence Award) Regulations 20xx ("the Regulations")].

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[103].

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. In accordance with the Regulations, the fee in consideration of which this licence is granted is [£**XXXX**].

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

9. The Licensee shall also pay interest to Ofcom on any amount which is due to Ofcom under the terms of this Licence or provided for in any regulations made by Ofcom under sections 12 and 13(2) of the Act from the date such amount falls due until the date of payment, at the then applicable Bank of England base rate. In accordance with section 15 of the Act any such amount and any such interest is recoverable by Ofcom.

[102] These are regulations on spectrum trading.

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

10. 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 the Regulations, 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

11. 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.

12. 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

13. 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

14. 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.

15. 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

16. Subject to the requirements of any coordination procedures notified to the Licensee pursuant Schedule 1 to this Licence, and excluding the areas set out in condition 17, the Licensee is authorised to establish, install and use the Radio Equipment in Great Britain. (The Licensee is not authorised to establish, install and use the Radio Equipment in Northern Ireland, the Channel Islands or the Isle of Man).

17. The areas excluded from this licence are:

(a) the Outer Hebrides, the Isle of Skye and the Small Isles;

(b) the territorial sea and any inland waters adjacent to the territorial sea, but in the case of streams, rivers or other watercourses which form part of such inland waters they are only excluded where such stream, river or watercourse is more than 2km wide.

Interpretation

18. 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 expression "territorial sea" shall be determined in accordance with the Territorial Sea Act 1987;

(e) the expression "inland waters" shall have the meaning given by section 221(1) of the Water Resources Act 1991;

(f) The Schedule(s) form part of this Licence together with any subsequent Schedule(s) which Ofcom may issue as a variation to this Licence.

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

Issued by Ofcom
Office of Communications

SCHEDULE 1 TO LICENCE NUMBER: XXXX

Schedule Date:XXXX 20XX

Licence category: Spectrum Access 2.3 GHz

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 this Schedule.

Interface Requirements for the Radio Equipment

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

   IR 2098: Terrestrial systems capable of providing electronic communications services in the 2.3 GHz band.

Special conditions relating to the Radio Equipment

3.

a) Subject to paragraph 3(b) of this Schedule, during the period that this Licence remains in force, unless consent has otherwise been given by Ofcom, the Licensee shall compile and maintain accurate written records of the following details relating to the Radio Equipment:

   i) postal address (including post code);

   ii) National Grid Reference, to at least 10m resolution;

   iii) antenna height (above ground level), type, and boresight bearing east of true north (if applicable);

   iv) radio frequencies which the Radio Equipment uses; and

   v) Transmitted power expressed in dBm / 5 MHz EIRP per cell.

and the Licensee must produce these records if requested by any person authorised by Ofcom.

b) The conditions relating to the keeping of records contained in sub-paragraphs 3(a)(ii) and (iii) of this Schedule shall not apply in respect of femto cell equipment and smart/intelligent low power repeater equipment.

c) The conditions relating to the keeping of records contained in paragraph 3(a) of this Schedule shall not apply in respect of licence exempt radio equipment.

d) The Licensee shall submit to Ofcom copies of the records detailed in sub-paragraph 3(a) above at such intervals as Ofcom may notify to the Licensee.

e) 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 in the 2350 MHz – 2390 MHz 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.

Permitted Frequency Blocks

7. The Radio Equipment may only transmit within the following frequency bands (the "Permitted Frequency Blocks"):

XXXX - XXXX MHz

Maximum power within the Permitted Frequency Blocks

8. Subject to any more restrictive limitations imposed by the coordination requirements notified by Ofcom in accordance with paragraphs 4 and 5 of this schedule, the power transmitted in the Permitted Frequency Blocks shall not exceed:

Radio Equipment	**Maximum mean power**
Base station (see Note 1)	61 dBm / 5 MHz EIRP*
Mobile or nomadic terminal station	25 dBm TRP*
Fixed or installed terminal station	25 dBm EIRP*

* The maximum mean power relates to the EIRP or TRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

Note 1: For femtocell base stations, power control must be applied to minimise interference to adjacent channels.

Maximum power of base stations outside the Permitted Frequency Blocks

9. When transmitting, 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;

10. 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

11. 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 12(a) to 12(d) are met.

Figure 2: 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

12. The EIRP emanating from the Radio Equipment transmissions at any frequency outside the Permitted Frequency Blocks shall not exceed the following band edge requirements:

2345 MHz – 2350 MHz 2390 MHz – 2395 MHz	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna	
2340 MHz – 2345 MHz 2395 MHz – 2400 MHz	Min(PMax – 43, 15) dBm / 5 MHz EIRP per antenna	
2300 – 2340 MHz	PMax > 35 dBm	-36 dBm / 5 MHz EIRP*
	PMax ≤ 35 dBm	-20 dBm / 5 MHz EIRP*
2400 MHz – 2403 MHz	Min(PMax – 43, 13) dBm / 5 MHz EIRP per antenna	
Above 2403 MHz	PMax > 42 dBm	1 dBm / 5 MHz EIRP*
	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.

Small Cells

13. The Licensee is required to comply with the Permissive Transmission Mask as set out in paragraph 10 of this Schedule but is not required to comply with the frame structure requirements set out in paragraph 11 for:

c) Indoor Domestic Small Cells; or

d) Indoor Non-domestic Small Cells, except where another licensee demonstrates that they are suffering undue interference as a result.

If another licensee demonstrates that they are suffering undue interference as a result of an Indoor Non-domestic Small Cell, the Indoor Non-domestic Small Cell must comply with the requirements set out in both paragraphs 9, and 11 above.

Interpretation of terms in this Schedule

14. 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) "femtocell" means Radio Equipment transmitting on the downlink frequencies, which operates at a power not exceeding 24 dBm EIRP per carrier, and which

is or will be used only by and under the control of the Licensee, following the establishment of a telecommunications link between the femtocell and a network of the Licensee;

e) “Fixed or installed” means used or installed at specific fixed points;

f) “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;

g) “Indoor Domestic Small Cell” means a base station with an EIRP of less than or equal to 24dBm per 20 MHz carrier that is located within a residential property;

h) “Indoor Non-domestic Small Cell” means a base station with an EIRP of less than or equal to 24dBm per 20 MHz carrier that is located Indoors but not within a residential property;

i) "IR" means a United Kingdom Radio Interface Requirement notified by Ofcom in accordance with Article 4.1 of Directive 1995/5/EC of the European Parliament and of the Council on radio equipment and telecommunications terminal equipment (RTTE) and the mutual recognition of their conformity;

j) “lower block edge” means, in relation to each Permitted Frequency Block, the lowest frequency in that Permitted Frequency Block;

k) “mobile or nomadic” means intended to be used while in motion or during halts at unspecified points;

l) “Permitted Frequency Blocks” has the meaning given to it in paragraph 7 of this Schedule;

m) “PMax” is the maximum mean power for the base station in question, measured as EIRP per carrier and determined irrespective of the number of transmit antennas;

n) “smart/intelligent low power repeater” means a repeater which operates with power not exceeding 24 dBm EIRP per carrier, which may be established by customers of the Licensee who have written agreements with the Licensee and:

- The Licensee has ultimate control of the repeater, i.e. each individual repeater can be disabled remotely by the Licensee;
- The repeater operates only on the Licensee’s frequencies and with their valid Public Land Mobile Network Identifier;
- Must not cause undue interference to other spectrum users; and
- The repeater only transmits on the uplink timeslot when actively carrying a call (voice, video or data) or signalling from serviced handsets.

o) “TDD” means the application of time-division multiplexing to separate outward and return signals;

p) “TD-LTE” means the TDD variant of LTE (Long Term Evolution or 4G technology);

q) “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;

r) “Uplink” means transmissions from a terminal station (handset) to a base station; and

s) “upper block edge” means, in relation to each Permitted Frequency Block, the highest frequency in that Permitted Frequency Block.

Ofcom

Annex 3

Example 3.4 GHz licence

[Header (to all pages)]

[Company] – Spectrum Access 3.4 GHz Licence Company registration number: xxxx First issued: xx/xx/xx – Licence Number: xxxxxxx – xx/xx/xx

Office of Communications (Ofcom)
Wireless Telegraphy Act 2006

SPECTRUM ACCESS 3.4 GHz LICENCE

Licence no: **XXXX**

Date of issue: **XXXX**

Fee payment date [(from **XXXX 2037**] **XXXX (annually)**

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

   [Company]
   (Company registration number **XXXX**)
   ("the Licensee")
   Add 1
   Add 2
   Add 3
   Postcode

   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) if, in connection with the transfer or proposed transfer of rights and obligations arising by virtue of the Licence, there has been a breach of any provision of regulations made by Ofcom under the powers conferred by section 30(1) and 30(3) of the Act[104];

(f) 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 (such notice not to be given before **XXXX** 2032)]; or

(g) if the Licensee has been found to the reasonable satisfaction of Ofcom to have been involved in any act, or omission of any act, constituting a breach of the [Wireless Telegraphy (Licence Award) Regulations 20xx ("the Regulations")].

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[105].

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. In accordance with the Regulations, the fee in consideration of which this licence is granted is [£**XXXX**].

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

9. The Licensee shall also pay interest to Ofcom on any amount which is due to Ofcom under the terms of this Licence or provided for in any regulations made by Ofcom under sections 12 and 13(2) of the Act from the date such amount falls due until the date of payment, at the then applicable Bank of England base rate. In accordance with section 15 of the Act any such amount and any such interest is recoverable by Ofcom.

[104] These are regulations on spectrum trading.

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

10. 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 the Regulations, 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

11. 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.

12. 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

13. 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

14. 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.

15. 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

16. Subject to the requirements of any coordination procedures notified to the Licensee pursuant Schedule 1 to this Licence, and excluding the areas set out in condition 17, the Licensee is authorised to establish, install and use the Radio Equipment in the United Kingdom. (The Licensee is not authorised to establish, install and use the Radio Equipment in the Channel Islands or the Isle of Man).

17. The areas excluded from this licence are the territorial sea and any inland waters adjacent to the territorial sea, but in the case of streams, rivers or other watercourses which form part of such inland waters, they are only excluded where such stream, river or watercourse is more than 2km wide.

Interpretation

18. 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 expression "territorial sea" shall be determined in accordance with the Territorial Sea Act 1987;

(e) the expression "inland waters" shall have the meaning given by section 221(1) of the Water Resources Act 1991;

(f) The Schedule(s) form part of this Licence together with any subsequent Schedule(s) which Ofcom may issue as a variation to this Licence.

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

Issued by Ofcom
Office of Communications

SCHEDULE 1 TO LICENCE NUMBER: XXXX

Schedule Date:XXXX 20XX

Licence category: Spectrum Access 3.4 GHz

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 this Schedule.

Interface Requirements for the Radio Equipment

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

   IR 2097: Terrestrial systems capable of providing electronic communications services in the 3.4 to 3.8 GHz band.

Special conditions relating to the Radio Equipment

3.

a) Subject to paragraph 3(b) of this Schedule, during the period that this Licence remains in force, unless consent has otherwise been given by Ofcom, the Licensee shall compile and maintain accurate written records of the following details relating to the Radio Equipment:

   i) postal address (including post code);

   ii) National Grid Reference, to at least 10m resolution;

   iii) antenna height (above ground level), type, and boresight bearing east of true north (if applicable);

   iv) radio frequencies which the Radio Equipment uses; and

   v) Transmitted power expressed in dBm / 5 MHz EIRP per cell.

   and the Licensee must produce these records if requested by any person authorised by Ofcom.

b) The conditions relating to the keeping of records contained in sub-paragraphs 3(a)(ii) and (iii) of this Schedule shall not apply in respect of femtocell equipment and smart/intelligent low power repeater equipment.

c) The conditions relating to the keeping of records contained in paragraph 3(a) of this Schedule shall not apply in respect of licence exempt radio equipment.

d) The Licensee shall submit to Ofcom copies of the records detailed in sub-paragraph 3(a) above at such intervals as Ofcom may notify to the Licensee.

e) 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 in the 3410 MHz – 3600 MHz 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.

Permitted Frequency Blocks

7. The Radio Equipment may only transmit within the following frequency bands (the "Permitted Frequency Blocks"):

XXXX - XXXX MHz

Maximum power within the Permitted Frequency Blocks

8. Subject to any more restictive limitations imposed by the coordination requirements notified by Ofcom in accordance with paragraphs 4 and 5 of this schedule, the power transmitted in the Permitted Frequency Blocks shall not exceed:

Radio Equipment	**Maximum mean power**
Base station (see Note 1)	65 dBm / 5 MHz EIRP*
Mobile or nomadic terminal station	25 dBm TRP*
Fixed or installed terminal station	35 dBm / 5 MHz EIRP*

* The maximum mean power relates to the EIRP or TRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

Note 1: For femtocell base stations, power control must be applied to minimise interference to adjacent channels.

Maximum power of base stations outside the Permitted Frequency Blocks

9. When transmitting, the Licensee must either transmit in accordance with the condition in paragraph (a) or in accordance with the condition in paragraph (b). –

   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, the Licensee must also transmit within the limits of transmission Frame Structure B.

10. 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

11. 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.

12. 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 12(a) to 12(d) are met.

13. Frame Structure B (also commonly 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 13(a) to 13(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 13(c) and 13(g);

g) the Licensee must cooperate with other licensees 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 downlink-only frame structures such as Supplementary Downlink (SDL) are not permitted.

Figure 1: 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

Figure 2: Frame Structure B

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

14. 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:

3405 MHz – 3410 MHz 3600 MHz – 3605 MHz	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna
3400 MHz – 3405 MHz	Min(PMax – 43, 15) dBm / 5 MHz EIRP per antenna
3390 MHz – 3400 MHz	Min(PMax – 43, 13) dBm / 5 MHz EIRP per antenna
Below 3390 MHz	- 50 dBm / MHz[106] EIRP*
Above 3605 MHz (see Note 2)	- 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.

Note 2: This limit shall not apply if the licensee of the Spectrum Access 3.6 GHz licence (above 3605 MHz), uses a TDD frame structure identical to Frame Structure A

Small Cells

15. The Licensee is required to comply with the Permissive Transmission Mask as set out in 10 of this Schedule but is not required to comply with the frame structure requirements set out in paragraphs 12 or 13 above, for:

e) Indoor Domestic Small Cells; or

f) Indoor Non-domestic Small Cells, except where another licensee demonstrates that they are suffering undue interference as a result.

If another licensee demonstrates that they are suffering undue interference as a result of an Indoor Non-domestic Small Cell, the Indoor Non-domestic Small Cell must comply with those requirements set out in both paragraphs 9, and 12 above, where Frame Structure A is used or those requirements set out in both paragraphs 9 and 13 above where Frame Structure B is used.

Interpretation of terms in this Schedule

16. 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);

[106] We note this level is defined in the Commission Decision 2014/276/EU as per MHz rather than per 5 MHz.

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) "femtocell" means Radio Equipment transmitting on the downlink frequencies, which operates at a power not exceeding 24 dBm EIRP per carrier, and which is or will be used only by and under the control of the Licensee, following the establishment of a telecommunications link between the femtocell and a network of the Licensee;

e) "Fixed or installed" means used or installed at specific fixed points;

f) "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;

g) "Indoor Domestic Small Cell" means a base station with an EIRP of less than or equal to 24dBm per 20 MHz carrier that is located within a residential property;

h) "Indoor Non-domestic Small Cell" means a base station with an EIRP of less than or equal to 24dBm per 20 MHz carrier that is located Indoors but not within a residential property;

i) "IR" means a United Kingdom Radio Interface Requirement notified by Ofcom in accordance with Article 4.1 of Directive 1995/5/EC of the European Parliament and of the Council on radio equipment and telecommunications terminal equipment (RTTE) and the mutual recognition of their conformity;

j) "lower block edge" means, in relation to each Permitted Frequency Block, the lowest frequency in that Permitted Frequency Block;

k) "mobile or nomadic" means intended to be used while in motion or during halts at unspecified points;

l) "Permitted Frequency Blocks" has the meaning given to it in paragraph 7 of this Schedule;

m) "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;

n) "smart/intelligent low power repeater" means a repeater which operates with power not exceeding 24 dBm EIRP per carrier, which may be established by customers of the Licensee who have written agreements with the Licensee and:

- The Licensee has ultimate control of the repeater, i.e. each individual repeater can be disabled remotely by the Licensee;
- The repeater operates only on the Licensee's frequencies and with their valid Public Land Mobile Network Identifier;
- Must not cause undue interference to other spectrum users; and

- The repeater only transmits on the uplink timeslot when actively carrying a call (voice, video or data) or signalling from serviced handsets.

o) "TDD" means the application of time-division multiplexing to separate outward and return signals;

p) "TD-LTE" means the TDD variant of LTE (Long Term Evolution or 4G technology);

q) "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;

r) "Uplink" means transmissions from a terminal station (handset) to a base station; and

s) "upper block edge" means, in relation to each Permitted Frequency Block, the highest frequency in that Permitted Frequency Block.

Ofcom

Annex 4

Example 3.4 GHz withdrawn lot licence

[Header (to all pages)]

[Company] – Spectrum Access 3.4 GHz Licence Company registration number: xxxx First issued: xx/xx/xx – Licence Number: xxxxxxx – xx/xx/xx

Office of Communications (Ofcom)
Wireless Telegraphy Act 2006

SPECTRUM ACCESS 3.4 GHz LICENCE

Licence no:	**XXXX**
Date of issue:	**XXXX**
Fee payment date [(from **XXXX 2037**]	**XXXX (annually)**

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

   [Company]
   (Company registration number **XXXX**)
   ("the Licensee")
   Add 1
   Add 2
   Add 3
   Postcode

   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) if, in connection with the transfer or proposed transfer of rights and obligations arising by virtue of the Licence, there has been a breach of any provision of regulations made by Ofcom under the powers conferred by section 30(1) and 30(3) of the Act[107];

(f) 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 (such notice not to be given before **XXXX** 2032)]; or

(g) if the Licensee has been found to the reasonable satisfaction of Ofcom to have been involved in any act, or omission of any act, constituting a breach of the [Wireless Telegraphy (Licence Award) Regulations 20xx ("the Regulations")].

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. In accordance with the Regulations, the fee in consideration of which this licence is granted is [£**XXXX**].

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

9. The Licensee shall also pay interest to Ofcom on any amount which is due to Ofcom under the terms of this Licence or provided for in any regulations made by Ofcom under sections 12 and 13(2) of the Act from the date such amount falls due until the date of payment, at the then applicable Bank of England base rate. In accordance with section 15 of the Act any such amount and any such interest is recoverable by Ofcom.

[107] These are regulations on spectrum trading.

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

10. 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 the Regulations, 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

11. 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.

12. 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

13. 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

14. 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.

15. 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

16. Subject to the requirements of any coordination procedures notified to the Licensee pursuant Schedule 1 to this Licence, and excluding the areas set out in condition 17, the Licensee is authorised to establish, install and use the Radio Equipment in the United Kingdom. (The Licensee is not authorised to establish, install and use the Radio Equipment in the Channel Islands or the Isle of Man).

17. The areas excluded from this licence are the territorial sea and any inland waters adjacent to the territorial sea, but in the case of streams, rivers or other watercourses which form part of such inland waters, they are only excluded where such stream, river or watercourse is more than 2km wide.

Interpretation

18. 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 expression "territorial sea" shall be determined in accordance with the Territorial Sea Act 1987;

(e) the expression "inland waters" shall have the meaning given by section 221(1) of the Water Resources Act 1991;

(f) The Schedule(s) form part of this Licence together with any subsequent Schedule(s) which Ofcom may issue as a variation to this Licence.

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

Issued by Ofcom
Office of Communications

SCHEDULE 1 TO LICENCE NUMBER: XXXX

Schedule Date:XXXX 20XX

Licence category: Spectrum Access 3.4 GHz

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 this Schedule.

Interface Requirements for the Radio Equipment

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

   IR 2097: Terrestrial systems capable of providing electronic communications services in the 3.4 to 3.8 GHz band.

Special conditions relating to the Radio Equipment

3.

a) Subject to paragraph 3(b) of this Schedule, during the period that this Licence remains in force, unless consent has otherwise been given by Ofcom, the Licensee shall compile and maintain accurate written records of the following details relating to the Radio Equipment:

   i) postal address (including post code);

   ii) National Grid Reference, to at least 10m resolution;

   iii) antenna height (above ground level), type, and boresight bearing east of true north (if applicable);

   iv) radio frequencies which the Radio Equipment uses; and

   v) Transmitted power expressed in dBm / 5 MHz EIRP per cell.

   and the Licensee must produce these records if requested by any person authorised by Ofcom.

b) The conditions relating to the keeping of records contained in sub-paragraphs 3(a)(ii) and (iii) of this Schedule shall not apply in respect of femtocell equipment and smart/intelligent low power repeater equipment.

c) The conditions relating to the keeping of records contained in paragraph 3(a) of this Schedule shall not apply in respect of licence exempt radio equipment.

d) The Licensee shall submit to Ofcom copies of the records detailed in sub-paragraph 3(a) above at such intervals as Ofcom may notify to the Licensee.

e) 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 in the 3410 MHz – 3600 MHz 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.

Permitted Frequency Blocks

7. The Radio Equipment may only transmit within the following frequency bands (the "Permitted Frequency Blocks"):

XXXX - XXXX MHz

Maximum power within the Permitted Frequency Blocks

8. Subject to any more restictive limitations imposed by the coordination requirements notified by Ofcom in accordance with paragraphs 4 and 5 of this schedule, the power transmitted in the Permitted Frequency Blocks shall not exceed:

Radio Equipment	**Maximum mean power**
Base station (see Note 1)	65 dBm / 5 MHz EIRP*
Mobile or nomadic terminal station	25 dBm TRP*
Fixed or installed terminal station	35 dBm / 5 MHz EIRP*

* The maximum mean power relates to the EIRP or TRP of a specific piece of Radio Equipment irrespective of the number of transmit antennas.

Note 1: For femtocell base stations, power control must be applied to minimise interference to adjacent channels.

Maximum power of base stations outside the Permitted Frequency Blocks

9. When transmitting, the Licensee must either transmit in accordance with the condition in paragraph (a) or in accordance with the condition in paragraph (b). –

   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, the Licensee must also transmit within the limits of transmission Frame Structure B.

10. 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

11. 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.

12. 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 12(a) to 12(d) are met.

13. Frame Structure B (also commonly 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 13(a) to 13(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 13(c) and 13(g);

g) the Licensee must cooperate with other licensees 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 downlink-only frame structures such as Supplementary Downlink (SDL) are not permitted.

Figure 1: 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

Figure 2: Frame Structure B

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

14. 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:

3405 MHz – 3410 MHz 3600 MHz – 3605 MHz	Min(PMax – 40, 21) dBm / 5 MHz EIRP per antenna
3400 MHz – 3405 MHz	Min(PMax – 43, 15) dBm / 5 MHz EIRP per antenna
3390 MHz – 3400 MHz	Min(PMax – 43, 13) dBm / 5 MHz EIRP per antenna
Below 3390 MHz	- 50 dBm / MHz[109] EIRP*
Above 3605 MHz (see Note 2)	- 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.

Note 2: This limit shall not apply if the licensee of the Spectrum Access 3.6 GHz licence (above 3605 MHz), uses a TDD frame structure identical to Frame Structure A

Small Cells

15. The Licensee is required to comply with the Permissive Transmission Mask as set out in 10 of this Schedule but is not required to comply with the frame structure requirements set out in paragraphs 12 or 13 above, for:

a) Indoor Domestic Small Cells; or

b) Indoor Non-domestic Small Cells, except where another licensee demonstrates that they are suffering undue interference as a result.

If another licensee demonstrates that they are suffering undue interference as a result of an Indoor Non-domestic Small Cell, the Indoor Non-domestic Small Cell must comply with those requirements set out in paragraphs 9, and 12 above, where Frame Structure A is used or those requirements set out in paragraphs 9 and 13 above where Frame Structure B is used.

Interpretation of terms in this Schedule

16. In this Schedule:

[109] We note this level is defined in the Commission Decision 2014/276/EU as per MHz rather than per 5 MHz.

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) "femtocell" means Radio Equipment transmitting on the downlink frequencies, which operates at a power not exceeding 24 dBm EIRP per carrier, and which is or will be used only by and under the control of the Licensee, following the establishment of a telecommunications link between the femtocell and a network of the Licensee;

e) "Fixed or installed" means used or installed at specific fixed points;

f) "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;

g) "Indoor Domestic Small Cell" means a base station with an EIRP of less than or equal to 24dBm per 20 MHz carrier that is located within a residential property;

h) "Indoor Non-domestic Small Cell" means a base station with an EIRP of less than or equal to 24dBm per 20 MHz carrier that is located Indoors but not within a residential property;

i) "IR" means a United Kingdom Radio Interface Requirement notified by Ofcom in accordance with Article 4.1 of Directive 1995/5/EC of the European Parliament and of the Council on radio equipment and telecommunications terminal equipment (RTTE) and the mutual recognition of their conformity;

j) "lower block edge" means, in relation to each Permitted Frequency Block, the lowest frequency in that Permitted Frequency Block;

k) "mobile or nomadic" means intended to be used while in motion or during halts at unspecified points;

l) "Permitted Frequency Blocks" has the meaning given to it in paragraph 7 of this Schedule;

m) "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;

n) "smart/intelligent low power repeater" means a repeater which operates with power not exceeding 24 dBm EIRP per carrier, which may be established by customers of the Licensee who have written agreements with the Licensee and:

- The Licensee has ultimate control of the repeater, i.e. each individual repeater can be disabled remotely by the Licensee;

- The repeater operates only on the Licensee's frequencies and with their valid Public Land Mobile Network Identifier;
- Must not cause undue interference to other spectrum users; and
- The repeater only transmits on the uplink timeslot when actively carrying a call (voice, video or data) or signalling from serviced handsets.

o) "TDD" means the application of time-division multiplexing to separate outward and return signals;

p) "TD-LTE" means the TDD variant of LTE (Long Term Evolution or 4G technology);

q) "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;

r) "Uplink" means transmissions from a terminal station (handset) to a base station; and

s) "upper block edge" means, in relation to each Permitted Frequency Block, the highest frequency in that Permitted Frequency Block.

Ofcom

Annex 5

Draft replacement licence for the current 3.4 GHz spectrum holder

N.B. Schedules (not attached) are the same as for 3.4 GHz licence set out in annex 2

[Header (to all pages)]

[Company] – Spectrum Access 3.4 GHz Licence Company registration number: xxxx First issued: xx/xx/xx – Licence Number: xxxxxxx – xx/xx/xx

Office of Communications (Ofcom)
Wireless Telegraphy Act 2006

SPECTRUM ACCESS 3.4 GHz LICENCE

Licence no:	**XXXX**
Date of issue:	**XXXX**
Fee payment date [(from **17th July 2018**]	**17th July (annually)**

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

   [Company]
   (Company registration number **XXXX**)
   ("the Licensee")
   Add 1
   Add 2
   Add 3
   Postcode

   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) if, in connection with the transfer or proposed transfer of rights and obligations arising by virtue of the Licence, there has been a breach of any provision of regulations made by Ofcom under the powers conferred by section 30(1) and 30(3) of the Act[110];

   (f) 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 or

   (g) if the Licensee has been found to the reasonable satisfaction of Ofcom to have been involved in any act, or omission of any act, constituting a breach of the [Wireless Telegraphy (Licence Award) Regulations 20xx ("the Regulations")].

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[111].

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. From 17 July 2018, the Licensee shall each year 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.

[110] These are regulations on spectrum trading.

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

8. The Licensee shall also pay interest to Ofcom on any amount which is due to Ofcom under the terms of this Licence or provided for in any regulations made by Ofcom under sections 12 and 13(2) of the Act from the date such amount falls due until the date of payment, at the then applicable Bank of England base rate. In accordance with section 15 of the Act any such amount and any such interest is recoverable by Ofcom.

9. If the Licence is surrendered, revoked or varied, no refund, whether in whole or in part, of any amount which is due under the terms of this Licence, payable in accordance with the Regulations, 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

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

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

Access and Inspection

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

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

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

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

Modification, Restriction and Closedown

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

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

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

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

Geographical Boundaries

15. Subject to the requirements of any coordination procedures notified to the Licensee pursuant Schedule 1 to this Licence, and excluding the areas set out in condition 16, the Licensee is authorised to establish, install and use the Radio Equipment in the United Kingdom. (The Licensee is not authorised to establish, install and use the Radio Equipment in the Channel Islands or the Isle of Man).

16. The areas excluded from this licence are the territorial sea and any inland waters adjacent to the territorial sea, but in the case of streams, rivers or other watercourses which form part of such inland waters, they are only excluded where such stream, river or watercourse is more than 2km wide.

Interpretation

17. 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 expression “territorial sea” shall be determined in accordance with the Territorial Sea Act 1987;

(e) the expression “inland waters” shall have the meaning given by section 221(1) of the Water Resources Act 1991;

(f) The Schedule(s) form part of this Licence together with any subsequent Schedule(s) which Ofcom may issue as a variation to this Licence.

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

Issued by Ofcom
Office of Communications

Annex 6

Notice of coordination procedures for MOD sites related to 2.3 GHz licences

A6.1 This Notice is notified to each 2.3 GHz Licensee under their respective 2.3 GHz licences.

A6.2 MOD has a small amount of on-going use within the band at two locations, one in the Outer Hebrides and one in West Wales. It also requires protection around a number of other fixed receiver sites.

A6.3 This Notice specifies the protection thresholds and coordination procedure necessary to ensure the protection of existing and continuing MOD usage in the 2310 to 2360 MHz band from potential harmful interference from the deployment of networks in the 2.3 GHz Band.

A6.4 In this Notice:

"2.3 GHz Band" means the following frequencies: 2350 MHz to 2390 MHz;

"2.3 GHz Base Station" means a Base Station which is licensed to transmit using frequencies in the 2.3 GHz Band;

"2.3 GHz Fixed or Installed Terminal Station" means a fixed or installed Terminal Station which is not exempt from licensing by the Wireless Telegraphy Act (Exemption) Regulations and which is licensed to transmit using frequencies in the 2.3 GHz Band;

"2.3 GHz Licensee" means the licensee under a licence authorising use in the United Kingdom of frequencies in the 2.3 GHz Band;

"Base Station" means radio equipment that transmits to a Terminal Station(s);

"2.3 GHz Deployment" means a 2.3 GHz Base Station or a 2.3 GHz Fixed or Installed Terminal Station deployed by a 2.3 GHz Licensee. For the purposes of this Notice indoor femtocells and indoor smart/intelligent repeaters, as defined in Schedule 1 of the 2.3 GHz licence, are excluded from a 2.3 GHz Deployment;

"MOD" means the Ministry of Defence;

"Protected Site" means the list of sites set out in this Notice;

"Signals" means the transmission in the 2350 to 2390 MHz band from the 2.3 GHz communications equipment;

"Site Protection Threshold" means the threshold that the 2.3 GHz Licensee must comply with as specified in this Notice;

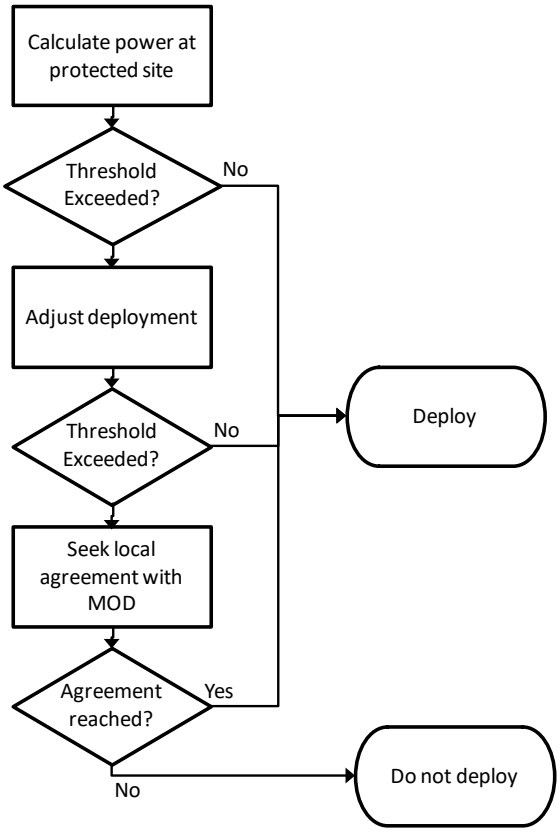
"Terminal Station" means radio equipment that receives downlink transmissions from a Base Station.

Overview of coordination procedure

A6.5 When planning its network deployment, the 2.3 GHz Licensee must check whether the protection thresholds set out in this document would be exceeded as a result of any proposed 2.3 GHz Deployment. To do so, the 2.3 GHz Licensee will need to calculate the communications signal at the relevant Protected Site location(s) (see Protection Thresholds section below). If these calculations show that the relevant threshold(s) will not be exceeded as a result of the planned deployment, then deployment can go ahead. If the calculations show that the relevant threshold(s) would be exceeded as a result of the planned deployment, the 2.3 GHz Licensee may consider adjusting the deployment.

A6.6 If it is not possible to adjust the deployment so that the threshold(s) are not exceeded, the 2.3 GHz Licensee may only deploy if agreement is reached with the operator(s) of the relevant site(s). In the first instance, contact should be made via Ofcom who will facilitate a discussion between the licensee's appropriately security cleared personnel and the operator of the Protected Site.

Figure A6.1: Flowchart illustrating coordination procedures for deployments within the coordination zone



List of sites to be protected

A6.7 The sites to which these coordination procedures apply are listed in Figure A6.2 below.

Figure A6.2: 2.3 GHz Band Protected Site Locations

Site	Location
Aberporth	SN 247 518
St Kilda	NF 094 987
Oakhanger	SU 776 357
Colerne	ST 808 717
Menwith Hill	SE 209 561
Boscombe Down	SU 178 392
Warton	SD 412 281
Portland Area	SY 836 593 SY 491 685
BUTEC Area	NG 635 490
Northern Ireland	At the coastline and within Northern Ireland

Protection thresholds

A6.8 The 2.3 GHz Licensee must use the methodology in this Notice to ensure that emissions from each proposed 2.3 GHz Deployment in its licensed 2.3 GHz Band do not exceed the threshold for the in-band communications signal given in Figure A6.3.

Figure A6.3: Site Protection Thresholds

In-band communication signal		
	Aberporth	
Site Protection Thresholds	Threshold for Signals in the 2350 to 2360 MHz band [1]	-59 dBm /5 MHz
	Height	143m above mean sea level
	Area where calculation is to be performed	Within an area described by the following 10km grid squares (reference point is the lower left hand corner): SN15 (SN 1000 5000) SN25 (SN 2000 5000) SN35 (SN 3000 5000) SN36 (SN 3000 6000)
	St Kilda	
Site Protection thresholds	Threshold for Signals in the 2350 to 2360 MHz band [1]	-149 dBm / 5 MHz
	Height	370m above mean sea level
	Area where calculation is to be performed	Up to 225km from St Kilda

	Oakhanger, Colerne, Menwith Hill	
Site Protection thresholds	Threshold for Signals in the 2350 to 2390 MHz band [1]	-52 dBm / 5 MHz
	Height	14m above ground level
	Area where calculation is to be performed	Up to 5km from each site location
	Boscombe Down, Warton	
Site Protection thresholds	Threshold for Signals in the 2350 to 2390 MHz band [1]	-62 dBm / 5 MHz
	Height	Boscombe Down: 15m above ground level Warton: 30m above ground level
	Area where calculation is to be performed	Up to 10km from each site location
	Portland Area – this requirement will cease on 31st December 2020	
Site Protection thresholds	Threshold for Signals in the 2350 to 2390 MHz band [1]	-103 dBm / 5 MHz
	Height	30m above sea level
	Area where calculation is to be performed Additionally, the 2.3 GHz Licensee cannot deploy Base Stations with an effective EIRP (including antenna pattern effects) of more than 56 dBm / 5 MHz in the direction of the Portland Area Protected Site location in the following grid squares without prior coordination and agreement from MOD. In this case, coordination will be required with a small number of additional locations within the sea around Portland ST90 ST91 ST92 SU00 SU01 SU02 SY99 SZ09	Within an area described by the following 10km grid squares (reference point is the lower left hand corner): ST10 (i.e. ST 1000 0000) ST20 SX57 SX83 SY07 SY66 SZ07 ST21 SX58 SX84 SY08 SY67 SZ08 ST30 SX65 SX85 SY18 SY68 SZ19 ST40 SX66 SX86 SY19 SY69 SZ28 ST50 SX67 SX87 SY28 SY77 SZ29 ST60 SX68 SX88 SY29 SY78 SZ38 ST70 SX69 SX89 SY38 SY79 SZ39 ST80 SX73 SX94 SY39 SY87 SZ47 ST81 SX74 SX95 SY48 SY88 SZ48 SU30 SX75 SX96 SY49 SY89 SZ49 SU40 SX76 SX97 SY58 SY97 SZ57 SU50 SX77 SX98 SY59 SY98 SZ58 SX78
	BUTEC Area – this requirement will cease on 31st December 2023	
Site Protection thresholds	Threshold for Signals in the 2350 to 2390 MHz band [1]	-100 dBm / 5 MHz
	Height	30m above sea level
	Area where calculation is to be performed	Within an area described by the following 10km grid squares (reference point is the lower left hand corner): NG 63 (i.e NG 6000 3000) NG54 NG78 NM78 NG81 NG55 NG66 NM79 NG82 NG74 NG70 NM68 NG86 NG64 NG75 NG72 NM69 NG87 NG65 NG76 NG56 NG73 NG53 NG77 NM77 NG79

	Northern Ireland	
Site Protection thresholds	Threshold for Signals in the 2350 to 2390 MHz band [1]	-125 dBm / 5 MHz
	Height	3m above ground level
Note [1]: The protection thresholds are defined during the 'on' period of the transmit signal and referenced to a 0dBi receive antenna		

Compliance with the thresholds

A6.9 Prior to deployment, the 2.3 GHz Licensee must use the methodology in this Notice to assess whether the protection thresholds specified in Figure A6.3 will be exceeded as a result of its planned 2.3 GHz Deployment for any Protected Site. There is no requirement to undertake an assessment outside of the calculation areas given in Figure A6.3, except as described in A6.10 below.

A6.10 The calculation areas in Figure A6.3 have been developed on the basis of Base Stations at 30m above ground level in order to constrain the area over which coordination must be undertaken. However, bidders are advised that sites which are higher than this but located outside of the coordination area may still cause interference to MOD systems in certain circumstances. The 2.3 GHz Licensee must therefore consider whether any of its deployments which are greater than 30m above ground level are likely to cause any impact to the Protected Site and coordinate it if it deems necessary.

A6.11 In carrying out this assessment for deployments within the calculation areas described in Figure A6.3 the 2.3 GHz Licensee must use propagation models described below with the parameters given in Figure A6.4.

A6.12 The 2.3 GHz Licensee must ensure that the protection thresholds for each 2.3 GHz Deployment are not exceeded at the Protected Site taking account of the relative horizontal antenna gain pattern described in Figure A6.6. The horizontal polar diagram will be used to calculate additional antenna discrimination loss in the direction of the 2.3 GHz Base Station. The antenna peak gain is accounted for in the protection thresholds and antenna polar diagrams provided are referenced to the maximum Protected Site antenna gain.

A6.13 The 2.3 GHz Licensee must maintain records of its calculations and assessments and make these available to Ofcom if required.

Exceeding the threshold

A6.14 The thresholds may only be exceeded in relation to a specific Protected Site if the 2.3 GHz Licensee has reached an agreement with the operator of that Protected Site (Ofcom will facilitate the necessary introductions). Any such agreement must be recorded in writing in a form agreed by both the 2.3 GHz Licensee and the site operator. The 2.3 GHz Licensee must maintain a record of all such agreements, and make them available to Ofcom on request.

Propagation Model

A6.15 The path loss will be calculated using ITU-R Recommendation P.452-16 "Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above 0.7 GHz"[112].

A6.16 It predicts signal levels exceeded for a given percentage of time, the assessment will use a time percentage of 10% as included in Figure A6.4 below.

A6.17 Predictions are based on the terrain profile and clutter along the path.

A6.18 Additional losses due to protection from local clutter shall be applied at both the transmitter and receiver where they are on land. This is based on a nominal clutter height and nominal obstacle distance assigned to each clutter category. The required values are given in Figure A6.5.

Figure A6.4: ITU-R P.452 parameters

Time percentage	10%
Sea level surface refractivity, N_0 (N-units)	Aberporth: 326 St Kilda, BUTEC Area: 321 Oakhanger, Colerne, Boscombe Down: 327 Menwith Hill, Warton: 324 Portland Area: 327
The average radio-refractive index lapse-rate through the lowest 1km of the atmosphere, ΔN (N-units/km)	Aberporth: 42 St Kilda, BUTEC Area: 41 Oakhanger, Colerne, Boscombe Down: 42 Menwith Hill, Warton: 42 Portland Area: 42
Dry air pressure (hPa)	1013
Temperature (°C)	15.0
Nominal path centre latitude φ (°)	Aberporth: 52 St Kilda, BUTEC Area: 57 Oakhanger, Colerne, Boscombe Down: 51 Menwith Hill, Warton: 54 Portland Area: 51
Clear-air propagation attenuation components included:	Line of sight/Diffraction - Diffraction - Multipath and focussing effects - Gaseous absorption Tropospheric scatter - Gaseous absorption Ducting/Layer reflection - Gaseous absorption
The path centre latitude φ may be selected on a case by case basis, in this case N_0 and ΔN should be calculated using the following equations: $N_0 = 328 - (\varphi - 50)$ $\Delta N = 42.5 - 0.25(\varphi - 50)$	

[112] www.itu.int/rec/R-REC-P.452/en

Terrain database

A6.19 Digital terrain map data with 50m resolution shall be used. Examples include Ordnance Survey "Landform Panorama®" or "OS Terrain® 50" datasets[113].

Clutter database

A6.20 A digital land classification ("clutter") dataset with 50m resolution such as "Infoterra 50m clutter" [114] or other equivalent shall be used.

A6.21 The Infoterra dataset identifies 10 different clutter categories. For location variation, these are mapped to the required clutter designations with nominal clutter heights and nominal obstacle distances.

A6.22 The default parameters, given in Figure A6.5, for nominal clutter heights and nominal obstacle distances are as defined in ITU-R Recommendation P.452-16.

Figure A6.5: Infoterra clutter code mapping

Infoterra Clutter Code	Description	Nominal height (m)	Nominal distance (km)
1	Open	4	0.1
2	Suburban	9	0.025
3	Urban	20	0.02
4	Villages	5	0.07
5	Open in Urban	4	0.1
6	Forest	15	0.05
7	Water	Not applicable	Not applicable
8	Dense Urban	25	0.02
9	Park recreation	4	0.1
10	Industry	20	0.05

Horizontal antenna pattern

A6.23 Figure A6.6 shows the horizontal antenna pattern that must be used for signal strength calculations.

Figure A6.6: Antenna pattern with reference to grid north

Angle from grid north (degrees)	Gain wrt to peak (dB) Aberporth	Gain wrt to peak (dB) All other sites
0	0	0
60	0	0
65	-8.3	0

[113] http://www.ordnancesurvey.co.uk/business-and-government/products/opendata-products-grid.html
[114] http://www.space-airbusds.com

70	-24	0
75	-30	0
80	-31	0
240	-31	0
245	-30.3	0
250	-24	0
255	-12.5	0
260	0	0
355	0	0
360	0	0

Annex 7

Notice of coordination procedure for MOD sites related to 3.4 GHz licences

A7.1 This Notice is notified to each 3.4 GHz Licensee under their respective 3.4 GHz licences.

A7.2 MOD has a small amount of ongoing use within the band at one location in Cornwall. It also requires protection for a number of Royal Navy and other radar locations in addition to those covered by the coordination procedure for air traffic control radar (see annex 8).

A7.3 This Notice specifies the protection thresholds and coordination procedure necessary to ensure the protection of existing and continuing MOD usage in the 3.4 to 3.6 GHz band from potential harmful interference from the networks in the 3.4 GHz Band.

A7.4 In this Notice:

"3.4 GHz Band" means the following frequencies: 3410 MHz to 3600 MHz;

"3.4 GHz Base Station" means a Base Station which are licensed to transmit using frequencies in the 3.4 GHz Band;

"3.4 GHz Fixed or Installed Terminal Station" means a fixed or installed Terminal Stations which is not exempt from licensing by the Wireless Telegraphy Act (Exemption) Regulations and which is licensed to transmit using frequencies in the 3.4 GHz Band;

"3.4 GHz Licensee" means the licensee under a licence authorising use in the United Kingdom of frequencies in the 3.4 GHz Band;

"Base Station" means radio equipment that transmits to a Terminal Station(s);

"3.4 GHz Deployment" means a 3.4 GHz Base Station or a 3.4 GHz Fixed or Installed Terminal Station deployed by a 3.4 GHz Licensee. For the purposes of this Notice indoor femtocells and indoor smart/intelligent repeaters, as defined in Schedule 1 of the 3.4 GHz licence, are excluded from a 3.4 GHz Deployment;

"MOD" means the Ministry of Defence;

"Protected Site" means the list of sites set out in this Notice;

"Signals" means the transmission in the 3410 to 3600 MHz band from the 3.4 GHz communications equipment;

"Site Protection Threshold" means the threshold that the 3.4 GHz Licensee must comply with as specified in this Notice;

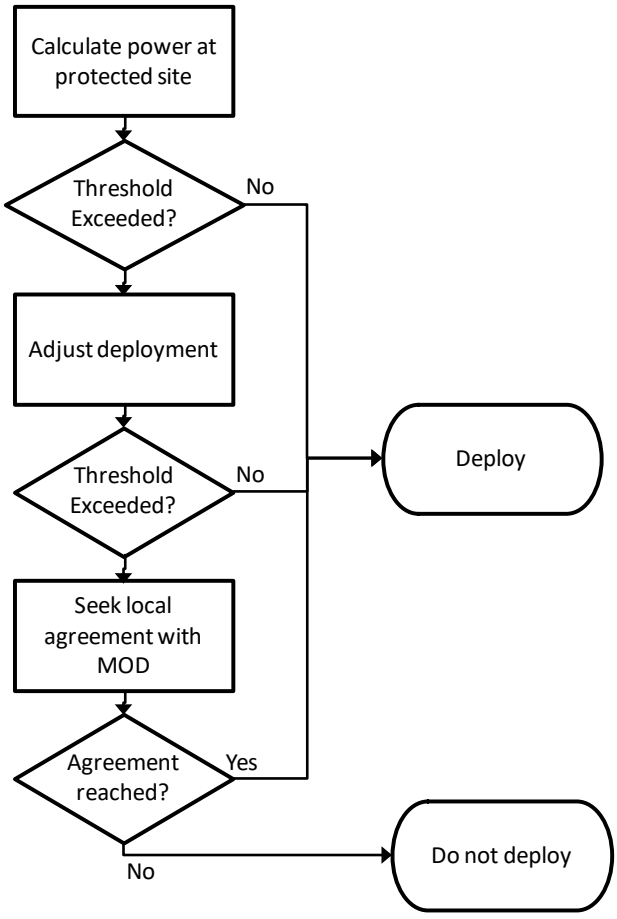
"Terminal Station" means radio equipment that receives downlink transmissions from Base Stations.

Overview of coordination procedure

A7.5 When planning its network deployment, the 3.4 GHz Licensee must check whether the protection thresholds set out in this document would be exceeded as a result of any proposed 3.4 GHz Deployment. To do so, the 3.4 GHz Licensee will need to calculate the communications signal at the relevant Protected Site location(s) (see protection thresholds section below). If these calculations show that the relevant threshold will not be exceeded as a result of the planned deployment, then deployment can go ahead. If the calculations show that the relevant threshold(s) would be exceeded as a result of the planned deployment, the 3.4 GHz Licensee may consider adjusting the deployment.

A7.6 If it is not possible to adjust the deployment so that the threshold(s) are not exceeded, the 3.4 GHz Licensee may only deploy if agreement is reached with the operator(s) of the relevant site(s). In the first instance, contact should be made via Ofcom who will facilitate a discussion between the licensee's appropriately security cleared personnel and the operator of the Protected Site.

Figure A7.1: Flowchart illustrating coordination procedures for deployments within the coordination zone



List of sites to be protected

A7.7 The sites to which these coordination procedures apply are listed in Figure A7.2 below.

Figure A7.2: 3.4 GHz Band Protected Site Locations

Site	Location
Bude	SS 208 126
Portsmouth Area	SU 632 013 SZ 489 945 SU 642 067
Portland Area	SY 836 593 SY 491 685
BUTEC Area	NG 635 490
Airborne Locations	1 SV 765 726 2 SS 437 670 3 TF 762 073 4 SE 555 695 5 NT 904 234 6 [115] 55.469417, 2.976250 7 [116] 56.200611, -8.466556 8 OL 106 675 9 NO 148 989 10 NE 225 490 11 HV 569 504 12 HT 347 471 13 OW 009 782

Protection thresholds

A7.8 The 3.4 GHz Licensee must use the methodology in this Notice to ensure that emissions from each proposed 3.4 GHz Deployment (or combination of deployments) in its licensed 3.4 GHz Band do not exceed the threshold for the in-band communications signal given in Figure A7.3.

[115] This position is outside the region covered by the OS grid reference
[116] This position is outside the region covered by the OS grid reference

Figure A7.3: Site Protection Thresholds

In-band communication signal		
	Bude	
Site Protection thresholds	Threshold for Signals in the 3410 to 3600 MHz band [1]	-56 dBm /5 MHz
	Height	18m above ground level
	Area where calculation is to be performed	Up to 25km from Bude
	Portsmouth Area	
Site Protection thresholds	Threshold for Signals in the 3410 to 3600 MHz band [1]	-56 dBm / 5 MHz
	Height	35m above ground level
	Area where calculation is to be performed	Up to 8km from each site
	Portland Area - this requirement will cease on 31st December 2020	
Site Protection thresholds	Threshold for Signals in the 3410 to 3600 MHz band [1]	-103 dBm /5 MHz
	Height	30m above sea level
	Area where calculation is to be performed Additionally, the 3.4 GHz Licensee cannot deploy Base Stations with an effective EIRP (including antenna pattern effects) of more than 60 dBm / 5 MHz in the direction of the Portland Area Protected Site location in the following grid squares without prior coordination and agreement from the MOD. In this case, coordination will be required with a small number of additional locations within the sea around Portland ST90 ST91 ST92 SU00 SU01 SU02 SY99 SZ09	Within an area described by the following 10km grid squares (reference point is the lower left hand corner): ST10 (i.e. ST 1000 0000) ST20 SX57 SX83 SY07 SY66 SZ07 ST21 SX58 SX84 SY08 SY67 SZ08 ST30 SX65 SX85 SY18 SY68 SZ19 ST40 SX66 SX86 SY19 SY69 SZ28 ST50 SX67 SX87 SY28 SY77 SZ29 ST60 SX68 SX88 SY29 SY78 SZ38 ST70 SX69 SX89 SY38 SY79 SZ39 ST80 SX73 SX94 SY39 SY87 SZ47 ST81 SX74 SX95 SY48 SY88 SZ48 SU30 SX75 SX96 SY49 SY89 SZ49 SU40 SX76 SX97 SY58 SY97 SZ57 SU50 SX77 SX98 SY59 SY98 SZ58 SX78
	BUTEC Area - this requirement will cease on 31st December 2023	
Site Protection thresholds	Threshold for Signals in the 3410 to 3600 MHz band [1]	-100 dBm /5 MHz
	Height	30m above sea level
	Area where calculation is to be performed	Within an area described by the following 10km grid squares (reference point is the lower left hand corner): NG44 (i.e. NG 4000 4000) NG61 NG54 NG78 NM78 NG81 NG62 NG55 NG66 NM79 NG82

		NG63 NG74 NG70 NM68 NG86 NG64 NG75 NG72 NM69 NG87 NG65 NG76 NG56 NG73 NG53 NG77 NM77 NG79 NB30 NB31 NB41 NG45 NG46 NG47 NG52
	Airborne Locations - this requirement will cease on 31st December 2018	
Site Protection thresholds [117]	Maximum **power-summed** power density from all licensee's Base Stations in the 3410 to 3600 MHz band [1]	-58.3 dBm / m^2 / 5 MHz+10*$\log_{10}$ ($\frac{BW}{BW\_used}$) [see note 2]
	Height	9,000m above mean sea level
	Area over which power integration calculation is to be performed [see note 3].	Sectors 1.2° wide in bearings of 1.2° steps east of true north from each Airborne Location. 93.5km from Airborne Location out to RF horizon (at least 410km for a 30m mast)
	Area where calculation is to be performed	For all Base Stations within power integration area above for relevant location.
Note **[1]**: The protection thresholds are defined during the 'on' period of the transmit signal and referenced to a 0dBi receive antenna Note [2]: Where: BW is the total 3.4 GHz bandwidth (in MHz) assigned to the licensee for downlink transmissions in the band 3410 to 3600 MHz in MHz and BW_used is the amount of spectrum in this band in use by the licensee (in MHz). The additional term allows a licensee to associate its full allowance of the coordination threshold to only the part of its allocated spectrum that is in use within the coordination area. Note [3]: The calculation shall be undertaken for and every 1.2° wide sector associated with the Airborne Location (limited by the minimum distance and maximum distamce). The calculation for each sector shall comply with the threshold specified.		

Compliance with the thresholds

A7.9 Prior to deployment, the 3.4 GHz Licensee must use the methodology in this Notice to assess whether the protection thresholds specified in Figure A7.3 will be exceeded as a result of its planned 3.4 GHz Deployment for any Protected Site. There is no requirement to undertake an assessment outside of the calculation areas given in Figure A7.3 except as described in paragraph A7.10 below.

A7.10 The calculation areas in Figure A7.3 have been developed on the basis of Base Stations at 30m above ground level in order to constrain the area over which coordination must be undertaken. However, bidders are advised that sites which are higher than this but located outside of the coordination area may still cause interference to MOD systems in certain circumstances. The 3.4 GHz Licensee must therefore consider whether any of its deployments which are greater than 30m above ground level are likely to cause any impact to the Protected Site and coordinate if it deems necessary.

A7.11 In carrying out this assessment for deployments within the calculation areas described in Figure A7.3 the 3.4 GHz Licensee must use propagation models described below with the parameters given in Figure A7.4.

[117] Radar parameters and platform altitude derived from airborne system A in "Recommendation ITU-R M.1465-2"

A7.12 The 3.4 GHz Licensee must maintain records of its calculations and assessments and make these available to Ofcom if required.

Exceeding the threshold

A7.13 The thresholds may only be exceeded in relation to a specific Protected Site if the 3.4 GHz Licensee has reached an agreement with the operator of that Protected Site (Ofcom will facilitate the necessary introductions). Any such agreement must be recorded in writing in a form agreed by both the 3.4 GHz Licensee and the site operator. The 3.4 GHz Licensee must maintain a record of all such agreements, and make them available to Ofcom on request.

Propagation Model

A7.14 With the exception of the airborne locations, the path loss will be calculated using ITU-R Recommendation P.452-16 "Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above 0.7 GHz"[118].

A7.15 It predicts signal levels exceeded for a given percentage of time, the assessment will use a time percentage of 10% as included in Figure A7.4 below.

A7.16 Predictions are based on the terrain profile and clutter along the path.

A7.17 Additional losses due to protection from local clutter shall be applied at both the transmitter and receiver where they are on land. This is based on a nominal clutter height and nominal obstacle distance assigned to each clutter category. The required values are given in Figure A7.5.

A7.18 In the case of the airborne locations, the path loss will be calculated using ITU-R P.528-3 "Propagation curves for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands"[119]. It predicts signal levels exceeded for a given percentage of time, the assessment will use a time percentage of 50%. Predictions are based on the terrain profile which must be modified by the nominal clutter height assigned to each clutter category. The required values are given in Figure A7.5.

Figure A7.4: ITU-R P.452 parameters

Time percentage	10%
Sea level surface refractivity, N_0 (N-units)	Bude: 327 Portsmouth Area, Portland Area: 327 BUTEC Area: 321
The average radio-refractive index lapse-rate through the lowest 1km of the atmosphere, ΔN (N-units/km)	Bude: 42 Portsmouth Area, Portland Area: 42 BUTEC Area: 41
Dry air pressure (hPa)	1013
Temperature (°C)	15.0

[118] www.itu.int/rec/R-REC-P.452/en

[119] www.itu.int/rec/R-REC-P.528/en

Nominal path centre latitude φ (°)	Bude: 51 Portsmouth Area, Portland Area: 51 BUTEC Area: 57
Clear-air propagation attenuation components included:	Line of sight/Diffraction - Diffraction - Multipath and focussing effects - Gaseous absorption Tropospheric scatter - Gaseous absorption Ducting/Layer reflection - Gaseous absorption
The path centre latitude φ may be selected on a case by case basis, in this case N_0 and ΔN should be calculated using the following equations: $N_0 = 328 - (\varphi - 50)$ $\Delta N = 42.5 - 0.25(\varphi - 50)$	

Terrain database

A7.19 Digital terrain map data with 50m resolution shall be used. Examples include Ordnance Survey "Landform Panorama®" or "OS Terrain® 50" datasets[120].

Clutter database

A7.20 A digital land classification ("clutter") dataset with 50m resolution such as "Infoterra 50m clutter" [121] or other equivalent shall be used.

A7.21 The Infoterra dataset identifies 10 different clutter categories. For location variation these are mapped to the required clutter designations with nominal clutter heights and nominal obstacle distances.

A7.22 The default parameters, given in Figure A7.5 for nominal clutter heights and nominal obstacle distances are as defined in ITU-R Recommendation P.452-16.

Figure A7.5: Infoterra clutter code mapping

Infoterra Clutter Code	Description	Nominal height (m)	Nominal distance (km)
1	Open	4	0.1
2	Suburban	9	0.025
3	Urban	20	0.02
4	Villages	5	0.07
5	Open in Urban	4	0.1
6	Forest	15	0.05

[120] http://www.ordnancesurvey.co.uk/business-and-government/products/opendata-products-grid.html
[121] http://www.space-airbusds.com

7	Water	Not applicable	Not applicable
8	Dense Urban	25	0.02
9	Park recreation	4	0.1
10	Industry	20	0.05

Annex 8

Notice of aeronautical radar coordination

Coordination procedure for air traffic control radar – notice issued to 3.4 GHz Licensees

A8.1 This Notice is notified to each 3.4 GHz Licensee under their respective 3.4 GHz licences. It specifies the protection thresholds and coordination procedure that Ofcom considers necessary to ensure the protection of existing radars operating in the 2.7 GHz bands from potential harmful interference from the deployment of networks in the 3.4 GHz Band.

A8.2 As part of the Award Process for licences in the 2.6 GHz spectrum band, a cross-Government radar remediation programme ensured that ATC radars in the 2.7 GHz band (2700-3100 MHz) were modified to become more resilient to interference from the 3.4 GHz Band (3410 MHz to 3600 MHz). However, the radars have retained some sensitivity to emissions from the 3.4 GHz Band.

A8.3 In this Notice:

"2.7 GHz band" means the following frequencies: 2700 MHz to 3100 MHz;

"3.4 GHz Band" means the following frequencies: 3410 MHz to 3600 MHz;

"3.4 GHz Base Stations" means Base Stations which are licensed to transmit using frequencies in the 3.4 GHz Band;

"3.4 GHz Deployment" means 3.4 GHz Base Stations and 3.4 GHz Fixed or Installed Terminal Stations deployed by a 3.4 GHz Licensee For the purposes of this Notice indoor femtocells and indoor smart/intelligent repeaters, as defined in Schedule 1 of the 3.4 GHz licence, are excluded from a 3.4 GHz Deployment;

"3.4 GHz Fixed or Installed Terminal Stations" means fixed or installed Terminal Stations which are not exempt from licensing by the Wireless Telegraphy Act (Exemption) Regulations and which are licensed to transmit using frequencies in the 3.4 GHz Band;

"3.4 GHz Licensee" means the licensee under a licence authorising use in the United Kingdom of frequencies in the 3.4 GHz Band;

"Base Station" means radio equipment that transmits to Terminal Station(s);

"The CAA" means the Civil Aviation Authority;

"The in-band communications signal threshold" means the threshold that the 3.4 GHz Licensee must comply with as specified in this Notice;

"MOD" means the Ministry of Defence;

"Noise" means the non-signal component of the communications transmissions;

"OOB emissions" means out of communications band emissions;

"Protected Radar" means the list of radars set out in this Notice;

"Radar" means aeronautical radio-navigation radar;

"Signals" means the transmission in the 3.41 to 3.6 GHz band from the 3.4 GHz communications equipment;

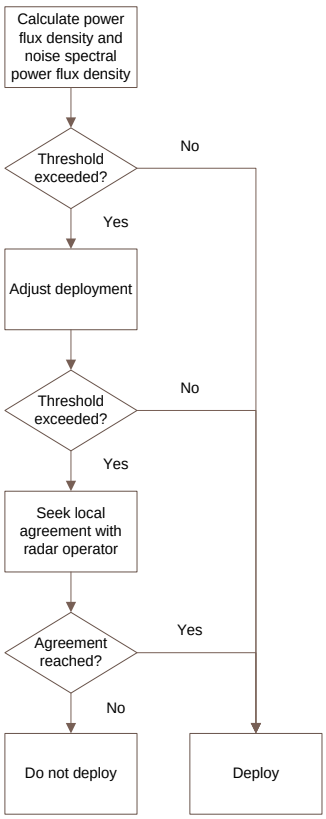
"Terminal Station" means radio equipment that receives downlink transmissions from a Base Stations.

Overview of coordination procedure

A8.4 When planning its network deployment, the 3.4 GHz Licensee must check whether the protection thresholds set out in this document would be exceeded as a result of any proposed 3.4 GHz Deployment. To do so, the 3.4 GHz Licensee will need to calculate the communications signal and the out of band noise at the relevant Protected Radar location(s) (see section below). If these calculations show that the relevant threshold(s) will not be exceeded as a result of the planned deployment, then deployment can go ahead. If the calculations show that the relevant threshold(s) would be exceeded as a result of the planned deployment, the 3.4 GHz Licensee may consider adjusting the deployment.

A8.5 If it is not possible to adjust the deployment so that the threshold(s) are not exceeded, the 3.4 GHz Licensee may only proceed to deployment if agreement is reached with the operator(s) of the relevant radar(s).

Figure A8.1: Flowchart illustrating coordination procedures



The Protected Radar list

A8.6 Details of the existing civil and military radars requiring protection are set out in the Protected Radar list referred to in paragraph A8.27 of this Notice. The area where the radar is protected is limited by the current position and within the airfield boundary. The 3.4 GHz Licensee must ensure that its planned deployment is able to comply with the thresholds in relation to all of that area based on the methodology in this Notice.

A8.7 The protection thresholds and coordination procedure apply to the protection of radars listed on the Protected Radar list at the time a new 3.4 GHz Deployment is made.

A8.8 The protection thresholds and coordination procedure do not apply to the protection of any new radar from 3.4 GHz Deployments in the 3.4 GHz Band already in operation when the radar is deployed. However, where a radar operator does wish to deploy a new radar and there is a 3.4 GHz Licensee with an existing 3.4 GHz Deployment that may interfere with that new radar, it would be open to the parties to seek to resolve between themselves any coordination issues that would arise as a result of the intended radar deployment. Any such agreement must be recorded in writing in a form agreed by both the 3.4 GHz Licensee and the radar operator. The 3.4 GHz Licensee must maintain a record of all such agreements, and make them available to Ofcom on request.

A8.9 Should the parties be unable to agree a resolution to a coordination issue for a new radar at a particular airport, the parties may refer the matter to Ofcom and the CAA for assistance. Ofcom and the CAA, in consultation with the relevant parties, shall use their reasonable endeavours to agree between them and subsequently recommend a proportionate solution to the parties. Ofcom and the CAA recognise that radar operators and mobile operators are likely to have a shared interest in ensuring both aircraft safety through radar protection and availability of mobile coverage at airports. Should the parties be unwilling to accept any recommended solution Ofcom and the CAA would consider the extent to which statutory powers could be used to resolve the situation.

A8.10 The Protected Radar list will be updated and re-issued from time to time. It is the responsibility of the 3.4 GHz Licensee to ensure that it uses the most recent version when planning its deployment.

Radar protection thresholds

A8.11 Protected ATC Radars have been subject to remediation work to make them less susceptible to interference from signals in the 3.4 GHz Band. Figure A8.2 contains values for the in-band communications signal threshold and the threshold for communications out of band noise.

A8.12 Subject to paragraph A8.18, in relation to each Protected Radar, the 3.4 GHz Licensee must ensure that emissions from each Base Station (based on the methodology in this annex) in the 3.4 GHz Band do not exceed the threshold in Figure A8.2

Figure A8.2: Radar protection thresholds

	In-band communication signal	Communications out of band noise
	Power flux density threshold for Signals in the 3410 to 3600 MHz band (dBm/m²) [1,2]	**Noise spectral power flux density threshold at 2720 MHz to 3100 MHz (dBm/MHz/m²) [1,2]**
Radar protection thresholds (per Base Station)	$5+10*\log_{10}(\frac{BW}{120})$	$-131+10*\log_{10}(\frac{BW}{120})$
Area where calculation is to be performed	Up to 7 km from the Protected Site location	
Where: BW is the total 3.4 GHz bandwidth assigned to the licensee for downlink transmissions in the band 3410 to 3600 MHz in MHz Note [1]: The protection thresholds are defined at the peak of the main radar beam. Note [2]: The protection thresholds are defined during the 'on' period of the transmit signal.		

Compliance with the thresholds

A8.13 Prior to deployment, the 3.4 GHz Licensee must use the methodology in this Notice to assess whether the protection thresholds specified in Figure A8.2 will be exceeded as a result of its planned deployment in the 3.4 GHz Band for any Protected Radar.

A8.14 In carrying out this assessment the 3.4 GHz Licensee must use the appropriate propagation Model as follows:

- For 3.4 GHz Deployments further than 1.5km from the Protected Radar, ITU-R P.452-16 with the parameters given in Figure A8.3.
- For 3.4 GHz Deployments at or within 1.5km from the Protected Radar, ITU-R P.525-2 (Free Space Path Loss) + 6 dB additional margin[122].

A8.15 The 3.4 GHz Licensee must ensure that the protection thresholds are not exceeded in any pointing direction of the Protected Radar antenna. The radar antenna peak gain (which is 34 dBi in the main beam direction) is accounted for in the protection thresholds .

A8.16 The field strength is the value that must not exceed threshold limits. The 3.4 GHz Licensee must take into account in its analysis the OOB emissions that would be generated in the presence of closely spaced 3.4 GHz Deployments.

A8.17 The 3.4 GHz Licensee must maintain records of its calculations and assessments and make these available to Ofcom if required.

[122] This margin accounts for multipath. It represents a single multipath Base Station signal reflection received coherently at the radar via a reflecting structure or surface (i.e. buildings, vehicles, pylons, reflective ground structures, etc.). This is assumed when a Base Station is located within 1.5km range of the radar.

Exceeding the threshold

A8.18 The thresholds may only be exceeded in relation to a specific Protected Radar if the 3.4 GHz Licensee has reached an agreement with the operator of that Protected Radar. However, any such agreement would be limited to that specific Protected Radar, and would not remove the obligation of the 3.4 GHz Licensee to comply with the relevant thresholds in relation to other Protected Radars. Any such agreement must be recorded in writing in a form agreed by both the 3.4 GHz Licensee and the radar operator. The 3.4 GHz Licensee must maintain a record of all such agreements, and make them available to Ofcom on request.

Propagation Model

A8.19 The path loss will be calculated using Recommendation ITU-R P.452-16 "Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above 0.7 GHz"[123].

A8.20 It predicts signal levels exceeded for a given percentage of time, the assessment will use a time percentage of 0.1% as included in the table below.

A8.21 Predictions are based on the terrain profile and clutter along the path.

A8.22 A propagation correction due to clutter shall be applied. This is based on a representative clutter height assigned to each clutter category.

Figure A8.3: ITU-R P.452 parameters

Time percentage	0.1%
Sea level surface refractivity, N_0 (N-units)	325
The average radio-refractive index lapse-rate through the lowest 1km of the atmosphere, ΔN (N-units/km)	45
Dry air pressure (hPa)	1013
Temperature (°C)	15.0
Nominal path centre latitude φ (°)	51.0
Clear-air propagation attenuation components included:	Line of sight/Diffraction - Diffraction - Multipath and focussing effects - Gaseous absorption Tropospheric scatter - Gaseous absorption Ducting/Layer reflection - Gaseous absorption
The path centre latitude φ may be selected on a case by case basis, in this case N_0 and ΔN should be calculated using the following equations: $N_0 = 328 - (\varphi - 50); \qquad \Delta N = 42.5 - 0.25(\varphi - 50)$	

[123] www.itu.int/rec/R-REC-P.452/en

Terrain database

A8.23 Digital terrain map data with 50m resolution shall be used. Examples include Ordnance Survey "Landform Panorama®" or "OS Terrain® 50" datasets[124].

Clutter database

A8.24 A digital land classification ("clutter") dataset with 50m resolution such as "Infoterra 50m clutter" [125] or other equivalent shall be used.

A8.25 The Infoterra dataset identifies 10 different clutter categories. For location variation these are mapped to the required clutter designations with nominal clutter heights and nominal obstacle distances.

A8.26 The default parameters, given in Figure A8.4 for nominal clutter heights and nominal obstacle distances are as defined in ITU-R P.452-16.

Figure A8.4: Infoterra clutter code mapping

Infoterra Clutter Code	Description	Nominal height (m)	Nominal distance (km)
0	Open	4	0.1
1	Suburban	9	0.025
2	Urban	20	0.02
3	Villages	5	0.07
4	Open in Urban	4	0.1
5	Forest	15	0.05
6	Water	0	Not applicable
7	Dense Urban	25	0.02
8	Park recreation	4	0.1
10	Industry	20	0.05

List of military and civil radars to be protected

A8.27 The radars to which these coordination procedures apply can be found at: http://stakeholders.ofcom.org.uk/binaries/spectrum/clearance-coexistence/Protected_radar.pdf. The list was updated on XXXXX to refer to 3.4 GHz licenses as well as the 2.6 GHz licences.

A8.28 The area where a radar is protected is limited by the current position and within the airfield boundary[126]. This list will be periodically updated.

[124] http://www.ordnancesurvey.co.uk/business-and-government/products/opendata-products-grid.html

[125] http://www.space-airbusds.com

[126] The CAA has records of airfield boundaries as part of its aerodrome licensing, available at http://www.caa.co.uk/default.aspx?catid=375&pagetype=90&pageid=5373.

Annex 9

International Coordination

MOU with France

2.3 GHz and 3.4 GHz

A9.1 Memorandum of understanding on frequency coordination between France and United Kingdom concerning the spectrum coordination of Land Mobile networks in the frequency bands 2300-2400 MHz and 3400-3800 MHz to be applied in the area including France, the United Kingdom and the Channel Islands – 19 November 2014 http://licensing.ofcom.org.uk/binaries/spectrum/mobile-wireless-broadband/cellular/licensee-frequency-technical-info/MoU_UK-CI-France_2300-2400_3400-3800_MHz_19-11-14.pdf.

MOU with Ireland

2.3 GHz

A9.2 Memorandum of understanding on frequency coordination between the Republic of Ireland and United Kingdom in the frequency bands 2300 - 2400 MHz to be applied in the area including the Republic of Ireland, the United Kingdom and Isle of Man – 1 January 2010 http://licensing.ofcom.org.uk/binaries/spectrum/mobile-wireless-broadband/cellular/licensee-frequency-technical-info/MoU_UK-Ireland_2300-2400_MHz__01-01-10.pdf.

3.4 GHz

A9.3 Memorandum of understanding on frequency coordination between the Republic of Ireland and United Kingdom for Wireless Access Services in the frequency band 3400 to 3800 MHz – 31 March 2008 http://licensing.ofcom.org.uk/binaries/spectrum/mobile-wireless-broadband/cellular/licensee-frequency-technical-info/MoU_UK-Ireland_3400-3800_MHz_01-04-08.pdf .

MOU with Isle of Man

2.3 and 3.4 GHz

A9.4 Memorandum of understanding on frequency coordination between Isle of Man and United Kingdom concerning the spectrum coordination of Land Mobile radio communications networks in the frequency bands 2300-2400 MHz and 3400-3800 MHz http://licensing.ofcom.org.uk/binaries/spectrum/mobile-wireless-broadband/cellular/licensee-frequency-technical-info/MoU_UK-IoM__2300_2400_MHz_and_3400-3800_MHz_-_09-12-15.pdf [127], [128]

[127] Footnote from previous edition removed

[128] Footnote from previous edition removed

Annex 10

Glossary of terms

2G	Second generation mobile phone standards and technology
3G	Third generation mobile phone standards and technology
4G	Fourth generation mobile phone standards and technology
5G	Fifth generation mobile phone standards and technology (not yet developed)
AIP	Administrative Incentive Pricing
ATC/ATM	Air Traffic Control/ Air Traffic Management
Award Process	The procedures set out in the in the Regulations for the award and issue of the Licences
Bluetooth	Wireless standard for short-range radio communications between a variety of devices such as PCs, headsets, printers, mobile phones, and PDAs.
BS	Base Station
CAA	Civil Aviation Authority
CEPT	European Conference of Postal and Telecommunications Administrations
Communications Act	The Communications Act 2003
ComReg	Commission for Communications Regulation: the communications regulator for the Republic of Ireland (https://www.comreg.ie/).
dB / dBm	Decibel. A notation for dealing with ratios that vary over several orders of magnitude by using logarithms / The power ratio in decibels (dB) of the measured power referenced to one milliwatt (mW).
DfT	Department for Transport
DTT	Digital Terrestrial Television – Broadcasting delivered by digital means. In the UK and Europe, DTT transmissions use the DVB-T and DVB-T2 technical standards
Duty Cycle	Defines the percentage of time within an observation period where the transmission is “on”

EC	European Commission
ECC	Electronic Communications Committee – One of the three business committees of the European Conference of Postal and Telecommunications Administrations.
ECN	Electronic Communications Network
ECS	Electronic Communications Service
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).
EMC	Electromagnetic compatibility
ERP	Effective radiated power
ES	Earth Station
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
Frame structure	The combination of downlink and uplink sub-frame transmissions that make a frame. A frame is 10ms long with TD-LTE.
GHz	Gigahertz. A unit of frequency of one billion (10^9cycles per second). .
IEEE	Institute of Electrical and Electronics Engineers (standards body)
IMT	International mobile telecommunications
Interface Requirements	UK Interface Requirements contain the requirements for the licensing and use in specified frequency bands
ITU	International Telecommunications Union - Part of the United Nations with a membership of 193 countries and over 700 private-sector entities and academic institutions. ITU's headquarters are in Geneva, Switzerland.
ISP	Internet Service Provider
kHz	Kilohertz: a unit of frequency of one thousand cycles per second.
LSA	Licence shared access of radio spectrum
LTE	Long Term Evolution. Part of the development of 4G mobile systems that started with 2G and 3G networks.
MCA	Maritime and Coastguard Agency
MHz	Megahertz. A unit of frequency of one million cycles per second.

MOD	Ministry of Defence
MFCN	Mobile/Fixed Communications Networks
MSS	Mobile Satellite Services
MoU	Memorandum of Understanding
NATS	NATS Holdings; a UK provider of air traffic control services
Ofcom	The Office of Communications
OBB	Out-of-band
PMSE	Programme-making and special events. A class of radio application that supports a wide range of activities in entertainment, broadcasting, news gathering and community events.
PSSR	Public Sector Spectrum Release
R&TTE Directive	Radio and Telecommunications Terminal Equipment Directive (1995/5/EC)
RED	Radio Equipment Directive – a new EU Directive (2014/53/EU) with requirements for radio transmitters and receivers
RF	Radio Frequency
RFID	Radio frequency identification
RSPP	Radio Spectrum Policy Programme
SDL	Supplementary Down Link – where unpaired spectrum is used for downlink transmission only
SINR	Signal-to-interference-plus-noise ratio
SMP	Significant market power
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.
TD-LTE	Time Division Long Term Evolution. Sometimes referred to as Long Term Evolution Time-Division Duplex.
TRP	Total Radiated Power. The TRP is defined as the integral of the power transmitted in different directions over the entire radiation sphere.
UIC	International Union of Railways
UKFAT	UK Frequency Allocation Table
UKSSC	UK Spectrum Strategy Committee
UWB	Ultra wideband
WDS	White Space Devices
Wi-Fi	Commonly used to refer to wireless local area network (WLAN)

	technology, specifically that conforming to the IEEE 802.11 family of standards. Such systems typically use one or more access points connected to wired Ethernet networks which communicate with wireless network adapters in end devices such as PCs
WiMAX	Worldwide Interoperability for Microwave Access is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates.
WLAN	Wireless Local Area Network
WRC	World Radiocommunication Conference (WRC-15 refers to the World Radiocommunication Conference which was held in 2015 and WRC-19 refers to the World Radiocommunication Conference to be held in 2019)
WT Act	Wireless Telegraphy Act 2006
ZigBee	Brand name for part of IEEE 802.15 Personal Area network Standards