VHF radio spectrum for the Internet of Things

Statement

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About this document

Spectrum for the Internet of Things

This document confirms that spectrum within the 55-68 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz bands can be used for Internet of Things (IoT) services and Machine-to-Machine (M2M) applications.

We have confirmed spectrum in the VHF range is suitable for some IoT services and M2M applications and our current licensing arrangements can and do provide access for this purpose.

We recognise that this might not be clear to stakeholders so we will launch a new product that makes specific provision for IoT/M2M, but continues to support current applications.

We will also make a web resource available that will provide information and help for those seeking to use spectrum for IoT.

In the meantime anyone can apply for our existing Business Radio Licence products.

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Section 1

Executive summary

1.1 Our aim is to encourage investment and innovation in the Internet of Things (IoT) by providing access to spectrum, so that products and services can be connected together wirelessly.

1.2 In September 2015[1] we published a consultation on use of the 55-68 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz for IoT services and M2M applications. In particular, we wanted to gain information on the suitability of these VHF bands for delivering IoT services in remote and rural areas, and to assess whether wider exploitation of these frequencies could be accommodated without affecting existing spectrum users.

1.3 At the same time, we sought to address a misconception that our existing Business Radio (BR) licence products were designed for voice-only communications and so were unsuitable for M2M/IoT applications. We asked for views on whether a new form of licensing specifically for M2M and IoT services would be more appropriate.

Our conclusions

1.4 After taking account of the views of stakeholders, we have concluded that spectrum in the VHF ranges identified in our consultation is suitable for M2M/IoT applications, and that those uses can be accommodated without adverse impacts on other users.

1.5 There was no evidence to suggest our existing BR licence products were unsuitable for M2M/IoT purposes. However, we recognise that this may not be clear to stakeholders.

1.6 To address this issue we will be launching a new licence product later this year that will to replace our existing BR products and make specific provision for M2M/IoT applications. In concert with this measure we will also launch a dedicated information and application web page for those seeking spectrum access for the IoT. We believe these measures will clarify the wide range of spectrum which is currently available to facilitate IoT.

1.7 The new product will replace our current BR products and support M2M/IoT and all current BR applications. Stakeholders with existing licences may continue to operate as they currently do, and the range of applications currently authorised under the current arrangements will continue to be so.

1.8 The technical parameters specified in the licences and our planning criteria for BR assignments adequately protect spectrum users and support sharing between other applications and IoT. We have therefore decided to retain these arrangements. However, we will consider specific changes to particular licences on a case-by-case basis as necessary.

[1] See http://stakeholders.ofcom.org.uk/consultations/radio-spectrum-internet-of-things/

Section 2

Introduction

2.1 We want to encourage UK investment and innovation in the Internet of Things (IoT) by providing access to spectrum, so that products and services can be connected together wirelessly. The machine to machine (M2M) connections which support the IoT are currently authorised by Ofcom through Business Radio (BR) spectrum licences.

2.2 In September 2015 we consulted on the suitability of using VHF frequencies (namely 55-68 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz) for IoT services and M2M applications[1]. We were particularly keen to gain information on the suitability of these bands for delivering IoT services in remote and rural areas. We also sought views on our assessment that wider exploitation of these bands for IoT can be accommodated without affecting existing spectrum users.

2.3 Additionally, we wanted to establish whether our existing BR licence products were suitable for IoT services and M2M applications.

Legal and regulatory framework

2.4 Ofcom's decisions on spectrum management are taken within a legal and regulatory framework.

2.5 Among the key elements of that framework is the Communications Act 2003, which sets out Ofcom's principal duties to further the interests of citizens and consumers, where appropriate by promoting competition. In doing so, we are required (among other things) to secure the optimal use of spectrum, as well as to have regard to the desirability of securing the availability and use of high speed data transfer services through the United Kingdom; the desirability of encouraging investment and innovation; and the interests of consumers in respect of choice, price, quality of services and value for money.

2.6 Associated duties are set out in the Wireless Telegraphy Act 2006.

Context for our consultation

2.7 VHF spectrum is not harmonised in Europe for M2M applications. However, we think access to VHF frequencies could help to stimulate the right environment for innovation. We wished to find out whether stakeholders agreed with this assessment.

2.8 Spectrum in the 55-68 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz bands can already be used for IoT services and M2M applications, and our existing BR licence products can be used to support these services and applications. We consider our BR licence products to be flexible, simple to apply for, relatively in-expensive and suited to a wide range of uses including narrow band, low data rate IoT services and M2M applications (but not broadband, high data rate services).

2.9 However, we believe there is a popular misconception that our BR licence products are for voice-only applications, and are not appropriate for the IoT. We were

[1] http://stakeholders.ofcom.org.uk/binaries/consultations/radio-spectrum-internet-of-things/summary/more_radio_spectrum_internet_of_things.pdf

concerned that this could be hindering investment and development in the IoT and in the VHF bands more generally. We therefore asked stakeholders whether a revised form of licence was necessary in order to encourage investment.

Document structure

2.10 The remainder of this document is structured as follows:

- Section 3 summarises the views of stakeholders to the questions raised in our September 2015 consultation and Ofcom's responses to these views.
- Section 4 sets out our decisions and gives information on how to obtain BR licences for services, including for IoT and M2M applications.

Section 3

Consideration of consultation responses

3.1 In this section of the document we summarise the responses to our September 2015 consultation and set out our assessment of the points raised by stakeholders.

Consultation questions

3.2 The consultation sought views on two distinct issues: 1) the value and suitability of VHF spectrum for IoT and M2M services; and 2) the most appropriate method of licensing M2M applications in the VHF frequencies for use by IoT services.

3.3 We asked two questions about the use of VHF spectrum for IoT and M2M services:

> **Question 1:** Do you agree that the spectrum we have identified… **[see question 2 below]**…is suitable for M2M applications for remote and rural locations? Please provide as much information as possible on likely applications.
>
> **Question 2:** Do you agree with our analysis that encouraging new IoT uses in the bands 55.75625-60 MHz, 62.75625-64.8 MHz and 64.8875-66.2 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz should still leave sufficient spectrum to meet demands for Business Radio in the VHF range?

3.4 We also asked two questions about how we should licence M2M applications for use by IoT services in the VHF frequencies:

> **Question 3:** Do you think the conditions associated with the current range of Business Radio (BR) licences available now should change to facilitate new IoT services uses? If you do, what should these changes be?
>
> **Question 4:** Do you think we should create a new licence product specifically for IoT services?

Stakeholder responses

3.5 A total of 18 stakeholders submitted responses to the consultation. Six of those responses were marked as confidential. The individuals and organisations which submitted non-confidential responses are listed below:

- Dynamic Spectrum Alliance
- Federation of Communications Services
- Heritage Broadcasting Ltd
- Joint Radio Company
- Maxwave

- Ministry of Defence
- Ordnance Survey
- Paul Grant
- Radio Society of Great Britain
- Sound Decisions Ltd
- TechUK
- Telecommunication Association of the Water Industry

3.6 The responses from these stakeholders are published on Ofcom's website at: http://stakeholders.ofcom.org.uk/consultations/radio-spectrum-internet-of-things/?

3.7 In addressing the responses, we first consider those responses submitted on questions concerning the use of VHF spectrum for M2M and IoT services (Questions 1 and 2). We then go on to consider the responses to our questions on the licensing of spectrum for IoT and M2M applications (Questions 3 and 4).

Responses on the use of VHF spectrum for M2M and IoT services

The value and suitability of VHF spectrum

3.8 We asked stakeholders:

> "*Do you agree that the spectrum we have identified… is suitable for M2M applications for remote and rural locations? Please provide as much information as possible on likely applications."*

3.9 Stakeholders had differing views on the suitability of VHF frequencies for M2M applications. Some, like Telecommunication Association of the UK Water Industry (TAUWI) said that reports on the performance of existing VHF links had been very positive. Most stakeholders, TAUWI included, were concerned about the limitations of the VHF bands in general. Those concerns included:

- Unsuitability of the VHF spectrum for broadband applications;
- Limitations on range, performance and costs posed by physically large antennas;
- The lack of standards and holistic security for IoT networks;
- Interference to other spectrum users from the wrong choice of technology: modulation scheme, transmission bandwidths etc.;
- The adverse effect of poor/variable propagation conditions and increasing background noise levels on quality of service;
- Limitations on the availability of equipment and the lack of harmonisation.

3.10 Other stakeholders, including the Joint Radio Company (JRC) Ltd and Sound Decisions Ltd were either using VHF spectrum for telemetry applications already, or

view the availability of the VHF bands for M2M as an opportunity to innovate. Ordnance Survey for example said that the VHF bands are ideally suited for longer range, low power and longer battery life connectivity, so rural deployments would be most logical.

3.11 Several stakeholders, including TAUWI and the Radio Society of Great Britain (RSGB), commented on the physical size of antennas needed for VHF communications and how inefficient antennas are when they are shortened.

3.12 Ordnance Survey (OS) welcomed the opportunity to deploy services in the VHF bands, but raised an issue not mentioned by others. It said there were concerns about standards and holistic security issues (spanning network to device to chip) that are unresolved at this time. OS also provided views on the future value of the VHF spectrum when superfast broadband is rolled out widely using fibre and 5G[2].

3.13 OS also questioned whether standards (e.g. IPv4/IPv6[3], TCP[4], HTTP[5], TLS[6]) are adequate, because equipment built to these standards will not work with sleeping nodes, smaller packet sizes, and lower bandwidths. It said it did not know whether today's standards address security concerns, but suggested that the standard 6LoWPAN[7] should be used to resolve issues because of the need to preserve universal addressing, but with a more efficient protocol. OS also said that UDP[8] will almost certainly have to be used too, because, although simpler, it overcomes the 'sleeping node' problem[9] and that HTTP will probably be replaced by CoAP[10] (which will work with UDP), and TLS likewise with DTLS[11].

3.14 The OS response went on to say that Government policy favours ever greater broadband deployment everywhere to provide superfast connection for all, using fibre deployment to overcome capacity problems. Over time, OS thought 'deep fibre' seems to be the way the UK will move. It concluded that this, in parallel with the impact that 5G, combined with predictive mapping (if developed) could have, will make it easier to use higher reaches of the radio spectrum, as the radio tails (back to trunk fibre infrastructure) will progressively shorten. OS said this trend could well impact on the economic viability of some services that might be being planned using VHF spectrum, implying that, over time, the VHF bands will become less valuable for M2M applications.

3.15 British Heritage Television did not agree that Band I spectrum - or indeed any spectrum lower than 55.75 MHz that may become available - is suitable for M2M applications for remote and rural locations (nor indeed that it was ideal for urban locations either) because of interference issues. It compared the performance of VHF unfavourably with that of UHF frequencies. However, BHTV said its own proposals

[2] 5th generation mobile networks or 5th generation wireless systems.
[3] Internet Protocol Versions 4 and 6. See for example http://electronicdesign.com/embedded/whats-difference-between-ipv4-and-ipv6
[4] Transmission Control Protocol. See for example http://www.networksorcery.com/enp/protocol/tcp.htm
[5] Hypertext Transfer Protocol. See for example http://www.webopedia.com/TERM/H/HTTP.html
[6] Transport Layer Security. See for example https://en.wikipedia.org/wiki/Transport_Layer_Security
[7] 6LoWPAN - IPv6 over Low power Wireless Personal Area Networks. See for example https://standards.ieee.org/about/get/802/802.15.html
[8] User Datagram Protocol. See for example https://en.wikibooks.org/wiki/Communication_Networks/TCP_and_UDP_Protocols
[9] 'Sleeping node' problem. Connecting low power wireless sensor network devices to the IoT when sensor nodes are in a sleep state. See for example http://eprints.soton.ac.uk/367120/1/pew09-Ward.pdf
[10] Constrained Application Protocol. See for example http://coap.technology/
[11] Datagram Transport Layer Security. See for example https://crypto.stanford.edu/~nagendra/papers/dtls.pdf

seeking to use a relatively modest portion of the VHF band might perhaps allow innovative modern solutions, making Band I as a whole more usable.

3.16 Other views from stakeholders on the value of the VHF bands for M2M – including some provided by individuals in confidential responses – were:

- Higher spectrum frequencies and licence exempt bands are more suited to M2M applications, where it is possible that equipment could be designed and manufactured in sufficient quantities to give the necessary economies of scale worldwide;
- Dedicated data-only channels should be made available;
- Ofcom should allocate this spectrum to specific TV and Amateur uses;
- Ofcom's definition for 'smart farming' is un-clear and this lack of clarity affects an assessment of the value of the VHF bands.

Ofcom assessment of responses on the value and suitability of spectrum

General suitability of VHF spectrum

3.17 We do not agree with those stakeholders who say that the VHF bands are unsuitable for M2M applications. We note that our licence records show several companies already using the VHF bands for M2M-like applications. For example, telemetering at VHF is used for monitoring and changing energy requirements in power networks and for rail transport operations.

3.18 However, while we do allow aggregation of channels to wider bandwidth under the current framework, we agree with stakeholders who think that these VHF bands are not suited to *broadband* applications because of the limited bandwidth available. The current 12.5 kHz channel's data capacity at these frequencies will be limited. Typically this might be 4.8 $kbps^{-1}$.

3.19 Overall, we think the VHF bands will be useful for M2M applications, but we also agree that the wider availability of superfast broadband, 5G and other wired and wireless technologies will change how valuable the VHF bands are for some M2M applications. We agree with the comment from OS that technological developments will make it easier to use higher reaches of the radio spectrum in future. Over time, therefore, the VHF bands could become less valuable for some M2M applications.

3.20 We think that being able to use the VHF spectrum either in isolation - or used to play a complementary/supporting role to harmonised spectrum bands - could encourage investment and innovation in new services and applications including those for the IoT, especially for those in remote and rural locations.

3.21 We now go on to address specific points made by stakeholders.

Propagation characteristics

3.22 We agree that the propagation characteristics of the VHF bands can make reliable communications difficult at times and that this can have an adverse effect on the quality of service that consumers can expect from services at VHF.

3.23 As set out at paragraph 4.14 of our consultation, we acknowledge that the ionosphere can influence the propagation of radio signals particularly at frequencies below about 90 MHz. However, the VHF bands remain usable for some communications even though they are subject to variable and anomalous propagation effects. We do not think that the VHF bands below 90 MHz are unsuitable for all M2M applications.

3.24 We agree that Band I spectrum may at times not be ideal for medium and long-range M2M applications. However, we note that communications in the VHF range below 90 MHz is still possible over distances greater than the coverage offered by a cellular mobile (LTE) base station at 900 MHz.

3.25 We think that variable propagation characteristics can be taken into account in the design of a system along with other design parameters (such as transmit power, antenna performance and desired range). If the combination of these yields a satisfactory availability for the desired use, then the band will be satisfactory for that use.

3.26 We agree with the JRC that the propagation characteristics of the VHF bands means that it has not traditionally been expected that this spectrum is suitable for resilient M2M (RM2M) systems. We note however that some uses (e.g. infrequent transmission of non-critical data) may not require very high availability. We welcome further information from the JRC on the outcome of trials within the utility industry of new digital equipment at VHF.

3.27 Ofcom is aware that there has been very little development of the propagation studies for the 50-100 MHz frequency range over recent years and welcomes the new insight provided by BHTV and others. We note that the Radiocommunication sector of the International Telecommunication Union (ITU-R) has a study question[12] that addresses all aspects of radio propagation and modelling for bands above 30 MHz, and that studies to answer that question are intended to be completed during the current study period, which ends in 2019.

3.28 Although we have no recent measurements or radio noise in the 50-100 MHz range we agree that noise levels can be high and that information from stakeholders indicates noise levels in this range are increasing.

3.29 From time to time we change our criteria for BR planning when we have evidence that the propagation characteristics or noise levels have changed enough to affect how we assign radio channels to licensees. We therefore openly welcome contributions from stakeholders that help us to further strengthen our understanding of propagation and noise levels in the 50-100 MHz range.

Antenna size

3.30 We agree with those stakeholders who identify that antenna size may prove a barrier to some IoT applications. At paragraph 4.22 of our consultation we note that the VHF spectrum could also be used for the sensors and not just for the link between LANs, but relatively large antenna sizes at VHF may not be practical for some sensor-to-sensor links.

[12] ITU-R Study Question 203-6

Standards and holistic security for IoT networks

3.31 We agree with the view of OS that standards and holistic security measures (spanning network to device to chip) do exist today, but require development to suit the IoT. Ofcom has a duty to ensure that appropriate measures are taken to prevent and minimise the impact of incidents that affect the security and resilience of networks and services[13].

3.32 As the IoT develops and encompasses an increasing number of services on which citizens and consumers come to rely, it will become increasingly important to ensure that the networks delivering these services are robust and the data delivered over them is secure. This creates particular challenges as the traditional security approaches used in telecommunications may not be applicable in the high volume, low cost devices likely to be used by many IoT services. We acknowledge that industry is aware of these challenges and work is ongoing to deliver secure and robust IoT networks and services.

3.33 Providers of networks and services are obliged under existing legislation to take appropriate measures to manage risks to security and resilience. The existing legislation does not explicitly refer to the IoT. However, to the extent that they fall under the definitions in the legislation, we believe IoT networks and services would be covered by these existing obligations.

3.34 The IoT also raises a wider set of policy issues, where Ofcom does not have a direct regulatory remit, but where we might play a potentially facilitating role, in particular in relation to the secure collection, sharing and analysis of personal or commercially sensitive data.

3.35 Hence, addressing the full range of policy issues raised by the IoT is likely to require a collaborative approach, with regulators, Government, industry and other stakeholders working together to deliver outcomes that secure the full range of benefits.

3.36 In our statement "*Promoting investment and innovation in the Internet of Things*" http://stakeholders.ofcom.org.uk/binaries/consultations/iot/statement/IoTStatement.pdf we said we will undertake work to consider the impact of the IoT on our existing security and resilience guidance, and whether this needs updating as a result. We believe that our existing overall approach of encouraging providers to consider security and resilience in line with established standards and best practice will remain the correct one in the IoT domain.

3.37 However, we may need to reference additional IoT-specific standards, or note the need for new ones where none currently exist. As specific gaps in existing approaches are identified, we will coordinate with other stakeholders to develop standards and best practice relevant to the IoT. Existing national and international groups, which draw on industry and government experts, are expected to be the focus for any required technical work.

[13] Ofcom's general duties and those for the purpose of fulfilling Community obligations are set out in sections 3 and 4 respectively, of the Communications Act (2003). See http://www.legislation.gov.uk/ukpga/2003/21/section/3

Definition of smart farming

3.38 At paragraph 4.6 of our consultation we provided a link to our publication on M2M communications: http://consumers.ofcom.org.uk/news/machine-to-machine-communications/#farms. Here, we say that 'smart farming' includes fertilizer, fodder and water distributed across the farm in the right quantities, in the right places, and at the right time. These are only intended to be examples of services that can be considered under the heading 'smart farming' and our intention was to highlight just a few of the many services that could benefit from M2M wireless connectivity. We did not intend this to be considered as a full definition for 'smart farming'.

3.39 One example of a definition for 'smart farming' is given by the Alliance for Internet of Things Innovation (AIOTI), which says smart farming is the application of data gathering, data processing, data analysis and automation technologies on the overall value chain that, jointly orchestrated, allow operation and management improvement (analytics) of a farm with respect to standard operations (near real time) and re-use of these data (animal-plant-soil) in improved chain transparency (food safety) and chain optimization (smart data). AIOTI says that such capabilities will be necessarily supported by IoT technologies. See: http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=11818

Sufficiency of spectrum available

3.40 We asked stakeholders:

> "*Do you agree with our analysis that encouraging new IoT uses in the bands 55.75625-60 MHz, 62.75625-64.8 MHz and 64.8875-66.2 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz should still leave sufficient spectrum to meet demands for Business Radio in the VHF range?"*

3.41 There was almost universal agreement with our analysis among those respondents who addressed this question, although some concern was expressed by radio amateurs about interference to neighbouring bands. No respondent suggested there was insufficient spectrum to meet the demands for business radio for the moment, although the possibility of future pressure on the band was noted.

3.42 The RSGB asked whether Ofcom could investigate whether the current spot frequencies retained by the Scottish Government for the Emergency Services could be reassigned to band edges (or elsewhere) to facilitate easier frequency release and re-use.

3.43 Other views from stakeholders on the availability of spectrum in the VHF bands, some provided in confidential responses, included the view that Ofcom should allocate this spectrum to specific TV and Amateur uses.

Ofcom assessment of responses on the sufficiency of spectrum

3.44 We do not currently consider spectrum availability to be a barrier to the development of the IoT in the short to medium term. The low data rates typical of the majority of emerging IoT applications mean that they can be supported within existing allocations and bands like those at VHF.

3.45 In paragraphs 2.7 and 2.8 of our consultation we said that we had already made other spectrum bands available for the IoT. For example, in 2014, we released the 870-876 MHz and 915-921 MHz bands for licence exempt devices including M2M.

We also set out the steps we are taking to ensure the UK plays a leading role in developing the IoT. This includes monitoring the demand for spectrum and identifying when (and what) additional spectrum is needed.

3.46 In our consultation (Figure 4.1) we identified both dedicated and shared spectrum for the IoT. All of the dedicated and shared bands listed are harmonised in Europe either for license exempt short range devices[14] or for cellular and broadband services. The VHF bands are currently designated[15] for pan-European Land Mobile services[16].

3.47 Ofcom is among the European spectrum regulators, organised through the European Conference of Postal and Telecommunications Administrations (CEPT)[17], studying the possibility of using a range of bands where IoT applications can be used. In addition, studies will commence this year in the ITU-R in preparation for World Radiocommunication Conference in 2019 (WRC-19)[18] to consider aspects around the implementation of narrowband and broadband machine-type communication (i.e. IoT).

Channels in Scotland

3.48 In response to the RSGB's point about the availability of channels in Scotland, in 2015 we asked the Scottish Government and the Public Safety Spectrum Policy Group (PSSPG)[19], which is responsible for ensuring that future access to Public Safety spectrum is consistent with the policy framework for spectrum management as determined by Government and Ofcom, whether this requirement might change. Access to 6 spot channels (70.5625MHz, 70.575MHz, 70.85MHz and 80.35MHz, 81.0MHz, 81.05MHz) has been retained by the Scottish Government and these channels are therefore not available for other uses in Scotland.

Use for Amateur Radio

3.49 Amateur Radio use of the 70.5–71.5MHz band is not protected and must not cause interference to other, authorised, users of the spectrum.

3.50 Radio Amateurs are permitted temporary access to the band to innovate and research narrowband broadcasting and voice communications. This temporary, innovative use is permitted in England, Wales and Northern Ireland. In Scotland Radio Amateur use of the band is not permitted.

[14] See UK Interface Requirement IR 2030 for details of European Normative standards and relevant European Decisions http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/interface-requirements/IR_2030-june2014.pdf

[15] The term 'designated' has the specific meaning given in section 4 the European Common Allocation Table (ERC Report 25). See http://www.erodocdb.dk/docs/doc98/official/pdf/ERCRep025.pdf

[16] See CEPT Recommendation T/R 25-08 http://www.erodocdb.dk/Docs/doc98/official/Pdf/Tr2508.pdf

[17] See http://www.cept.org/cept

[18] See WRC-19 Agenda Item 9.1.8 at https://www.itu.int/md/dologin_md.asp?lang=en&id=R00-CA-CIR-0226!C1!MSW-E

[19] The PSSPG's Terms of reference can be found here: https://licensing.ofcom.org.uk/binaries/spectrum/business-radio/airwave-emergency-services/tor.pdf

TV broadcasting

3.51 Our consultation was focussed on IoT applications and did not consider whether our BR licensing arrangements are suited to TV broadcasting applications or whether Ofcom should consider licensing TV broadcasting applications.

3.52 However, we will consider proposals for change to BR licences on a case-by-case basis (see section 4). This may give Licensees greater freedom to decide how frequencies are used – although we will retain the safeguards needed to protect other spectrum users from interference.

3.53 Licensees proposing to liberalise the technical conditions of their BR licence(s) to allow for alternative uses of the VHF bands, like TV Broadcasting should note that Ofcom may consult on these proposals. We cannot determine in advance whether other spectrum users will oppose these proposals or support them. Ofcom will determine whether a liberalisation proposal is acceptable based on the evidence available, the views of other spectrum users and our legal duties.

Responses on the licensing of IoT and M2M services

3.54 We asked stakeholders two questions about the licensing of VHF spectrum:

> "*Do you think the conditions associated with the current range of Business Radio (BR) licences available now should change to facilitate new IoT services uses? If you do, what should these changes be?"*
>
> *"Do you think we should create a new licence product specifically for IoT services?"*

3.55 We received fewer responses to these questions than to our questions about use of the band. A number of respondents answered 'yes' or 'no' to the questions without offering further argument or evidence. Six respondents explicitly said they had 'no comment' on these matters.

3.56 Overall, a large majority of those stakeholders who responded to the questions agreed that changes to licence conditions were not needed at the moment. Of the seven respondents who submitted more than 'yes' or 'no' answers to the question, only two (one confidential) suggested changes to licences may be necessary.

3.57 The Joint Radio Company Ltd said no changes were necessary to the current licences, but said major system owners would seek area defined licences in future. TechUK said that dedicated data channels could assist some M2M applications and allow a greater degree of sharing between users to take place under more controlled conditions.

3.58 Other suggestions included support for specific changes to conditions, such as wider bandwidths, different duplexing arrangements and new or different modulation schemes. Some stakeholders said no long-range or high power VHF service should move to a licence-exempt regime, and that licences for the VHF bands should continue to be made available on a first-come, first-served basis.

3.59 Although it did not address the question directly, the Ministry of Defence (MOD) did not want to see the introduction of unlicensed devices into bands adjacent to military[20] spectrum.

3.60 Three respondents supported the idea of creating a new licence product for IoT services, but did not put forward any reasons or evidence in support of that view.

Ofcom assessment of responses on licensing matters

3.61 We believe the conditions attached to our BR licences cater for a range uses, and can support IoT services and M2M applications. However, we note the comments of some respondents in support of some specific technical changes to our licence conditions, and we have taken account of these in our decisions (see next section).

3.62 We note that no evidence was presented by respondents to support the introduction of a new class of licence. However, to address the address a misconception that our existing BR licence products are unsuitable for M2M/IoT applications, we will be launching a new licence product later this year to ensure that they cater for M2M/IoT applications and that this is clear to all stakeholders. The new product will support M2M/IoT and all current BR applications. Stakeholders with existing licences may continue to operate as they currently do. We will also launch a dedicated information and application web page.

[20] The MOD refers to military spectrum as 'UK2'. This means footnote UK2 of the UK Frequency Allocation Table. See http://stakeholders.ofcom.org.uk/spectrum/information/uk-fat/

Section 4

Our conclusions and decisions

4.1 In this section of the statement we set out our conclusions on the suitability of VHF spectrum for M2M and IoT uses, and our consequent decisions on licensing. We go on to provide information on how to obtain BR licences for those interested in providing services, including for IoT and M2M applications.

Conclusions on the suitability of VHF spectrum for IoT

4.2 In light of responses to our September 2015 consultation, and our subsequent assessment of those responses, we conclude that the VHF spectrum bands we identified are suitable for use by M2M applications for IoT.

4.3 The VHF spectrum is not harmonised in Europe for M2M applications and we do not think this spectrum can deliver broadband services to rural and remote locations. However, we think access to it will help to stimulate the right environment for innovation.

4.4 We do not consider spectrum availability to be a barrier to the development of the IoT in the short to medium term. When all the VHF bands available to BR licensees are considered, it is Ofcom's view that encouraging new IoT uses in the bands 55.75625-60 MHz, 62.75625-64.8 MHz and 64.8875-66.2 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz should still leave sufficient spectrum to meet demands for BR in the VHF range.

4.5 The VHF bands will continue to support a wide range of uses including narrow band, low data rate IoT services and M2M applications. Exclusive access for IoT services and M2M applications in Band I and Low Band is not required at this time.

4.6 We will continue to monitor the demand for VHF M2M, voice and data applications and contribute to the international debate that has begun on the demand for IoT spectrum to identify when (and what) additional spectrum may be needed to encourage investment and innovation in the IoT.

Our decisions on licensing

4.7 We have concluded that the technical conditions of our existing BR licence products are well suited to catering for a wide range uses, including some IoT services and M2M applications.

4.8 Our current licence products cater for a wide range of technologies and applications and the planning criteria are adequate to facilitate access with a wide range of users in a way that adequately protects spectrum users and supports efficient use of the available spectrum. However, we recognise that this may not be clear to stakeholders.

4.9 To address this issue we will be launching a new licence product later this year that will replace our existing BR products and make specific provision for M2M/IoT applications. In concert with this measure we will also launch a dedicated information and application web page for those seeking spectrum access for the IoT. We believe these measures will help make it clear to stakeholders which spectrum is currently available to facilitate IoT.

4.10 The new licence product will replace our current BR products and support M2M/IoT and all current BR applications. Stakeholders with existing licences may continue to operate as they currently do, and the range of applications currently authorised under the current arrangements will continue to be so.

BR Licence technical conditions unchanged

4.11 We have noted that the majority of stakeholders agree that change to our BR licence conditions is not needed at the moment. However, as noted above, since some responses support some specific technical changes to our BR licence conditions (such as wider bandwidths, different duplexing arrangements and new/different types of modulation) we will consider specific proposals for change from Licensees on a case-by-case basis.

4.12 We have implemented a liberalisation process[21] for spectrum that Licensees can use if they wish to propose their own changes to the conditions of their BR licence(s). This may give Licensees greater freedom to decide how frequencies are used and the possibility to offer new M2M services that might not be possible with the current technical conditions of our BR licences.

4.13 We need to take into account both the concerns of stakeholders worried about interference to their use of the spectrum, and also the interests of stakeholders who think they need greater freedom to decide how frequencies are used. We think that keeping the current technical conditions specified by our BR licence products unchanged, but allowing Licensees to use our established liberalisation process, is a proportionate response.

4.14 Because some stakeholders are concerned about potential interference to their uses of the spectrum if we change the technical conditions specified by our BR licences, we will retain necessary safeguards against interference, for example from harmful intermodulation products. We may consult on any proposals to liberalise licences for alternative uses.

4.15 Our Post Issue Support Process[22] is necessary for Band I, Band III, and UHF 1 systems and we will continue to require Area Defined Licensees to notify Ofcom if they are not able to independently predict and confirm the potential for harmful interference to other UK services or those of neighbouring administrations.

4.16 We agree that licensees using Low Band should independently predict and confirm their own coverage areas. Licensees will not be required to apply our Post Issue Support Process[23], but may request Ofcom's assistance if they cannot independently predict and confirm their own coverage area.

4.17 Ofcom will continue its active role investigating and resolving interference problems, including any that arise following licence variation. Further detail of Ofcom’s

[21] See http://stakeholders.ofcom.org.uk/binaries/consultations/brtrading/statement/brstatement.pdf

[22] See publication OfW64 Page 11, para 4.6 of our Business Radio Technical Frequency Assignment Criteria: http://licensing.ofcom.org.uk/binaries/spectrum/business-radio/technical-information/tfac/ofw164.pdf

[23] Information on the Post Issue Support Process can be found here http://licensing.ofcom.org.uk/binaries/spectrum/business-radio/technical-information/tfac/ofw164.pdf

enforcement policies can be found here http://stakeholders.ofcom.org.uk/enforcement/spectrum-enforcement/ .

The way we allocate licences is unchanged

4.18 We agree with stakeholders that no long-range or high power VHF service should move to a licence-exempt regime and that licences for the VHF bands should continue to be made available on a first-come, first-served basis.

4.19 We believe that our current first-come, first-served approach to allocating BR licences is proportionate to the risks associated with the demand for spectrum licences and the management of interference to all users. This is because there is no evidence of excess demand for this spectrum. Other more complicated methods of allocating these licences are not necessary because licences are already available on a first come, first served basis. This approach provides a sensible way of providing a range of users with access to the spectrum they require.

Licence fees are being reviewed

4.20 Licence fees are determined using the existing Administrative Incentive Pricing (AIP) method for these bands. We will review these fees from time-to-time.

4.21 In our March 2014 Statement*: Spectrum Pricing*[24]*: A framework for setting cost based fees*, we indicated our intention to review fees for Business Radio licences. That review is currently underway and a separate consultation will be published later this year. It is generally not appropriate to provide AIP concessions in order to promote innovation[25].

Licence duration unchanged

4.22 Licences in the BR category will continue to be issued in perpetuity and continue in force until revoked by Ofcom or surrendered by the Licensee.

Spectrum access and licensing

VHF Band One (55.75-68 MHz) spectrum is available

4.23 Figure 4.1 below summarises how the 55.75-68 MHz frequency range can be used. The sub-bands highlighted in blue are those we are confirming for a wide range of uses including IoT services and M2M applications.

[24] See http://www.ofcom.org.uk/content/about/annual-reports-plans/cost-based-fees/Spectrum_management_costs_and_fees_2014-15.pdf

[25] SRSP: The revised Framework for Spectrum Pricing - Our policy and practice of setting AIP spectrum fees. See AIP principle 7, section 4.262, page 64 http://stakeholders.ofcom.org.uk/binaries/consultations/srsp/statement/srsp-statement.pdf

Figure 4.1 VHF Band One

VHF Low Band (70.5-71.5 MHz and 80.0-81.5 MHz) spectrum is available

4.24 Figures 4.2 and 4.3 below summarise how the relevant parts of VHF Low Band (70.5-72.3813 MHz and 76.80625-83.4875 MHz) can be used. The sub-bands highlighted in blue are those we are confirming for a wide range of uses, including IoT services.

Figure 4.2. VHF Low Band (70.5-71.5 MHz)

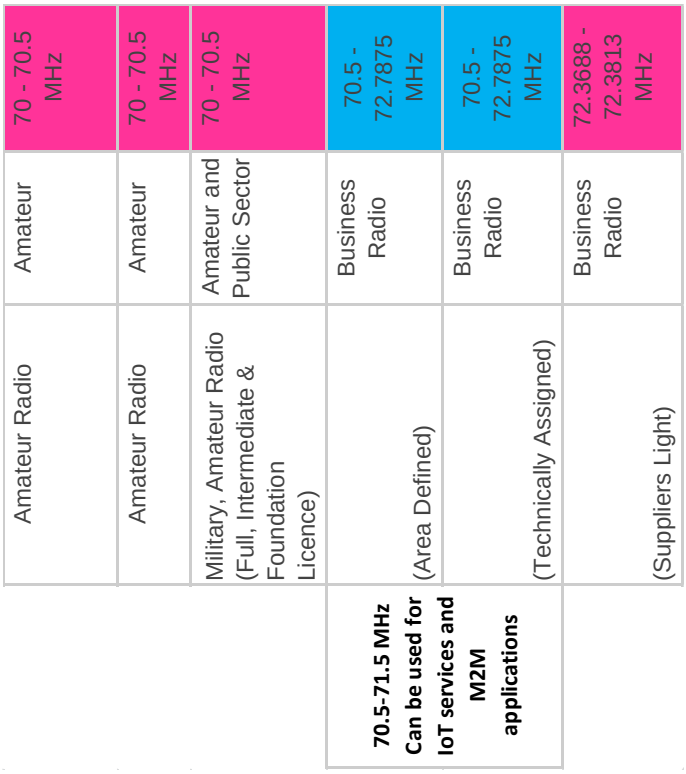

Figure 4.3. VHF Low Band (80.0-81.5 MHz)

International coordination will be required for Band I

4.25 Because 47-68 MHz is used differently in France and the UK, a technical frequency co-ordination procedure has been agreed to manage country-to-country interference. This procedure is set out in a Memorandum of Understanding[26] (see text link Band One MoU).

4.26 The co-ordination procedure is based on the concept of preferential frequencies. The 47-54 MHz, 54-61 MHz and 61-68 MHz duplex frequency bands are apportioned as groups of frequencies which can be assigned in an equitable manner by both countries. Field strength thresholds[27] are applied inside each neighbouring country to protect the uses in each.

4.27 There is no formal or binding agreement that requires the UK to coordinate VHF Low Band frequency assignments. However, our existing practice, which is consistent with our duty to ensure that spectrum is used efficiently[28], is to endeavour to reduce cross-border harmful interference to a minimum by coordinating VHF Low band assignments where necessary.

4.28 Although parts of Europe, including some of our nearest European neighbours, have agreed to a formal coordination procedure, called the Harmonised Calculation

[26] See http://licensing.ofcom.org.uk/binaries/spectrum/business-radio/technical-information/MoU_for_Band_1_between_the_1.pdf

[27] For international coordination purposes a field strength threshold of 6 dBμV/m at 10 metres above ground level at all points 80 km inside the neighbouring country has been established.

[28] Under section 154 of the Communications Act (2003). See http://www.legislation.gov.uk/ukpga/2003/21/section/154

Method (HCM)[29], the UK has not signed this and we are not bound by it. But we do voluntarily apply it if we believe that the interfering field strength from a transmitter is likely to exceed +6dB micro Volts per metre (μVm^{-1}) close to the UK's border or to the territory of other countries.

4.29 We think these coordination arrangements for VHF Band I and Low Band must continue to apply because we are not changing the technical conditions of our BR licences.

Other spectrum uses and users

Temporary access for Radio Amateurs unchanged

4.30 Radio Amateurs will continue to be permitted temporary access to the 70.5–71.5 MHz band to innovate and research narrowband broadcasting and voice communications. This temporary, innovative use is permitted in England, Wales and Northern Ireland. In Scotland Radio Amateur use of the band is not permitted.

4.31 Amateur Radio use of the 70.5–71.5 MHz band is not protected and must not cause interference to other, authorised, users of the spectrum. Ofcom retains the right to withdraw the facility for temporary access to the band. If we decide to do this Ofcom we will not consult on this decision, but we will publish our intention 12 months prior to discontinuing this arrangement.

Programme Making and Special Events unchanged

4.32 The bands 55.75625-60 MHz, 62.75625-64.8 MHz and 64.8875-66.2 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz are not used for Programme Making and Special Event (PMSE) services. There will be no change to this arrangement within these bands.

Military uses

4.33 Our decision confirming that the bands 55.75625-60 MHz, 62.75625-64.8 MHz and 64.8875-66.2 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz are available for a wide range of uses including IoT services and M2M applications does not affect military uses in the VHF range or those adjacent to these VHF bands. This is because, in the UK, there are no military allocations systems within the 55-68 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz bands, we have decided that we will continue to grant licences on a first come, first served basis and the conditions of our BR licences do not need to change.

Wind profiler radar to be protected

4.34 Ofcom may reject applications to use the 62.75625-64.8 MHz and 64.8875-66.2 MHz if these are within 20km of the Met Office's site at 57.353 N, 7.375 W.

4.35 We encourage applicants to select frequencies in the 70.5-71.5 MHz and 80.0-81.5 MHz bands if they wish to deploy equipment within 20km of the Met Office's site at 57.353 N, 7.375 W.

[29] The HCM agreement can be found here: http://www.hcm-agreement.eu/http/englisch/verwaltung/index_berliner_vereinbarung.htm

Spectrum licences are available

4.36 Our range of BR Spectrum licences for the 55-68 MHz, 70.5-71.5 MHz and 80.0-81.5 MHz bands are available on demand. They can be used for IoT services and M2M applications now using the information below.

BR licence products available for IoT

Three licence products are available. *Click on the in-text links below to learn more about these*:

- Area Defined Licences: Frequency assignments are made in 50km^2 geographic squares aligned to the Ordnance Survey grid or for one or more Nations that make up the UK. A Spectrum Leasing clause may be added by request.
- Technically Assigned Licences: Assignments are coordinated with existing users by us. We will use our spectrum management tools to do this.
- Light Licences: There are three different sub-types of BR Light Licence, each of which has a pre-selected set of radio channels for each of the bands.

Our BR Online service enables users to apply for a range of licences for Business Radio uses. Details of what these licences cover is available in our guidance notes.

You can use our Online Licensing Service to apply for any BR licence product quickly and easily by clicking on this link Apply for a BR Licence.

You may download a paper application form from the Ofcom website.

Annex 1

International harmonisation

International context

A1.1 In the UK VHF Band I and VHF Low Band are allocated to the Land Mobile Service[30]. The VHF bands are currently designated[31] for pan-European Land Mobile services[32].

A1.2 International harmonisation is particularly important in relation to mobile services because there are large economies of scale in equipment manufacture. Mass market mobile devices are typically produced at the largest global scale possible and ideally the number of regional variants is kept as small as possible. In addition, harmonisation can allow consumers to use their mobile devices in other countries without modification. However, there is currently no harmonisation measure for the IoT for these VHF bands.

ITU World Radiocommunication Conference 2019

A1.3 The ITU is a specialised agency of the United Nations, which harmonises the allocation of spectrum internationally. It does so through the ITU Radio Regulations, which are amended approximately every four years by World Radiocommunication Conferences (WRCs). Ofcom takes the lead for the United Kingdom (UK) in WRC negotiations under direction from the Government. We are therefore actively engaged in UK, European and international preparations for the next WRC in 2019 (WRC-19).

A1.4 WRC-19 Agenda Item 9.1.8 calls for studies on the technical and operational aspects of radio networks and systems, as well as spectrum needed, including possible harmonized use of spectrum to support the implementation of narrowband and broadband machine-type communication infrastructures, in order to develop Recommendations, Reports and/or Handbooks, as appropriate, and to take appropriate actions within the ITU Radiocommunication Sector (ITU-R).

European Union

A1.5 Within the European Union, the Radio Spectrum Policy Programme (RSPP) has set out a series of policy objectives, including an obligation on member states to consider the demand for harmonised spectrum bands for Short Range Devices (SRDs) for various applications. These include M2M applications[33].

A1.6 Due to growing demand for harmonised SRDs bands for various applications, the European Commission regularly updates spectrum harmonisation conditions for

[30] Land Mobile Service is defined by Article 1.26 of the ITU Radio Regulations. It means *a mobile service between base stations and land mobile stations, or between land mobile stations.* A Land Mobile station is defined by Article 1.70 of the ITU Radio Regulations. It means *a station in the land mobile service capable of surface movement within the geographical limits of a country or continent.*
[31] The term 'designated' has the specific meaning given in section 4 the European Common Allocation Table (ERC Report 25). See http://www.erodocdb.dk/docs/doc98/official/pdf/ERCRep025.pdf
[32] See CEPT Recommendation T/R 25-08 http://www.erodocdb.dk/Docs/doc98/official/Pdf/Tr2508.pdf
[33] See http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1399300944635&uri=CELEX:52014DC0228

SRDs. As part of this regular update process, the technical annex of Commission Decision 2006/771/EC[34] has been updated five times since it was first adopted in 2006, most recently in 2013 (See Commission Decision 2013/752/EU[35]).

[34] See http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:312:0066:0070:EN:PDF
[35] See http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0752&from=EN

Annex 2

Technical conditions of BR Licences

Detail of technical conditions

A2.1 In table A1.1 of annex the conditions associated with our current BR licence products are set out.

A2.2 We will be launching a new licence product later this year to ensure that they cater for M2M/IoT applications and that this is clear to all stakeholders. The new product will support M2M/IoT and all current BR applications. Stakeholders with existing licences may continue to operate as they currently do. We will also launch a dedicated information and application web page.

Table A1.1 Conditions associated with the current range of BR licences

Parameters	Licence class	Terms and conditions of our licence products
Channel bandwidth(s)	Area Defined licence	Any channel bandwidth permitted, but typically single or dual channel based on 6.25 kHz, 12.5 kHz, 25 kHz
	Technically Assigned licence	
Maximum transmit power limit	Area Defined licence	IR 2044 applies[36] Base stations: 100Watts[37], 50Watts[38], 25Watts[39] ERP Mobile stations: 25Watts ERP for all channel bandwidths

[36] IR 2044: http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/interface-requirements/ir20441.pdf

[37] For 25kHz channel bandwidth
[38] For 12.5kHz channel bandwidth
[39] For 6.25kHz channel bandwidth

Parameters	Licence class	Terms and conditions of our licence products
	Technically Assigned licence	*Simple Site Light* The maximum permitted ERP power for base stations is 2 Watts with a maximum antenna height of 15m. The maximum permitted ERP power for mobile stations is 2 Watts, except for the 25 kHz bandwidth channels where the maximum permitted ERP power is 0.02 Watts. *Simple UK Light* The maximum permitted ERP power for mobile stations is 5 Watts ERP. *Suppliers Light* The maximum permitted ERP power for base stations is 10 Watts; The maximum permitted ERP power for mobile stations is 25 Watts; The maximum permitted base station antenna height above ground level is 20m.
Duplex type/separation	All licence products	Various duplex type/separation permitted e.g. 8.7125 MHz,10 MHz, 13.5 MHz
Geographical coverage	Area Defined licence	Frequency assignments are made in 50km^2 geographic squares aligned to the Ordnance Survey grid or for one or more Nations that make up the UK. (See Technical frequency Coordination Criteria[40]) Each licensed grid square is subject to field strength limits at the boundary (–116 dBm/12.5 kHz).
	Technically Assigned licence	Determined from the parameters supplied at the time of application.
		Simple Site Light This licence authorises the use of a radio system operating a base station and mobile stations within a small geographical area (typically 1 kilometre or less). This licence authorises the use of hand-portable or mobile radio equipment anywhere within the UK. *Simple UK Light* This licence authorises the use of hand-portable or mobile radio equipment anywhere within the UK.
Other conditions	Area Defined licence	Analogue or digital transmission permitted. IR 2044 applies[41]

[40] http://licensing.ofcom.org.uk/binaries/spectrum/business-radio/technical-information/tfac/ofw164.pdf
[41] IR 2044: http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/interface-requirements/ir20441.pdf

Parameters	Licence class	Terms and conditions of our licence products
	Technically assigned licence	Signalling Codes (CTCSS and DCS) for analogue systems or timeslots or Channel Access Codes for digital systems. IR 2044 applies[42] IR 2008[43] technology permitted
		Simple Site Light and Simple UK Light IR 2044 applies[28] Base station use is not permitted. *Suppliers Light* IR 2044 applies[28] This licence product is a specialist licence for Radio Suppliers.

[42] IR 2044: http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/interface-requirements/ir20441.pdf

[43] IR 2008: http://www.ofcom.org.uk/static/archive/ra/publication/interface/word-pdf/ir2008v1-2.pdf

Annex 3

Glossary

ADS	(Audio Distribution Service) equipment for transmitting audio content
AIOTI	Alliance for Internet of Things Innovation
AIP	Administrative Incentive Pricing
BHTV	British Heritage Television
BR	(Business Radio) Use of radio for business purposes. Business radio users range from taxi companies and factories, to hospitals, care homes, industrial sites and transport operators
CCIR	(The Consultative Committee on International Radio) Former technical advisory group within the International Telecommunications Union (ITU), that provided Recommendations, technical advice, and technical information related to the allocation and use of the radio spectrum
CEPT	(Conference of European Postal and Telecommunications Administrations). CEPT is the European regional organisation dealing with postal and telecommunications issues.
CoAP	Constrained Application Protocol
2003 Act	Communications Act 2003
CTCSS	(Continuous Tone-Coded Squelch System). A circuit that is used to reduce the annoyance of listening to other users on a shared two-way radio communications channel.
dBm	An abbreviation for the power ratio in decibels (dB) of the measured power referenced to one milliwatt (mW).
dBµV/m	Radio signal field strength expressed in decibel-microvolts per meter.
DCS	(Digital-Coded Squelch). A digital replacement for CTCSS. DCS code is used in a group of radios to reduce the annoyance of listening to other users on a shared two-way radio communications channel.
DTLS	Datagram Transport Layer Security
E.R.P.	(Effective Radiated Power). This is the product of the power supplied to the antenna and the antenna gain in a given direction.
HTTP	Hypertext Transfer Protocol
IoT	(Internet of things). Refers to the interconnection [wirelessly] of uniquely identifiable embedded computing-like devices within the existing Internet infrastructure.

IR (Interface Requirements) Published by Ofcom, these provide a link between the requirements of the R&TTE Directive and how spectrum is used nationally for radio equipment.

IPv4/IPv6 Internet Protocol Versions 4 and 6

ITU (International Telecommunication Union) The ITU is the United Nations specialized agency for information and communication technologies.

ITU-R (International Telecommunication Union Radiocommunication sector) One of the three sectors (divisions or units) of the International Telecommunication Union (ITU) and is responsible for radio communication.

ITU-R Recommendations The ITU-R Recommendations constitute a set of international technical standards developed by the Radiocommunication Sector (formerly CCIR) of the ITU.

JRC Joint Radio Company

kbs^{-1} (Kilobits per second) . $1x10^3$ binary digits of information per second

kHz (Kilohertz). A measurement of frequency in the International System of Units (SI). It is defined as $1x10^3$ cycles per second.

km (Kilometre) . A unit of length in the metric system, equal to one thousand metres (kilo- being the SI prefix).

LAN (Local Area Network) A computer network that spans a relatively small area.

LTE (Long term Evolution) A standard for wireless communication of high-speed data for mobile phones and data terminals.

MHz (Megahertz). A measurement of frequency in the International System of Units (SI). It is defined as $1x10^6$ cycles per second.

MOD Ministry of Defence

MoU (Memorandum of Understanding) A formal agreement between two or more parties.

M2M (Machine to Machine) Refers to technologies that allow both wireless and wired systems to communicate with other devices of the same type.

OS Ordnance Survey

PMR (Private Mobile Radio) Radio communications systems which use portable, mobile, base station and dispatch console radios.

PMSE	(Programme Making and Special Events) Equipment that is used to support broadcasting, news gathering, theatrical productions and special events.
PSSPG	(Public Safety Spectrum Policy Group), Committee responsible for ensuring that future access to Public Safety spectrum is consistent with the policy framework for spectrum management as determined by Government and Ofcom
R&TTE Directive	(Radio and Telecommunications Equipment Directive) Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications equipment and the mutual recognition of their conformity.
RSPP	Radio Spectrum Policy Programme
SRD	Short Range Device
TAUWI	Telecommunication Association of the UK Water Industry
TCP	Transmission Control Protocol
T&D	(Test and Development) This term is still used colloquially for a licence granted by Ofcom under the Non-Operational Development class of licence, for non-operational use of radio spectrum for innovative purposes.
TLS	Transport Layer Security
UDP	User Datagram Protocol
UK	United Kingdom
VHF	(Very High Frequency). Spectrum between 30 MHz and 300 MHz.
VHF Band One	Frequencies within the 55.75-68 MHz range
VHF Low Band	Frequencies within the 68.08125–87.49375 MHz range
WiFi	The name of a popular wireless networking technology that uses radio waves to provide wireless high-speed Internet and network connections. Wi-Fi is a trademarked phrase for the standards IEEE 802.11x.
WPR	(Wind Profiling Radar) A type of weather observing equipment that uses radar or sound waves to detect the wind speed and direction at various elevations above the ground.
WT Act	Wireless Telegraphy Act 2006
WRC	World Radio Conference
5G	5th Generation mobile networks or 5th generation wireless systems
6LoWPAN	IPv6 over Low power Wireless Personal Area Networks