OFFICE OF COMMUNICATIONS

Managing the spectrum above 275 GHz

A consultation on the licence-exempt use of the 275-3000 GHz band

Consultation

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Contents

Section 1

Executive Summary

1.1 In December 2007, we published the Licence Exempt Framework Review (LEFR) Statement describing our policy on managing spectrum used by licence-exempt devices. One of the recommendations of the LEFR Statement was to open higher frequency bands for licence-exempt use.

1.2 The spectrum at high frequencies is characterised by severe atmospheric attenuation due to oxygen and water molecules among others. To improve the link budget, directional antennas are used. Due to these factors and the large swathes of frequency available, the probability of harmful interference at high frequencies is low.

1.3 In this document, we propose to release the 275-3000 GHz band for licence-exempt use, subject to certain constraints such as power limits and excluding bands specified by Footnote 5.565 for spectral line measurements.

1.4 Given the low probability of harmful interference in the 275-3000 GHz band, on the basis of good spectrum management principles, it is reasonable to make this band available for licence-exempt use. In addition, taking such an approach may encourage innovation and the emergence of new applications while reducing regulatory overheads.

1.5 The spectrum above 275 GHz is mainly used by the scientific community (radio-astronomy, space research and earth exploration satellite services) for spectral line measurements. However, other potential uses for the band include short range anti-collision radar devices, detection of skin cancer and other non destructive evaluation methods used in industrial processes.

1.6 We have used the power limits associated with non-generic short range devices (SRDs) in the 244-246 GHz band as a proxy for the power limit at 275 GHz. We believe that non-generic SRDs are a suitable proxy given that devices in the band of interest are likely to be short range and potentially be used for a range of applications. However, we propose to extrapolate this power limit appropriately for frequencies above 275 GHz to account for increased path loss with frequency.

1.7 We understand that the World Radiocommunication Conference 2011 has an agenda item to review the spectrum used by passive services in the 275-3000 GHz band. Depending on the outcome of the conference, Ofcom may revise the relevant Statutory Instruments as a result.

Section 2

Introduction

Licence Exempt Framework Review (LEFR) recommendation

2.1 In December 2007, we published the Licence Exempt Framework Review (LEFR) Statement[1] describing our policy on managing spectrum used by licence-exempt devices. Among a range of issues, the LEFR Statement addressed the question of whether there was a frequency limit above which spectrum could be made licence-exempt and if this was the case, what would the frequency limit be. The analysis of this issue focused on the spectrum between 40-105 GHz and the spectrum above 105 GHz.

2.2 In this perspective, one of the recommendations of the LEFR Statement was to allow use of the spectrum in the 275-1000 GHz range by licence-exempt devices, excluding frequencies used by radio-astronomy (RAS), space research (SRS) and earth exploration satellite services (EESS) as specified by Footnote 5.565.

Purpose of this document

2.3 In this document, we propose to extend the above policy to the 275-3000 GHz band and consult on further detailed proposals around the implementation of this policy. We welcome views from stakeholders on our proposals.

2.4 Given the low probability of harmful interference in the 275-3000 GHz band, on the basis of good spectrum management principles, it is reasonable to make this band available for licence-exempt use. In addition, taking such an approach may encourage innovation and the emergence of new applications while reducing regulatory overheads.

Structure of this document

2.5 This document is structured as follows:

- Section 3 describes the current regulatory status of the spectrum of interest, the characteristics and uses of this spectrum.
- Section 4 outlines our proposals for the spectrum in the 275-3000 GHz range followed by Section 5 which contains our future plans in this space.
- Annexes 1 to 3 provide information on how to respond to the consultation questions which are listed in Annex 4.
- Annex 5 contains an impact assessment of our proposals given in this document.

[1] http://www.ofcom.org.uk/consult/condocs/lefr/lefr_statement/

Section 3

The 275-3000 GHz band

Introduction

3.1 Sandwiched between the infra-red and microwave (more precisely millimetre wave) parts of the spectrum is the region known as the Terahertz (THz) gap as shown in Figure 3.1 below. In a tutorial paper[2] on terahertz technology, Siegel defines the terahertz region as extending from 300-3000 GHz while other researchers[3] have suggested the 100 GHz to 10 THz band. In this consultation document, we are interested in the 275-3000 GHz frequency range, which we assume to be within the terahertz band.

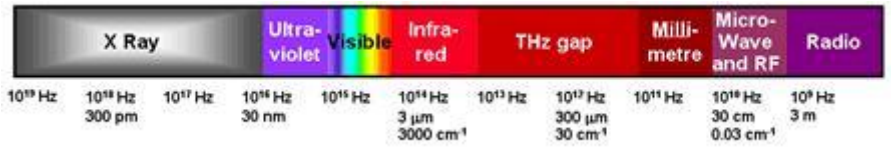

Figure 3.1: Electromagnetic spectrum showing the Terahertz region (Source: HT Consultants[4])

3.2 In this Section, we first give a brief overview of the current situation at ITU and European levels pertaining to the 275-3000 GHz band before describing the regulatory status of this spectrum in the UK. Then, we outline the propagation characteristics and technology constraints of the spectrum above 275 GHz. Finally, we provide an overview of the uses of this spectrum.

Regulatory status of the spectrum

3.3 Article 5 of the Radio Regulations contains a table of frequency allocations (also referred to as the ITU Frequency Allocation Table) where spectrum between 9 kHz to 275 GHz is allocated to a range of radiocommunication services. However, there is no spectrum allocation beyond this upper limit. In fact, the last entry in the ITU Frequency Allocation Table (FAT) is for the 275-1000 GHz band and no services are allocated to this spectrum although Footnote 5.565 applies. Footnote 5.565, which is described later in this Section, pertains to the protection of spectral line measurements used by passive services such as radio astronomy, space research service and earth exploration satellite service.

3.4 The European Table of Frequency Allocations (ERC Report 25) and the UK Frequency Allocation Table also mirrors the ITU FAT with no allocation of services to the 275-1000 GHz band. However, in June 2008, the Electronics Communications Committee (ECC) consulted on the European table of frequency allocations. One of the proposed changes is to extend the table up to 3000 GHz while not allocating any services to the 275-3000 GHz band.

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[2] P. H. Siegel, 'Terahertz technology', IEEE Transactions of microwave theory and techniques, Vol. 50, No. 3, pp. 910-928, March 2002.
[3] R. A. Lewis, 'Physical phenomena in electronic materials in the terahertz region', Proceedings of the IEEE, Vol. 95, No. 8, pp. 1641-1645, August 2007.
[4] www.htconsultants.com

3.5 In the UK, radio spectrum is regulated by the Wireless Telegraphy Act (WT Act) 2006. Section 8 of the WT Act 2006 allows the use of a wireless telegraphy apparatus under a wireless telegraphy licence, unless the said apparatus is exempted by appropriate regulation. The definition of wireless telegraphy as given in Section 116 of the WT Act 2006 encompasses the emission and reception of electromagnetic energy up to a frequency of 3000 GHz[5,6].

3.6 In the absence of any exemptions, use of the 275-3000 GHz band in the UK currently requires a wireless telegraphy licence.

Propagation and technology constraints

Propagation constraints

3.7 When radio waves travel through the Earth's atmosphere, they interact with the gaseous molecules therein resulting in an attenuation of the signal. Below 10 GHz, gaseous absorption levels can be assumed to be negligible[7]. However, as shown in Figure 3.2, this attenuation tends to increase with frequency, with peaks at certain frequencies corresponding to the resonance frequency of molecules such as oxygen and water vapour among others.

3.8 A key characteristic of the spectrum above 275 GHz is the high gaseous absorption levels which can be around a few hundreds of dB per kilometre at frequencies above 500 GHz (see Figures 3.2 and 3.3).

[5] According to Section 116(3) of the WT Act 2006, the Secretary of State may by order modify the definition of wireless telegraphy by altering the frequency limit.
[6] This is in line with the definition of radio waves given by the Radio Regulations. Item 1.5 of Article 1 of the Radio Regulations defines radio waves as "*electromagnetic waves of frequency arbitrarily lower than 3000 GHz, propagated in space without artificial guide*".
[7] www.mike-willis.com/Tutorial/gases.htm

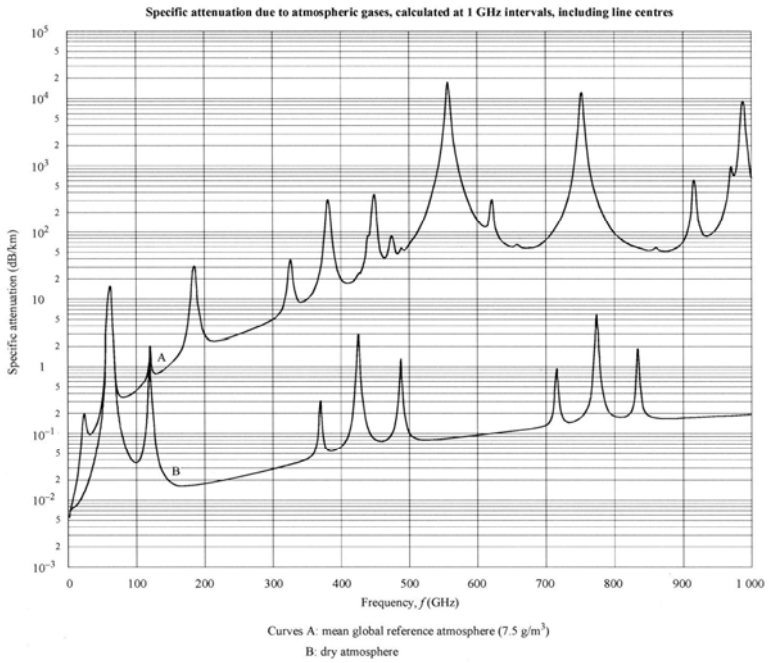

Figure 3.2: Specific attenuation due to atmospheric gases up to 1000 GHz (Source: ITU-R P. 676-5[8])

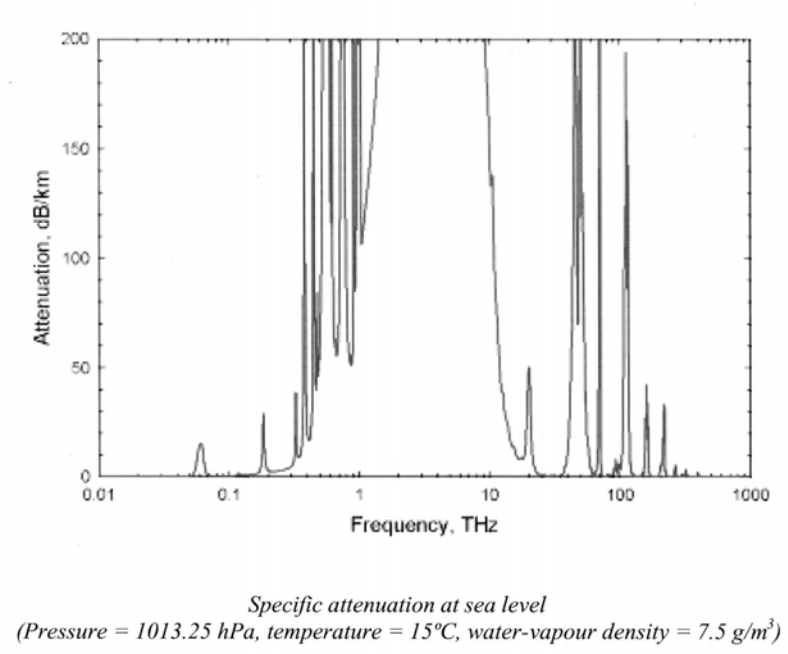

Figure 3.3: Specific attenuation due to atmospheric gases over the frequency range of 10 GHz to 1000 THz (Source: Norbury *et al*[9])

3.9 In addition, outdoor wireless systems at such high frequencies may have to cope with rain attenuation and other effects such scintillations[10]. Rain can have a critical effect, particularly, in cases where high availabilities are required.

[8] 'Attenuation by atmospheric gases', ITU-R P.676-5.
[9] J. Norbury, C. Gibbins and D. Matheson, 'A theoretical appraisal of the highest usable frequencies', Rutherford Appleton Lab, May 2003.

3.10 The LEFR Statement noted that at frequencies beyond 40 GHz, radio waves are increasingly subject to line-of-sight propagation because of attenuation due to obstructions and atmospheric loss due to gaseous and water vapour absorption. Due to these attenuations, wireless systems at such frequencies are likely to have limited range.

Technology constraints

3.11 As mentioned by Norbury *et al* in a report by the Rutherford Appleton Laboratories (see footnote 9), terahertz technology development has been mainly driven by scientific applications such as radio astronomy and remote sensing. While devices up to at least 1000 GHz have been demonstrated, the authors note that they remain highly specialised, expensive and limited in performance.

3.12 In fact, according to their survey of transmitter and receiver technologies, few demonstrations of radio technology have been made above 1500 GHz. According to the literature (see Siegel's paper), it is clear that the development of transmitters has been slower than that of receivers or sensors. A key challenge is to have sufficiently powerful and compact sources. The consultants at RAL identified that generating even modest power levels (of the order of tens of milliwatts) in the 100-1000 GHz range was a challenge but pointed out that with technological development, this might change. Although more expensive, an increase in power levels might be achieved by combining multiple sources. More recently, Hwu *et al*[11] have highlighted a promising approach to achieve small size but relatively high power sources using micro-fabrication techniques to manufacture vacuum electronic terahertz sources.

3.13 The consultants at RAL also highlighted that the main reason for the difference in cost between terahertz and microwave devices was essentially due to the niche market at high frequencies such that economies of scale were not achieved.

Uses of the spectrum

3.14 The spectrum above 275 GHz is mainly used by passive services for spectral line measurements. Molecules of various compositions radiate energy at a series of discrete frequencies or spectral lines. Each molecule generates a specific set of spectral lines which are used by scientists to identify the radiating source.

3.15 While Footnote 5.565 allows administrations to use the 275-1000 GHz frequency band for experimentation and development of various active and passive services, it urges administrations to take all practicable steps to protect passive services from harmful interference until the date when the allocation table is established in the 275-1000 GHz band.

3.16 The bands specified by Footnote 5.565 for spectral line measurements by passive services such as radio astronomy, space research service and earth exploration satellite service are given below:

- Radio astronomy: 275-323 GHz, 327-371 GHz, 388-424 GHz, 426-442 GHz, 453-510 GHz, 623-711 GHz, 795-909 GHz and 926-945 GHz. These bands account for a total bandwidth of 422 GHz.

[10] Scintillations are caused by turbulence in the atmospheric boundary layer.
[11] R. J. Hwu and L. Sadwick, 'Terahertz sources and applications', Asia Pacific Microwave Conference (APMC) Proceedings, Vol. 5, December 2005.

- Earth exploration satellite service (passive) and space research service (passive): 275-277 GHz, 294-306 GHz, 316-334 GHz, 342-349 GHz, 363-365 GHz, 371-389 GHz, 416-434 GHz, 442-444 GHz, 496-506 GHz, 546-568 GHz, 624-629 GHz, 634-654 GHz, 659-661 GHz, 684-692 GHz, 730-732 GHz, 851-853 GHz and 951-956 GHz. These bands account for a total bandwidth of 155 GHz.

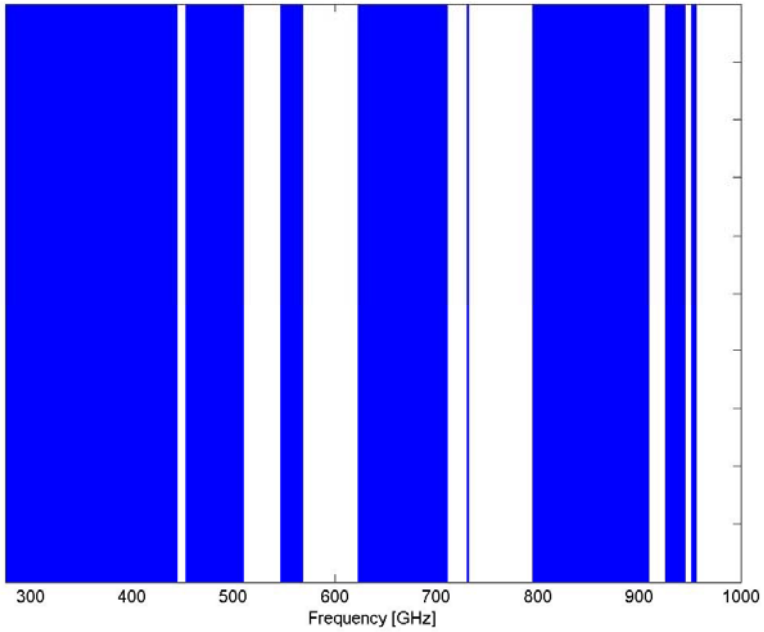

Figure 3.4: Bands specified by Footnote 5.565 for spectral line measurements by passive services (radio astronomy, space research service and earth exploration satellite service).

3.17 These allocations, shown graphically in Figure 3.4, comprise some 476 GHz (Note that the radio astronomy service shares certain bands with the Earth exploration satellite and space research services) in total and represent 66 % of the spectrum between 275 GHz and 1000 GHz and 17 % of the spectrum between 275 GHz and 3000 GHz.

3.18 According to the Committee on Radio Astronomy[12] (CRAF), there are only two observation sites in Europe (in France and Spain) using the 275-1000 GHz band. These sites are typically located at high altitudes to minimise attenuation due to the atmosphere. Although there are no observation sites in the UK, we understand from UK radio astronomers that the bands specified for radio astronomy in Footnote 5.565 are used in the development of equipment.

3.19 While receivers used for radio astronomy are directed towards space to, say, identify the composition of galaxies etc, receivers onboard satellites used by the earth exploration satellite service are directed towards the Earth's surface for remote sensing purposes. If we were to allow low power use of the spectral line bands designated for the earth exploration satellite service, this might be problematic given the very low wanted signals encountered in remote sensing and the receiver pointing to the source of interference. We note that while receivers used for observation by

[12] www.craf.eu

the space research service are likely to be in orbit and pointing to outer space, the space research service share the same bands for spectral line measurements as the earth exploration service.

3.20 In line with the recommendation in Footnote 5.565 and our policy decision stated in the LEFR, we will protect the bands used for spectral line measurements by passive services. These bands are excluded from our proposals in Section 4.

3.21 The aforementioned services are not the only users of the spectrum above 275 GHz. In fact, applications in fields such as medicine and security are possible due to the properties of terahertz waves. These waves are able to penetrate materials that are usually opaque to both visible and infra-red radiation. Although, terahertz waves are absorbed by metals or water, they can penetrate through fabrics, plastics, paper or oil among others[13]. Terahertz technology can be used for a slew of applications[14] in the fields listed below:

- Medical: Detection of skin cancer by the reflection of terahertz waves off cancerous tissues.

- Industrial applications: Non destructive evaluation methods such fault analysis of large-scale integrated circuits using a laser THz emission microscope (LTEM), the fault detection of heat insulation panels or monitoring the water content of fruits/vegetables to assess damage.

- Security: Detection of explosives and narcotics based on their distinct signature in the terahertz spectra. In addition, hazardous gas such as carbon monoxide can be detected at fire sites where infra-red gas detection is not appropriate.

3.22 The above list of comprises a mix of active and passive applications which are characterised by a short range of operation (a few metres) and are mostly expected to operate in a controlled environment (e.g. a laboratory). Hence, it is reasonable to envisage licence exemption for the use of spectrum by these applications.

3.23 In addition, the Rutherford Appleton Laboratories (RAL) report assessed the suitability of a range of communication systems in the 100-1000 GHz frequency. Based on the link budget, the following applications are able to operate in the spectrum above 275 GHz as shown below. An estimate of the maximum operating frequency limit at which an application can be used is given in brackets. Interestingly, the RAL report highlighted that short range devices used within personal area networks (e.g. wearable devices) or within home communication system are likely to have an upper frequency limit below 275 GHz given the power levels required so that radiation safety levels are not exceeded by the low gain antennas used in such devices.

- Short range point-to-point fixed links (up to ~ 440 GHz)

- Aircraft to satellite links (up to ~ 350 GHz)

- Indoor Gigabit WLAN (up to ~ 300 GHz)

[13] I. Hosako *et al*, 'At the dawn of a new era in terahertz technology', Proceedings of the IEEE, Vol. 95, No. 8, pp. 1611-1623, August 2007.
[14] M. Tonouchi, 'Prospect of terahertz technology', 19th International Conference on Applied Electromagnetics and Communications, September 2007.

- Short range radar (700-900 GHz)

3.24 Of the above set of applications, the short range point-to-point fixed links, aircraft to satellite links and Indoor Gigabit WLAN applications have a maximum operating frequency limit that occurs within the bands specified by Footnote 5.565 (See Figure 3.4). Since these bands are protected under the policy outlined in this document, it is unlikely for these three applications to make use of the 275-3000 GHz band based on the assumptions used by RAL.

3.25 However, the short range radar application, with a maximum operating frequency of 700-900 GHz, can potentially use the spectrum above 275 GHz which is not protected by Footnote 5.565. In their report[15], Quotient Associates concluded that short range radar applications at high frequencies were suited to a licence-exempt regime and the high spatial/time resolution could be of assistance to drivers. .

3.26 Proof of concept of some of the applications mentioned in this section has been achieved in the terahertz band but it may take a while before some or all of the applications become common place. Key factors influencing this outcome are advances made in the terahertz technology and cost of manufacturing devices using this technology.

[15] 'Higher frequencies for licence-exempt applications', Quotient Associates, Indepen and University of York, February 2007.

Section 4

Licence-exempt use of the 275-3000 GHz band

Introduction

4.1 The LEFR Statement sets out two situations when use of a band should be licence-exempt, namely:

- The economic value derived from the band under a licence-exempt use is greater than the corresponding value if the spectrum was for a licensed use; or
- Harmful interference is unlikely (e.g. where the demand for spectrum in a given frequency band is less than the supply) such that the administrative overhead of licensing is unnecessary.

4.2 We next explain the basis on which our policy with respect to spectrum above 275 GHz was derived by assessing a range of options. Subsequently, we present detailed proposals on the implementation of our preferred option.

Assessment of the options

4.3 In the main, we list three policy options that can be applied to the frequency band of interest.

- **Option 1**: Do not change the regulatory status of the spectrum in the 275-3000 GHz band until such time there is clear evidence of demand.
- **Option 2**: Release the entire spectrum in the 275-3000 GHz band for use by licence-exempt devices.
- **Option 3**: Release the spectrum in the 275-3000 GHz band for use by licence-exempt devices, excluding the bands identified for spectral line measurements in Footnote 5.565.

4.4 Essentially, Option 1 is about maintaining the status quo whereby use of the 275-3000 GHz band requires a licence. As mentioned earlier, there are two (economic and interference) criteria to determine whether use of a band should be made licence-exempt or should be licensed. We assess Option 1 in the light of these criteria.

4.5 From our review of the uses of the 275-3000 GHz spectrum in Section 3, it is clear that the technology for this frequency range is still under development. At this stage, it is difficult to determine which applications will eventually emerge into the market, when this will happen and if it does, what is the likely take up of such applications. Given this uncertainty, we believe that it is unreasonable to apply the economic criterion in determining the spectrum management approach to the 275-3000 GHz band.

4.6 Regarding the interference criterion, the studies (report by Quotient Associates and others) commissioned by Ofcom in preparation of the LEFR indicate that radio

congestion and hence harmful interference are unlikely above 105 GHz. The LEFR consultation document[16] listed three reasons to substantiate a lower likelihood of congestion[17] at higher frequencies. The reasons are:

- The high propagation loss limits the range of the interfering signals.
- Use of directional antennas at high frequencies mitigates the impact of interference.
- Large swathes of frequency imply a low probability of co-channel collision.

4.7 Given the low probability of harmful interference in the 275-3000 GHz band, on the basis of good spectrum management principles, it is reasonable to make this band available for licence-exempt use. Hence, we do not favour Option 1.

4.8 In addition, we do not believe a spectrum reserve for licensed or light-licensed use is justified in the 275-3000 GHz band. As argued in the LEFR Statement, a spectrum reserve above 275 GHz can only be justified if an application is expected to emerge in the future with the following characteristics:

a) It is unable to operate in the presence of other co-channel uses.

b) It cannot be accommodated at other frequencies.

4.9 Of the potential applications for the terahertz band as discussed in Section 3, we identified that only short range point-to-point fixed links were not suitable for licence-exempt use and instead were more appropriate to use a light-licensed spectrum. Today, many links of this type are capable of operating in the presence of other co-channel uses, when assisted by various interference avoidance and mitigation technologies. With advances in such technologies, we infer that item (a) is unlikely to occur. In addition, as mentioned in the LEFR Statement, the amount of spectrum (about 40 GHz) proposed for light-licensing in the 105-275 GHz band is more than enough bandwidth to accommodate the (unlikely) emergence of applications which may be intolerant of co-channel uses. Hence, we conclude that item (b) above is also unlikely.

4.10 On balance, therefore, we believe that a spectrum reserve is not justified.

4.11 The release of the entire spectrum in the 275-3000 GHz band for licence-exempt use according to Option 2 may affect the activities of the science community utilising the bands designated for spectral measurement lines. Given the generous amount of spectrum available in the 275-3000 GHz band, we believe there is no need for such an approach.

4.12 Our preferred approach is Option 3 where we respect use of the spectrum (as specified by Footnote 5.565) for spectral line measurements but make the remainder of the spectrum in the 275-3000 GHz band available for licence-exempt use given that harmful interference is unlikely to occur at such frequencies. Taking such an approach may encourage innovation and the emergence of new applications while reducing regulatory overheads.

[16] http://www.ofcom.org.uk/consult/condocs/lefr/lefr.pdf
[17] Congestion refers to the potential for radio devices to generate harmful interference towards other devices.

Our proposals

4.13 We propose to make the spectrum in the 275-3000 GHz band available for licence-exempt use, with the exclusion of the bands specified in Footnote 5.565. The same policy was outlined in the LEFR Statement except that the 275-1000 GHz band was considered.

4.14 The arguments for making the 275-1000 GHz band available for licence-exempt use are equally valid, if not more so, at higher frequencies, particularly taking into account the increase in propagation loss above 1 THz (See Figure 3.3). However, we have to determine an upper frequency limit at which the licence-exempt use applies. As mentioned in Section 3, the WT Act 2006 extends up to 3000 GHz (i.e. 3 THz) which is also the upper limit of the definition of radio waves in the Radio Regulations (Item 1.5 of Article 1). In the absence of any strong evidence as to what the upper frequency limit should be, we believe that 3000 GHz is a reasonable value.

Q1: Is 3000 GHz a reasonable value for the upper frequency limit for licence-exempt use?

4.15 Licence-exempt use of spectrum is typically allowed on the basis of certain constraints such as power levels, duty cycles, bandwidth etc. However, setting these constraints is somewhat complicated by the absence of any specific technology or standards applicable to the 275-3000 GHz band and by the uncertainty surrounding the applications that will emerge for this band. As a result, we need a proxy for this purpose. We have selected the exemption rules associated with non-generic short range devices (SRDs) in the 244-246 GHz band. We believe that non-generic SRDs are a suitable proxy given that devices above 275 GHz are likely to be short range and potentially be used for a range of applications. According to Annex 1 of the ERC Recommendation 70-03, the only constraint on non-generic SRDs at 244-246 GHz is a power limit of 100 mW EIRP[18] (effective isotropic radiated power).

4.16 Hence, we also set an EIRP limit of 100 mW (i.e. 20 dBm) at 275 GHz. This limit is scaled with frequency across the 275-3000 GHz band using a positive gradient of 20 dB per decade as shown in Figure 4.1. It should be noted that the limit does not apply to passive bands identified under Footnote 5.565 (See paragraph 3.16).

Q2: Do you agree with the constraints specified for licence-exempt use of the 275-3000 GHz band?

[18] The effective isotropic radiated power (EIRP) is defined as the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna.

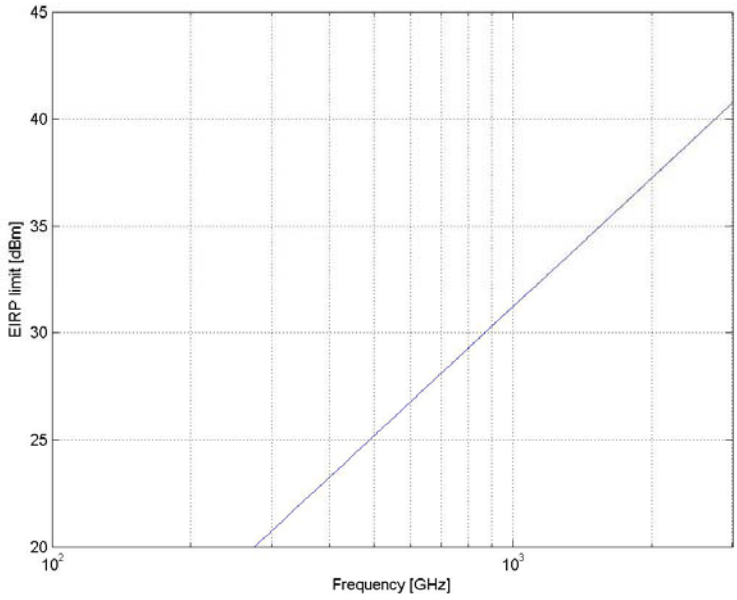

Figure 4.1: Variation of the EIRP limit with frequency over the 275-3000 GHz band

4.17 This scaling accounts for the deterioration in the free-space radio propagation link budget with the square of frequency for a specific receiver antenna gain[19]. Because of this, a high-frequency high-power transmitter effectively generates the same amount of co-channel interference as a low-frequency low-power transmitter.

4.18 Use of a device operating with an EIRP below the limit specified in Equation 1.1 will be exempted from the need of a licence. This applies to the frequency range of 275-3000 GHz, with the exclusion of bands specified by Footnote 5.565.

$$P_{\text{limit}} = 20 + 20 * \log_{10}\left(f/275\right) \qquad \text{[Equation 1.1]}$$

where P_{limit} is the peak EIRP limit[20] in dBm, and f is frequency in GHz. Equation 1.1 applies over the frequency range of 275-3000 GHz, excluding the bands specified by Footnote 5.565.

4.19 We appreciate that according to item 1.6 of the provisional agenda for the 2011 World Radiocommunication Conference (WRC 11)[21], Footnote 5.565 be will reviewed "*in order to update the spectrum use by the passive services between 275 GHz and 3000 GHz*".

4.20 With respect to changes to Footnote 5.565, we maintain the same position as outlined in the LEFR Statement which states: "*While we would expect all authorisations of licence-exempt spectrum use to be for an indefinite period, there are certain specific grounds for their revocation, including the emergence of other more valuable uses of spectrum. Therefore, depending on the value of the licence-*

[19] This assumes that over short distances, other frequency-dependent attenuation effects such as gaseous and water vapour absorption may be ignored.
[20] ERC Recommendation 70-03 only specifies an EIRP limit of 100 mW for non-generic SRDs in the 244-246 GHz band. Given the low likelihood of interference due to significant propagation losses in the terahertz band, we set the limit as a peak EIRP limit.
[21] Resolution [COM6/7] (WRC 07) of the World Radiocommunication Conference Provisional Final Acts, Geneva, 22 Oct – 16 Nov 2007.

exempt applications which may emerge over the 275-3000 GHz band, Ofcom will react appropriately to any future motions to extend the frequencies listed under Footnote 5.565. It should also be noted that the implementation of any such extensions would inevitably be associated with notice periods of the order of 4 to 6 years through the WRC process".

4.21 We also highlight that despite the above power limit, users should respect radiation hazard limits[22] as stipulated by the Health Protection Agency, bearing in mind that they may be amended from time to time. As new applications emerge in the spectrum above 275 GHz and research[23] on the health impacts of radiation at these frequencies is carried out, the radiation hazard limits may be extended beyond the current upper frequency limit of 300 GHz.

4.22 In May 2008, we consulted on the concept of defining multiple classes of spectrum commons[24]. Each class is intended to have applications with broadly similar interference generating characteristics as determined by an interference indicator. The interference indicator of an application captures its potential to cause interference based on the geographic or spatial, time and frequency domains. The consultation document proposed three spectrum classes namely low, medium and high interference classes. The boundaries of these classes are set at specific interference indicator values.

4.23 Given the large amount of spectrum available and the low power limits applicable to the 275-3000 GHz band, we anticipate that the interference indicator of applications in this band will result in the band being categorised as a low interference class, should this concept be implemented to the 275-3000 GHz band in the future.

[22] A. McKinlay *et al*, 'Advice on limiting exposure to electromagnetic fields (0-300 GHz)', Documents of the NRPB, Vol. 15, No. 2, 2004.
[23] K. Kawase, 'Terahertz imaging – new steps towards real-life applications', 12th International Conference on Terahertz electronics, pp. 553-554, 27 Sept -1 Oct 2004.
[24] http://www.ofcom.org.uk/consult/condocs/scc/SpecCommonsClasses.pdf

Section 5

Next steps

5.1 Following the publication of this consultation document, stakeholders are welcome to provide their feedback. The deadline to submit responses to Ofcom is 4 December 2008. We expect to release a Statement on this consultation in the first quarter of 2009, having taken into account the stakeholder responses to our proposals. Subsequently, Ofcom will publish appropriate exemption regulations in the form of interface requirements.

5.2 We view the release of the spectrum in the 275-3000 GHz for licence-exempt use as part of a broader strategy of encouraging innovation and removing regulatory overheads. We aim to encourage discussion about our policy for this band at international level and will support initiatives to produce harmonised standards at higher frequencies.

Annex 1

Responding 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 4 December 2008**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://www.ofcom.org.uk/consult/condocs/275ghz/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 abdus.owadally@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

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

Dr. Abdus Owadally
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 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.

A1.6 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.

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 before the end of 2008.

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 Vicki Nash, Director Scotland, who is Ofcom's consultation champion:

Vicki Nash
Ofcom
Sutherland House
149 St. Vincent Street
Glasgow G2 5NW

Tel: 0141 229 7401
Fax: 0141 229 7433

Email vicki.nash@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 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

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 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.

A2.5 We will consult for up to 10 weeks depending on the potential impact of our proposals.

A2.6 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.

A2.7 If we are not able to follow one of these principles, we will explain why.

After the consultation

A2.8 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

Q1: Is 3000 GHz a reasonable value for the upper frequency limit for licence-exempt use?

Q2: Do you agree with the constraints specified for licence-exempt use of the 275-3000 GHz band?

Annex 5

Impact Assessment

Introduction

A5.1 The analysis presented in this annex represents an impact assessment, as defined in section 7 of the Communications Act 2003 (the Act).

A5.2 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 is reflected in section 7 of the Act, which means that generally we have to carry out impact assessments where our proposals would be likely to have a significant effect on businesses or the general public, or when there is a major change in Ofcom's activities. However, as a matter of policy Ofcom is committed to carrying out and publishing impact assessments in relation to the great majority of our policy decisions. For further information about our approach to impact assessments, see the guidelines, Better policy-making: Ofcom's approach to impact assessment, which are on our website: http://www.ofcom.org.uk/consult/policy_making/guidelines.pdf

A5.3 In this consultation document, we are proposing to make the spectrum in the 275-3000 GHz range available for licence-exempt use subject to certain power limits and excluding the bands designated for spectral line measurements according to Footnote 5.565.

The citizen and/or consumer interest

A5.4 By removing regulatory overheads, the release of the spectrum in the 275-3000 GHz may encourage innovation and the emergence of new applications of value to citizens and consumers. Potential new applications for this band include short range anti-collision radar devices, detection of skin cancer and other non destructive evaluation methods used in industrial processes. However, given that it is unclear at this stage which applications will be successful and when this will happen, it is difficult to estimate the economic benefits to citizens and consumers.

A5.5 As we are removing regulatory barriers, our policy should not result in additional cost to users. We are also accounting for the use of certain bands for spectral line measurements by the scientific community. Hence, our policy is not detrimental to these users.

A5.6 Although it is difficult to quantify the cost and benefits resulting from our policy, we believe that on balance, it is better to make the spectrum in the 275-3000 GHz band available for licence-exempt use subject to certain restrictions. This is because of the low likelihood of harmful interference in this band.

Ofcom's policy objective

A5.7 In the main, we list three policy options that can be applied to the frequency band of interest.

- **Option 1**: Do not change the regulatory status of the spectrum in the 275-3000 GHz band until such time there is clear evidence of demand.

- **Option 2**: Release the entire spectrum in the 275-3000 GHz band for use by licence-exempt devices.

- **Option 3**: Release the spectrum in the 275-3000 GHz band for use by licence-exempt devices, excluding the bands identified for spectral line measurements in Footnote 5.565.

A5.8 Essentially, Option 1 is about maintaining the status quo whereby use of the 275-3000 GHz band requires a licence. As mentioned earlier, there are two (economic and interference) criteria to determine whether use of a band should be made licence-exempt or should be licensed. We assess Option 1 in the light of these criteria.

A5.9 From our review of the uses of the 275-3000 GHz spectrum in Section 3, it is clear that the technology for this frequency range is still under development. At this stage, it is difficult to determine which applications will eventually emerge into the market, when this will happen and if it does, what is the likely take up of such applications. Given this uncertainty, we believe that it is unreasonable to apply the economic criterion in determining the spectrum management approach to the 275-3000 GHz band.

A5.10 Regarding the interference criterion, the studies (report by Quotient Associates and others) commissioned by Ofcom in preparation of the LEFR indicate that radio congestion and hence harmful interference are unlikely above 105 GHz. The LEFR consultation document listed three reasons to substantiate a lower likelihood of congestion at higher frequencies. The reasons are:

- The high propagation loss limits the range of the interfering signals.

- Use of directional antennas at high frequencies mitigates the impact of interference.

- Large swathes of frequency imply a low probability of co-channel collision.

A5.11 Given the low probability of harmful interference in the 275-3000 GHz band, on the basis of good spectrum management principles, it is reasonable to make this band available for licence-exempt use. Hence, we do not favour Option 1.

A5.12 In addition, we do not believe a spectrum reserve for licensed or light-licensed use is justified in the 275-3000 GHz band. As argued in the LEFR Statement, a spectrum reserve above 275 GHz can only be justified if an application is expected to emerge in the future with the following characteristics:

a) It is unable to operate in the presence of other co-channel uses.

b) It cannot be accommodated at other frequencies.

A5.13 Of the potential applications for the terahertz band as discussed in Section 3, we identified that only short range point-to-point fixed links were not suitable for licence-exempt use and instead were more appropriate to use a light-licensed spectrum. Today, many links of this type are capable of operating in the presence of other co-channel uses, when assisted by various interference avoidance and mitigation technologies. With advances in such technologies, we infer that item (a) is unlikely to occur. In addition, as mentioned in the LEFR Statement, the amount of spectrum (about 40 GHz) proposed for light-licensing in the 105-275 GHz band is

more than enough bandwidth to accommodate the (unlikely) emergence of applications which may be intolerant of co-channel uses. Hence, we conclude that item (b) above is also unlikely.

A5.14 On balance, therefore, we believe that a spectrum reserve is not justified.

A5.15 The release of the entire spectrum in the 275-3000 GHz band for licence-exempt use according to Option 2 may affect the activities of the science community utilising the bands designated for spectral measurement lines. Given the generous amount of spectrum available in the 275-3000 GHz band, we believe there is no need for such an approach.

A5.16 Our preferred approach is Option 3 where we respect use of the spectrum (as specified by Footnote 5.565) for spectral line measurements but make the remainder of the spectrum in the 275-3000 GHz band available for licence-exempt use given that harmful interference is unlikely to occur at such frequencies. Taking such an approach may encourage innovation and the emergence of new applications while reducing regulatory overheads.