Public Sector Spectrum Release

Amateur use of 2310 to 2450 and 3400 to 3475 MHz

Consultation

Publication date: 11 June 2013

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Section 1

Executive summary

1.1 The Ministry of Defence (MoD) plan to release 40 MHz of spectrum between 2350 and 2390 MHz (the 2.3 GHz release band) and a further 150 MHz from 3410 to 3600 MHz (the 3.4 GHz release band) for new civil uses.[1]

1.2 The technical and regulatory aspects of this release will be the subject of a full consultation in due course. In advance of this, this document seeks feedback on the implications for amateurs.

1.3 It sets out analysis and technical assessments which suggest that the impact and likelihood of harmful interference being caused by amateurs to new uses in the release bands (i.e. 2350 to 2390 MHz and 3410 to 3475 MHz) are sufficiently severe to preclude continued use by amateurs following the MoD's release. We are therefore consulting on proposals to vary the amateur licence to remove these bands.

1.4 This document also details the uncertainty about continued amateur access to the adjacent bands (i.e. 2310 to 2350 MHz, 2390 to 2400 MHz and 3400 to 3410 MHz). This is based on the likelihood that other existing uses will be concentrated in the adjacent bands and on the conclusions drawn from our technical assessments. Three options are proposed:

i) Remove access to the adjacent bands

ii) Retain access to the adjacent bands on the current terms but with clarification of the notice period required for future amateur use to cease if amateurs cause interference to other users in the release band or the adjacent band.

iii) Restrict amateur access to a smaller part of one or more adjacent bands.

1.5 Of these three options our preference is for option two. That is for amateurs to retain access to the adjacent bands with clarification of the notice period required in the case of interference.

1.6 We are therefore consulting on proposals to make changes to the Amateur Radio Licence which if implemented would:

i) remove the frequencies of the release bands from the licence.

We have set out three options for the adjacent bands and are recommending option two which if implemented would:

ii) introduce a procedure to enable removal of additional frequencies (i.e. the adjacent bands) to quickly if harmful interference arises in the future.

1.7 Table 1 sets out the terms used in this document to describe the frequency bands under discussion and their relevance to this consultation.

[1] https://www.gov.uk/government/news/mod-to-auction-off-radio-spectrum

Table 1: Terms used in this document to describe the frequency bands under discussion and their significance

Term used	Frequency band	Significance
From the current Amateur Radio Licence		
"the 2300 MHz amateur band"	2310 to 2400 MHz	Included in the Amateur Radio Licence as a band amateurs have access to
"the 2400 MHz amateur band"	2400 to 2450 MHz	
"the 3400 MHz amateur band"	3400 to 3475 MHz	
The release bands		
"the 2.3 GHz release band"	2350 to 2390 MHz	The MoD plans to release these bands for new civil uses* Proposal to remove these bands from the amateur licence.‡
"the 3.4 GHz release band"	3410 to 3600 MHz	
The adjacent bands		
	2310 to 2350 MHz	Amateurs currently have access to this spectrum. These are the frequencies we proposed would be subject to quick removal if harmful interference arises.
	2390 to 2400 MHz	
	3400 to 3410 MHz	

‡ The proposal is to vary the Amateur Radio Licence to remove 3400 to 3475 MHz, which is the portion of the 3400 amateur band which overlaps with the MoD's 3.4 GHz release band.
* 40 MHz between 3410 and 3600 MHz is already under civil licence to UK Broadband

Section 2

Introduction and background

2.1 The Ministry of Defence (MoD) plan to release 40 MHz of radio spectrum from 2350 to 2390 MHz and a further 150 MHz from 3410 to 3600 MHz for new civil uses.[2] An illustration of these bands and their current use is set out in Section 3.

2.2 The MoD's plans are part of a Government commitment to release 500 MHz of spectrum by 2020. This aims to address the increasing demand for spectrum fuelled by devices such as smartphones and tablets. The MoD's plans have been set out in various consultations and announcements over several years.[3]

2.3 This consultation considers the impact on amateur radio licence holders of the MoD's planned release. It goes on to set out our proposal to make changes to the Amateur Radio Licence which if implemented would (a) remove certain frequencies from the licence and (b) introduce a procedure to enable removal of additional frequencies quickly if harmful interference arises in the future.

Context for amateur licensees

2.4 At present, amateurs have access to 53 different bands from 135.7 kHz to 250 GHz. These bands have various uses depending on each band's propagation properties. Amateurs favour bands that suit their chosen use and not all bands would be suitable for any given use.

2.5 Two amateur bands overlap with the MoD's release bands: the 2300 MHz amateur band and the 3400 MHz band.[4] Both of these bands also contain frequencies adjacent to the MoD's release bands. In addition amateurs also have access to the 2400 MHz amateur band. There are no proposals to vary access to the 2400 MHz amateur band but it may be good practice for users to follow the recommendations in Annex 6 such as the use of good filters for wide band systems.

2.6 Amateurs share the 2300 MHz and 3400 MHz bands with other uses (i.e. the MoD, other Government departments, and Programme Making and Special Events (PMSE)). Amateur licences authorise use of both the 2300 MHz and 3400 MHz band on a secondary basis. This secondary status means amateurs operate on the basis that they should not cause harmful interference to others and can expect no protection from interference themselves from primary licensed users (non-interference/non-protection).

2.7 The non-interference/non-protection convention of amateurs' secondary access also applies to adjacent frequencies. This means that amateur access to adjacent frequencies is also threatened, if there is potential for harmful interference to use in the MoD's release bands or to other uses displaced from that release band which are relocated in the adjacent bands. These could be a new primary licensee or other primary and secondary uses (e.g. the MoD, other Government departments, and

[2] https://www.gov.uk/government/news/mod-to-auction-off-radio-spectrum
[3] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/77429/Spectrum_Release.pdf; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/35937/dsm_consultation_report.pdf; http://stakeholders.ofcom.org.uk/binaries/consultations/3_4ghz/summary/3_4ghz.pdf
[4] There are three classes of amateur licence: Full, Intermediate and Foundation. Full and Intermediate licence holders has access to 53 spectrum bands. Further information about classes of amateur licences is set out in Section 3.

Programme Making and Special Events (PMSE)). Following the release we anticipate these uses may increase.

2.8 Amateur licences are issued by Ofcom under the Wireless Telegraphy Act 2006 ('the WT Act'). If amateurs are required to end their use of particular frequencies either through licence revocation or variation, we are required to give "reasonable notice" for reasons related to the management of radio spectrum.[5]

2.9 Whilst new licences for the release bands will ultimately be likely to be issued on a technology neutral basis, ongoing harmonisation of spectrum for Mobile/Fixed Communication Networks (MFCN) means it is likely that the released MoD spectrum will be used for wireless broadband using 4G Long Term Evolution (LTE) or LTE advanced technology.

2.10 We have therefore conducted initial tests to measure emissions from amateur radio equipment in order to consider the potential interference to 4G handsets and/or base stations if they operated in or adjacent to the released spectrum. The results of the tests are discussed in Section 3 and Annex 7.

2.11 Based on our technical analysis we believe that the impact and likelihood of harmful interference being caused by amateur uses to new uses in the release band are sufficiently severe to preclude continued use following the release.

2.12 We are therefore consulting on plans to remove the right to operate equipment in the release bands from amateur licences. This decision is discussed in the context of our previous statements in Section 3.

2.13 We are also consulting on proposals for the adjacent bands. Our current thinking is that amateurs should continue to be granted access to the adjacent bands although with additional terms in the licence which amend the current terms of access to these bands. Continued access would be on the basis that interference may not be caused to new and existing uses in the release and adjacent bands and that no protection from interference from those new uses can be expected.

2.14 Specifically, these proposals would require amateur usage to stop with a 'reasonable notice' period of three months without further consultation if amateur use in one or more of the adjacent bands is found to cause interference to new uses (either in the release bands or other uses in the adjacent bands) and dealing with interferences cases becomes too onerous. Specifics of this proposal are set out in Section 4.8.

The use of spectrum by Crown bodies and the role of Ofcom

2.15 The MoD is a Crown body and, as a result, it has no requirement to hold a WT Act licence issued by Ofcom in order to use the spectrum it has been assigned. However, in order to release spectrum, the MoD must first obtain from Ofcom a grant of Recognised Spectrum Access (RSA).

2.16 Once a grant of RSA is made, the MoD may then transfer those access rights and obligations to another user through the spectrum trading mechanism. The rights can then be converted into one or more WT Act licences, issued by Ofcom, allowing a non-Crown body or bodies to make use of the spectrum. Ofcom has two key roles in that regard:

[5] Clause 4 (2)(e) of the current amateur licence (http://licensing.ofcom.org.uk/binaries/spectrum/amateur-radio/guidance-for-licensees/samplelicence07.pdf)

- To make the grant of RSA;
- To regulate spectrum trades and conversions under the WT Act under the Spectrum Trading Regulations[6].

2.17 Before granting the RSA we must take into account our duties under the Communications Act 2003, the WT Act itself and under applicable EU legislation, including the Authorisation Directive[7] and the Framework Directive[8].

2.18 Section 3 of the Communications Act 2003 provides that our principal duties are:

- to further the interests of citizens in relation to communications matters; and
- to further the interests of consumers in relevant markets, where appropriate, by promoting competition.

2.19 In fulfilling these duties, we are required to secure, among other things, the optimal use of the spectrum for wireless telegraphy, and the availability throughout the UK of a wide range of electronic communication services. We must have regard to the different needs and interests of everyone who may wish to use the spectrum for wireless telegraphy.

Impact Assessment

2.20 This consultation as a whole, including its Annexes, comprises an impact assessment as defined in Section 7 of the Communications Act 2003.

2.21 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy-making. This consultation sets out the potential impacts for stakeholders, and the reasons we are proposing particular options.

2.22 In particular, this consultation considers the potential impact of the proposed release of spectrum by the MoD on one group of stakeholders – the amateur radio community.

Equality Impact Assessment

2.23 Ofcom is separately required by statute to assess the potential impact of all our functions, policies, projects and practices on race, disability and gender equality. Equality Impact Assessments (EIAs) also assist us in making sure that we are meeting our principal duty of furthering the interests of citizens and consumers regardless of their background or identity.

2.24 By its nature, amateur radio is an activity accessible to people with disabilities - including those with mobility, sight and hearing impairments. Organisations representing the amateurs stress their inclusivity and their encouragement of all participants on an equal basis.

[6] http://stakeholders.ofcom.org.uk/spectrum/spectrum-trading/
[7] Directive 2002/20/EC on the authorisation of electronic communications networks and services, as amended by Directive 2009/140/EC
[8] Directive 2002/21/EC on a common regulatory framework for electronic communications networks and services, as amended by Directive 2009/140/EC.

2.25 However, there are no specific concerns that apply just to this frequency range and it is not apparent to us that any proposals included in this document are likely to have any particular impact on race, disability or gender equality. Specifically, we do not envisage the impact of any outcome to be to the particular detriment of any one group of amateur users of the spectrum compared to another.

2.26 We have not seen the need to carry out separate EIAs in relation to race or gender equality or equality schemes under the Northern Ireland and Disability Equality Schemes. This is because we anticipate that our proposals will affect all relevant stakeholders equally and will not have a differential impact in Northern Ireland in relation to people of different gender; ethnicity, or disability, compared to consumers in general.

Structure of this document

2.27 The rest of this document sets out our further consideration of the impact on amateurs of the planned release by the MoD of spectrum in the 2300 MHz and 3400 MHz bands.

- Section 3 identifies the nature of the spectrum planned for release; sets out the current pattern of amateur use within the bands earmarked for release; considers the MoD's plans and their impact on amateur users; and sets out a summary of the technical analysis of potential interference issues.

- Section 4 sets out our proposed approach to the issues raised for amateurs affected by the planned spectrum releases; and sets out our proposed recommendations to the MoD.

- An initial technical analysis of the compatibility of known use and future LTE use in the release bands is set out at Annex 6.

Section 3

Use of the 2300 and 3400 MHz amateur bands

3.1 This section of the consultation examines the current use by amateur radio enthusiasts of the 2300 and 3400 MHz bands and the impact of the proposed release of spectrum by the MoD. It identifies the spectrum involved; considers Ofcom's role in licensing the frequencies used by amateurs; and assesses the issues arising from the MoD's proposed spectrum release. In particular, it considers the options available in addressing potential interference issues if the spectrum is used for mobile applications.

Activities of amateur radio users

3.2 We consider amateur radio to be a constructive and beneficial use of radio spectrum. Radio amateurs have a long history of contributing to research and technical developments in radio communications. On occasions, they have also provided the first links between stricken communities and the rest of the world following natural disasters, such as the 2004 Boxing Day tsunami in South-East Asia.

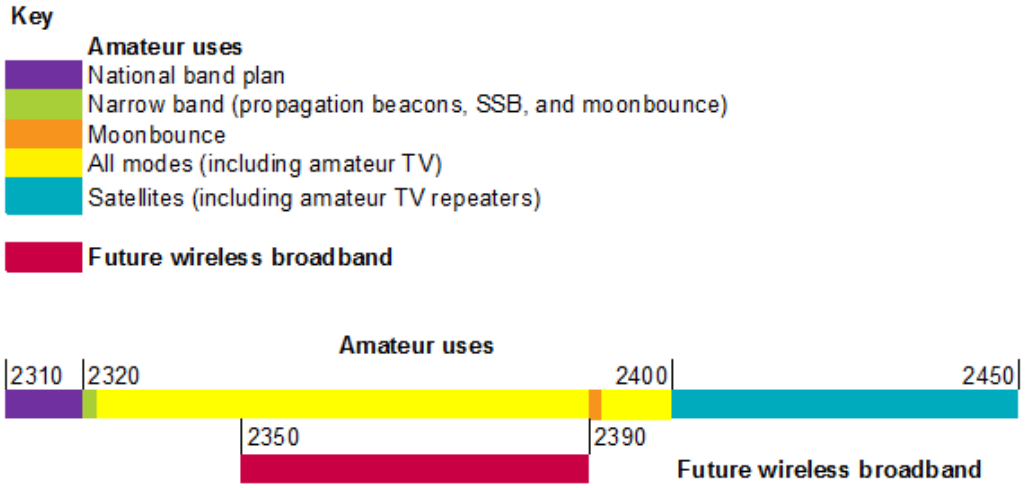
3.3 Amateur radio enthusiasts communicate with fellow amateurs at home and abroad using a broad range of technologies.[9] Amateurs may use the spectrum for any purpose provided they operate within the terms specified in their licence. This is a valued characteristic of the amateur licence as it enables experimentation with different uses in any of the frequency bands on the amateur licence.

3.4 However, this characteristic means we cannot be sure of the number and type of uses in each band. One indication of use type is the Radio Society of Great Britain's (RSGB) band plan for amateur use.[10] The band plan helps amateurs avoid interference from incompatible uses and has allowed for developments of specific interests in common spectrum.

3.5 Uses specified in the band plan in the release bands are detailed in Figure 1 and Figure 2. Further information about these uses is below. We understand that amateurs' current use of the release bands is relatively low density which, along with the ability of the amateur community to adapt and experiment with equipment, enables amateur uses to coexist with others.

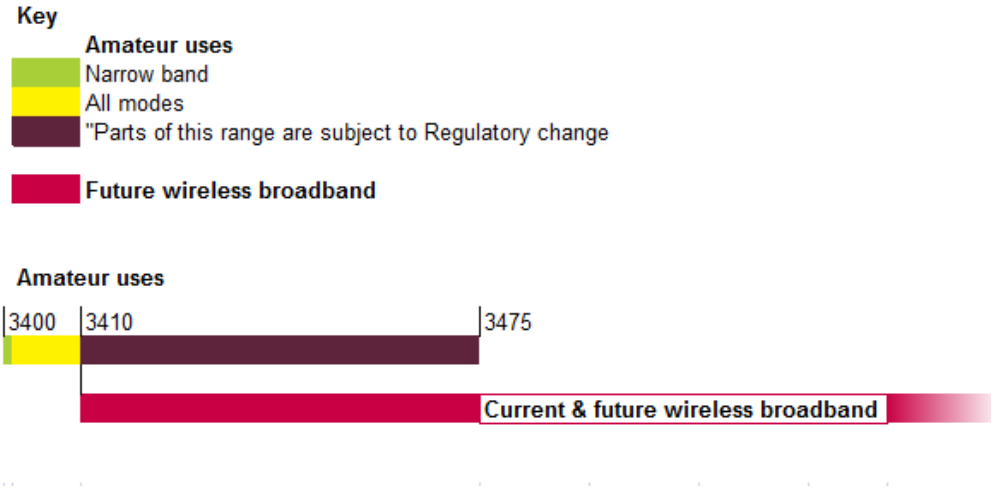
[9] http://licensing.ofcom.org.uk/radiocommunication-licences/amateur-radio/guidance-for-licensees/monthly-stats/
[10] http://rsgbbeta.org/operating/band-plans/

Figure 1: Use by amateurs of the 2300 MHz band



Source: RSGB band plan[11]

Figure 2: Use by amateurs of the 3400 MHz band



Source: RSGB band plan

The spectrum being released by the MoD

3.6 The 2013 UK Frequency Allocation Table (FAT) indicates the MoD has oversight of the management of the primary uses of spectrum between 2310 and 2450 MHz and the spectrum between 3400 and 3600 MHz[12]. However, there is some civil usage in some parts of these bands.

3.7 For example, following an auction by one of Ofcom's predecessor regulatory bodies, the Radiocommunications Agency, spectrum between 3480 and 3500 MHz and between 3580 and 3600 MHz is already under licence for civil use (currently by UK Broadband). Other civilian users of MoD spectrum include the emergency services,

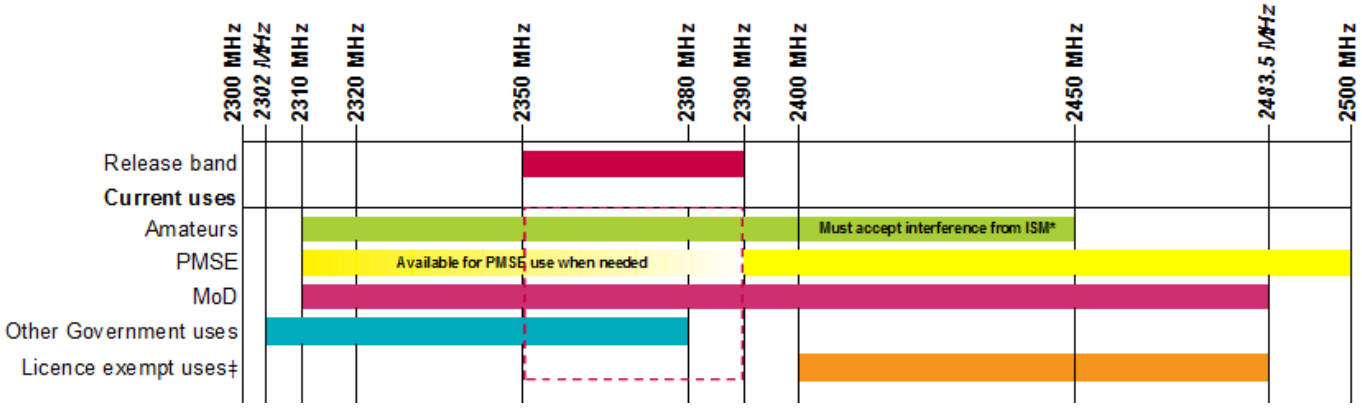
[11] www.rsgb.org/committees/spectrumforum/band-plans.php

[12] The UK FAT details the uses to which various frequency bands are put in the UK (referred to as 'allocations') and which bodies are responsible for planning and managing them, including making frequency assignments to individual users or installations at particular locations. It also shows the internationally agreed spectrum allocations of the International Telecommunication Union. http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-information/UKFAT_2013.pdf

PMSE, and amateurs. As Figure 3 and Figure 4 show, amateurs' current use of these bands coexists with many other uses.

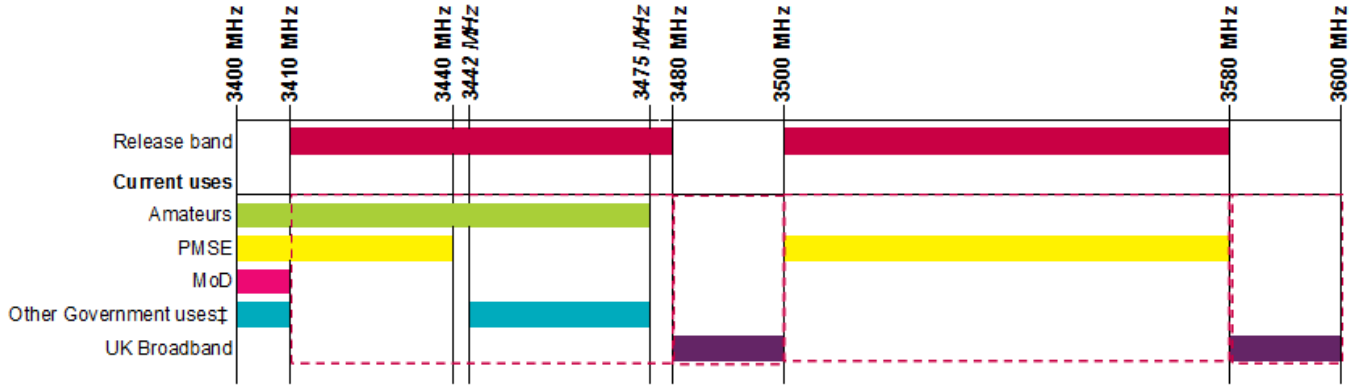
3.8 The MoD now plans to release 40 MHz of spectrum within the 2300 MHz band (2350 to 2390 MHz), together with a further 150 MHz of spectrum within the 3400 MHz band (3410 to 3600 MHz) for new civil uses. These release bands overlap spectrum currently used by radio amateurs (between 2310 and 2450 MHz; and between 3400 and 3475). Figures 3.3 and 3.4 below illustrates the current uses of the spectrum in the 2300 MHz and 3400 MHz bands.

Figure 3: Current use of 2300 to 2500 MHz



Source: UK FAT 2013
* 2400 to 2450 MHz may also be used by the amateur satellite service
‡ 2400 to 2500 MHz is designated for Industrial, Scientific and Medical (ISM) applications

Figure 4: Current use of 3400 to 3600 MHz



Source: UK FAT 2013
‡ 3400 to 3410 MHz is likely to see increased use by other Government departments with agreement from the MoD

International context

3.9 Ofcom issues licences to amateurs for the United Kingdom as well as Crown Dependencies – Jersey, Guernsey and the Isle of Man. The process is the same for UK and Crown Dependency applicants and the licences and their terms and conditions are consistent. Although the spectrum will not be released for new uses in

the same way in the Crown Dependencies, we are proposing to keep these licences consistent with those issued to UK amateurs.

3.10 The European Conference of Postal and Telecommunications Administrations (CEPT) working group ECC FM52 is developing plans to harmonise 2300 to 2400 MHz for use by future mobile/fixed communications networks (MFCN).[13]

3.11 A 2008 European Commission decision aimed to harmonise the 3400 to 3800 MHz band for terrestrial systems capable of providing electronic communications services such as mobile and fixed broadband.[14] From January 2012 members states were required to make the 3400 to 3800 MHz band available for this use on a non-exclusive basis (i.e. current uses of the band not covered by this decision did not need to be removed from the band but member states cannot allow future use by services that do not qualify as "terrestrial electronic communications networks".)

3.12 These ongoing moves towards pan-European harmonisation of spectrum use suggest it is likely that the released MoD spectrum will be obtained by telecommunications companies wishing to develop next generation fixed and mobile services using 4G or Long Term Evolution (LTE) technology.

3.13 Harmonisation of spectrum is valuable as closer integration between countries means equipment works across borders. This is convenient for consumers and valuable for commercial operators when economies of scale are created allowing one product to be sold in several markets.

3.14 The spectrum between 2300 and 2350 MHz is internationally allocated to the amateur radio service in all three regions.[15] This means administrations are encouraged to make these frequencies available for amateur use, but they are under no obligation to do so. The implication of this allocation in the context of the proposed Amateur Radio Licence variation is discussed further in Section 4.

Ofcom's role in licensing amateur radio

3.15 Ofcom is responsible for authorising the use of amateur radio in the UK through licences issued under the WT Act. At present, 79,779 people and 1,486 clubs hold UK amateur radio licences.[16]

3.16 There are three levels of amateur radio licences; Foundation, Intermediate and Full. These levels are progressive, and a particular class of licence is only issued to an applicant who has demonstrated the appropriate level of practical ability. They must have passed all necessary examinations in radio theory, radio operating techniques, electromagnetic compatibility and in the legal aspects of licence regulations. The Radio Communications Foundation runs the examination process on behalf of Ofcom.

3.17 As noted above amateurs may use the spectrum for any purpose provided they operate within the terms of their licence. Amateurs holding a Full licence can undertake additional uses which would not be possible under the standard terms of the licence. This is achieved with the grant of an individual Notice of Variation (NoV)

[13] As it is likely that the released MoD spectrum will be used for wireless broadband using 4G LTE or LTE advanced, the initial technical analysis was conducted on this basis.
[14] 2008/411/EC (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:144:0077:0081:EN:PDF)
[15] http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-information/UKFAT_2013.pdf
[16] http://licensing.ofcom.org.uk/radiocommunication-licences/amateur-radio/guidance-for-licensees/monthly-stats/

to the licence.[17] NoVs are required to operate repeaters and beacons in the release bands.

3.18 The amateur licence specifies the bands available as well as the permitted power level and status of amateur radio and amateur satellite operation (primary or secondary) for each band and for each of the particular licence classes (Foundation, Intermediate and Full). The terms restrict power levels and geography but otherwise allow for varied amateur usage. Each class grants access to a wide range of frequencies in different parts of the radio spectrum.

3.19 Full licensees are authorised to use 53 bands from 135.7 kHz to 250 GHz. Amateurs use these bands for various uses depending on each band's propagation properties. For example, amateur TV is carried out in four sets of paired bands between 1.3 GHz and 10 GHz but not all of the 53 bands are suitable for amateur TV uses. RSGB provides guidance in the form of a band plan to facilitate sharing of spectrum by different types of amateur use. Annex 5 shows the bands currently available to amateurs holding Intermediate and Full licences.

3.20 Two bands overlap with the release bands: the 2300 MHz amateur band (2310 to 2400 MHz) and the 3400 MHz band (3400 to 3475 MHz). Both bands also contain adjacent frequencies to the MoD's release bands. In addition amateurs also have access to the 2400 MHz amateur band (2400 to 2450 MHz).

3.21 We understand from amateurs that use towards the 2400 MHz end of the band is impeded by interference from licence exempt devices such as Wi-Fi. As there are no proposals to vary the amateur licence to remove the 2400 MHz amateur band, compatibility studies have not been included in the technical annex. Notwithstanding coexistence issues with licence exempt devices, we expect that the current use of the 2400 MHz amateur band can continue after the MoD's release. Amateur use of this band on a non-interference, non-protection means that users may benefit from noting guidance issued for the adjacent bands to limit interference risks to the release bands as set out in Annex 6.

3.22 The amateur licence grants access to some bands on a 'primary' basis and others on a 'secondary' basis. Amateur licences indicate access is secondary in both the 2300 MHz amateur band (2310 to 2400 MHz) and the 3400 MHz amateur band (3400 to 3475 MHz). Both of these bands overlap with the release bands.

3.23 The meaning of secondary access is not defined in the current amateur licence. However the former Amateur Radio licence terms and conditions booklet indicates that amateurs using bands allocated on a secondary basis are "required not to cause undue interference to stations of a primary or permitted service to which frequencies are already assigned or to which frequencies may be assigned at a later date."[18]

3.24 Accordingly, in our statement following a grant of RSA in the 3400 to 3600 MHz band we indicated amateurs' use in this band is on the basis that it does not cause interference to primary services and could not expect protection from primary uses.[19]

3.25 These applications are consistent with the principles of the International Telecommunications Union's (ITU)[20] definition of secondary status used to consider

[17] NoVs allow amateurs to operate at higher powers than the standard licence conditions allow.
[18] http://www.ofcom.org.uk/static/archive/ra/publication/ra_info/br68r11/br68.htm
[19] http://stakeholders.ofcom.org.uk/consultations/3_4ghz/

cross border spectrum interference and protection issues. The ITU defines secondary status in the following terms under its Radio Regulations. This status is summarised as non-interference, non-protection:

- Stations shall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date.
- Stations cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or may be assigned at a later date.
- Stations can claim protection, however, from harmful interference from stations of the same or other secondary service(s) to which frequencies may be assigned at a later date.

3.26 The MoD is responsible for managing primary uses in both the 2300 MHz band (i.e. fixed and mobile and in the 3400 MHz band (i.e. mobile and radiolocation).[21] Amateur use of these bands has been agreed by the MoD but it is administered by Ofcom.

Preparation for spectrum release

3.27 As indicated above, the MoD intends to release 40 MHz of spectrum between 2350 and 2390 MHz and a further 150 MHz of spectrum from 3410 to 3600 MHz for new civil uses. This is the next step in the programme of work looking at Government spectrum release that started with Martin Cave's Independent Audit of Spectrum Holdings.[22] It is also part of a Government commitment to release 500 MHz of spectrum by 2020. The Government's rationale for spectrum release is set out in the document *'Enabling UK growth – releasing public spectrum'*[23] which details the benefits this is expected to bring to citizens and consumers.

3.28 For several years the Government has undertaken work looking at which spectrum would be released. Likely candidate bands including 2.3 GHz and 3.4 GHz have been discussed in many consultations and statements. For example, the possibility of the MoD releasing spectrum between 3400 and 3600 MHz and the impact this would have on amateurs was raised in a 2008 MoD consultation *'An Implementation Plan for Reform'.*[24] The subsequent statement also indicated the MoD's intention to review the 2.3 GHz band for potential release.[25]

3.29 The MoD has previously signalled their intent to request a grant of RSA for the 3.4 GHz band. We consulted on this request and in our subsequent statement said that amateur access could continue in the frequencies from 3400 to 3475 MHz after a grant of RSA to the MoD and following the proposed trade.[26] Since that time, the ongoing harmonisation work in Europe and more recent MoD release plans suggest

[20] The ITU is a specialised agency of the United Nations operating as an inter-governmental organisation with responsibility for co-ordinating global telecommunication networks and services. It manages the use of the radio frequency spectrum internationally through the Radio Regulations.
[21] http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-information/UKFAT_2013.pdf
[22] http://www.spectrumaudit.org.uk/
[23] www.culture.gov.uk/images/publications/Spectrum_Release.pdf
[24] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/35937/dsm_consultation_report.pdf
[25] https://www.gov.uk/government/consultations/uk-defence-spectrum-management
[26] http://stakeholders.ofcom.org.uk/binaries/consultations/3_4ghz/summary/3_4ghz.pdf

that fixed and mobile 4G usage may be more widespread than previously assumed. In considering the MoD's request we have been mindful of the indication that amateur uses in this band concentrate in the bottom 10 MHz (i.e. 3400 to 3410 MHz).[27]

3.30 Notwithstanding our previous statements, amateurs have been aware of the MoD's plans and the associated uncertainly for several years. This has been reflected in the RSGB's band plan which has noted 3.4 GHz is 'subject to regulatory change.' [28] At the same time, users cannot reasonably expect spectrum to be available indefinitely. There must be scope for the use of spectrum to change over time if we are to promote optimal usage.

Benefits for UK consumers and citizens

3.31 Ofcom, as the UK spectrum regulator, has to take account of a number of factors in undertaking its statutory duties. Our duties include the need to ensure optimal use of spectrum – but our principle duties are to UK citizens and consumers.

3.32 Spectrum use makes a substantial contribution to the economy and society in the UK, but it is a scarce resource. Spectrum below 5 GHz is especially scarce as its technical characteristics mean it can be used for a wide range of applications.

3.33 Ofcom has powers to change the use of radio spectrum where this is in the best interests of UK citizens and consumers and/or in line with other domestic or international decisions. Changes may result in more spectrum being made available to a particular use (e.g. radio amateurs) or they may result in the loss of some spectrum.

3.34 As discussed above, we recognise amateur radio as a beneficial activity which has provided the stimulus for technical careers and communications research.

3.35 However, the Government's commitment to opening up spectrum for new civil uses is based on growing demand from UK consumers for spectrum hungry devices such as smartphones and tablets. Use of mobile data more than doubled in the 18 months to January 2012. Almost 40% of UK adults now own a smart-phone, up 12% on 2011. And tablet ownership rose to 11% of UK homes, up 9% on 2011. In order to provide these services suitable spectrum needs to be available.

3.36 An award for next generation fixed and mobile services would provide benefits for UK citizens and consumers as take up of connected devices such as mobiles and tablets increases.[29]

3.37 Now that the MoD and other government uses have been moved from the release bands, we believe it is likely that the benefits to UK consumers and citizens will be greater from the MoD's release than from retaining only the current amateur use. This means that we must withdraw authorisation to use of this spectrum from amateurs if coexistence between amateurs and new uses would not be possible.

Q1. Do you agree that it is likely that the benefits to UK consumers and citizens will be greater from the MoD's release of spectrum in the 2.3 GHz and 3.4 GHz release bands than from retaining the current amateur use?

[27] http://stakeholders.ofcom.org.uk/consultations/3_4ghz/
[28] www.rsgb.org/committees/spectrumforum/band-plans.php
[29] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr12/uk/

Impact of the MoD's plans for amateur use of the spectrum

Release bands

3.38 On the basis that amateur licences give access to the release bands on a secondary basis (i.e. amateurs must not cause interference to primary uses) in the technical analysis we have considered the impact of amateur use to LTE. For further information on this analysis see Annex 6.

3.39 The analysis showed that large separation distances (up to 65 km) may be required between amateurs and LTE base stations in order to protect the LTE base station from harmful interference. The frequency separation required to protect TV repeater locations could be from harmful interference from an LTE base station could be up to 90 km.

3.40 This means there would be a high risk of harmful interference if amateur and LTE use was to coexist in the release bands. As we do not believe that amateurs could practically coexist with new uses, we are proposing to vary the Amateur Radio Licence to remove access to the release bands.

3.41 Paragraphs 3.2 to 3.5 review the context of amateurs' access to spectrum. As amateurs may use the spectrum for any purpose, we cannot be sure of the number and type of use in the release bands. However, based on initial information we believe that many current amateur uses of these bands may be accommodated in other existing frequency allocations. A copy of the Amateur Radio Licence, Schedule 1 which lists the frequencies available to licensees is at Annex 5.

Q2. Are there current uses in the release bands other than those detailed in RSGB's band plan and discussed in Section 3 of this consultation?

Q3. Are there further consequences of removing the release bands from amateur licences that have not been considered in our analysis?

Uncertainty about future use of the adjacent bands

3.42 The frequencies adjoining the release bands, 2310 to 2350 MHz, 2390 to 2400 MHz and 3400 to 3410 MHz (the adjacent bands) are currently used by the MoD as well as other government departments and PMSE. Due to high demand for this spectrum it is likely that existing uses will be concentrated in the adjacent bands.

3.43 In order to remove their own uses from the release band, the MoD will be moving a number of their existing systems into the adjacent bands and it anticipates use of the adjacent bands will increase. To this end the MoD has indicated it would like amateur use of the adjacent band to cease. We are also aware of other government departments with sharing agreements with the MoD whose use may increase as a result of systems migrating from the release bands.

3.44 To date the MoD has also permitted ad hoc access to Programme Making and Special Events (PMSE) uses (wireless cameras) to certain parts of the 2300 MHz bands on a geographical and time limited basis for certain high demand events. PMSE have already lost access to similar spectrum used for wireless camera as a result of the 2.6 GHz award. Now they will also lose access to additional spectrum as a result of the proposed MoD release (most notably in the 3400 MHz band).

Therefore it is likely their use of spectrum in the adjacent bands may also increase in the future, placing an additional demand on this spectrum as well. This means that there is a high level of uncertainty about future use of the adjacent bands.

Option to remove access to the adjacent bands

3.45 Potentially, future demand for access to spectrum in the adjacent bands will be higher than it is currently. As the new band plans for the MoD and other users in between 2300 and 2450 MHz are not yet complete, there may be parts of the adjacent bands or particular uses where the risk of interference is sufficiently high that amateur use should be restricted further or ultimately cease in the adjacent bands.

3.46 We have therefore considered the option of removing amateurs' access to the adjacent bands. This would provide certainty about future access and availability of these bands to amateurs as well as to other users. It would also remove the risk of harmful interference into new and current uses in the release band, as well as current uses in adjacent bands (i.e. the MoD, other Government users and PMSE).

3.47 However, we do not think it would be appropriate to remove amateurs' access to the adjacent bands completely if there is the potential for amateur use to coexist with current uses in the spectrum adjacent to the release bands.

3.48 Amateurs' current use of these bands is relatively low and amateurs currently coexist with other uses. We believe it would be pre-emptive to remove access to the adjacent bands without a greater degree of certainty about future demand, even though demand from other current users may increase in the future creating a situation where amateur access to the adjacent bands is no longer possible.

Q4. There is an option (although not preferred) to remove access to the adjacent bands, as well as to the release bands. What are the consequences of removing access to the adjacent bands from amateur licences?

Potential for continued access to the adjacent bands

3.49 We have therefore conducted technical analysis to assess the interference issues to help inform decisions on whether amateurs are able to remain in these bands. A more detailed summary of this work is set out in Annex 6.

3.50 Our analysis was based on the following premise:

- Amateur use will be able to continue in the future providing there is not a risk of amateurs causing harmful interference into the release band. Continued amateur use would be on a non-interference non-protected basis, so if there are interference issues then these should be resolved by usual regulatory mechanisms.

- However, if it is considered that there is a reasonable risk of interference by the continuing amateur use of the adjacent bands, it would be appropriate to make measures to avoid likely problems in the future, by either removing access to the adjacent band/s where there is a risk or by providing appropriate guidance to minimise the risk of harmful interference to new uses in the release band.

3.51 Details of options, including our preferred option, are set out in Section 4. These are options to enable amateur use to coexist with current and future uses in the spectrum adjacent to the release bands.

Analysis of the impact from current amateur uses to LTE

3.52 In considering whether amateurs should cease using the release and adjacent bands we have reviewed current users as detailed on RSGB's band plan.[30]

Wide band adjacent uses (Amateur TV)

3.53 Amateur TV usage involves the transmission of a signal (usually a test card with call letters and tone) to a repeater (by the user) and re-transmission by the repeater itself. Other amateurs can then receive these re-transmitted signals. Amateur TV users will only transmit to repeaters intermittently but the repeater itself usually continuously transmits.

3.54 Amateurs currently use four bands for TV. These are 1.3 GHz, 2.3 GHz, 3.4 GHz and 10 GHz. The amount of spectrum allocated for TV in the RSGB's band plan is currently 315 MHz. The loss of both the release and adjacent bands would remove 165 MHz – approximately half – of the spectrum amateurs currently use for amateur TV.

3.55 TV repeaters are used in both the 2300 MHz and 3400 MHz amateur bands. This use is coordinated around the country and both analogue and digital TV repeaters are in operation. Each analogue use requires 16 MHz bandwidth to operate with digital use stated as requiring 4 MHz.

3.56 To operate a TV repeater an amateur must hold a NoV allowing them to transmit above the terms of the standard intermediate and full licence. The NoV states the location of the repeater and the receive and transmitting frequencies.

3.57 There are currently eight amateur TV repeaters that use spectrum in either the 2300 and/or 3400 MHz amateur bands – five are using spectrum in the release bands. In addition to these repeater operators there are approximately 1,000 members of amateur TV clubs in the UK and thought to be 100 active members who regularly use these bands for amateur TV.

Table 2: Amateur TV repeater operators impacted by band removal of release and adjacent bands in 2310 to 2400 MHz and 3400 to 3475 MHz

Bands removed	Number of repeaters impacted	Reason impacted
Release band	5	transmitting or receiving the MoD release bands
Release band plus any of the three adjacent bands	8	transmitting or receiving in the MoD release bands or any of the adjacent bands

3.58 Our technical analysis examines the following amateur TV equipment: analogue user equipment; digital user equipment and digital TV repeaters. Annex 6 contains details for each of these systems.

[30] Ofcom notes RSGB's longstanding role in planning amateur spectrum use and is not proposing to suggest future uses of these bands following MoD's release.

3.59 The calculations for these uses equipment suggests out of band (OOB) emissions could cause interference to LTE base stations. However, previous experience suggests the risk of interference can be reduced with mitigations such as additional filtering of amateur transmissions, the use of a guard band and reduced operating powers.

3.60 In order to avoid causing harmful interference to new uses amateur TV users may need to limit their OOB band emissions within the geographical vicinity of base station and terminal equipment operating in the release band. With suitable mitigation measures (such as limiting OOB emissions into the release bands) the separation distances to avoid desensitising LTE systems can be reduced to less than 1km. We are therefore minded not to include a maximum emission level in the amateur licence at this time to avoid being overly restrictive about amateur use but we retain the option to do so in the future if the need arises.

Data links

3.61 Data links are often made from adapted Wi-Fi equipment. We have limited information on these bespoke data systems but the information we have obtained has been used to analyse the risk of harmful interference if use continues in the adjacent bands. See Annex 6.

3.62 The results indicate amateurs experimenting with data links in the adjacent bands should apply additional mitigation techniques. These techniques could include a reduction of transmit power, additional filtering and/or a frequency separation to avoid causing harmful interference to LTE systems.

Narrow band uses including moonbounce (EME)

3.63 Narrow band uses include communications between amateurs as well as moonbounce or Earth-Moon-Earth (EME). Moonbounce involves an amateur transmitting a signal to the moon in order to listen for the ‘reflection’ of the signal to be returned. Moonbounce is one of several narrow band uses of amateur spectrum possible within the terms of an amateur licence. These uses are technically challenging and are used by amateurs to develop expertise and experiment by building new transmission systems and methods of resolving a signal from the noise floor.

3.64 Typically these uses are intermittent with peak activity on weekends, evenings, special events and amateur competitions. Moonbounce use is limited to when the moon is above the horizon. Initial estimates indicate there are approximately:

- Narrow band: ~200 users in the 2300 and 3400 MHz amateur bands
- Moonbounce: ~50 users in the 2300 MHz amateur band, fewer in 3400 MHz

3.65 Although narrow band use is often very high power, we believe that the risk of harmful interference is limited in practice by the improved selectivity of the LTE systems outside the release band at frequency separations of 9 MHz (from the 3.4 GHz release band) and 20 MHz (from the 2.3 GHz release band) as well as by sensible amateur use.

3.66 Amateurs could take mitigation measures to lower the risk of causing interference. These could include the use of lower transmit power, more directional antennas, and/or increased azimuth offsets between the antennas of the amateur and LTE.

3.67 Based on the low level of amateur use, a typical usage pattern of just a few hours a day and the number of base stations that might fall within the 1km protection zone then the probably of amateur uses causing harmful interference to new uses is low.

3.68 We note that the RSGB's band plan refers to moonbounce use at 2390 MHz. We understand that this channel is not heavily used for moonbounce in practice. If it is being used for this purpose we would have some concerns as this is immediately adjacent to the band edge used by future LTE systems. It is likely that the selectivity of the LTE system would be more vulnerable to interference by a high power moonbounce system transmitting on 2390 MHz with minimal frequency separation compared to a moonbounce system at 2320 MHz with 30 MHz frequency separation.

Propagation beacons

3.69 Propagation beacons are another type of narrow band use. Amateurs use signals from beacons to alert them to changes in radio spectrum propagation conditions. Detecting a distant beacon is an indication to amateurs that their own signal could be picked up further away than normally possible. Amateurs also use beacon signals to investigate the combination of factors that influence signal propagation properties in different bands.

3.70 To operate a beacon an amateur must hold a NoV allowing them to transmit above the terms of the standard intermediate and full licence. The NoV states the location of the beacon and the transmit frequency.

3.71 Unlike moonbounce, propagation beacons are transmitting continuously. There are currently seven beacons operating in the 2300 MHz amateur band and six in the 3400 MHz amateur band. None are operating in the release band. A community of approximately 200 amateurs actively uses these beacons.

Table 3: Amateur beacon operators in 2310 to 2400 MHz and 3400 to 3475 MHz

Number approved	Reason impacted
7	transmitting at 2320 MHz
6	transmitting at 3400 MHz

3.72 Even though propagation beacons transmit all the time and in many directions they do not pose a different problem to narrow band and EME uses. This is because there are a low number of beacons operating in the release band. Using the known locations of these beacons (specified on their NoVs) and likely LTE coverage we have estimated that the risk of this continued use causing harmful interference into LTE is a fraction of a percent. We therefore do not anticipate revoking any NoVs for propagation beacons.

Q5. Are there current uses in the adjacent bands other than those detailed in the RSGB's band plan and discussed in Section 3?

Retaining amateur access to the adjacent bands

3.73 The problem with the level of uncertainty discussed above with regards to future use of the adjacent band with which amateurs currently exist is that some of these uses are critical and/or operations of the primary user (i.e. the MoD).

3.74 Due to the very geographical nature of the MoD and other uses and the level of uncertainty of developments in the release band and future PMSE and government uses in the adjacent bands we are unable to issue such guidance at this stage.

3.75 Even with this level of uncertainty about other new and current uses we propose retaining access to the adjacent bands. The details of these proposals are set out in Section 4.

Section 4

Proposal to vary the Amateur Radio Licence

4.1 This section explains the proposed changes to the amateur licences and our basis for making them.

4.2 Amateur licences detail the terms and process for revocation and variation. With reference to the paragraphs relevant to revocation and variation in the WT Act, Clause 4 (2) of the amateur licence allows for changes "for reasons related to the management of the radio spectrum, provided that in such cases the power to revoke may only be exercised after first giving reasonable notice to Licensees."[31]

4.3 As referenced above, the MoD itself has made the amateur community aware of future changes affecting their access through a series of public consultations and statements starting in 2008.

4.4 Nevertheless, we currently propose (subject to taking account of all responses to this consultation) that our forthcoming statement will give 12 months' notice from the date of its publication that the amateur licence will be varied to remove access to the release bands and to change the licence conditions for the adjacent bands. A12 month notice period is considered reasonable for the 2300 MHz and 3400 MHz amateur bands given the circumstances of these bands. In the future, other periods of reasonable notice may be used for other amateur bands if applicable.

Retaining access to the adjacent bands

4.5 We are proposing to vary the amateur licence to remove access to the current 2300 MHz amateur band and the current 3400 MHz amateur band. Access to all (or part of) the adjacent bands would then be added to the licence subject to the additional terms proposed below.

4.6 We are proposing to add new terms for the adjacent bands to make it clear that the adjacent bands would be removed if following the release it was shown that amateurs were causing harmful interference to new uses. Annex 6 sets out a number of proposed mitigation measures based on the technical analysis which amateurs using these bands may want to consider.

Q6. Are there additional mitigation measures which would provide demonstrable proof that amateurs would not cause interference into LTE in the release bands following the release?

Dealing with interference

4.7 Each year between 2010 and 2012 we received between four and 14 cases of interference where amateurs had caused interference to other spectrum users.[32] These instances were across all amateur bands across the UK and Crown Dependencies. In the unlikely event that amateur uses were to cause harmful interference to current and new uses following the MoD's release, Ofcom will

[31] http://licensing.ofcom.org.uk/binaries/spectrum/amateur-radio/guidance-for-licensees/samplelicence07.pdf
[32] Source: Ofcom database. Cases of reported interference

investigate the interference complaint through the usual channels and consider direct regulatory action.

- Providing the amateur licence holder the opportunity to correct the problem by employing one or more mitigation options. For example, operating at a lower power, or changing out of band emissions (i.e. use a filter)

- If interference persisted or reoccurred subsequently we might then seek to vary the individual licence to restrict or remove access to the bands. However each case would be considered on its merits.

Reasonable notice and access to the adjacent bands

4.8 However, if dealing with interference cases in the adjacent bands on an individual basis and following the process above became too onerous then we would consider varying all amateur licences to remove access to the adjacent band/s in question.

4.9 If such action were considered we would remove access under a new paragraph to Section 2, Clause 5 of the amateur licence. This would set out that if, for reasons of interference, we proposed to remove access to the adjacent bands (i.e. 2310 to 2350 MHz, 2390 to 2400 MHz and/or 3400 to 3410 MHz) then the 'reasonable notice' period would be three months. See paragraph 4.21 for proposed wording.

4.10 The proposal is that this notice period would apply only to the case of Ofcom exercising powers under Clause 4(2)(e) of the licence in the case of the adjacent bands. (i.e. it would not apply to instances where we would revoke/vary licences under schedule 1, paragraph 8(5)).

Q7. Do you agree with the proposed process for varying licences following cases of reported interference and our proposal to vary licences should dealing with the number of reported cases become too onerous?

Retaining access to a reduced portion of the adjacent bands

4.11 We have considered the relatively low level of amateur use in this band and believe that there isn't currently a sufficiently serious spectrum management reason to remove amateurs from the adjacent bands given the existing level of uncertainty about future use.

4.12 However as discussed in Section 3, due to the varied nature of amateur use, the changing use of the MoD as well as likely increased use by PMSE wireless cameras, it would not be practical to set out tightly defined coordination procedures which might constrain innovative solutions for sharing from radio amateurs.

4.13 Following conversations with the RSGB and other amateur groups, we have considered how after the MoD's release both amateurs and other users could have more certainty following the licence variation about where different uses were in the adjacent bands.

4.14 One way of reducing the level of uncertainty would be to restrict amateur access to a smaller part of one or more of the adjacent bands. If appropriate this could include additional restrictions on power and bandwidth limits. This could reduce the level of uncertainty for both amateurs and other users.

4.15 At the present time primary/other government users are not able to provide any degree of certainty about which parts of the band could be reserved for amateurs and which part would be reserved for their own continued use. However, in principle there could be the potential for further investigation of this option prior to the licence variation exercise.

4.16 This would therefore involve giving 12 months' notice from the date of the statement following this consultation that the amateur licence would be varied, to remove access to the release bands as well as to the adjacent bands. During this notice period we would aim to facilitate an agreement as to the parts of the adjacent bands different uses would be allocated to. This would involve representatives of the amateur community (for example, RSGB and British Amateur Television Club (BATC)) and other users.

4.17 After an agreement was reached, we would publish notice of the parts of the adjacent bands proposed for continued amateur access. This would give amateurs the opportunity to comment on accepting access to parts of the adjacent bands (with greater certainty about other uses) or opting for access to all of the adjacent bands (with the associated risk of causing harmful interference and therefore having to cease use).

Preferred option

4.18 As discussed above, amateurs are currently coexisting in the adjacent bands with many other uses. Therefore we believe the best option is to retain amateurs' access to the adjacent bands in the licence on the current terms, but with clarification of the notice period required for future amateur use to cease if it transpires that amateurs cause interference to other users within the release band or the adjacent band.

Q8. Do you agree with our preferred option?

Licence variation

4.19 We are therefore consulting on plans to make changes to the Amateur Radio Licence in Table B 'Intermediate Licence Parameters' and in Table C 'Full Licence Parameters' to remove the release bands and retain the adjacent frequencies.

4.20 These changes mean the row 2310-2400 and the row 3400-3475 would be amended with the terms and conditions as set out in Figure 5.

Figure 5: Proposed amendments in tables B and C of the amateur licence

Frequency Bands (in MHz)	**Status of allocations in UK to the Amateur Service**		
2310-2350	Secondary. Available on the basis of non-interference to other services inside or outside the UK		
2390-2400	Secondary. Available on the basis of non-interference to other		

	services inside or outside the UK		
3400-3410	Secondary. Available on the basis of non-interference to other services inside or outside the UK		

4.21 We would also propose to insert the text below as a new paragraph to the Amateur Radio Licence terms and conditions, Section 2, Clause 4(6)

"In relation to the following bands:

a) 2310 to 2350 MHz

b) 2390 to 2400 MHz

c) 3400 to 3410 MHz

Ofcom may vary this licence for reasons related to interference management after first giving reasonable notice of three months."

Q9. Are there additional changes to the Amateur Radio Licence which would assist amateurs in lowering the risk of causing harmful interference to new uses?

Process for changes to licences

4.22 Ofcom will analyse the responses to this consultation and (subject to taking account of all responses to this consultation) publish a statement detailing our response to issues raised during the consultation. This statement will set out the plans to be taken forward. It will also provide 12 months' notice (under the licence) that licences will be varied to remove the release bands and, potentially (although not currently our preferred option), the adjacent bands.

Variation of licences

4.23 Prior to this licence variation we will write to each licensee setting out the proposed variation to the terms and conditions of the wireless telegraphy licence. As provided for by the WT Act, licensees will then be given a minimum of one month (under the WT Act) to make any representations about the changes proposed. We shall then reach our decision will within one month of the deadline for representations and post a notice of that decision on our website within one week of reaching it.[33]

4.24 There are also other changes to amateur licences being proposed in addition to those discussed in this consultation as a result of the MoD's release of 2.3 and 3.4 GHz. We will endeavour to make all these changes at the same time in order to reduce the administrative burden for both amateurs and Ofcom. None of these changes involve removing spectrum access. Consultations about these further

[33] http://licensing.ofcom.org.uk/radiocommunication-licences/amateur-radio/

changes, should they take place, will be published on our website prior to the licence variation.

4.25 NoVs where amateurs still have access to the relevant spectrum band will be considered for renewal in the normal way. We believe that all the NoVs granting access to spectrum bands due to be removed expire before the release. Those NoVs will not be removed. We propose amateurs holding these NoVs contact Ofcom in good time in order to propose alternative spectrum if they wish to continue their current use. Ofcom will review these requests with the MoD in the normal way and will endeavour to issue fresh variations prior to the licence variation date.

Implications of proposals for non-UK amateurs

4.26 The UK has signed up to a CEPT agreement which allows certain licensed amateurs to operate when visiting any country which has also implemented the agreement.[34] At the same time amateurs from such countries are able to operate under their own licences in the UK.

4.27 These amateurs operate under exemption regulations[35] which enable amateurs holding a foreign licence to operate for up to three months in the UK without acquiring additional permission (i.e. applying for a WT Act licence or obtaining a Harmonised Amateur Radio Examination Certificate)[36].

4.28 The spectrum between 2300 and 2350 MHz is internationally allocated to the amateur radio service. This means amateurs who are licensed overseas could come over to the UK unaware that the UK has withdrawn these services from service and attempt to use these frequencies.

4.29 Even though visiting amateurs must comply with the conditions of the appropriate authorisation of the country they are visiting, to address these concerns, we propose to update the existing exemption regulations. We could also reference an information sheet for eligible licensed amateurs visiting the UK. This information sheet would be similar to the existing 'Use of Amateur Radio Overseas by UK Amateur Radio Licensees' and would detail the terms and conditions in the amateur licence.[37] We would also provide information about the withdrawal of these internationally allocated amateur bands in the UK to the RSGB and its sister organisations as well as CEPT.

[34] CEPT (European Conference of Postal and Telecommunications Administrations) Recommendation T/R 61-01
[35] http://www.legislation.gov.uk/uksi/1988/2090/made
[36] https://services.ofcom.org.uk/faqs?faqcat=amateurradio
[37] http://licensing.ofcom.org.uk/binaries/spectrum/amateur-radio/guidance-for-licensees/FKM.pdf

Annex 1

Responses to this consultation

How to respond

A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made by 5pm on Monday 15 July 2013.

A1.2 Ofcom strongly prefers to receive responses using the online web form at https://stakeholders.ofcom.org.uk/consultations/public-sector-spectrum-release/howtorespond/form, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response cover sheet (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email pssr@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

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

Helen Charles
Floor 3
Spectrum Policy Group
Riverside House
2A Southwark Bridge Road
London SE1 9HA

Note that we do not need a hard copy in addition to an electronic version. Ofcom will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.

A1.5 It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at Annex 4. It would also help if you can explain why you hold your views and how Ofcom's proposals would impact on you.

Further information

A1.6 If you want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Helen Charles on 020 7981 3029.

Confidentiality

A1.7 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt. If you think your response should be kept confidential, can you please specify what part or whether

all of your response should be kept confidential, and specify why. Please also place such parts in a separate annex.

A1.8 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and will try to respect this. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.9 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/about/accoun/disclaimer/

Next steps

A1.10 Following the end of the consultation period, Ofcom intends to publish a statement in summer 2013.

A1.11 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details please see: http://www.ofcom.org.uk/static/subscribe/select_list.htm

Ofcom's consultation processes

A1.12 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.13 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

A1.14 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Graham Howell, Secretary to the Corporation, who is Ofcom's consultation champion:

Graham Howell
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA

Tel: 020 7981 3601

Email Graham.Howell@ofcom.org.uk

Annex 2

Ofcom's consultation principles

Before the consultation

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

During the consultation

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

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

A2.4 We will consult for up to 10 weeks depending on the potential impact of our proposals.

A2.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and reach out to the largest number of people and organisations interested in the outcome of our decisions. Ofcom's 'Consultation Champion' will also be the main person to contact with views on the way we run our consultations.

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

After the consultation

A2.7 We think it is important for everyone interested in an issue to see the views of others during a consultation. We would usually publish all the responses we have received on our website. In our statement, we will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency and good regulatory practice, we will publish all consultation responses in full on our website, www.ofcom.org.uk.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality where appropriate.

A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at www.ofcom.org.uk/consult/.

A3.5 Please put any parts of your response you consider should be kept confidential in a separate annex to your response and include your reasons why this part of your response should not be published. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your cover sheet only, so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

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

Nothing ☐

Whole response ☐

Part of the response ☐

Name/contact details/job title ☐

Organisation ☐

If there is no separate annex, which parts?

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

DECLARATION

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

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

Name

Signed (if hard copy)

Annex 4

Consultation questions

The release bands

Q1. Do you agree that it is likely that the benefits to UK consumers and citizens will be greater from the MoD's release of spectrum in the 2.3 GHz and 3.4 GHz release bands than from retaining the current amateur use?

Q2. Are there current uses in the release bands other than those detailed in RSGB's band plan and discussed in Section 3 of this consultation?

Q3. Are there further consequences of removing the release bands from amateur licences that have not been considered in our analysis?

The adjacent bands

Q4. There is an option (although not preferred) to remove access to the adjacent bands, as well as to the release bands. What are the consequences of removing access to the adjacent bands from amateur licences?

Q5. Are there current uses in the adjacent bands other than those detailed in the RSGB's band plan and discussed in Section 3?

Q6. Are there additional mitigation measures which would provide demonstrable proof that amateurs would not cause interference into LTE in the release bands following the release?

Q7. Do you agree with the proposed process for varying licences following cases of reported interference and our proposal to vary licences should dealing with the number of reported cases become too onerous?

Q8. Do you agree with our preferred option?

Q9. Are there additional changes to the Amateur Radio Licence which would assist amateur in lowering the risk of causing harmful interference to new uses?

Annex 5

Schedule 1 of the Amateur Radio Licence

Schedule 1

Where this Licence is a Foundation Licence, the Licensee shall only be permitted to operate the Radio Equipment using the frequency bands and power levels set out in Table A of this Schedule 1.

Table A
Foundation Licence Parameters

Frequency Bands (in MHz)	Status of allocations in UK to the Amateur Service	Status of allocations in UK to the Amateur Satellite Service	Maximum Peak Envelope Power level in Watts (and dB relative to 1 Watt)
0.1357-0.1378	Secondary. Available on the basis of non-interference to other services inside or outside the UK.	Not allocated	1W (0 dBW) e.r.p.
1.810-1.830	Primary. Available on the basis of non-interference to other services outside the UK.	Not allocated	10W (10 dBW)
1.830-1.850	Primary	Not allocated	10W (10 dBW)
1.850-2.000	Secondary. Available on the basis of non-interference to other services inside or outside the UK.	Not allocated	10W (10 dBW)
3.500-3.800	Primary. Shared with other services	Not allocated	10W (10 dBW)
7.000-7.100	Primary	Primary	10W (10 dBW)
7.100-7.200	Secondary. Available on the basis of non-interference to other services inside or outside the UK.	Not allocated	10W (10 dBW)
10.100-10.150	Secondary	Not allocated	10W (10 dBW)
14.000-14.250	Primary	Primary	10W (10 dBW)
14.250-14.350	Primary	Not allocated	10W (10 dBW)
18.068-18.168	Primary	Primary	10W (10 dBW)
21.000-21.450	Primary	Primary	10W (10 dBW)
24.890-24.990	Primary	Primary	10W (10 dBW)
28.000-29.700	Primary	Primary	10W (10 dBW)
50.00-51.00	Primary. Available on the basis of non-interference to other services outside the UK	Not allocated	10W (10 dBW)
51.00-52.00	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	10W (10 dBW)
70.00-70.50	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	10W (10 dBW)
144.0-146.0	Primary	Primary	10W (10 dBW)
430.0-431.0	Secondary	Not allocated	10W (10 dBW) e.r.p.
431.0-432.0	Secondary. Not available for use within 100km radius of Charing Cross, London (51°30'30"N, 00°07'24"W)	Not allocated	10W (10 dBW) e.r.p.
432.0-435.0	Secondary	Not allocated	10W (10 dBW)
435.0-438.0	Secondary	Secondary	10W (10 dBW)
438.0-440.0	Secondary	Not allocated	10W (10 dBW)
10000-10125	Secondary	Not allocated	1W (0 dBW)
10225-10450	Secondary	Not allocated	1W (0 dBW)
10450-10475	Secondary	Secondary	1W (0 dBW)
10475-10500	Not allocated	Secondary	1W (0 dBW)

Table B
Intermediate Licence Parameters

Frequency Bands (in MHz)	Status of allocations in UK to the Amateur Service	Status of allocations in UK to the Amateur Satellite Service	Maximum Peak Envelope Power level in Watts (and dB relative to 1 Watt)
0.1357-0.1378	Secondary. Available on the basis of non-interference to other services inside or outside the UK.	Not allocated	1W (0 dBW) e.r.p.
1.810-1.830	Primary. Available on the basis of non-interference to other services outside the UK	Not allocated	50W (17 dBW)
1.830-1.850	Primary	Not allocated	50W (17 dBW)
1.850-2.000	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	32W (15 dBW)
3.500-3.800	Primary. Shared with other services	Not allocated	50W (17 dBW)
7.000-7.100	Primary	Primary	50W (17 dBW)
7.100-7.200	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	50W (17 dBW)
10.100-10.150	Secondary	Not allocated	50W (17 dBW)
14.000-14.250	Primary	Primary	50W (17 dBW)
14.250-14.350	Primary	Not allocated	50W (17 dBW)
18.068-18.168	Primary	Primary	50W (17 dBW)
21.000-21.450	Primary	Primary	50W (17 dBW)
24.890-24.990	Primary	Primary	50W (17 dBW)
28.000-29.700	Primary	Primary	50W (17 dBW)
50.00-51.00	Primary. Available on the basis of non-interference to other services outside the UK	Not allocated	50W (17 dBW)
51.00-52.00	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	50W (17 dBW)
70.00-70.50	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	50W (17 dBW)
144.0-146.0	Primary	Primary	50W (17 dBW)
430.0-431.0	Secondary	Not allocated	40W (16 dBW) e.r.p.
431.0-432.0	Secondary. Not available for use within 100km radius of Charing Cross, London (51°30'30"N, 00°07'24"W)	Not allocated	40W (16 dBW) e.r.p.
432.0-435.0	Secondary	Not allocated	50W (17 dBW)
435.0-438.0	Secondary	Secondary	50W (17 dBW)
438.0-440.0	Secondary	Not allocated	50W (17 dBW)
1240-1260	Secondary	Not allocated	50W (17 dBW)
1260-1270	Secondary	Secondary. Earth to space only	50W (17 dBW)
1270-1325	Secondary	Not allocated	50W (17 dBW)
2310-2400	Secondary	Not allocated	50W (17 dBW)
2400-2450	Secondary. Users must accept interference from ISM users.	Secondary. Users must accept interference from ISM users.	50W (17 dBW)
3400-3475	Secondary	Not allocated	50W (17 dBW)
5650-5670	Secondary	Secondary. Earth to space only	50W (17 dBW)
5670-5680	Secondary	Not allocated	50W (17 dBW)
5755-5765	Secondary. Users must accept interference from ISM users.	Not allocated	50W (17 dBW)
5820-5830	Secondary. Users must accept interference from ISM users.	Not allocated	50W (17 dBW)
5830-5850	Secondary. Users must accept interference from ISM users.	Secondary. Users must accept interference from ISM users. Space to Earth only.	50W (17 dBW)
10000-10125	Secondary	Not allocated	50W (17 dBW)
10225-10450	Secondary	Not allocated	50W (17 dBW)
10450-10475	Secondary	Secondary	50W (17 dBW)
10475-10500	Not allocated	Secondary	50W (17 dBW)
24000-24050	Primary. Users must accept interference from ISM users	Primary. Users must accept interference from ISM users	50W (17 dBW)
24050-24150	Secondary. May only be used with the written consent of Ofcom. Users must accept interference from ISM users	Not allocated	50W (17 dBW)
24150-24250	Secondary	Not allocated	50W (17 dBW)
47000-47200	Primary	Primary	50W (17 dBW)
75500-75875	Secondary	Secondary	50W (17 dBW)
75875-76000	Primary	Primary	50W (17 dBW)
76000-77500	Secondary	Secondary	50W (17 dBW)
77500-78000	Primary	Primary	50W (17 dBW)
78000-79000	Secondary	Secondary	50W (17 dBW)
79000-81000	Secondary	Secondary	50W (17 dBW)
122250-123000	Secondary	Not allocated	50W (17 dBW)
134000-136000	Primary	Primary	50W (17 dBW)
136000-141000	Secondary	Secondary	50W (17 dBW)
241000-248000	Secondary	Secondary	50W (17 dBW)
248000-250000	Primary	Primary	50W (17 dBW)

Table C
Full Licence Parameters

Frequency Bands (in MHz)	Status of allocations in UK to the Amateur Service	Status of allocations in UK to the Amateur Satellite Service	Maximum Peak Envelope Power level in Watts (and dB relative to 1 Watt)
0.1357-0.1378	Secondary. Available on the basis of non-interference to other services inside or outside the UK.	Not allocated	1W (0 dBW) e.r.p.
1.810-1.830	Primary. Available on the basis of non-interference to other services outside the UK	Not allocated	400W (26 dBW)
1.830-1.850	Primary	Not allocated	400W (26 dBW)
1.850-2.000	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	32W (15 dBW)
3.500-3.800	Primary. Shared with other services	Not allocated	400W (26 dBW)
7.000-7.100	Primary	Primary	400W (26 dBW)
7.100-7.200	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	400W (26 dBW)
10.100-10.150	Secondary	Not allocated	400W (26 dBW)
14.000-14.250	Primary	Primary	400W (26 dBW)
14.250-14.350	Primary	Not allocated	400W (26 dBW)
18.068-18.168	Primary	Primary	400W (26 dBW)
21.000-21.450	Primary	Primary	400W (26 dBW)
24.890-24.990	Primary	Primary	400W (26 dBW)
28.000-29.700	Primary	Primary	400W (26 dBW)
50.00-51.00	Primary. Available on the basis of non-interference to other services outside the UK	Not allocated	400W (26 dBW)
51.00-52.00	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	100W (20 dBW)
70.00-70.50	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	160W (22 dBW)
144.0-146.0	Primary	Primary	400W (26 dBW)
430.0-431.0	Secondary	Not allocated	40W (16 dBW) e.r.p.
431.0-432.0	Secondary. Not available for use; within 100km radius of Charing Cross, London (51°30'30"N, 00°07'24"W)	Not allocated	40W (16 dBW) e.r.p.
432.0-435.0	Secondary	Not allocated	400W (26 dBW)
435.0-438.0	Secondary	Secondary	400W (26 dBW)
438.0-440.0	Secondary	Not allocated	400W (26 dBW)
1240-1260	Secondary	Not allocated	400W (26 dBW)
1260-1270	Secondary	Secondary. Earth to space only	400W (26 dBW)
1270-1325	Secondary	Not allocated	400W (26 dBW)
2310-2400	Secondary	Not allocated	400W (26 dBW)
2400-2450	Secondary. Users must accept interference from ISM users.	Secondary. Users must accept interference from ISM users.	400W (26 dBW)
3400-3475	Secondary	Not allocated	400W (26 dBW)
5650-5670	Secondary	Secondary. Earth to space only	400W (26 dBW)
5670-5680	Secondary	Not allocated	400W (26 dBW)
5755-5765	Secondary. Users must accept interference from ISM users	Not allocated	400W (26 dBW)
5820-5830	Secondary. Users must accept interference from ISM users	Not allocated	400W (26 dBW)
5830-5850	Secondary. Users must accept interference from ISM users	Secondary. Users must accept interference from ISM users. Space to Earth only.	400W (26 dBW)
10000-10125	Secondary	Not allocated	400W (26 dBW)
10225-10450	Secondary	Not allocated	400W (26 dBW)
10450-10475	Secondary	Secondary	400W (26 dBW)
10475-10500	Not allocated	Secondary	400W (26 dBW)
24000-24050	Primary. Users must accept interference from ISM users	Primary. Users must accept interference from ISM users	400W (26 dBW)
24050-24150	Secondary. May only be used with the written consent of Ofcom. Users must accept interference from ISM users	Not allocated	400W (26 dBW)
24150-24250	Secondary	Not allocated	400W (26 dBW)
47000-47200	Primary	Primary	400W (26 dBW)
75500-75875	Secondary	Secondary	400W (26 dBW)
75875-76000	Primary	Primary	400W (26 dBW)
76000-77500	Secondary	Secondary	400W (26 dBW)
77500-78000	Primary	Primary	400W (26 dBW)
78000-79000	Secondary	Secondary	400W (26 dBW)
79000-81000	Secondary	Secondary	400W (26 dBW)
122250-123000	Secondary	Not allocated	400W (26 dBW)
134000-136000	Primary	Primary	400W (26 dBW)
136000-141000	Secondary	Secondary	400W (26 dBW)
241000-248000	Secondary	Secondary	400W (26 dBW)
248000-250000	Primary	Primary	400W (26 dBW)

Notes to Schedule 1

(a) dBW is the power level in dB relative to one Watt.

(b) Peak envelope power is the average power supplied to the antenna by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions.

(c) Effective radiated power (e.r.p.) (in a given direction) is the product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction.

(d) ISM is an abbreviation for industrial, scientific and medical applications.

(e) In all frequency bands, high intensities of radio frequency radiation may be harmful and safety precautions should be taken. Advice concerning safe levels of exposure to radio frequency radiation is provided by the Health Protection Agency.

Annex 6

Technical analysis of coexistence between amateurs and MFCN

Introduction

A6.1 This annex provides some initial technical analysis of the compatibility of known amateur use and future Mobile/Fixed Communications Networks (MFCN) use in the MoD's 2.3 and 3.4 GHz release and adjacent bands. We have conducted our analysis on the basis that the released MoD spectrum will be used for wireless broadband such as using 4G Long Term Evolution (LTE) technologies or LTE advanced.[38]

A6.2 This technical analysis sets out our current assessment as to whether amateurs and future LTE will be able to coexist in the release band (i.e. co-channel). It details our assessment of co-channel interference risk to amateurs from future LTE use and co-channel interference risk from amateurs to future LTE use. It also details our initial assessment of the potential for interference from continued amateur use in the adjacent bands into the future LTE use in the MoD's release bands.

A6.3 We have not assessed the potential impact of new LTE systems (as a primary use), to amateur use (a secondary use) in the adjacent spectrum as we are proposing amateur use in the adjacent bands continues on a secondary non-interference non-protected basis.[39]

A6.4 The analysis supports our recommendations that (a) amateur use will not be able to continue co-channel and (b) our proposals that if there are interference issues then these should be resolved by mitigation by the amateur user or by enforcement mechanisms by Ofcom.

A6.5 It is also expected that continued amateur use of the 2400 – 2450 MHz band also must not cause harmful interference to new uses in the release bands and can expect no protection from interference from those new users, although the continued access to this band is not subject to this consultation. Compatibility studies of amateur use of 2400 – 2450 MHz have not been included in this annex. However the recommendations in this annex such as the use of good filters for wide band systems may also be needed for future amateur use of 2400 – 2450 MHz.

A6.6 To support the assessment within this technical annex we have researched future LTE use. We have reviewed the relevant technical harmonisation work currently underway in the European Conference of Postal and Telecommunications Administrations (CEPT) working group ECC FM52 (for the 2.3 GHz band) and working group ECC PT1 (for the 3.4 GHz band.) This harmonisation work has been used to inform the parameters used for modelling LTE systems (see paragraphs A6.29 to A6.44.

[38] Paragraphs 3.9 to 3.13 discuss this likelihood on the basis of ongoing pan-European spectrum harmonisation.
[39] This annex does not assess the potential impact of other potential new users in the adjacent bands to the release spectrum, for example new military and government uses.

A6.7 Similarly, we have researched known amateur uses of the release and adjacent bands. We have asked amateurs using the MoD's release bands for information on known uses of the spectrum in 2310 – 2400 MHz and 3400 – 3475 MHz and how the systems are typically used. Amateurs were initially contacted via RSGB although we have also spoken to members of other amateur groups. Unless otherwise stated evidence on amateur use has been provided by amateur users of the relevant bands including amateurs who took part in a testing/open day at Ofcom's monitoring station in Baldock.

Summary of amateur uses and technical characteristics

A6.8 An amateur licence enables flexibility to use spectrum on a non-interference non-protected basis. There is some band planning advice that is given by RSGB, often informed from the International Amateur Radio Union (IARU) band plan, for guidance to allow development of specific interests in common spectrum and to avoid interference to and from dissimilar radio systems.

A6.9 The amateur licence currently enables transmissions up to 400W (26 dBW) peak envelope power supplied to the antenna for the bands 2310 – 2400 MHz and 3400 – 3475 MHz. This is a higher power than is used in practice by the amateur uses of the bands that we know about.

A6.10 We have made our compatibility assessments against existing uses of the bands. The following Tables 1 - 7, provide an overview of the characteristics we have obtained of the amateur systems via RSGB. These uses are:

- TV User Equipment (analogue and digital) - Table 4
- TV Repeaters (digital) - Table 5
- Data Links - Table 6
- Narrow Band Communications - Table 7
- Earth-Moon-Earth (Moonbounce) - Table 8
- Propagation Beacons - Table 9 (in the 2300 MHz amateur band) and Table 10 (in the 3400 MHz amateur band)

Table 4: Summary information of TV user equipment and use

TV User equipment	
Frequencies currently used in bands 2310 – 2450 MHz and 3400 - 3475 MHz	Transmissions on 2328, 2335, 2340, 2355 and 2388 MHz
Tuning range of the equipment	2300 - 2450 MHz (but limited by internal filters)
Typically used e.i.r.p, dBW	10 dBW (PA) - 3 dB(feed-loss) + 17dB(Ant Gain) = 24 dBW e.i.r.p
Typical beamwidth of transmission	20 degrees (from a 25 element Yagi antenna)
Typical height of transmitter	10 metres
What are the bandwidths used?	Analogue: 16 MHz FM Digital: 4 MHz QPSK (DVB-S)
Typical emission mask	See Annex 7 of measurements taken
Approximately how many users are there?	British Amateur Television Club has ~800 UK members; however there are only approximately 100 users in the 2.3 GHz band.
Where are the users?	Largely within repeater coverage areas (see Figure 4). The user

	equipment transmits to TV repeater sites that re-broadcast the information on a different output frequency (which is currently within the 2.4 GHz licence exempt band, except for the two repeater sites detailed in Table 5). There may also be some direct user to user transmissions.
Are transmissions intermittent, or continuous?	Very intermittent - peaks on activity evenings

A6.11 Figure 6 below shows coverage areas of TV repeaters where TV user equipment may operate in the 2310 – 2400 MHz band.

Figure 6: Coverage areas of TV repeaters where TV user equipment may operate in the 2310 – 2400 MHz band

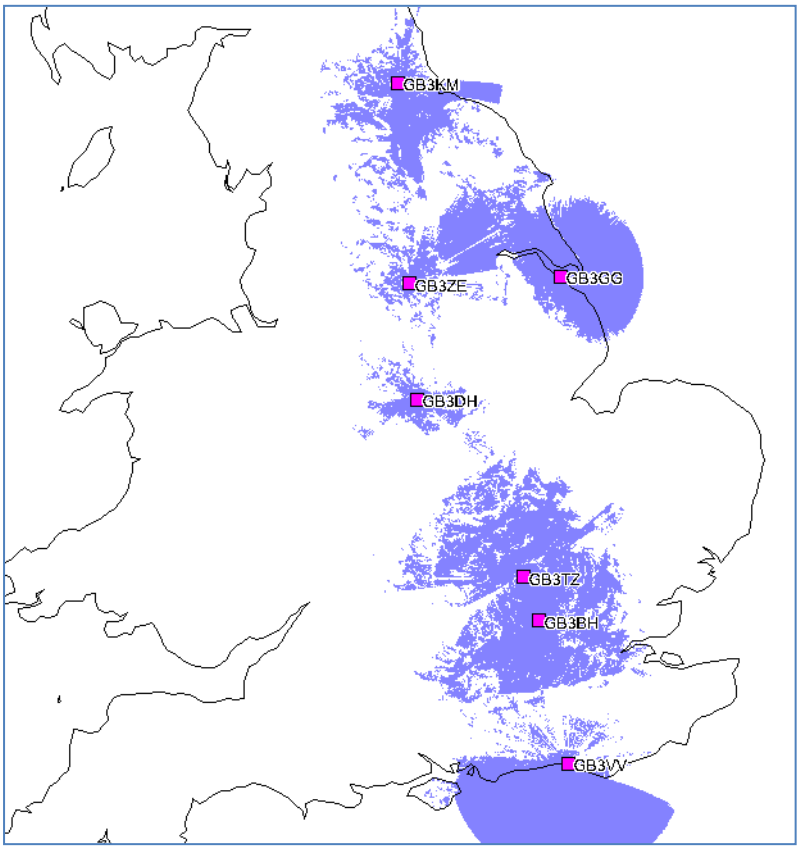


Table 5: Summary information of TV repeater equipment in 2300 – 2400 MHz and 3400 – 3475 MHz band

TV Repeaters	
Frequencies currently used in bands 2310 – 2450 MHz and 3400 - 3475 MHz	Digital: 2326 and 3406 MHz
Tuning range of the equipment	Fixed by Specific band Interdigital Duplex filters
Typically used e.i.r.p, dBW	16.15 dBW (or 14 dBW erp)
Typical beamwidth of transmission	360 deg azimuth, horizontal polarisation
Typical height of transmitter	20 metres
What are the bandwidths used?	Digital: 4 MHz QPSK (DVB-S)
Typical emission mask	See Annex 7 of measurements taken

Approximately how many users are there?	2 repeaters within the frequency range 2310 – 2400 MHz and 3400 – 3475 MHz[40]
Where are the transmitters?	See Figure 7: below for digital repeaters
Are transmissions intermittent, or continuous?	Continuous transmission, may revert to transmit the test card with call sign if no other input available to the repeater

* Note that most of the TV user equipment highlighted in Table 4 above are paired with repeaters currently using 2400 – 2450 MHz.

Figure 7: Digital TV repeaters used in 2310 – 2350 MHz and 3400 - 3475 MHz band

***** Includes Ordnance Survey© data (Crown copyright and database right 2012)

Table 6: Summary information of data link equipment and use

Data Links	
Frequencies currently used in bands 2310 – 2450 MHz and 3400 - 3475 MHz	Band 2312 – 2397 MHz
Tuning range of the equipment	2312 - 2397 in 5MHz channels
Typically used e.i.r.p, dBW	28dBm Tx - 2 dB(feed-loss) + 21dB(AntGain) = ~17 dBW e.i.r.p
Typical beamwidth of transmission	25 element yagi = 20 degrees Yagi antennas for longer distance up to 9-16km Most UK links typically shorter (still with Yagis or Panel antennas http://www.wimo.de/panel-antennas_e.html)
Typical height of transmitter	8-16m
What are the bandwidths used?	5MHz (for 6Mb/s)
Typical emission mask	We have been given information on one system of: Bandwidth: Power level relative to carrier ± 2 MHz: -3 dBC ± 2.5 MHz: -25 dBC ± 8 MHz: -50 dBC
Approximately how many users are there?	Probably only a few dozen for long distance Many others exploit WiFi/Bluetooth in 2400-2483

[40] There are further analogue repeaters that receive on the frequencies in Table 1 but transmit within the 2400 MHz band and are not listed here

Where are the users?	May be anywhere in the UK. Some also used to provide internet links to amateur DStar repeaters.
Are transmissions intermittent, or continuous?	Repeater Links 24/7, others intermittent

Table 7: Summary information of narrow band equipment and use

Narrow band communications	
Frequencies currently used in bands 2310 – 2400 MHz and 3400 - 3475 MHz	2320-2322 MHz and 3400-3401 MHz
Tuning range of the equipment	2320-2322 or 3400-3401 MHz
Typically used e.i.r.p, dBW	20 dBW(PA) - 3 dB(feed-loss) + 23dB(AntGain) = 40 dBW e.i.r.p
Typical beamwidth of transmission	Yagis, small dishes - 5-10 degrees, horizontal polarisation Antennas - 2.3GHz (67-element Yagis - 22dBi) http://www.wimo.de/yagi-antennas-shf-wimo_e.html Antennas - 3.4GHz (112 element Loop Yagi - 25dBi) http://www.directivesystems.com/PDF/9112LYK.PDF
Typical height of transmitter	10 metres (on a mast)
What are the bandwidths used?	CW/SSB - and WSJT MGM modes - all <3kHz BW
Typical emission mask	No - but all <3kHz
Approximately how many users are there?	~200 (UKuG has ~600 members over the 1.3GHz and higher bands)
Where are the users?	Pan-UK
Are transmissions intermittent, or continuous?	Very intermittent - peaks on activity evenings, special events, UKuG[41], RSGB & IARU contests

Table 8: Summary information of EME equipment and use

Earth – Moon – Earth (EME) communications	
Frequencies currently used in bands 2310 – 2400 MHz and 3400 - 3475 MHz	2320 MHz and 3400-3401 MHz
Tuning range of the equipment	2320-2322 or 3400-3401 MHz
Typically used e.i.r.p, dBW	20 dBW(PA) - 1 dB(feed-loss) + >30dB(AntGain) = approx. 50 dBW e.i.r.p Power Amplifiers: 2.3GHz: 200W 3.4GHz: 50- 100W
Typical beamwidth of transmission	1-4 degrees, circular polarisation, antennas wire mesh steerable parabolic dishes (3-6m diameter).
Typical height of transmitter	3m
What are the bandwidths used?	All <3kHz BW
Typical emission mask	No - but all <3kHz BW
Approximately how many users are there?	~50 (fewer in 3.4GHz)
Where are the users?	Pan-UK
Are transmissions intermittent, or continuous?	Very intermittent - peaks on activity evenings, special events, UKuG, RSGB & IARU contests Limited to time when Moon is above horizon.

[41] UK Microwave Group (UKuG)

A6.12 All transmissions are omni directional, except for Kilsyth (for both 2320 and 3400 MHz emissions), and Leicester (for only 2320 MHz emissions). Carrier Wave identification is sent every ~30-60 seconds.

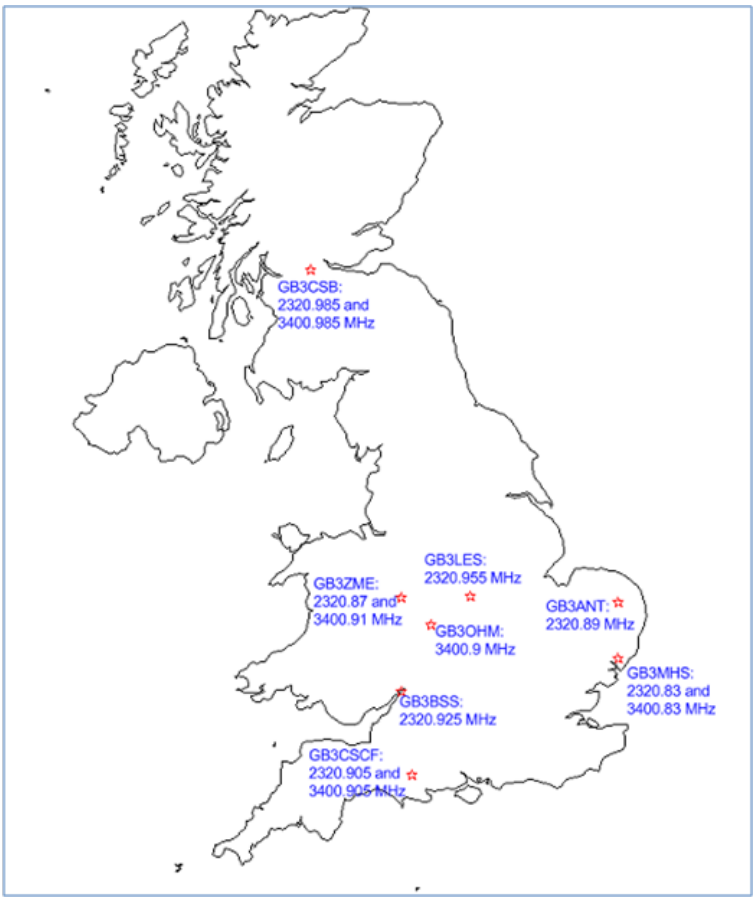
Table 9: Beacons within the 2.3 GHz band

CALL SIGN	Spot Frequency	Location	British NGR	e.r.p, dBW	Transmission height, m	Emission code
GB3CSB	2320.985	Kilsyth	NS731802	14	45	1K00F1AAN
GB3LES	2320.955	Leicester	SK485108	15	12	1K00F1AAN
GB3ANT	2320.890	Norwich	TG224084	7	52	1K00F1AAN
GB3MHS	2320.830	Martlesham	TM251448	14	63	1K00F1AAN
GB3SCS	2320.905	Bell Hill	ST801083	18	28	1K00F1AAN
GB3ZME	2320.870	Telford	SJ686081	19	10	1K00F1AAN
GB3BSS	2320.925	Stroud	SO673025	16	15	1K00F1AAN

Table 10: Beacons within the 3.4 GHz band

CALL SIGN	Spot Frequency	Location	British NGR	e.r.p, dBW	Transmission height, m	Emission code
GB3CSB	3400.985	Kilsyth	NS731802	14	45	1K00F1AAN
GB3LEF	3400.955	Leicester	SK485108	8	12	1K00F1AAN
GB3MHS	3400.830	Martlesham	TM251448	14	63	1K00F1AAN
GB3OHM	3400.900	Birmingham	SP026779	20	12	1K00F1AAN
GB3ZME	3400.910	Telford	SJ686081	18	21	1K00F1AAN
GB3SCF	3400.905	Bell Hill	ST801083	18	28	1K00F1AAN

Figure 8: Locations of propagation beacons on 2320 MHz and 3400 MHz frequencies



Parameters for LTE systems

A6.13 We have reviewed the relevant technical harmonisation work that is currently underway in the European Conference of Postal and Telecommunications Administrations (CEPT) working group ECC FM52 for the 2.3 GHz band and working group ECC PT1 for the 3.4 GHz band. We have also consulted standards documentation of likely candidate technologies of the spectrum, such as 3GPP standards, to assist in the selection of parameters.

A6.14 Whilst new licences will ultimately be issued on a technology neutral basis, ongoing harmonisation of spectrum means it is likely that the released MoD spectrum will be used for wireless broadband such as using 4G Long Term Evolution (LTE) or LTE advanced technology and therefore we have conducted our analysis on this basis.

A6.15 The susceptibility of LTE systems has been assessed by considering the interference power needed to cause a specified desensitisation. The figures used can be found in Table 11 and Table 12. This is a common way to calculate the potential interference effect of another system on LTE systems. The desensitisation levels represent a noise rise at the base station or user equipment so that the capacity, throughput and the maximum range of the cell are reduced.

A6.16 Below in Table 11 and Table 12 are the parameters assumed for LTE base stations within this technical annex.

Table 11: General parameters for LTE base stations

e.i.r.p	64 dBm / 10 MHz
Antenna gain	18 dBi
Antenna height	20 m
Interference to cause specified 1 dB desensitisation	-105 dBm / 10 MHz (noise figure 5 dB)

A6.17 The selectivity performance requirements for wide area base stations, as defined in 3GPP TS 36.104 v11.3.1, are summarised below in Table 12.

Table 12: Selectivity parameters of LTE base station receivers

Operating band	**Centre Frequency of Interfering Signal, MHz**	**Selectivity of base station receiver, dB**
2300 – 2400 MHz and 3400 – 3600 MHz	First adjacent channel	43.5
	Beyond first adjacent channel within the operating band	52.5
	> 20 MHz out of operating band (CW)	80.5

A6.18 In practice, equipment often performs better than the standard. The ACS value of 52.5 dB is specified for an LTE system being interfered with by a 5 MHz LTE system within the operating band. The LTE may be more robust to interference in practice from a lightly modulated signal that is less than 3 kHz in bandwidth, as a higher powered narrow band signal is likely to cause fewer harmonics and thus interfere with only a limited number of resource blocks than a wider band interferer and the error correction of the system may well be able to cope better.

A6.19 The 3GPP TS 36.104 v11.3.1 standard has a conformance value of 80.5 dB for CW interference ± 20 MHz outside of the operating band (28 dB improvement over 52.5 dB). It is possible that the selectivity performance of the base station to a CW like signal, such as the emissions from the narrow band systems, may tend to the 80.5 dB value, particularly if additional filtering of the licensed band only is applied to the base station. However, this may be a more appropriate assumption for narrow band systems around 2320 MHz that are 30 MHz from the release band edge than narrow band systems around 3400.9 MHz that are only 9 MHz from the release band edge.

A6.20 ECC Report 172 states that the equipment performance can actually be much better than the standards: “In practice, it is common for infrastructure vendors to offer products with significantly better performance for various reasons such as to accommodate special sharing situations in various markets or for deployment in co-siting situations or for improving the interference behaviour in specific sites.”

A6.21 We think it is likely – based on the European work on a Licence Spectrum Access (LSA) framework designed to facilitate greater spectrum sharing in bands including the 2300 MHz band – that equipment vendors or operators may choose to have improved receiver performance of their base stations in order to facilitate greater spectrum sharing in the band.

A6.22 It is likely that greater improvements on selectivity of base stations will be achieved with greater frequency separation from the LTE channel edge. Draft ECC Report “Least Restrictive Technical Conditions suitable for Mobile/Fixed Communication Networks (MFCN), including IMT, in the frequency bands 3400-3600 MHz and

3600-3800MHz" states, "for a macro cell base station, a ceramic filter with a bandwidth of 20 MHz can achieve 50 dB suppression within 5 MHz offset from the channel edge." "For 100 MHz channel bandwidth, 10 MHz roll-off region is required to achieve this suppression". Therefore it may be more appropriate to consider improvements in the performance of the selectivity of LTE systems below 2345 MHz, above 2395 MHz, and below 3405 MHz.

A6.23 For the scenarios where the LTE base stations are the potential victims, additional calculations have been performed to take into account additional mitigation margin of 10 dB, 20 dB and 28 dB in some cases (unless the separation distances to avoid desensitising the base station is already very short).

A6.24 Below in Table 13 and Table 14 are the parameters assumed for LTE user equipment within this technical annex.

Table 13: General parameters for LTE user equipment

Antenna gain	0 dBi
Antenna height	1.5 m
Body loss	3 dB
Interference to cause specified 3 dB desensitisation	-95 dBm / 10 MHz (noise figure 9 dB)

A6.25 The selectivity performance requirements for user equipment, as defined in 3GPP TS 36.101 v11.3.1, are summarised below in Table 14.

Table 14: Selectivity parameters of LTE user equipment receivers

Operating band	**Centre Frequency of Interfering Signal, MHz**	**Selectivity of user equipment receiver, dB**
2300 – 2400 MHz and 3400 – 3600 MHz	First adjacent channel	33
	Beyond first adjacent channel within the operating band	45

A6.26 It is also expected that the selectivity performance of user equipment may be better than the standards.

A6.27 Ofcom has previously commissioned some measurements into 2.1 GHz user equipment[42]. The user equipment measured performed up to 30 dB better than the standards specified.

A6.28 For the scenarios where the LTE systems are the potential victims, an additional calculation is performed to take into account an additional mitigation margin of 10 dB and 20 dB.

General modelling assumptions

A6.29 This section gives an overview of the approach taken to model the potential risks of interference. These are the general modelling assumptions used in the analysis as set out in this technical annex.

[42] http://stakeholders.ofcom.org.uk/binaries/consultations/2ghzregsnotice/annexes/era.pdf

Modelling potential interference from adjacent systems

A6.30 The interference mechanisms modelled within this report are based on:

- an assessment of the effect of the out-of-band emissions of an interfering system in an adjacent channel spilling into a potential victim's receive channel;
- an assessment of the effect of the potential victim's receiver capability to receive its wanted signal in the presence of another signal in a different channel. Often known as adjacent channel selectivity (ACS) or blocking.

A6.31 Blocking is a measure of the receiver's ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted interferer on frequencies other than the adjacent channels. Adjacent channel selectivity (ACS) is a measure of the receiver ability to receive a wanted signal at its assigned channel frequency in the presence of an adjacent channel signal with a specified centre frequency offset of the interfering signal to the band edge of a victim system. Within this document we use selectivity to represent both adjacent channel selectivity and blocking.

A6.32 Where a system has a wider bandwidth than the potential victim, a bandwidth (BW) e.i.r.p conversion of $10*\log(BW_1/BW_2)$ is used.

A6.33 There are several amateur uses of narrow band systems that have a bandwidth of less than 3kHz. For these narrow band systems that are several MHz away from the release band it is assumed that the only interference mechanism to consider is the selectivity of the potential victim's receiver. When the bandwidth of the interferer is lower than the potential victim's system, no bandwidth e.i.r.p conversion is assumed.

A6.34 This annex contains minimum coupling loss calculations that calculate the separation distance needed to minimise the risk of interference based on assumptions on the performance of the systems.

Decoupling losses of antennas

A6.35 Modelling detailed in this annex shows both the worst case scenario (whereby the potential interfering transmitter is pointing directly with its maximum beam of intensity at the highest gain point of a potential victim's receiving antenna) as well as less pessimistic outcomes. While the technical conditions for the worst case scenario are a possibility these conditions are likely to occur only rarely and in some cases with non typical configuration of antenna tilts and orientations. This means the worst case scenarios are overly pessimistic results that are unlikely to occur in practice.

A6.36 In practice, there is the potential for additional losses due to antenna discrimination. This can be due to:

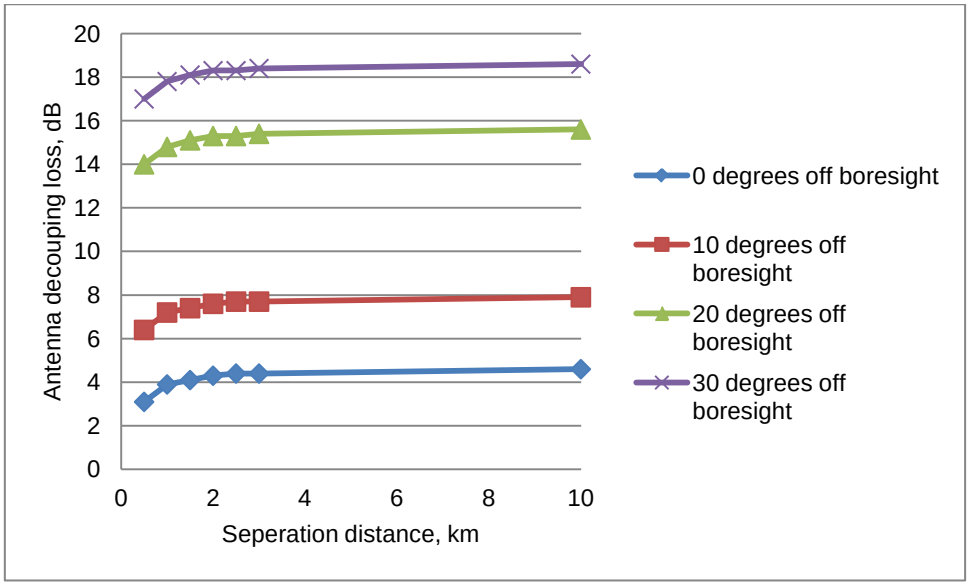
- different heights of the transmitting antenna and receiving antenna;
- different electrical or mechanical tilts of antennas;
- directional antennas may not be pointing directly towards each other in practice.

- polarisation mismatch, for example LTE base stations may use dual slant polarisation, and TV repeater stations typically use horizontal polarisation.

A6.37 Recommendation ITU-R F.1336-3, gives reference models of the peak and average antenna patterns of omni directional, sectoral and directional antennas in point-to-multipoint systems to be used in sharing studies in the frequency range 1 GHz to about 70 GHz. Our analysis has used this recommendation to determine a suitable antenna decoupling loss between a potential victim and potential interferer.

A6.38 Example estimated antenna decoupling losses from ITU-R F.1336-3 can be seen in Figure 9 for an LTE base station with a sectored antenna at a height of 20m and ATV user with a yagi antenna at a height of 10m. The graph shows different sets of values for antenna decoupling losses for when the antennas are pointing directly at each other in the horizontal plane, when there is a 10, 20 or 30 degrees offset between them in the horizontal plane.

Figure 9: Estimate of antenna decoupling losses between an LTE base station and an Amateur TV user at different horizontal



A6.39 If the antennas are pointing more directly towards each other then there would be a higher signal level at the potential victim. If there was a greater angular offset between the antennas, then there would be additional antenna decoupling losses, and a lower signal level at the potential victim.

A6.40 We have chosen to use values representing antennas that are pointing towards each other with a 0 degrees offset; this represents the worse case protection scenario. For systems with highly directional antennas, we have provided some additional calculations with a 10 degree azimuth antenna offset to demonstrate the potential benefits that may be achieved through additional antenna discrimination.

A6.41 An LTE base station is modelled having typically three sectors. LTE base stations can also have up to twelve sectors; in this case there is less opportunity for antenna discrimination between the potential interferer and victim antenna. A sample network was investigated based on a 2100 MHz deployment, 4% of the base stations currently have more than 3 sectors, therefore antenna azimuth offset of 10 degrees may be more representative of the actual geometries of real systems whereby the amateur antenna is highly directional.

A6.42 We recognise that the different antenna decoupling losses, shown in Figure 9 are examples for one particular configuration of potential interfere and victim antenna configuration and there are many others. We have therefore used values in our following calculations from the set of values: 0, 5, 7.5, 10, 15 and 17.5 dB decoupling loss, the choice of values used in the calculation has been based on the typical antenna patterns and likely geometry of the interference paths.

Propagation models

A6.43 The minimum coupling loss calculations in this annex which assess the potential interference risk for the different scenarios have used a number of different propagation models depending on the scenario being modelled. These are outlined in Table 15 below.

Table 15: Propagation models chosen for minimum coupling loss calculations

Scenario being modelled	Propagation model used
A potential victim and interferer have differing heights where one is above 20m and one is below 10m, ie below clutter. The separation distance is greater than 1 km.	Extended Hata in a suburban environment
A potential victim and interferer have low heights where both are below 10m. The separation distance is greater than 1 km.	Extended Hata for short range devices in a suburban environment
The separation distance is less than 1 km.	Free Space path loss
A potential victim and interferer have heights greater than 10 m. The separation distance is up to 10 km.	Free Space path loss
A potential victim and interferer have heights greater than 10m, ie above clutter. The separation distance is greater than 20 km.	ITU-R P. 452, 50% time

A6.44 There are a few cases in this annex where, if the Extended Hata model is used the separation distance calculated is less than 1 km, however when the free space path loss model is used, the separation distance calculated is slightly greater than 1 km. In these instances the separation distance is noted as ~ 1km.

Probability analysis

A6.45 Some amateur transmissions are continuous, such as from propagation beacons, TV repeaters and some data links. The propagation beacons and TV repeaters are at known locations so an analysis was done in these cases to get some perspective on the potential for interference. Analysis has been done in this annex to assess the probability of a base station falling within the separation distance calculated to protect base stations from the specified desensitisation. For this analysis an example 2.1 GHz network was assumed. It is possible that an operator may not have an extensive network using 2.3 GHz and 3.4 GHz spectrum as the example 2.1 GHz network, as the spectrum may be used to solve capacity issues in an existing network.

A6.46 Our understanding, from feedback we have received to date from some amateurs, is that many of the applications of the spectrum are for intermittent use limited to activity evenings and special events, such as from narrow band communication systems and TV user equipment use. If an amateur is transmitting 2 hours a week, they are transmitting 1.2% of the time. This intermittent use reduces the likelihood of potential interference occurring.

Results of co-channel analysis

A6.47 Analysis of the coexistence of existing amateur systems currently in the proposed release band (TV user equipment and repeaters) the future LTE systems have been performed with both the amateur system and the LTE system as potential victims of interference. The results are presented in Table 16.

Table 16: Separation distance to protect amateur and LTE systems from each other in a co-channel spectrum configuration

e.i.r.p of interferer, dBm	Power bandwidth conversion, dB	Antenna decoupling loss, dB	Receiver gain, dBi	Power level to desensitise victim , dBm	Total Loss, dB	Distance to protect power level, km
Amateur TV user equipment interference to LTE base station						
54	2	5	18	-105	168	65
LTE base station interference to amateur TV repeater						
64	N/A	5	9	-102	178	50 – 90 km[43]

A6.48 Table 16 shows that a separation distance of 65 km or greater is needed to prevent analogue TV user equipment desensitising an LTE base station. While a similar distance (50 – 90 km depending on the exact terrain and clutter along the path profile) is needed to avoid interference from an LTE base station to analogue TV repeater equipment that will be trying to listen to the transmitting user equipment.

A6.49 The potential separation distances between LTE base stations and both TV repeaters and amateur TV transmitters to provide adequate protection to both systems are significant. For example, 60 km is the diameter of the M25 and the straight line distance between Manchester and Leeds, therefore there is likely to be a high probability that a significant number of LTE base stations could be interfered with by co-channel amateur use. Therefore co-channel operation between amateurs and LTE is not recommended.

Results of adjacent band analysis of wide band amateur systems to LTE

A6.50 In the following paragraphs A6.52 and A6.80, we have outlined the adjacent band compatibility assessments of the existing wide band amateur uses in the adjacent bands (2310 – 2350 MHz, 2390 – 2400 MHz and 3400 – 3410 MHz) against LTE systems. This analysis is done against the following wide band systems:

- Amateur TV users;
- Amateur TV repeaters;
- Data links.

A6.51 For narrow band systems 9 MHz and 30 MHz away from the release band edge only need to be considered on the basis of the receiver performance of the LTE

[43] Using ITU R P. 452 – separation distance depends on the terrain and clutter on the exact path profile

receiver, data links and TV transmissions have much greater out of band emissions and may currently be located right up to the release band edge. The following analysis looks at the effect of out-of-band emissions and the effect of selectivity to LTE systems. The analysis is laid out in this way to assist understanding in the mechanisms that may cause an interference risk. It is worth noting that if both interference mechanisms act together they can have a combined effect of up to 3 dB extra interference to the potential victim receiver.

Analogue Amateur TV User equipment

A6.52 Table 17 and Table 18 gives the calculation for the separation distance to protect desensitising LTE systems from analogue user equipment on centre frequencies between 2310 – 2350 MHz.

A6.53 The out-of-band emission levels used in Table 17 have been taken from the measured analogue user equipment Tx1. For more information on the measurements taken of amateur TV equipment, see Annex 7.

A6.54 The spectrum analyser equipment has a dynamic range of the peak measured frequency of around 65 dB. This dynamic range limit of the spectrum analyser was met between 20 - 30 MHz frequency separation of the centre frequency of the digital repeater equipment. We expect that the filter performance of the TV user equipment to further reduce the out-of-band emissions in practice from a frequency separation of 20 - 30 MHz than indicated by the measurements.

A6.55 This uncertainty in the actual out-of-band emissions is reflected in the calculations below where the measured out-of-band emissions are likely to include noise of the spectrum analyser from 20 - 30 MHz from the centre frequency of the TV user equipment. The calculated distance to protect against desensitising base stations is referred to being less than or equal to a calculated value for when the digital user equipment is 20 - 30 MHz from the LTE band edge.

A6.56 The additional mitigation margin modelled in Table 17 and Table 18 may also be provided by improved LTE device performance (see paragraphs A6.18 to A6.23 as well as A6.26 to A6.28), lower amateur transmit powers or increased azimuth decoupling loss by greater offsets between the antennas of the amateur and the use of more directional antennas. For example Figure 9 indicates that the antenna decoupling loss can increase to around from 5 dB to 17.5 dB with a greater azimuth offset.

A6.57 An amateur may in practice use less power than the typical value of 54 dBm e.i.r.p indicated to us. This would reduce the risk of harmful interference. For example, we believe a 10 W power amplifier is typical, however one of the systems that we measured, see Annex 7, had a 1 W power amplifier. Conversely, if a higher power was used than assumed in our analysis then greater separation distances will be required.

Table 17: Separation distance to protect future LTE systems from out-of-band emissions analogue user equipment in the 2310 – 2350 MHz band

Separation from channel centre to LTE band edge	Out-of-band e.i.r.p of amateur system, dBm	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect against desensitising LTE systems, km

Analogue user equipment to LTE base stations due to out-of-band emissions					
10	17.9	5	0	135.9	8.3
			10	125.9	4.3
			20	115.9	2.2
20	0.3		0	118.3	≤ 2.6
			10	108.3	≤ 1.4
			20	98.3	≤ 0.7
30	-0.8		0	117.2	≤ 2.4
			10	107.2	≤ 1.3
			20	97.2	≤ 0.7
Analogue User equipment to LTE user equipment due to out-of-band emissions					
10	17.9	0	0	109.9	1.9
20	0.3			118.3	0.4
30	-0.8			117.2	0.4

Table 18: Separation distance to protect future LTE systems from analogue user equipment in the 2310 – 2350 MHz band due to selectivity

e.i.r.p of amateur system, dBm	Selectivity level of LTE receiver, dB	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km
Analogue User equipment to LTE base stations due to selectivity					
54	43.5	5	0	126.5	4.3
			10	116.5	2.3
			20	106.5	1.2
	52.5		0	117.5	2.5
			10	107.5	1.3
			20	97.5	0.8
Analogue User equipment to LTE user equipment due to selectivity					
54	45	0	0	99.0	0.9
			10	0.3	0.3

A6.58 The assessment of the impact of digital TV user equipment on LTE systems due to selectivity are the same as calculated in Table 18 for the potential impact from analogue TV user equipment.

A6.59 The results in Table 16 indicate that a separation of 10 MHz from the amateur TV channel centre to the LTE band edge may not be large enough to avoid causing unreasonable interference to LTE systems. Therefore it could be sensible for an amateur to apply additional mitigation techniques such as a reduction of transmit power, additional filtering and/or a larger frequency separation to avoid causing interference to LTE systems.

A6.60 TV user equipment is used very intermittently with peaks on activity evenings. If an amateur is transmitting 2 hours a week, they are transmitting 1.2% of the time. This intermittent use reduces the likelihood of potential interference occurring.

Digital Amateur TV User equipment

A6.61 The out-of-band emission levels used in Table 19 and have been taken from the measured digital user equipment Tx2. For more information on the measurements taken of amateur TV equipment, see Annex 7.

A6.62 Table 19 gives the separation distance to protect desensitising LTE systems from digital user equipment on centre frequencies between 2310 – 2350 MHz due to out of band emissions. These calculations relate to the amateur TV user equipment as defined in Table 4.

A6.63 The measurements taken of the user equipment, see Annex 7, demonstrates the importance of filtering of user equipment, as there was a marked performance improvement of the out-of-band emissions with a filter. Our calculations were done based on the equipment that had a filter on, as we are lead to believe it is typical for the equipment to have a filter.

A6.64 The additional mitigation margin modelled in Table 19 may also be provided by improved LTE device performance (see paragraphs A6.18 to A6.23 as well as A6.26 to A6.28), lower amateur transmit powers or increased azimuth decoupling loss by greater offsets between the antennas of the amateur and the use of more directional antennas. For example Figure 9 indicates that the antenna decoupling loss can increase to around from 5 dB to 17.5 dB with a greater azimuth offset.

A6.65 The spectrum analyser equipment has a dynamic range of the peak measured frequency of around 65 dB. This dynamic range limit of the spectrum analyser was met between 30 MHz frequency separation of the centre frequency of the digital repeater equipment. In practice, we expect that the filter performance of the TV user equipment to further reduce the out-of-band emissions from a frequency separation of 30 MHz than indicated by the measurements.

A6.66 This uncertainty in the actual out-of-band emissions is reflected in the calculations below where the measured out-of-band emissions are likely to include noise of the spectrum analyser at more than 30 MHz from the centre frequency of the TV user equipment. The calculated distance to protect against desensitising base stations is referred to being less than or equal to a calculated value for when the digital user equipment is 30 MHz from the LTE band edge.

Table 19: Separation distance to protect future LTE systems from out-of-band emissions from digital user equipment in the 2310 – 2350 MHz band

Separation from channel centre to LTE band edge	Out-of-band e.i.r.p of amateur system, dBm	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km
Digital user equipment to LTE base stations due to selectivity					
10	1.1	5	0	119.1	2.8
			10	109.1	1.4
			20	96.6	0.7
20	-3.0		0	115.0	2.1
			10	105.0	1.1

			20	95.0	0.3
30	-9.1		0	108.9	≤ 1.4
			20	98.9	≤ 0.9
			20	88.9	≤ 0.2
Digital user equipment to LTE user equipment due to out-of-band emissions					
10	1.1	0	0	93.1	0.5
20	-3.0			89.0	0.3

A6.67 The results above indicate that a separation of 10 MHz from the amateur TV channel centre to the LTE band edge may not be large enough to avoid causing unreasonable interference to LTE base stations. Therefore it could be sensible for an amateur to apply additional mitigation techniques such as a reduction of transmit power, additional filtering and/or a larger frequency separation to avoid causing interference to LTE systems.

Digital repeater equipment

A6.68 The out-of-band emission levels used in Table 20 have been taken from the measured digital repeater equipment. This table gives the separation distance to protect desensitising LTE systems due to out-of-band emissions from a digital repeater equipment on centre frequencies between 3400 – 3410 MHz. The measured repeater, on 2326 MHz, had a data rate of 4 MSps, the repeater on frequency 3406 MHz uses 2 MSps. Provided that an adequate filter is used, we would expect that the out-of-band emissions would be less for a system transmitting 2 MSps.

A6.69 The calculations have been based on the existing digital repeater that has a transmit height of 10m. A transmission height of 10m gives the TV repeater additional protection as it is below within the clutter. If a higher height was modelled, for example 20m, the typical antenna height for TV repeaters, the separation distances calculated in would be greater.

Table 20: Separation distance to protect future LTE systems from out-of-band emissions from digital repeater equipment in the 3400 – 3410 MHz band

Separation from channel centre to LTE band edge	Out-of-band e.i.r.p of amateur system, dBm	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km	Percentage probability of base stations within distance to existing repeater
Digital repeater equipment to LTE base stations due to out-of-band emissions						
4	13.9	5	0	131.9	6.9	0.2%
			10	121.9	3.6	0 out of approximately 8000 base stations within distance to protect against
			20	111.9	1.9	
6	2.6		0	120.6	3.3	
			10	110.6	1.7	
			20	100.6	0.8	
8	-7.9		0	110.1	1.7	

			10	100.1	0.7	desensitisation.
			20	90.1	0.2	
Digital repeater equipment to LTE user equipment due to out-of-band emissions						
4	13.9	0	0	108.9	1.9	
6	2.6			97.6	0.8	
8	-7.9			87.1	0.2	

Table 21: Separation distance to protect future LTE systems from digital repeater equipment in the 3400 – 3410 MHz band due to selectivity

e.i.r.p of amateur system, dBm	Selectivity level of LTE receiver, dB	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km	Percentage probability of base stations within distance to existing repeater
Digital repeater equipment in the 3400 – 3410 MHz band to LTE base stations due to selectivity						
46.15	43.5	5	0	118.6	2.9	0 out of approximately 8000 base stations within distance to protect against desensitisation.
	52.5		0	109.6	1.6	
			10	99.6	0.7	
			20	89.6	0.2	
Digital repeater equipment in the 3400 – 3410 MHz band to LTE user equipment due to selectivity						
46.15	45	0	0	91.1	0.3	

A6.70 The transmission height of the digital repeater has been assumed to be 20m as outline is typical in Table 5: and this is reflective of the height of the digital repeater in the 2310 – 2350 MHz spectrum centred on 2326 MHz.

A6.71 The spectrum analyser equipment has a dynamic range of the peak measured frequency of around 65 dB. This dynamic range limit of the spectrum analyser was met between 20 MHz frequency separation of the centre frequency of the digital repeater equipment. We expect that the filter performance of the TV repeater equipment to further reduce the out-of-band emissions in practice from a frequency separation of 20 MHz than indicated by the measurements.

Table 22: Separation distance to protect future LTE systems from out-of-band emissions from digital repeater equipment in the 2310 – 2350 MHz band

Separation from channel centre to LTE band edge	Out-of-band e.i.r.p of amateur system, dBm	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km	Percentage probability of base stations within distance to existing repeater
Digital repeater equipment in the 2310 - 2350 MHz band to LTE base stations due to out-of-band emissions						
8	-7.9	5	0	110.1	2.3	0 out of approximately 8000 base
			10	100.1	0.7	

			20	90.1	0.2	stations within distance to protect against desensitisation.
10 – 40	-10		0	108.0	1.8	
			10	98.0	0.6	
			20	88.0	0.2	
Digital repeater equipment in the 2310 - 2350 MHz band to LTE user equipment due to out-of-band emissions						
8	-7.9	0	0	87.1	0.2	
10 – 40	-10	0	0	85.0	0.2	

A6.72 Table 23 gives the calculation for the separation distance to protect desensitising LTE systems from digital repeater equipment on frequencies between 2310 – 2350 MHz due to selectivity.

Table 23: Separation distance to protect future LTE systems from digital repeater equipment in the 2310 – 2350 MHz band due to selectivity

e.i.r.p of amateur system, dBm	Selectivity level of LTE receiver, dB	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km	Percentage probability of base stations within distance to existing repeater
Digital repeater equipment in the 2310 - 2350 MHz band to LTE base stations due to selectivity						
46.15	52.5	5	0	109.6	3.1	0 out of approximately 8000 base stations within distance to protect against desensitisation.
			10	99.6	1	
			20	89.6	0.3	
Digital repeater equipment in the 2310 - 2350 MHz band to LTE user equipment due to selectivity						
46.15	45	0	0	91.1	0.3	

A6.73 The results above indicate that it could be sensible for an amateur to apply additional mitigation techniques such as a reduction of transmit power, additional filtering and/or a frequency separation to avoid causing interference to LTE systems.

A6.74 The probability analysis considering the two existing digital repeaters against an example 2.1 GHz mobile broadband network have no base stations within the protection distances for all but the worse case modelled due to out-of-band emissions where the there was a frequency separation of 4 MHz between a digital repeater and the LTE band edge at 3410 MHz. The analysis was done based on a measured repeater, centred on frequency 2326 MHz, which had a data rate of 4 MSps. The existing repeater on frequency 3406 MHz uses 2 MSps. Provided that an adequate filter is used, we would expect that the out-of-band emissions would be less for a system transmitting 2 MSps.

Data Links

A6.75 Data links are often made from adapted Wi-Fi equipment. Whereas other amateur activity tends to be associated with a particular interest group of amateurs, such as

amateur TV and the British Amateur Television Club, the adaption of Wi-Fi equipment can be done for adhoc amateur use that is not associated with any particular interest group. We have limited information on these bespoke systems, the information we have gathered on these systems can be found in Table 6: .

A6.76 We have received some information on the performance of single a 5 MHz carrier system. The separation distances to protect against desensitising LTE systems based on the out-of-band emission levels are given in Table 25 below.

A6.77 The additional mitigation margin modelled in Table 24 may also be provided by lower amateur transmit powers or increased azimuth decoupling loss by greater offsets between the antennas of the amateur and the use of more directional antennas.

A6.78 The assessment of the impact of data link equipment on LTE systems due to selectivity are similar as those calculated in Table 23 for the potential impact from digital repeater equipment.

Table 24: Separation distance to protect future LTE systems from data links in the 2310 – 2350 MHz and 2390 – 2400 MHz band due to out-of-band emissions

Separation from channel centre to LTE band edge	Out-of-band e.i.r.p of amateur system, dBm	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km
Digital user equipment to LTE base stations due to selectivity					
2.5	22	5	0	140.0	10.8
			10	130.0	5.6
			20	120.0	2.9
8	-3.0		0	115.0	2.1
			20	105.0	1.1
			20	95.0	0.6
Digital user equipment to LTE user equipment due to out-of-band emissions					
2.5	22	0	0	93.1	2.5
8	-3.0			89.0	0.5

A6.79 We note however that some data links may be transmitting continuously and some use is intermittent. We have received information via RSGB that indicates that there may only be a few dozen links that are transmitting continuously.

A6.80 The results above indicate that it could be sensible for an amateur to apply additional mitigation techniques such as a reduction of transmit power, additional filtering and/or a frequency separation to avoid causing interference to LTE systems.

Results of adjacent band analysis of narrow band amateur systems to LTE

A6.81 In the following section we outline the adjacent band compatibility assessments of the existing narrow band amateur uses in the adjacent bands (2310 – 2350 MHz,

2390 – 2400 MHz and 3400 – 3410 MHz) against LTE systems. This analysis is done against the following narrow band systems:

- Narrow band communications systems;
- Earth-Moon-Earth systems;
- Propagation beacons.

Narrow band communication systems including EME

A6.82 We have an estimate that there are around 200 narrow band users of this band for narrow band transmissions. There transmissions are very intermittent with peaks on activity evenings, special events and competition days.

A6.83 Table 25 gives the calculation for the separation distance to protect desensitising LTE systems from narrow band communication transmissions on the frequency 2320 MHz. These calculations relate to the narrow band systems as defined in Table 7:.

A6.84 The separation distances can also be considered suitable for Earth-moon-earth communications defined in Table 8:. The Earth-Moon-Earth communications systems are assumed to be pointing 10 degrees above the horizon. Although the EME system is using a higher e.i.r.p than other narrow band communications by 10dB, it is typically transmitting from a lower height (3m compared to 10m) and is using a more directional antenna pointing above the horizon.

A6.85 The additional mitigation margin modelled in Table 25 and Table 26 may be provided by improved LTE device performance (see paragraphs A6.18 to A6.23 as well as A6.26 to A6.28), lower interferer transmit powers or increased azimuth offsets between the antennas of the amateur and the LTE. Additional mitigation for EME systems may be achieved by the EME pointing higher than 10 degrees above the horizon and if a more directional transmitting dish is used.

Table 25: Separation distance to protect future LTE systems from narrow band communication systems using 2320 MHz

e.i.r.p of amateur system, dBm	Selectivity level of LTE receiver, dB	Antenna discrimination	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km
Narrow band communications systems on 2320 MHz to LTE base stations due to selectivity						
70	52.5	No antenna azimuth offset	5	0	135.5	8.0
		10 degree azimuth antenna offset	10	0	135.5	5.8
				10	120.5	3.0
				20	110.5	1.6
				28	102.5	~ 1
Narrow band communications systems on 2320 MHz to LTE user equipment due to selectivity						
70	45	No antenna azimuth	0	0	123.0	~ 1

		offset				
		10 degree azimuth antenna offset	7.5	20	95.5	0.3

Table 26: Separation distance to protect future LTE systems from narrow band communication systems using 3400 MHz

e.i.r.p of amateur system, dBm	Selectivity level of LTE receiver, dB	Antenna discrimination	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km
Narrow band communications systems on 3400 MHz to LTE base stations due to selectivity						
70	52.5	No antenna azimuth offset	5	0	135.5	8.7
		10 degree azimuth antenna offset	15	0	125.5	4.5
				10	115.5	2.4
				20	105.5	1.4
				28	97.5	0.6
Narrow band communications systems on 3400 MHz to LTE user equipment due to selectivity						
70	45	No antenna azimuth offset	0	0	117	~ 1
		10 degree azimuth antenna offset	10	10	97	0.5

A6.86 It is an important assumption that the EME use is pointing at least 10 degrees above the horizon, as an EME antenna pointing at a lower trajectory and towards a LTE base station or user equipment would have a much higher risk of causing desensitisation.

A6.87 We note that the RSGB band plan on their website refers to EME potentially being used at 2390 MHz. We understand from our initial enquiries that this channel is not used in practice. We would have some concern if 2390 MHz was used for EME systems, as it is immediately adjacent to the band edge used by future LTE systems. It is likely that the selectivity of the LTE system would be more vulnerable to interference by a high power EME system on 2390 MHz with minimal frequency separation compared to the EME system at 2320 MHz with 30 MHz frequency separation.

A6.88 Likewise we would expect that the selectivity of LTE systems will be potentially better at 2320 MHz which is 30 MHz from the LTE band edge, compared to 3400.9 that is only 9 MHz from the band edge. Therefore there may well be a greater risk of interference from the EME use on 3400.9 MHz compared to EME use on 2320 MHz.

A6.89 There are approximately 50 EME users of 2320 MHz within the UK, with fewer users around 3400 MHz. Their operations are very intermittent and limited to when the moon is above the horizon.

A6.90 As with the amateur TV equipment, use of narrow band communications is intermittent with peaks on activity evenings and special events. If an amateur is transmitting 2 hours a week, they are transmitting 1.2% of the time. This intermittent use reduces the likelihood of potential interference occurring.

Propagation beacons

A6.91 Unlike the narrow band communication systems and EME, propagation beacons are transmitting continuously. Propagation beacons also tend to be transmitting from a higher site to enable amateurs interested in narrow band frequencies and/or propagation conditions to listen to the signal over potentially large distances. For example some propagation beacons in the UK on a day with good propagation conditions may be picked up by an amateur within another country in Europe.

A6.92 The propagation beacons typically use an omni antenna, so there is not much additional antenna decoupling loss that can be achieved by different antenna orientations of the amateur equipment relative to the future LTE systems. (Two of the six propagation beacons on 2320 MHz do not have omni directional transmission. One of the six propagation beacons using 3400 MHz does not have an omni directional transmission.)

A6.93 The additional mitigation margin modelled in Table 27 may be provided by improved LTE device performance (see paragraphs A6.18 to A6.23 as well as A6.26 to A6.28), lower interferer transmit powers or by a different relative geometry of the modelled system.

A6.94 The probability analysis was done looking at the locations of the existing propagation beacons and base stations from an existing 2.1 GHz network to see what percentage of base stations fall within the separation distance calculated. For example, for an assumption of selectivity of 52.5 dB and a 10 dB additional mitigation, 7 of approximately 8000 base stations were within 1.5 km of the existing 2.3 GHz beacons, so if a 2.3 GHz network follows a similar deployment pattern to the 2.1 GHz network potentially 0.1% base stations are affected.

Table 27: Separation distance to protect future LTE systems from propagation beacons using 2320 MHz

e.i.r.p of amateur system, dBm	Selectivity level of LTE receiver, dB	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km	Percentage probability of base stations within distance to existing beacons
Propagation beacons on 2320 MHz to LTE base stations due to selectivity						
48	52.5	5	0	113.0	4.9	0.5%
			10	101.4	1.5	0.1%
			20	91.4	0.5	0.0%
Propagation beacons on 2320 MHz to LTE user equipment due to selectivity						
48	45	0.5	0	100.5	0.6	
			10	90.5	0.2	

A6.95 An additional piece of analysis was done looking at the locations of the existing propagation beacons and base stations from an existing 2.1 GHz network to see what percentage of base stations fall within the separation distance calculated. For example, for an assumption of selectivity of 52.5 dB and a 10 dB additional mitigation, 4 of approximately 8000 base stations were within 1.1 km of the existing 3.4 GHz beacons, so if a 3.4 GHz network follows a similar deployment pattern to the 2.1 GHz network with 0.046% base stations potentially affected.

Table 28: Separation distance to protect future LTE systems from propagation beacons using 3400 MHz

e.i.r.p of amateur system, dBm	Selectivity level of LTE receiver, dB	Antenna decoupling loss, dB	Additional mitigation	Total Loss, dB	Distance to protect desensitising LTE systems, km	Percentage probability of base stations within distance to existing beacons
Propagation beacons on 3400 MHz to LTE base stations due to selectivity						
48	52.5	5	0	113.0	3.3	0.3%
			10	103.0	1.1	0.0%
			20	93.0	0.3	0.0%
Propagation beacons on 2320 MHz to LTE user equipment due to selectivity						
4	4	0	0	1	0	
			10	90.5	0.1	

A6.96 The exact performance of the LTE base stations is currently unknown but it is not unreasonable to assume that the performance will be better than the standards, particularly for narrowband signals on 2320 MHz that are 30 MHz away from the release band edge.

A6.97 The probability analysis of that looks at the percentage probability that there is a base station within the proposed separation distance from the propagation beacons to avoid desensitising LTE base stations based on an example 2.1 GHz network. With an improved performance of 10 dB of the LTE base stations the probability is lower than 0.1% for both the 2320 MHz and 3400 MHz propagation beacons.

A6.98 The separation distances to avoid desensitising LTE user equipment is less than 0.6 km for all modelled assumptions.

Conclusions

Co-channel use

A6.99 Our analysis shows that separation distances up to 65 km may be needed between an LTE base station and amateur TV user equipment in order to protect the LTE base station from suffering harmful interference and up to 90 km to protect the TV repeater locations.

A6.100 Given the locations of the TV repeaters and likely coverage radius of these, we think that the mutual interference would be potentially significant and permitting these two services to coexist in the same frequency range would not lead to an efficient use of the spectrum.

A6.101 Consistent with our previous policy on high power releases on a nationwide basis the MOD has requested the release be unencumbered by amateur uses within the band and our technical analysis shows that there is a significant risk of interference (in both directions) and therefore co-channel operation between amateurs and LTE should not be permitted.

Adjacent-channel use

A6.102 Our analysis shows that there are instances where there is a risk of interference from adjacent channel amateur use to LTE systems. The results indicate that it could be sensible for amateurs to apply additional mitigation techniques such as a reduction of transmit power, additional filtering and/or a frequency separation to avoid causing harmful interference to LTE systems.

A6.103 We believe that due to the low numbers of amateur users in the band, the intermittent nature of some transmissions and careful operation by the amateurs that adjacent channel use could continue with limited risk.

A6.104 We have are minded not to include additional technical restrictions on adjacent channel use in the licence at this time to avoid being overly restrictive about amateur use, but we retain the option to do so in the future should the need arise.

Wideband adjacent uses

Amateur TV user equipment

A6.105 The measurements taken of amateur TV user equipment demonstrates the importance of filtering of user equipment, as there was a marked performance improvement of the out-of-band emissions with a filter present. Our calculations were based on the equipment that had a filter, as we are led to believe it is typical for the equipment to have a filter.

A6.106 The results indicate that a separation of 10 MHz from the amateur TV channel centre to the LTE band edge may not be large enough to avoid causing unreasonable interference to LTE systems. Therefore it could be sensible for an amateur to apply additional mitigation techniques such as a reduction of transmit power, additional filtering and/or a larger frequency separation to avoid causing harmful interference to LTE systems.

A6.107 With suitable mitigations by the amateur such as limiting out-of-band emissions into the 2350 – 2390 MHz release band the separation distances to avoid desensitising systems can be reduced to less than a 1km.

A6.108 It has been indicated to us, via RSGB, see Table 4, that TV user equipment is used very intermittently with peaks on activity evenings. If an amateur is transmitting 2 hours a week, they are transmitting 1.2% of the time. This intermittent use reduces the likelihood of potential interference occurring.

Digital TV repeaters

A6.109 Our analysis, based on current usage parameters, is that the amateur TV repeater transmissions do not cause significant interference zones (less than 1km in most cases) with LTE base stations or UEs.

A6.110 The probability analysis considered the two existing digital repeaters against an example 2.1 GHz mobile broadband network. It showed that there were no base stations within the protection distances for all but the worse case modelled (due to out-of-band emissions) where the there was a frequency separation of 4 MHz between the carrier frequency of a digital repeater and the LTE band edge at 3410 MHz. The analysis was done using a measured repeater, centred on frequency 2326 MHz, which had a data rate of 4 MSps. The existing repeater on frequency 3406 MHz uses 2 MSps. Provided that an adequate filter is used, we would expect that the out-of-band emissions would be less for a system transmitting 2 MSps.

Data links

A6.111 The results above indicate that it could be sensible for an amateur to apply additional mitigation techniques such as a reduction of transmit power, additional filtering and/or a frequency separation to avoid causing harmful interference to LTE systems.

Narrow band adjacent uses

A6.112 The analysis has assumed that the potential interference mechanism from narrow band systems is due to the selectivity performance of the LTE systems only and not due to out-of-band emissions from the narrow band signal.

A6.113 We think it is likely – based on the European work on a Licence Spectrum Access (LSA) framework designed to facilitate greater spectrum sharing in bands including the 2300 MHz band – that equipment vendors or operators may choose to have improved receiver performance of their base stations in order to facilitate greater spectrum sharing in the band.

A6.114 The exact performance of the LTE base stations is currently unknown but it is not unreasonable to assume that the performance will be better than the standards, particularly for narrowband signals on 2320 MHz that are 30 MHz away from the release band edge, or where specific licence-band filtering is fitted to the base station.

A6.115 Although narrow band use is often very high power, we believe the improved selectivity of the LTE systems outside of the release band at frequency separations of 9 MHz from the 3410 – 3600 MHz release band and 20 MHz from the 2350 – 2390 MHz release band and sensible amateur operations limits the risk of harmful interference in practice. The specific conclusions of each highlighted use are detailed below in paragraphs A6.116 to A6.120.

<u>Narrow band communication systems including EME</u>

A6.116 Mitigation measures can be taken, including the use of lower amateur transmit powers or increased azimuth offsets between the antennas of the amateur and the LTE. Additional mitigation for EME systems may be achieved by the EME pointing higher than 10 degrees above the horizon and if a more directional transmitting dish is used.

A6.117 It is an important assumption that the EME use is pointing at least 10 degrees above the horizon, as an EME antenna pointing at a lower trajectory and towards a LTE base station or user equipment would have a much higher risk of causing desensitisation.

A6.118 It has been indicated to us that narrow band communications equipment including EME is used very intermittently with peaks on activity evenings and special events. If an amateur is transmitting 2 hours a week, they are transmitting 1.2% of the time. This intermittent use reduces the likelihood of potential interference occurring.

A6.119 We note that the RSGB band plan on their website refers to EME potentially being used at 2390 MHz. We understand from our initial enquiries that this channel is not used in practice. We would have some concern if 2390 MHz was used for EME systems, as it is immediately adjacent to the band edge used by future LTE systems. It is likely that the selectivity of the LTE system would be more vulnerable to interference by a high power EME system on 2390 MHz with minimal frequency separation compared to the EME system at 2320 MHz with 30 MHz frequency separation.

Propagation beacons

A6.120 If LTE base stations have an improved performance of 10 dB above the standards, the probability that the 2320 MHz and 3400 MHz propagation beacons were within the separation distance from the propagation beacons to avoid desensitising LTE base stations based on an example 2.1 GHz network is lower than 0.1%.

Annex 7

Spectral emission measurements from amateur TV equipment

Introduction

A7.1 Amateur TV is the transmission of broadcast quality video and audio over short distances using the frequency bands allocated to the amateur service. This report provides the results of spectral emission measurements from typical Amateur TV (ATV) equipment operated in the 13cm (2300 MHz) band.

A7.2 Measurements were obtained from both analogue and digital user equipment (i.e. the equipment used to generate and transmit TV content), and from the output of the ATV repeater at Luton (the equipment used to receive and re-broadcast the TV signals). The resulting spectral emission plots have been normalized to show the level of out-of-band emissions in relation to the peak carrier power to allow easy comparison across the different equipment.

Equipment Under Test

ATV User Equipment

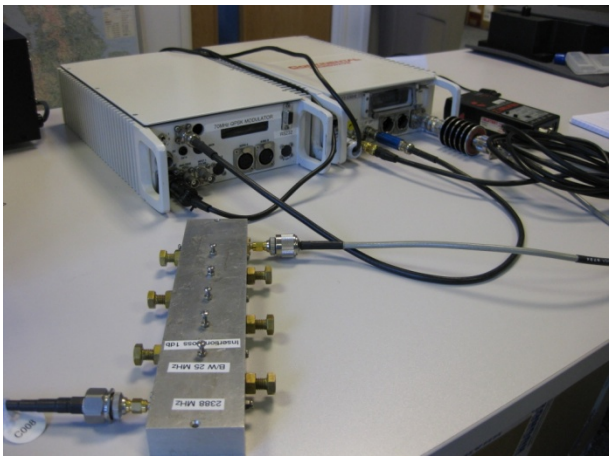
A7.3 Amateur TV enthusiasts often construct much of their own equipment, or assemble equipment from commercially available kits. An ATV system generally consists of a video camera (or other modulation source), a low cost transmitter with composite video input, a power amplifier, filter and a directional antenna (such as a high gain Yagi).

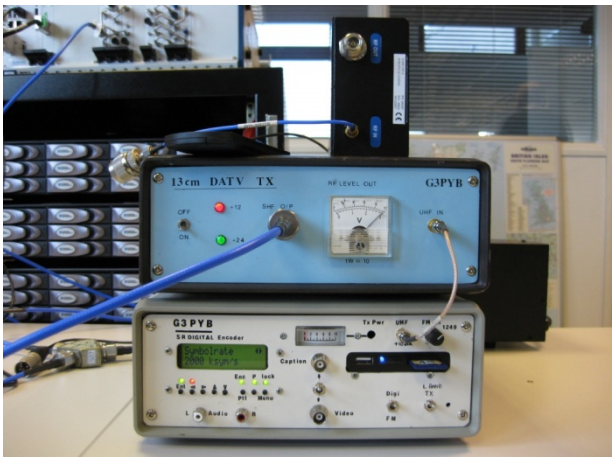
A7.4 A representative selection of ATV user equipment was tested during an open day held for invited members of the amateur community at Ofcom's Spectrum Management Centre in Baldock, Hertfordshire. The equipment parameters are summarised in Table 29 and a selection of the equipment tested is shown in Figure 10 below.

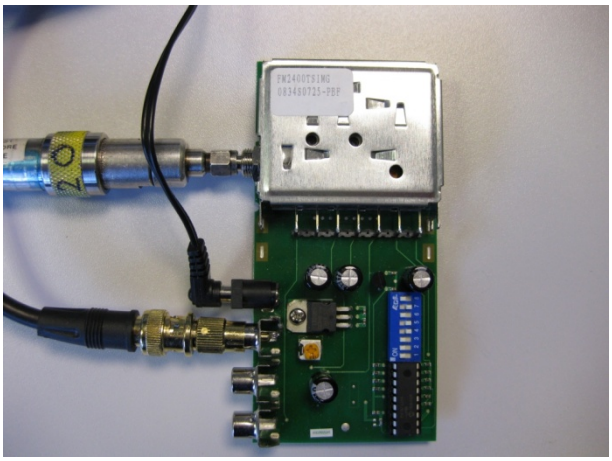
Table 29: Summary of ATV user equipment parameters

Equipment Reference	Tx1	Tx2	Tx3	Tx4	Tx5
Operating mode	Analogue	Digital	Digital	Digital	Analogue
Tx Frequency (MHz)	2388	2388	2330	2330	2340
Stated Bandwidth (MHz)	16	4	2	4	16
Tx Power (W)	2	1	10	10	[60]
Modulation	FM	QPSK	QPSK	QPSK	FM

Figure 10: Examples of ATV user equipment







ATV Repeater Equipment

A7.5 There are ten amateur analogue TV repeaters and one digital TV repeater within the 2300 MHz band. Six of these have receive frequencies (and thus user transmissions) that overlap with the release band 2350 to 2390 MHz. Two other repeaters have receive frequencies that could be considered adjacent to the 2300 MHz release band.

A7.6 To inform our studies, Ofcom measured the spectral emissions from the ATV repeater station located at Luton (GB3TZ), see Figure 11. This is able to operate in either analogue or digital transmission mode, as summarised in Table 30.

Table 30: Luton repeater operating parameters

CALL SIGN	Mode	Tx Frequency (MHz)	Rx Frequency (MHz)	Tx Power to feed cable (Watts)	Transmission height (m)	Emission code
GB3TZ	Analogue	2440.00	2388.00	2	20 agl	16M0F8WWN

GB3TZ	Digital	2326.00	2388.00	15	20 agl	4M00G7WWF

Figure 11: GB3TZ Luton Repeater

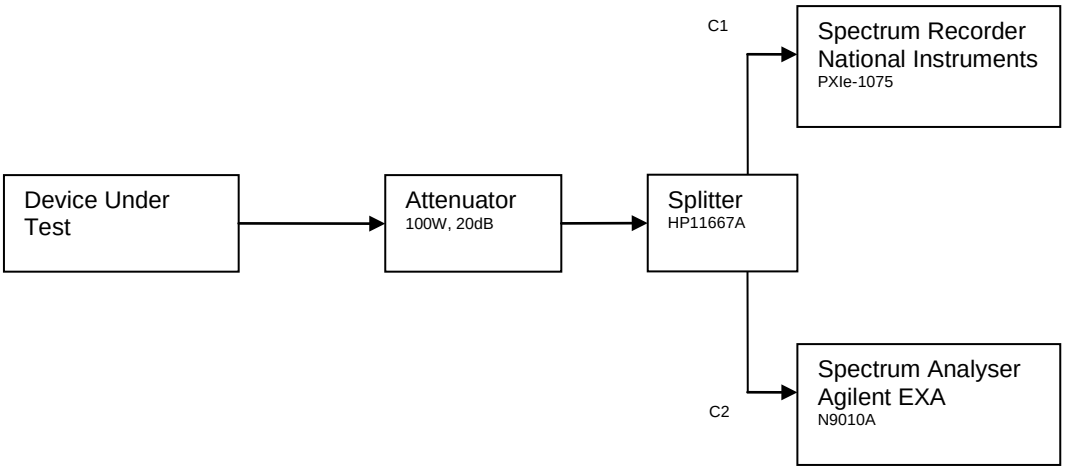
Test Arrangement

Test Configuration

A7.7 Both user equipment and repeater spectral emissions were recorded with a test setup similar to the one shown in Figure 12 below. Conductive testing was preferred since it removes uncertainties in the measurement results due to, for example, propagation, terrain and atmospheric effects.

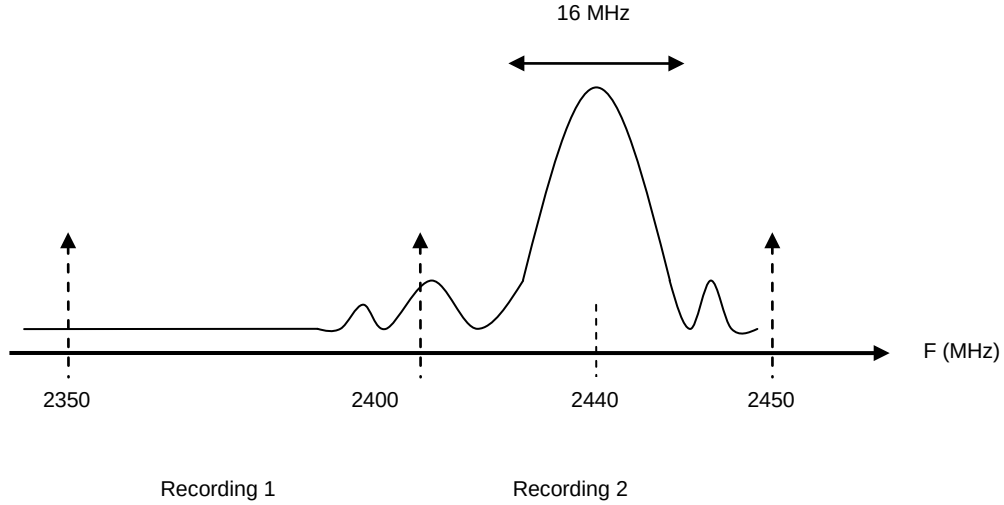
A7.8 Emissions were recorded using both a National Instruments (NI) spectrum recorder and with a standard spectrum analyser. The NI system allowed real time recording of emissions with a measurement bandwidth of 50 MHz. These results can be subsequently post-processed to obtain statistical data on any variation in the recorded emissions over the capture period, or used as an interference source for further coexistence analysis with other systems.

Figure 12: Conductive Test Setup



A7.9 Figure 13 shows an example of the spectrum bandwidth captured for the frequencies of interest.

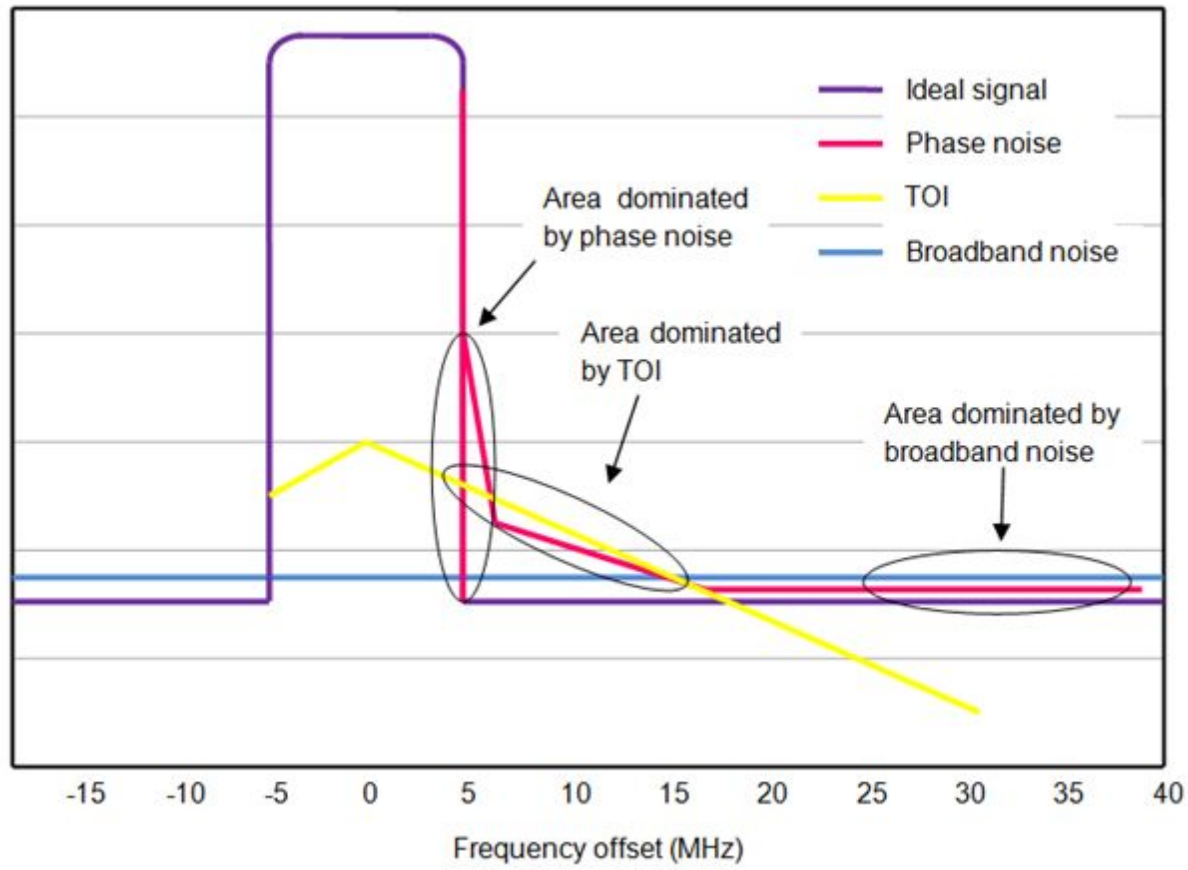
Figure 13: Example capture bandwidth for frequency bands of interest



Measurement Limitations

A7.10 Due to the relatively high power of the in-band ATV equipment emissions, the measurement of out-of-band (OOB) emissions is limited by the dynamic range of the spectrum analyser. Dynamic range is defined as the difference between the highest and lowest power signals that the analyser can simultaneously measure. Three mechanisms inherent to the spectrum analyser limit this dynamic range; the broadband noise floor of the analyser, phase noise and intermodulation distortion (or third order intercept (TOI)), illustrated in the figure below. In practice, the noise floor of the analyser is almost always the limiting factor.

Figure 14: Relationship between phase noise, TOI and noise floor



A7.11 Usually, the maximum power level that can be applied to the input of the analyser without causing any damage to the circuitry is limited to 1 Watt (+30 dBm). The noise floor then determines the lower limit of the measurement range; signals below the noise floor are not visible on the spectrum analyser's display.

Results

A7.12 The figures below show the spectral emissions captured from the ATV equipment described above. Figure 15 to Figure 19 show the emissions from a selection of user equipment identified in Table 29.

A7.13 Figure 20 and Figure 21 show the Luton repeater operating in analogue and digital mode, respectively.

ATV User Equipment

Figure 15: User equipment emissions, analogue operation

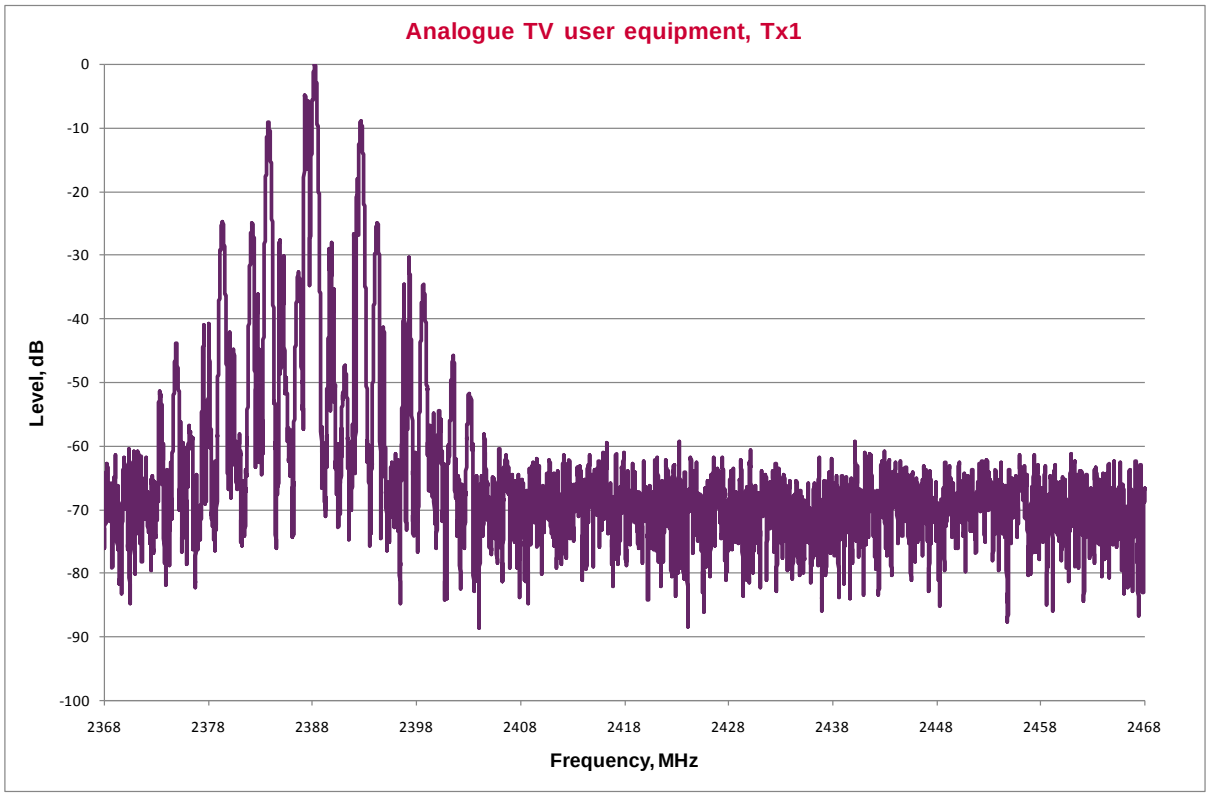


Figure 16: User equipment emissions, digital operation

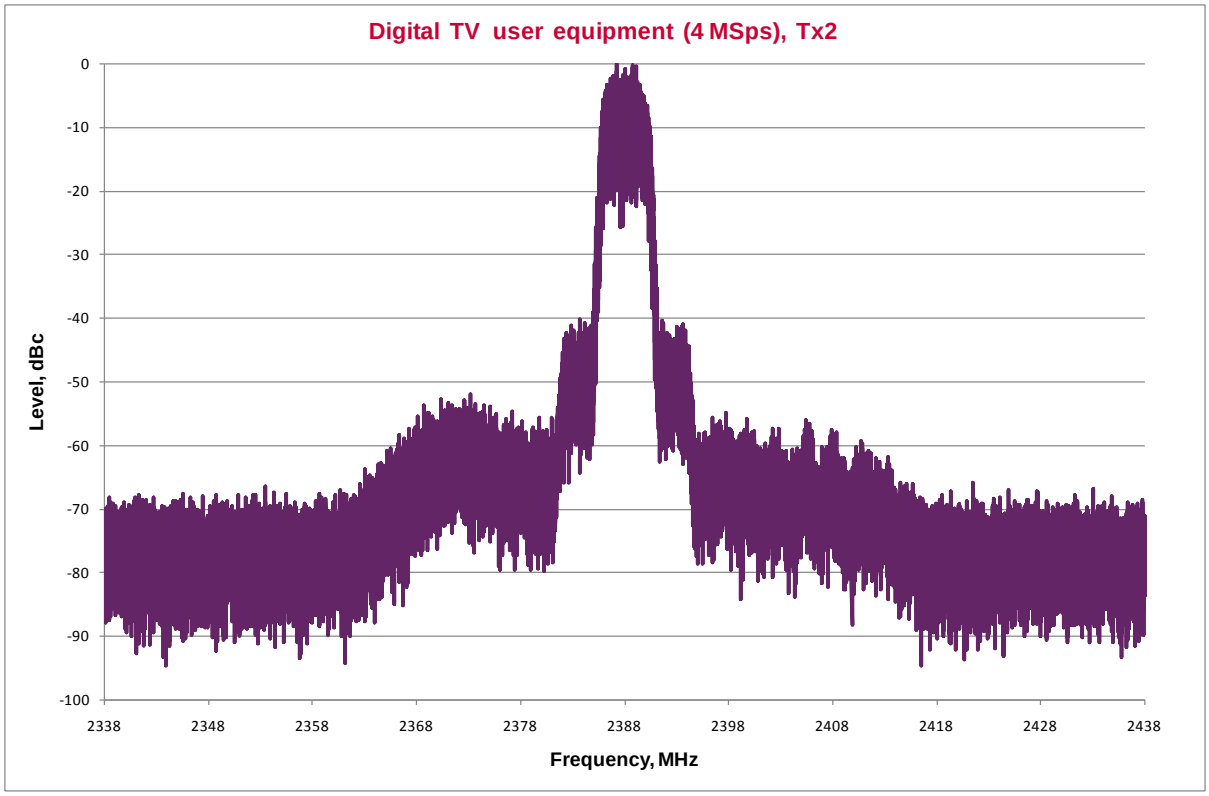


Figure 17: User equipment emissions, digital operation

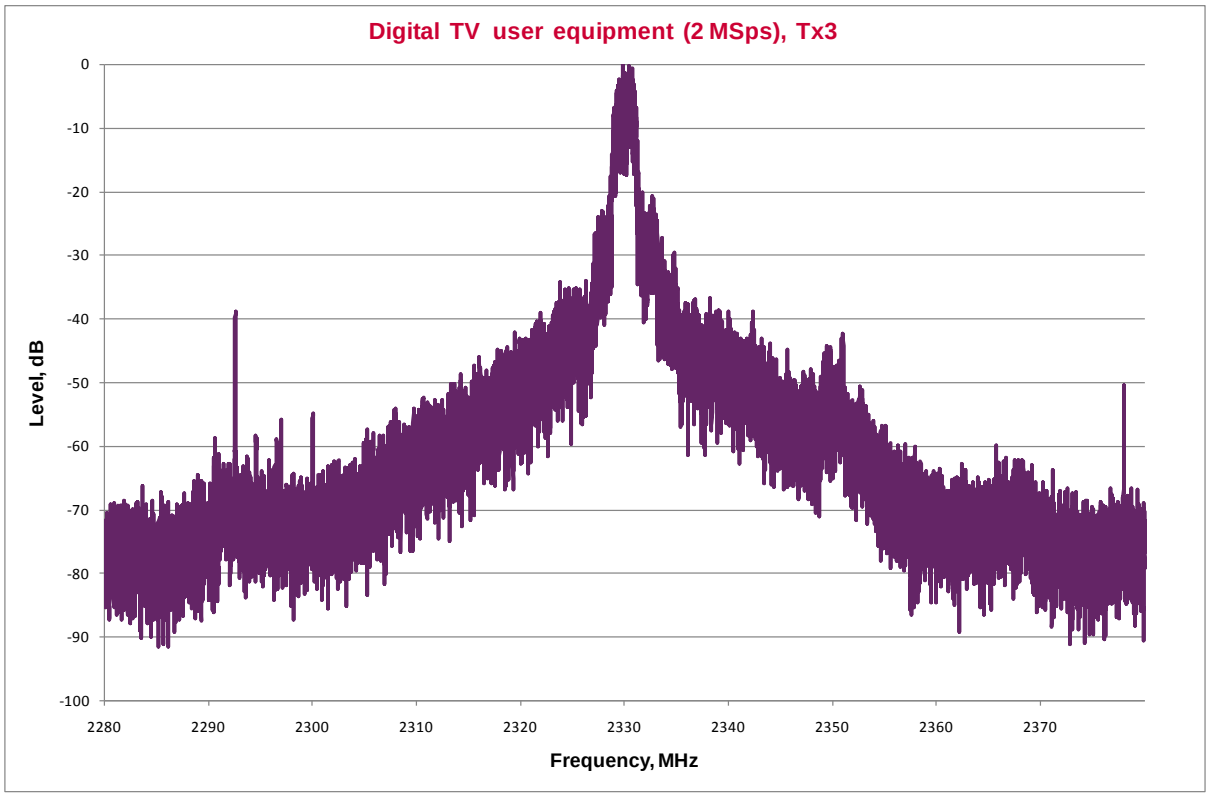


Figure 18: User equipment emissions, digital operation

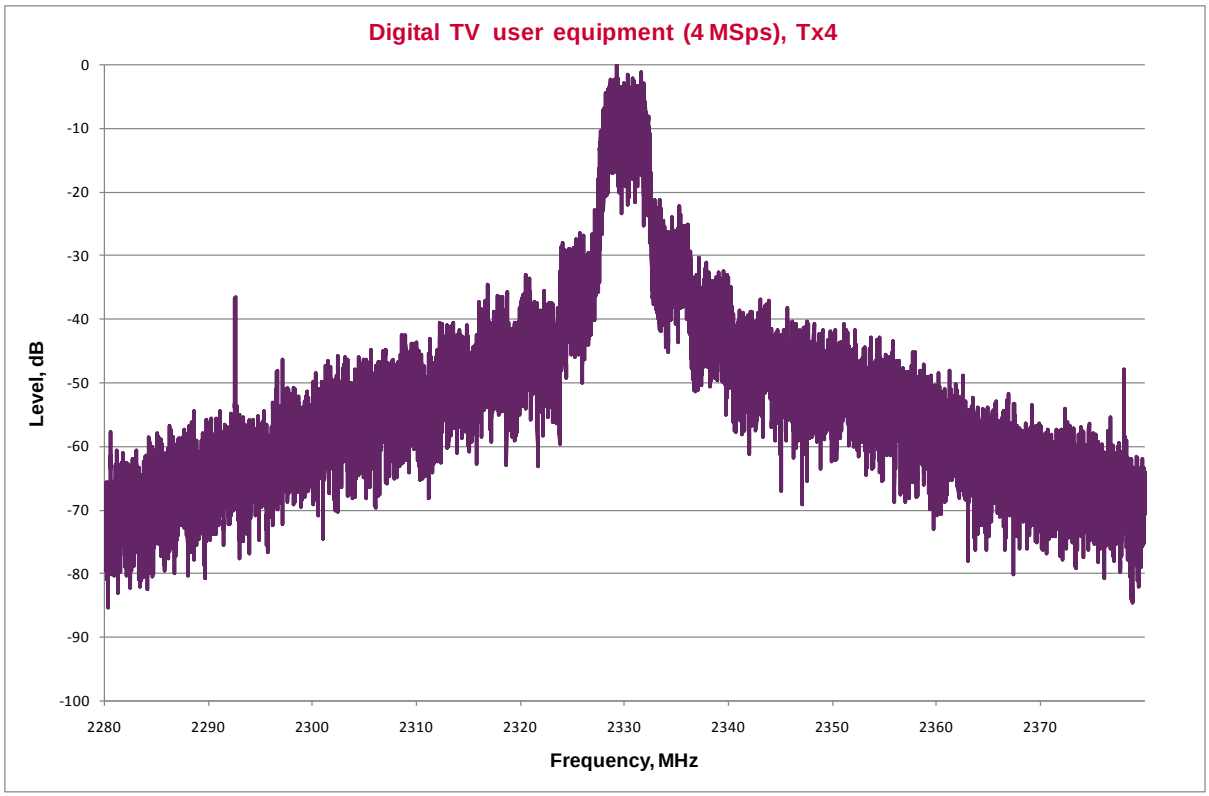
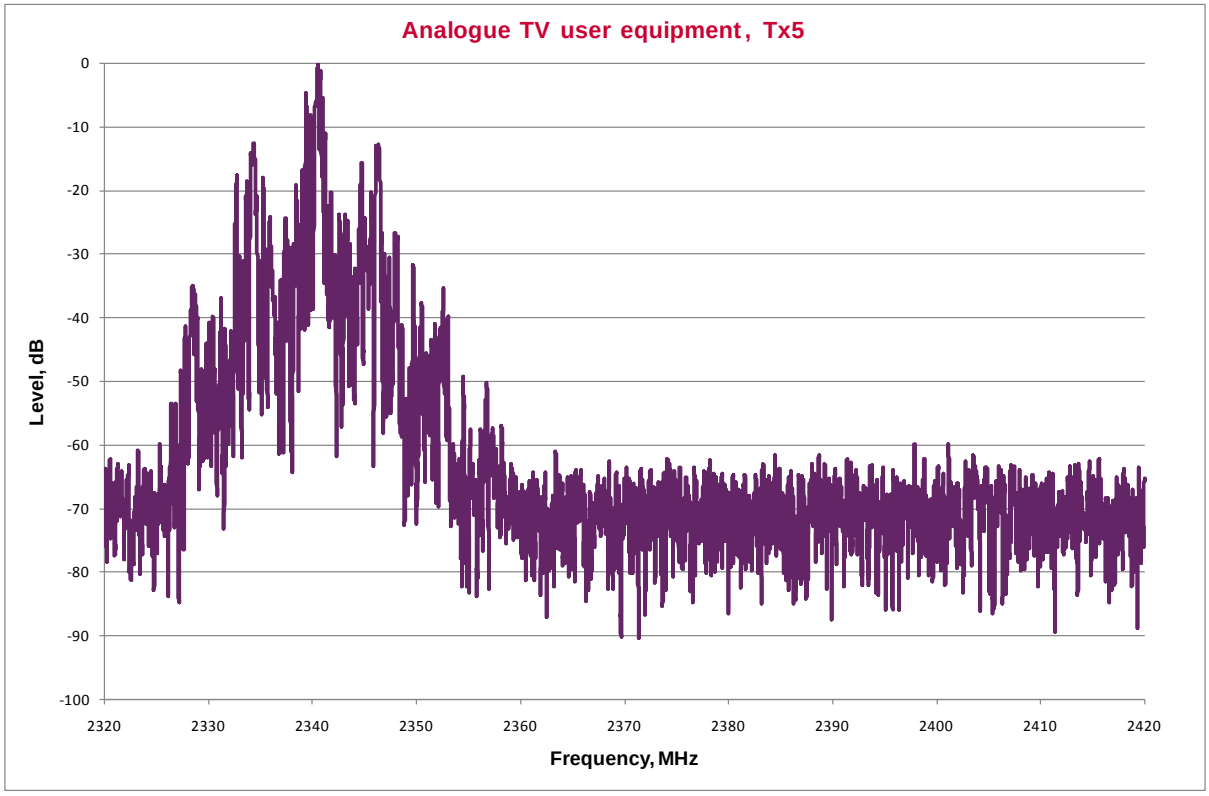


Figure 19: User equipment emissions, analogue operation (expanded frequency range)



ATV Repeater

Figure 20: Repeater emissions, analogue operation

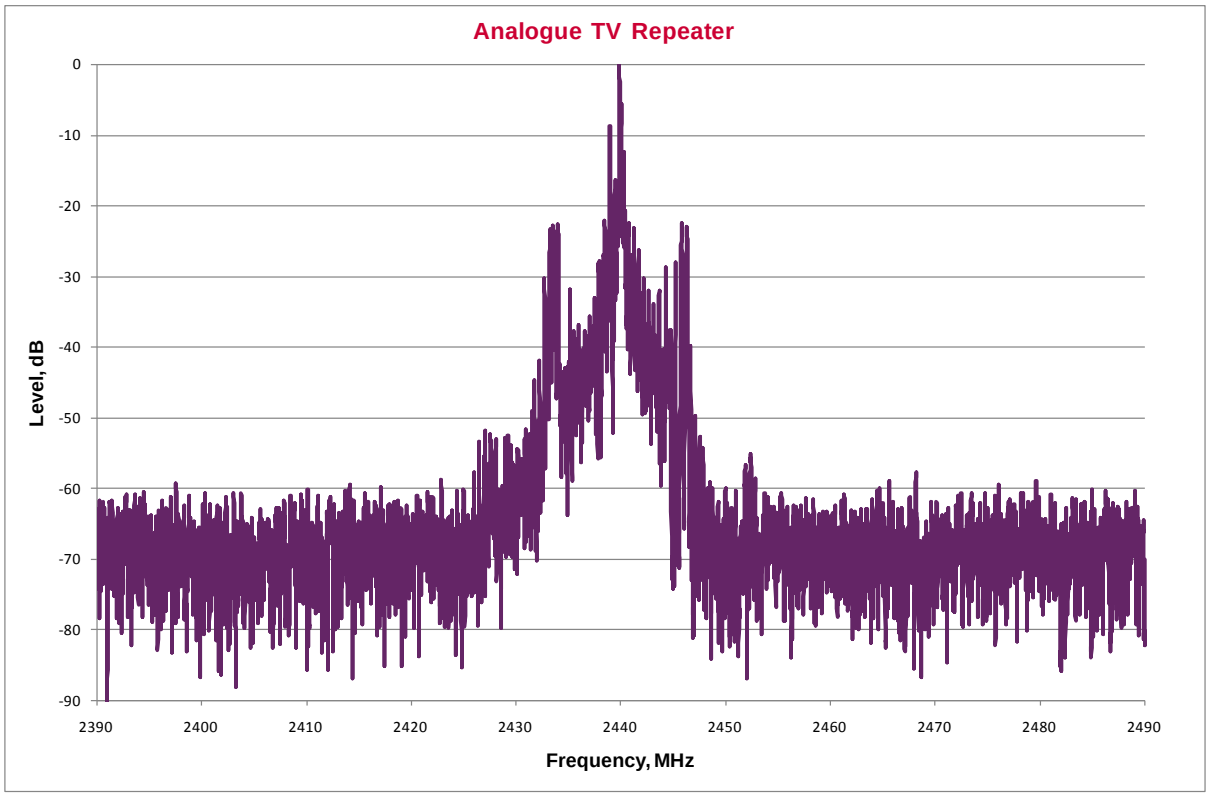
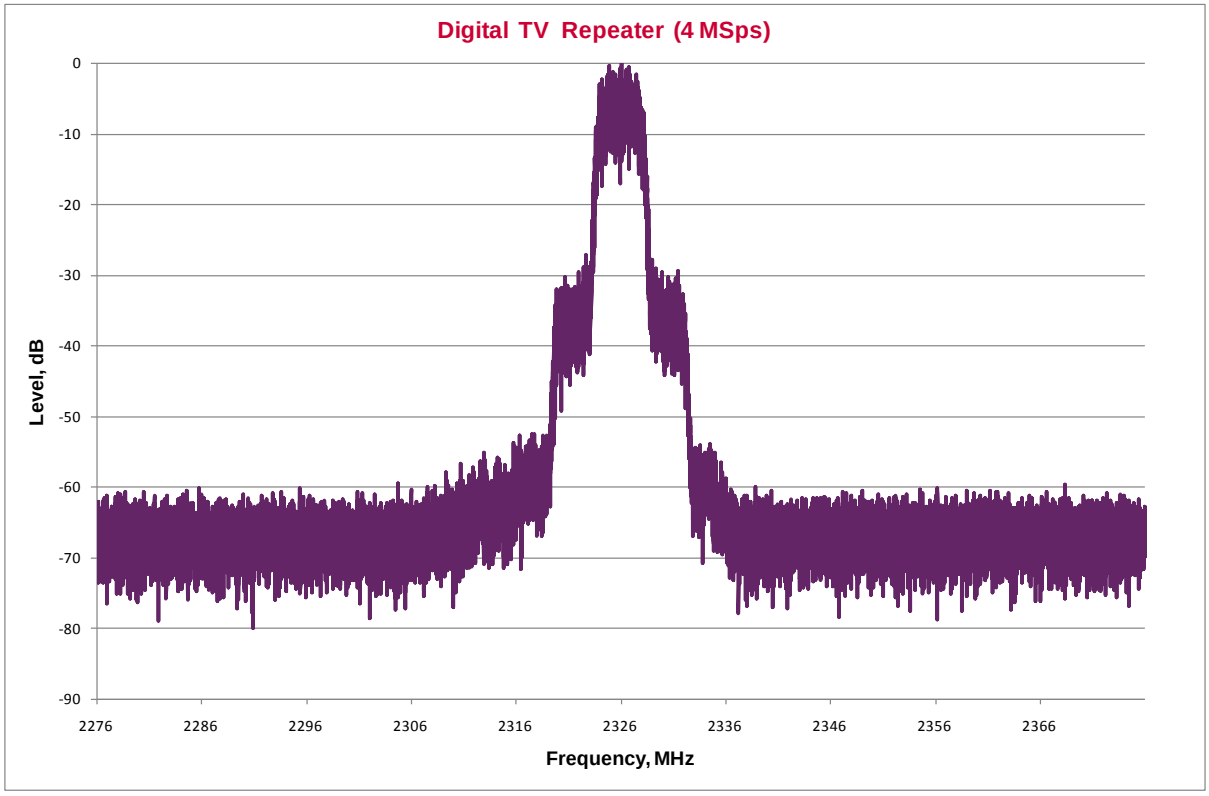


Figure 21: Repeater emissions, digital operation



Observations

A7.14 The figures above show the in-band and out-of-band emissions recorded for a selection of ATV user equipment, and from the Luton ATV repeater (GB3TZ).

A7.15 As discussed, the OOB emissions are limited by the noise floor of the spectrum analyser for frequency offsets of approximately ±30 MHz from the wanted centre frequency. At these offsets, the dynamic range is approximately 65 dB, meaning that any signals that are 65 dB or more below the peak signal level of the carrier cannot be displayed by the spectrum analyser.

A7.16 This is true of all the results except for Tx3 and Tx4 (Figure 17 and Figure 18), where the noise floor is the limiting factor at frequency offsets of ±50 MHz from the carrier. These spectral emissions were recorded from the same ATV user equipment but operating in different transmit modes (2 Msps and 4 Msps, respectively). The results show that this particular unit was operating without a filter on the output stage at the time of the measurements. We understand that these results, therefore, may not be particularly representative as in the majority of cases a filter would be used to reduce the impact of any spurious and out-of-band emissions.

Calculating out-of-band emissions for compatibility calculations

A7.17 The analysis of the effect of out-of-band emissions from amateur TV systems to LTE systems (Annex 6) was calculated by using the measurements for the out of band emission calculations detailed in this Annex.

A7.18 For each transmitter emissions from the power amplifier were then attenuated before being split between a National Instruments (NI) spectrum recorder and to a standard spectrum analyser, see Figure 12. For our calculations in Annex 6, we need to know the e.i.r.p out-of-band emissions that may appear into LTE systems to calculate the potential risk of interference from the amateur system.

A7.19 We have taken the typical e.i.r.p in Table 5: for both user equipment and repeater equipment.

A7.20 The power within the specified bandwidth of the emission envelope was calculated and the emission envelope was uniformly offset by the difference between the calculated power and the expected e.i.r.p value. Therefore this method is sensitive to the assumed bandwidth of the signal. For the analogue TV systems it is assumed that the e.i.r.p is applied across all of the specified bandwidth of 16 MHz and the digital TV systems the e.i.r.p is applied across the 4 MHz specified bandwidth.

A7.21 The calculated out-of-band e.i.r.p levels within 10 MHz at different frequency offsets from the channel centre were calculated by the normalised linear power sum of the relevant portion of the emission envelope.

A7.22 As highlighted in paragraphs A7.15 and A7.16, the dynamic range of the spectrum analyser is around 65 dB, therefore for the analogue user equipment where there is a large range of power within the channel, the out-of-band emissions may be over-estimated as the noise floor of the spectrum analyser becomes dominant.

A7.23 The Tables below give the calculated out-of-band emissions for each piece of equipment used in the calculations in Annex 6 for amateur TV equipment.

ATV User Equipment

Table 31: The out-of-band emissions from the analogue user equipment calculated assuming an e.i.r.p of 54 dBm

Tx1 Analogue User Equipment	
Distance from channel centre	**Estimated transmit power with an assumed e.i.r.p of 54 dBm**
Resultant power in 4 - 14 MHz	43.3 dBm
Resultant power in 6 - 16 MHz	27.7 dBm
Resultant power in 8 - 18 MHz	21.1 dBm
Resultant power in 10 - 20 MHz	17.9 dBm
Resultant power in 20 - 30 MHz	0.3 dBm
Resultant power in 30 - 40 MHz	-0.8 dBm
Resultant power in 40 - 50 MHz	-1.6 dBm
Resultant power in 50 - 60 MHz	-0.5 dBm
Resultant power in 60 - 70 MHz	-0.3 dBm
Resultant power in 70 - 80 MHz	-1.0 dBm

Table 32: The out-of-band emissions from the digital user equipment calculated assuming an e.i.r.p of 54 dBm

Tx2 Digital User Equipment	
Distance from channel centre	**Estimated transmit power with an assumed e.i.r.p of 54 dBm**
Resultant power in 4 - 14 MHz	12.2 dBm
Resultant power in 6 - 16 MHz	4.5 dBm
Resultant power in 8 - 18 MHz	1.9 dBm
Resultant power in 10 - 20 MHz	1.1 dBm
Resultant power in 20 - 30 MHz	-3.0 dBm
Resultant power in 30 - 40 MHz	-9.1 dBm
Resultant power in 40 - 50 MHz	-9.6 dBm

Analogue Repeater

Table 33: The out-of-band emissions from the analogue repeater equipment calculated assuming an e.i.r.p of 46.15 dBm

Analogue Repeater Equipment	
Distance from channel centre	**Estimated transmit power with an assumed e.i.r.p of 46.15 dBm**
Resultant power in 4 - 14 MHz	27.8 dBm
Resultant power in 6 - 16 MHz	23.8 dBm
Resultant power in 8 - 18 MHz	0.3 dBm
Resultant power in 10 - 20 MHz	0.2 dBm
Resultant power in 20 - 30 MHz	-1.0 dBm
Resultant power in 30 - 40 MHz	-0.5 dBm

Digital Repeater

Table 34: The out-of-band emissions from the digital repeater equipment calculated assuming an e.i.r.p of 46.15 dBm

Digital Repeater Equipment	
Distance from channel centre	**Estimated transmit power with an assumed e.i.r.p of 46.15 dBm**
Resultant power in 4 - 14 MHz	13.9 dBm
Resultant power in 6 - 16 MHz	2.6 dBm
Resultant power in 8 - 18 MHz	-7.9 dBm
Resultant power in 10 - 20 MHz	-9.8 dBm
Resultant power in 20 - 30 MHz	-10.0 dBm
Resultant power in 30 - 40 MHz	-10.0 dBm